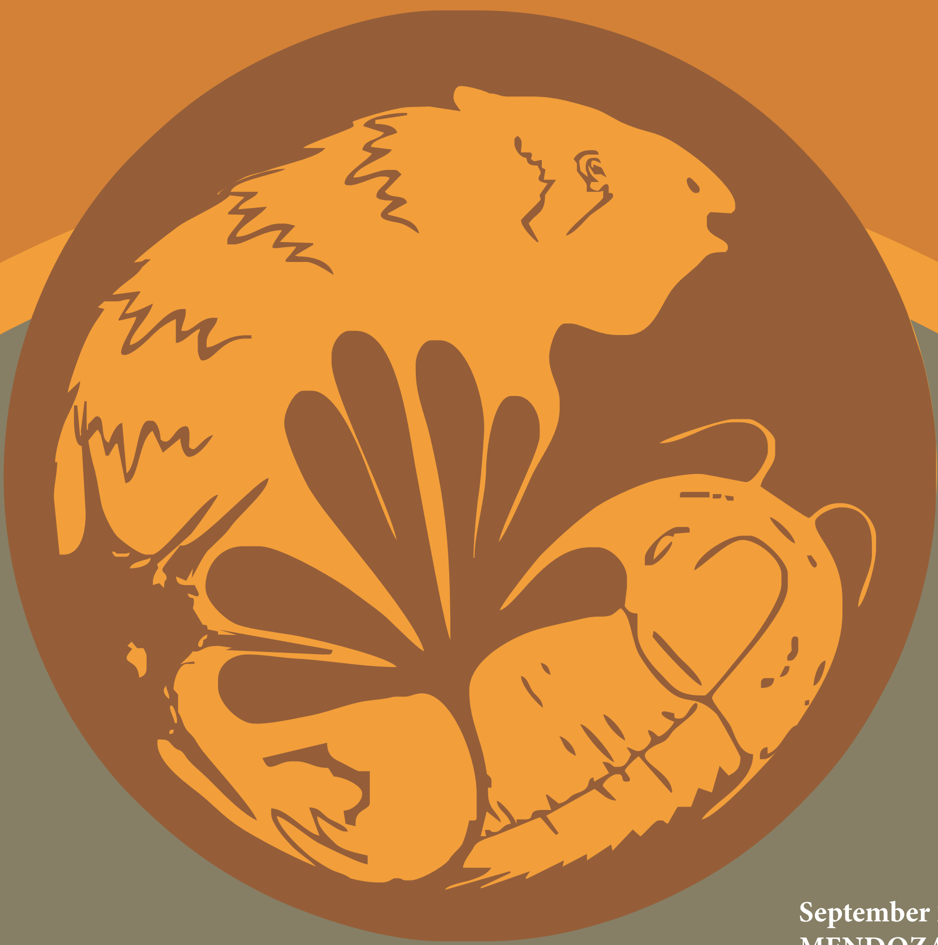
ABSTRACT VOLUME

4th INTERNATIONAL PALAEONTOLOGICAL CONGRESS

The history of life: A view from the Southern Hemisphere



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4th INTERNATIONAL PALAEONTOLOGICAL CONGRESS

THE HISTORY OF LIFE: A VIEW FROM THE SOUTHERN HEMISPHERE

ABSTRACT VOLUME

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Esperanza CERDEÑO | IANIGLA, CCT-CONICET Mendoza. Argentina

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FOREWORD

The 4th International Palaeontological Congress held in Mendoza, at the foothills of the Andes, from September 28th to October 3rd, 2014, constitutes the first time this important event takes place in America. It is hosted by the Centro Científico Tecnológico CONICET Mendoza and organized by top specialists, both local and international, in leading fields of paleontological research. Its venue, strategically located in downtown Mendoza City, is the Sheraton Mendoza Hotel while several academic and social events are simultaneously being held in the nearby Huentala Boutique Hotel.

The 2014 IPC involves 862 scientific participants, of whom a staggering 262 are students, coming from 46 countries, fact which renders the conference truly international. A total amount of 894 abstracts, herein included, are to be presented during the congress. Such presentations, both oral and poster, are orchestrated in a varied array of meeting styles including plenary lectures (5), symposia on leading issues (22), interactive workshops (4) and technical sessions (24). This meeting provides participants with the unique opportunity to discuss experiences, explore new research directions and debate topics with specialists from across the globe. Furthermore, attendees can embark on several field trips, pre-, post- and intra-congress, covering not only some of the most relevant palaeontological settings in the country but also including visits to the main tourist attractions all over Argentina.

We sincerely thank all participating scientists and students, particularly those contributing with oral and poster presentations, for coming to enjoy Mendoza, the sun and wine Argentine province, and making our 4th IPC an unforgettable event.

Claudia V. Rubinstein **Claudia A. Marsicano** **Beatriz G. Waisfeld**

PLENARY LECTURES

PALAEONTOLOGY IN THE SOUTHERN WORLD: BENCHMARKS IN THE HISTORY OF DISCOVERY AND RESEARCH

Beatriz Aguirre-Urreta[1]

1. Instituto de Estudios Andinos "Don Pablo Groeber", Intendente Güiraldes 2160 - Ciudad Universitaria, Pabellón 2, Ciudad Autónoma de Buenos Aires, C1428EGA, Argentina.
aguirre@gl.fcen.uba.ar

The presentation explores the early research and exploration of the southern continents with special reference to South America and Antarctica. The pioneer palaeontological knowledge in South America started in the XVIth century with the military and priests that came to these lands from the Kingdom of Spain. The earliest records are mostly related to findings of huge bones that were linked with the presence of giant humans that had inhabited the region before the Deluge. Besides, the European navigators that travelled along the southern oceans also provided early references to fossil vertebrate and invertebrate remains. By the XVIIIth the amount of references of fossil findings all along the west of South America and also in the Pampean region of what is now Argentina increased exponentially, while the first report of fossils of what is now Brazil is by the end of the XVIIIth century with the testimony of the exceptionally preserved fossil fishes from Ceará. It is worth noting here that this description includes interesting taphonomic inferences. The next stage in the history of discovery and research is that related to several voyages of European naturalists in the XIXth century. The three most important expeditions were performed by Alexander von Humboldt, Alcide d'Orbigny and Charles Darwin. Humboldt in the company of Aimé Bonpland toured extensively northwestern South America, collecting fossils that were later described by great naturalists of the stature of George Cuvier and Leopold von Busch. Alcide d'Orbigny travelled for 8 years (1826-1834) in almost exactly the region of South America that was not covered by Humboldt, conducting major studies in what is now Bolivia, the Paraná River banks and the regions bordering the oceanic coasts of southern South America. The results of these studies were published in the *Voyage dans l'Amérique méridionale* with a volume devoted to the paleontological findings. Charles Darwin on board of the Beagle stayed almost five years investigating geology and palaeontology and making natural history collections all around the world, but mostly in the southern hemisphere. In fact, Darwin spent most of this time exploring on land while the Beagle surveyed and charted coasts. He kept careful notes of his observations and his theoretical speculations, that enabled him when he went back home, to work in his famous theory on the origin of species by natural selection. It is important to mention here his findings of fossil mammals in the coasts of Argentina and his geological and palaeontological observations across the Main Andes of Argentina and Chile which are as, or even more important, than his research in the Galápagos Islands. In the late XIXth century, Florentino Ameghino, an Argentine *savant*, devoted much of his life to the study of Cenozoic fossil mammals with the help and expertise of his brother Carlos who made more than a dozen field trips to Patagonia. George Gaylord Simpson, eminent palaeontologist and one of the founders of the Synthetic Theory of Evolution said "*The partnership of the Ameghino brothers was an outstanding example of teamwork, and their achievement was one of the most remarkable in scientific history*". The survey of the southernmost region of the world during the second expedition of James Cook (1772-1775) in search for the *Terra Australis Incognita*, demonstrated that the Antarctic land was much smaller than previously thought and mostly covered by ice. This fact set the stage for the XIXth and XXth century explorations of Antarctica. The expedition of Otto Nordenskjöld around Antarctic Peninsula is relevant from the palaeontological point of view, specially taking into account the paleoclimatic inferences that were postulated from the study of the Mesozoic paleofloras of Hope Bay, showing that Antarctica has been a much warmer place in the past. The fossils recovered many months after the ill fated end of Robert Scott second expedition to the South Pole included representatives of *Glossopteris*, a seed fern only known at that time from India, Australia and South Africa. The studies of Juan Keidel in Argentina together with those of Alexander Du Toit in South Africa regarding many geological similarities between Late Paleozoic rocks of both regions combined with the geographic distribution of *Glossopteris* and *Mesosaurus*, a small aquatic reptile, were key elements in Alfred Wegener theory of continental drift and also in the existence of Gondwana. His hypothesis was controversial and not accepted until much later when other discoveries provided support for continental drift which is a substantial basis for today's model of plate tectonics. Some revolutionary scientific theories may take many years to be accepted among scientists. This is certainly true of plate tectonics, one of the most important geological theories of all times and of evolution of species by natural selection, one of the most important theories in modern biology. Finally I would like to end this presentation stressing that both theories got strong inputs from early palaeontological discoveries in the southern world, an area that may still hold some hidden treasures for the palaeontology of the future.

RECOVERY FROM THE GREATEST MASS EXTINCTION OF ALL TIME; DATA AND MODELS

Michael J. Benton[1]

1. School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK.
Mike.benton@bristol.ac.uk

Mass extinctions are of great interest to biologists as times that mark major changes in floras and faunas. Famously, the Permo-Triassic Mass Extinction (PTME) was said to have 'punctuated' or 're-set' the history of life. The PTME wiped out 90% or more of Palaeozoic species on land and in the sea, and providing an opportunity for surviving lineages to radiate and provide the origin of the 'modern' fauna and flora.

A key question concerns whether radiations (= diversifications) of clades in post-extinction times are in some ways different from radiations in 'normal' times. A second, and more general, question about radiations concerns their shape and mode – do clades expand primarily by increasing the number of species first, by increasing disparity (= morphological diversity) first, or by both processes occurring in parallel?

The severity of the PTME meant that the recovery of life began from a much lower level than after other mass extinctions. Particularly notable were the major perturbations of the Early Triassic physical world, with several sharp episodes of global warming in the 5-6 Myr after the crisis, marked also by a 'coral gap' in the oceans (absence of coral reefs) and a coal gap on land (absence of forests).

Until now, most work on recovery from the PTME has focused on 'geological ' approaches to marine rock sections, in which stratigraphic sections are measured in detail, stable isotopes are assessed throughout, and invertebrate fossils are collected, measured, and identified. The marine successions in South China have been especially fruitful and influential in such studies, and the general consensus is that recovery was fitful, with certain groups such as ammonoids and foraminifers recovering fast, but then suffering numerous setbacks during the continuing grim Early Triassic conditions.

These kinds of studies have been hugely important, in setting much more precise time scales to the Triassic recovery than had been possible 10 or 20 years ago, and in showing how individual taxa evolved through time, and how ecosystems reconstructed themselves. However, they do not provide direct answers to macroevolutionary questions about radiations. Ever since George Gaylord Simpson introduced a Darwinian approach to macroevolution in 1944, in his classic 'Tempo and Mode of Evolution', researchers have sought to understand how clades diversify. Simpson argued that diversifications, or 'adaptive radiations', were important times in the evolution of clades, when their morphological characteristics were acquired and their ecological roles established. He was interested in the reasons why some clades are highly successful, or at least represented by many species, and others are not.

It is now possible to extend a Simpsonian approach to macroevolution to the fossil record, using a combination of three tools: phylogenetic reconstruction (trees), accurate dating of fossils, and numerical, statistical methods. Large, dated phylogenetic trees provide rich information about missing data (ghost ranges, Lazarus gaps), and they can be used to explore rates of evolution of particular characters (e.g. body size, snout length), diversification shifts (times of unusually fast or slow evolution), evolutionary models (e.g. is there a statistically significant trend or not?), and relative rates of evolution of diversity and disparity.

Overviews of numerous fossil examples suggest that, in most radiations, **diversity and disparity are decoupled**, an unexpected result, and that generally **disparity expands first, then diversity**. This suggests that the 'early burst' model of adaptive radiation, proposed by Simpson, is commonplace, but is expressed first in morphospace occupation. In more detail, recent studies of the recovery of three key tetrapod groups in the Triassic, the archosaurs, anomodonts, and cynodonts, showed that members of each clade explored the limits of morphospace rather fast, within the first 5-10 Myr of the Triassic, and then the morphospace did not expand any more; many new species arose, but these filled gaps in morphospace. If general, this suggests a new model of macroevolution in which radiating clades use their opportunity (i.e. empty ecospace; new key adaptation) to explore the limits of morphology, and then retain that space, perhaps as a result of peripheral competition from other clades, or constraints in the adaptatability of their unique features. Later evolution of the clade is expressed by expansion of diversity and specialization.

On the second key question, there is no evidence that these findings are restricted to post-extinction times. Diversifications after mass extinctions and in 'normal' times show the same disparity-first pattern.

It is interesting to know whether diversification occurs unusually fast after mass extinctions, which would certainly be a possibility. In the past, many diversifications and biotic replacements were characterized as active or 'competitive'. For example, the radiation of dinosaurs in the Late Triassic was often described as a result of their successful competition with precursor clades among archosauromorphs and synapsids. Numerical macroevolutionary studies have, however, suggested that many diversifications occur passively. For example, dinosaurs showed expanded disparity during the first 50 Myr of their existence, but apparently did not seriously impact on disparity of a key competitor clade, the Crurotarsi, nor did they jump in disparity after the large-scale extinction of Crurotarsi at the end of the Triassic. Further, although archosauromorphs showed marked size increases through the Triassic, these cannot be distinguished from a passive model (Brownian motion), and so the possibility of Cope's rule (a driven trend of size increase) is rejected.

New numerical and phylogenetic work on recovery of life after the PTME has confirmed three general principles in macroevolution: (1) diversity and disparity are decoupled; (2) disparity normally expands first in a radiation; and (3) many long-term trends and biotic replacements appear to be passive rather than active. The fusion of excellent, well dated fossil records with new methods in phylogenetic tree reconstruction and comparative statistical analysis provide insights into the fundamentals of evolution that concerned Darwin and Simpson.

ORDOVICIAN ORIGINS – EXCEPTIONAL PRESERVATION AND THE HISTORY OF MARINE LIFE

Derek E. G. Briggs[1]

1. Department of Geology and Geophysics, and Yale Peabody Museum of Natural History, Yale University, PO Box 208109, New Haven, CT 06520 USA. derek.briggs@yale.edu

Our knowledge of the diversity of marine life during the Cambrian used to rely largely on the Middle Cambrian Burgess Shale of British Columbia. Exceptional preservations such as the Burgess Shale (Konservat-Lagerstätten – conservation deposits – that preserve evidence of soft-bodied animals) were formerly considered a research interest somewhat peripheral to mainstream paleontology. Special conditions were required to preserve soft-bodied fossils and therefore, by definition, the faunas were not representative of 'normal' marine life. They were of marginal relevance to the history of biodiversity through geologic time. That perception changed with the discovery of many more Cambrian Konservat-Lagerstätten, deposits categorized as Burgess-Shale-type. There is a tendency to conflate the identity of the animals with their mode of preservation in identifying deposits as Burgess-Shale-type, but it is clear that most Cambrian Konservat-Lagerstätten are united by a notable level of organic preservation (although authigenic mineralization often occurs in association with the specimens). More significantly, as recently demonstrated, the chemistry of the oceans was different in the Cambrian. Low sulfate concentrations and high alkalinity contributed to decay inhibition and early cementation in a way that promoted widespread soft tissue preservation. Thus taphonomic conditions in the Cambrian were unusual in favoring the preservation of soft bodied fossils on a global scale. Exceptional preservation is common in sequences of this age ensuring that the products of the Cambrian explosion are available for investigation.

The creatures of the Cambrian continue to receive a great deal of attention because of their remarkable preservation and significance to our understanding of the origin of the major metazoan groups. However, phylogenetic analyses have shown that many of these Cambrian animals were early offshoots of the major lineages (stem groups) with little to say about the origins of the modern biota. Research is already focused on the equally important Great Ordovician Biodiversity Event when all the crown groups diversified, but efforts have concentrated to date on information from the shelly fossil record. Konservat Lagerstätten are beginning to emerge as an important source of data on the Ordovician even though examples of this age are rare compared to Cambrian ones. And just as Burgess-Shale-type faunas have proved much more widespread than originally thought, more Ordovician examples are now coming to light, some preserving significant soft bodied diversity.

The most important Ordovician soft bodied fossils discovered to date are those in the Fezouta formations of Morocco, which are Tremadocian to Floian in age. Here exceptionally preserved fossils range through a considerable thickness and productive layers crop out over some 500 km^2 in an area north of Zagora. The different fossiliferous levels could be styled as separate Lagerstätten. The fauna includes marrellomorphs, anomalocaridids and other forms that would not look out of place in a Cambrian Burgess-Shale-type deposit. In addition the Fezouata fauna includes the earliest known representatives of some modern groups, such as horseshoe crabs. It appears that conditions favoring Burgess-Shale-type preservation persisted until at least the Early Ordovician explaining the widespread occurrence of soft-bodied preservation in the Fezouata formations where extensive shales occur.

A second well known Ordovician exceptional preservation is Beecher's Trilobite Bed, discovered in the 19th century in Upper New York State. This Late Ordovician, Katian fauna is famous for the preservation of pyritized specimens of the trilobite *Triarthrus* with preserved limbs. The oldest ostracods with preserved appendages, some specimens with in situ embryos, were also recently reported from this Lagerstätte. Recent discoveries have shown that several localities, separated by a distance of over 50 km, yield the same kind of remarkable pyritized fossils. The conditions required for extensive pyritization differ from those for fossil preservation in Burgess-Shale-type Lagerstätten, including those of the Fezouata Formations. But Beecher's Bed type Lagerstätten may also be widespread – the Upper New York State area is covered by farmland and woods, much less promising prospecting country than the Moroccan desert.

Not all exceptional preservations of Ordovician age occur in a setting that promises discoveries at many different localities. The fossils of the Middle Ordovician (Darriwilian) Winnishiek Lagerstätte in northeast Iowa, for example, include plant remains, abundant eurypterids, bivalved arthropods, and conodont elements. The absence of normal marine animals suggests a restricted setting, and geophysical and other evidence demonstrates that the organic rich laminated layers that make up the Winneshiek Shale were deposited in a meteorite impact crater. In contrast, the Silurian Lagerstätte most intensively studied at present, the Wenlock age Herefordshire deposit, yields a diverse marine assemblage of small invertebrates. But the mode of preservation – void fills in carbonate concretions in a volcanic ash – appears to be unique to this small site; it has not come to light elsewhere.

Adolf Seilacher observed that Konservat-Lagerstätten have the potential to reveal patterns in the evolution of the biosphere. Discovering patterns in these deposits relies on the availability of information from multiple sites preserving soft-bodied fossils. Patterns are already emerging for the Cambrian through Early Ordovician where global factors promote preservation. Later Ordovician Lagerstätten, in contrast, include examples from unusual sites where the fossils may not be representative of marine life in general. Nonetheless the animals that are preserved provide invaluable evidence of the evolution of particular taxonomic groups. The identification of broader patterns will require the discovery of more Konservat-Lagerstätten, a task in which many are already engaged. The geologic setting and taphonomy of the Lagerstätten that we already know will provide a guide.

LOWER PALAEOZOIC VERTEBRATES FROM SOUTH AMERICA: WHY ARE THEY SO RARE AND SO STRANGE?

Philippe Janvier[1]

1. CR2P – UMR 7207 CNRS, MNHN, Université Paris 06, Paris, France.
Janvier@mnhn.fr

The segment of Earth history commonly referred to as the "age of fishes" ranges essentially from the Ordovician to the Devonian. However, "fishes", that is, primitively aquatic vertebrates, may be already present in the Cambrian, and still remained at the top of the aquatic food chains after the Devonian. Early Palaeozoic vertebrates have been extensively studied since the nineteenth century on the basis of fossils from northern Europe, Russia, North America, the Arctic, and Australia. Later on, new material turned up in Africa, Antarctica, the Middle East and China, but, strangely, South America has only yielded very sparse evidence of such early vertebrates. This had been regarded as due to various reasons: poor exposures, unsuitable sedimentary facies, tropical weathering, lack of interest from geologists for such reputedly poor stratigraphic fossils, or austral and inhospitable climatic conditions in lower Palaeozoic times. Further field investigations in South America have largely confirmed this comparatively poor vertebrate record, with the exception of the Middle-Late Devonian vertebrate localities of Venezuela and Colombia, which provide evidence for abundant fish faunas of mixed, Gondwanan and Euramerican affinities, but with assemblages that are generally characteristic of the Devonian tropical belt. In contrast, data from the Silurian and Lower Devonian, "Malvinokaffric" vertebrate faunas from Peru and Bolivia (and South Africa) still appear unusual by comparison to coeval vertebrate faunas from other continents, with a marked predominance of acanthodians and chondrichthyans, notably the still puzzling taxa *Pucapampella* and *Ramirosuarezia.* Some clues are presented here to investigate this peculiar palaeobiogeographical pattern.

THE EVOLUTION OF GIANTS: SELECTION, PRODUCTIVITY, AND GEOGRAPHY OF GIGANTISM IN PLANTS AND ANIMALS

Geerat Vermeij[1]

1. Dept. of Earth and Planetary Sciences, University of California at Davis, One Shields Avenue, Davis, CA 95616, USA. gjvermeij@ucdavis.edu

Gigantic animals and plants differ from smaller organisms in many important ways, yet we understand little about the conditions that enable their evolution and maintenance. Specific cases, such as dinosaurs and trilobites, have been discussed, but there have been few attempts to seek or understand patterns of occurrence of gigantic animals and plants. Among many factors, a high metabolic rate seems to be the most important attribute that enables organisms to become gigantic: all the largest marine and terrestrial predators and herbivores maintain high body temperatures either by producing copious heat or by conserving heat in a body with a low surface to volume ratio. Bottom-dwelling marine suspension-feeders, photosymbiotic animals, and chemosymbiotic animals are ectotherms, but their metabolic rates are higher among gigantic forms than in smaller forms with lower activity levels. An analysis of gigantism over time indicates that the largest animals and plants are all of Mesozoic or Cenozoic age. In part this reflects global increases in primary productivity and in metabolic rates. On land, the largest animals in most habitat and trophic categories are fossil, whereas in the sea, many of the largest species in these categories are Recent or Holocene. These and other differences indicate that a proper study of gigantism and other phenomena require attention to different ecologies and not just to phylogeny.

SYMPOSIUM

FORM, FUNCTION AND PALAEOBIOLOGY

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(WITH THE COLLABORATION OF EUAN CLARKSON)

FUNCTIONAL SIGNIFICANCE OF THE SHELL/LIGAMENT SYSTEM IN OPISTHOGYRATE ROSTRATE BIVALVES

Javier Echevarría[1], Susana E. Damborenea[1] and Miguel O. Manceñido[1]

1. CONICET - Museo de La Plata, Paseo del Bosque s/n, La Plata, 1900, Argentina.
javierechevarria@fcnym.unlp.edu.ar

In bivalve molluscs the ligament joins both valves dorsally, and being flexible, provides the thrust for opening the shell, acting as the resistance in a lever system against which adductor muscles effort applies. Commonly the outer lamellar layer of the ligament is subjected to tensile stress, whereas the inner fibrous layer is exposed to compression, with the pivotal axis located between them, hence resulting in a combination of classes 1 and 2 levers. However, some shells display a concave dorsal margin, as often happens in opisthogyrate rostrate bivalves, probably because such growth favours the upward orientation of the posterior margin for reaching the water-sediment interface. When this happens, the umbo and the dorsal-posterior angle of the shell project dorsally relative to the ligament, which then fails to act as a pivotal axis and so, the adductor muscles-ligament system should act as a class 2 lever. In this contribution three opisthogyrate rostrate genera of unrelated lineages are analyzed, each showing a somewhat different solution to this morpho-functional challenge: Cuspidaria (Anomalodesmata), Nuculana (Paleotaxodonta) and Pterotrigonia (Paleoheterodonta). In Cuspidaria the ligament becomes completely internal, hence it is subjected only to compression and can act ventrally to the pivotal axis. Nevertheless, a secondary ligament develops joining the straight anterior part of the dorsal margins of the valves, forcing them to act as pivotal axis despite the dorsal projection of the rostrum; consequently, the posterior parts of dorsal margins of the calcified valves tend to diverge from the sagittal plane as they direct dorsally. In Nuculana the inner layer of the ligament is well developed and becomes internal, whereas the outer layer is external but strongly reduced, so the whole shell can effectively act as a class 2 lever; nevertheless, some species develop a dorsal ridge parallel to the commissural plane, thus resulting in a straight dorsal margin leveled with the rostrum and acting as pivotal axis. In Pterotrigonia (as well as in other rostrate trigoniides) the ligament is external opisthodetic, and so tensile stress on the outer layer would prevent the opening of the valves. Although these species usually develop a dorsal ridge, the rostrum projects dorsally to it, but without divergent dorsal margins. When compared with other trigoniides lacking a rostrum, the ligament seems to be shorter in rostrate species; this may point to a reduction in the opening action of the ligament, a function possibly taken over by the strongly muscular foot.

REPRODUCTIVE STRATEGY OF METRIORHYNCHID CROCODYLIFORMS: A COUNTER-INDUCTIVIST ARGUMENT

Marta S. Fernández[1], Susana G. Lamas[2] and Yanina Herrera[1]

1. CONICET and División Paleontología Vertebrados, Museo de La Plata. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. Paseo del Bosque s/n, La Plata, W1900FWA, Argentina. martafer@fcnym.unlp.edu.ar

2. Cátedra de Lógica y Metodología de la Ciencia. Facultad de Ciencias Naturales y Museo. Universidad Nacional de La Plata. Avenida 122 y 60, La Plata, W1900FWA, Argentina.

A major concern when testing scientific hypotheses in general and palaeobiological hypotheses in particular, should be whether it is more accurate to find cases that confirm them or cases that disconfirm them. The former is basically an inductivist approach. The latter is counter-inductivist, and is the approach that which will be used herein. To this end, a case study on the reproductive mode of Jurassic metriorhynchids (Crocodylomorpha, Archosauria) has been selected in order to evaluate available arguments for testing two alternative hypotheses: egg laying (oviparity) and the bearing of live young (including egg retention and viviparity). It must be noted that no pregnant metriorhynchid female or egg containing an embryo have been found. Traditional and recent reviews of the reproductive strategies of reptiles (including Mesozoic marine forms) avoid dealing with the second hypothesis and assume oviparity to be the only reproductive strategy for archosaurs. The oviparity hypothesis for metriorhynchids is principally based on their phylogenetic position within crocodylomorph archosaurs, and on comparison with living forms. As all living archosaurs (birds and crocodiles) are oviparous and some extinct archosaurs (i.e. dinosaurs and pterosaurs) were oviparous, it is generalized that all archosaurs (extinct and extant) were oviparous. However, certain aspects of these peculiar crocodyliforms have been overlooked and, according to a counter-inductivist approach, should be analyzed, as they contradict the oviparity hypothesis. These aspects are related to the peculiar body plan of metriorhynchids, including forelimbs that are transformed into paddles, femur and zeugopodial hindlimb bones that are relatively flattened with rounded articular surfaces, the osteoporotic-like bone tissue of the femur, and a hypocercal tail. All this evidence seems to contradict the possibility of the body being supported outside the aquatic medium. On this basis, consideration should be given to other possibility, that is, that metriorhynchids were not only marine nektonic but also obligatory aquatic forms. In this case, oviparity seems unlikely. Gas diffusion is considerably slower in water. If eggs were laid underwater, oxygen deprivation (hypoxia) would have seriously affected embryonic development. Experimental studies on aquatic reptiles that lay their eggs in seasonal ponds have demonstrated that the embryos remain in developmental arrest as long as they are immersed in water, and resume development only after the soil dries and oxygen tension rises. Then, if it is accepted that metriorhynchid crocodylomorphs were not only marine pelagic but also obligatorily aquatic, the live-bearing hypothesis could be accepted.

THE FUNCTIONAL AND EVOLUTIONARY SIGNIFICANCE OF THE CROCODYLIFORM PTERYGOMANDIBULAR JOINT

Casey M. Holliday[1]

1. Integrative Anatomy, University of Missouri, Columbia, 65212, USA.
hollidayca@missouri.edu

Crocodyliforms evolved a series of key innovations responsible for their Mesozoic adaptive radiation. Among these is the pterygoid buttress, the characteristic hypertrophied pterygoid flange in the skull. Although historically approached as simply a palatal element, the buttress actually forms a complex articulation with the mandible here referred to as the pterygomandibular joint. The joint bears the necessary anatomical features, such as a capsule and cartilage, to be considered an enthesis organ. Biomechanically, the joint acts as a fulcrum between the bite point and jaw muscles and resists medial bending and long axis rotation of the mandible during feeding. Although all jaw muscles act about the jaw joint (i.e., the quadratoarticular joint), they also create strong mediolaterally and vertically-oriented moments about the pterygomandibular joint such that this latter joint, albeit a secondarily-acquired craniomandibular joint, may be loaded more than the primary jaw joint during particular feeding behaviors. Finally, the crocodyliform pterygomandibular joint bears striking resemblance to the therian temporomandibular joint as both joints possess sesamoid-like fibrocartilages and evolved along similar musculoskeletal trajectories. Thus, crocodyliforms and mammals convergently evolved dual craniomandibular joint systems with strikingly similar joint morphologies. These new findings enable significant new insights into cranial biomechanical modeling, skeletal development and vertebrate evolution.

INTERPRETING CONODONT FEEDING ECOLOGY AND PHYLOGENY

Carlos Martínez-Pérez[1], Emily J. Rayfield[1] and Philip C. J. Donoghue[1]

1. University of Bristol, Wills Memorial Building, Queen's Road, Bristol, BS8 1RJ, UK.
Carlos.Martinez-Perez@bristol.ac.uk

Conodonts had a wide geographical distribution and underwent rapid morphological evolution. As a result, they have been used with great success for refining Phanerozoic stratigraphy and intercontinental-scale correlation. In addition, this fast morphological evolution has formed the basis of different evolutionary hypotheses. Unfortunately, the functional significance of these morphological changes through lineages remains unclear, showing a traditional discrepancy between conodont taxonomy and palaeobiology. Conodont P_1 elements have been shown to be widely used as dental tools, allowing us to establish a framework in which to read conodont taxonomy in terms of feeding ecology, and hence study classic conodont genealogies in terms of evolving feeding strategies. In the present work, we demonstrate this through a biomechanical analysis of a classic evolutionary sequence within the early evolution of the genus *Polygnathus*, one of the most prolific conodont lineages, capturing the early morphological change during the transition from a blade-like morphology to a typical platform conodont. Using state-of-art methods such us synchrotron tomography and Finite Element Analysis (FEA) we produced different virtual models of *Polygnathus* clusters from the Upper Devonian of Australia. These models were used to describe its occlusal cycle, supported by microwear data, in order to constrain our FE analysis of several 2D idealized outlines throughout its early evolution, from *Polygnathus pireneae* to *Polygnathus inversus*. The FEA results suggest that the morphological changes that occurred during the early evolution of the genus are oriented to a functional optimization to accommodate and dissipate the stress accumulation. In particular, some morphological features seem to be strongly related with functional adaptation, for instance the inversion of the basal cavity, or the development of the adcarinal troughs to improve the articulation between both elements, supporting the idea that these elements functioned as teeth. Therefore, our analyses allow us for the first time to show a direct relationship between morphological innovations in conodonts and its functional and ecological consequences, enabling us to decode the whole conodont fossil record in terms of their morphological variations.

ABOUT THE VISIONS OF FOSSILISED EYES

Brigitte Schoenemann[1] and Euan N. K. Clarkson[2]

1. Neurobiology/Animal Physiology Dep. University of Cologne, Zülpicherstrasse 47, D-50674 Köln
Steinmann Institute (Palaeontology), University of Bonn, Nussallee 8, D-53115 Bonn, Germany. B.Schoenemann@uni.koeln.de
2. Grant Institute, University of Edinburgh, West Mains, Road Edinburgh EH3 9JW, UK.

In human beings eyes are the "mirror of the soul" in the words of an old saying. Compound eyes especially, however, may tell us something about the light-ecological conditions to which the eyes were adapted, and in which their bearers lived. By investigating the metrics and morphological design of these eyes, one can assess how much light was required in order that they might work effectively, and also their acuity. Because in fossils coumpound eyes often are well preserved, even extinct organisms can be characterised in the same way approximately, and compared to organisms living today, even half a billion years after they were alive. To understand the evolution of visual systems it would be helpful to know something about the internal sensory structures of the ancient eyes. Normally just hard parts of the organisms are preserved during fossilisation, such as shells, bones or teeth. Application of modern techiques, such as x-ray computer tomography of different kinds, however, reveals that sometimes there are still traces, even at a cellular level, of the internal structures of fossilised visual systems, which can give a firmer basis for a deeper understanding of the evolution of eyes. Such will be presented here for trilobites, extinct arthropods almost half a billion years old.

RESILIENCE OF PLANT-INSECT INTERACTIONS IN AN OAK LINEAGE THROUGH QUATERNARY CLIMATE CHANGE

Tao Su[1], Zhe-Kun Zhou[1,2], Jonathan M. Adams[3], Torsten Wappler[4], Yong-Jiang Huang[2], Frédéric M. B. Jacques[1] and Yu-Sheng Liu[5]

1. Key Laboratory of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla 666303, China. sutao@xtbg.org.cn

2. Key Laboratory of Biodiversity and Biogeography, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650204, China.

3. College of Natural Sciences, Seoul National University, Gwanak-Gu, Seoul 151, Republic of Korea.

4. Steinmann Institute for Geology, Mineralogy and Palaeontology, Division Palaeontology, University of Bonn, Nussallee 8, D-53115 Bonn, Germany.

5. Department of Biological Sciences and Don Sundquist Center of Excellence in Paleontology, Box 70703, East Tennessee State University, Johnson City, Tennessee 37614-1710, USA.

Plant-insect interactions are vital for structuring terrestrial ecosystems. It is still unclear how climate change in deep time might have shaped plant-insect interactions leading to modern ecosystems. We investigated the effectof Quaternary climate change on plant-insect interactions by observing insect herbivory on leaves of an evergreen sclerophyllous oak lineage (*Quercus* section *Heterobalanus*, HET) from a late Pliocene floraand eight living forests in SW China. Damage diversity is lower in the fossil florathan in modern HET populations, even a warmer climate than the present day. All damage types in the fossil flora,except for one distinctive gall type, can be found in modern HET populations. These results indicate Quaternary climate change did not cause extensive extinction of insect herbivores in HET forests. The accumulation of a more diverse herbivore fauna over time supports the view of plant species as evolutionary 'islands' for colonization and turnover of insect species.

BODY SHAPE, PELVIC MORPHOLOGY AND LOCOMOTOR ADAPTATION IN HOMINOID EVOLUTION

Carol V. Ward[1]

1. Department of Pathology and Anatomical Sciences, M263 Medical Sciences Building, University of Missouri, Columbia, MO, 65211, USA. wardcv@missouri.edu

Locomotor adaptation in vertebrates is reflected in the torso as well as the limbs. This is particularly important in hominoids. It is generally assumed that great apes share a homologous pattern of torso morphology related to adaptations for below-branch arboreality found in an intermediate state in hylobatids and atelines. Monkeys have narrow thoraces with scapulae on the lateral sides with the glenoid fossae facing ventrally so that humeral joints are oriented to the direction of load. Great apes have reoriented their shoulder joints to face laterally so that the scapulae and associate musculature lie in a coronal plane to facilitate adduction movements of the upper limb. It has been hypothesized that apes have commensurate alterations of the rib cage, thoracolumbar vertebrae, and pelvis. This presumed variation in torso structure is pivotal to interpretations of locomotor adaptation and evolutionary history of fossil apes, including hominins. However, little is actually known about the overall 3D shape of the primate thorax, or how this is reflected in the morphology of constituent skeletal elements. To evaluate torso shape, 56 anthropoid cadavers were CT-scanned. In addition, standard landmark and metric data were collected from the pelvis, vertebrae, ribs, and sterna of over 200 anthropoid skeletons. Morphology of the intact torso and that of individual bones were compared across taxa and among locomotor and phylogenetic groups, and covariation was assessed among skeletal elements and with aspects of whole torso shape. Results broadly support the hypothesis that suspensory anthropoids differ from non-suspensory taxa in having a broader rib cage and modified iliac portion of the pelvis. CT reconstructions, though, show more varied and subtle patterns of overall torso shape among taxa that are not always tightly correlated the morphology of isolated bones. The cranial rib cage does not always covary with the caudal portion, and the ilium appears to reflect adaptations relating to spinal mobility at least as much as it does shoulder reorientation as traditionally interpreted. Phylogenetic and locomotor groups also vary in allometric patterns among anatomical regions. These data reveal nuances of morphological variability that provide much greater insight into the functional correlatesof variation in torso structure among anthropoid primates, and form a more accurate basis from which to interpret isolated elements of fossil apes. [Research supported by NSF BCS 0716244].

MICRO-BIOMECHANICS OF THE KEBARA 2 HYOID AND ITS IMPLICATIONS FOR SPEECH IN NEANDERTHALS

Stephen Wroe[1], Ruggero D'Anastasio[2], Claudio Tuniz[3,4], Lucia Mancini[5], Deneb T. Cesana[2], Diego Dreossi[5], Mayoorendra Ravichandiran[6], Marie Attard[2], William C. H. Parr[7], Anne Agur[6] and Luigi Capasso[2]

1. Function, Evolution and Anatomy Research lab, Zoology, School of Environmental and Rural Sciences, University of New England, New South Wales, Australia. swroe@une.edu.au
2. University Museum – State University "G. d'Annunzio", Piazza Trento e Trieste 1, Chieti, Italy.
3. Multidisciplinary Laboratory, The "Abdus Salam" International Centre for Theoretical Physics, Strada Costiera 11, Trieste, Italy.
4. Centre for Archaeological Science, University of Wollongong, Wollongong, New South Wales, Australia.
5. Elettra-Sincrotrone Trieste, Area Science Park, Basovizza, Trieste, Italy.
6. Division of Anatomy, University of Toronto, Department of Surgery, Toronto, Ontario, Canada.
7. Computational Biomechanics Research Group, School of Biological, Earth and Environmental Sciences, University of New South Wales, Kensington, New South Wales, Australia.

The description of a Neanderthal hyoid from Kebara Cave (Israel) in 1989 fuelled scientific debate on the evolution of speech and complex language. Gross anatomy of the Kebara 2 hyoid differs little from that of modern humans. However, whether *Homo neanderthalensis* could use speech or complex language remains controversial. Similarity in overall shape does not necessarily demonstrate that the Kebara 2 hyoid was used in the same way as that of *Homo sapiens*. The mechanical performance of whole bones is partly controlled by internal trabecular geometries, regulated by bone-remodelling in response to the forces applied. Here we show that the Neanderthal and modern human hyoids also present very similar internal architectures and micro-biomechanical behaviours. Our study incorporates detailed analysis of histology, meticulous reconstruction of musculature, and computational biomechanical analysis with models incorporating internal micro-geometry. Because internal architecture reflects the loadings to which a bone is routinely subjected, our findings are consistent with a capacity for speech in the Neanderthals.

FIRST DESCRIPTION OF SPIRAL COLOLITES FROM *SAURICHTHYS* (ACTINOPTERYGII, SAURICHTHYIDAE): BODY SHAPE AS A FACTOR FOR DETERMINING INTESTINAL MORPHOLOGY

Thodoris Argyriou[1], Erin E. Maxwell[2], Heinz Furrer[1] and Marcelo R. Sánchez-Villagra[1]

1. Paläontologisches Institut und Museum, Universität Zürich, 8006 Zürich, Switzerland. thodoris.argyriou@pim.uzh.ch
2. Staatliches Museum für Naturkunde, 70191 Stuttgart, Germany.

Cololites (intestinal casts made of fossilized fecal matter) associated with taxonomically recognizable individuals are very rare in the fossil record and can provide unique information about the morphology of intestines that are otherwise rarely preserved. Here we provide the first description of spiral cololites from late Anisian-early Ladinian *Saurichthys* fishes from the Monte San Giorgio fossil Lagerstaette, in Switzerland. This locality is famous for producing fossils (including *Saurichthys*) with exceptional preservation of delicate structures, such as stomach contents, embryos, intestinal casts, and soft tissue. The morphology of the cololites reveals the presence of an intestinal spiral valve in *Saurichthys*. The main function of this structure is to increase the absorptive surface of the intestine while maintaining its length relatively short (when compared to non-spiral intestines of other fishes). Although most of our data derive from a single individual of *S. paucitrichus* exhibiting a complete cast of the spiral intestine, other incomplete *S. paucitrichus* and *S. curionii* specimens were used for complementary observations and measurements. We compared the spiral intestine of *Saurichthys* to that of other extant basal actinopterygians (bichirs, sturgeons, paddlefish and gars). The spiral intestine of *Saurichthys* differs from that of other basal actinopterygians in being shallower and more elongate (its length being greater than 16% of an individual standard length) and by exhibiting around 30 turns in the valve, an unusually high number, previously unreported in bony fishes. The increased length of the intestine cannot be linked with the inferred (based on gastric contents) piscivorous diet of *Saurichthys*, as carnivorous fishes are known to have longer intestines than herbivores. We suggest that this increase in intestinal length is correlated with the axial elongation that characterizes the Saurichthyidae. This work provides a unique insight in the intestinal morphology in an extinct clade. We suggest that body shape along with dietary preferences and the influence of phylogeny are the main factors determining the morphology and arrangement of the intestines and viscera in general. In addition, the presence of a spiral valve in *Saurichthys* supports the idea that the spiral intestine is a plesiomorphic character for actinopterygians and likely homologous to that of other major fish clades like chondrichthyans and sarcopterygians.

MOA DIET FITS THE BILL: CLIP AND PLUCK FEEDING STRATEGIES OF NEW ZEALAND'S EXTINCT GIANT FLIGHTLESS BIRDS

Marie Attard[1], Peter Johnston[2], Paul Schofield[3], Trevor Worthy[4], Laura Wilson[5], William Parr[5] and Stephen Wroe[1]

1. University of New England, School of Environmental and Rural Science, Armidale, New South Wales, 2351, Australia. mattard3@une.edu.au

2. University of Auckland, Department of Anatomy with Radiology, Private Bag 92019, Auckland 1142, New Zealand.

3. Canterbury Museum, Rolleston Avenue, Christchurch, 8013, New Zealand.

4. Flinders University, School of Biological Sciences, Adelaide, South Australia, 5001, Australia.

5. University of New South Wales, Evolution and Ecology Research Centre, School of Biological, Earth and Environmental Sciences, Sydney, New South Wales, 2052, Australia.

The moa (Dinornithiformes) comprised nine species of extinct flightless birds endemic to New Zealand. Moas were the only truly wingless birds, having completely lost even the vestigial wings present in all other ratites. They were the dominant terrestrial herbivores of New Zealand's forest, shrubland and subalpine ecosystems and regularly co-existed in the same habitats. Ecological separation may have been maintained by partitioning the available food, though the mechanisms have not been fully explored. Here we apply three-dimensional Finite Element Analysis to the skulls of five moa species representing separate genera to assess their biomechanical performance in a comparative context. Digitally constructed jaw adductor muscles of a mummified Upland Moa (*Megalapteryx didinus*) were used to determine muscle origin and insertion regions and as a basis for estimating muscle forces. Bite forces were estimated by simulating a bilateral bite, with muscle forces generated by the jaw adductors. Scaled forces were also applied. In addition, three loading cases simulating the movement of the animal's skull relative to the food (lateral shake, pullback and dorsoventral) were used to compare food acquisition strategies across species. We found that the Stout-legged moa (*Euryapteryx curtus*) had a relatively weak bite for its size (133 N) and exhibited notably higher stress in the mandible compared to all other species for each loading case except for a dorsoventral. These findings support the hypothesis that *E. curtus* had a more specialized diet than other moas. The rounded bill tip of *E. curtus* appears well adapted to plucking soft leaves and fruit, whereas moa species with sharper or more pointed bills were better suited to clipping fibrous leaves and twigs. Biomechanical limitations of the skull may have forced *E. curtus* to travel further than other moas in search for suitable food. Biomechanical differences observed in the feeding strategies among moas likely facilitated niche partitioning among sympatric moa species and emphasizes the ecological diversity of this unique taxon.

ENDOCRANIAL MORPHOLOGY AND NEUROANATOMY OF *GRYPOSUCHUS NEOGEUS* (CROCODYLIA: GAVIALOIDEA)

Paula Bona[1,3] and Ariana Paulina-Carabajal[2,3]

1. División Paleontología Vertebradas, Facultad de Ciencias Naturales y Museo, UNLP, Paseo del Bosque s/n, 1900, La Plata, Buenos Aires, Argentina. pbona@fcnym.unlp.edu.ar

2. Museo Carmen Funes. Av. Córdoba 55, 8318, Plaza Huincul, Neuquén, Argentina.

3. CONICET , Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina.

Here we present a detailed description of the endocranium and neuroanatomy of *Gryposuchus neogeus* from the Miocene of Argentina, using CT scans. The braincase and internal morphology were studied. The reconstructed cranial endocast is relatively sub-horizontal and the angle formed between the mid-brain and the hind-brain is poorly marked. When compared with *Gavialis gangeticus*, the dorsal margin of the endocast of *G. neogeus* shows that the mid-brain is relatively shorter, although the distribution of cranial nerves is similar. An interesting trait is observed in the floor of the endocranial cavity, posterior the *dorsum sellae*. There are three small foramina near to the midline, the lateral ones correspond to cranial nerve VI, whereas the median foramen corresponds to a canal that runs anteroventrally through the basisphenoid to penetrate the posterior wall of the pituitary fossa (open foramen for the basilar artery?). The same structure is present in *Gavialis* but absent in other living crocodilians. The pneumaticity of the skull roof in *G. neogeus* is markedly reduced, affecting only the parietal. Also, the lateral branches of the pharingotympanic system are reduced when compared with the extant species. Preliminary conclusions based on comparisons with the living *Gavialis* indicate that the pattern of braincase morphology of Gavialidae was present in the Miocene. However, the internal morphology, including brain shape, pneumaticity of the skull roof and basicranium is different in the two species. Morphological studies of the braincase and endocranial morphology of fossil crocodylians, especially gavialids, are scarce. This work is the first step to understand the endocranial morphological pattern and the neuroanatomy variation in this group of archosaurs.

MID-CRETACEOUS SOUTH AMERICAN ABELISAURIDS AND CARCHARODONTOSAURIDS (DINOSAURIA, THEROPODA): COMPARISON OF PALEOECOLOGICAL ASPECTS USING MORPHOLOGICAL FEATURES

Carlos R. A. Candeiro[1]

1. Laboratório de Geologia, Curso de Geografia, Campus Pontal, Universidade Federal de Uberlândia, Avenida 20, 1.600 Bairro Tupã, Ituiutaba, Minas Gerais, Brazil. candeiro@pontal.ufu.br

Two families of theropod dinosaurs, Abelisauridae and Carcharodontosauridae, comprise significant representatives of large-bodied dinosaurs from Patagonia, South America, during the Cenomanian. The paleoecology of these families is poorly understood, despite their relative abundance in southern Gondwana assemblages. Possible competitive exclusion between the two families, or unequal success in adapting to different ecological conditions, may be potential explanations for the resulting distribution of these taxa in space and time. Dental morphology could provide information for addressing paleoecological aspects of theropods. In this work, teeth characters of abelisaurid and carcharodontosaurid species dentitions were compared. Abelisaurid (*Carnotaurus sastrei*, *Aucasaurus garridoi*) teeth are thick in cross-sections, with the medial and apical regions lacking wrinkles in the enamel, but with square-shape denticles, and smooth, pronounced interdenticular blood grooves. The length of the teeth ranges from 2.8 mm to 7.2 mm. Carcharodontosaurid (*Giganotosaurus carolinii*, *Mapusaurus roseae*, *Tyrannotitan chubutensis*) teeth have cross-sections with the medial and apical regions altered in length and hardness. They have pronounced wrinkles in the enamel, with rectangular denticles, and smooth, pronounced interdenticular blood grooves. The length of the teeth ranges from 3.4 mm to 14.3 mm. The comparisons indicate that, during the time abelisaurids and carcharodontosaurids were contemporaneous (mainly during Early Cretaceous to Cenomanian), they occupied adjacent but distinct regions in dental morphospace. The subsistence of abelisaurids subsequent to the extinction of carcharodontosaurids changed little. However, arguing against competition as an explanation for the disappearance of carcharodontosaurids. Diversity of post-Cenomanian carcharodontosaurids expanded in the Turonian with the presence of *Mapusaurus*, which would have occupied the same paleogeographical area of large-bodied abelisaurids (*Skorpiovenator bustingorryi*, *Ilokelesia aguadagrandensis*).

THE MASTICATORY APPARATUS AND PALEOBIOLOGY OF EARLY MIOCENE NATIVE SOUTH AMERICAN UNGULATES

Guillermo H. Cassini[1,2]

1. División Mastozoología, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", CONICET, Av. Angel Gallardo 470, Ciudad Autónoma de Buenos Aires, C1405DJR, Argentina. gcassini@macn.gov.ar

2. Departamento de Ciencias Básicas, Universidad Nacional de Luján, Ruta 5 y Av. Constitución, Luján, 6700, Buenos Aires, Argentina.

The exposures of the Santa Cruz Formation (Early Miocene Santacrucian Age) in the Atlantic coast of the Santa Cruz Province, Patagonia, provide a large number of well preserved specimens constituting an excellent sample for paleobiological studies. Three orders of South American extinct native ungulates are among the most representative mammals. These are Notoungulata (*Adinotherium, Nesodon, Interatherium*, *Protypotherium*, *Hegetotherium* and *Pachyrukhos*), Litopterna (*Theosodon, Anisolophus*, *Tetramerorhinus*, *Diadiaphorus* and *Thoatherium*) and Astrapotheria (*Astrapotherium*). This coexistence of many ungulates from different lineages suggests a marked resource partitioning of vegetation. To evaluate this hypothesis, the masticatory system was studied in the theoretical framework of functional morphology and ecomorphology with focus on body size, habitat use, diet and digestive physiology. Body mass estimates were obtained using quantile regressions equations based on centroid size. Habitat preference and diet types were assessed with a geometric morphometric approach (allometric scaling, principal component analyses and phylogenetic generalized estimating equations), based on the relationship between craniomandibular traits and environmental attributes using a broader reference sample composed of 141 Artiodactyla, 16 Perissodactyla, and 5 Hyracoidea species. Digestive physiology was evaluated by analyzing the relationship between the occlusal surface area of the cheek teeth and body mass. The results allow grouping of Santacrucian ungulates into three body size categories: (i) small sized (1-10 kg); (ii) medium-sized (10-100 kg) and (iii) large-sized ungulates (100-1000 kg). The notoungulates were characterized as open habitat dwellers, with some taxa foraging on grass (*Protypotherium*, *Interatherium*), and others on grass and leaves (*Hegetotherium*, *Pachyrukhos*, and *Adinotherium*. *Nesodon* may have dwelled in mixed habitats with a mixed feeding behavior, whereas small proterotheriids (*Anisolophus* and *Thoatherium*) may have fed predominantly on dicotyledonous plants. The remaining litopterns (*Tetramerorhinus*, *Diadiaphorus*, and *Theosodon*) and *Astrapotherium* may have foraged in closed habitats and fed on dicotyledonous plants. The relationship between dental occlusal surface and body mass indicates that litopterns, especially proterotheriids, carried out extensive intraoral food processing rather than having relied on a specialized digestive physiology. Conversely, notoungulates, which have lower occlusal surface per unit mass, would have had a better digestive capacity than litopterns. Finally, a paleoecological generalization was made based on the paleobiological reconstructions; niche partitioning by herbivore ungulates was based on the differential use of habitats (open, mixed and closed) and the differentiation of feeding behavior, and is mainly reflected by three biological attributes: (1) body size, (2) shape and function of cranio-dental features, and (3) energy requirements.

MORPHOLOGICAL EVOLUTION OF THE PECTORAL GIRDLE AND HUMERUS IN MODERN BIRDS (NEORNITHES)

Beatriz Chamero[1,2], Jesús Marugán-Lobón[2,3] and Ángela D. Buscalioni[2]

1. CONICET. Museo Paleontológico Egidio Feruglio. Av. Fontana 140, Trelew, 9100, Argentina.
2. Unidad de Paleontología, Dpto. Biología, Universidad Autónoma de Madrid, C / Darwin 2, Madrid, 28049, Spain. jesus.marugan@uam.es
3. The Dinosaur Institute, Natural History Museum of Los Angeles County, 900 Exposition Blvd, Los Angeles, CA 90007, USA.

Avian evolution has captured the attention of researchers over centuries, with the origin of flight as one of the main focus of interest. The development of different flight styles is a milestone for the radiation of avians, and skeletal adaptations to such end should therefore help to understand the ecological diversity of birds. In spite of extensive work in avian skeletal anatomy, little is known about the morphological variation of forelimb bones across avian clades. Using geometric morphometrics we analyzed the patterns of morphological diversification of the elements of the shoulder joint (scapula, coracoid and humerus) across modern birds (Neornithes). The fact that these three elements are involved in the wing stroke movements suggests that their morphology encompasses information about flight performance across different species. The studied samples comprise 58 scapulae, 58 coracoids and 54 humerus of the same number of species covering a wide range of Neornithes morphology across phylogeny. To test the relationship between size and shape in phylogeny (evolutionary allometry), a multivariate regression of independent contrasts data (shape and size) was performed. We found that evolutionary allometry is statistically significant in all the three bones, although size accounts for a larger percentage of shape variation in the humerus. Moreover, shape changes associated with evolutionary allometry are different between the bones. Namely, larger humeri are relatively thinner and larger pectoral girdle bones tend to be stouter. We interpret that these differences are related with the structural role played by the pectoral girdle to support larger bodies when airborne, a constraint which does not affect the humerus. Interestingly, we also found that the phylogenetic structure of non-allometric shape data was statistically significant in the pectoral and forelimb elements, yet there are cases of convergence mainly associated to ecology (i.e., terrestrial vs aquatic birds). In particular the scapular blade of aquatic and terrestrial birds is definitively different, being straight or curved, respectively. We interpret that the match between morphological and phylogenetic/ecological patterns (i.e., and the flight diversity associated with them) possibly reflects an important divergence event across major avian clades, particularly that of the land birds.

THE HIND LIMB MORPHOMETRY OF TERROR BIRDS (AVES, CARIAMIFORMES, PHORUSRHACIDAE): THEIR FUNCTIONAL IMPLICATIONS FOR SUBSTRATE PREFERENCES AND LOCOMOTORY LIFESTYLE

Federico J. Degrange[1,2]

1. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), CONICET - Universidad Nacional de Córdoba. Av. Vélez Sarsfield 1611, X5016GCA, Córdoba, Argentina. fjdino@gmail.com

2. Centro de Investigaciones Paleobiológicas (CIPAL), Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Argentina.

The hind limbs of birds have long been considered a key feature in the conquest of different environments. However, the high level of morphological diversity encountered complicates the foundation of a good theoretical correlation between morphology, locomotory habits and substrate preference, and this in turn complicates paleobiological interpretations. Phorusrhacids (Aves, Cariamiformes) are a good example since they have been unequivocally categorized as terrestrial birds, due to their reduced forelimbs, and as apex predators with the ability to pursue prey, based only on their hind limb morphology. Multivariate techniques (PCA and discriminant analysis) based on traditional metrics and geomorphometrics of the hind limb and pelvis were applied in order to explore terrestriality and cursoriality in phorusrhacids. Although several groups of birds could be identified, some phorusrhacids appear to be associated with walking and others with cursorial birds, when looking solely at hind limb metrics. However, the pelvis separates cursorial birds (including phorusrhacids) from walking and wading birds. This scenario is further complicated by a lack of clear definitions of the different locomotory modes and substrate preferences in extant birds, which makes difficult to confirm phorusrhacid cursoriality based solely on morphometrics. However, some qualitative features of the pelvis and foot make the panorama a little clearer. To study limb adaptations in fossil birds, a more holistic study of the whole posterior locomotory module is necessary, with emphasis on qualitative features, since morphometrics leaves some issues unresolved. A comparison with the wings is also needed in order to make a more complete analysis of locomotory behavior.

SKULL SHAPE IN LIVING AND FOSSIL CARNIVORANS (MAMMALIA, CARNIVORA) AND THEIR RELATIONSHIP WITH DIET, SIZE AND THE PHYLOGENETIC LEGACY

Sebastián Echarri[1,2] and Francisco J. Prevosti[1,3]

1. División Mastozoología, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Ángel Gallardo 470, CP 1405, Argentina. sebastian.echarri@macn.gov.ar

2. CONICET. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina.

3. Departamento de Ciencias Básicas, Universidad Nacional de Luján, Argentina.

Carnivora is a group of mammals specialized on preying on other vertebrates. However, there is a huge variation of feeding habits, from strictly hypercarnivores to exclusively herbivores. The morphology of the skull partly conditions the dietary habits, whereas evolutionary history and constraints affect shape variation in this group. We study the influence of dietary habits, phylogenetic relationships and allometry on the shape of the cranium of carnivorans. We used 2D geometric morphometry of the cranium and performed Principal Component Analysis (PCA) to study the distribution of the specimens in the morphospace in relationship to diet habits and taxonomy. Also, a redundancy analysis (RDA) was used to study the influence of dietary habits, phylogenetic relationships and allometry in shape. We found that carnivorans mainly grouped by taxonomy in the PCA, with Arctoidea, Canidae and Feliformia being separated. The last clade showed a separation in three distinct groups, Felidae, Hyanenidae plus Nimravidae, and the rest of Feliformia. The last group included a large variation of ecomorphs, grouping species of Herpestidae, Eupleridae and Viverridae between Canidae and Arctoidea. All these groups showed some overlap between them. The RDA showed strong influence of the phylogeny (about 80%), diet (about 37%) and a softer influence of size (about 5%). When diet and phylogeny were analyzed together, the shape variance explained exclusively by diet was very small, and most of the variance explained by diet was also explained by phylogeny. Results indicate that cranial shape is mainly explained by phylogenetic relationships, what could point to the existence of some kind of constrain. Dietary habits are also structured phylogenetically, which indicates that diet was also a relevant factor in the evolution of the group.

THE EVOLUTION OF SPEED

Tom M. Fletcher[1], John D.Altringham[2], Jeffrey Peakall[1] and Paul B.Wignall[1]

1. School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, United Kingdom. tomfletcher.palaeo@gmail.com
2. School of Biology, Faculty of Biological Sciences, University of Leeds, Leeds, LS2 9JT, United Kingdom.

The placoid scales of extant sharks have several important functions, amongst which drag-reduction has been a particular focus in biomechanical and engineering investigations. Several mechanisms contribute to this effect, including region-specific scale morphology, but the most important appears to be ribletting of the scale crown surface. The parallel riblets that ornament the dermal denticles of some of the fastest modern sharks are known to reduce skin friction by up to 10%, improving the efficiency and speed of their movement. Despite early observations that some Palaeozoic fish scales resemble those of modern sharks, the hydrodynamic significance in these extinct taxa has not been investigated. Riblets have been identified in several 'acanthodians' and thelodonts, allowing direct comparison with extant shark species of observable ecology. Analysis of 50 modern sharks revealed significantly narrower riblet spacing in faster-moving species, suggesting a functional optimum for higher speeds.Values for the fastest pelagic sharks are comparable to those in both thelodonts and acanthodians that show the same adaptation. *Tantalepis,* the oldest (mid Ordovician) microsquamation yet described, also has parallel riblets, with spacing in the mid-range of modern pelagic sharks. The occurrence of these modifications is evidence for niche partitioning during the Palaeozoic nektonic revolution, which saw a largescale ascent into the pelagic realm. In an environment with three dimensions where food is not evenly distibuted and there is nowhere to hide, speed and efficiency of sustained movement is a key advantage. Our results demonstrate that novel and sophisticated drag-reduction adaptations for speed existed at a remarkably early stage of vertebrate evolution.

MORPHOLOGY OF THE SACRAL REGION OF *CRICOSAURUS ARAUCANENSIS* (CROCODYLOMORPHA: THALATTOSUCHIA): INSIGHTS INTO METRIORHYNCHIDS REPRODUCTIVE STRATEGIES

Yanina Herrera[1], Marta S. Fernández[1], Zulma Gasparini[1] and Lisandro Campos[1]

1. División Paleontología Vertebrados, Museo de La Plata. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. Paseo del Bosque s/n, La Plata, W1900FWA, Argentina, CONICET. yaninah@fcnym.unlp.edu.ar

Metriorhynchids were a successful group of Mesozoic marine crocodylomorphs. Their fossil record is abundant and most of it has been recovered from the European margins of the Western Tethys as well as from the South American margins of the Eastern Pacific. The evolutionary history of these crocodylomorphs, characterized by extensive skeletal and physiological adaptations to a pelagic lifestyle, ranges from the Middle Jurassic to Early Cretaceous. After their extinction, no crocodile has developed such lifestyle. Adaptations to marine lifestyle resulted in certain morphological traits that parallel those of other marine reptile predators, namely limbs transformed into paddles, 'osteoporotic-like' pattern in some bones, lack of heavy armour and hypocercal tail. Along with these traits, the pelvic region was also modified. In this study, the pelvic region of *Cricosaurus araucanensis* (holotype, MLP 72-IV-7-1) was reconstructed. As in all metriorhynchids, in *C. araucanensis* there are two sacral vertebrae with the sacral ribs strongly ventrally deflected, a feature unique among crocodylomorphs. Due to this particular morphology, the ilium is ventrally displaced in relation to the vertebral column in such a way that the space between the vertebral column, dorsally, and the pubis and ischium, ventrally, is maximized. In this sense, the transverse section of the pelvic region is higher than wider, and resulted in the increase of the available space for the abdominal cavity at the level of the pelvic region. The described morphology is convergent with that of basal ichthyosaurs (*e.g.*, *Chaohusaurus*) and basal sauropterygians (*e.g.*, *Keichousaurus hui*). Noteworthy, both clades are known for developing a convergent evolution of live-bearing reproduction (*i.e.*, giving birth to autonomous, free-living offspring, whatever their state of maturity). In metriorhynchids, this reproductive strategy has been proposed since the 70s by some authors based on postcranial characteristics, such as the absence of osteoderms, the paddle-like forelimbs and the hypocercal tail. We propose that the peculiar morphology of the metriorhynchid sacral region was functionally associated with live-bearing reproduction.

MORPHOMETRIC RELATIONS OF JAW ELEMENTS FROM *PAULINITES PARANAENSIS* (SCOLECODONT - DEVONIAN, PONTA GROSSA FORMATION) AND ONTOGENETIC IMPLICATIONS

Isabela Kukimodo[1] and Sandro M. Scheffler[2]

1. Universidade Federal de São Paulo – UNIFESP, Campus Diadema, Rua Prof. Artur Riedel, 275, Jardim Eldorado, Diadema, SP, 09972-270, Brazil.

2. Laboratório de Paleoinvertebrados - LAPIN, Departamento de Geologia e Paleontologia, Museu Nacional, Universidade Federal do Rio de Janeiro - UFRJ, Quinta da Boa Vista, São Cristóvão, Rio de Janeiro, RJ, 20940-040, Brazil. schefflersm@gmail.com.br

The scolecodonts are jaw elements of Polychaeta, among which *Paulinites paranaensis* is the most common species in the Devonian Ponta Grossa Formation. The forceps are characterized by a jagged inner edge, a large anterior hook and a pit in the ventral region. We photomicrographed and measured 86 forceps of the *Paulinites paranaensis* (UNIFESP/Mi 304-314) coming from the Desvio Ribas – Tibagi and Sutil (municipality of Ponta Grossa) and Tibagy 2 (municipality of Tibagi) outcrops. The dimensions were: 1) length (L) 1.47 ± 0.35 mm (left), 1.48 ± 0.30 mm (right); 2) width of the base (B) 0.48 ± 0.11 mm (left), 0.54 ± 0.12 mm (right); 3) above the pit width (P) 0.37 ± 0.10 mm (left), 0.42 ± 0.07 mm (right); 4) length of the hook (H) 0.36 ± 0.09 mm (left), 0.33 ± 0.07 mm (right). In the C/B, C/F, B/F ratios there was a positive linear correlation in scatter plots, indicating that is a good character to use in systematic studies. Mean values for L and L/B are consistent with previous descriptions. The length of *P. caniuensis* is greater than 3.50 mm, and it is a strong indicator that this is a different species. In scatter plots of L/H ratios, L increases proportionally more than H, which increases to approximately 0.4 mm and them stabilizes. The L/B ratio shows that the right forceps are slightly narrower than the left and L increases more than B. These results indicate that older individuals are less robust and have proportionately smaller hooks. Preliminary analysis of dental plate length (mean - 1.23 mm)/base width (mean - 0.194 mm) and length/ramus (mean 0.42mm) ratios shows that there is a tendency for the ramus and the width of the base to stop growing, whereas the length of the element continues the process. This indicates that dental plates from older individuals are also proportionally thinner and with smaller ramus. The next research step will be to analyze more samples, from articulated jaw apparatus and in order to compare with the lifestyle and food habits of living polychaetes. This could bring new inferences about the significance of these ontogenetic variations in terms of functional morphology. Furthermore, future studies may also clarify phylogenetic issues of the Paulinitidae and Eunicidae families, since that seedling of juveniles reflect the morphology of ancestral species. [Support: CNPq, process 474952/2013-4; MEC, PET (Programa de Ensino tutorial) Ciências Biológicas UNIFESP]

EVIDENCE OF PYOGENIC OSTEOMYELITIS IN THE DENTARY OF SOME SPECIMENSOF *CLEVOSAURUS BRASILIENSIS* (LEPIDOSAURIA, RHYNCOCEPHALIA) FROM THE LATE TRIASSIC OF BRAZIL

Paula R. Romo de Vivar Martínez[1], Voltaire Dutra Paes Neto[1] and Marina Bento Soares[1]

1. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul. Avenida Bento Gonçalves, 9500, Agronomia, Porto Alegre, RS, CEP 91540-000, Brazil. paulaoirasor@gmail.com

Clevosaurus was a cosmopolitan rhynchocephalian genus restricted from the Late Triassic to the Early Jurassic. In Brazil one of the most conspicuous species collected from the top of the Upper Triassic Santa Maria 2 Sequence (*Riograndia* Assemblage Zone - Norian age) is *C. brasiliensis*. Numerous specimens of this rhynchocephalian are deposited at the Laboratório de Paleontologia de Vertebrados of the Instituto de Geociências-UFRGS, and consists mainly on jaws and partial skulls. Some of these jaws present a relatively small protuberant bony callus on the buccal side of the anterior lower margin of the dentary, evidenced by a different tissue pattern filled with small punctuations and grooves on the surface of the bone. These features are mostly observed on the specimens UFRGS-PV-0748-T (type-specimen) and UFRGS-PV-0752, but also moderately observed on UFRGS-PV-0753-T, UFRGS-PV-0754-T and UFRGS-PV-0758-T. This pattern is very similar to one locally present in the lower margin of the dentary of extant *Sphenodon*, what is considered to be a common pathology. This abnormal tissue is caused by bacterial infection due to injuries produced after fighting between conspecifics individuals, resulting on a pyogenic osteomyelitis. Whereas macroscopic evidence suggests that this same process probably occurred in *C. brasiliensis*, further analysis, such as histological cuts, M.E.V, tomography and radiologic images, are necessary to confirm this hypothesis. A pyogenic osteomyelitis in the dentary is direct evidence of behavior on extant rhyncocephalians and other bone-injuries are also found in other lepidosaurians due to the same reason. Our study shows that probably similar ethological conditions were also present at the beginning of the Mesozoic, during the initial irradiation of the Lepidosauria Clade.

FUNCTIONAL ANALYSIS AND ONTOGENY IN THE EARLIEST GNATHOSTOMES

Carlos Martínez-Pérez[1], Martin Rücklin[2], Ottmar Kullmer[3], Laurent Darras[4], Mark Purnell[4], Zerina Johanson[5], Kate Trinajstic[6], Emily J. Rayfield[1] and Philip C. J. Donoghue[1]

1. University of Bristol, Wills Memorial Building, Queen's Road, Bristol, BS8 1RJ, UK. Carlos.Martinez-Perez@bristol.ac.uk
2. Naturalis Biodiversity Center, Postbus 9517, 2300 RA Leiden, Netherlands.
3. Senckenberg Research Institute. Senckenberganlage 25m Frankfurt am Main, 60325, Germany.
4. University of Leicester, University Road Leicester, Leicester, LE1 7RH, UK.
5. Natural History Museum, Cromwell Road, London, SW7 5BD, UK.
6. Department of Chemistry, Curtin University, Kent St, Bentley 6102, Australia.

The diversity of modern vertebrates is based upon a major innovation that occurred about 400 Myr ago with the evolution of jaws and teeth in the first gnathostomes. This novelty was a key innovation that opened-up new trophic niches, facilitated a massive adaptive radiation, and allowed jawed vertebrates to outcompete their jawless rivals. Therefore, this evolutionary transition, with profound effects on ecosystems and biodiversity, is fundamental to understand gnathostome origins and the evolution of more derived gnathostome dentitions. Among them, 'placoderms' were a major component of Devonian aquatic ecosystems, and the first jawed vertebrates. In this work we investigate the functional changes during the ontogeny of the jaws of the arthrodiran 'placoderm' *Compagopiscis croucheri* from the Upper Devonian of Australia. Applying cutting-edge methods, such us synchrotron tomography and micro-CT, we produced different virtual models of the supragnathals and infragnathals of single individuals in different ontogenetic stages. These models were used for occlusion analysis (Occlusal Fingerprint Analysis, OFA) and Finite Element Analysis (FEA), additionally the microwear of the jaws was also analysed. The occlusion and wear patterns of the teeth and jaws show notable changes during ontogeny. The growth pattern of the statodont dentition pre-patterns the development of the wear-facets that increase during the ontogeny, enabling a functional occlusion and interlock. The finite element analysis, constrained by the results obtained from the OFA (extracting the contact areas and direction of the loads during the occlusal cycle), showed a relatively constant mechanical response during ontogeny and just slight change in the optimization of the stress-resistance occurs in the mature specimens. Functionally early ontogenetic stages are comparable to recent crown-group gnathostomes, whereas later stages show a unique development of the wear pattern. These results provide direct evidence of complex mechanical interactions between the functional components of the jaws, allowing us to establish hypotheses on trophic strategies and shift in diet during ontogeny in the earliest gnathostomes.

3D GEOMETRIC MORPHOMETRICS OF THE PROXIMAL ULNAR ARTICULAR SURFACE OF SMALL MAMMALS AND ITS APPLICATION IN PALEOBIOLOGICAL INFERENCES OF TWO TYPOTHERES (NOTOUNGULATA) FROM THE SANTA CRUZ FORMATION

Nahuel A. Muñoz[1], **Sergio F. Vizcaíno**[1] **and Adriana M. Candela**[1]

1. División Paleontología Vertebrados, Museo de La Plata, CONICET, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina. nahuelmunoz@fcnym.unlp.edu.ar

Articular surfaces of limb bones are very informative in morphofunctional studies, providing information about the relative movements between adjacent bones. The elbow joint is a particularly complex hinge involved in flexo-extension movements between humerus and ulna as well as rotational movements between these two and the radius. The proximal articular surface of the ulna was examined in living and extinct small mammals in order to assess its usefulness as a proxy for this articulation in functional studies. The extant sample was composed with 11 species of eutherians: 5 hystricomorph rodents, 6 carnivorans and one primate. The extinct species studied were the Early Miocene (Santacrucian) typotheres (Notoungulata) *Hegetotherium mirabile* (Hegetotheriidae) and *Interatherium robustum* (Interatheriidae). These typotheres have been described as rodent-like in overall form, with estimated body masses of less than 10 kg. The proximal articular surfaces of the ulnas were examined through geometric morphometrics in three dimensions after digitizing with a Next Engine Desktop 3D Scanner. Forty five landmarks were taken with the Landmark Editor software and Principal Component Analyses (PCA) was used to explore the morphospace structure. The PCA of the whole surface was inconclusive; therefore successive analyses were made subdividing it. The PCA for the posterior part of the facet is the most informative allowing recognizing morphospaces with functional value. In PC1, shape changes from narrower to a wider facet. In PC2, shape varies from laterally flattened and less anteroposteriorly concave trochlea, medial width sub-equal to posterior width, and non-projected proximal lip, to a more laterally convex and more anteroposteriorly concave trochlea, medial width narrower than posterior width, and projected proximal lip. Diggers and generalized species lie at high values of PC1 and more cursorial species at mid-low values of PC1 and high of PC2; the rest at mid-low values of PC1 and PC2, with climbers at lowest values of PC2. The typotheres lie with the cursorial species. These results differ from those obtained in a previous work with the distal humeral facet, which placed *I. robustum* among climbers and *H. mirabile* in its own morphospace. This may be due to differential optimization of the facets of a joint, and must be considered before making paleobiological inferences. The study of a portion of a facet permits a better focus on the details of the chosen area, and allows detecting patterns produced by differential optimization on certain parts of a joint.

A CAMBRIAN PROBLEMATICA REINTERPRETED AS A SUSPENSION FEEDER OF CNIDARIAN AFFINITY

Qiang Ou[1,2], Jian Han[2], Zhifei Zhang[2], Ge Sun[1], Qianping Lei[3] and Degan Shu[1,2]

1. Early Life Evolution Laboratory, State Key Laboratory of Biogeology and Environmental Geology, University of Geosciences, Beijing 100083, China. ouqiang@cugb.edu.cn

2. Early Life Institute, Collaborative Innovation Center of Continental Tectonics, State Key Laboratory of Continental Dynamics, Northwest University, Xi'an 710069, China.

3. Changzhou Museum, Changzhou 213022, China.

Ciliary suspension feeding is a common adaptive strategy represented by extant marine tentaculate animal taxa as diverse as annelids (sabellid and serpulid polychaetes), phoronids, bryozoans, brachiopods, entoprocts, and hemichordates (pterobranchs). They utilize their ciliary system to create feeding currents, filtrate sea water, and collect and transport food particles to the mouth. *Xianguangia sinica* Chen and Erdtmann, one of the iconic fossil metazoans of the early Cambrian Chengjiang biota in southern China, has invited divergent speculations on its systematic placement. Current study reveals that this animal possessed a polypoid body form coupled with plumose tentacles with densely ciliated pinnules arranged in an alternating pattern, a trait strongly indicative of suspension feeding behavior. Given the muco-ciliary suspension feeding as a supplementary strategy extensively occurring in living anthozoans, the polypoid *Xianguangia* is tentatively demonstrated to be a stem-group cnidarian. Thus, trapping suspended food particles using a ciliary system is proposed to be an ancestral feeding strategy (plesiomorphy) of cnidarians. This study further corroborates the basal position of Anthozoa among cnidarians and strengthens the hypothesis that the sessile polyp predated the swimming medusa in the evolution of Cnidaria.

A CRYPTIC HISTORY OF SKELETONIZED CTENOPHORES

Qiang Ou[1,3], Shuhai Xiao[2], Jian Han[3], Zhifei Zhang[3], Jianni Liu[3], Fang Zhang[4] and Degan Shu[3,1]

1. Early Life Evolution Laboratory, State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China. ouqiang@cugb.edu.cn

2. Department of Geosciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, USA.

3. Early Life Institute, Collaborative Innovation Center of Continental Tectonics, State Key Laboratory of Continental Dynamics, Northwest University, Xi'an 710069, China.

4. Tsinghua University, Beijing 100084, China.

The phylum Ctenophora (comb jellies) is represented by a group of soft-bodied predators in modern marine communities. Although resembling medusoid cnidarians in a diploblastic grade of organization, oral-aboral body axis and overall morphology, they show unique derived characters including eight rows of comb-like ciliary plates (ctenes) used for locomotion, an aboral sense organ, biradial symmetry, and specialized adhesive cells (colloblasts) for feeding. They are phylogenetically significant, traditionally resolved as basal metazoans, but their exact position in the animal tree remains controversial. They are generally considered to have evolved from a soft-bodied precursor. Here, however, we report three new taxa of primitive ctenophores and new material of their described kin with a skeletonized framework from the early Cambrian Chengjiang biota, South China. They form a distinctive clade (Scleroctenophora class nov.) characterized foremost by hard parts (sclerotized or mineralized) integrated as a supportive/defensive system, as well as an octamerous body with ctene rows and an apical organ diagnostic of extant ctenophores. This clade throws light on the sequence of evolutionary events leading to extant groups and suggests that primitive ctenophores during the Cambrian revolutions possessed a skeleton, lacked tentacles, were nektonic, and presumably were octoradially symmetrical. These reinforced ctenophores shed unexpected light on the early evolution of the phylum and expand the glory of the coeval massive skeletonization event.

MUSCULAR AND BIOMECHANICAL INFERENCES ON AN EARLY SAUROPODOMORPH DINOSAUR FROM THE BRAZILIAN LATE TRIASSIC

Andressa Paim[1], Flávio A. Pretto[1], and Cesar L. Schultz[1]

1. Universidade Federal do Rio Grande do Sul, Instituto de Geociências, Setor de Paleovertebrados, Av. Bento Gonçalves, 9500 - Bloco J, Prédio 43127, Campus do Vale, Agronomia. CEP 91540-000, Porto Alegre, Rio Grande do Sul, Brazil. dessapaim@gmail.com

Recent work at the "Sítio Janner" outcrop (Santa Maria 2 Sequence, *Hyperodapedon* Assemblage Zone) resulted in the collection of a new sauropodomorh dinosaur specimen. The material (UFRGS-PV-1099-T) preserved a large part of the skeleton, including most of the hindlimb elements and partial pelvis (except for the ischia, not preserved). The good preservation of the specimen allowed the inference of some muscular attachment areas related with hindlimb protraction and retraction. Additionally, some preliminary biomechanical estimates are presented. Muscular inferences were made using the 'Extant Phylogenetic Bracket', comparing anatomical features of UFRGS-PV-1099-T with extant members of Crocodylia and Aves. Among the inferred muscular groups involved in hindlimb protraction are the *mm. iliotibiales* (originated in the dorsal iliac lamina), *ambiens* (originated in a rough tubercle in the lateral pubis) and *femorotibiales* (originated in the craniolateral and craniomedial surfaces of the femoral shaft). These muscles (also recognized as *triceps femoris*) converged in a patellar tendon, which inserted in proximal tibia. They acted primarily in the crus extension, but may also have promoted femoral protraction. The iliofemoral musculature, which inserted in the femoral lesser trochanter and trochanteric shelf, was also involved in femoral protraction. Its origin site is of difficult assessment in UFRGS-PV-1099-T, but may be located in the lateral surface of the dorsal iliac lamina (as inferred for the sauropodomorph *Saturnalia*). The contraction of the iliofemoral musculature could also have promoted some degree of femoral abduction. The main retractors of the hindlimb, whose attachment areas were recognized for UFRGS-PV1099-T, were the *m. caudofemoralis brevis*, which was inserted in the mediocaudal surface of the fourth trochanter, and the *m. caudofemoralis longus*, with insertion in a rugosity in the medial surface of the femoral shaft, cranially to the fourth trochanter (but not in an oval depression, as described for *Saturnalia*). Biomechanical parameters were calculated, based on linear measurements of the specimen. Assuming a bipedal posture for the specimen, an optimal walking speed of 3.9 km/h was inferred. This speed corresponds to a Froude number (Fr) equivalent to 0.25, regarded as the speed that results in minimum energy expenditure during walking. Additionally, at a speed between Fr= 0.5 and 0.7 it is assumed that animals change their gaits from walk to run. In UFRGS-PV1099-T, these Fr would correspond to a speed between 5.52 and 6.54 km/h. For higher speeds, the specimen would adopt a running gait.

SINUS SIZE AND BRAIN SIZE IN THE MARSUPIAL GIANT *DIPROTODON OPTATUM*: A COMPARATIVE ANALYSIS OF EXTINCT AND EXTANT MARSUPIALS

Alana C. Sharp[1]

1. Monash University, School of Geosciences, Building 28, Wellington Road, Clayton, Victoria, 3800 Australia. alana.sharp@monash.edu

The extinct *Diprotodon optatum* was the largest ever marsupial, reaching over two tonnes. However, despite its large size, the cranium of *Diprotodon* is remarkably light and fragile, composed of thin bone and extensive endocranial sinuses. Cranial sinuses are air-filled cavities resulting from the resorption and deposition of bone through pneumatisation in response to biomechanical stress. The morphology of a pneumatic bone represents an optimisation between strength and being light weight. The extraordinary preservation of the *Diprotodon* skulls found at Bacchus Marsh, southern Australia (37°40′ S, 144°26′ E), provide a unique opportunity to investigate hypotheses regarding the size and function of the atypically voluminous sinuses. Sinus function is difficult to test without first obtaining data on sinus variation within and between species. Therefore, the crania of *Diprotodon* and nine species of extinct and extant vombatiform marsupials were studied using CT scans to provide a volumetric assessment of the endocast and cranial sinuses. Sinus volume strongly correlates with skull size. In the extinct palorchestids and diprotodontids the sinuses expand around the dorsal and lateral parts of the braincase. The adult *Diprotodon* has extremely enlarged sinuses, but they are relatively smaller than predicted from the sinus volume of other vombatiform marsupials. Brain size scales negatively with skull size in vombatiformes. In large species the brain typically fills less than one third of the total width of the endocranial space, and in very large species, it can be less than a quarter. The sinuses may have expanded in order to increase the surface area for attachment of the temporalis muscle. The brain case itself would have provided insufficient surface area for the predicted muscle masses. Future work should involve investigation into the variation between individuals of the same species, and variation between marsupial and placental mammals. It has been suggested that the sinuses in marsupials are relatively more extensive than those in such placentals as elephants and pigs, and originate from different regions of the cranium. Thus, the reasons for the development of sinuses may differ for marsupials and placentals.

IT'S A BRACHIOPOD, IT'S A CORAL, IT'S A BRACHIOPOD – AN ENIGMATIC MIDDLE CAMBRIAN ORGANISM ADAPTED TO REEF-LIKE ENVIRONMENTS?

Michael Streng[1], Aodhán D. Butler[1] and Russell J. Garwood[2]

1. Department of Earth Sciences, Uppsala University, Villavägen 16, 75236 Uppsala, Sweden. michael.streng@geo.uu.se

2. School of Earth, Atmospheric and Environmental Sciences and The Manchester X-Ray Imaging Facility, School of Materials, The University of Manchester, Manchester, M13 9PL, UK.

The middle Cambrian Stephen Formation near Odaray Mountain, British Columbia (Canada) contains in its lower part an approximately 0.5 m thick packstone bed, which represents an amalgamation of several syndepositional slumping events. Acid dissolution of bulk samples from this bed revealed a rich fauna of ptychoparid trilobites and phosphatic shells, including several species of linguliform brachiopods, bradoriids and tube dwelling organisms (*Hyolithellus* and *Byronia*), but also a variety of silicified skeletal material such as large helcionellids, numerous articulated *Stenothecoides*, ordinary rhynchonelliform brachiopods (chiefly *Diraphora*), echinoderm ossicles bearing epispires, and an unexpected variety of coral-like organisms. A common morphology among these are solitary cylindrical corallites that broaden at the base to form a circular attachment disk. Solitary conical forms showing budding from the inside of the parental cup are present but rare. However, most conspicuous is a third coral-like organism, which shows resemblance to two, systematically rather different taxa, i.e., the operculate coral *Cothonion* described from somewhat older strata in Australia and Greenland, and the unusual brachiopod *Anomalocalyx* from about coeval deposits in Australia. The bilateral shape and the lack of distinct septa support a brachiopod affinity and the specimens from Odaray Mountain are best considered as a new taxon close to *Anomalocalyx*. The two taxa differ in exterior ornamentation, curvature of the ventral valve and features of the dorsal valve. The association with true corals and the coral-like morphology suggests that the shell of the new taxon might represent an early specialization and adaption of brachiopods to a reef-like environment, analogous to shell modifications of the hermatypic late Paleozoic richthofenioid brachiopods and the late Mesozoic rudist bivalves. A similar ecology has previously also been discussed for *Anomalocalyx*. The detailed morphology of the new taxon is presented, including micro CT-scans that reveal the gross morphology and internal structure of articulated shells. From this data possibilities for the systematic affinity are investigated. An affinity with a small group of early and middle Cambrian brachiopods, the naukatids, currently appears to be the most parsimonious, further shedding light on this poorly understood group.

A NEW METHOD OF TOOTH MESOWEAR APPLIED TO FOSSIL GIRAFFIDS FROM NORTH CHINA

Sukuan Hou[1] and Nikos Solounias[2]

1. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences142 Xizhimenwai Street, Beijing 100044, China. housukuan@ivpp.ac.cn

2. New York Institute of Technology College of Osteopathic Medicine 8000 Northern Boulevard Old Westbury, NY 11568 8000, USA.

Mesowear is the wear of enamel bands that can be used to study the diet of ungulates. In ruminants, there are four bands of enamel, which are separated by dentine. The buccal-most band is termed band 1, and the lingual-most band is termed band 4, with bands 2 and 3 in between. As such, the paracone and the metacone are constructed by bands 1 and 2. So far, band 1 has been used in various methods. The original mesowear investigated band 1 of the second molar from a buccal view, addressing the height of the relief of the paracone and the metacone, and subdividing the morphotypes of the apices, to evaluate large numbers of individuals quickly and easily. Mesowear II combined the relief and the apical morphology into a single variable, which also utilized band 1 of M2 from a buccal view. The new method of tooth mesowear, mesowear III, draws data from enamel band 2 of the upper second molar using an occlusal view. It is a promising method in separating diet of ruminants, and data so far allow a better separation between browsers, grazers, and mixed feeders. Therefore, we use mesowear III to study the diet of fossil giraffids from North China for the first time. Among 6 species from the Subfamily Palaeotraginae, *Samotherium boissieri*, *Palaeotragus coelophrys*, and *P. rouenii*are all mixed feeders. *Alcicephalus neumayri*, *S. sinense*, and *S.* sp. cannot be determined with statistical significance because we only have 2 individuals of each. But the mesowear III scores for *S.* sp. and *A. neumayri* are similar to the mixed feeders. The *S. sinense* mesowear III scores appear to be more on the grazing side. Additionally, *S.* sp. is morphologically a very primitive *Samotherium*. *Honanotherium schlosseri* from the Subfamily Bohliniae was determined to be a mixed feeder. Another unnamed species was also determined to be a mixed feeder. Other specimens of undetermined taxa of Bohliniae had a small sample size and could not be analyzed with statistically significant, but their mesowear III suggests grazing. *Bramatherium* sp. from the Subfamily Sivatheriinae was determined to be a mixed feeder. *Schansitherium tafeli* and *Sch. decipiens* are not yet assigned to a subfamily but their mesowear III appears to be more on the grazing side. Our results are in agreement with previous studies.

3-DIMENSIONAL ANALYSIS OF THE MIDDLE JURASSIC AMMONITE *NORMANNITES* AND ITS FUNCTIONAL MORPHOLOGY

Amane Tajika[1], Carole Naglik[1] and Christian Klug[1]

1. Paleontological Institute and Museum, University of Zurich, Karl-Schmid-Strasse 4, 8006 Zürich, Switzerland. amane.tajika@pim.uzh.ch

Some ammonoids have external shells with peculiar features in their terminal apertures such as an apertural shell thickening, an apertural constriction, changes in ornamentation and apertural appendages. These prominent features are referred to as mature modifications. In ammonoids, shell allometry including mature apertural modifications is of great importance because ammonoids used their shells as buoyancy devices and such modifications might have changed the orientation of the shell. Two-dimensional approaches have been taken as the standard method to study ammonoids. However, the shell volume, which yields important clues to unravel the mystery of ammonoid palaeobiology, cannot be quantified by this approach. In our study, an ammonite is virtually reconstructed in three dimensions in order to calculate shell and chamber volumes. Two ammonite *Normannites* specimens were reconstructed. *Normannites* is commonly regarded as a microconch genus of the Stephanocerataceae (Ammonitina), partially because of its large lappets. The specimens are from the Middle Bajocian (Middle Jurassic) of northern Switzerland. In order to obtain empirical data, serial sections of the specimen were produced. Each section was automatically scanned. An obtained set of 114 scans was used to produce a virtual 3D-model of the ammonite. The resulting 2D-scans were imported into Adobe Illustrator® and manually traced. Each segment (shell, siphuncle and septa) was marked by different colors so that the volumes could be calculated separately. We use the software VGstudiomax®2.1, which constructs 3D-models out of 2D-stacks. These models were then used to measure shell volumes and to evaluate the spatial distribution of mass, which was then used to reconstruct shell orientation.

THE FORELIMB OF *CYONASUA* SP. (PROCYONIDAE, CARNIVORA): SUBSTRATE PREFERENCE AND LOCOMOTORY MODE INFERENCE

Juliana Tarquini[1,2], Nestor Toledo[1,2], Cecilia C. Morgan[1,3] and Leopoldo H. Soibelzon[1,2]

1. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina. ntoledo@fcnym.unlp.edu.ar

2. División Paleontología Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.

3. División Zoología de Vertebrados, Sección Mastozoología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.

The family Procyonidae is represented in South America by two extinct genera: †*Cyonasua* and †*Chapalmalania*, and five extant ones: *Bassaricyon*, *Nasuella*, *Potos*, *Procyon* and *Nasua*. The living forms have adapted to a wide variety of arboreal and terrestrial habitats, preferably near water bodies. In this work we draw inferences about the substrate preference and locomotory mode of †*Cyonasua*, being the first quantitative approach to this question. Twenty-two linear measurements from the forelimb stylopodium and zeugopodium were taken; for each individual, the raw values were divided by the geometric mean of all measurements to minimize the effect of size. The transformed values were analyzed by Principal Component Analysis (PCA) to explore variation. The sample included 11 taxa of Carnivora with different substrate preference and locomotory modes: tree-dwellers (*Potos*, *Arctictis*), semi-aquatic (*Lontra*), scansorial (*Nasua*, *Eira*), terrestrial-climbers (*Procyon*, *Leopardus*, *Tremarctos*), terrestrial-non-cursorial (*Galictis*, *Conepatus*), and terrestrial-cursorial (*Lycalopex*). The first two principal components (PC) summarized 42.8% of the total variation of the sample. PC-1 explained 23.7% of the variation; the taxa with semi-aquatic, terrestrial-cursorial and terrestrial-non cursorial habits occupied the positive extreme of this axis, associated to narrower ulnar diaphyses, elongated humeral heads and distally projected humeral trochleas. The tree-dwellers, scansorials and terrestrial-climbers, located on negative values of PC-1, showed wider ulnar diaphyses, shorter humeral heads, and less distally projected humeral trochleas. PC-2 explained 19.08% of the total variation; the semi-aquatic, tree-dwelling, scansorial and terrestrial-non cursorial taxa occupied the positive extreme, showing a wide distal humeral articular facet, well protruding entepicondyle and shorter ulna. Toward the negative values of PC-2, the terrestrial-climbers and terrestrial-cursorials presented longer ulnae, narrow distal humeral articular facet and less protruding entepicondyle. In this context, the location of †*Cyonasua* sp. in the morphospace was unique, with near-zero values on PC-1 and negative values on PC-2, reflected in a relatively long ulna with somewhat narrow distal humeral articular surface, and entepicondyle slightly more protruding than in terrestrial-climbers and cursorials; this would be associated to greater development of hand flexor muscles, and elbow movements restricted to sagittal plane. Accordingly, in terms of the ecologic groups separated along PC-1, the forelimb of †*Cyonasua* can be characterized as intermediate, while regarding PC-2 it was most similar to that of *Procyon*. Thus, for †*Cyonasua* sp. we infer terrestrial habits with potential climbing abilities. In-progress studies about hind limb will provide additional information about substrate preference and locomotory mode.

PHYLOGENETIC SIGNAL OF BODY SIZE IN SLOTHS AND ANTEATERS (XENARTHRA, PILOSA)

Néstor Toledo[1,2], M. Susana Bargo[2,] , Sergio F. Vizcaíno[1,2], François Pujos[4,5] and Gerardo De Iuliis[6]

1. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina. ntoledo@fcnym.unlp.edu.ar

2. División Paleontología Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.

3. Comisión de Investigaciones Científicas, Buenos Aires, Argentina.

4. IANIGLA, CCT-CONICET-Mendoza, Avda. Ruiz Leal s/n, 5500 Mendoza, Argentina.

5. Institut Français d'Etudes Andines (IFEA), Casilla 18-1217, Av. Arequipa 4595, Lima 18, Peru.

6. Department of Ecology and Evolutionary Biology, University of Toronto, 25 Harbord Street, Toronto M5S 3G5, Ontario, and Section of Palaeobiology, Department of Natural History, Royal Ontario Museum, 100 Queen's Park Crescent, Toronto, Ontario, M5S 2C6 Canada.

Pilosa xenarthrans includes sloths (Folivora) and anteaters (Vermilingua). Modern tree sloths are represented by two genera, *Bradypus* and *Choloepus* (less than 10 kg), whereas the fossil record is very diverse and rich (~ 80 genera) ranging from the Oligocene to the Early Holocene periods. The fossil group includes four main clades, Megalonychidae, Megatheriidae, Nothrotheriidae, and Mylodontidae, with body sizes from tens of kilograms to several tons. Vermilinguans are represented today by three genera, *Cyclopes*, *Tamandua*, and *Myrmecophaga* (from 0.5 to about 35 kg), and their fossil record is quite scarce and fragmentary but maybe similar in size. We analyzed in this contribution the dependency of the body size from the phylogenetic pattern of Pilosa, following the current cladistic hypotheses and using previously published body size estimates for 35 taxa (extant and extinct). An orthonormal decomposition analysis of the variance of body size is also performed. The observed distribution of this variable in the cladograms is compared using four statistical parameters, with a theoretical random distribution as null-hypothesis. Three of the four parameters were significantly different from the null-hypothesis, supporting the possibility that body size variation correlates with the cladograms topologies and, hence, with the phylogenetical pattern. This dependence is not restricted to a single node, but it is that was called diffuse phylogenetic signal. In the first cladogram, most of the phylogenetic signal is concentrated within Vermilingua, and much less within Mylodontidae, Megatheriidae and Nothrotheriidae. In the second cladogram, a great proportion of phylogenetical signal is concentrated in Megatheria (Megatheriidae and Nothrotheriidae), and less in Megalonychidae. In anteaters, a relationship between diet and phylogenetic constraints to body size's diversification is proposed; their specialized, strict insectivory may have played a lead role restraining the evolution of body size. Concerning sloths, the trend is not clearly related to a single factor. Mylodontids and megatherians show a tendency to increased body size through time, whereas Megalonychidae retain a wider diversity in body size until the early Holocene. Biological attributes such as dietary habits (herbivorous bulk feeding *vs.* selective feeding) and paleoenvironmental factors such as climate changes throughout the Cenozoic are doubtlessly involved in the evolution of sloth's body size. Next steps will be to use alternative methods to assess phylogenetic dependency and more accurate body size estimates. When available, more inclusive phylogenetical proposals could be necessary, allowing expanding the analysis to a greater diversity.

GREAT ONTOGENETIC VARIATION IN SHELL FORM WITH MINIMUM MODIFICATION OF APERTURE MAP IN AMMONOIDS

Takao Ubukata[1]

1. Department Geology and Mineralogy, Kyoto University, Kitashirakawa-oiwakecho, Sakyo-ku, Kyoto, 606-8502, Japan. ubukata@kueps.kyoto-u.ac.jp

In accretionary growing system, the pattern of relative rate of shell accretion for each point around the shell margin, or aperture map, is significant in determining shell form. Substantial modification of the basic pattern of the aperture map requires a considerable change of behavior of cells around the mantle edge. If the regulation of the aperture map acts as a sort of developmental constraint, it is possible to predict which kinds of ontogenetic change, within-species variation or morphological evolution are achieved readily or with difficulty. In many ammonoids, the manner of shell coiling and the shape of the aperture often change with growth. The basic question in the present study is whether or not the ontogenetic changes commonly observed in ammonoids consist with the constructional paradigm to maintain basic pattern of the aperture map. To test this hypothesis, relationship between gross shell form and pattern of the aperture map was analyzed using a theoretical morphologic model. The aperture maps were generated for many theoretical models with varying the whorl expansion rate (W), umbilical width (D) and breadth/height ratio of the aperture (S). Each hypothetical aperture map was decomposed into a Fourier series. Analyses of the relationship between Fourier coefficients and theoretical morphologic parameters revealed that keeping the basic pattern of the aperture map tends to make a negative correlation between W and D within ontogenetic variation. The results of morphometric analyses based on more than 100 species were concordant with the theoretical prediction; i.e., increase (or decrease) in whorl expansion rate through growth tends to be accompanied by reducing (or enlarging) of the umbilical width. The results of the computer simulations also indicated that the effect of the aperture shape (S) on the pattern of the aperture map is considerably smaller than that of the properties of shell coiling (W and D). The results threw a light on the role of the aperture map in relation to ontogenetic variation of ammonoid shells.

SYMPOSIUM

THE INVASION OF LAND: WHEN AND WHERE?

ORGANIZERS:

NICHOLAS MINTER - CHARLES WELLMAN

A CAMBRIAN COLONIZATION OF LAND BY ECDYSOZOANS AS REVEALED BY MOLECUALR TIMETREES

Allison C. Daley[1], Omar Rota-Stabelli[2] and Davide Pisani[3]

1. Oxford University, Department of Zoology & Museum of Natural History, Oxford, OX1 3PS, UK. allison.daley@zoo.ox.ac.uk

2. Sustainable Agro-ecosystems and Bioresources Department, IASMA Research and Innovation Centre, Fondazione Edmund Mach, Via E. Mach 1, 38010 San Michele all'Aldige, Trento, Italy.

3. University of Bristol, Schools of Earth Sciences and Biological Sciences, Bristol, BS8 1UG, UK.

As the most abundant and diverse animals on Earth since the early Cambrian, ecdysozoans are ideal proxies for studying major evolutionary events in the Phanerozoic. Several ecdysozoan lineages colonized land independently, and understanding when these events took place could help shape our understanding of the impacts and influences that terrestrialisation had on evolving ecosystems.With the aim of providing a robust time scale for ecdysozoan evolution, we undertook a comprehensive molecular clock analysis that employed five molecular datasets, mostly on a genomic scale, and were calibrated with the most complete set of fossil calibrations to date. Divergence times of lineages were generated using a relaxed molecular clock analysis that incorporated a phylogeny reconstructed from Bayesian inference, and upwards of 30 fossil calibrations per tree. Sensitivity experiments were developed to test the robustness of our results, showing that the major results of our timetree are stable. The molecular timetrees were used to estimate the timing of terrestrialisation by examining when the first diversification of currently terrestrial animal groups took place. Our results suggest that millipedes and centipedes diverged in Cambrian Series 2 Stage 4 at approximately 510 Mya. This was soon followed by divergences within the arachnids and hexapods in the Early Ordovician, at approximately 472 Mya and 483 Mya respectively. These results find support from the fossil record. While the earliest body fossils of terrestrial myriapods and arachnids are from the Silurian, trace fossils indicating amphibious activity of an unknown arthropod are known from the Cambrian-Ordovician boundary and recent work has identified trilobite trace fossils in tidal-flat deposits as early as Cambrian Stages 2-3. Palaeontological and molecular timetree evidence suggests that terrestrialisation by the arthropods is broadly synchronous with the origination and diversification of land plants in the late Cambrian to Middle Ordovician. Our timetree estimates diversifications of nematodes and insects concurrent with the appearance of vascular plants at the Ordovician-Silurian boundary, and radiations within onychophorans, enoplean nematodes and flying insects when the first forests appeared in the Middle-Upper Devonian. The combination of molecular data and paleontological data in these timetrees provides a tool with which to examine major events in the evolution of animals.

A HIGH LATITUDE LATE DEVONIAN (FAMENNIAN) LAGERSTATTEN FROM SOUTH AFRICA: A WINDOW INTO MARGINAL MARINE AND TERRESTRIAL GONDWANAN ECOSYSTEMS

Robert W. Gess[1]

1. Geology Department, Rhodes University, Grahamstown, South Africa.
robg@imaginet.co.za

The Waterloo Farm locality exposed in 1985 by roadworks south of Grahamtown, South Africa represents a lagoonal system partially separated from the Agulhas Sea by a barrier island complex. Important fossils have been recovered from various sedimentary environments. Most importantly fine black anaerobic muds deposited in still portions of the lagoon accumulated a huge mixed assemblage representing the life of marine and fresh water influenced parts of the lagoonal system, as well as that of adjacent terrestrial environments.The aquatic vertebrate fauna is the most comprehensive one recorded from the Devonian Agulhas Sea and includes many specimens displaying exceptional soft tissue preservation. Vertebrate groups represented include lampreys (the earliest known), diverse placoderms, acanthodians, chondrichthyans, actinopterygians and sarcopterygians including onychodontiforms, actinistians, dipnoans and tetrapodomorphs. These are preserved alongside the remains of finely preserved phaeophyte and charophyte algae, eurypterids, conchostracans, ostracods and bivalves. Terrestrial remains largely consist of plant material, but also include scorpion remains, representing the earliest terrestrial animal remains from Gondwana. The terrestrial plant assemblage is the most diverse flora known from the Late Devonian Agulhas Sea, comprising a minimum of fifteen taxa. These represent most major Late Devonian groups including zosterophyllopsids, trimerophytes, sphenophytes, herbaceous and arborescent lycopdsids, iridopterids and progymnosperms. The Waterloo Farm lagerstatte represents an important biogeographic outlier. Whereas Late Devonian faunas and floras found in North America, Europe, China, Australia and Eastern Antarctica were tropical, that found at Waterloo Farm was situated within the Antarctic circle. Systematic excavation over many years has resulted in a very large collection of material which allows for reconstruction of a fairly complete ecological system. Relationships are determinable from, for example, stomach contents within certain vertebrates, numerical analysis of size ranges present, the presence or absence of vertebrate hatchlings and growth of aquatic algae on terrestrially derived axes. Ongoing research is creating a unique holistic picture of high latitude continental life in Gondwana immediately predating the End Devonian Extinction event.

THE TRACE FOSSIL RECORD OF ECOSPACE EXPANSION AND ECOSYSTEM ENGINEERING DURING THE COLONIZATION OF LAND

Nicholas J. Minter[1]

1. School of Earth and Environmental Sciences, University of Portsmouth, Burnaby Building, Burnaby Road, Portsmouth, PO1 3QL, UK. nic.minter@port.ac.uk

The colonization of land was a major evolutionary transition. This process began in the terminal Ediacaran, followed by organisms making their first unequivocal amphibious terrestrial forays during the Cambrian. Only by the late Ordovician, had organisms managed to establish themselves in truly alluvial environments. Following this protracted early stage, the remainder of the Paleozoic bore witness to an explosion of diversity and expansion of benthic biotas into new environments and niches; with a progressive expansion from coastal settings into rivers, floodplains, deserts and lakes, as well as increasing colonization of infaunal ecospace. A framework is presented for analyzing ecospace occupation and ecosystem engineering using trace fossil data. Significantly, this allows for precise environmental context and analysis of the diversification of behavioral programmes and exploitation of new ecological niches. A pattern is emerging that, following initial colonization of a new environment there is a rapid filling of available ecospace, after which organisms subsequently diversify by establishing new behavioral programmes represented by the creation of original architectural designs, and a proliferation of ichnogenera representing variation upon these established themes.

THE 'ESTUARY EFFECT': BROAD IMPLICATIONS OF CONTINENTAL INVASION ON TAXONOMIC RICHNESS AND SURVIVORSHIP IN BIVALVE AND GASTROPOD MOLLUSCS

Gary J. Motz[1] and Lisa E. Park Boush[2]

1. University of Cincinnati, 500 Geology/Physics Building, Cincinnati, OH 45221-0013, USA.
motzgy@mail.uc.edu
2. University of Akron, 302 Buchtel Ave., Akron, OH 44325, USA.

The timing and mechanisms of how faunas established themselves within the continental realm is critical to our understanding of clade origination, radiation, and derivation. Determining the conditions and physiological traits necessary for clades to invade continents allows us to better characterize the nature of these invasions and understand the requirements for survival in non-marine environments as well as informing on the possible causes of diversity and disparity across the tree of life. The invasion of continental habitats by marine organisms has occurred numerous times across a large number of clades, but has done so via a single pathway: occasional connection of freshwater fluvial systems to marine conditions in mixed salinity and high environmental heterogeneity contexts along continental margins. Throughout the Phanerozoic, many clades have become constituents of freshwater aquatic and terrestrial ecosystems and in doing so have secured a place in natural history as successful speciators and long-lived genera across many phyla. The invasion of the continental realm by broadened ecological tolerances, physiological generalization, and prolonged taxonomic longevity allows for broad comparisons to be drawn between clades that exist in continental and marine habitats as compared to those that reside in exclusively marine habitats. This study elaborates upon the distinct differences between a number of ecological, physiological, and other parameters that promote the differential success of invading clades by documenting apparent trends in taxonomic survivorship, phylogenetic constraints on physiological adaptation, and diversification in molluscs that are documented in the fossil record in exclusively marine habitats as well as those invaders that have successfully crossed the salinity divide. Data for this project is comprised of large, community-supported databases (e.g. PaleoBiologyDataBase) and the Lake Faunas Through Time dataset compiled primarily by the authors of this study. Analyses to date demonstrate distinct differences between the continental record of invading clades that are distinct from the well-studied marine invertebrate literature that are not artifacts of the addition of novel ecospace for successful invaders to radiate but rather that ecophenotypic and physiological constraints have been overcome in order to allow for the radiation of invading clades to dramatically enhance their taxonomic richness, survivorship, and environmental breadth in the marine realm as well. For gastropods and bivalves, high taxonomic richness is strongly associated with continental affinities and highly derived gill morphologies that allow for osmoregulation, sediment filtration, and advanced feeding mechanisms are good indicators of the ability of a clade to invade the continental realm.

ORIGIN AND EVOLUTION OF THE EARLY LAND PLANTS IN ARGENTINA AND SOUTH AMERICA THROUGH THE PALYNOLOGICAL RECORD

Claudia V. Rubinstein[1], Victoria J. García Muro[1] and Philippe Steemans[2]

1. IANIGLA, CCT CONICET Mendoza, A. Ruiz Leal s/n, Parque General San Martín, Mendoza, M5502IRA, Argentina. crubinstein@mendoza-conicet.gob.ar

2. Palaeogeobiology – Palaeobotany – Palaeopalynology, Allée du 6 Août, Bât. B-18, parking 40, University of Liège, Liège 1, B-4000, Belgium.

The first evidence of land plants comes from the Central Andean Basin (CAB) in northwestern Argentina, where a diverse cryptospore assemblage composed of five genera pushes back the beginning of the colonization of continents until *c.* 473-471 Ma. This finding in Dapingian (early Middle Ordovician) rocks of the CAB confirms the first appearance of land plants in Gondwana. From the same locality, low-diversity and commonly poorly-preserved cryptospores were found in Darriwilian and Hirnantian rocks. The non-continuous cryptospore record could be related to the Ordovician foreland basin and particularly to marginal marine deposits with frequent sea level changes. However, in the Precordillera Basin, scarce and low-diversified cryptospores, mainly represented by naked tetrads, have been found in the Sandbian and Katian. It should be noted that these deposits correspond to a tectonically complex paleoenvironment, related to the accretion of the Precordillera terrane to the western Gondwanan margin during the Middle-Late Ordovician. The latest Ordovician CAB deposits, related to the Hirnantian glaciation, yielded one of the most abundant and diversified Ordovician cryptospore assemblages worldwide. To date, palynological data from other Ordovician basins of South America are sparse, and there are no records of land-derived palynomorphs outside Argentina. The oldest record of trilete spores in South America comes from the Hirnatian glacial deposits of the CAB and is represented by the *Ambitisporites avitus-dilutus* Morphon. Surprisingly, no trilete spores were found in the Lower Silurian (Llandovery) of Argentina, neither in the CAB nor in the Precordillera. Meanwhile, the *Ambitisporites avitus-dilutus* Morphon first appears in Paraguay, in the late Aeronian of the Parana Basin and the *Archaezonotriletes chulus-nanus* Morphon in Brazil, in the Telychian of the Parnaiba Basin. In the Wenlock of the Precordillera some taxa such as *Archaezonotriletes chulus-nanus* Morphon, *Retusotriletes* sp. and *Emphanisporites* sp. have been recognized while there are no other records of land-derived palynomorphs from the Wenlock of South America. The Late Silurian was a period when the richness and diversity of trilete spore assemblages significantly increased, particularly in the Argentinean Precordillera and the Brazilian Amazon Basin. Among the South American trilete spores, taxa considered as biostratigraphic markers for the Late Silurian-Early Devonian, allow correlation with biozones established for Euramerica, Gondwana and Peri-Gondwanan terranes. Similarities between terrestrial palynomorphs from South America and those from other palaeocontinents and palaeolatitudes, suggest a cosmopolitan distribution for some species of the Late Silurian flora.

EVOLUTION IN PRECAMBRIAN TERRESTRIAL ECOSYSTEMS

Paul K. Strother[1]

1. Boston College, Department of Earth and Environmental Sciences, Weston MA 02493, USA.
strother@bc.edu

Most evidence of life on land during the Precambrian comes from geochemical studies, but two geological deposits, the Nonesuch Shale (Michigan, USA) and the Torridonian Sequence (Scotland), provide direct evidence of the organisms that inhabited non-marine habitats approximately 1 Ga ago. These are lacustrine ecosystems which contain some cyanobacteria, including species whose colonial habit mimics that of *Microcystis aeruginosa*, but which otherwise appear to be dominated by unicellular eukaryotic remains. Individual cells can be quite large, and multicellular forms are scarce. Morphological asymmetry in cell form, including attachment features, indicates that protists had adapted to benthic settings. Rare, small dorsiventral thalli could be the remains of early amphibious gametophytes, although this would considerably pre-date the origin of true land plants. The occurrence of *Moyeria cabotti*, which is clearly euglenoid in character, establishes that the supergroup Excavata is ancient. Specimens of *Moyeria* showing whorl reduction were probably photosynthetic, so their presence is indirect evidence of the prior origin of the green algae by this time. Multicellular balls of cells appear to be related to the opisthokants, establishing a Mesoproterozoic origin to this clade as well. Ecologically it is not possible to rule out that cyanobacteria were still the primary producers at 1 Ga. The direct evidence of photosynthetic algae is by inference only – there are no unique morphologies that establish the photosynthetic nature of many of these eukaryotic microfossils. Given a wide range of unicellular morphotypes however, one would assume that a fair proportion of the microfossils recovered from these deposits would have been primary producers, i.e. algae. Indeed, the number of morphotypes recovered from these deposits far exceeds that found in coeval marine settings. This leads to the conclusion that non-marine settings provided a refuge for eukaryotes during the 1800 to 800 Ma period of oceanic anoxia dictated by geobiological studies. In addition, habitat heterogeneity associated with non-marine settings, may have been an important selective driver of speciation during this time. At the very least, the fossil record of terrestrial settings at the Meso-Neoproterozoic boundary supports recent phylogenomic studies suggesting a terrestrial origin to the primary endosymbiotic acquisition of the chloroplast.

THE ROLE OF FUNGI IN EARLY TERRESTRIAL ECOSYSTEMS

Christine Strullu-Derrien[1] and Paul Kenrick[1]

1. Department of Earth Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK. c.strullu-derrien@nhm.ac.uk

Fungi were of key importance to the early evolution of life on land, yet direct fossil evidence of plant fungal interactions and fungal diversity in general is still very limited. We are investigating the evolution of this relationship through re-examination of historic slide collections of petrified plants and through the analysis of new materials, focussing on the Devonian and Carboniferous Periods. One key aim is to understand the contribution of plant-fungal relations to the evolution of forest ecosystems. Our general approach is therefore to compare and contrast the nature of these relations in pre- and post-arborescence ecosystems. One of the few well-studied early fossil fungi sites is the Lower Devonian (ca 407 Ma) Rhynie Chert (Scotland, UK), which preserves in exquisite detail the remains of an early terrestrial herbaceous biota. Documented fungi include species assignable to Chytridiomycota, Blastocladiomycota, Zygomycota, Glomeromycota, Ascomycota and most recently Mucoromycotina. We are using a suite of methods, including Confocal Laser Scanning Microscopy, to further explore fungal diversity. I will provide a brief overview of fungal diversity and interactions with plants in early terrestrial ecosystems, including results of our recent research on the Rhynie Chert and the roots of late Middle Devonian trees. We are documenting new fungal endobionts of plant axes and rooting systems, including the first fossil evidence of Mucoromycotina, which are a major living basal clade of true fungi that have recently been shown to form symbiotic relations with some modern bryophytes.

A REVIEW OF OUR CURRENT UNDERSTANDING OF LOWER PALEOZOIC LAND DERIVED PALYNOMORPHS USING FOSSIL AND ACTUALISTIC APPROACHES

Wilson A. Taylor[1]

1. University of Wisconsin-Eau Claire, Eau Claire, Wisconsin, 54701, USA.
taylorwa@uwec.edu

Forty years ago, debates on the colonization of the land surface focused on identifying the timing of the move to land by plants, and the resultant acquisition of traits associated with extant primitive vascular plants. First estimates of this event were placed at about the Silurian-Devonian boundary. With the recognition, naming, and increasing investigation of "cryptospores" through the 1980s and 1990s, the picture became more complicated, and more interesting. The time line expanded to include the Ordovician and Silurian, but some uncertainty remained about the nature of the parent plants. Once charcoalified axes were discovered that contain many of the categories of cryptospores, their link to embryophytes was confirmed. Increased scrutiny of lower Paleozoic sediments uncovered remains that diverge from the "normal" cryptospores. Cambrian assemblages contain some specimens that are clearly dyads and tetrads, but also irregular forms, leading some to question their affinity with younger embryophytes. In truth, it is to be expected that gradual evolution will produce just such a pattern in the fossil record. It is less important that the specimens be assigned to a specific group (i.e., algae or embryophytes) than to fully document what did occur, when and where. Toward this end, two concerted approaches have been taken: first, thorough analysis of individual assemblages, including wall ultrastructure using transmission electron microscopy (TEM); and second, simulated fossilization studies (using acetolysis as a screen for resistant wall compounds) of extant organisms, in order to identify potential candidates for having produced some of the enigmatic remains in the fossil assemblages. With respect to the first approach, various types of laminated walls figure prominently in Cambrian specimens, in contrast to thicker, homogeneous walls that are more common in younger trilete spores, and those of many primitive extant land plants (except the liverworts). Whether this reflects any sort of phylogenetic association with the liverworts is very much in debate, and may never be determined given the lack of preservable tissues in those organisms today (and presumably in the past). With respect to the second approach, various extant algal groups produce remains that survive acetolysis. At least one highly desiccation tolerant green alga – *Protosiphon* – has a wall ultrastructure that consists of one or two lamella. Another normally aquatic alga – *Coleochaete* – produces vegetative thalli when grown subaerially that have a multilamellated wall ultrastructure. Together, these results contribute to an emerging picture of the gradual acquisition of embryophtye characters throughout the lower Paleozoic.

QUANTIFYING THE ADAPTIVE RADIATION OF EARLY LAND PLANTS

Charles H. Wellman[1]

1. Dept. of Animal and Plant Sciences, University of Sheffield, Alfred Denny Building, Western Bank, Sheffield S10 2TN, UK.
c.wellman@sheffield.ac.uk

The Silurian-Devonian adaptive radiation of land plants has been likened to the Cambrian explosion of animal life. Following the origin of land plants, most likely in the Mid Ordovician, there was 40 million years of apparent stasis, as evidenced by the dispersed cryptospore fossil record. Then land plants began to rapidly diversify as witnessed by the explosive radiation in the diversity and disparity of both dispersed spores/pollen and plant megafossils. By the end of the Devonian all of the major land plant groups had appeared (except the angiosperms), maximum plant stature had increased from a few millimetres to trees tens of metres in height, and palaeophytogeographical differentiation was well established. This adaptive radiation is often portrayed as a rapid diversification fuelled by invasion of new habitats and experimentation with new ecologies as: (i) the evolution of progressively more sophisticated reproductive strategies negated reliance on free water for reproduction; (ii) morphological innovations were explored, including those associated with an increase in maximum stature (above and below ground) as plants competed for sunlight, space and access to air currents vital for dispersal of reproductive propagules. This talk will analyse the early land plant fossil record in terms of: (i) apparent patterns of diversity, disparity and palaeophytogeographic differentiation as measured using standard palaeobiological techniques; (ii) potential biases in the fossil record (particularly those related to variations in the amount of continental strata deposited at any given time). In particular I will analyse patterns of origination/extinction based on individual taxon duration and Assemblage Biozone duration as a proxy for lifespan of floral 'ecological assemblages'.

STRATIGRAPHY AND DEPOSITIONAL SETTINGS OF THE LATE FAMENNIAN IN SOUTHERN BELGIUM – A SNAPSHOT OF THE PALEOENVIRONMENTS FOR LATE DEVONIAN TETRAPODS AND ARTHROPODS

Julien Denayer[1,2], Cyrille Prestianni[1,3], Pierre Guerau[4,5], Sébastien Olive[1,3] and Gaël Clément[4]

1. Service de Paléontologie animale et humaine, Département de Géologie, Université de Liège, Allée du Six-Août, B18, Sart Tilman, Liège, B4000, Belgium. julien.denayer@ulg.ac.be
2. School of Earth Science, the University of Queensland, St-Lucia, QLD 4068, Australia.
3. Palaeontology Department, Earth and Life History O.D., Royal Belgian Institute of Natural Sciences, 29 Rue Vautier, Brussels B1000, Belgium.
4. CR2P, UMR 7207 CNRS/MNHN/UPMC-Paris 6, MNHN, CP 38, 57 rue Cuvier, F75231 Paris cedex 05, France.
5. IPANEMA, USR 3461 CNRS/MCC, BP48 Saint-Aubin, F91192 Gif-sur-Yvette, France.

The Belgian Famennian recently received much attention after the discoveries of *Ichthyostega*-like tetrapod remains and outstandingly preserved continental arthropods. The Strud locality has yielded a diverse flora and fauna including seed-plants, tetrapods, various placoderm, actinopterygian, acanthodian and sarcopterygian fishes, crustaceans (decapods, conchostracans, notostracans and anostracans) and a putative complete insect. Most of the fossils are currently under examination but the assemblage is one of the oldest continental, probably fresh-water ecosystems recording such a vertebrate and invertebrate diversity. The study of the paleoenvironment of the Strud Lagerstätte is thus primordial because it took place during the earliest phase of tetrapod evolution (i.e. after their emergence and before their terrestrialisation). It raises the question of the environmental and ecological conditions for Devonian aquatic settings and of selection pressures occurring at the onset of terrestrialisation.This study characterized the fluvial facies of the late Famennian of Strud and surrounding area. The exceptional preservation of arthropods and plants in the main fossiliferous layers is explained by quick burial in fine-grained sediment of the calm and confined floodplain environment. Moreover, the correlation of the investigated sections allowed a review of the age of the fossiliferous horizon, which is now confirmed as Late Famennian.

THE ENIGMATIC PALYNOMORPH *TORTOTUBUS PROTUBERANS* FROM THE LATEST ORDOVICIAN–EARLY SILURIAN: A POSSIBLE LAND-DERIVED PLANT FRAGMENT IN NEARSHORE DEPOSITIONAL ENVIRONMENTS

Bindra Thusu[1,2], Florentin Paris[3], Syed Rasul[1], Guido Meinhold[4], Graham Booth[5], Gil Machado[5], Yousef Abutarruma[6] and Andrew Whitham[2]

1. Maghreb Petroleum Research Group, Department of Earth Sciences, University College London, Gower Street, London WC1E 6BT, UK. bindraban.thusu@gmail.com
2. CASP, University of Cambridge, 181A Huntingdon Road, CB3 0DH Cambridge, UK.
3. Rue des Jonquilles, 35235 Thorigné-Fouillard, France; Géosciences Rennes, CNRS UMR 6118, Université de Rennes 1, Rennes cedex, France.
4. Geowissenschaftliches Zentrum der Universität Göttingen, Abteilung Sedimentologie, Goldschmidtstr. 3, 37077 Göttingen, Germany.
5. Petroleum Development Oman (PDO), MAF camp P.O. Box 81, Muscat 100, Oman.
6. Mellitah Oil & Gas B.V., Dat Al Imad Complex Tower 5 Floor 13, P.O. Box 91651, Tripoli, Libya.

Tortotubus protuberans was first described from the Silurian (Llandovery) near Mill Hall in Pennsylvania, USA Since then it has been described from a number of northern Gondwana localities (Chad, Libya, Oman, Saudi Arabia) and Laurentia ranging in age from latest Ordovician to Silurian. *T. protuberans* occurs as tubular organic structures believed to derive from nematophytes – a group of probable land plants of uncertain affinities. Tubular organic structures comparable to *T. protuberans* have been reported from drill cores from shallow boreholes in the eastern Kufra Basin of southeastern Libya and in the southwestern Kufra Basin in northern Chad in uppermost Hirnantian or lowermost Rhuddanian sedimentary strata. In this study, *T. protuberans* fragments up to 1 mm long were recovered for SEM analysis by moderate acid treatment with HCl and HF without bleaching and centrifugation. The resulting organic residue was sieved through a 50-micron sieve, and *T. protuberans* was then hand-picked with a glass micropipette from a watch glass filled with distilled water. In Libya, *T. protuberans* has a wide geographical distribution. In addition to the reported presence in the Kufra Basin, it is reported in well A1-46 in the Cyrenaica Platform and in wells A1-81 and I1C-81 in the Quattara Graben and well E1-81 in the Dalma High in the southern Cyrenaica Platform, eastern Libya. In these localities, *T. protuberans* is associated with cryptospores, *Tasmanites* sp., scolecodonts, acritarchs, chitinozoans and remains of eurypterids. In the Llandovery of central Pennsylvania, it is associated with an abundant and predominantly land-derived palynoflora. The cryptospore–*Tortotubus* association observed in several, geographically separated basins may suggest that both palynomorphs may be outwash, land-derived plant debris deposited in nearshore sedimentary environments. In conclusion, *T. protuberans* shows a wide geographical distribution but seems to be restricted to marginal marine (nearshore) environments in close proximity to the shoreline. Therefore, it may be useful as an environmental indicator. Its presence in Lower Paleozoic nearshore shales in North Africa may be accompanied by diminished source rock potential as recorded in the examined cores from the Kufra Basin. It is interesting to note that the occurrence of *T. protuberans* and cryptospores in the stratigraphic record coincides with the evolutionary period of early land plants in the latest Ordovician to earliest Silurian. These observations encourage future studies.

SYMPOSIUM

EVOLUTION OF EARLY ANGIOSPERMS

ORGANIZERS:

ALEJANDRA GANDOLFO - KEVIN C. NIXON

GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTIONS OF THE SANTONIAN-PALEOCENE TRIPROJECTATE POLLEN (EASTERN ASIA)

Eugenia V. Bugdaeva[1] and Valentina S. Markevich[1]

1. Institute of Biology and Soil Science FEBRAS, 159, Prosp. 100-letiya, Vladivostok, 690022, Russia.
bugdaeva@biosoil.ru

During the Late Cretaceous *Triprojectacites* Mtchedlishvili, a group of now-extinct fossil pollen, appeared. The plants that produced triprojectates apparently spread from the then-contiguous Siberia-western North America landmass (an area referred to as the *Aquilapollenites* province) since the Santonian. Triprojectates represent a group of parent angiospermous plants of unknown affinities. Their pollen shows unusual bizarre morphology: three equatorial projections containing all or part of the purported germinal apertures and as many as two polar projections. Triprojectate pollen appeared in the geological record of Asia and North America in the Turonian, reached its peak in the Maastrichtian, and then step-by-step became extinct. The findings of these palynomorphs are very rare in the Paleogene deposits. Based on our material, including more than 7000 palynological samples, we have retraced its geographical and taxonomical distribution from the Santonian to the Danian of the Amur River region, North-East Russia, Primorye region, Sakhalin Island and Kuril Islands. The high taxonomical diversity of the Late Cretaceous-Danian palynofloras of this vast region was revealed. These palynofloras were mainly dominated by ferns and Pinaceae and Taxodiaceae. The percentage of triprojectate pollen in the palynological assemblages is usually not great, but it is a constant constituent. This palynoflora included more than 50 species of the genera *Aquilapollenites, Pseudoaquilapollenites, Parviprojectus, Triprojectus, Mancicorpus, Integricorpus, Pseudointegricorpus, Pentapollenites, Fibulapollis,* and *Duplosporis*. In intracontinental basins (Zeya-Bureya Basin, Songliao Basin) triprojectate pollen appeared in the Santonian (13 species). Its diversity rose culminating in the late Maastrichtian (43 species) and sharply declined in the Danian. In the regions of active volcanism (Primorye region, Sakhalin Island, Central Japan) this pollen type appeared in the Santonian (6 species), reaching acme in the middle Maastrichtian (35 species). At the end of the Maastrichtian only 26 are present, at the early Danian - 8, and at the late Danian - 3. It should be noted that along with lesser taxonomical diversity the quantity of triprojectate pollen in the palynospectra is higher; its percentage can be more 80%. In marine and shoreline sediments (Sakhalin Island, Kuril Islands, Hokkaido Island) the number of triprojectate pollen decreased, and its diversity was low: the Coniacian - 1 species, the Santonian - 5, the Campanian and lower Maastrichtian - 15, middle and late Maastrichtian -12, and Danian -10. Paleoecological analysis revealed that plants produced triprojectate pollen constituted slope plant communities.

ENDURING ISSUES IN ASSESSING ANGIOSPERM ORIGINS

William L. Crepet[1] and Kevin C. Nixon[1]

1. L. H. Bailey Hortorium and Department of Plant Biology, Cornell University, Ithaca, NY 14853, USA.
wlc1@cornell.edu

Questions surrounding angiosperm origin persist among the most durable and fascinating of evolutionary mysteries in spite of new fossil discoveries, advances in analytical methodologies, molecular genetics, and imaging techniques. Homology determination remains at the core of the mystery. Defining angiosperms precisely on the basis of structure alone is problematical. While angiosperms are often defined by core morphological/anatomical features, they overlap with other taxa in suites of characters that are typical but not exclusive to them, clouding the boundary of what constitutes an angiosperm structurally. Even within core angiospermous characters there are complexities. Such issues make interpreting fossil evidence particularly difficult in the absence of unequivocal mosaics that might illuminate angiosperm ancestry. In their absence, prominent members of the field of palaeobotany have debated angiosperm relationships since early in the 20th century. There are two principal components to this debate: the search for angiosperm taxa (fossil and extant), that might retain ancestral characters that reveal possible angiosperm sister groups; and the search for gymnosperms (fossil or extant), that might have characters linking them to the angiosperms. Since the early 20th Century, the search for gymnospermous mosaics has focused on artificial assemblages of plants variously known as “anthophytes”. While an “anthophyte” clade has been resolved in virtually all structurally based hypotheses of phylogeny, the component groups vary greatly, and the advent of molecular systematics has challenged the integrity of this clade by indicating that certain structural commonalities among anthophytes appear to be parallel developments. At the same time, recent analyses of the bennettitalean-cycad relationship raise questions about the integrity of anthophytes from a purely structural perspective, while yet other structural analyses featuring seed characters of the Erdtmanithecales suggest homologies that would link Gnetales and Bennettitales; a result that is ambiguous with respect to angiosperm origins given the context provided by molecular genetics-based analyses. New analyses based largely on molecular genetics suggest basal angiosperms had smaller, simpler flowers than previously thought. However the growing consensus on likely “basal” angiosperm taxa has not yet provided obvious links to non-angiospermous seed plants, while the implications and phylogenetic position of the interesting fossil angiosperm *Archaefructus* has been vigorously debated in spite of the fact that it too fails to link angiosperms to non-angiospermous seed plants. We take stock of the status of the mystery and review the significance of hypotheses in identifying potential angiosperm outgroups.

PHYLOGENETIC ANALYSES OF EARLY CRETACEOUS FOSSILS RELATED TO CHLORANTHACEAE AND THEIR EVOLUTIONARY IMPLICATIONS

James A. Doyle[1] and Peter K. Endress[2]

1. Department of Evolution and Ecology, University of California, Davis, CA 95616, USA.
jadoyle@ucdavis.edu
2. Institute of Systematic Botany, University of Zurich, 8008 Zurich, Switzerland.

Since Couper compared Wealden *Clavatipollenites* with pollen of modern *Ascarina*, much fossil evidence has accumulated that Chloranthaceae were one of the most important lines during the initial radiation of angiosperms. By excluding Chloranthaceae from the basal ANITA grade, molecular data have refuted speculation that their unusually simple flowers are primitive, but their position among the remaining angiosperms is unresolved. We evaluated the phylogenetic relationships and evolutionary implications of published Early Cretaceous and Cenomanian chloranthoid mesofossils by adding fossil taxa individually or together to backbone trees of living angiosperms in which the sister group of Chloranthaceae is either Magnoliidae or *Ceratophyllum*, the main alternatives observed in molecular and morphological analyses. Ironically, chloranthaceous affinities of the first mesofossils to be associated with *Clavatipollenites*-type pollen, Cenomanian fruits called *Couperites*, which contain a single anatropous ovule, are uncertain; they may be crown group Chloranthaceae, stem relatives of the family, or not directly related. Albian plants that produced *Asteropollis* pollen (with a several-branched sulcus), which had female flowers with one carpel and three adnate tepals and male flowers consisting of one stamen, were nested in crown group Chloranthaceae, with *Hedyosmum*. *Canrightia* was a stem relative of Chloranthaceae (with or without *Ceratophyllum*) that illustrates an intermediate stage in floral reduction, with bisexual flowers with several carpels and stamens but a perianth reduced to one whorl. *Zlatkocarpus* (Cenomanian), which had female flowers with a reduced perianth, may be sister to *Ascarina*, *Sarcandra*, and *Chloranthus*, or a stem relative of Chloranthaceae plus *Ceratophyllum*. Plants that produced reticulate-noncolumellar *Pennipollis* pollen (Aptian and Albian) have been interpreted as monocots, but they are more likely stem relatives of Chloranthaceae and/or *Ceratophyllum*. Albian *Appomattoxia* fruits, associated with continuous-tectate *Tucanopollis* pollen, may be either near the base of the ANITA grade or related to Chloranthaceae and/or *Ceratophyllum*. These results clarify scenarios for floral evolution, indicating that a shift to unisexual flowers with one carpel and one stamen occurred before loss of the perianth, and that the peculiar bisexual flowers of *Sarcandra* and *Chloranthus* represent a later reversal. Many uncertainties could be resolved with evidence on the floral organization of taxa known as isolated stamens and carpels, while association with vegetative organs could test the possibility that some of these fossils were links between terrestrial ancestors of Chloranthaceae and aquatic *Ceratophyllum*.

AN UPDATED COMPREHENSIVE STUDY OF CRETACEOUS-PALEOGENE ANGIOSPERMS FROM ARGENTINA

María A. Gandolfo[1], María C. Zamaloa[2], Ana Archangelsky[3], Sergio Archangelsky[3], Viviana Barreda[3], N. Rubén Cúneo[4], Elizabeth J. Hermsen[5], Ari Iglesias[6], Magdalena Llorens[7], Paula L. Narvaez[8], Mauro G. Passalia[6], Valeria Pérez Loinaze[3], Leticia Povilauskas[9], Mercedes B. Prámparo[8], G. Griselda Puebla[8], Mirta Quattrocchio[10], Edgardo J. Romero[3], Patricia Vallati[11] and Peter Wilf[12]

1. L.H. Bailey Hortorium, Department of Plant Biology, Cornell Un1viersity, Ithaca, NY 14853, USA. MAG4@cornell.edu
2. Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires. Intendente Güiraldes 2620, C1428EHA Buenos Aires, Argentina.
3. Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Av. Angel Gallardo 470, C1405DJR Buenos Aires, Argentina.
4. Museo Paleotológico Egidio Feruglio, Av. Fontana 140, Trelew, C9100, Chubut, Argentina.
5. Department of Environmental and PlantBiology, Ohio University, Athens, OH 45701, USA.
6. Instituto de Investigaciones en Biodiversidad y Medioambiente, Universidad Nacional del Comahue-CONICET. Quintral 1250, S.C. de Bariloche, C8400, Río Negro, Argentina.
7. Comisión Nacional de Energía Atómica, Regional Patagonia, 26 de Noviembre s/n. C9100 Trelew, Chubut, Argentina.
8. Centro Regional de Investigaciones Científicas y Tecnológicas, Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, Adrián Ruiz Leal s/n, Casilla Correo 131, C5500, Mendoza, Argentina.
9. División Paleobotánica, Facultad de Ciencias Naturales y Museo,Universidad Nacional de La Plata, Paseo del Bosque s/n. C1900, La Plata, Buenos Aires, Argentina.
10. Universidad Nacional del Sur, INGEOSUR- Departamento de Geología, San Juan 670. GCS Argentina, Haití 123, C8000, Bahía Blanca, Argentina.
11. Departamento de Geología, Facultad de Ciencias Naturales, Universidad Nacional de la Patagonia San Juan Bosco, Ruta Prov. No 1 S/N km 4, C9000 Comodoro Rivadavia, Chubut, Argentina.
12. Department of Geosciences, Pennsylvania State University, University Park, PA 16802, USA.

Today, the angiosperms constitute the largest clade of seed plants with more than 300,000 species worldwide distributed. They are found on every continent including Antarctica and in all types of terrestrial and even marine environments. During the last decade and with the advent of molecular biology techniques, major advances have occurred for elucidating their origin and evolution; however, there are still many aspects of their evolutionary life that remain enigmatic. Paleobotanists have long recognized that the plant fossil record is incomplete and therefore biased; nevertheless, it is the only tangible evidence of angiosperm presence throughout time contribution the backbone of information towards our understanding of their origin, life habits, history, radiation and diversification. The majority of data on fossil angiosperms comes from the Northern Hemisphere because it has been intensively studied, whereas the Southern Hemisphere's paleofloras, in contrast, have been understudied and are in generally poorly understood. Nevertheless, sedimentary rocks from Argentina, southern South America offer a wealth of angiosperm floras that are providing critical data for addressing some of those questions. Herein, we present a comprehensive review of the fossil record (pollen grains and plant remains) of the angiosperms that inhabited Argentina from their first appearance during the late Barremian (earliest Early Cretaceous) to the Cretaceous-Paleogene (Danian) boundary. Data were gathered from 24 formations outcropping in Salta, Mendoza and San Luis provinces, and Patagonia. This review covers micro and macrofossil remains, and it consists of a detailed report on the alpha taxonomy with the major goal of identifying: 1- what taxonomical groups (based on APGIII) were dominant at what times, 2- the development (components) of plant communities, and 3- an interpretation of the environments in which they lived. The angiosperm fossil record of Argentina indicates that members of the ANITA grade, Chloranthales, and several monocots were already present during the Aptian-Albian; by the Cenomanian to the Campanian, the monocots, the eudicots (including members of the core eudicots) and the rosids (rosid I and II) became more diverse and similar to extant genera, while clearly by the Paleocene the asterids are already members of the paleocommunities.

MACROFLORAS IN THE AUSTRAL BASIN, ARGENTINA: A COMPLETE RECORD OF LATE-CRETACEOUS ANGIOSPERMS

Ari Iglesias[1], Augusto N. Varela[2], Daniel G. Poiré[2], Mariel S. Luengo[3], Sebastián M. Richiano[2] and Patricio E. Santamarina[4]

1. Instituto de Investigaciones en Biodiversidad y Medioambiente INIBIOMA-CONICET, Quintral 1250, San Carlos de Bariloche, 8400, Argentina. ari_iglesias@yahoo.com.ar
2. Centro de Investigaciones Geológicas, Universidad Nacional de La Plata-CONICET, Calle 1 n° 644, La Plata, 1900, Argentina.
3. Facultad de Ciencias Naturales y Museo, Universidad de La Plata, La Plata, 1900, Argentina.
4. Museo Argentino de Ciencias Naturales MACN-CONICET, Av. Angel Gallardo 470, Buenos Aires, C1405DJR, Argentina.

We found several new and historical fossil localities in mid-Cretaceous littoral and continental sediments in northern Austral Basin, Santa Cruz Province, Southern Patagonia. Four localities comprise a new flora at the highest levels of Piedra Clavada Formation (Albian), where ferns and conifers are the megaflora dominant. The upper fossiliferous level in this unit shows an unusual diversity of thirteen angiosperms leaf forms. The age of Piedra Clavada Formation based on ammonoids and pollen is lower Albian. The above unit, the Mata Amarilla Formation, has been dated by zircons in 96.23 ± 0.71My, constraining the unit to the Cenomanian. Fifteen leaf angiosperm morphotypes has been recorded in several fossiliferous levels, few of them found across the Albian-Cenomanian. Podocarps have dominated the forest canopy, and petrified trees preserved in life position in a huge forced regression surface at the Mata Amarilla Formation allow a more complete reconstruction of the forest structure. Taxodiaceae and Araucariaceae were also recorded on higher fossiliferous levels. Angiosperms seem to occupy the forest understory and over banks with mostly small flowers and winged seeds. Several insect injuries in leaves and woods were also noticed. The uppermost littoral-marine unit in the area, La Anita Formation, hosts a complete different megaflora, although the precise age is ambiguous (Coniacian?-Campanian?). Angiosperms are abundant within the lowermost section, but their diversity decreases. A lower Maastrichtian flora was recorded in the continental Cachorro Formation, although the palyno- and megaflora were deposited in a freshwater pond. Most leaf forms correspond to simple broad leaves of entire margin physiognomy correlated with climate interpretations of hydromorphic paleosols (gleysols) previously recorded for the Mata Amarilla Formation. Growth ring analyses on petrified trunks also agree with the paleosols interpretation of a marked seasonality by water supply. Tree ferns, cycads and probable palms also support frost free environments at these middle-high latitudes in southern Patagonia during the mid-Cretaceous. These data strengthen previous hypothesis based on palynofloras and establish a floristic change characterized by a rapid diversification of angiosperms during plant-favorable temperatures and humidity in the Albian-Cenomanian. The study of these floras and the age confirmation, state down that angiosperm diversification and dominance occur early in time at high latitudes in Patagonia.

EVOLUTION OF EARLY ANGIOSPERMS IN THE LATE CRETACEOUS OF CENTRAL EUROPE

Jiří Kvaček [1]

1. National Museum, Prague, Václavské nám. 68, Praha 1, 115 79, Czech Republic.
jiri.kvacek@nm.cz

Late Cretaceous sedimentary basins in Central Europe provide a window to Cenomanian - Campanian terrestrial palaeoenvironments dominated by angiosperms. Number of the Late Cretaceous angiosperms has recent representatives in the families Chloranthaceae, Lauraceae and Platanaceae, others belong to extinct lineages. One of them is a fossil herbaceous plant *Pseudoasterophyllites cretaceus*. Its thick linear leaves have an opposite-decussate phyllotaxis. Female structure consists of an elongate, unilocular carpel, borne singly, containing a single orthotropous ovule of the *Spermatites* type. Preliminary phylogenetic analyses indicate that *Pseudoasterophyllites cretaceus* is related to the Chloranthaceae-*Ceratophyllum* clade. The family Chloranthaceae is represented by the genus *Zlatkocarpus* consisting of two species *Z. pragensis* and *Z. brnikensis*. They show spikes with helically arranged unicarpellate and unilocular fruits. Each fruit contains a single, orthotropous seed. The fruits are supported at the base by a small floral cup and a bract. Pollen grains adhering to stigmatic areas and other surfaces of the fossil are of the *Retimonocolpites* type. The family Lauraceae in Cenomanian underwent fast evolution. It is characterised in the Cretaceous of Central Europe by several genera: *Mauldinia*, *Pragocladus* and *Antocephale*. Inflorescences of *Mauldinia bohemica* consist of distinctly bilobed lateral inflorescence units helically arranged on elongated central axes. The units are dorsi-ventrally flattened and composed of small leaflike scales that are closely attached in a distichous arrangement on each lobe. Flowers are borne in axils of leaflike scales on bilobed ctructures. Flowers are trimerous with two perianth whorls, nine fertile and bivalvate stamens in three whorls, three staminodes and a single carpel. Mid European Cretaceous monocots come mostly from the Campanian of Grünbach (Austria). They are represented by leaves of *Sabalites* (Arecaceae), *Pandanites* (Pandanaceae), *Oronciophyllum* (Araceae). The Platanaceae occur nearly in all Late Cretaceous floras in Central Europe. The family is characterised by female reproductive structures *Friisicarpus* and male reproductive structures *Platananthus*. The male inflorescences are globular with pentamerous flowers with a well-developed perianth and androecium. Each stamen has a short filament and a large wedge-shaped apical extension of its connective. Pollen grains preserved *in situ* are tricolporate with microreticulate sculpture. Platanoid leaves are assigned to the genus *Ettingshausenia*.

RECONSTRUCTING THE GENOME SIZE OF EARLY ANGIOSPERMS

Barry H. Lomax[1], Ian R. A. Smillie[1], Charles A. Knight[1] and Garland R. Upchurch[3]

1. The School of Biosciences, The University of Nottingham, Leicestershire, LE12 5RD, UK. barry.lomax@nottingham.ac.uk
2. Biology Department, California Polytechnic State University, San Luis Obispo, California, USA.
3. Department of Biology, Texas State University San Marcos, Texas, USA.

Darwin in his often quoted letter, dated 22nd July 1879 to JD Hooker remarked that "…*the rapid development, so far as we can judge, of all the higher plants* [angiosperms] *within recent geological times is an abominable mystery*". Today some 130 years later scientists are still grappling with this key question. Recent sequencing work suggest that the angiosperm diversification event was accompanied by successive whole genome duplication events, suggesting that polyploidy may have played an important role in this diversification event. The relationship between cell size and genome size is well known and has been used to reconstruct the palaeogenome size of a range of disparate fossil animal groups. Recent experimental work using *A. thaliana* has shown that the relationship between guard cell length (GCL) and genome size is independent of environment. With GCL showing minimal variation when exposed to a wide range of ecologically and geologically relevant environmental perturbations (e.g. CO_2, drought, UV-B radiation). This presentation will outline how through the integration of fossils and experimental data advances are being made in this area, leading to the reconstruction of angiosperm genome size as they radiated.

A METACALIBRATED DIVERSIFICATION ANALYSIS OF FLOWERING PLANTS

Susana Magallón[1], Luna L. Sánchez Reyes[2], Sandra Gómez Acevedo[1] and Tania Hernández Hernández[3]

1. Instituto de Biología, Universidad Nacional Autonóma de Mexico, 3er Circuito de Ciudad Universitaria, Del. Coyoacan, Mexico City, 04510, Mexico. s.magallon@ib.unam.mx

2. Posgrado en Ciencias Biológicas, Universidad Nacional Autonóma de Mexico, 3er Circuito de Ciudad Universitaria, Del. Coyoacan, Mexico City, 04510, Mexico.

3. Instituto de Ecología, A.C., Biología Evolutiva, Km. 2.5 Carretera Antigua a Coatepec 351, Congregación El Haya, Xalapa, 91070, Mexico.

Flowering plants (Angiospermae) include an extraordinary richness, morphological diversity, and play fundamental structural and trophic roles in modern terrestrial ecosystems. Estimates on the timing of angiosperm diversification are incongruent: molecular estimates are different from each other, and most are substantially older than the Early Cretaceous oldest angiosperms fossils. Angiosperms are characterized by many unique reproductive and vegetative innovations. However, previous works indicate that the clues to angiosperm success do not lie directly on their innovations, but presumably on further elaborations deployed in particular ecological or environmental contexts, which drove independent radiations. A variety of factors have been linked with angiosperm diversity, including intrinsic attributes, ecological interactions, and responses to extrinsic physical conditions. In this study, we investigate angiosperm diversification in the context of a metacalibrated timetree. A maximum likelihood phylogram, derived from sequences of three plastid and two nuclear markers and including placeholders for 87% of angiosperm families, was dated with penalized likelihood and the uncorrelated lognormal method. A thorough literature-based review of the angiosperm fossil record yielded a data base from which fossils that reliably represent the oldest record of well-supported clades were selected, spanning from genera to orders. The selected fossils were implemented as conservative minimum age constraints to particular nodes in the tree. The angiosperm crown age was bound within a 95% confidence interval obtained with a method derived from quantitative paleobiology that considers the age of the oldest fossil of the group, and the number of branches in the phylogeny that occur in the fossil record. The two relaxed clock methods yielded similar ages across the tree, but those from penalized likelihood are usually older. There is greater age variability in regions of the tree where calibration density is low. The origins of angiosperm families span from the Hauterivian (Early Cretaceous) to the Miocene (Neogene), with peaks in the Cenomanian, Campanian, Paleocene and Early Eocene. Based on the timetree, we conducted a diversification analysis to identify significant diversification shifts across angiosperms, with their estimated rates of diversification and turnover. Our results explicitly document that extant angiosperm species-richness and its distribution is the product of several non-synchronous radiations and depletions in independent lineages, which responded to different diversification dynamics in terms of the underlying rates speciation and extinction; and are associated with a variety of potential intrinsic, ecological and extrinsic drivers.

EARLY AQUATIC ANGIOSPERMS AND THE MYSTERY OF *CERATOPHYLLUM*

Kevin C. Nixon[1] and William L. Crepet[1]

1. Department of Plant Biology, Cornell University, Ithaca, 14853, USA.
kcn2@cornell.edu

Most recent molecular analyses of seed plant phylogeny place the extant aquatic Nymphaeales clade as one of the first divergences relative to the remainder of angiosperms. These analyses variously show a pattern of ((*Amborella* (Nymphaeales Other angiosperms)) or sometimes ((Nymphaeales *Amborella*) (Other Angiosperms)). An intriguing development is the occurrence of early angiosperm fossils that are clearly aquatic from the Lower Cretaceous of China including *Archaefructus* (ca. 125 mybp). Although the affinities of *Archaefructus* have been contested, it has no perianth associated with the carpels or stamens, which are associated on an erect, obviously emergent axis, with dichotomously divided/veined leaves. However, another aquatic modern angiosperm, *Ceratophyllum*, has been variously placed within different molecular analyses, originally as sister to all angiosperms (rbcL), and variously as a sister to the monocots (using parsimony with numerous genes) or as a sister to all eudicots (using maximum likelihood with numerous genes). Fossil fruits possibly related to *Ceratophyllum* (*Donlesia*) have been described from the Lower Cretaceous of Kansas as well as others from the Tertiary of Europe, Asia and North America. The morphology of *Ceratophyllum*, like many other aquatics, has often been interpreted as highly reduced – lacking any secondary growth, without roots, dichotomously divided and openly veined leaves, and flowers (or inflorescences) simplified with a subtending whorl of bracts (or perianth?). Analyses of separate genes with many taxa, with both maximum likelihood and parsimony suggest that the position of *Ceratophyllum* is still uncertain, as reflected in poor support in total evidence analyses, but that it may be placed as a sister taxon to monocots, to eudicots, to magnoliids, or to all other extant angiosperms. In light of this uncertainty, and other evidence that at least some of the most primitive angiosperms may have been aquatic, it is premature to dismiss *Ceratophyllum* as just an isolated, highly reduced aquatic.

SYMPOSIUM

ACTUALISTIC PALAEONTOLOGY: USING THE PRESENT TO STUDY THE PAST

ORGANIZERS:

CLAUDIO DE FRANCESCO - MICHAL KOWALEWSKI

LIVE-DEAD AGREEMENT OF TROPICAL BENTHIC MARINE COMMUNITIES IN THE PERSIAN (ARABIAN) GULF

Paolo G. Albano[1], Adam Tomašových[2], Michael Stachowitsch[3], Nadezhda Filippova[1], Jan Steger[1] and Martin Zuschin[1]

1 Department of Palaeontology, University of Vienna, Althanstraße 14, Wien, A-1090, Austria. paolo.albano@univie.ac.at

2 Geological Institute, Slovak Academy of Sciences, Dúbravská cesta 9, P.O. Box 106, Bratislava, SK-840 05, Slovak Republic.

3 Department of Limnology and Bio-Oceanography, Center of Ecology, University of Vienna, Althanstraße 14, Wien, A-1090, Austria.

Live-dead (LD) studies of benthic communities are critical in determining how well a fossil assemblage can reflect the original living community, but can also inform us about the magnitude of recent shifts in ecosystem diversity and composition in marine habitats. Mismatches observed between the richness or species composition of a death assemblage (DA) and the local living assemblage (LA) can be generated by time averaging and by natural post-mortem processes, particularly by interspecific differences in skeletal durability. Recent research, however, suggests that live-dead (LD) agreement is significantly poorer in anthropogenically disturbed settings. This observation reflects the so-called "compositional inertia" of DAs to recent environmental change; i.e., DAs still capture earlier community states not affected by such disturbance. The inertia to changing ecological conditions can be particularly strong under conditions of anthropogenic modification because the rapidity of many human-driven changes is unprecedented in natural systems. Here, we evaluate the agreement between the LA and DA in benthic communities at two major oil fields in the Persian (Arabian) Gulf. This is a basin with intense oil extraction, periodically subject to major oil spills, but also to chronic discharges from extraction infrastructures. In contrast to temperate latitudes, few LD studies were conducted in tropical settings. The assemblages analysed in this study contained 340 molluscan species, exceeding similar-scale studies from the Caribbean. The communities were dominated by bivalves. The semelid *Ervilia purpurea* was remarkably abundant in the DA (mean 40%), but totally absent from the LA. As in other LD studies from tropical habitats, LAs at the scale of single stations contained few individuals and thus did not permit conclusive LD analyses. Ordinations showed that station-scale LAs were highly dissimilar: they were highly overdispersed relative to DAs. However, mean compositions of LAs and DAs overlapped in multivariate space. At the field scale, rarefied species richness and evenness were not higher in the DA, in contrast with the expectation of time-averaging. However, this finding was largely determined by the dominance of *Ervilia purpurea* in DAs that determined the signature of species richness and evenness at the rarefied sample size ($n \approx 250$). The analytical removal of *E. purpurea* led to higher richness and evenness observed in DAs than in LAs at the field scale. The rank-order correlation in species abundance was moderately high (0.40-0.48). Regardless of whether *E. purpurea* was considered, the DAs allowed for the distinction of the two fields, notwithstanding that much β-diversity was lost.

COASTAL ECOSYSTEM CHANGES ASSOCIATED WITH THE 2010 DEEPWATER HORIZON OIL SPILL AND THEIR IMPLICATIONS FOR THE FOSSIL RECORD

Laurie C. Anderson[1], Peter D. Roopnarine[2], Deanne Roopnarine[3], Brian Fry[4] and Annette S. Engel[5]

1. South Dakota School of Mines and Technology, 501 E St. Joseph St., Rapid City, SD 57701, USA. Laurie.Anderson@sdsmt.edu

2. California Academy of Sciences, 55 Music Councourse Dr., San Francisco, CA94118, USA.

3. Nova Southeastern University3301 College Ave., Fort Lauderdale, FL 3314, USA.

4. Griffith University, 170 Kessels Road, Nathan, Brisbane, Queensland 4111, Australia.

5. University of Tennessee, 1412 Circle Dr, Knoxville, TN 37996, USA.

The 2010 Deepwater Horizon (DWH) incident released an estimated 685,000 tons of crude oil into the Gulf of Mexico (GoM) during the summer of 2010, making it the largest accidental oil spill in maritime history. Immediate impacts were evident and included oil slicks, fouled beaches and marshes, and wildlife losses. Longer-term impacts of the spill, and of response efforts that included major freshwater diversions and unprecedented releases of dispersants, are beginning to be detected and are complex. For instance, while microbial diversity in marsh sediments have undergone substantial changes in composition and diversity, planktonic microbial activity in bay waters was not elevated. Further, the link between classic (macro-floral and -faunal) and microbial foodwebs may be inefficient, as natural abundance carbon isotope analyses indicate that filter-feeding invertebrates (*Balanus* sp., *Geukensiademissa*) incorporated only 0.3% oil carbon (near detection limit) into their soft tissues in the 6 months after the spill. Nonetheless, *Crassostrea virginica* exhibits metaplasia (reversible transformations of soft tissues) in ciliated gill and digestive epithelia that likely compromise filter feeding and digestion. These metaplasia have persisted, and compared with geographic controls, the overall condition of GoMsoft tissues were noticeably more flaccid. Further, soft-tissue health has also altered shell growth patterns in *Crassostrea*, leading to lower growth rates and other morphologic anomalies. Therefore, although incorporation of oil-derived carbon does not appear to be driving changes in coastal macro-foodwebs, the toxic effects of the spill and response efforts will have implications for coastal ecosystems that are likely long-term. Such changes are potentially detectable in the historical and fossil record using a suite of morphologic and geochemical proxies, and may elucidate the causes of ecologic disturbances associated with environmental perturbations (i.e., coastal erosion, salinity changes), including those associated with historical spills.

FACULTATIVE DRILLING BEHAVIOR OF *NUCELLA* SPECIES (MURICIDAE) UPON THE THATCHED BARNACLE (*SEMIBALANUS CARIOSUS*) FROM FIELD AND EXPERIMENTAL OBSERVATIONS: CONSEQUENCES FOR THE FOSSIL RECORD OF PREDATION

Fernando M. Archuby[1] and Lindsey R. Leighton[2]

1. Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, Avenida Roca n° 1292, General Roca, 8332, Argentina. farchuby@unrn.edu.ar

2. Earth & Atmospheric Sciences, University of Alberta, T6G 2E3, Edmonton, Alberta, Canada.

Gastropod drilling predation leaves identifiable traces that permit the study of this biotic interaction in the fossil record. Study of these drilling patterns have mainly focused on prey bearing one (gastropods) and two (bivalves, brachiopods) valves, but not on the multiple-plated shells of barnacles. In addition, it is generally accepted that a shell with a complete hole indicates successful predation while incomplete traces are the result of a failed attack. However, it has been shown that some gastropod species can kill without drilling or leaving incomplete holes. To address these issues, we examined the predator-prey relationship between *Nucella* spp. (predator) and the thatched barnacle *Semibalanus cariosus* (prey) using both field sampling of dead shells and experiments. A total of 720 dead shells of *S. cariosus* with complete walls were collected from multiple localities on San Juan Island, Washington State, USA, and examined for drill holes. In addition, three size classes of *S. cariosus* and *Nucella lamellosa* were combined in nine treatments and set in water tables with continuous marine water flow to permit direct observation of drilling patterns and barnacle mortality. Drill holes were described in terms of: plate of occurrence, vertical position on plates and with respect to contact between plates. 9% of the dead shells have drill holes on their wall plates. 53 out of 54 barnacles killed during the experiments were not drilled or the holes they bear are incomplete or failed. *Nucella* species exhibit site selection for drilling in favor of the ventral plates that cover the soft tissues of the barnacles, and of positions below the articulation of aperture plates. Aperture plates are never drilled. Drill holes are rarely complete or functional which indicates that *Nucella* rarely eat *S. cariosus* through the holes, and are thus capable of killing and consuming the barnacles without necessarily drilling. This raises the possibility that *Nucella* species narcotize the barnacle prey by applying a salivary toxin and eat the soft tissues through the aperture. Such a toxin has previously been described for *Nucella haemostoma*. Thus, the record of predation traces in this particular predator-prey system differs markedly from other systems: most of the prey is killed without drilling and the majority of the incomplete drill holes are probably not examples of predator failure, suggesting that complete/incomplete drilling frequencies observed on fossil barnacles may not be indicative of predator success.

STAND, SHED, CREEP OR CRAWL: CRINOID ESCAPE STRATEGIES FROM ECHINOID PREDATION

Tomasz K. Baumiller[1], Forest J. Gahn[2] and Hans Hess[3]

1. Museum of Paleontology, University of Michigan, 1109 Geddes, Ann Arbor, MI 48109, USA. tomaszb@umich.edu
2. Department of Geology, Brigham Young University, Rexburg, ID 83460, USA.
3. Naturhistorisches Museum Basel, Augustinergasse 2, Basel, 4001, Switzerland.

Over the past two decades exploration of the deep-sea has revealed evidence of predator-prey interactions between echinoids and crinoids, including between the cidaroid, *Calocidaris,* and motile isocrinids, and also between the camarodont, *Stenechinus,* and the sessile hyocrinid, *Ptilocrinus.* To further explore the taxonomic breadth of echinoid-crinoid interactions, we conducted aquarium experiments with several taxa of echinoids, including camarodonts and diadematoids, and the most diverse and abundant of extant crinoids, the comatulids. Our results indicate that when presented with comatulid body parts, all of these echinoids will readily consume them. However, when placed in aquaria with live comatulids, the echinoids' apparent predatory attempts typically fail, suggesting that the behavioral repertoire of the highly motile comatulids usually allows them to escape such encounters unharmed. Since the stalkless condition of comatulids is derived, and their early Mesozoic ancestor was stalked, it is worth asking whether stalked crinoids were subject to echinoid predation in the Mesozoic. Echinoid-like bite marks on crinoid elements from the Jurassic have been previously reported, but it is uncertain whether those represent ingestion of shed or dead body parts, or the consumption of living animals. Echinoid predation on live, intact crinoids is illustrated by a well-preserved articulated cup and brachials of the robustly-stalked Jurassic *Apiocrinites roissyanus* showing scratches matching the teeth of the echinothuroid, *Pelanechinus corallinus*, found in close proximity. In light of the fossil data, deep-sea observations, and aquarium experiments with echinoids and comatulids, predation by echinoids on crinoids extends well into the Mesozoic and appears to have been taxonomically broad. Sessile crinoids, such as the modern *Ptilocrinus,* would be especially vulnerable because predators may target their crowns. Various crinoid escape strategies, ranging from least to most effective, may include the thickening of the root structure, as in *Apiocrinites roissyanus;* shedding of distal stalk elements and limited creeping ability, as in isocrinids; and permanent loss of the stalk and well-developed crawling and/or swimming, as in comatulids.

TOWARDS AN UNDERSTANDING OF FOSSILIZATION PROCESSES IN FRESHWATER ENVIRONMENTS: COMPARING MOLLUSK LIFE, DEATH, AND FOSSIL ASSEMBLAGES IN PAMPEAN SHALLOW LAKES

Claudio G. De Francesco[1], Eleonor Tietze[1] and Paula A. Cristini[1]

1. Instituto de Investigaciones Marinas y Costeras (IIMyC), Consejo Nacional de Investigaciones Científicas y Técnicas - Universidad Nacional de Mar del Plata, Juan B. Justo 2550, Mar del Plata, B7608FBY, Argentina. cgdefra@mdp.edu.ar

The development of taphonomic studies in freshwater environments has been scarce and restricted to certain regions of the globe (mainly the Northern Hemisphere), which has largely prevented the understanding of how the freshwater fossil record forms and how it differs when compared to other records that have been more extensively studied (marine, estuarine). We present here a detailed comparison of the composition, abundance, and preservation of live, dead, and fossil mollusk samples in freshwater shallow lakes of the southeastern Argentinean Pampas. Live-dead comparisons were conducted in four shallow lakes on a seasonal basis, during one year. Additionally, the taphonomic signature of death assemblages was analyzed. A sedimentary core, recovered from the deepest point of one of these lakes, was used to compare modern data with fossil assemblages. Results indicated that death assemblages reflected the richness, evenness, and relative abundance of living species, and exhibited variations due to local environmental conditions (salinity, hardness, productivity). The main process affecting shell surface was dissolution, as indicated by the granular texture and chalky appearance of shells. Slight differences in preservation were recorded between thin- and thick-shelled species, mainly attributed to the higher influence of dissolution on thinner shells. Fossil assemblages (since circa 6000 cal. years B.P.) preserved the rank-order of abundance of the dominant species, but exhibited live-fossil discordance in brackish species. Fragmentation and surface alteration were lower between 6000 and circa 700 cal. years B.P. in coincidence with the development of brackish-water conditions. After the modern-style freshwater environments were established (circa 700 cal. years B.P.), shells became increasingly affected by dissolution and fragmentation, reaching modern-level poor preservation values towards the top of the core. This strongly suggests that mollusk preservation has varied during the Holocene in relation to fluctuations in productivity and salinity, being favored under brackish-water low-productivity conditions. The increased biological activity and low carbonate concentration, together with the shallow nature and associated wind reworking characteristic of these lakes act against mollusk preservation by enhancing shell dissolution and fragmentation. Because water bodies developed before 700 years B.P. were characterized by significantly higher salinities and very low productivity regimes, their depositional conditions contrast with those of modern lakes, highlighting the need for expanding actualistic studies to cover a wider range of taphonomic conditions.

QUANTITATIVE ENVIRONMENTAL INTERPRETATION BASED ON DAMAGE PROFILE OF RECENT MOLLUSCAN ASSEMBLAGES FROM BRAZIL CONTINENTAL SHELF

Fernando Erthal[1], Carla B. Kotzian[2] and João C. Coimbra[1]

1. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Cx. P. 15001, Porto Alegre, Rio Grande do Sul, 91501-970, Brazil. fer.erthal@gmail.com

2. Departamento de Biologia, Centro de Ciências Naturais e Exatas, Universidade Federal de Santa Maria, Av. Roraima, 1000, Camobi, Santa Maria, Rio Grande do Sul, 97119-900, Brazil.

Dead molluscan remains accumulating on the marine sedimentary surface can indicate the environmental factors which control fossil preservation. But the extent to which the environment is responsible for fossilization of skeletal remains can only be quantified by studying modern assemblages. Few actualistic studies i) focus on mesh sizes lower than 4 mm, commonly used in processing subsurface samples, or ii) analyze these relationships using spatial scales larger than local, especially with the explicit purpose of testing environmental factors on local and large scales. In the fossil record, only large-scale environmental gradients can be recovered in certain cases, which is the main reason for evaluating the relationship between modern environmental factors and taphonomic signatures in mollusks. Here, we determine degree to which the variation in environmental factors (salinity, temperature, current velocity, sediment granulometry and composition), usually observed at local scales, influences the style of taphonomic alteration present in marine molluscan remains, when analyzed at large scales. Most of the studied material was represented by shells from *remaniés* located on the South Brazilian Shelf (SBS), and therefore, the present study also investigated whether modern environmental factors can be deduced from taphonomic profiles of reworked death assemblages. In the SBS, it was found that (i) despite absolute differences, the taphonomic profile of micro and macroclasts does not vary, and that (ii) when the study is conducted at larger spatial scales, up to 60% of variation in the taphonomic profile can be explained by environmental variation. The main environmental factors influencing damage are: i) salinity, which reflects the freshwater input, and ii) the proportion of carbonate in the sediment, which reflects the existence of bioclastic deposits. The proximal bioclastic deposits (south of Lagoa dos Patos outflow) were affected by relatively more extensive dissolution and physical reworking, while the distal bioclastic deposits (located within the bathymetric range from 100 to 200 m) displayed a relatively higher quality of preservation. Furthermore, it was also possible to determine that color alteration in bioclasts from SBS (a ubiquitous feature in samples associated with gravel and carbonate) is significantly linked to sediment redox status. The analysis conducted at large spatial scale, including material from the Northeastern Brazilian Shelf, indicated that depth, an environmental factor significant in influencing taphonomic damage in PSB, was less important at coarser geographic scale, where current velocity, salinity and sedimentary carbonate became the main controlling factors. These environmental factors reflect the influence of different water masses (North Brazilian Current vs. Malvinas Current) and different sedimentary regimes (relict siliciclastics vs. modern carbonates).

EXPERIMENTS AND MODERN ANALOGUES IN TAPHONOMY

Yolanda Fernandez-Jalvo[1]

1. Museo Nacional de Ciencias Naturales (CSIC), José Gutiérrez Abascal, 2, 28006 Madrid, Spain.
yfj@mncn.csic.es

Actualistic studies have frequently been useful to observe processes that are happening today to interpret results in the past (uniformitariarism). Actualistic studies play an important role in geology, and may also be applied to paleontology (e.g., comparative anatomy, population profiles, community structures, among others). The most extended use of actualistic studies in paleontology may be in the field of taphonomy. Experimentation is, frequently, the basis to demonstrate the origin of modifications affecting fossils and/or processes reorganizing the distribution of fossil assemblages. Actualistic studies include experiments in the laboratory, while controlling parameters that may influence the resulting modification; observations in nature of modern analogues with regard to dispersal, weathering or predation; and field experiments (e.g., deliberate burials or water immersion according to the soil or water quality). Each type of actualistic study may assist in interpreting processes and events in the past and can yield reliable results that can be extrapolated to different settings. Most importantly, however, taphonomy is not just the description of modifications superimposed on the original (paleobiological) surface, histology or geo- and bio-chemical composition. Taphonomy is a historical science that also involves delineation and calibration of processes and events through time, which is a prerequisite for reliable reconstructions of the past.

USING EXPERIMENTAL NEOICHNOLOGY AND QUANTITATIVE ANALYSES TO IMPROVE THE INTERPRETATION OF CONTINENTAL TRACE FOSSILS

Daniel I. Hembree[1]

1. Department of Geological Sciences, Ohio University, 316 Clippinger Laboratories, Athens, Ohio, 45701, USA.
hembree@ohio.edu

The successful interpretation of continental ichnofossils is impeded by our limited knowledge of the burrows produced by modern continental animals. This paucity of data inhibits our understanding of ancient soil ecosystems despite the presence of trace fossils in even Early Paleozoic paleosols. Actualistic studies of modern burrowing animals in the field and laboratory provide the data that make trace fossils invaluable to paleoecological and paleoenvironmental reconstructions. These studies allow for the interpretation of tracemakers, associated behaviors, and the environmental factors that influenced both burrow production and preservation. The goal of this project is to determine how well burrows produced by known terrestrial tracemakers engaged in known behaviors under controlled environmental conditions can be differentiated on the basis of qualitative and quantitative morphology. This project involved the analysis of burrows produced by 15 species of scorpions, whip scorpions, spiders, millipedes, centipedes, salamanders, toads, and skinks in a laboratory setting. The burrows produced by these animals were first described qualitatively and classified based on their architecture, shape, orientation, internal structure, and surficial features. The burrows included a diverse assemblage of shafts, tunnels, ramps, U-, J-, W-, Y-shaped and helical burrows, mazeworks, and boxworks. Next, measured and calculated quantitative properties were collected for each burrow including depth, slope, length, tunnel/chamber width, height, and circumference, width:height ratio, complexity, and tortuosity. On average, each species produced three distinct burrow morphologies with a range of two to six. There was overlap in several basic burrow architectures between even disparate taxonomic groups including vertical shafts and U-shaped burrows. The quantitative aspects of the burrow morphologies were compared using nonparametric similarity and distance indices as well as cluster analyses to determine if the burrow casts could be effectively differentiated based upon their tracemakers, behaviors, and environmental conditions. By using multiple properties of burrow morphology to compare the burrows statistically, many of the burrows were separated according to different behaviors and tracemakers although overlaps did occur. Levels of similarity were highest amongst animals with similar morphologies, burrowing techniques, and behavioral patterns. Differences due to environmental conditions, however, were minimal. Results from these analyses provide an assessment of our ability to reconstruct ancient soil ecosystems based on trace fossil morphology. By assembling a comprehensive analysis of the burrows of modern terrestrial animals, trace fossils may be described in a similar manner and compared directly to these modern analogs. This will be invaluable to improving the interpretation of tracemakers and behaviors.

PREDATION AND PRESERVATION: INITIAL FOSSILIZATION OF MODERN ECHINOIDS FACILITATED BY DRILLING GASTROPODS

Michal Kowalewski[1], Troy A. Dexter[1], Majken K. Schimmel[2], Roger W. Portell[1] and Thomas Rothfus[3]

1. Florida Museum of Natural History, University of Florida, 1659 Museum Road, Gainesville, FL 32611, USA. kowalewski@ufl.edu
2. EOG Resources Inc., 19100 Ridgewood Pkwy #2, San Antonio, TX 78259, USA.
3. Gerace Research Centre, San Salvador, Bahamas.

Predators are often viewed as destructive taphonomic agents that obliterate or damage skeletons of their victims thus inhibiting fossilization of the prey. However, observations from present-day tropical environments reported here indicate that some predators can facilitate prey preservation. Tests of the irregular echinoids *Meoma ventricosa* and *Leodia sexiesperforata* were collected from shallow (<5 m water depth) tropical environments of San Salvador (Bahamas) over multiple field seasons. Tests were measured and analyzed for taphonomic characteristics and predation traces. The overwhelming majority of tests (96.8% for *M. ventricosa* and 85.5% for *L. sexiesperforata*, respectively) contained drillholes interpreted here as records of successful predatory attacks by cassid gastropods. Most likely, as suggested by field and laboratory observations, a single predatory species, *Cassis tuberosa*, was responsible for majority of the attacks. The recovered echinoids tests were found either on the surface or partly/entirely buried under the sediment surface. Laboratory and field observations consistently indicated that the predators devoured prey without destroying their skeletons and then discarded the tests of the consumed echinoids either on the sediment surface or partially buried within sediment. Numerous completely buried tests were also recovered and >90% of them were drilled. The results indicate that (1) drilling predators facilitated the initial preservation of echinoid tests via non-destructive predation and partial burial and (2) echinoids that died due to other causes were not being incorporated into the initial death assemblage. Consequently, the results suggest that the predation-enabled preservation may introduce severe biases by creating an echinoid fossil record that overestimates mortality rates due to drilling predation and over-represents species and size-classes of echinoids that are preferentially attacked by drilling predators. Drilling gastropods may enable preservation of intact echinoids tests, while concurrently introducing substantial taphonomic biases.

NO EVIDENCE FOR PREDATOR SELECTIVITY IN TROPICAL MOLLUSCAN ASSEMBLAGES FROM ONE TREE REEF (GREAT BARRIER REEF, AUSTRALIA)

Julieta C. Martinelli[1], Matthew A. Kosnik[1] and Joshua S. Madin[1]

1. Department of Biological Sciences, Macquarie University, 2109, Australia.
julieta.martinelli@mq.edu.au

Predation is a key biotic interaction that has been suggested to shape a wide range of ecological communities. However, it is unknown whether the drivers of predation are primarily ecological and how they vary (or not) between recent and past environments. In this study, we hypothesize that predators are not selective and that predation rate is determined by encounter rate (i.e., a predator eats the first prey it finds). In order to test this hypothesis, we use the drill holes left by molluscan predators as an indication of predation. We collected the >4mm macrobenthic fauna from 15 sites in three soft-sediment reef lagoons at One Tree Reef on the southern Great Barrier Reef, Australia. Living (n=2912)and dead (n=6545) molluscs were counted and identified, and predation frequencies were calculated as the relative proportion of drill holes per species relative to the total number of drill holes per site. If our non-selective predator hypothesis verifies, then the relationship between predation frequency and encounter frequency should not be statistically different from 1. We tested which of three explanatory variables (relative abundance, life habitat and lagoon) best predicted drilling frequencies in the living (LA) and dead (DA) shell assemblages using a generalized linear mixed-effects model. The best-fitting model for LA indicated that predation increased with prey abundance, and this rate of increase varied only marginally between life habits. The best-fitting model for DA includes only encounter frequency, life habit was not found to be significant. These results demonstrate that predators do not eat significantly more or less than expected by chance, suggesting that drilling predators are non-selective. This lack of evidence for predator selectivity suggests that previous studies of predation may have overestimated the role of ecological factors as explanatory variables.

THE ROLE OF MICROBORING ORGANISMS IN THE DEGRADATION OF SHELL CARBONATE

Karla Parsons-Hubbard[1], Eint Kyi[1], Kathryn Hobart[1] and Claire Hoffman[1]

1. Department of Geology, Oberlin College, 52 W. Lorain St., Oberlin, OH 44074, USA.
Karla.hubbard@oberlin.edu

Following death, bivalve shells quickly lose luster, color, and ornamentation, especially in shallow marine environments. Taphonomic descriptions variously assign this degradation to dissolution, bioerosion, microboring, abrasion, and/or corrasion (a term used by workers who admit to being unable to sort out the causes of the degraded surfaces). It is important to be able to accurately distinguish the exact causes of degradation to better understand the environmental conditions experienced after death, which is the goal of this research. Pristine bivalve shells were placed on the sediment surface in many depositional environments and varying water depths in the Bahamas, the US Virgin Islands, and the Gulf of Mexico. To establish rates of degradation samples in the USVI were collected periodically over the course of one year, whereas samples from Bahamas and Gulf of Mexico were collected after two years, six years, and thirteen years from most experimental sites. Immediately after collection, each shell was photographed and described using standard taphonomic criteria (including dissolution, abrasion, loss of color, and encrustation). The use of a light microscope at 10x power, previously employed to analyze those data, limited out ability to distinguish different types of taphonomic alterations. This study returns to the same shell samples and examines the role of microboring bacteria, fungi, and algae in surface degradation. Samples from shells used in the original experiments were impregnated in epoxy under vacuum, then shells were dissolved. This technique allows detailed examination of the traces of microborings using scanning electron microscopy (SEM). Under the SEM we were also able to closely examine the texture of the shell surface, especially if microborers were not present. Results show that shallow warm seas promote extensive destruction of exposed shell surfaces by microbial borers. In fact, microboring is far more important than dissolution or abrasion. In the Bahamas, experiments deployed along a transect extending from 15m to 285m shows that microboring density and depth within the shell declines with depth. Chemical dissolution does not play an important role in shell degradation in Bahamas environments. In the Gulf of Mexico, shells placed within the euphotic zone also experienced extensive microboring. Sites deeper than about 100 meters show very slow colonization by microboring organisms and only minor evidence for dissolution with the exception of a few seep-related environments. The results of monthly collections in the US Virgin Islands show that microborers are established within the shells in only a few months of exposure at the sediment-water interface.

MOLLUSCAN DEATH ASSEMBLAGES LEAVE NO RECORD IN THE SUBSURFACE ASSEMBLAGES OF A CARIBBEAN BIOTURBATED LAGOON

Karla Parsons-Hubbard[1], Caitlin Tems[2], Dennis Hubbard[1], Ashley Burkett[3] and Seth Nachimson[1]

1. Department of Geology, Oberlin College, 52 W. Lorain St., Oberlin, OH 44074, USA. Karla.hubbard@oberlin.edu
2. Dept. of Earth Sciences, University of Southern California, 3651 Trousdale Pkwy, ZHS, Los Angeles, CA 90089, USA.
3. Dept. of Earth and Environmental Systems, Indiana State University, 200 North Seventh St., Terre Haute, IN 47809, USA.

Paleoecological studies often compare fidelity of the living community to the local death assemblage to make predictions about the translation of living communities to their fossil shell accumulations. Results are then applied to adjacent Pleistocene (or older) assemblages to interpretecosystem changes over time. This practice was tested by comparing surface mollusc assemblages to assemblages from twelve vibrocores extracted from Tague Bay lagoon (St. Croix, US Virgin Islands) that provide a detailed picture of the stratigraphy and shell content below the sediment-water interface. The comparison reveals that the mollusc content of the surface and near-surface sediments bear little relationship, either taphonomically or taxonomically, to the sub-fossil faunas preserved throughout the underlying lagoon sediment package. The sediments of Tague Bay have been extensively bioturbated by callianassid shrimps that sequester the coarse-grained fraction (mostly molluscan shell) into thick (up to 1m) lag deposits that sit atop the hard Pleistocene subsurface. Above the lag, molluscs are scarce but where they occur they are small, belong to infaunal taxa, and are generally in good taphonomic condition. The shell-rich lag is dominated by infaunal species and shell fragments, while surface death assemblages are rich in epifaunal and shallow infaunal species and tend to be more taphonomically degraded than shells in the core and in the lag. Based on probes and cores that penetrated the entire sequence, the sedimentary package ranges from 1-4 m in thickness above the Pleistocene bedrock. Four meters of sediment (the thickest measured) extrapolated over 7000 years since sea level flooded the lagoon (data based on radiocarbon dating of reef cores) indicate a maximum sedimentation rate of 57 cm/1000 yrs. Bulk radiocarbon dates from mollusks in the shell lags averaged ~3,500 yrs. BP, suggesting that the lag represents a complete mixing of shell ages between 0 and 7000 years ago and steady accumulation and mixing of the sequence since early flooding of the surface beneath the present lagoon. Constituent analyses of sediment grains in the cores confirm that the package is well mixed by the burrowing shrimp. Loss of the epifaunal mollusk record and accumulation of a long-term time-averaged lag bed urges caution for those who would relate results from surface fauna in modern environments to sub-fossil and fossil assemblages wherever deep bioturbation is suspected.

INFERRING SPECIES CO-EXISTENCE IN FOSSIL METACOMMUNITIES THROUGH NULL MODEL ANALYSIS

Marcelo M. Rivadeneira[1]

1. Laboratorio de Paleobiología, Centro de Estudios Avanzados en Zonas Áridas (CEAZA) & Universidad Católica del Norte, Avenida Ossandón 877 Coquimbo, 1781421, Chile. marcelo.rivadeneira@ceaza.cl

In absence of direct physical evidence, elucidating the existence of species interactions in the fossil record has been problematic, and several indirect proxies have been criticized. Here I evaluate the reliability of the use of null model analysis, an approach widely used in ecology, to infer the degree of species co-existence in fossil assemblages based on binary (presence/absence) species-site matrices. Numerical simulations were used to generate meta-communities driven by fully stochastic and niche processes (i.e. species interactions), mimicking taphonomic processes (e.g. time-averaging and an exponential post-mortem age distribution), hence producing 'artificial' live and dead assemblages. The C-score and V-ratio indexes were used to assess co-existence patterns, using the fixed-fixed and fixed-equiprobable null models. In fully neutral meta-communities C-score had a very high statistical power, in both live and dead assemblages, indicating the existence of stochastic assemblages in 88 and 92% of the cases, respectively. In meta-communities driven by niche-based processes, reduced species co-existence (i.e. high species interactions) was detected in the vast majority of live and dead assemblages, especially when using the C-score index (99 and 100 % of cases, respectively), implying a very low type I error. These results were robust to a wide range of variability in the temporal fidelity of species composition between live and dead assemblages. The V-ratio performed poorly in all cases, with a very low statistical power and high type I error. Comparisons of empirical live-dead mollusk assemblages confirm that patterns of species co-existence can be detected in fossil meta-communities using binary matrices and null models. Given the growing availability of spatially explicit paleontological datasets, these results open new avenue toward evaluating the structuring role of species interactions in local assemblages across spatial and evolutionary timescales. [Project funded by FONDECYT grant 1140841].

ACTUALISM FOR DOCUMENTING PAST SYMBIOSES: A NEW INTERSPECIFIC ASSOCIATION DETECTED FROM MESOZOIC TO OUR DAYS

Ninon Robin[1], Gilles Petit[1], Sylvain Bernard[2], Jennyfer Miot[2] and Sylvain Charbonnier[1]

1. Muséum national d'Histoire naturelle, Centre de Recherche sur la Paléobiodiversité et les Paléoenvironnements, UMR 7207 MNHN-CNRS-UPMC-Paris6, CP48, 57 rue Cuvier, Paris Cedex, 75231, France. ninon.robin@edu.mnhn.fr

2. Muséum national d'Histoire naturelle, Institut de Minéralogie, Physique des Matériaux et Cosmochimie, UMR 7590 MNHN-CNRS-UPMC-Paris6, IRD, CP 52, 57 rue Cuvier, Paris Cedex, 75231, France.

Documenting interspecific associations of ancient life may provide valuable insights into paleoecosystems and paleocommunities. Epibioses, which represents one of the closest possible association between two species, is challenging to document in the fossil record because of the degradation of organic remains that inevitably occurs during diagenesis. For this reason, paleoparasitologists need to adopt an actualistic approach when characterizing fossil symbioses. Unidentified 160 Ma old fossil epibionts have been detected on the carapace of fossil decapod crustaceans from the Lagerstätte of La Voulte-sur-Rhône (Jurassic, France). By examining collections of modern crustaceans for possible comparisons, we succeeded in finding their extant counterparts. Here, we identify these undescribed microscopic epibionts and characterize their association with decapod crustacean hosts. Because morphological features needed for a formal identification of the modern epibionts (global mineral components) are lacking, X-ray spectro-microscopy has been used to determine their organic signature, which led to their identification as bacterial colonies. This insight provides the first evidence of interspecific association involving epibiotic calcifying bacteria and eukaryotes. In order to characterize this association, fossil and modern crustacean hosts have been described (systematics/environment); counts of bacterial colonies have been carried out for assessing their prevalence and intensity; SEM views have been examined to consider their colonial growth patterns; and histological sections of the modern colonies nested in the cuticle have been topologically stained for determining their incidence on the carapace of their decapod host. We report this association on specimens of Penaeoidea from rather deep-water environments (Jurassic Lagerstätte of La Voulte-sur-Rhône), with bacteria colonies inhabiting up to 2 cm^2 of the whole body shrimp. A non-random distribution of colonial growth patterns is observed consistent with preferential feeding along the shrimp's ventral margin. SEM views and stained sections reveal the strong embedment of the colony within the cuticle as well as damages manifested as the bumping of the cuticular layers. This bioeroding effect, likely associated with feeding by the bacteria, suggests that this interspecific association, existing since at least 160 Ma, may represent parasitism. In addition to representing a rare case of extant interaction uncovered thanks to its initial discovery in the fossil record, this case highlights the key role of the extant record for understanding past symbioses and their evolution through the geological time.

PRESERVATION OF INSECTS IN LACUSTRINE DEPOSITS: LESSONS LEARNED FROM THE FIELD AND THE LAB

Dena M. Smith[1,2], Jenell Thoene-Henning[2], Amanda Cook-Hatfield[2] and Amy Moe-Hoffman[2]

1. Geological Society of America, 3300 Penrose Place, Boulder, CO 80301, USA. dsmith@geosociety.org
2. CU Museum of Natural History -265 UCB, University of Colorado, Boulder, CO 80309, USA.

Insects are a species-rich group that has come to dominate most modern terrestrial ecosystems. They are well represented in the fossil record with first occurrences in the Early Devonian. Exceptionally preserved insect specimens are found in several different types of Lagerstätten, with their preservation in amber and in lake sediments being of greatest importance in terms of overall diversity and abundance. A variety of field and lab-based approaches have been used to study the preservation of insects in lacustrine environments, focused primarily on Cenozoic deposits in North America. A combination of live-dead studies, decay experiments and comparative approaches has yielded intriguing results. Namely, these works have shown that the spatial, temporal and compositional resolution of fossil insect assemblages are influenced by insect ecology, morphology, the method by which an insect enters a lake environment and the final resting position of specimens within the lake. In general, North American lacustrine insect assemblages appear to have experienced very little spatial and temporal averaging. Compositional fidelity of assemblages tends to be low, with an overabundance of allochthonous taxa from smaller size classes and with morphologies that are more physically robust. The composition of fossil insect assemblages can be biased depending on where they are located within a lake, dependent on both water depth and distance from shore. This is likely due to differences in biotic activity and levels of physical disturbance in these settings. Focus areas for future research are outlined, as are recommendations for improving field collecting methods and statistical approaches.

LATE QUATERNARY ENVIRONMENTAL CHANGES IN SAN MATÍAS GULF (PATAGONIA ARGENTINA): A MULTI-PROXY APPROACH BASED ON *AMIANTIS PURPURATA* (LAMARCK) (BIVALVIA)

M. Sol Bayer[1,2], Sandra Gordillo[1,2] and Enrique Morsan[3]

1. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), CONICET and Universidad Nacional de Córdoba, Av. Vélez Sársfield 1611, Córdoba, X5016CGA, Argentina. sol.bayer@conicet.gov.ar

2. Centro de Investigaciones Paleobiológicas (CIPAL), FCEFyN, Universidad Nacional de Córdoba, Av. Vélez Sársfield 299, Córdoba, 5000, Argentina.

3. Instituto de Biología Marina y Pesquera Almirante Storni, Universidad Nacional del Comahue, Güemes 1030, San Antonio Oeste, 8520, Argentina.

Multi-proxy studies to evaluate environmental and climatic changes during the Quaternary have intensified in the last few years because such interdisciplinary research provides strong evidence for environmental reconstructions and interpretations. In this work several proxies, including taphonomy, paleoecology, paleobiogeography, morphometry and sclerochronology, were used simultaneously to evaluate whether *Amiantis purpurata* from the San Matías Gulf (northern Patagonia, Argentina) records environmental changes during the late Quaternary. Extant and fossil *A. purpurata* shells from different localities from Pleistocene MIS5e, mid-Holocene and modern times were analyzed by integrating the above proxies. Different taphonomic attributes (articulation, R-L valves ratio, fragmentation, abrasion and teeth preservation), size and shape, historical-geographical, and stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) were considered in this interdisciplinary analysis. Our data indicated that the southernmost fossil record of *A. purpurata* was that of the San Matías Gulf, being also the most abundant taxon in Pleistocene, Holocene and modern molluscan assemblages. Pleistocene shells were smaller and exhibited different shape with respect to Holocene and modern shells, probably due to changes in primary productivity (i.e., variation of quality and nutrient availability) through the Late Quaternary within this gulf. Valves were well preserved (100% original aragonite), but they showed variations in intensity of the taphonomic attributes which was associated with local conditions of each site. Oxygen and carbon isotope profiles suggest climate seasonality, which also was variable over the time period considered; this variation could be associated with changes in sea surface temperature, salinity and/or water circulation. This multi-disciplinary approach showed that *A. purpurata* exhibited variations between modern and fossil shells mainly associated with changes in substrate, seasonality and water paleocirculation, although local and global events such as the Last Glacial Maximum, San Matías Gulf´s configuration (12,000 yrs. BP) and Holocene Climatic Optimum may also have played a role. Therefore, *A. purpurata* is a good indicator to reconstruct the late Quaternary paleoenvironment of San Matías Gulf. The strategy of multi-proxy analysis was very useful to strengthen the interpretation of taphonomic, paleobiogeographical, paleoecological, paleoclimatic, and morphometric variations recorded in mollusks shells in relation to environmental changes that occurred during the Quaternary. [Part of the Doctoral Thesis of S.B.].

THE TAPHONOMIC BAHAMIAN STORY: UNVEILING THE CONSEQUENCES OF SPECIES ABUNDANCE ON TAPHOFACIES IN SAN SALVADOR ISLAND

M. Sol Bayer[1,2], Diego Balseiro[1,2], Diego F. Muñoz[1,2] and Sandra Gordillo[1,2]

1. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), CONICET and Universidad Nacional de Córdoba, Av. Vélez Sársfield 1611, Córdoba, X5016CGA, Argentina. sol.bayer@conicet.gov.ar

2. Centro de Investigaciones Paleobiológicas (CIPAL), FCEFyN, Universidad Nacional de Córdoba, Av. Vélez Sársfield 299, Córdoba, 5000, Argentina.

Several previous studies have underscored the importance of how intrinsic variations in shell characteristics affect the final taphonomic attributes of shell deposits. Other studies have shown that the composition of shell supply only affects the intensity of each attribute but not its rank-order. Although these are promising results for taphofacies analysis, we still cannot confidently assess that taphofacies are free from biological biases. If species with different taphonomic responses differ dramatically in their abundances among rather similar environments, contrasting taphofacies could be identified for the same environment without reflecting real differences. In this contribution we evaluate how intrinsic differences influence the definition of taphofacies in San Salvador Island. For this goal we studied (1) intrinsic differences between species in the rank-order and intensity of taphonomic attributes, and (2) the effects of differences in species relative abundances on the definition of taphofacies. Seven beaches were sampled around the island based on their geographical position with respect to the wind trades (windward or leeward), their environmental features based on the presence or absence of rock patches (sandy or rocky beaches) and beach zones (three equidistant samples from the maximum level of spring tides to the minimum level of the normal tide, and samples from the subtidal zone). We studied taphonomic attributes (fragmentation, abrasion, teeth preservation, muscle scars, color, external glossy, external cementation, internal glossy, internal cementation and biological incrustation) in the four most abundant bivalve species, and calculated their relative abundance. Using multivariate analysis, two taphofacies were recognized among geographical location and two between beach types, but none between beach zones. Intrinsic differences in the intensity of taphonomic attributes were commonly observed within taphofacies, while differences in the rank-order of taphonomic variables were seldom observed between taphofacies. To further test whether taxa's relative abundance influenced the definition of taphofacies, we tested the correlation between samples' taphonomic response taking and not taking into account the taxa's abundance. A mantel test indicated that both were significantly correlated. Differences in abundance of taxa with different intrinsic characteristics seem to have little effect on the whole sample taphonomic signature. Therefore, two scenarios appear to be possible, either (1) intrinsic differences among taxa, or (2) differences in their relative abundances, were not strong enough to bias the taphonomic signature of the samples. However, because taphonomic signatures based on each single taxon are also correlated between all four taxa, the first scenario seems to be the most probable one.

RECONSTRUCTING THE LAS HOYAS PALAEOECOSYSTEM TROPHIC NETWORK (BARREMIAN, EARLY CRETACEOUS, SPAIN)

Ángela D. Buscalioni[1], Jesús Marugán-Lobón[1], Francisco Poyato-Ariza[1], Carlos de Miguel[1], Marian Fregenal-Martínez[2], Bernard Gomez[3] and Xavier Delclòs[4]

1. Departamento de Biología, Facultad de Ciencias, Universidad Autónoma de Madrid, Darwin, 2, Cantoblanco, Madrid, 28049, Spain. angela.delgado@uam.es

2. Departamento de Estratigrafía, Facultad de Ciencias Geológicas, Instituto de Geociencias (UCM-CSIC), Universidad Complutense de Madrid, José Antonio Novais, 2, Madrid, 28040, Spain.

3. Département de Biologie, CNRS-UMR 5276 Terre, Planètes, Environnement, Université Lyon 1 (Claude Bernard), 2, rue Dubois, Villeurbanne Cedex, 69622, France.

4. Departamento de Estratigrafia, Paleontologia y Geociencias Marinas, Facultad de Geología, Universidad de Barcelona, Martí i Franquès, s/n, Barcelona, E-08028, Spain.

Ecological networks represent food-webs where consumer-resource interactions among organisms are represented as graphs. In such graphs, vertices signify trophic guilds or individual species, so that links between the vertices simulate the direct interaction among species. Abstracting food webs into graphs requires the making of an adjacency zeroes-ones matrix to represent a feeding relationship between each predator-prey pairing. We present the trophic web of an Early Cretaceous ecosystem that has been characterized as a seasonal subtropical wetland. The locality of Las Hoyas is an exceptional fossil Lagerstätte, from which 115 families and 191 species of plants and animals have been determined. Taphonomically, it is featured as a spatio-temporally confined, highly resolved co-occurring biota. The plant assemblage comprises aquatic Clorophyta, Zynematales and Charales, and a wide spectrum of terrestrial Embryophyta (Marchantiophytina, Licopodophytina, Spermatophyina). Animals constitute the 77% of the total species-level diversity and include Nematoda, Annelida, Platyhelmithes, Mollusca, Araenoidea, Opiliones, Myriapoda, Ostracoda, Malacostraca, Arthropoda, and Vertebrata. In order to build the matrix, actualistic criteria were applied whenever unambiguous living analogues were available, although the ecomorphological implications of special traits such as size, locomotion, dental morphology or eye diameter were considered to infer trophic relationships. In our first approach, we grouped the taxa into large ecological categories, pursuing to highlight the interactions among organisms across the aquatic, amphibious, and terrestrial environments in order to test the configuration of this Early Cretaceous continental ecosystem. Invertebrate interactions stand out in the Las Hoyas food web: they represent aquatic, amphibious, and terrestrial insect vertices that bear the maximal number of trophic connections. Insects and fishes have the highest trophic interactions in the aquatic realm, while conifers and ferns are linked to coleopterans and neuropterans at the terrestrial realm. In turn, the trophic interactions of vertebrates are biased towards the obligate aquatic and amphibious categories, which represent organisms foraging on micro-invertebrates and small fishes. Frogs, albanerpetontids, and crocodylomorphs would constitute a strong link between the aquatic and the terrestrial environments. The carnivorous tetrapods from the terrestrial environment are relatively diverse, although, for obvious evolutionary reasons, they lack the great ecological disparity of birds, mammals, and snakes in Recent wetland ecosystems. Instead the most ecologically diversified group within reptiles at Las Hoyas are the squamates. The network shows an apparent discrepancy in the relative abundance of herbivores and carnivores in the terrestrial realm.

THE TEMPORAL SCALE OF DIET AND DIETARY PROXIES

Matt Davis[1] and Silvia Pineda Munoz[2,3]

1. Yale University, Department of Geology and Geophysics, PO Box 208109, New Haven, 06520, USA. matthew.davis@yale.edu
2. Macquarie University, Department of Biological Sciences, Macquarie Park, 2109, Australia.
3. Smithsonian Institution, Department of Paleobiology, PO Box 37012, MRC 121, Washington, 20013, USA.

Dietary reconstructions estimated from different proxies such as dental microwear, jaw morphometrics, and stable isotopes often do not match, especially for extinct species suspected of being generalists. These mismatched diet reconstructions are only incongruent if one assumes an idealized situation where diet is constant and scale invariant. Because diet can change greatly over ontogenetic, ecological, and evolutionary time, what appear to be incongruences in diet reconstructions might actually reflect the normal range of dietary variation time averaged by differently scaled proxies. We used statistically rigorous multiyear diet classifications of 139 mammals and several high temporal resolution mammal datasets to simulate the range of values that could be obtained from frequently used dietary proxies. We show that natural variation in diet can lead to highly disparate dietary reconstructions if proxies record diet at different temporal scales. For example, a single African elephant (*Loxodonta africana*) can be classified as a strict browser, mixed feeder, or a grazer depending on whether tusk or hair samples are used for isotopic analysis as each proxy averages diet over a different length of time. Grizzly bears (*Ursus arctos horribilis*) can be classified as carnivores, herbivores, omnivores, insectivores, or granivores depending on when and for how long their diets are measured. With the wide range of dietary proxies available to both paleontologists and neontologists, diet can be roughly inferred from seconds of an animal's life to many millions of years of evolutionary history, almost 16 temporal orders of magnitude. These differing dietary reconstructions are not a nuisance but a desirable tool that allows us to create multi scale reconstructions that represent a species' diet over time and are much more informative than any single proxy. The utility of different proxies depends on the nature of the research question and the temporal scale examined. Care should be taken to avoid "scale jumping" by grossly mismatching the time scale of the ecological or evolutionary question with the temporal extent of the data. When one population of generalists like grizzly bears can show more variation in diet in just four months than is found among hundreds of species in one year, any scale-blind dietary reconstructions or comparisons should be made cautiously.

RECENT BENTHIC FORAMINIFERA DISTRIBUTION FROM COASTLINE ENVIRONMENTS OF THE UNITED ARAB EMIRATES

Flavia Fiorini[1] and Stephen W. Lokier[1]

1. The Petroleum Institute, P.O. Box 2533, Abu Dhabi, United Arab Emirates.
ffiorini@pi.ac.ae

The benthic foraminifera and sedimentary facies distribution from Recent coastline environments of Abu Dhabi, United Arabs Emirates (UAE) was studied with the aim to provide modern analogs for understanding and interpreting the depositional environment of ancient shallow-marine deposits from the UAE. A total of 120 sea-floor sediment samples were collected in nearshore shelf, beachfront, channels, ooid shoals, lagoons, mangals and intertidal hypersaline ponds close to the coastline of Abu Dhabi. Six foraminiferal assemblages were recognized in the studied areas. Miliolidae species mainly belonging to the genera *Quinqueloculina*, *Triloculina*, *Spiroloculina*, and *Sigmoilinita* are common in the nearshore shelf, beach-front and lagoonal areas. Hyaline foraminifera mostly belonging to the genera *Elphidium*, *Ammonia*, *Bolivina* and *Rosalina* are also common together with Miliolidae in the nearshore shelf and beach-front. Agglutinated foraminifera (*Clavulina*, *Textularia*, *Ammobaculites* and *Reophax*) are present at low percentages in most of the shallow-marine, lagoonal and mangal samples. The species belonging to the genera *Ammobaculites* and *Reophax* are present only in the finest grained samples particularly in lagoons and mangal environments. The majority of the ooid shoal sediments, the coarser sediments of the beach-front and the channels do not contain living foraminifera and the death assemblage is mostly composed of a few specimens of coarse-sized Miliolidae with fragmented or abraded tests, which were probably transported from nearby environments. Epiphytic larger benthic foraminifera *Peneroplis* spp. and *Spirolina* spp. are particularly abundant in samples collected on seaweed. Specimens with abnormal test growth belonging to the genera *Peneroplis*, *Spirolina* and *Sorites* were abundant in samples collected from hypersaline coastal ponds. The recorded data on benthic foraminifera constitute both a taxonomical data bank on species from shallow-water carbonate settings of the Persian Gulf and a foraminifera distribution model that can be used in paleoenvironmental reconstructions.

DECOUPLING OF COMPOSITIONAL AND ENVIRONMENTAL FIDELITY IN DEATH DIATOM ASSEMBLAGES FROM SHALLOW LAKES

Gabriela S. Hassan[1]

1. Instituto de Investigaciones Marinas y Costeras (IIMyC), Consejo Nacional de Investigaciones Científicas y Técnicas - Universidad Nacional de Mar del Plata, Juan B. Justo 2550, Mar del Plata, B7608FBY, Argentina. ghassan@mdp.edu.ar

Comparisons between death assemblages and their source living communities are among the most common actualistic methods of evaluating the preservation of compositional and environmental information by fossil assemblages. While live-dead studies have been commonly focused on marine mollusks, the potential of diatoms to preserve ecological information in continental settings has been overlooked. This lack of knowledge on the nature and magnitude of the taphonomic biases affecting live-dead agreement of diatom assemblages contrasts significantly with their extensive application as modern and fossil bioindicators in paleoecological and paleoenvironmental reconstructions. In this study, three live-dead datasets are analyzed in order to evaluate the compositional and environmental fidelity exhibited by death diatom assemblages in shallow lakes. Compositional fidelity was assessed by comparing richness, diversity and abundances of seasonally collected living (LAs) and death (DAs) assemblages using multivariate techniques. Environmental fidelity was evaluated by analyzing the relationship between LAs and DAs and environmental variables, and comparing the performance of both analyses in terms of explained variance and statistical significance. I find that diatom death assemblages do differ significantly in their taxonomic composition from living assemblages, mainly as a consequence of (1) differences in the temporal resolution between time-averaged DAs and non-averaged LAs, and (2) differential preservation of diatom taxa related to the intrinsic properties of their valves. Despite those compositional dissimilarities, DAs were able to capture the same environmental gradients delineated by LAs. This decoupling between live-dead agreement in community composition and community response to gradients can be related to the existence of at least two mutually exclusive subsets of species that captured compositional dissimilarities based on the full set the species in the three lakes. This functional redundancy implies that the between-sample relationships of living assemblages can be preserved by DAs even if some taxa are removed by taphonomic processes. Hence, as the preservation of environmental gradients does not require a good preservation of all living taxa, structural redundancy compensates the loss of compositional fidelity caused by postmortem processes in this diatom dataset.

RECENT AND MESOZOIC SERPULIDS IN PENTAGONAL TUBES: TESTING THE AFFINITY BY THE TUBE ULTRASTRUCTURES

Alexei P. Ippolitov[1] and Elena K. Kupriyanova[2]

1. Geological Institute of Russian Academy of Sciences, Pyzhevsky lane 7, Moscow, 119017, Russia. ippolitov.ap@gmail.com
2. The Australian Museum, 6 College Street, Sydney, NSW 2010, Australia.

Fossil serpulids, a group with rich fossil record, receive only little attention from paleontologists. As their tube morphology is highly variable in many genera, there are obvious difficulties in estimating generic affinity of fossil species, and, consequently, in obtaining reliable interpretations based on actuopaleontological approach. This study deals with free-lying, variously curved pentagonal tubes that are relatively common in European Mesozoic, and are classified within the genera *Pentaditrupa* and *Genicularia*. Such morphology was not described for any of known Recent serpulids before, and Mesozoic pentagonal tubes were commonly interpreted as direct ancestors of the well-known *Ditrupa*, which is characterized by free-lying scaphopod-like tubes that are round in cross-section. However, we have found recently free tube fragments with pentagonal cross-section in one population of Recent deep-sea *Bathyvermilia* sp. nov., a species that normally exhibits tetragonal tubes. This challenges common interpretation of fossil pentagonal tubes because *Bathyvermilia* and *Ditrupa* belong to different major clades within the Serpulidae. To check how fossil pentagonal tubes can be related to Recent forms, we analyzed with SEM Recent pentagonal *Bathyvermilia* sp. nov. and four fossil species ranging from the Early Jurassic to the Late Cretaceous. As serpulids have very variable tube ultrastructures counting 13 ultrastructural types arranged in one to four layers, SEM studies provide a powerful tool for verifying taxonomic interpretations obtained from tube external morphology. Recent pentagonal *Bathyvermilia* sp. nov. has unilayered tubes with an irregularly oriented prismatic (IOP) ultrastructure with characteristic cavities near the lumen. This ultrastructure is indistinguishable from that observed for tetragonal representatives of the same species. Most fossil pentagonal species demonstrated well-preserved ultrastructures. Both *Pentaditrupa* and *Genicularia* had two-layered tubes with a thick outer layer of simple prismatic (SP) structure, and thin inner layer of homogenous granular (recrystallized IOP?) structure. This is concordant with the tube structure described for Recent *Ditrupa*. Moreover, the presence of oriented prismatic layers is not compatible with the major clade B that includes *Bathyvermilia*, and therefore, the classical hypothesis linking fossil pentagonal tubes with *Ditrupa*appears well-supported by ultrastructural data, while morphological similarity of fossil pentagonal tubes with that of a certain species of *Bathyvermilia* is convergent. [Supported by RFBR grant no. 14-05-31413 and RAS Presidium Program no. 28 to API and ABRS grant RF213-19 to EKK].

OSTRACODS FROM PARANAGUÁ BAY ESTUARINE COMPLEX, SOUTH BRAZIL

Cláudia Pinto Machado[1]

1. Centro Tecnológico (CENT), Universidade de Caxias do Sul (UCS), Alameda João Dal Sasso, 800, Bento Gonçalves, 95700-000, Brazil. machadocpm@gmail.com

Ostracod assemblages from estuarine environments have been poorly documented in Brazil. Taphonomic and ecological characteristics of these assemblages are an essential tool for paleoenvironmental interpretations of estuarine environments. The aim of this research is to conduct a preliminary survey of ostracod species and characterize their associations in two areas of the Complex of Paranaguá Bay: Baía dos Pinheiros and Rio Medeiros. The study material included 29 sediment samples (13 samples from Baía dos Pinheiros and 17 from Rio Medeiros), collected with a Petite Ponar type sampler. In this survey, 19 taxa were identified. The species *Auricythere sublitoralis*, *Bairdopillata* sp. *Caudites* sp. *Cythereretta punctata*, *Keijella dictyon*, *Neocaudites triplistriatus*, *Neocytherideis* sp. 1, *Whatleyella* sp., occurred only in Baía dos Pinheiros and all identified taxa are usually found in shallow marine environment. Among the exclusive representatives of Rio Medeiros are *Cyprideis salebrosa*, *Paradoxostoma* sp., *Sclerochilus* sp. 1, *Sclerochilus* sp 2, *Semicytherura* sp., *Xestolebereis*? sp. 1, *Xestolebereis*? sp. 2 and *Xestolebereis*? sp. 3. All these genera are commonly found in marine and estuarine areas. The species *Cyprideis multidentata*, *Loxoconcha bullata* and *Tanella* sp. were found in both areas. *C. multidentata*, the most abundant species in the samples (50.7%), is typical of coastal marine areas of southern and southeastern Brazil. The taphonomic analysis based on the proportions of juvenile and adult specimens, in the absence of evidence of transport and signs of fragmentation and abrasion of valves and/or shells, suggests that most of the taxa are autochthonous. Only three taxa, *Bairdopillata* sp., *Caudites* sp., and *Xestolebereis* sp. 1 are probably allochthonous and can be considered as marine assemblage.

ACTUOPALEONTOLOGY OF BIVALVE MOLLUSCS FROM THE PARANAGUA ESTUARINE COMPLEX, PARANA, BRAZIL

Andrea T. P. Marcondes[1], Annie. S. Hsiou[1], Marcelo R. Lamour[2] and Renato P. Ghilardi[3]

1. Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto (FFCLRP), Universidade de São Paulo (USP), Av. Bandeirantes 3900, Ribeirão Preto, 14040-901, Brazil. athayspm@gmail.com

2. Centro de Estudos do Mar (CEM), Universidade Federal do Paraná (UFPR), Av. Beira-mar, s/n, Pontal do Sul – Pontal do Paraná, 83255-976, Brazil.

3. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP), Av. Eng. Luiz Edmundo C. Coube 14-01, Bauru, 17033-360, Brazil.

Actuopaleontology is the branch of Paleontology that aims to enhance paleoecological and paleoenvironmental interpretations. One of its aspects is the interpretation of taphonomic signatures. In order to characterize the taphonomy of bivalve mollusk associations from the Paranagua Estuarine Complex (CEP), 11 stations were sampled along environmental gradients. Here, we present the preliminary results based on data from two of these stations. Samples were collected in partnership with the Laboratory of Geological Oceanography (LOGeo - CEM / UFPR), and the taphonomic signatures present on the bioclasts were analyzed in terms of chemical, physical and/or biological origin. The first sampling point (472) is located in an inner area of bay in the CEP, near the mangrove. During low tide, water depth at this site can be less than 4 m, depending on tidal cycle. The bioclasts in this point are mussels of the genus *Mytella*, represented mostly by shell fragments. The second sampling point (696) is located in one of the tidal channels that connect the CEP with the open sea. Thirteen genera were found at this site (*Tellina*, *Chione*, *Strigilla, Solen*, *Nucula*, *Mactra*, *Macoma*, *Dosinia*, *Donax*, *Divaricella, Cyclinella*, *Anadara* and *Abra*). For both stations, encrustation and bioerosion were infrequent and variable in origin, mostly representing algae, and less frequently, sponges and crustaceans (barnacles). Holes of predatory origin were found in only seven bioclasts from the station 696. The two stations do not differ notably in terms of dissolution, abrasion and corrosion. Most of the mussels from the station 472 exhibit abrasion in the umbo region, which might be the result of the activity of his foot in life, rather than the post-mortem physical and chemical factors. Fragmentation and valve disarticulation are more frequent at the station 696, as well as the largest disparity in the occurrence of valves type (right valves were almost two times more frequent than left valves), which may indicate more intense energy levels. The fragmentation present in these two areas is distinguished due to the fact that the fragmentation of the mussels can be also attributed to the action of durophagous predators, and not just to physical or chemical factors. The marks of this type of predation are, most often, at the ventral region of the shell.

SIZING UP THE LEAVES OF AN EOCENE PATAGONIAN PALEORAINFOREST AND ITS AUSTRALIAN ANALOGS

Lisa Merkhofer[1], Peter Wilf[1], Robert Kooyman[2], Lawren Sack[3], Christine Scoffoni[3] and Néstor R. Cúneo[4]

1. Department of Geosciences, Pennsylvania State University, University Park, PA 16802, USA. lmerkhofer@gmail.com.
2. Department of Biological Sciences, Macquarie University, Sydney, NSW 2109, Australia.
3. Department of Ecology and Evolution, University of California Los Angeles, Los Angeles, CA 90095, USA.
4. Museo Paleontológico Egidio Feruglio, CONICET, Trelew 9100, Chubut, Argentina.

Although no ancient forest has one ideal modern analog, the Laguna del Hunco (LH) paleoflora from early Eocene Patagonia, Argentina, possesses remarkable similarities to well-studied, extant subtropical rainforests in Australia, in terms of leaf size, floristic composition, and diversity. Here, we use a new method of highly detailed fossil-modern comparison that combines both floristic and leaf size analysis to identify LH's closest living analog rainforests within Australia. We include leaf size because it correlates with modern forest structure and is classically used to categorize Australian rainforest habitats. This study (1) provides a novel, comprehensive analysis of LH leaf size, (2) uses LH leaf size, the occurrences of 11 Australian genera known as LH fossils, and family-level ecology to identify the most similar modern Australian analog rainforests, and (3) evaluates these analog rainforests using the niche envelopes of some of LH's nearest living relatives (NLRs) that are ex-Australians, i.e., that have fossil records in Australia but modern ranges that are restricted to other parts of Australasia. Leaf area was either measured directly or estimated from fragmented leaves using the Cain and Castro formula, the Raunkiaer-Webb size classes, or a new method that utilizes a scaling relationship between secondary vein density and leaf area that has not yet been applied to fossils. By testing all methods on 160 intact leaves from LH, we found that vein scaling was as accurate for estimating leaf area as size classes and applicable to more fragmentary leaves, but that both methods were less accurate than the Cain and Castro formula. This allowed us to choose the most appropriate method for area measurement based on specimen fragmentation. Across 155 species, the LH modal and average leaf size for 1163 leaves was microphyll, and using the vein scaling method recovered previously undetected large leaf areas. Comparisons to modern Australian rainforests confirmed that subtropical rainforests of New South Wales have both the most similar sizes and floristics to LH. However, ex-Australian NLRs inhabit a cool, wet montane biome that is not represented in any Australian rainforest. This suggests that closer analogs for LH may be found if comparative analysis is extended to include more types of Australasian rainforests. This new quantitative method of fossil-modern comparison can be applied to other paleofloras that have many well-identified nearest living relatives, allowing paleoecological interpretations to be more precisely based on both taxon-free and taxon-informed data.

CHIRONOMIDS AS INDICATORS OF PALEOPRODUCTIVITY IN THE PAMPAS REGION, ARGENTINA

Fernanda Montes de Oca[2], Rodrigo Martín[1], Julieta Massaferro[2] and Cecilia Laprida[1]

1. Institute of Andean Studies "Don Pablo Groeber" (UBA – CONICET), Int. Güiraldes 2160, Buenos Aires, 1428, Argentina. rodrigosmartin88@gmail.com

2. Program of Applied Studies for the Conservation of Nahuel Huapi National Park (APN-CONICET), Fagnano 244, Bariloche, 8400, Argentina.

Subfossil assemblages of chironomids (Diptera: Insecta) have been broadly utilized in mid-latitudes of South America as biological proxies for high resolution air paleotemperature reconstruction. Most of these research projects were conducted in the southern South America, especially in Patagonia (Argentina and Chile). On the other hand, chironomids can provide information to reconstruct the trophic status of lakes, as their assemblages respond rapidly to changes in nutrients concentration (N, P) and organic matter availability. However, in Argentina this insect group was been scarcely used in studies of lake paleoproductivity. The subfossil chironomids of the Pampas could provide an opportunity for an interesting case study. Most Pampean lakes show changes in their trophic status on decadal to centennial timescales, as a consequence of regional climatic fluctuations and anthropogenic activities that alter drainage in the catchment area (for example, intensive soy harvesting with fertilizer application). In this study, we present the preliminary results for subfossil chironomids assemblages from 10 lakes of the Pampean region, Argentina (36°S, 62°W). The ultimate goal is to retrieve ecological information about the subfossil chironomids taxa present in the Pampean region and recognize which of these taxa reflect lake productivity. Samples were collected in the (Austral) summer of 2014, using a dredge or short corer. Samples for chironomid analysis (3 g wet weight) were disaggregated in warm 10% KOH solution and sieved. All chironomid head capsules were picked under binocular microscope and mounted on slides using Hidromatrix© solution. A minimum of 35 head capsules were mounted and identified using taxonomic keys. Our preliminary results document the appearance of *Polypedilum*/*Chironomus*/*Goeldochironomus*/*Dicrotendipes* assemblage in most of the hypereutrophic lakes, thus revealing the potential of Pampean chironomids as paleoproductivity proxies. The hypereutrophic state of these lakes could be related to a marked increase in agricultural activity around 1990, with intensive soybean production with the widespread use of pesticides and fertilizer. We interpret the assemblage as a record of high productivity conditions. We anticipate that Pampean chironomids assemblages will allow for discrimination of climatic and anthropogenic processes in paleolimnological studies.

SUBAQUATIC ENVIRONMENT AND LEAF/ PALINOMORPHS ASSEMBLAGES IN THE ALLUVIAL PLAIN OF MOGI-GUAÇÚ RIVER, BRAZIL

Fresia Ricardi-Branco[1], Sueli Yoshinaga Pereira[1], Melina M. Souza[1], Francisco Santiago[1], Paulo Ricardo Brum Pereira[2], Fabio C. Branco[3], Victor Ribeiro[1] and Karen Molina[1]

1. Department of Geology and Natural Resources, Institute of Geosciences, 51 J, Pandiá Calógeras Street, University of Campinas – UNICAMP, Campinas, 13083 -870, SP, Brazil. fresia@ige.unicamp.br

2. Forestry Institute, São Paulo State Environmental Secretariat, 874, 7 de Setembro Street, Mogi Mirim, 13801-350, SP, Brazil.

3. Environmentality, 177 Michigan Street, São Paulo, 04566-000, SP, Brazil.

The study and evolution of landscapes is an important tool regarding paleoenvironmental reconstructions. For that, it is essential to know how the biomass enters the sedimentary record, the depositional environment, and the subaquatic/ aquatic environment. The Cerrado biome covers the fluvial plain of Mogi-Guaçú. This research investigates the dynamics of subaquatic environment, the current pollen rain and climatic implications of leaf morphologies. The Ecological Station of Mogi-Guaçú (EEcMG) is located in the São Paulo State. The hydrogeological study was performed in 23 monitoring wells in two areas over a period of one year. Leaf assemblages were collected from the ground and trees, and the samples for current pollen rain where collected from the ground and bromeliads growing over forests. The dynamics of groundwater in alluvial plains of Mogi-Guaçú River was influenced by river flow and aquifer permeability. The groundwater flows towards the river meanders and ponds along the year. These meanders, which dry up during the less rainy season, are also paths of preferential subsurface water flow. The study areas have low groundwater residence time, therefore the waters are characterized by low mineralization, acidic pH and oxidized environment, and mixed bicarbonate and calcium-bicarbonate. At EEcMG, the current pollen rain is composed of Poaceae, Cyperaceae, *Euphorbia*, Araliaceae, Malpiguiaceae, Arecaceae, *Pinus* and spores. Forest elements are dominant compared to herbaceous elements. The leaf assemblages are consistent with tropical climatic conditions (hot and seasonal), with average temperature between 20.5°C and 22.5°C, and high average annual rainfall, concentrated in few months of the year. At the river margin, the forest reflects the temperature accurately, but not the rainfall, which can be explained by the influence of groundwater, type of soil, and temperature. The current pollen rain also shows this result since the dominant pollen belongs to arboreal plants. The trees have developed a root system and can reach the water table, depths of which vary from 4 to 16 meters. In the inner bank of meander bend, the assemblages of leaves better reflect rainfall, since the temperature can be changed by the proximity of water bodies. The physical environment and water chemical promote the preservation of plant biomass. The integrated and multidisciplinary approaches are important tools in studying modern and past environment, contributing to understand the processes that can lead to the preservation of environmental signature into the fossil record. [FAPESP 2010/20379-6 and FAPESP 2013/22729-2].

TIME-AVERAGING REMARKS OF MOLLUSCAN ASSEMBLAGES IN THE COASTAL PLAIN OF SOUTH BRAZIL

Matias do Nascimento Ritter[1], Fernando Erthal[2] and João C. Coimbra[2]

1. Programa de Pós-graduação em Geociências, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, CEP 91501-970, Porto Alegre, Cx. P. 15001, Brazil. mnritter@gmail.com

2. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, CEP 91501-970, Porto Alegre, Cx. P. 15001, Brazil.

Molluscan shell accumulations (shell beds) are very common in shallow marine and estuarine environments in South America and also on the continental shelf of Argentina and southern Brazil. These shell beds are restricted to the Quaternary and can provide an excellent opportunity for taphonomic studies. In previous papers, it has been shown that dissolution is the main taphonomic process biasing biological information in estuarine and lagoonal environments. These deposits are within estuarine facies, despite being formed by the mixing of marine and estuarine species, indicating the possibility of such deposits to be time-averaged in a species-dependent manner. This study investigates (i) how much time-averaging is involved in these deposits and (ii) what are the implications for stratigraphic studies. For this purpose, fossil specimens were sampled from two lagoon outcrops in the south coastal plain of Rio Grande do Sul State (CPRS), Southern Brazil. These outcrops are located in the most recent lagoon-barrier depositional system, which was fully developed during the maximum Holocene transgression. The ^{14}C AMS dating was conducted on marine and estuarine shells species from each outcrop. Both outcrops include both estuarine and marine species. The outcrops are representing different moments of the evolution of the lagoonal system, at retrogradational lies of the south CPRS. The outcrop exposes in the beach (S1) represents the final phase of the lagoonal system as indicated by the presence of a turf layer at the top, as well as presents an erosional surface with marine sediments at the base. The Chuí outcrop (S2) represents the early formation of the lagoonal system, associated with the maximum Holocene transgression. In the S1, the age difference between marine and estuarine shells was around 1,000 yrs. (*Anomalocardia brasiliana*: 5,020 yrs. BP and *Heleobia* sp.: 4,030 yrs. BP), while in the S2 it was lower, about ~250 yrs (*Pitar* sp.: 5,590 yrs. BP and *Tagelus plebeius*: 5,330 yrs. BP). These preliminary results show that time-averaging may be related to the geological/evolutionary context of the lagoonal system. Nevertheless, the time-averaging can also be species-related that is, dependent of species' composition of the fossil assemblages. Furthermore, as it has been shown in previous studies, the recent (lagoon) geological record is rich in marine species, although estuarine species are preserved in their fully. Therefore, the results presented here are preliminary, and more radiocarbon dates are needed to understand the patterns of time-averaging in those lagoonal deposits.

EXPERIMENTAL ENCRUSTATION IN TIME-AVERAGED MARINE MOLLUSCAN DEPOSITS

Matias do Nascimento Ritter[1], Vanessa Ochi Agostini[2], Erik Muxagata[3] and Fernando Erthal[4]

1. Programa de Pós-Graduação em Geociências, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, CEP 91501-970, Porto Alegre, Cx. P. 15001, Brazil. mnritter@gmail.com

2. Programa de Pós-Graduação em Oceanografia Biológica, Instituto de Oceanografia, Laboratório de Zooplâncton, Universidade Federal de Rio Grande, Rio Grande, CEP 96201-900, Brazil.

3. Instituto de Oceanografia, Laboratório de Zooplâncton, Universidade Federal de Rio Grande, Rio Grande, CEP 96201-900, Brazil.

4. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, CEP 91501-970, Porto Alegre, Cx. P. 15001, Brazil.

The southern Brazilian continental shelf includes several surficial sandy biodetritic deposits, distributed parallel to the present coastline and composed of time-averaged molluscan shells with a minimum age range from 0 to17 ka. These shell beds are transgressive lag deposits (associated with transgressive systems tracts and condensed sections) formed after the Last Glacial Maximum. These expressive shell beds are suitable hard substrate for the development of communities with varied recruitment strategies. This study evaluated and compared the potential for colonization of sclerobionts on shells of four bivalve species, with different outer textures. This experimental study is assessing encrustation in time-averaged shells assemblages, simulating the input and reworking in the taphonomically active zone (TAZ). A laboratory experiment was conducted in fishbowls with a diameter of 20 cm and a height of 18 cm and with a 5 cm layer of sand covered with 10 cm of seawater, during five weeks, simulating marine subtropical conditions. Shells of *Anadara brasiliana*, *Amiantis purpurata*, *Mactra janeiroensis* and *Amarilladesma mactroides* were randomly deployed in each fishbowl, totalizing six replicates. Weekly, the seawater of the fishbowls, was partly renewed, together with the plankton (larvae fouling in potential), which was collected, for two minutes, with a plankton net (200 µm of mesh) in Cassino Beach, Brazilian southern coast, to supply larvae to the experiments. At the end of the experimental trial, the numbers of recruits on the bivalve shells were tallied under a stereoscopic microscope. The density of encrusters (org 25cm^{-2}) was significantly higher ($F_{(3,40)}$=14.343; p=0.000) for *A. brasiliana*, followed by *M. janeiroensis*, *A. purpurata* and *A. mactroides*. This pattern was also observed for taxa richness, although the difference was not significant ($F_{(3,40)}$=0.987; p=0.408).When the larval recruitment density and richness was compared for ventral versus dorsal sides of the shells, a higher density was seen dorsally, regardless of the bivalve shell species, although the difference was not significant ($F_{(1,46)}$=1.506; p=0.225). On the other hand, the higher richness was observed ventrally ($F_{(1,40)}$=5.090; p=0.029). In all bivalves' species, oyster, barnacle and gastropod encrusters were identified. Shells with reinforcement structure, like *A. brasiliana*, showed the highest encrustation density, probably due to larger niches availability to larvae. Nevertheless, infaunal species experienced lower encrustation rates, possibly due to intrinsic shell features, such as more moderate morphological heterogeneity.

PALYNOFACIES ANALOGUES AND APPLICATIONS TO HYDROCARBON EXPLORATION IN NEW ZEALAND

Lucia Roncaglia[1], Christopher J. Hollis[1] and Poul Schioler[2]

1. GNS Science, 1 Fairway Dr., Avalon, Lower Hutt, 5010, New Zealand. l.roncaglia@gns.cri.nz
2. Morgan Goodall Palaeo, Unit 1, 5 Arvida St., Malaga WA 6090, Australia.

Visual kerogen and palynofacies analyses are useful tools for determining the origin, composition and petroleum generative potential of organic-rich sedimentary rocks and the depositional conditions for a wide range of sediments and sedimentary rocks. Firstly, we provide an example of analogues in a high latitude setting to test existing palynofacies models through comparing quantitative palynofacies and environmental data from sediments deposited over the last 1500 yrs. Secondly, we use the palynofacies model to interpret the conditions of deposition for a potential Paleocene source rocks in New Zealand's sedimentary basins, the coeval Tartan and Waipawa Formations. Results from the analogue study show that the distribution of particulate organic matter in environments ranging from near-shore to deep-sea is controlled by the distance from the shore and water depth. Phytoclasts and amorphous matter represent the major components of the total assemblage in coastal and shelfal settings; phytoclasts are rare to absent in the distal, deep-water sediments. In deep-water, palynomorphs consist of a selection of organic material, which could result from transport, sorting or grading. In the Great South Basin, palynofacies analysis of the Tartan Formation (early Late Paleocene) (10% average TOC) indicates that it was deposited in a marginally marine environment with strong influx of terrestrial plants. Analysis of the underlying and overlying units indicates that they were deposited in more distal conditions. The changes observed are best explained by as base-level fall and short-lived regression, including deposition of the Tartan Formation, followed by latest Paleocene–Eocene transgression. To the north, analysis from the Tartan Formation in the Canterbury Basin and the Waipawa Formation in the East Coast Basin shows that they share palynofacies and geochemical characteristics, indicating that a base-level fall also controlled the deposition of the these units in northern basins, although it occurred over a wider range of depositional settings. The extent of the area affected by the base-level fall indicates that it was probably caused by eustasy. Associated studies also show that deposition was accompanied by short-lived but pronounced climatic cooling at ~59 Ma. Implications for hydrocarbon potential are that these units may have a larger and possibly more continuous offshore distribution than previously thought.

MODERN ESTUARIES AS ANALOGUES FOR PERMIAN AND CRETACEOUS INTRACRATONIC SEAS

Luke Strotz[1]

1. Macquarie University, Department of Biological Sciences, Building E8A, North Ryde, 2109, Australia.
luke.strotz@mq.edu.au

It has been proposed that physiochemical conditions within Australian Early Permian and Early Cretaceous intracratonic seas resembled conditions currently prevalent in modern marginal marine systems. This assertion is based upon the parallels between foraminiferal assemblages recovered fromboth of these ancient high-latitude interior seas and those found in modernmid- to high-latitude estuaries. For all threecases, the foraminiferal microbiota is dominated by organic-cemented siliceous agglutinated taxa. With an aim to determining whether the proposed comparison is justified and establishing a better understanding of physiochemical conditions in these fossil interior seas, a detailed examination of modern southeastern Australian estuarine foraminiferal assemblages was undertaken. Results reveal strong morphological and taxonomic similarities between the modern and fossil assemblages, with comparable patterns of within-system distribution. It is also identified that estuarine foraminiferal assemblages represent a discrete assemblage that may be recognised in the fossil record and that Permian and Cretaceous intracratonic sea foraminiferal assemblages largely reflect the composition of the living biota at the time of deposition. Combined, these three results indicate that comparisons of Australia's Early Permian and Early Cretaceous intracratonic seas to modern marginal marine systems are justified and that, over much of their area, these fossil interior seas were shallow-water, hyposaline environments, physiochemically similar to what is observed in present-day cool-temperature estuaries and marshes.

ACTUALISTIC TAPHONOMY OF FRESHWATER MOLLUSKS IN SHALLOW LAKES FROM THE SOUTHEASTERN PAMPAS

Eleonor Tietze[1] and Claudio G. De Francesco[1]

1. Instituto de Investigaciones Marinas y Costeras (IIMyC), Consejo Nacional de Investigaciones Científicas y Técnicas–Universidad Nacional de Mar del Plata, Juan B. Justo 2550, Mar del Plata, B7608FBY, Argentina. cgdefra@mdp.edu.ar

The main purpose of paleoecological studies is to perform accurate reconstructions of past environments. Following this objective, it is fundamental to understand and estimate the importance of constructive and destructive processes that influence the development of death and fossil assemblages. The first step is to evaluate which taphonomic processes act during the residence time of remains residing around the sediment-water interface and to what extent do they reflect their original living communities. Southeastern Pampean lakes are very shallow (1-3 m in depth). Depositional processes dominate over erosive ones, allowing shell accumulation accessible to be used in environmental reconstruction. Mollusks are abundant organisms in these lakes, commonly recorded alive, dead and fossil. With the aim of understanding the taphonomic processes that affect freshwater mollusk remains, compositional fidelity and preservation was assessed in four lakes applying qualitative and quantitative (uni- and multivariate) techniques. A total of 15 species were collected. Two of them were allochthonous species for freshwater habitats, and were thus, excluded from the analyses. Despite the homogeneity of the area, differences in diversity and taphonomy were recorded in living and death assemblages. Life and death assemblages varied greatly among lakes both in terms of abundance (n= 67–3102) and richness (2–9). Some death assemblages presented higher abundances than life assemblages, while other death assemblages were less abundant than their molluscan community. These differences in abundance affected the fidelity in richness but not in Shannon-Weiner and Simpson indexes. However, all death assemblages were represented by within-habitat time-averaged samples without several effects of premortem and postmortem processes. The taphonomic attributes that mainly affected shells were loss of proteinaceous parts, fragmentation and fine-scale surface alteration. Life/death agreement and taphonomic differences were related both to environmental conditions (extrinsic factors) and faunistic composition (intrinsic factors). In these environments, which are highly dynamic and productive, one of the extrinsic factors affecting death remains is carbonate saturation, which may vary among lakes, seasons and years. Besides, productive systems favor microbioerosion by promoting carbonate dissolution facilitated by boring microorganisms. In the case of intrinsic factors differential preservation and input rates of thin-/thick-shelled species were especially important, despite the high dominance of one species, *Heleobia parchappii*. Although the degree of taphonomic alteration across lakes and environments was variable, all mollusk assemblages still preserved their biological signature from the precursor communities.

SYMPOSIUM

NEOPROTEROZOIC PALAEOBIOLOGY: PRESERVATION, PALAEOBIOLOGY, ENVIRONMENTS AND PHYLOGENY

ORGANIZERS:

JIM GEHLING - GUY NARBONNE

PALAEOBIOLOGICAL INSIGHTS INTO A DOUSHANTUO-PERTATATAKA-TYPE MICROBIOTA FROM THE BISKOPÅS FORMATION OF SOUTHERN NORWAY

Peter W. Adamson[1] and Nicholas J. Butterfield[1]

1. Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge, CB2 3EQ, UK.
pwa24@cam.ac.uk

The early Ediacaran is marked by a distinctive assemblage of large acanthomorphic acritarchs, best known from the Doushantuo Formation of South China, but also occurring globally. These large acanthomorphic acritarchs, known as the Doushantuo-Pertatataka Microbiota (DPM), are key to illuminating early evolutionary developments in the Ediacaran. The affinities of this microbiota are hotly contested, with fossils from the Doushantuo Formation in South China purportedly yielding taxa with metazoan characteristics. The DPM is also preserved in phosphorite pebbles of the Ediacaran Biskopås Formation in southern Norway, stratigraphically constrained by Gaskiers equivalent tillites of the Moelv Formation above and by a 620 ± 14 Ma U/Pb age from detrital zircons of the Brøttum Formation below. These phosphorites were incorporated into the base of the Biskopås conglomerate as angular pebbles, deposited within the shallow marine Hedmark Group. To date we have identified thirteen acanthomorphic acritarch taxa from the phosphorites, including the genera *Eotylotopalla*, *Ericiasphaera*, *Mengeosphaera*, *Papillomembrana*, and *Tanarium*, along with a range of sphaeromorphic acritarchs and microbial filaments. This assemblage shares marked taxonomic and taphonomic similarities with the phosphatized Doushantuo acritarchs, i.e. early diagenetic apatite rims forming on vesicle walls and secondary silica replacement. Analysis of acritarch vesicle collapse shows the extent and frequency of collapse in acanthomorphic (ornamented) acritarchs are appreciably higher than for sphaeromorphic (unornamented) acritarchs. Significantly, a strong dichotomy also exists between specific acanthomorph taxa; *Papillomembrana* exhibits the greatest propensity to collapse, while taxa bearing conical processes (e.g. *Mengeosphaera*) exhibit the least. In the absence of any observed taphonomic controls, vesicle collapse must indicate differing *in vivo* vesicle plasticity and can potentially be used to elucidate *in vivo* function and mode of life, e.g. cyst versus vegetative cell. The interspecific variation in acritarch vesicle collapse demonstrates the artificial nature of acanthomorphic acritarchs as a group, and that certain sphaeromorphic and acanthomorphic acritarchs are best considered together. These early findings reveal a significantly higher acanthomorphic acritarch diversity in the Biskopås than previously documented, while taphonomic analysis of the populations can help to create meaningful taxonomic divisions.

BIODIVERSITY AND REDOX CONDITIONS THROUGH THE PROTEROZOIC TAOUDENI BASIN OF MAURITANIA

Jérémie Beghin[1], Simon Poulton[2], Nur Gueneli[3], Jochen Brocks[3], Jean-Yves Storme[1], Christian Blanpied[4], Jean-Pierre Houzay[5] and Emmanuelle Javaux[1]

1. University of Liège, Liège, 4000, Belgium. jbeghin@ulg.ac.be
2. University of Leeds, Leeds, LS2 9JT, United Kingdom.
3. Australian National University, Canberra, ACT 0200, Australia.
4. TOTAL, Projets Nouveaux, Paris, France.
5. TOTAL, Fluids and Geochemistry Dept., Pau, France (retired).

Prokaryotes and microscopic eukaryotes are known to have appeared well before the Cambrian's adaptive radiation, when the macroscopic world flourished. What do we know about the trigger events which stimulated eukaryotic diversification during the Proterozoic? Biological innovations or environmental changes, and indeed probably both, played a fundamental role controlling this important step of life's evolution on Earth. A diversification pattern of early eukaryotes divided into three steps and focusing on different taxonomic levels of the domain Eukarya, from stem group to within crown group, remains to be tested. Supercontinent formation and break-up, widespread glaciations, meteor impacts, atmosphere and ocean oxygenation and chemistry are the main environmental changes which probably led to eukaryotic diversification. A stratified ocean, during the so-called 'boring billion' (~ 1.8-0.8 Ga), with anoxic ferruginous deep water, euxinic mid-depths, and oxygenated shallow-waters, is thought to have delayed eukaryotic diversification after the Great Oxidation Event (~ 2.4 Ga) by restricting eukaryote evolution and limiting nutrient availability. Here we present new, exquisitely preserved and morphologically diverse assemblages of organic-walled microfossils from three drill cores of the ~ 1.1 Ga Atar/El Mreïti Groups (Taoudeni Basin, Mauritania, Northwestern Africa). These assemblages include beautifully preserved microbial mats comprising pyritized filaments, prokaryotic filamentous sheaths and filaments, microfossils of uncertain biological affinity including smooth isolated and colonial sphaeromorphs (eukaryotes and/or prokaryotes), diverse protists (ornamented and process-bearing acritarchs), as well as purported green algae and multicellular microfossils interpreted in the literature as possible xanthophyte algae. Several taxa are reported for the first time in Africa, but are known worldwide. Palynofacies and Raman microspectroscopy analyzes were performed to investigate thermal maturity and the preservation state of organic matter; iron speciation was also conducted to reconstruct the ocean palaeoredox conditions. This study improves the microfossil diversity previously reported and demonstrates the presence of unambiguous eukaryotes. These new microfossil assemblages, in combination with global data sets, provide evidence of early and worldwide diversification of eukaryotes around 1 billion years ago. To better understand the palaeobiology (stem or crown group, aerobic or anaerobic metabolism) and palaeoecology (habitat diversity) of these early eukaryotes, we are combining morphological, microchemical, ultrastructural and quantitative analyzes of microfossils with a high-resolution characterization of eukaryotic biomarkers and palaeoenvironmental and palaeoredox proxies.

EVIDENCE OF EDIACARAN MOTILITY AND THE ORIGINS OF BILATERIANS

James G. Gehling[1] and Mary L. Droser[2]

1. South Australian Museum and University of Adelaide, South Australia. Jim.Gehling@samuseum.sa.gov.au
2. Department of Earth Sciences, University of California, Riverside, CA, USA.

Fossils of the Ediacara biota are the earliest evidence of large and diverse organisms on Earth. While the animal affinities of the Ediacara biota have been challenged, there is little disagreement that animals of poriferan and cnidarian affinities were a major component of the earliest known fossil assemblages in Newfoundland and NW Canada and, to a lesser extent, the younger assemblages in South Australia, NW Russia and Namibia. Although cnidarians and even protozoans are capable of producing crude locomotive traces, these are limited in style and continuity. Even after detailed taphonomic analysis of casts, moulds and carbonized imprints of Ediacara fossils, comparative morphology alone cannot demonstrate the existence of basal, stem group bilaterians with any confidence. The feeding traces associated with body fossils of *Kimberella*, *Dickinsonia* and *Yorgia*, from Ediacaran assemblages in Australia and Russia, are the exceptions in that they provide the strongest evidence of bilaterians in the White Sea Association of the Ediacara Biota. Distinctive tubes and traces of animal activity appear in a variety of palaeogeographic and sedimentary settings of the late Ediacaran and early Cambrian periods (circa 555 to 525 Ma). This trace fossil record preceded the widespread preservation of skeletal fossils and special body-fossil deposits of the Early Cambrian. The increasing sophistication of trace fossils spanning the Ediacaran-Cambrian boundary offers the best evidence of a significant shift in the benthic ecology of marine animals. Trace fossils provide the only reliable evidence for the rise of scavengers and predators that triggered the "Cambrian explosion".

DID BIOTURBATION CAUSE THE FUSE TO THE CAMBRIAN EXPLOSION TO BURN FASTER?

Alan J. Kaufman[1], Kalev Hantsoo[1], Huan Cui[1] and Guy M. Narbonne[2]

1. University of Maryland, Geology Department and Earth System Science Interdisciplinary Center, College Park, MD 20742-4211, USA.

2. Queens University, Department of Geological Sciences and Geological Engineering, Kingston, ONK7L 3N6, Canada. narbonne@queensu.ca

Animals capable of stirring up sediments in search of food appeared suddenly in the trace fossil record at the dawn of the Cambrian Period about 541 million years ago. By actively ventilating marine sediments for the first time in Earth history, these animals enabled the oxidation of reduced organic matter and toxic hydrogen sulfide, and thus permanently changed the carbon and sulfur cycles. A high-resolution stratigraphic collection of mudstones from the Chapel Island Formation — the internationally recognized stratotype for the Fortunian Stage of the Cambrian Period — was used to test the hypothesis that progressive bioturbation caused systematic shifts in the abundance and isotopic composition of residual kerogen and pyrite preserved in sediments. Although concentrations of organic carbon are low in these samples, time-series trends in isotopic compositions reveal the progressive enrichment of ^{13}C (from baseline values of ca. -28‰ to as high as -21‰) in the first 20 meters of the succession above the GSSP associated with the FAD of *Treptichnus*, *Skolithos*, *Monomorphicnus*, *Gyrolithes*, and *Curvolithus*. Over the next 300 meters (where*Taphrhelminthopsis*, *Helminthopsis*, and *Rusophycus* occur sequentially) the carbon isotope composition of organic matter is variably enriched, but shows an overall trend back towards baseline values. The carbon isotope excursion notably ends and $d^{13}C$ compositions stabilize at baseline values of -28‰ through the FAD of biomineralized fossils, including *Ladatheca*, *Halkeria*, *Watsonella*, and *Igorella*. Comparison with published records of carbonate carbon isotopes through the Fortunian indicate a strong decoupling of organic and inorganic reservoirs. We suggest that the efficient transport of organic carbon from surface waters to sediments spurred the burrowing adaptations revealed by the Chapel Island trace fossils and that oxidation of buried organic matter resulted in the measured ^{13}C enrichments. Consistent with the bioturbation hypothesis, mudstone samples were found to contain between 10 to 20% diagenetic carbonate, which we suggest to be authigenic in origin. These observations are consistent with the metabolic activities of sulfate-reducing bacteria, which selectively oxidize ^{13}C-depleted organic compounds using sulfate as an oxidant, while leaving behind refractory carbon enriched in the heavy isotope. Chapel Island carbon isotope compositions return to pre-event values and stabilize near the first appearance of biomineralized fossils associated with the Cambrian Explosion. The FAD of these organisms thus appears to be related to the stabilization of marine environments after a prolonged interval of carbon cycle instability following the Ediacaran-Cambrian boundary.

BIOLOGICAL INNOVATION IN THE EDIACARAN OF CHARNWOOD FOREST: STRATEGIES AGAINST SEDIMENT OCCLUSION

Charlotte G. Kenchington[1] and Philip R. Wilby[2]

1. Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge, CB2 3EQ, UK. cgk27@cam.ac.uk
2. British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK.

The Avalon Assemblage of Charnwood Forest (UK) and Newfoundland (Canada) collectively comprise amongst the oldest known occurrence of complex Ediacaran macrofossils. Although long considered the poor cousin of the Newfoundland succession, recent cleaning and silicone rubber moulding of bedding surfaces in Charnwood Forest has revealed a diverse and well-preserved biota, including at least seven previously undescribed taxa. All are preserved as low-relief impressions on upper bedding plane surfaces. Detailed petrographic work in Newfoundland and Charnwood Forest has revealed a strong correlation between the nature of the beds directly underlying the fossiliferous horizons and the composition of the hosted biota, particularly in terms of their functional morphology. Stalked forms such as *Primocandelabrum* preferentially occur on beds with abundant out-size silt-sand grains. In contrast, flat-lying forms such as *Fractofusus* are dominant on beds with a homogenous, massive character which lack the silt-sand-grade sediment influx. Some of the coarsest grains observed in any of the studied sections from Avalonia are present in Charnwood Forest, with grains up to very fine sand present immediately beneath the fossil-bearing surface. The unusual abundance of such coarse grains had an important impact on the structure of the assemblage, which typifies the stalked-dominant/flat-lying absent association. Two of the new taxa, the colloquially-named "Dumbbells" and "Basil Brushes", display novel adaptations which would have been beneficial in this environment. The "Dumbbells" have large holdfast discs, proportionally long stalks and a dense, multi-branched, frondose crown. Although the stalks may have originally evolved as a response to nutrient competition (tiering), they would have also served to raise the frondose part of the organism well above sediment accumulating from small-scale, sub-lethal events that would have smothered flat-lying forms. Their unusual length may thus represent modification of a pre-adaptation to this environment. The 'Basil Brushes' possess a proportionally shorter stalk, but have a novel structure which enshrouds the frond and which would have shielded the frondose parts from incoming sediment. Access of nutrients to these parts may have been facilitated either via the open top part of the shroud, or by diffusion through the shroud. Broad scale correlations between depositional environment and biotic association have been demonstrated in the White Sea and SE Australia. Detailed petrographical microfacies analysis in these assemblages, coupled with detailed studies of the functional morphology of the hosted biotas, may reveal finer correlations between biota and depositional environment, and help refine understanding of their ecology.

EDIACARAN CLADES

Marc Laflamme[1]

1. Department of Chemical and Physical Sciences, University of Toronto Mississauga, Mississauga, Ontario, L5L 1C6, Canada. marc.laflamme@utoronto.ca

The Ediacara biota are globally-distributed and temporally restricted (579-542 Ma) organisms representing a diverse assortment of unrelated higher-order groups (clades) including extinct lineages and rare animals. The higher-order disparity of Ediacaran-aged macro-organisms is however poorly resolved. The necessity to understand the evolutionary relationships among these enigmatic fossils is staggering, especially considering the fact that these organisms form the prelude to the Cambrian explosion of bilaterian animals. Previous classification schemes had a tendency to ally all of these macroscopic forms into a single clade, be it as stem and crown Metazoa or more controversially as an extinct clade on par with metazoans - the Vendobionta. Instead, it is proposed herein that Ediacara-type biota consist of several higher-order clades both within and outside of Metazoa. A detailed reevaluation of the classification hierarchy of Ediacaran fossils is proposed, with the goal of building a framework for future phylogenetic and evolutionary studies. Without a proper phylogenetic hierarchical scaffolding in place, Ediacaran studies of diversity, disparity, community ecology, and overall evolutionary patterns are difficult to construct and almost impossible to evaluate. This novel classification identifies shared derived morphological, behavioral, ontogenetic, and taphonomic-based characters allowing for hierarchical constructions within individual clades, and sets the framework for future studies pertaining to Ediacaran diversity and evolution.

LATE EDIACARAN SPECIES OCCURRENCES IN AVALONIA, AND THEIR UTILITY FOR BIOSTRATIGRAPHIC AND EVOLUTIONARY STUDIES

Alexander G. Liu[1]

1. Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge, CB2 3EQ, U.K.
agscl2@cam.ac.uk

Late Ediacaran macrofossils from sites deposited offshore from the ancient micro-continent of Avalonia record some of the oldest large and complex life-forms on Earth. Localities in eastern Newfoundland (Canada) and the United Kingdom contain 1000s of fossils, distributed across hundreds of siliciclastic bedding planes. Moderately diverse assemblages of large, soft-bodied organisms, dominated by frondose rangeomorph taxa, are observed throughout several kilometres of sedimentary succession, spanning around 20 million years of geological time. I here present the first attempt to accurately constrain the stratigraphic ranges of late Ediacaran macrofossil taxa across Avalonia. Previously published biostratigraphic information regarding Ediacaran organisms from Avalonian sites is limited to one regional study on the Bonavista Peninsula, and a handful of broad literature reviews. Given the potential utility of macrofossils for sub-division of the Ediacaran Period, it is now timely to assess species occurrence data, and to determine whether they can be relied upon for regional or global correlation. A systematic study of Ediacaran macrofossil occurrences measured the stratigraphic position of 220 fossil-bearing bedding planes and the occurrence and relative abundance of taxa on them, yielding over 800 species occurrences. Stratigraphic range charts for the Bonavista, Avalon, and Baccalieu Peninsulas were compiled, and are supplemented by data from Charnwood Forest in Leicestershire, U.K. These regions were treated separately to acknowledge uncertainties in regional lithostratigraphic correlation. The data reveal that individual taxa vary markedly in their stratigraphic ranges, with peak diversity occurring within the Mistaken Point and Trepassey Formations. Fossil preservation potential appears to be strongly controlled by sedimentology, which may limit the utility of these range charts in regional correlation. Differences in the relative abundance of species on bedding planes reveal that certain taxa are commonly found to be dominant on the ancient seafloor (e.g. *Fractofusus*), whereas others appear to form preferred bedding plane assemblages with other taxa. The observed ranges can be used to constrain previous hypotheses regarding relationships between taxa, and their ancestry. They also reveal patterns of character acquisition amongst the taxa, informing us about evolutionary progress and ecological innovation within these earliest macrobiotic communities. Finally, discoveries of previously undocumented bedding planes exhibiting exceptional preservation and several new species of both rangeomorph and non-rangeomorph taxa, greatly enhance our knowledge of late Ediacaran palaeobiology within Avalonian marine assemblages.

A MUSCULAR METAZOAN FROM THE LATE EDIACARAN MARINE SUCCESSIONS OF NEWFOUNDLAND, CANADA

Alexander G. Liu[1], Martin D. Brasier[2,3], Latha R. Menon[2], Jack J. Matthews[2] and Duncan McIlroy[3]

1. Department of Earth Sciences, University of Cambridge, Cambridge, CB2 3EQ, U.K. agscl2@cam.ac.uk
2. Department of Earth Sciences, University of Oxford, Oxford, OX1 3AN, U.K.
3.Department of Earth Sciences, Memorial University of Newfoundland, St. John's, NL, A1B 3X5, Canada.

In recent years, biomarker and molecular studies have constrained the search for the earliest animal fossils to late Neoproterozoic fossil assemblages. Convincing body fossil evidence for members of recognisable metazoan phyla in the Neoproterozoic is scarce, and is mostly confined to latest Ediacaran strata younger than 555 million years in age. In older sections, most evidence for the presence of metazoans currently stems from ichnological data. We report a remarkable new fossil from the ~560 Ma Fermeuse Formation of the Bonavista Peninsula, Newfoundland. This specimen, found within a distal turbidite sequence alongside frondoserangeomorph taxa more typical of late Ediacaran successions, possesses prominent bundles of fibrous ridges, 4-fold radial symmetry, a basal holdfast disc, and bifurcating branches. Our analysis of the bundle arrangements, fibre thickness and taphonomy are regarded as consistent with the muscular structure of a benthic cnidarian organism. The specimen invites comparison with living stauromedusans and scyphozoans, including the fossil Conulata, to which some enigmatic impressions of Ediacaran age (e.g. *Corumbella*) have been compared. Such an interpretation has significant implications for both the study of early animal evolution, and for our understanding of ecological complexity within late Ediacaran marine ecosystems.

THE FIRST SKELETONIZED ORGANISMS: EDIACARAN CALCAREOUS AND TUBULAR FOSSILS

Sara J. Mason[1] and Marc Laflamme[1]

1. University of Toronto Mississauga, 3359 Mississauga Rd, Mississauga, ON, L5L 1C6, Canada.
s.mason@mail.utoronto.ca

The Ediacaran-Cambrian boundary (541 Ma) records one of the most significant transitions in the history of life. One of the most notable changes across this boundary is the transition from the strictly soft-bodied macroscopic fossils typical of the Ediacara Biota to the mineralized shells and other hard parts that characterize the Phanerozoic fossil record. The first calcified animal fossils occur in the latest Ediacaran Period, from approximate 548 Ma, in numerous locations across the globe. Most of these calcified fossils have a tubular morphology, and problematic non-calcified tubular fossils, which are also common in fossiliferous late Ediacaran strata, may be taphomorphs of calcareous taxa or otherwise taxonomically related. Latest Ediacaran "small shelly fossil" taxa such as *Cloudina* and *Sinotubulites* and/or similar tubular fossils have been reported from terminal Neoproterozoic successions on nearly every continent. We have consolidated available information on Ediacaran small shelly fossils from numerous known localities, notably those in Namibia, China, Oman, Paraguay, Canada, the United States, Spain, and Russia. Data recorded in the database include geographic locations, stratigraphic information, paleoenvironmental settings, taxa present, size, preservational style and quality, presence and extent of possible predatory boring, associated microbial structures and sedimentary structures, and age estimates. From this database, trends are drawn concerning global biogeographic distribution, paleoenvironmental settings, and paleoecological associations. This information will help to guide field research on Ediacaran small shelly fossil reefs in Namibia, as well as future research on Ediacaran calcareous and tubular fossils from other sites internationally.

THREE-DIMENSIONAL MICRO-CT ANALYSIS OF THE EDIACARA FOSSIL *PTERIDINIUM SIMPLEX* SHEDS NEW LIGHT ON ITS ECOLOGY AND PHYLOGENETIC AFFINITY

Mike Meyer[1,2], Shuhai Xiao[2], David Elliott[3], Andrew Wood[4], Nicholas Polys[4], Matthew Colbert[5], Jessica Maisano[5], Patricia Vickers-Rich[3], Michael Hall[3], Karl Hoffman[6] and Gabi Schneider[6]

1. Geology Department, Bucknell University, Lewisburg, PA, USA. mbm033@bucknell.edu
2. Department of Geosciences, Virginia Tech, Blacksburg, Virginia, 24061, USA.
3. School of Geosciences, Monash University, Clayton, Victoria, 3800, Australia.
4. Advanced Research Computing, Virginia Tech, Blacksburg, Virginia, 24061, USA.
5. Jackson School of Geosciences, The University of Texas, Austin, Texas, 78712, USA.
6. Geological Survey of Namibia, Windhoek, Namibia.

Ediacara fossils often exhibit enigmatic taphonomy that complicates morphological characterization and ecological and phylogenetic interpretation; such is the case with *Pteridinium simplex* from the late Ediacaran Aar Member in southern Namibia. *Pteridinium simplex* is often preserved as three-dimensional (3D) casts and molds in coarse-grained quartzites, making detailed morphological characterization difficult. By utilizing microfocus X-ray computed tomography (microCT) techniques, we are able to trace individual specimens and digitally restore the 3D morphology of this enigmatic fossil. Our analysis shows that *P. simplex* has a very flexible integument that can be bent, folded, twisted, stretched, and torn, indicating a certain degree of elasticity. In the analyzed specimens, we find no evidence for vane identity change or penetrative growth that were previously used as evidence to support a fully endobenthic lifestyle of *P. simplex*; instead, evidence is consistent with the traditional interpretation of a semi-endobenthic or epibenthic lifestyle. The elastic integument of *P. simplex* is consistent with the presence of collagen, chitin, and cellulose, an inference that would provide constraints on the phylogenetic affinity of *P. simplex*.

RECOGNIZING THE REPRODUCTIVE MODE OF *FRACTOFUSUS* THROUGH SPATIAL ANALYSIS

Emily G. Mitchell[1] and Nicholas J. Butterfield[1]

1. Department of Earth Science, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK.
ek338@cam.ac.uk

Fractofusus is one of the most distinctive members of the Rangeomorpha, a clade of "fractally branching" macroscopic fossils that has perennially defied palaeobiological resolution. Known exclusively from Avalonian biotas in SE Newfoundland (565-570 Ma), its preservation in large in-situ bedding plane populations allows original spatial distributions to be analysed, shedding light on their reproductive biology. Using differentiated GPS we mapped the spatial distribution of *Fractofusus* on three separate bedding surfaces to millimeter accuracy: 1) D surface, Mistaken Point – 1067 specimens over 47.7 m^2; 2) E surface, Mistaken Point – 1137 specimens over 54.8 m^2; and 3) H surface, Bonavista Peninsula – 1141 specimens over 37.7m^2. In each case, the spatial patterns of fossils were described using pair correlation functions and then compared with different types of clustering models. All three of the *Fractofusus* populations were found to exhibit Thomas clustering (i.e., individuals normally distributed about cluster centers), a pattern characteristic of internally mediated population dynamics, such as reproduction. Moreover, the clusters on E and H surfaces are themselves clustered (nested double-Thomas clusters), reflecting a reiterated biological pattern. Analysis of the spatial distributions of three size classes of *Fractofusus* on H surface revealed that the largest size-class (3.0–11.5 cm) is randomly distributed, whereas the medium size-class (1.5–3.0 cm) is clustered following a single Thomas cluster model, and the smallest size-class (< 1.5 cm) occurs as clusters of clusters following a nested double-Thomas cluster model. Intriguingly, the smallest size class clusters around the medium size class, and the medium size class around the largest size class. Taken together, these spatial distributions point to reproductive dynamics with three generations of *Fractofusus* present on E and H surfaces, and two generations on D surface. Comparison of pair correlation functions, cluster directionality, and mean cluster radius, further suggest that the *Fractofusus* clusters grew via a process of stolon-like reproduction, analogous to that seen in plants that propagate via asexual runners. The identification of this particular type of reproduction, across three generations, represents a fundamental new level of palaeobiological understanding for early Ediacaran rangeomorphs.

EVOLUTION AND ECOLOGY OF EDIACARAN ASSEMBLAGES IN NW CANADA

Guy M. Narbonne[1], Calla Carbone[1] and Marc Laflamme[2]

1. Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, ON, K7L 3N6, Canada. narbonne@queensu.ca

2. Department of Chemical and Physical Sciences, University of Toronto Mississauga, 3359 Mississauga Road N., Mississauga, ON, L5L 1C6, Canada.

Ediacaran fossils occur through more than 1 km of mostly deep-water strata at Sekwi Brook in the Mackenzie Mountains of NW Canada. Three assemblages are present in this section, and collectively permit evaluation of relative roles of evolution, ecology, taphonomy, and changes in chemical oceanography in controlling the taxonomic composition of Ediacaran assemblages. The "June beds" (ca. 580-560 Ma) contain abundant discoid holdfasts along with Ediacaran fronds (*Beothukis, Charnia, Charniodiscus, Primocandelabrum*) and recliners (*Fractofusus*) strikingly similar to coeval deep-water Avalonian assemblages from Newfoundland and Charnwood Forest in England. Taphonomic factors resulted in discs being preserved preferentially on turbidite soles and fronds being preserved preferentially within contourite beds. Bilaterian burrows are absent despite favourable facies for their preservation. The rangeomorph-dominated assemblage of the June beds is separated from the overlying Blueflower Formation by the Shuram anomaly, the most extreme ^{13}C excursion in Earth history. The lower part of the Blueflower Formation (ca. 550 Ma) comprises deep-water carbonates with abundant bilaterian burrows, mainly microbial grazers and near-surface deposit feeders, along with sporadic Ediacaran attachment discs and fronds. Shoaling in the uppermost Blueflower Formation resulted in an Ediacaran assemblage dominated by tubular body fossils with sporadic discoid holdfasts and a single specimen of the probable dickinsoniomorph *Windermeria*. A major regional unconformity 100 m higher in the section is at or near the Ediacaran-Cambrian boundary. The shallow-water upper Blueflower assemblage, dominated by bilaterian burrows and tubular body fossils, has no taxa in common with the rangeomorph-dominated, deep-water June beds assemblage lower in the section except for non-diagnostic attachment discs, but has some similarities with coeval shallow-water assemblages elsewhere in the world. These different assemblages occur in a single stratigraphic section and thus cannot represent biogeographic differences. Comparison of the Ediacaran assemblages at Sekwi Brook and elsewhere suggest that evolution and ecology were key, interlinked factors in determining the composition of Ediacaran assemblages worldwide.

WAXING AND WANING OF MICROBIAL LAMINITES IN THE AFTERMATH OF A PROTEROZOIC GLACIATION - MIRASSOL D´OESTE FORMATION, SOUTHERN MARGIN OF THE AMAZON CRATON (BRAZIL)

Guilherme Raffaeli Romero[1],Thomas R. Fairchild[1], Evelyn Mecenero Sanchez[1] and Afonso C. Rodrigues Nogueira[2]

1. IGC- USP, Rua do Lago 562, São Paulo, 05508-080, Brazil. graffaeli@gmail.com
2. IG-UFPA, Campus Universitário Guamá, Belém, 66075-110, Brazil.

In the mid to late Neoproterozoic, the Earth underwent a series of glaciations so intense that ice caps extended well into the tropics and possibly to the equator (Snowball Earth hypothesis). These ice ages have been documented worldwide partly by the occurrence of glaciogenic diamictites. Many of these diamictites are immediately overlain by cap carbonates with negative $\delta^{13}C$ signatures, whose origin is attributed to the equally intense greenhouse effect that put an end to these glaciations. In the northern Paraguay Fold Belt (west-central Brazil), the Mirassol D´Oeste Formation is one of these cap carbonates and consists of 16 m of dolostone deposited directly upon diamictites of the Puga Formation. Laterally continuous and morphologically simple stromatolites, a common component of Marinoan cap carbonates worldwide, occur two meters above the base of the Mirassol D´Oeste Formation and continue upwards as stratiform microbial boundstones for 10 m. These microbialites are made up of alternating thin and thick laminae of peloids (micritized remains of microbial colonies) and subordinate micrite with spar-filled fenestrae, which differ only in the greater abundance of fenestrae in the thicker laminae. Commonly, these laminites form meter-sized domical mounds cut by clearly defined sub-cylindrical vertical structures up to 3.5 cm in diameter filled by massive dolomicrite. This association comprises a peculiar carbonate facies known as "tubestone", that seems to be exclusively associated with Marinoan cap carbonates (c. 635 Ma). In the present case, generally evenly spaced tubes occur in clusters always associated with the flattest, most elevated portions of the mounds. The homogeneous fill and the restriction of these tubes to domed stromatolitic laminites suggest the following hypothesis: interstitial fluids saturated in gaseous products of subsurface organic decomposition (and probably trapped under impermeable matgrounds) migrated under pressure to topographic highs (the domes) on the seafloor, eventually rupturing incipiently lithified stromatolitic laminae, thereby generating homogeneous carbonate mud that was immediately redeposited within the tubes. Above the tubestones, stratiform laminites form a 1-m-thick succession of irregularly wavy, commonly asymmetrical, laterally continuous stromatolites having decimetric dimensions. This is followed by dolomitic peloidal grainstone-packstone with megaripple marks and millimetric megapeloids apparently generated by wave action during hyper-storms. Such storms and a rising sea level put an end to microbialite deposition in the cap carbonate of the Mirassol D´Oeste Formation.

PLACING *DICKINSONIA* SPRIGG 1947 AND THE "DICKINSONIOMORPHS" ON THE TREE OF LIFE

Bruce Runnegar[1], David A. Gold[2], David K. Jacobs[1,2] and James G. Gehling[3]

1. Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles, CA 90095, USA. runnegar@ucla.edu
2. Department of Ecology and Evolutionary Biology, University of California, Los Angeles, CA 90095, USA.
3. South Australian Museum, Adelaide, SA 5000, Australia.

The iconic Ediacaran organism, *Dickinsonia costata*, is a member of a group known conventionally as the Family Dickinsoniidae or alternatively as the monophyletic clade Dickinsoniomorpha. A major challenge to understanding the biology—and hence the affinities—of this group has been the use of the term "glide symmetry" since the 1980s, especially in the Russian literature. Glide symmetry refers to a purported misalignment of serial body units termed "isomeres" across the midline. We consider this phenomenon to be the result of taphonomic noise. Sufficiently well-preserved fossils of *Dickinsonia* and allied genera (*Marywadea*, *Yorgia*, *Andiva*, *Ivovicia*) are demonstrably or (at least) ambiguously bilaterally symmetrical animals that increased in size through the terminal addition of meristic units from a posterior, subterminal growth zone. We base our understanding of the biology of *Dickinsonia costata* on a cohort of ~150 small (and presumably young) individuals found on the base of a single, 3-5 cm-thick bed of ripple-crested sandstone near Crisp Gorge in the central Flinders Ranges, South Australia. This community, which lived below fair weather wave base, allows us to assess the density, proximity, and orientation of individuals as well as to document their early ontogeny. Key specimens of larger individuals from other deposits confirm that *D. costata* was symmetrical across the midline and that there is no evidence for "segments" that branch laterally, contra Brasier and Antcliffe. We mapped the presence/absence of terminal addition on a Bayesian time-calibrated phylogeny of 44 unikont taxa ranging from fungi through choanozoans and basal metazoans to protostomes and deuterostomes. We then used ancestral state reconstruction to estimate the probability that terminal addition was a feature of the last common ancestor of the Bilateria, the Bilateria + Cnidaria, the Eumetazoa, or the total group Metazoa. Only the Bilateria node received strong support. Thus we conclude that stem and/or crown group bilaterians, including *Dickinsonia*, made up a significant proportion of the Ediacaran biota.

THE EARLIEST PROTO-GONDWANA SEAWAY

Lucas V. Warren[1], Fernanda Quaglio[1], Marcello G. Simões[2], Claudio Riccomini[3], Daniel Poiré[4], Nicolás M. Strikis[2], Luis E. Anelli[2] and Pedro C. Strikis[2]

1. Instituto de Geociências e Ciências Exatas - Universidade Estadual Paulista (UNESP), Avenida 24A, 1515, Rio Claro-SP, 13506-900, Brazil. quaglio@gmail.com
2. Instituto de Biociências - Universidade Estadual Paulista (UNESP), Rubião Júnior, s/n, Botucatu-SP, 18618-970, Brazil.
3. Instituto de Geociências - Universidade de São Paulo (USP), Rua do Lago, 562, Cidade Universitária-SP, 05508-080, Brazil.
4. Centro de Investigaciones Geológicas (UNLP-Conicet), Calle 1, 644, La Plata 1900, Argentina.

The occurrence of the Late Ediacaran guide fossil *Cloudina* sp. with other skeletal organisms and trace fossils is herein reported from the basal unit of the Bambuí Group (central Brazil). The new finding in the Sete Lagoas Formation represents one of the most important paleontological discoveries ever made in the Precambrian of South America, helping to solve an old paleogeographic puzzle of Gondwana supercontinent. So far, the age of the Bambuí Group is based on questionable geochronologic data spanning from 740 Ma to 590 Ma, which is now finally better constrained. Indeed, sedimentologic, stratigraphic and isotopic similarities of *Cloudina* interval in the Bambuí Group and other Neoproterozoic successions of Brazil, Uruguay, Argentina, Antarctica and Namibia suggest temporal and spatial correlation between these units. The Late Ediacaran age definition for the base of Bambuí Group changes drastically the interpretation that this unit was deposited in a foreland basin related to the evolution of an adjacent orogenic fold belt. The paleogeographic position of *Cloudina*-bearing successions of South America and Africa, including the central Bambuí Group, reinforces the hypothesis of ocean connectivity of coeval intracratonic basins at the end of Ediacaran. This new occurrence of shelled metazoans and trace fossils produced by soft-bodied organisms also represents a unique opportunity to understand ecologic and palaeobiologic issues of benthic communities that thrived in the epeiric sea of proto-Gondwana.

BIMODAL POPULATIONS AND INDETERMINATE GROWTH IN RANGEOMORPHS: NEW INSIGHTS INTO THEIR ECOLOGY

Philip R. Wilby[1], Charlotte G. Kenchington[2] and Robert L. Wilby[3]

1. British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK. prwi@bgs.ac.uk
2. Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge, CB2 3EQ, UK.
3. Department of Geography, Loughborough University, Loughborough, LE11 3TU, UK.

Rangeomorphs are common contingents of Ediacaran biotas, but their growth and development is poorly constrained. Data are currently available for only a few taxa, and these suggest differences in the dominance of inflation -versus insertion- programmes. Given the pseudofractal architecture of the clade and the size that some of its members may attain, the importance of deterministic versus non-deterministic growth is also intriguing. In the absence of definitive morphological evidence, such information may help constrain their biologic affinity. *Charnia masoni* has a highly organised and well-resolved architecture, rendering it a useful model for investigating rangeomorph growth. It occurs in abundance in Charnwood Forest (UK) within high-diversity and high-density deep-water assemblages that were felled *en mass* and preserved *in situ* beneath gravity-flow deposits. On several surfaces, including its type surface, some individuals of the taxon attain lengths of >0.5 m. These outsized specimens were previously assigned to *Charnia grandis*, but are now confidently synonymised with *C. masoni*: their branching architecture is indistinguishable from that of the holotype and their length to width ratio correlates strongly (R^2=0.96) with that of their more diminutive compatriots. Nevertheless, they bear substantially fewer primary branches per unit length: the holotype is 19.4 cm long and has 17 primary branches, whereas an associated 46.9 cm long individual has only 21. Additionally, they form a discrete cohort on size-frequency distribution plots, revealing a level of complexity (bimodality) exceeding that previously envisaged for Ediacaran biotas. Taken as a whole, the growth pattern of *C. masoni* resembles that of extant organisms with indeterminate developmental programmes. The morphological plasticity that these provide better enables organisms to respond to changes in environmental conditions (beneficial and detrimental), and would have aided the survival of *C. masoni* in the dynamic environments in which it lived. We show outsized fronds to be survivors of disturbance, and argue that their persistence influenced the ultimate structure of their communities. Outsized organisms in other assemblages may similarly record vestiges of this signal and their recognition enhances understanding of Ediacaran recruitment and competition.

SYMBIOTIC RELATIONSHIPS ON THE EVE OF METAZOA DIVERSIFICATION?

Bruno Becker-Kerber[1], Juliana M. Leme[2], Setembrino Petri[2], Douglas Galante[3], Fabio Rodrigues[3] and Mírian L. P. Forancelli[4]

1. Postgraduate Programme in Geochemistry and Geotectonic, Institute of Geosciences, University of São Paulo, Rua do Lago, 562, São Paulo, CEP 05508-080, Brazil. bruno.becker92@gmail.com
2. Institute of Geosciences, University of São Paulo, Rua do Lago, 562, São Paulo, CEP 05508-080, Brazil.
3. Brazilian Synchrotron Light Laboratory, Campinas, São Paulo, CEP 13083-970, Brazil.
4. Federal University of São Carlos, Sorocaba, João Leme dos Santos highway, CEP 18052-780, Brazil.

The emergence of animals capable of synthesizing hard parts in the Ediacaran fossil record is one of the most important evolutionary innovations in the history of life and was the prelude to the Cambrian "explosion" of diversity. *Cloudina* was one of those first biomineralized shells described from Ediacaran rocks, but even after 40 years since its description some questions remain regarding about its paleoecology, ontogeny and taxonomy. A recent recovered sample from Tamengo Formation (Corumbá Group) shows horizontal specimens of *Cloudina* interpreted to be in life position associated with microbial textures. In this sample, framboidal pyrite and goethite are widespread in the matrix. It is remarkable that almost all specimens hold a high concentration of those minerals in the spaces between the flare of the *Cloudina* funnels. By the means of Raman microspectroscopy, it was possible to confirm bands of goethite, the inferred altered form of pyrite, in those once "empty" spaces. Besides goethite, those spaces also contain early diagenetic calcite. A scenario that could explain this peculiarity involves the presence of biofilms or microbial communities within those spaces of *Cloudina* tubes that prevented the input of sediments and provided organic matter for decomposition by sulfate-reducing bacteria. Some specimens show this covering of calcite and goethite only on one side of the tube, suggesting that this side was in contact with the microbial mat whereas the other was slightly above the sediment-water interface. *Cloudina* occurs with microbialites in Namibia, China, Canada and Paraguay. The co-occurrence of *Cloudina* with microbialites implies an intrinsic relationship between these organisms, perhaps some kind of symbiotic relationship.

NANO-SCALE SPHEROIDS AND FOSSILS FROM THE EDIACARAN DOUSHANTUO FORMATION IN CHINA

Tenger Borjigin[1], Leiming Yin[2*], Lizeng Bian[3], Xunlai Yuan[2], Chuanming Zhou[2], Fanwei Meng[2], Xiaomin Xie[1] and Fang Bao[1]

1. Key Laboratory of Petroleum Accumulation Mechanisms, Wuxi Research Institute of Petroleum Geology, SINOPEC, Wuxi 214151, Jiangsu, China.

2. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, Jiangsu, China. myin2012@gmail.com

3. School of Earth Sciences and Engineering, Nanjing University, Nanjing 210008, Jiangsu, China.

Exceptionally preserved nano-scale spheroids derived from microbial processes and nano-scale fossils have been discovered from the black shales of the Jijiawan section of the Ediacaran Doushantuo Formation in the Yangtze Gorge area of Hubei Province, southern China. The numerous soccer ball-like spheroids are pyritized. Their morphology and abundant preservation may suggest that they could possibly be related to larger spheroids, regardless of the tremendous dimensional gap found in the phosphorite and cherts of the Doushantuo Formation, including those recognized as 'embryos'. The colony-like spheroids preserved *in situ* and obtained by acid maceration are compared with known Neoproterozoic microfossils—*Bavlinella faveolata* (or *Sphaerocongregus variabilis*). Additionally, nano-scale fossil bodies, characterized by morphological features comparable to living cyanobacteria, fungi and possible unicellular heterotrophic protists were observed in different minor laminae of the black shale samples. This study aims to reveal the aspects of nano-scale biota preserved in the black shale of the Ediacaran Doushantuo Formation, and highlight the taphonomy of microorganisms during the key transition from the anoxic deeper oceans to the oxygenated oceans of the early Ediacaran interval.

TESTATE AMOEBAE THROUGH TIME: EVALUATING THE GEOLOGICAL RECORD OF VASE-SHAPED MICROFOSSILS IN THE GEOLOGICAL RECORD

Luana Morais[1], Thomas R. Fairchild[1], Mírian L. A. F. Pacheco[2] and Daniel Lahr[3]

1. Instituto de Geociências, Universidade de São Paulo (USP). Rua do Lago, 562, São Paulo, SP. 05508-080, Brazil. lumoraiss@ymail.com

2. Departamento de Biologia, Universidade Federal de São Carlos (UFSCar – Campus Sorocaba). Rodovia João Leme dos Santos (SP-264), Km 110. Bairro do Itinga – Sorocaba, SP. 18052-780, Brazil.

3. Instituto de Biociências, Universidade de São Paulo (USP). Rua do Matão, trav.14, 231, São Paulo, SP. 05508-090, Brazil.

The geological record of testate amoebae dates from at least the middle Proterozoic in the Chuar Group (USA) (ca. 742 ± 6 Ma.) until the present. Many of these fossils are described as "vase-shaped microfossils" (VSM): an informal category of spheroidal to ellipsoidal microfossils of various chemical compositions and open at one end, interpreted as the tests of unicellular heterotrophs with uncertain systematic position. Just as the term "acritarch" is useful for grouping microfossils (probably microalgae) of uncertain systematic position, the term VSM is used here for testate microfossils that cannot be confidently attributed to established groups of similarly shaped foraminifera, tintinnids or chitinozoans. Although a few of them may possibly be foraminifera, the great majority is classified as thecamoebans belonging either to the Amoebozoa (*e.g.* Arcellinids) or the Rhizaria (*e.g.* Euglyphids), two phylogenetically distant groups that can present similar morphology and composition. In order to differentiate taxonomic affinities among such microfossils, the present study suggests a combination of four approaches for critically evaluating VSMs: (a) petrographic analysis to establish the relationship between the microfossils and the host rock and thereby exclude the possibility of contamination by modern organisms; (b) Energy-dispersive X-ray and Raman spectroscopy to determine chemical composition of uncoated specimens, essential for establishing the biogenicity and identity of the specimens; (c) X-ray microtomography, for viewing specimens in three dimensions; and finally (d) palynological preparation for isolating specimens in order to verify results generated by the previous techniques. The distribution of VSMs over time is marked by two intervals —Ordovician to Devonian (I) and Permian to Jurassic (II) — with practically no fossil record of the group. The first interval coincides with the period of proliferation and diversification of the Chitinozoa, and the second includes two major extinctions (end-Permian; late Triassic). Are these intervals taphonomic (or taxonomic) artifacts or might they attest to critical moments in the evolution of testate amoebae? The first step to answering this question is to reevaluate the reports of VSMs in the record using the combination of techniques suggested above.

THE PENETRATIVE TRACE FOSSIL *ARENICOLITES* FROM THE LATE EDIACARAN OF WESTERN MONGOLIA

Tatsuo Oji[1], Stephen Q. Dornbos[2], Hitoshi Hasegawa[1], Gonchigdorj Sersmaa[3] and Takafumi Mochizuki[4]

1. Nagoya University Museum, Nagoya University, Nagoya 464-8601, Japan. oji@num.nagoya-u.ac.jp
2. Department of Geosciences, University of Wisconsin-Milwaukee, Milwaukee, WI 53211, USA.
3. School of Geology and Petroleum Engineering, Mongolian University of Science and Technology, Ulaanbaatar 46/520, Mongolia.
4. Iwate Prefectural Museum, Ueda Aza Matsuyashiki, Morioka 020-0102, Japan.

An increasing number of ichnofossils have been reported from the Ediacaran, providing an important view of the early evolution of animals. Ichnofossils with clear penetrative vertical structures, however, have yet to be confirmed from the Ediacaran. Vertical burrows, some of which are U-shaped, are newly described here from muddy, bedded limestones of the late Ediacaran Zunne Arts Member of the Tsagaan Oloom Formation, Bayan Gol Valley, Gobi Altai, western Mongolia. The beds containing the traces are in member 15 of Khomentovsky and Gibsher, and the surrounding strata often contain flat pebble conglomerate, suggesting deposition above storm wave base. Based on the characteristic morphology of these burrows, they should be assigned to the ichnogenus *Arenicolites*. At least 25 circular and semicircular openings of *Arenicolites*, including doubtful ones, are found on the upper surface of one bedding plane (979 cm^2). The diameters of the openings range from 3 to 8 mm. At least three pairs of openings are closely positioned, and two of these pairs have similar opening diameters within the pair. In another limestone bed, two well-defined vertical shafts have been confirmed on the vertical edge of the limestone. These shafts both penetrate the sediment to approximately 4 cm in depth. Considering the compaction of this muddy limestone, the ichnofossil producers should have originally penetrated much deeper into the sediment. The Zunne Arts Member of the Tsagaan Oloom Formation contains some early types of small shelly fossils, such as *Anabarites*, but a recent carbon isotope profile obtained in nearby equivalent strata suggests that this member should be assigned to the uppermost Ediacaran. These *Arenicolites* also occur well below the first appearance of *Treptichnus pedum* in this section, which is at the base of the overlying Bayan Gol Formation. The age of these *Arenicolites* therefore confirms that vertically burrowing animals had evolved by the latest Ediacaran.

RECONSTRUCTING *RANGEA*: NEW TECHNOLOGY AND PALAEOBIOLOGICAL INTERPRETATIONS

Alana C. Sharp[1], Patricia Vickers-Rich[1], Peter W. Trusler[1] and Thomas H. Rich[2]

1. School of Geosciences, Monash University, Clayton, Victoria, 3800, Australia. alana.sharp@monash.edu
2. Museum Victoria, Melbourne, Victoria, 3001, Australia.

Digital techniques to study fossils have been gaining popularity in recent years. Surface scanning, computed tomography (CT) and synchrotron scanning can provide insight into the structure, function and ecology of extinct animals in a non-destructive way. *Rangea* is the type genus of the Rangeomorpha, an extinct clade near the base of the evolutionary tree of large, complex organisms which radiated during the late Neoproterozic. *Rangea* was probably an epibenthic frond that rested upright on the sea bottom, and all known fossil specimens were transported prior to their final burial in storm deposits. *Rangea* specimens are rare and sometimes very fragile making it difficult to produce an accurate reconstruction. The discovery of well-preserved specimens from Farm Aar in southern Namibia reveal the internal and external features of these animals, permitting new interpretations of *Rangea* morphology and lifestyle. Several of these specimens were scanned using synchrotron and high definition surface scanning to examine in more detail. Surface scanning allows us to magnify and visualise the external structure of fossils in incredible detail, and from these surface scans we can produce 3D models that can be printed in plastic or resin, replicated, and shared between institutes. In addition, CT and synchrotron scanning provide ways to visualise the internal anatomy of fossils. Faint features can be seen in the synchrotron scans of *Rangea* that may be the boundaries between internal structures such as the vanes that are arranged radially around the hexaradial axial bulb. This may provide further insight into the internal structure of *Rangea* and its palaeobiology.

SYMPOSIUM

TRACKING EVOLUTIONARY INNOVATIONS IN THE FOSSIL RECORD

ORGANIZERS:

DOUG ERWIN - JEREMY JACKSON

EVOLUTION OF THE LOPHOPHORE AND ITS MINERALIZED SUPPORTS

Sandra J. Carlson[1], Holly A. Schreiber[1] and David W. Bapst[1]

1. University of California, Davis, Department of Earth and Planetary Sciences, One Shields Avenue, Davis, CA, 95616, USA. sjcarlson@ucdavis.edu

What is evolutionary innovation? How does it differ from novelty or synapomorphy? It has been argued that hypotheses of innovation require not only the detection of macroevolutionary patterns, but also an evaluation of the ecological context and developmental mechanisms behind such patterns. In this study, we trace the evolution of the lophophore, a tentacular organ that directs the flow of ambient water, enabling the extraction of nutrients and oxygen and the expelling of gametes and waste products. Of the higher taxa that possess a true lophophore —bryozoans, phoronids, and brachiopods— only brachiopods contain the lophophore within a mantle cavity between two mineralized valves. Furthermore, different brachiopod lineages have evolved a variety of unique mineralized structures (e.g., crura, spiralia, loops, brachial ridges) to support and position the lophophore within the mantle cavity. We use these mineralized structures that support the lophophore to trace 'terminal' lophophore geometries (spirolophe, plectolophe, ptycholophe) and their ontogenies (trocholophe, schizolophe, zygolophe, terminal adult geometry) across the Phanerozoic. Using a comprehensive framework of data on brachiopod embryology and growth, phylogenetic relationships and environmental proxies, we can evaluate the developmental and ecological conditions that precede the origin of new lophophore geometries. Using both morphological and molecular phylogenies, we can compare and contrast the macroevolutionary patterns implied by different data sources. Furthermore, we predict that changes in lophophore geometry should drive change, via functional constraints, in body size (i.e. the volume of the mantle cavity between the valves). Mantle cavity volume, valve gape, and commissural geometry, in addition to lophophore and mineralized support geometries, directly affect the particular patterns of water flow into and out of the mantle cavity. Body size can vary among adults of different brachiopod species by several orders of magnitude, perhaps due to heterochrony. We can describe the impact of different combinations of lophophore geometries with body size as potential evolutionary innovation using the relative patterns of diversity over time as a measure of their relative macroevolutionary 'success'. Tentatively, the combination of a lophophore within a bivalved shell can be considered an evolutionary innovation, given the relative success of brachiopods as measured by species diversity over the Paleozoic Era. However, the limited recovery of brachiopods from the end-Permian mass extinction event suggests that this innovation had a limited 'lifespan' and underscores the transient nature of innovations over the full expanse of geological time.

A CONCEPTUAL MODEL FOR EVOLUTIONARY INNOVATION

Douglas H. Erwin[1]

1. Dept. of Paleobiology, National Museum of Natural History, PO Box 37012, Washington, DC 20013 USA.
erwind@si.edu

Evolutionary novelty and innovation has become an increasingly popular topic in evolutionary biology over the past decade, driven in part by the wealth of new information about the mechanisms of phenotypic change coming from comparative evolutionary developmental biology ("evo-devo"). Discussions of novelty have included disagreements over definitions: character-based definitions focus on the construction of new elements of a body plan that are not homologous to pre-existing structures, while process-based definitions involve transitions between adaptive peaks and the breakdown of ancestral developmental constraints. Focusing exclusively on novel morphologies, while important, ignores the larger ecological and evolutionary context that determines the success or failure of evolutionary novelties. I distinguish between a successful *evolutionary invention* (the origin of a novel morphology) and successful *evolutionary innovations*. As in technological innovation, many viable inventions never become innovations. Here I present a conceptual model for evolutionary innovations, derived from an earlier suggestion by Rich Lenski and colleagues: 1) New evolutionary spaces are *potentiated* by the broader environmental setting (physical, genetic, ecologic); *actualized* by genetic and developmental innovations, often involving changes in the nature of available variation in developmental gene regulatory networks, leading to a novel morphology; 3) *refined* by further developmental and ecologic changes; and 4) *realized* as evolutionary innovations by ecological expansion (which may be via increased abundance or taxic diversity) and evolutionary success. Importantly, these steps need not occur in this sequence. For example, innovations may be actualized by new phenotypes, and even by the establishment of a clade prior to the environmental potentiation that allows the clade to become successful, leading to a macroevolutionary lag. This conceptual framework illuminates events such as the Ediacaran-Cambrian metazoan radiation. The emerging research program in evolutionary innovation acknowledges that there is no simple mapping from genotype to phenotype, multiple forms of inheritance and multiple levels of selection, and the evolution of the evolutionary process over time (non-uniformitarianism).

TRACKING GNATHOSTOME INNOVATIONS IN THE JAWLESS FOSSILS BY SYNCHROTRON X-RAY MICROTOMOGRAPHY

Zhikun Gai[1]

1. Laboratory of Vertebrate Evolution and Human Origins of Chinese Academy of Sciences, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing,100044, China. gaizhikun@ivpp.ac.cn

The huge morphological gaps between cyclostomes and gnathostomes have been attributed to the burst of morphological innovations, which is linked with the genome duplication during the origin of jaws. However, 'ostracoderms'(fossil bony jawless vertebrates) elucidated a much less dramatic pattern of morphological change. Using synchrotronX-ray microtomography, here, we show that galeaspids, 435–370-million-year-old jawless fishes from China, have acquired mosaic gnathostome characters before jaws. The virtual head of galeaspid revealed two separated nasal sacs, a buccohypophyseal duct, trabecular process, ossified sclera, elongate olfactory tracts, terminal nerves, united spinal nerves, and paired dorsal aortae, a suite of anatomical features that distinguish gnathostomes from their living jawless relatives. The new body-preserved materials reveal, for the first time, that galeaspids have two or three dorsal fins, and an epicercal tail. The mosaic gnathostome characters in jawless fishes indicate that the assembly of gnathostome characters accrued piecemeal before jaws. Galeaspids are, in many ways, a better proxy than osteostracans for reconstructing the pre-gnathostome condition. This raises the potential possibility that galeaspids might be the closest jawless relatives of jawed vertebrates.

FLIGHT: CRUCIAL INNOVATION IN INSECT EVOLUTION

Thomas Hörnschemeyer[1] and Jakub Prokop[2]

1. Georg-August-University, Johann-Friedrich-Blumenbach-Institute for Zoology & Anthropology, Dept. Morphology & Systematics, Berliner Str. 28, 37073 Göttingen, Germany. thoerns@gwdg.de

2. Department of Zoology, Charles University in Prague, Faculty of Science, Vinicná 7, 128 43 Praha 2, Czech Republic.

The evolutionary success of the Pterygota (winged insects), which make up more than half of all known species, seems to be essentially connected to their ability to fly. Nevertheless, the origin of insect flight, its morphological foundations and the subsequent evolutionary events are still not properly understood. One aspect that probably contributes significantly to our problems in deciphering the processes in the evolution of insect flight is the considerable age of this trait. Pterygote insects with fully developed wings are known from sedimentary rocks discovered close to the transition period between the Early and Late Carboniferous, approximately 325 million years ago. This indicates that the group had its origin significantly earlier, perhaps in the earliest Carboniferous or, even more likely, in the Late Devonian. Surprisingly, based on molecular data the divergence of Pterygota is estimated to have occurred as early as the latest Ordovician to the Silurian. Investigations of the morphology of extant pterygotes, of their embryological development and of insect fossils had previously resulted in several contradicting hypotheses on different aspects of the origin and evolution of insect flight. Recent comprehensive studies of the flight apparatus morphology, including musculature and sclerites, of numerous representatives of extant Ephemeroptera, Odonata and Neoptera led to new interpretations of several aspects in the sequence of events of the evolutionary origin and development of insect flight. The talk will present first results of our current project that is intended to analyze the past and present diversity of flight apparatus types and morphologies to clarify the early evolution of the insect flight apparatus and the relationships between the earliest and the extant winged insects. [Supported by the Grant Agency of the Czech Republic (No. 14-03847J) and the Deutsche Forschungsgemeinschaft (No. HO 2306/12-1)].

EVOLUTIONARY INNOVATIONS FOR THE ANTHROPOCENE APOCALYPSE

Jeremy B. C. Jackson[1,2]

1. Department of Paleobiology, National Museum of Natural History, PO Box 37012, Washington, DC 20013, USA. jeremybcjackson@gmail.com

2. Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography, La Jolla, CA 92093, USA.

Humanity increasingly dominates global ecosystems and resources causing massive destruction of habitats and species extinctions. Such ecological supremacy by a single species is unprecedented in earth history and seemingly irreversible barring the collapse of civilization. Projected losses of biodiversity rival those of the greatest recorded mass extinctions in the fossil record. Nevertheless, human dominated ecosystems also provide rich and novel resources for a never-increasing diversity of predominantly small and opportunistic species that exhibit strikingly diverse "exaptations" to the environmental consequences of human excess. Following Erwin (this symposium), the new ecospace for evolutionary innovation is *potentiated* by human degradation of environments and *realized* as innovations by the explosive expansion of species like rats and pigeons in cities and agricultural and other pests across the rural landscape. Much less is known about the *actualization* and *refinement* of genetic and developmental changes in response to Anthropocene environments, but there are numerous examples of shifts to smaller body size and more r-selected life histories of fisheries species and greater tolerance to pollutants. Domesticated animals and plants, agricultural pests, vermin, parasites, and disease vectors are obvious terrestrial examples of species exploiting humanity. However, a less familiar but potentially even greater transformation of ocean ecosystems is also underway. The big three human drivers of ocean degradation are overfishing, myriad forms of local pollution, and the burning of fossil fuels driving global climate change. Overfishing distorts food webs with disproportionate losses of large predatory fishes and shellfish and their replacement by smaller species. These changes drive trophic cascades with massive shifts in seafloor community composition. Nutrient pollution causes eutrophication and hypoxia of coastal oceans worldwide. Inhabitants of these coastal "dead zones" include small invertebrates tolerant of hypoxia and the denizens of the microbial loop. Jellyfish are the new top predators in dead zones, rivaling in biomass that of the collapsed fisheries they replaced. Global warming is breaking down symbioses of reef corals that are being replaced by seaweeds and non-calcifying invertebrates and ocean acidification poses increasing threats to all calcifying species. The consequences of all these changes will include tremendous losses in species but not in biological abundance as the ragtag assemblage of species hitchhiking upon humanity takes their place. Whatever our own future, these fellow travelers will be the progenitors of the next great radiation of global biological diversity.

RECONCILING PATTERNS OF CONVERGENCE AND INNOVATION IN MARINE TETRAPOD MACROEVOLUTION FROM TRIASSIC TO RECENT

Neil P. Kelley[1] and Nicholas D. Pyenson[1]

1.Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, PO Box 37012, Washington, DC 20013, USA. kelleynp@si.edu

Terrestrial tetrapods have repeatedly invaded marine ecosystems since the Triassic. During the Mesozoic dozens of reptile lineages (e.g., mosasaurs, ichthyosaurs, turtles) adapted to marine life. In the Cenozoic, most of these groups were replaced by marine mammals (e.g. whales, sirenians). Each of these transitions from terrestrial to marine life has been facilitated by innovations in physiological, sensory, reproductive and feeding systems. Some innovations (e.g., hydrofoil limbs, pachyostosis) have evolved convergently in multiple clades, while others (e.g., echolocation, baleen) are unique to individual lineages. We present a synthetic history of the marine tetrapod fossil record comparing the sequence and timing of key innovations and identifying their impacts on evolution, dispersal, and diversification. Locomotory systems are characterized by convergent innovation, whereby homologous development pathways (e.g. regulation of limb element patterning and proportion) were co-opted repeatedly in marine tetrapod lineages. Moreover, the evolution of derived swimming adaptations correlates with clade longevity and geographic dispersal. Patterns of reduction and elaboration in feeding morphology likewise evolved repeatedly in marine tetrapods, following specific syndromes (e.g., teuthophagy, piscivory). However, phylogeny and shifting ecological opportunities have constrained the trophic avenues exploited by particular clades. Whereas marine mammals are constrained to placental life history patterns, viviparity evolved convergently in multiple marine reptile lineages. Nevertheless, the most enduring clade of extant marine tetrapod–chelonioid sea turtles–retain terrestrial reproduction, as have other successful viviparous and oviparous marine tetrapod clades (e.g., pinnipeds, sea birds). Lastly, we investigate the latency or outright absence of particular innovations in marine tetrapod macroevolution: for example, despite controversial claims to the contrary, evidence of herbivory in Mesozoic marine reptiles is scarce until the advent of herbivorous sea turtles in the Late Cretaceous, coincident with the origin of seagrasses. The apparent inability of Mesozoic marine tetrapods to occupy the full range of trophic ecologies observed in Cenozoic marine mammals (e.g., filter feeding, herbivory) might be a consequence of phylogenetic constraints or incumbency effects. This limited exploitation of marine ecospace among Mesozoic marine tetrapods may also be linked to striking discrepancies in standing levels of species richness. The sustained increase in Cenozoic marine tetrapod (primarily marine mammal) fossil diversity well above intermittent Mesozoic marine tetrapod diversity peaks mirrors patterns documented from the abundant invertebrate record. These patterns are consistent with the view that increases in marine ecospace over the Phanerozoic have been driven largely by innovation and escalation across all trophic levels.

A REINVESTIGATION OF SEPKOSKI'S DATASET: AN ECOLOGICAL DIMENSION TO THE EVOLUTIONARY FAUNAS

Christian M. Ø. Rasmussen[1,2], Claus Nielsen[1], Mats Eriksson[2], Gilles Cuny[1], Arne T. Nielsen[1], Jan A. Rasmussen[1] and David A.T. Harper[2,3]

1. Natural History Museum of Denmark, University of Copenhagen, ØsterVoldgade 5–7, 1350 Copenhagen K, Denmark. christian@snm.ku.dk

2. Department of Geology, Lund University, Sölvegatan 12, Lund, 223 62, Sweden.

3. Department of Earth Sciences, Durham University, Durham, DH1 3LE, UK.

Estimates of Phanerozoic biodiversity change and the processes which governed it have long been debated. Although the first estimates were produced more than 150 years ago, it is only within the last 30 years that research has intensified dramatically. With his landmark paper in 1981, John (Jack) Sepkoski published a Phanerozoic diversity curve for marine families which since then probably has become the most depicted diagram in palaeobiology, thus stressing the broad interest in this field. Although not addressing the actual drivers to the dramatic fluctuations in his diversity curve, he did recognize three so-called Evolutionary Faunas. These were characterized by groups of clades with similar patterns in origination and extinction. Since then Sepkoski continued to expand the dataset producing a number of updated curves. Today this dataset still form the framework for what is now grown into the Paleobiology Database (PBDB). During the last decade several significant contributions have addressed the obvious caveats when constructing such a dataset. Efforts have concentrated on biases related to taphonomy, such as incompleteness of the fossil record, rock volume bias, as well as the 'pull of the recent' effect, to name some of the larger biases. Most interestingly, when all these biases are taken into account by the use of sample standardization, a picture emerges where present-day biodiversity levels seem to have been reached already by some 420 million years ago during the latest Silurian–Devonian periods, but yielding a diversity curve much different from the original Sepkoski curve. Of key interest to this aspect is trying to understand the processes that governed early Paleozoic biodiversity change. Notably, the Great Ordovician Biodiversification Event (GOBE) seems to have been the most pivotal interval with respect to the marine radiations. However, with the efforts to unravel the various sampling biases the GOBE event now seem only to be part of a larger Cambrian–Devonian expansion of marine faunas. We are, however, puzzled, by the apparent decoupling of these recent biodiversity estimates with what is actually seen in the rock record. Therefore, we specifically focus on which ecological trajectories could have been the drivers for the largest increases in biodiversity and notably if the evolution of certain morphological innovations could have fueled the sustained Paleozoic radiation. For this it is more appropriate to use Sepkoski's unedited compendium. In this way we have generated ecological sub-divisions which are more readily recognizable when compared to his pioneer studies.

EARLY BURSTS ARE NOT ENOUGH: EVIDENCE THAT INTEGRATED CHANGES GENERATE RAPID RISES IN DISPARITY AND INNOVATIONS

Peter J. Wagner[1]

1. Dept. of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20013-7012, USA. wagnerpj@si.edu

Innovations concern two distinct issues: 1) their possible effects on long-term evolution; and, 2) their origins. The latter is a special case of disparity: how do new portions of morphospace originate? Here I examine nearly 300 character matrices to assess three issues: 1) whether initial radiations accompany high disparity (and thus many possible innovations); 2) the extent to which high early disparity reflects "early bursts" (i.e., high rates of change early in clade history); and, 3) the extent to which high early disparity reflects "linked" character evolution (e.g., integration). I use Monte Carlo analyses to estimate expected disparity generated by the first half of clade evolution among the first given best-fit models constant rates and early bursts of independent (unlinked) change, with those models determined from inverse modeling observed matrix structure (here, compatibility) among early taxa (the first third or half) and all taxa. The same analyses estimate expected stratigraphic compatibility given constant rates and early bursts, as the most likely explanation for too little stratigraphic compatibility is non-independent character change. These analyses corroborate prior studies by finding that nearly 80% of clades generate more early disparity than given best-fit constant rate models. They further corroborate prior predictions that high early disparity correlate with early bursts. However, these analyses also find that early disparity in nearly 70% of clades exceeds that predicted by early bursts alone. This additional excess disparity is strongly correlated with high stratigraphic *in*compatibility (i.e., intermediate character combinations appearing after apparently primitive and derived ones). Moreover, early linked changes would effectively mimic early bursts because by inducing high frequencies of individual character changes. Thus, these findings likely understate the role of linked changes, and thus of processes such as integration, in generating potential novelties. Although this does not identify particular innovations driving any example, it is consistent with scenarios where integrated change simultaneously alters multiple characters at once, with benefits of one or more innovative state outweighing any costs to changes in other linked characters. In some cases, linked characters later revert to the original states (creating stratigraphic incompatibility); however, in other cases the characters change to still more derived states, generating additional disparity. Although character linkage models such as integration might inhibit character change in most cases, it seems that rare successful integrated changes contribute to high morphological diversity in groups that we subsequently recognize as distinct higher taxa.

LOST INNOVATIONS? EXTINCT BUGS (INSECTA: HETEROPTERA) FROM THE EOCENE OF GREEN RIVER (USA) AND MESSEL (GERMANY)

Sonja Wedmann[1], Torsten Wappler[2], Conrad C. Labandeira[3,4], Petr Kment[5] and Dena M. Smith[6]

1. Senckenberg Forschungsinstitut und Naturmuseum, Forschungsstation Grube Messel, Markstraße 35, D-64409 Messel, Germany. sonja.wedmann@senckenberg.de
2. Steinmann Institut für Geologie, Mineralogie und Paläontologie, Universität Bonn, Nussallee 8, 53115 Bonn, Germany.
3. Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, MRC-121, Washington, DC 20013-7012, USA.
4. Department of Entomology, University of Maryland, College Park, MD 20742, USA.
5. Department of Entomology, National Museum, Kunratice 1, CZ-148 00 Praha 4, Czech Republic.
6. CU Museum of Natural History and Department of Geological Sciences, UCB 265, University of Colorado, Boulder CO 80309-0265, USA.

Ongoing studies of heteropteran insects (true bugs) from the Green River Fm. (earliest middle Eocene of Colorado, USA) and Messel (middle Eocene of Hesse, Germany) have revealed unusual and structurally exaggerated morphological features among constituent clades of these insects. These distinctive features seem to have become extinct in the most closely related heteropteran groups since the Eocene, but have been convergently re-evolved elsewhere. In one example, our studies have focused on Green River Tingidae (lace bugs) whose antennae have an extremely enlarged and dilated last segment situated on a long antennal stalk. Such strongly apically enlarged antennae are completely unknown in extant lace bugs. Nevertheless, in the Coreidae (leaf-footed bugs) enlarged antennal segments occur today, and this is certainly an example of convergent evolution. In extant Corediae, the terminally dilated antenna function as a display that may be associated with the presence of conspecific males (male-male competition) or it may serve as a long-distance female attractant involved in courtship. Bizarre Green River and Messel pentatomid bugs, which remain undescribed, also exhibit an exaggerated morphology in possessing prominent humeral angles of the pronotum and a spinose pronotum and abdomen. In particular, the humeral angles of the pronotum are unique, consisting of expansive, rounded projections equipped with strong spines. This, or a similar morphology, is rare among pentatomids. The characteristic shape of the head and presence of the spinose humeral angles of the pronotum and connexivum suggests a relationship to the tribe Triplatygini, which today occurs exclusively in Madagascar. Ongoing studies are investigating whether these fossils are related to the recent Madagascaran representatives or represent a case of remarkable convergence. A hypothesis for the function of this extreme morphology is defense against predators, and most probably defense against small vertebrate predators such as birds or insectivores. The spines and protuberances of the body complicate predator handling of the bugs, and in combination with effective secretion of their repugnatorial glands, would be an effective defense mechanism. These two examples add to a significant list that indicates convergence at the structural level is a ubiquitous phenomenon in insects. An equally fascinating issue is understanding the evolutionary developmental origin of these structures and whether there is a relatively simple genetic switch that expresses or de-expresses these features.

SYMPOSIUM

THE ORIGIN AND EARLY EVOLUTION OF BIRDS

ORGANIZERS:

LUIS CHIAPPE – JINGMAI O'CONNOR

EXCEPTIONALLY PRESERVED FOSSIL BIRDS FROM THE EOCENE OF DENMARK SHEDS LIGHT ON AVIAN EVOLUTION

Sara Bertelli[1] and Gerald Mayr[2]

1. FML-CONICET, Miguel Lillo 251, San Miguel de Tucumán, CP4000, Tucumán, Argentina. sbertelli@lillo.org.ar
2. Forschungsinstitut Senckenberg, Sektion Ornithologie. Senckenberganlage 25, D-60325 Frankfurt am Main, Germany.

The Paleogene fossil record has played a key role in debates surrounding the timing of the appearance and divergence of the extant lineages. Although specimens are now known from the Paleocene and Eocene, relatively few examples of three-dimensionally preserved, articulated fossil birds have been described. Most fossil birds from the early Eocene of Denmark (Fur Formation, aged approximately 54 Ma) are unusual for early Paleogene birds because of the fact that they are completely articulated and preserved in three dimensions. Such preservation, however, is necessary if fossils are to be included meaningfully in a morphological and phylogenetic context encompassing extant taxa. Because of its remarkable preservation, specimens like those from Fur Formation have clear implications for our understanding of the early evolution of modern birds.

XINGHAIORNIS LINI: STRADDLING THE DIVIDE BETWEEN ENANTIORNITHINES AND ORNITHUROMORPHS

Luis M. Chiappe[1], A. Bell[1], Anusuya Chinsamy[2], X. Wang[3], F.-F. Teng[4] and Q. Ji[3]

1. The Dinosaur Institute, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007, USA. lchiappe@nhm.org

2. Department of Biological Sciences, University of Cape Town, Private Bag X3, Cape Town 7700, South Africa.

3. Chinese Academy of Geological Sciences, Beijing, China.

4. Xinghai Museum of Prehistory, Dalian, China.

Recent discoveries of fossils from the Early Cretaceous Jehol Biota have begun to erode the morphological support for the monophyly of the two main clades of ornithothoracine birds: Enantiornithes and Ornithuromorpha. We elaborate on the morphology and bone microstructure of *Xinghaiornislini*, a large and toothless basal ornithothoracine from the Yixian Formation. A long bill and elongated legs with an elevated hallux suggest *Xinghaiornis* may have foraged along the shore of the Yixian lacustrine paleoenvironment. *Xinghaiornis* shows a number of skeletal characters that have been traditionally interpreted as either diagnostic of Enantiornithes (e.g., slender and Y-shaped furcula, minor metacarpal projecting more distally than major metacarpal) or Ornithuromorpha (e.g., ball-shaped humeral head, reduced pedal claws, craniocaudal expansion of proximal phalanx of major manual digit). In light of this, and on information from other Jehol taxa, we argue that some of these characters are better optimized as synapomorphies of Ornithothoraces. *Xinghaiornis* is perhaps the taxon with the greatest degree of intermediacy between Enantiornithes and Ornithuromorpha, a fact that underscores its proximity from the evolutionary divergence of these two clades. This study provides anatomical and microstructural details of this important taxon and examines the differential weights of the cladistic hypotheses supporting its assignment to either Enantiornithes or Ornithuromorpha.

PALAEOBIOLOGICAL DEDUCTIONS FROM THE BONE MICROSTRUCTURE OF MESOZOIC BIRDS

Anusuya Chinsamy[1] and Luis Chiappe[2]

1. Department of Biological Sciences, University of Cape Town, Private Bag X3, Cape Town 7700, South Africa. anusuya.chinsamy-turan@uct.ac.za

2. The Dinosaur Institute, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007, USA.

Osteohistological studies of modern birds provide direct insight into their life history and growth dynamics. Generally modern birds grow rapidly and reach adult body size within a single year, and as such, annual rhythms in growth are rarely observed in their bones. However, over the past few years cyclical rates of bone deposition have been documented in several extinct birds (Dinornithidae; the Eocene *Diatryma*; *Pezophapssolitaria*, a flightless bird from the Mascarene Islands; and more recently in the giant Mesozoic bird, *Gargantuavis*), as well as among the extant birds, *Amazona amazonica* and *Apteryx spp*. Investigations of the bone microstructure of Mesozoic birds suggest that there are two types of growth patterns during *early* stages of ontogeny: 1. Early growth can be rapid and uninterrupted (as in the Enantiornithines) or 2. Early growth can be periodic and punctuated with periods of arrests in growth (as in *Patagopteryx*). Once sexual maturity is attained, there is a distinctive change in the nature of the bone tissue, and, unlike most modern birds, it is common for nonornithurine birds to take several years to reach somatic maturity. This is reflected in the number of lines of arrested growth (LAGs) that form within the cortical bone. In some enantiornithines, for example, the large Le Brete enantiornithine 4-5 LAGs occurs in the parallel-fibred bone of the OCl, and we can assume that this is the *minimum* age of the animal (earlier lines may have been resorbed), and that it took this long for somatic maturity to be attained. Osteohistological differences between the different Mesozoic bird taxa appear to be in the nature and organization of the bone tissues, the period of rapid growth during early ontogeny, the type and distribution of vascularization, the development of LAGs and or annuli, and the duration of the protracted growth to somatic maturity. The most striking observation is that all nonornithurine Mesozoic bird taxa show a flexible growth strategy (i.e., they show periodic arrests in growth during ontogenetic development). Our analysis of early bird bone growth also suggests that the variable bone microstructure evident among Avialans reflects plasticity in development rather than a reflection of differences in body size. We suggest that several "modern" fossil and extant bird taxa as well as nonornithurine Mesozoic birds could invoke the plesiomorphic flexible growth trajectories of extended post-hatching growth when environmental conditions so dictated.

THE EIGHTH SPECIMEN OF *ARCHAEOPTERYX*

Martin Kundrát[1], Raimund Albersdörfer[2], John Nudds[3] and Per E. Ahlberg[1]

1. Evolutionary Biology Centre, Uppsala University, Norbyvägen 18A, Uppsala, 75236, Sweden.
martin.kundrat@ebc.uu.se

2. Bergstrass 8, Schnaittach, 91220, Germany.

3. School of Earth, Atmospheric and Environmental Sciences, The University of Manchester, Oxford Road, Manchester, M139PL, UK.

The archaeopterygids from Bavaria have been considered the earliest known predecessors of modern birds for the last 150 years. However, some of their pivotal phenotypic characters used to distinguish a bird from a dinosaur have become ambiguous or invalid due to numerous 'feathered' dinosaurs found in China. We report here on the investigation of locality and the 3D morphology of the 8th specimen of *Archaeopteryx*. The specimen was allegedly discovered in a quarry near Daiting, Bavaria in the early 1990s. Recently, the specimen has been offered on long-term loan to the Bavarian State Collection of Paleontology and Geology in Munich. Skeletal remains are confined to less than half of a slab of lithographic limestone measuring 28.7x25.5x2.5 cm. We verified the critical provenance of the specimen by comparing weight percentages of major and minor elements detected by XRF analysis of limestone samples from the Solnhofen and Mörnsheim Formations, as well as the matrix from the 8th specimen. The geochemical results demonstrate that the samples of Mörnsheim Formation and the 8th specimen consistently contain more SiO (%) and Zn (ppm) than do the samples of Solnhofen Formation. This leads us to conclude that the 8th specimen is from the Mörnsheim Formation and is thus the youngest of all known Bavarian archeopterygids and enables us to better understand evolutionary patterns of their morphological diversity. The 8th specimen is represented by strongly compressed remains comprising approximately 30% of the skeleton. Most complete are the remains of the skull including dentition, the shoulder girdles, and the left wing. In size, the 8th specimen corresponds best with the Munich and Thermopolis specimens by humerus length. 3D model of the 8th specimen enhances our understanding of the cranial morphology of *Archaeopteryx* in such aspects as dental implantation, tooth replacement, bone fusion, and detailed anatomy of the quadrate, quadratojugal, squamosal, laterosphenoid, prootic, opisthotic-exoccipital and basioccipital. For the first time, the distribution patterns of air-filled spaces inside cranial bones, shoulder girdles and wing bones have become available. Furthermore, we provide both external and internal characters of the furcula, scapulae, and coracoids. The manus of the left wing reveals the positional and notable ontogenetic relationship between the metacarpal and carpal bones. Finally, putative imprints of the wing remiges were detected inside the slab. We conclude that the 8th specimen provides critical information about previously inaccessible anatomical features that are important for understanding the phylogeny of *Archaeopteryx*.

LIFE-HISTORY AND ECOLOGY OF THE MESOZOIC BIRD *CONFUCIUSORNIS SANCTUS*

Jesús Marugán-Lobón[1,2] and Luis M. Chiappe[2]

1. Unidad de Paleontología, Dpto. Biología. Universidad Autónoma de Madrid. Darwin 2, 28049 Cantoblanco, Madrid, Spain. jesus.marugan@uam.es

2. The Dinosaur Institute, Natural History Museum of LA County. 900 Exposition Boulevard, Los Angeles, 90007 CA, USA.

The remarkable abundance of *Confuciusornis sanctus* stands out among the Jehol Biota's paleontological wealth (Early Cretaceous, Liaoning Province, northeastern China). It is estimated that more than a thousand largely complete and articulated specimens have been unearthed, thus rendering unprecedented evidence for the study of the intra-specific variation, ontogenetic development, and life-history of a Mesozoic bird. Here we present the results of a decade-long study of these fossils on a sample that today encompasses nearly 200 specimens from public institutions worldwide. In our analyses we recursively found that it is impossible to differentiate between the different named species of *Confuciusornis*. Yet the sample is easily discriminated in three size classes: strikingly, we found support for unambiguous and unidimensional for a tri-modal size distribution of *C. santus* specimens. Multiple preservational and paleobiological phenomena can potentially explain the observed size polymorphism but none is fully congruent with the overall evidence. For example, sexual size dimorphism provides a plausible explanation, yet there is evidence indicating that the ornamental caudal feathers of some specimens are secondary sexual traits and there is no statistical correlation between the tri-modal size distribution and the presence/absence of these feathers. This unprecedented sample provides tantalizing evidence about the ecology of these early birds. The fact that specimens of different size classes are contained in the same slab strongly indicates that such individuals likely belonged to a panmictic (interbreeding) population and the ratio between the two sexes suggests that females outnumbered males. Furthermore, the variation in size of the rostrum (the beak) does not show major differences between small (younger) and medium sized among these size classes. Nonetheless, statistical variation suggests that larger (older) specimens could have exploited larger—yet-unknown—food resources.

SCAPULAR GIRDLE MORPHOLOGY IN PARAVIANS AND IMPLICATIONS FOR THE ORIGIN OF FLIGHT

Fernando E. Novas[1] and Federico L. Agnolín[1,2]

1. CONICET - Laboratorio de Anatomía Comparada y Evolución de los Vertebrados, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Ángel Gallardo 470 (C1405DJR), Buenos Aires, Argentina. fernovas@yahoo.com.ar

2. Fundación de Historia Natural "Félix de Azara", Universidad Maimónides, Hidalgo 775 (C1405BDB), Buenos Aires, Argentina.

Although it is well known that many skeletal features associated with powered flight in extant adult birds are conspicuously absent in basal avialans, discussions about origin of flight assumes that early birds positioned and moved their wings in the same manner as do living birds. Opinions against this view were expressed in different papers by J. Ostrom, F. Jenkins, and P. Senter. We concur with these authors in that the structure of the scapular girdle avoided the same degree of upward extension of the wing during upstroke. Moreover, we think that just as important as the range of the wingstroke is the direction of the wing beat. Study of the basal paravians *Saurornitholestes*, *Buitreraptor*, *Anchiornis*, and *Archaeopteryx* shows that they share a closely similar morphology of the scapula and the coracoid. They exhibit a glenoid cavity that is laterally faced and with the greater axis subvertically oriented. These features resemble the condition present in flightless ratites (e.g., *Rhea*, *Struthio*), in which the wings are predominantly moved in an anterolateral to posteromedial abduction-adduction arch. The glenoid morphology of basal paravians sharply differs from the laterodorsally faced and horizontally oriented glenoid of living, flying birds, which allows upward and downward wing excursions. We believe that early paravians were able to flap their forelimbs following an abduction-adduction arch greater than in basal theropods, yet the direction of flapping was not dorsoventral (as in living flying birds), but anterodorsal to posteroventral, in a condition intermediate between ostriches and flying neognathans. Coincidently (or probably causally), the anterodorsal to posteroventral direction of flapping excursions here inferred for basal paravians, recalls the direction of movements that living birds describe when performing the wing assisted incline running (WAIR), a form of terrestrial locomotion in steeply inclined surfaces involving flapping and running behavior. In maximum abduction, the wing of basal avialans (e.g., *Archaeopteryx*) oriented its surface posteroventrally (that is, oblique to the ground), thus the flapping of these wings produced thrust, but no lift. In sum, the rotation of the glenoid constitutes the main responsible for the direction of humeral movements and consequently for the entire forelimb. The wingbeat movements here hypothesized for basal avialans are congruent with a flapping-running behavior, but not with gliding abilities as those performed by flying neognaths, which require a positioning of the wings parallel to the ground.

EVOLUTION OF THE BIOLOGICALLY MODERN BIRD: EVIDENCE FROM THE EARLY CRETACEOUS JEHOL BIOTA

Jingmai K. O'Connor[1]

1. Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China. jingmai.oconnor@gmail.com

Neornithes, the clade that includes all living birds, is the most diverse clade of land vertebrates on the planet, and members of this group are adapted to occupy nearly every ecological niche. Biologically, birds are very different from other amniotes; not only are they highly skeletally modified with the unique use of integument unparalleled by any other clade, but compared to other animals they show major departures in their biological systems. Current ornithologists commonly state that these differences are an evolutionary response to the intense energetic demands and physical restrictions of powered flight. Currently Aves only has a phylogenetic definition based on *Archaeopteryx*, a taxon argued by some not to be a bird; relying on skeletal evidence alone, the dinosaur-avian transition cannot be clearly defined. Therefore, we seek to understand when dinosaur birds became avian in the biological sense. Although evidence of the soft tissue biological (organ) systems is normally extraordinarily rare in the fossil record, the Early Cretaceous Jehol Biota is unique in that soft tissue and other delicate traces have been reported in a diversity of taxa, sampling the entire spectrum of Cretaceous birds. For the first time, ornithological hypotheses regarding the evolution of derived avian features can be tested in the fossil record. We discuss the biology of basal birds in two aspects, the digestive and reproductive systems and attempt to reconstruct these systems across the phylogeny of basal birds. The feeding mechanism in birds was decoupled and the derived feeding apparatus evolved much later than the derived digestive system itself, which appears early in Aves, fully in place in the oldest basal ornithuromorphs. Although inferred to have evolved in the absence of teeth and the ability to orally process food items, the flexible esophagus and grinding gizzard evolved before the loss of teeth, and powered flight clearly did not immediately limit dentition, which is retained by birds until the end Cretaceous. The reproductive system also evolved derived features early in avian history with the right ovary already lost in the long bony tailed bird *Jeholornis*, only more derived than *Archaeopteryx*; however, due to their lower basal metabolic rate, Early Cretaceous birds probably had protracted folliculogenesis compared to neornithines as evidenced from the weak follicular hierarchy in *Jeholornis* and enantiornithines. The early evolution of several derived biological features probably facilitated the Cretaceous radiation of birds.

A NEW DIVERSE ENANTIORNITHINE FAMILY (BOHAIORNITHIDAE FAM. NOV.) FROM THE LOWER CRETACEOUS OF CHINA

Min Wang[1], Zhonghe Zhou[1], Jingmai K. O'Connor[1] and Nikita V. Zelenkov[2]

1. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Xizhimenwai Street, Beijing, 100044, China. wangmin@ivpp.ac.cn

2. Borissiak Palaeontological Institute of the Russian Academy of Sciences, Profsoyuznaya Street 123, Moscow, 117997, Russia.

Over the last three decades, numerous enantiornithines have been collected from all continents except Antarctica—from deposits that span the entire Cretaceous, indicating that Enantiornithes were the dominant avian group during Cretaceous. The Lower Cretaceous Jehol Group has yielded many exquisitely preserved enantiornithines, documenting the early evolution of this diverse avian clade, which greatly advances our understanding of the morphology, phylogeny, and biology of Enantiornithes. Here, two new enantiornithine birds, *Parabohaiornis martini* and *Longusunguis kurochkini*, are reported based on three nearly complete skeletons from the Jiufotang Formation in Liaoning, northeastern China. The two new species strongly recall *Bohaiornis*, *Sulcavis*, *Shenqiornis*, and *Zhouornis*, taxa that are similar in morphology but have never been extensively compared to each other. The unique combination of features such as the robust rostrum with robust, subconical teeth, furcula with blunt omal expansions, sternal trabeculae caudolaterally directed, and short and stout tarsometatarsus with hypertrophied unguls on digit III, all distinguish these six taxa from other enantiornithines. A close relationship among the two new species and the four previously described taxa is confirmed by a comprehensive phylogenetic analysis targeting the phylogeny of Mesozoic birds, leading us to erect the Bohaiornithidae fam. nov. With six known taxa, Bohaiornithidae is the most diverse recognized enantiornithine family. Principal components and ternary plot analysis suggest that bohaiornithids occupied a specialized ecological niche compared to other Early Cretaceous enantiornithines.

A HISTORICAL SPECIMEN OF ENANTIORNITHINE BIRD FROM THE EARLY CRETACEOUS OF MONGOLIA

Nikita V. Zelenkov[1] and Alexander O. Averianov[2]

1. Borissiak Paleontological institute of Russian Academy of Sciences, Profsoyuznaya 123, Moscow, 117997, Russia. nzelen@paleo.ru

2. Zoological Institute of the Russian Academy of Sciences, Universitetskaya nab. 1, 199034 Saint Petersburg and Laboratory of Mesozoic and Cenozoic Continental Ecosystems, Tomsk State University, Prospekt Lenina 36, Tomsk 634050, Russia.

We describe a historical specimen of an enantiornithine bird from the Early Cretaceous sediments of Mongolia, unearthed in 1977 and known as *Holobotia ponomarenkoi* Kurochkin 1991 (nomen nudum). The specimen comprises an incomplete, partially articulated skeleton, which represents the first discovered, partly articulated specimen of Enantiornithes, and the only known Early Cretaceous enantiornithine from Mongolia. The specimen was first identified by E. N. Kurochkin as a bird in 1979, but it was later considered to be a pterosaur. Only in 1990, when Enantiornithes were already a well-known clade, was the specimen again recognized as a bird. "*Holobotia ponomarenkoi*" is represented by a partial skull, a poorly preserved wing and a relatively well-preserved and partly articulated hindlimb from a subadult individual. The specimen shows a series of morphological details that are either unique or very poorly known for Enantiornithes. Among the unique features are previously unobserved specialized cervical morphology and the development of the lateral crest on the posterior surface of distal tibia (as in derived Ornithuromorpha). The specimen preserves a partial palate in ventral view, which in Enantiornithes was previously known only from the Late Cretaceous, highly-specialized edentulous *Gobipteryx*. The morphology of the palate of "*Holobotia ponomarenkoi*" is different from that of *Gobipteryx* and is roughly similar to those of *Archaeopteryx* and the non-avian paravians.

ARCHAEOPTERYX: DETAILS OF THE PRESERVATION OF FEATHERS

Niels Bonde[1]

1. Zoological Museum (SNM), Universitetsparken 15, DK-2100 Copenhagen Ø, and Fur Museum (Mus. Salling), Nederby, DK-7884 Fur, Denmark. Nielsb.pal@gmail.com

Feathers of *Archaeopteryx* have an important place in the discussions of the origin of birds. However, surprisingly, quite a number of details are overlooked or ignored or misinterpreted. It is always claimed that apart from the single feather that appears black (and of which we now know exactly that colour), all other feathers are only preserved as imprints. This is incorrect. The flight feathers of the London specimen (counterpart) preserve some material from the feathers in small spots observed nearly 10 years ago. The same is true for two tiny feathers apparently never mentioned publicly. One of these small feathers placed close to the dissociated thumb may be a 'thumb-wing' (alula). Description was submitted by Per Christiansen and I several times, in vain, and refuted by 'unbelieving' reviewers, even though the idea is not surprising at all, as one *Microraptor gui* is described and figured with one apparent alular feather. Ironically, these small, preserved parts of the flight feathers were one of the reasons Fred Hoyle used to claim that the feathers, in general, were a hoax! Hoyle claimed that somebody smeared dissolved limestone powder on the fossils and made the imprints by pressing modern feathers into this 'paste.' Afterwards, a little of the paste was left by mistake. Neither he nor his opponents in London understood that this is, in fact, some material from the original feathers preserved (but probably changed by diagenesis), quite like most of *Archaeopteryx* specimens have some keratinous material preserved from the claws of the feet. Annoyingly, some young Americans discovered the same phenomenon in the tenth specimen ('Thermopolis' which I have never seen) and published the same sort of analyses that I asked in vain a colleague to do in co-operation after the observations years ago in London, where I was offered excellent photos of the details. So this preservation is not unique, and I suspect that most of the London counterpart had preserved the material that fell out when the rock was split (if not deliberately removed to 'clean' the fossil). In the Berlin specimen such material has not been observed, and neither have alular feathers at its much better preserved fingers (though mistakenly mentioned by Dames in the description 1884), presumably because the wings are seen from the ventral face. The Thermopolis specimen should be carefully scrutinized for traces of small alular feathers, as should those other specimens with well-preserved wing-feathers.

THE IMPORTANCE OF FOSSILS IN HISTORICAL BIOGEOGRAPHIC INFERENCE: INSIGHTS FROM A PALAEOGENE STEM-GROUP TURACO (NEORNITHES: PAN-MUSOPHAGIDAE) FROM NORTH AMERICA

Daniel J. Field[1,2] and Allison Y. Hsiang[1]

1. Department of Geology & Geophysics, Yale University, 210 Whitney Avenue, New Haven, 06511, USA. daniel.field@yale.edu

2. Department of Vertebrate Zoology, National Museum of Natural History, Smithsonian Institution, 10th Street and Constitution Avenue, Washington DC, 20560, USA.

Living birds represent the world's most diverse and ubiquitously distributed tetrapods. They inhabit a myriad of different environments and exhibit incredible disparity in their forms and lifestyles. However, this overwhelming diversity is not distributed evenly across the globe. Today, Earth's lower latitudes boast the majority of avian species-level and higher-order diversity, and many deeply diverging clades are restricted to vestiges of Gondwanaland: Africa, Australasia, and South America. This common distribution pattern has prompted several workers to propose a 'Gondwanan' origin for living birds, a hypothesis that has been used to corroborate arguments for an ancient Mesozoic diversification of the avian crown group. Such arguments, which favor a vicariant Gondwanan origin for crown birds (Neornithes), tend to ignore data gained from the Palaeogene fossil bird record, which has improved substantially in recent years thanks to new discoveries and diagnoses based on rigorous phylogenetic analyses. In fact, strongly supported phylogenetic hypotheses for many Northern Hemisphere Palaeogene bird fossils cast considerable doubt on the hypothesis of a Mesozoic Gondwanan origin of Neornithes; many crown-clades with restricted extant distributions appear to have stem-group relatives in very different parts of the world. For example, recent analyses have suggested that taxa as diverse as frogmouths (Podargidae), Seriemas (Cariamidae), Mousebirds (Colliidae), and Hoatzins (Opisthocomidae)—all of which are currently restricted to Gondwana—all have early stem-group representatives in the Palaeogene of the Northern Hemisphere. Here, we present evidence for a new addition to this list: new phylogenetic analyses strongly support the hypothesis that the heretofore enigmatic fossil bird *Foropanarium*, from the Early Eocene of Wyoming, USA, represents a stem-group turaco (Pan-Musophagidae). Extant turacos comprise a clade of ~23 species, all of which are endemic to sub-Saharan Africa. *Foropanarium* offers the first strong evidence for a stem-group musophagid and reveals surprising new information on the early biogeography of this clade. This study provides a valuable addition to the known diversity of birds from the Green River Formation and more broadly emphasizes the relictual nature of extant neornithine biogeography. An ancestral state reconstruction incorporating all Palaeogene fossils definitively referred to the stems of modern neornithine clades illustrates the fundamental role played by the fossil record in accurately inferring the historical biogeography of modern birds, and it serves an important cautionary purpose—namely, that ignoring fossil biogeographic data may lead to strongly supported, yet entirely spurious, conclusions.

CLAWS OF FLIGHTLESS BIRDS FROM ITABORAÍ BASIN (PALEOCENE): LOCOMOTOR BEHAVIOR AND PALEOBIOLOGY

Tiago Martins Metello[1] and Lilian Paglarelli Bergqvist[1]

1. UFRJ, DEGEO, Rua Athos da Silveira Ramos, 274, Rio de Janeiro, 21941-916, Brazil.
tiagometello@gmail.com

Claws are the first and the last bone to touch the substrate during locomotion. The studies of ungual phalanges morphology are an important way to predict biomechanics, paleoautoecology, and locomotor behavior of tetrapods. In birds, the locomotor behavior could be categorized as ground-dweller, percher, climber, or raptorial. There are four species of fossil birds in São José de Itaboraí Basin, but only three with weak or no capability of flight: *Paleopsilopterus itaboraiensis*, the oldest record of a phorusrhacid; *Diogenornis fragilis*, first described as a rheid but further studies placed as Casuariidae (also the earliest record of a ratite and the last described bird species of Itaboraí Basin); and the cariamae *Itaboravis elaphrocnemoides*. All fossil bird remains were recovered from the infilling fissures of the Itaboraí Basin (upper Paleocene). No ungual phalanges were originally referred to any of the three species, but recently two (UFRG-DG 305-M, MCT 1839-R) were referred to *D. fragilis* and another two (MCT 1836-R and MCT 1837-R) to *P. itaboraiensis.* In birds, the claw curvature can reveal its locomotor behavior—usually, weakly curved claws are related to terrestrial animals and strongly curved claws to climbers. However, its determination is subjective, enforcing authors to create a geometrical evaluation of claws. This study employs two different methodologies: inner and outer claw curvature. The inner curvature of the claws of *D. fragilis* ranges between 19.2° and 28.9°, and outer curvature between 59° and 63.6°. The inner curvature of the claws of *P. itaboraiensis* ranges between 62.3° and 62.6°, and outer curvature between 91.2° and 95°. Those curvatures strongly support ground-dwelling habits for both *D. fragilis* and *P. itaboraiensis* but they cannot exclude a predator behavior. The primitive ratite *D. fragilis*is therefore interpreted as a well-established ground-dweller, even if still had weak flight capability. It may have behaved as recent tinamous—foraging and nursing in the ground with the ability to fly for short distances in order to run away from predators. The ground-dwelling behavior for *P. itaboraiensis* gives support to the theory that phorusrhacids hit its prey with its massive skull, but the possibility of a predatory capability does not exclude the claw usage in a raptorial behavior. Palinological and paleobotanical studies reconstructed the paleoenvironment of Itaboraí Basin as a lake with a riparian forest and surrounded by an open scrubland. This environment agrees with the presence of a couple of flightless birds in the basin.

TAIL MORPHOLOGY IN EARLY PARAVIAN THEROPODS

Fernando E. Novas[1] and Federico L. Agnolín[1,2]

1. CONICET - Laboratorio de Anatomía Comparada y Evolución de los Vertebrados, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Ángel Gallardo 470 (C1405DJR), Buenos Aires, Argentina. fernovas@yahoo.com.ar.

2. Fundación de Historia Natural "Félix de Azara", Universidad Maimónides, Hidalgo 775 (C1405BDB), Buenos Aires, Argentina.

Tail morphology of non-avian paravians is well known among Dromaeosauridae (e.g., *Deinonychus*, *Velociraptor*, *Linheraptor*, *Sinornithosaurus*, and *Microvenator*). Less well described is the caudal series of other paravian groups, mainly Troodontidae and Unenlagiidae. We offer below some features of the latter clade, based on observations made on *Buitreraptor gonzalezorum* (MPCA 245 - Museo Carlos Ameghino, Cipolletti; MPCN-PV-598 - Museo Patagónico de Ciencias Naturales de Río Negro, General Roca). Proximal caudals (Cds 1 through 5) look similar to dromaeosaurids in having robust prezygapophyses, well developed transverse processes, and tall and caudally inclined neural spines. Centra of proximal caudals are box-like and ventrally grooved, and with parallel and cranially inclined articular surfaces. In sharp distinction with dromaeosaurids, *Buitreraptor* is devoid of the extensive system of bony rods (caudotheca) that encase most of the mid- to distal caudals. Also, mid-caudals (Cds ?9-?12) exhibit prezygapophyses that are short and dorsally projected, thus occupying a caudal position with respect to the cranial margin of centrum. Moreover, Cds?10 and ?11 show a low neural spine that, together with the associated postzygapophyses, are caudally projected and overlapping the caudally succeding vertebrae. In contrast, Cd?13 exhibits slender and elongate prezygapophyses that roughly overlaps half of the preceeding caudal. Prezygapophyses slender and elongate keep in more distal caudals. Accompanying transformations of the neural arch described for Cds ?10 through ?12, is the conspicuous and sudden elongation of their centra. Haemal arches of caudals distal to Cd?11 are boat-shaped and considerably extended. Some othe features reconized above for *Buitreraptor* are also documented among early avialans: in *Archaeopteryx* caudals 6 through 9 (and probably also Cd10), prezygapophyses are short and postzygapophyses are elongate, but in more distal caudals the prezygapophyses show an elongate and slender condition, similar to other theropods. In *Rahonavis* some caudals show short prezygapophyses and neural arches (and accompanying postzygapophyses) that distally surpass the level of centrum. This suite of modifications in proximal to mid-caudals probably respond to movements of the feathered tail: proximal caudal segments acted in co-lateral as well as upward and downward movements, instead the portion of caudal vertebrae with shortened prezygapophyses probably acted to increase the upward flexion of the tail. The distal portion of the tail (that in which the prezypapophyses are elongate), probably acted as an almost rigid unit.

SYMPOSIUM

VERTEBRATE TAPHONOMY:
APPLICATIONS AND IMPLICATIONS

ORGANIZERS:

YOLANDA FERNÁNDEZ JALVO - CLAUDIA MONTALVO

CHALLENGES AND BENEFITS OF USING VERTEBRATE MICROFOSSIL BONEBEDS FOR UNDERSTANDING TERRESTRIAL PALEOECOSYSTEMS

Matthew T. Carrano[1] and Matthew P. J. Oreska[2]

1. Smithsonian Institution, P.O. Box 37012, Washington, DC 20012, USA. carranom@si.edu
2. University of Virginia, P.O. Box 400123, Charlottesville, VA 22904, USA.

Vertebrate microfossil bonebeds (VMBs, or "microsites") are specimen-rich, locally restricted concentrations of small-sized vertebrate fossils that occur throughout the terrestrial vertebrate fossil record. They are especially valuable sources for small and rare taxa. Generally high sample sizes at VMBs offer opportunities for addressing paleoecological aspects that rely on abundances and/or diversities; however, numerous factors related to specimen input, mixing, and preferential preservation complicate analyses based on raw abundance counts. We collected VMB data from localities in the Lower Cretaceous Cloverly Formation in the western United States, and analyzed their diversity, abundance, taphonomic, and paleoecological dimensions. This study revealed important new data about the Cloverly Formation vertebrate fauna, including several previously undiscovered taxa and improved stratigraphic ranges for many taxa. We were also able to make robust comparisons to penecontemporaneous faunas in North America known from similar VMB assemblages. In conducting this study, we attempted to address the many potential biases and difficulties associated with VMB abundance data. Although many biases are generally understood and can be addressed (at least in part), differentiating between taphocoenotic and biocoenotic effects—i.e. the contributions made to the sample from dead versus still-living organisms—remains a challenge. Another is the potentially varied contributions to the biocoenotic sample from organisms with different rates of tooth replacement. These complications can probably be addressed with future study, including additional knowledge about the biology of contributing organisms and the application of maximum likelihoods to assemblage formation processes. Despite these complications, VMBs can be utilized for robust intra- and inter-formational comparisons, both penecontemporaneously and across geologically long time intervals, because they only form under a limited set of taphonomic settings. As such, VMBs represent a powerful tool for examining geographic, environmental, and temporal variations in paleoecosystems.

THE INFLUENCE OF TRIASSIC ATMOSPHERIC CO_2 IN THE EVOLUTION AND TAPHOCENOSIS OF A PALEOVERTEBRATE ASSEMBLAGE: AN EXAMPLE FROM THE ISCHIGUALASTO FORMATION, NW ARGENTINA

Carina Colombi[1], Isabel Montañez[2], Amanda Porter[3] and Jennifer McElwain[3]

1. CONICET - Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan, Argentina. ccolombi@unsj.edu.ar
2. California University, Davis, California, USA.
3. University College Dublin, Ireland.

The carbon balance (incoming and losses) between different carbon reservoirs is regulated by the carbon cycle and affects all life processes as well as the preservation or biotic material. In this study we present the results of a preliminary study of the Upper Triassic Ischigualasto Formation, Ischigualasto Basin, showing how carbon perturbations of the paleoatmosphere, evidenced by paleosol geochemistry and paleofloral stomatal frequency, influenced the vertebrate biota and taphocenocis. Carbonate nodules of Calcisols permit the estimation of the paleoatmospheric CO_2 over a 300 m succession recording the period 231 to 229 Ma. Initial CO_2 concentrations are high (~1000 ppmv ± 300 ppmv) falling abruptly within a half million years to half the original levels. This perturbation is remarkably coeval with the most fossiliferous level (paleovertebrate bone-beds) of the Ischigualasto Formation. Following the CO_2 minima, concentrations once again increase to 900 ppmv ± 300 ppmv and subsequently gradually decrease to near present-day levels at around 229 Ma. This process is accompanied by a gradual decrease in the amount of preserved vertebrates, culminating in the boundary between *Scaphonix-Herrerasaurus-Exaeretodon* biozone and *Exaeretodon* biozone of the Ischigualasto Formation. For the interval 229 to 227 Ma, near the top of the Ischigualasto succession (300 to 550 m), paleoatmospheric CO_2 concentrations are estimated using cuticle stomatal frequency. Despite a tentative calibration of stomatal frequency to atmospheric CO_2, the data define a sharp increase in CO_2 followed by a clear trend of gradually decreasing values. This gradual decrease is coeval with an important reduction in diversity characterized by the extinction of common vertebrate-groups as well as by a significant decrease in the abundance of preserved specimens. The latter includes the transition between the *Exaeretodon* and *Jachaleria* Ischigualasto biozones, where most of the paleovertebrates disappear, leaving only one representative, more related with the fauna of the overlying Los Colorados Formation than the Ischigualasto itself. Based on these results, we propose that, in general terms, (1) the inferred decrease in CO_2 and consequent surface temperature is contemporaneous with the observed decrease in the amount of preserved vertebrates, and (2) large-scale perturbations in atmospheric CO_2 were mechanistically linked to important changes in the biota and taphocenosis recorded by paleofaunistic changes and/or paleovertebrate bonebeds.

TAPHONOMY OF THE LATE MIOCENE *HIPPARION* FAUNA FROM THE LINXIA BASIN IN GANSU, CHINA

Tao Deng[1], Zhong Liang[1], Sukuan Hou[1] and Shiqi Wang[1]

1. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, 100044, China. dengtao@ivpp.ac.cn

Late Cenozoic deposits are well exposed in the Linxia Basin of Gansu Province in northwestern China, and outcrops in various parts of this basin yielded vertebrate fossils, especially mammalian fossils of the Late Miocene *Hipparion* fauna. Up to now, over one hundred known localities, more than thirty thousand specimens were recovered, mainly including skulls, mandibles, and some skeletons. The localities in the Linxia Basin are notable for abundant, relatively complete, well-preserved, and in places partially articulated skeletons of large mammals, which commonly occur in dense concentrations. We studied in detail the taphonomy with some basic methods in order to reconstruct the environment of the Linxia *Hipparion* fauna, to recognize the effect of water currents in the burial process, and to find the sources of the red clay deposits. Large mammals are very sensitive to climatic and environmental changes, and the composition of a fauna depends on the ecology and environment. As a result, knowing how the population is structured is very important when trying to understand environmental characteristics by studying mammal fossils. The weathering, abrasion, accumulation of fossils and the current dynamical characters of the Linxia *Hipparion* fauna are analysed herein. Most of the mammalian fossils of the *Hipparion* fauna in the Linxia Basin are affected by weathering stages 1 and 2, and they have been transported by water for short distance, which implies that their burial places are not far from the death sites, and that the deposits bearing fossils have been altered by water before the bones were buried. The *Hipparion* fauna from the Linxia Basin had rhinoceroses as the most abundant mammalian fossils, and the genus *Chilotherium* was the most abundant during the Late Miocene. Analysing the age structure of the representative *Chilotherium* fossils in the Late Miocene *Hipparion* fauna from the Linxia Basin, we know the percentage of each age group and the population dynamics. Therefore, the age structure pattern of the *Chilotherium* fossils is consistent with that of living populations. We, therefore, may conclude that the cause of death for population of the *Hipparion* fauna should be due to a natural catastrophe. In order to determine the feature of the catastrophe, we combine the sedimentary and geochemical data as well as the evidence from the pollen flora and the granularity composition of the Neogene red clay in the Linxia Basin, which would indicate that the catastrophe was the drought during the Late Miocene.

TAPHONOMIC MODES IN A TRIASSIC-JURASSIC LOESSITE FROM PATAGONIA, ARGENTINA

Adriana C. Mancuso[1], Roger M.H. Smith[2], Diego Pol[3] and Claudia A. Marsicano[4]

1. IANIGLA, CCT-CONICET, Mendoza, Adrián Ruiz Leal s/n, Parque Gral. San Martín, 5500 Mendoza CC330, Argentina. amancu@mendoza-conicet.gov.ar

2. Iziko South African Museum, PO Box 61 Cape Town, 8000. South Africa.

3. CONICET, Museo Paleontológico Egidio Feruglio, Av. Fontana 140, Trelew 9100, Chubut, Argentina.

4. IDEAN (UBA-CONICET), Dto. de Cs. Geológicas, Universidad de Buenos Aires, Ciudad Universitaria, Pab. II, C1428EHA, Ciudad Autónoma de Buenos Aires. Argentina.

Bones of the basal sauropodomorph *Mussaurus patagonicus* are found in three successive loessite horizons within the Late Triassic-Jurassic high latitude El Tranquilo Basin in southern Argentina. The Laguna Colorada Formation (El Tranquilo Group) consists of reddish to brownish siltstones and claystones, fine- to medium-grained sandstones and subordinate thin conglomerates deposited by a fluvial system with moderate sinuosity channels. The faunal remains are concentrated in a 3-meter thick interval of structureless mottled light reddish- brown/olive-grey massive siltstone with scattered small mudrock pebbles which we interpret as floodplain loess. The *Mussaurus* specimens range from neonates to adults, which can be histologically divided in six different ontogenetic stages. An unusual aggregation of at least 11 similar-sized juvenile *Mussaurus patagonicus* includes partially and fully-articulated individuals. Some of these skeletons retain a life-like crouched position with flexed limbs, whereas other have articulated limbs that penetrate up to 13 cm into the underlying strata. Taphonomic evidence suggests these are the result of synchronous death and burial of behaviourally aggregated individuals that were all less than one year old (based on their long bone histology). The partially articulated carcasses are mainly juvenile and subadult ontogenetic stages. The bones are generally un-weathered (weathering stages 0 to 2) with low incidence of post-mortem modification such as abrasion, cracking, or breakage. All the taphonomic features documented in these carcasses suggest short post mortem/pre burial periods. In contrast, the occurrences of disarticulated but associated skeletons, disarticulated and dispersed skeletons, or isolated bones, are of mainly subadult and adult individuals. These bones display a large range of post-mortem modifications: 0 to 4 pre-burial weathering stages, very low to high abrasion, cracking and rounding, and transverse and/or irregular breakage. The main diagenetic features are the growth of calcareous nodules and discoloration of the matrix around the bones. The taphonomic signature of the Laguna Colarada *Mussaurus* fossils indicates a mixture of behavioural aggregations with rapid burial events interspersed with long periods of pre-burial exposure that weathered the exposed portions of embedded carcasses. We characterize this as an attritional bone accumulation from a stable sauropodomorph population living all year-round (non-migratory) on semi-arid sub-polar floodplains prone to seasonal drying and aeolian dust storms.

INVESTIGATIONS OF INSECT-BONE INTERACTIONS AT COOPER'S D (CRADLE OF HUMANKIND, SOUTH AFRICA) AND A POTENTIALLY NEW ICHNOTAXON

Alexander H. Parkinson[1] and Christine Steininger[2]

1. Evolutionary Studies Institute & School of Geosciences, University of the Witwatersrand, Private Bag 3, Wits, 2050, South Africa. palaeoparky@gmail.com

2. Ditsong National Museum of Natural History,Paul Kruger Street,Pretoria, 0001, South Africa.

The fossil sites within the cradle of humankind are renowned for the number and diversity of hominin taxa recovered from the region. One particular site – Cooper's D – is best known for its rich non-hominin faunal diversity as well as the discovery of various post cranium skeletal elements and a partial cranium associated to *Australopithecus robustus*. The site has been aged at between 1.5–1.4 Ma using uranium series dating. Taphonomic investigations at Cooper's D have resulted in the discovery of 12 non-hominin skeletal specimens which show clear evidence of insect bone interactions. The majority of the modifications can be ascribed to established morphological categories: striae, boreholes, furrows and sub-cortical tunnels/cavities. However one particular modification which occurs on three different specimens falls outside of the range of standard general morphology and may warrant the establishment of a new ichnotaxa. This new morphology is best described as a near circular borehole associated with a crescent shaped depression which partly surrounds the boring. The absence of isolated crescent shaped depressions in the collection supports the interpretation that these two structures are representative of a single modification type. This presentation shall: describe all evidence of insect bone interactions at Cooper's D with a particular emphasis on providing quantitative and qualitative descriptions of represented morphologies with a particular emphasis on this potentially new ichnotaxa which is still under investigation.

POTENTIAL TAPHONOMIC BIASES IN ECOMORPHOLOGICAL RECONSTRUCTIONS OF PALAEOENVIRONMENTS

Briana Pobiner[1] and Kris Kovarovic[2]

1. Human Origins Program, Department of Anthropology, Smithsonian Institution, National Museum of Natural History, MRC 112, 10th Street and Constitution Avenue, NW, Washington, DC 20013-0112, USA. pobinerb@si.edu

2. Department of Anthropology, Durham University, Dawson Building, South Road, Durham, DH1 3LE, UK.

Palaeoenvironmental reconstructions based on fossil mammal ecomorphology largely use models derived from measurements of complete or near-complete skeletal elements or portions, long bones and astragali in particular. However, possible taphonomic biases such as carnivore damage and destruction of epiphyseal ends from gnawing, crushing or breakage, which affect whether these elements survive or if the relevant measurements can be taken, have not been systematically investigated. If such biases exist, we are likely to be basing our palaeoenvironmental reconstructions on fossil bone samples that are not accurately representations of past mammal communities, therefore leading to an incorrect assessment of the proportion of habitats that they exploited on a local level. To investigate the possible effect of carnivore activity on ungulate ecomorphology studies here we present preliminary data on a long-term landscape study of modern mammalian bone assemblages from Ol Pejeta Conservancy, Laikipia District, Kenya. We focus firstly on determining if the species-specific mammal community at OPC can be accurately reconstructed on the basis of the bone communities; secondly, on identifying whether carnivore damage is more intense in certain habitat types; and thirdly, if bovid remains can accurately reconstruct the OPC habitats via ecomorphological analyses given the amount of carnivore damage sustained by the remains during predation and consumption.

PATTERNS OF PRESERVATION IN ANCIENT COASTAL WETLANDS: TAPHONOMY OF VERTEBRATE MICROFOSSIL BONEBEDS IN THE UPPER CRETACEOUS (CAMPANIAN) JUDITH RIVER FORMATION, MONTANA, USA

Raymond R. Rogers[1]

1. Geology Department, 1600 Grand Avenue, Macalester College, Saint Paul, MN 55105, USA.
rogers@macalester.edu

Vertebrate microfossil bonebeds (VMBs) are concentrated deposits of small, disarticulated, and taxonomically diverse vertebrate hard parts. Fairly common in Mesozoic and Cenozoic terrestrial records, VMBs have been exploited to recover otherwise rarely found small-bodied taxa as well as to estimate relative abundance and species richness in ancient vertebrate communities. Nevertheless, their taphonomic origins and attributes are poorly understood. The Campanian Judith River Formation (JRF) of Montana preserves abundant VMBs in both lacustrine and fluvial facies. Study of VMBs in the JRF has clarified that initial accumulation of vertebrate hard parts transpired in wetlands, where background mortality over periods ranging from hundreds to many thousands of years produced enormous concentrations of fossils. These assemblages are time-averaged (a good thing if the goal is to reconstruct community membership) and are not transported out of life habitat. Reworking of preexisting wetland VMB concentrations best explains VMBs in fluvial sandstones, which are intercalated with the finer-grained facies that host wetland VMBs. Data indicate that while fluvial VMBs are reworked and out of facies context, they are not transported far from source facies. An automated sieving system that minimizes damage and maintains associations was used to process matrix from ten VMB sites in the JRF. All bioclasts >0.5 mm were separated by hand picking under light microscopy, yielding over 56,000 vertebrate specimens from 230 kg of matrix. Surface collections from the same sites yielded ~17,000 specimens. This sizeable sample permits detailed taphonomic analysis of VMB formation. Most fossils are unidentifiable fragments in the 1-2 mm size range, but ~20% of recovered specimens are identifiable. Teeth, vertebrae, fish scales, and osteoderms dominate the identifiable fraction. Image analysis software was used to recover size data from sieved samples, and size sorting is comparable regardless of facies context. Shape data (compact, platy, elongate, conical) were documented for both sieve and surface collections, and both are dominated by compact and platy elements. Taxonomic representation was also compared within individual sites in relation to collection strategy (sieve vs. sample), and here there is clear distinction, with sieve samples dominated by fish remains (95+%). Surface collections yield a more diverse array of taxa. Evidence of feeding ecology was also collected, and the frequency of predator occurrence correlates with the frequency of feeding traces. This taphonomic inquiry into the nature of VMBs is ongoing, with the goal of understanding the origins and biases of these spectacular fossil deposits.

TAPHONOMY OF LARGE MAMMALIAN FAUNA: EXAMPLE FROM INDIAN QUATERNARY PALAEONTOLOGY

Vijay Sathe[1]

1. Department of Archaeology, Deccan College Postgraduate and Research Institute, Pune 411006. India.
vijay19sathe@gmail.com

The Pleistocene vertebrate fossil record of Peninsular India brings to light diverse large mammalian species whose fluvial origin makes it mandatory that the stringent research methods of taphonomy be employed to examine and identify the initial history of deposition which has been invariably assigned to being allochthonous. A few notable exceptions to the general notion that early human interactions with Pleistocene fauna and their precise ecological coordinates rest in the mere assumptions are further strengthened by the fossil record which lacks stratigraphic integrity, thus reducing the important piece of evidence into a mere part of documentation of ancient life. However, discovery of a large number of fossilised skeletal elements of a large predator and several herbivores and molluscs from the Late Pleistocene ossiferous gravels in Manjra river valley, near Harwadi (18 28 12N: 76 36 58E), Latur Dist., Maharashtra state has presented us with a new set of data that merits a detailed taphonomic assessment with special reference to fluvial dispersal processes. Further complimented by palynological and molluscan assemblages, the site has emerged as an important point of reference for its larger applications in developing taphonomic models for other fossil bearing locations in Peninsular India. The composite picture that emerges confirms the evidence of palaeolake like situations where the fauna is found in very close proximity to the primary context of its deposition in the Late Pleistocene, between 50-60 ka ago. The present paper discusses in detail the taphonomic analysis with special reference to its role in reconstruction of palaeoenvironments in Western India with special reference to Manjra valley.

DOES VOLCANIC ASH ENHANCE CONTINENTAL FOSSIL PRESERVATION ACROSS BASINS?

Leif Tapanila[1] and Eric M. Roberts[2]

1. Department of Geosciences and Idaho Museum of Natural History, Idaho State University, Pocatello, 83201 USA. tapaleif@isu.edu

2. James Cook University, School of Earth and Environmental Sciences, Townsville, Australia.

An analysis of continental fossils in the Mesozoic Western Interior of North America reveals a striking link between periods of intense volcanism and greatly elevated distribution of richly fossiliferous (vertebrate, invertebrate, plant) deposits across broad regions in continental sedimentary basins. The number of fossil collections and volcanic ash deposits (from detrital zircons and bentonite maps) were compared for Mesozoic rocks from Canada to Mexico (25°N to 50°N modern latitude). The timing and geographic regions of fossiliferous units and volcanic ash show broad correspondence. In the Triassic Period, the greatest volcanic ash deposits and fossil occurrences occur between 30–40°N during Carnian-Norian stages, as part of the fossil-rich Chinle Formation. Similarly during the Late Jurassic, volcanic ash is concentrated from 35–45°N, which overlaps the deposition of the fossiliferous Morrison Formation. Elevated fossil collection corresponds with volcanic ash, but not the reverse. For example, Middle Jurassic volcanism produced copious bentonites between 35–45°N, but coeval deposits as this latitude have contributed few fossil collections. High-resolution geochronology of Late Cretaceous basins spanning 25–50°N in the Western Interior also show correspondence between fossil preservation and volcanic ash. Richly fossiliferous units of the Campanian, dated between 77–74 Ma, include formations of Dinosaur Park, the upper Two Medicine and Judith River, Fruitland, lower Kirtland, Kaiparowits, and upper shale of the Aguja. This temporal preservation window of 3 myr spans multiple discrete basins, each with differing climates, sediment supply, accumulation and subsidence histories, and paleoenvironment. Ash delivered from arc volcanism west of these retroarc basins is the common regional feature, and that may have led to this enhanced preservation. We posit that the addition of volcanic ash is significant in enhancing preservation by altering the effects of groundwater in burial diagenesis. Large volumes of ash deposits, now degraded to bentonite (smectitic swelling clays), effectively seal parts of the basin by forming localized aquitards, or by contributing to poorly sorted "dirty" sandstones that have low porosity and permeability. Reduced permeability diminishes groundwater flux through the fossil-bearing rocks, and provides a chemically more stable diagenetic subsurface environment for fossil materials. Validation and generalization of this taphonomic mode has implications for a new megabias for continental fossils ultimately governed by the tectonomagmatic history of a region.

TAPHONOMIC ANALYSIS OF *CROSSVALLIA UNIENWILLIA*: SIGNIFICANCE OF THE OLDEST PENGUIN OF ANTARCTICA

Carolina Acosta Hospitaleche[1,3] and Leandro M. Pérez[2,3]

1. División Paleontología Vertebrados, Museo de La Plata. Facultad de Ciencias Naturales y Museo (UNLP) Paseo del Bosque s/n, B1900FWA, La Plata, Argentina. acostacaro@fcnym.unlp.edu.ar
2. División Paleozoología Invertebrados, Museo de La Plata. Facultad de Ciencias Naturales y Museo (UNLP). Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.
3. CONICET, Argentina.

The taphonomic attributes of the oldest Antarctic penguin *Crossvallia unienwillia* Tambussi, Reguero, Marenssi and Santillana were analyzed. It comes from the type section of the Selandian-Thanetian Cross Valley Formation, Marambio (=Seymour) Island, Antarctica. It was collected *in situ* in Cross Valley C Allomember, in which plant leaves are common, but few invertebrates have been described. Among vertebrates, the partial skeleton of *Crossvallia* (MLP 00-I-10-1), an isolated penguin diaphysis (MLP 00-I-1-16) and Teleostei remains (MLP 00-I-17/18) were recovered. *Crossvallia* enables to understand the taphonomic history of the vertebrates from this unit. Petrographic, EDAX, X-ray diffractometry, and sections for MEB were performed. The humerus is not deformed; periosteal bone and epiphyses are well preserved with signs of alteration. Trabecular tissues are observed. Siliciclastic sediment is accreted, with mineralogical deposits in patches. Perpendicular or oblique fractures are abundant. Femur and tibiotarsus are badly damaged. Periosteal bone and epiphyses are highly corroded. Mineral deposits and weathering erased details leaving uncovered the trabecular bone. Diaphyseal periosteal bone remains unaltered, and mineral precipitation filled the spaces. Fragments associated to *Crossvallia* have flat and clean fractures, perpendicular to the axes. Macroscopic analysis evidenced bad preservation; bones appeared in several pieces with altered surfaces. However, geochemical studies and microscopic analyses show that composition and tissular structure are preserved. Bones were found neither articulated nor in any anatomical preferential position (random arrangement). The association in a reduced area suggests little transportation, representing a typically parautochthonous deposit. It is consistent with the absence of weathering and abrasion, and the presence of diagenetic fractures. Disarticulation and early burial, is also interpreted from the absence of irregular fractures produced when collagen is still present. Geochemical processes during fossil-diagenesis are evidenced by damage in epiphyses, diaphysis filling, corrosive deterioration of surfaces, mineral attachments of sulfates (gypsum), and siliceous grains preserving the bone morphology after dissolution. The last one implies the dissolution of superficial grains by contact between elements of different hardness in Mohs scale (Apatite of bone, 5; Quartz of sediment, 7). Carbonate minerals percolate through fractures and fill the inner spaces as a coating in the walls and crystals with centrifugal growth in the center. Gypsum/anhydrite deposits are responsible of accelerating destruction due to its expansionary in presence of water, like the wedge action of ice, normal in the Antarctic dynamics. However, fluorapatite allowed a greater resistance to chemical destruction, allowing a differential preservation.

VERTEBRATE TAPHONOMY IN REGIONAL SCALE – QUATERNARY VERTEBRATES OF TANK DEPOSITS OF BRAZIL

Hermínio I. de Araújo-Júnior[1], Kleberson de O. Porpino[2] and Lílian P. Bergqvist[1]

1. Departamento de Geologia, Universidade Federal do Rio de Janeiro, Av. Athos da Silveira Ramos, 274, Cidade Universitária-Ilha do Fundão, 20.941-916, Rio de Janeiro, Brazil. herminio.ismael@yahoo.com.br

2. Departamento de Ciências Biológicas, Universidade do Estado do Rio Grande do Norte, Av. Professor Antônio Campos, s/n, 59.610-090, Costa & Silva, Mossoró, Brazil.

Tank deposits preserve one of the most intriguing types of fossil accumulations of Quaternary megafauna in South America. Up to now, only local taphonomic analyses have been performed, but regional taphonomic analyses would be crucial for identifying regional-scale biases and generative processes associated to the formation of vertebrate assemblages in tank deposits. This work provides a regional-scale taphonomic analysis of tank deposits in northeastern Brazil to cast light on those biases and processes. Five tank assemblages were considered: João Cativo (JC; 621 specimens) and Jirau (JI; 1,405 specimens), Ceará State; Campo Alegre (CA; 332 specimens) and Curimatãs (CU; 118 specimens), Paraíba State; and Lage Grande (LG; 220 specimens), Pernambuco State. The following taphonomic features were evaluated: taxonomic diversity, weathering stages, abrasion marks, trample marks, tooth marks, sorting andpattern of colors. The higher taxonomic diversities are observed in JI and JC. Furthermore, these two assemblages have the larger array of taphonomic modifications and categories of taphonomic features, such as desiccation marks and colors. The pattern of weathering stages indicates a longer time span of subaerial exposure in northern assemblages (JC and JI) and a shorter one in southern assemblages (CA, CU and LG). Biogenic marks were observed only in JI and JC, reinforcing that inference. The patterns of abrasion and sorting arealmost similar in all tank deposits studied, suggesting a similar intensity and agent of transportation – debris flows, in the case of tanks. The higher taxonomic diversity observed in northern assemblages can reflect: (i) the high diversity in ancient biocoenoses; or (ii) a higher rate of time-averaging. The variation in color observed in JC and JI suggests different types of impregnation and supports the second hypothesis. We conclude that transportation by high-energy debris flows is a regional-scale process in tank deposits. However, taxonomic diversity and weathering can vary locally and is likely a result of spatial variations in the rates of time-averaging and time span of subaerial exposure, respectively.

IDENTIFYING TAXA WITH ATYPICAL TAPHONOMIC FEATURES IN VERTEBRATE FOSSIL ASSEMBLAGES USING MULTIVARIATE ANALYSES: AN EXAMPLE FROM THE QUATERNARY OF BRAZIL

Hermínio I. de Araújo-Júnior[1], Kleberson de O. Porpino[2] and Lílian P. Bergqvist[1]

1. Departamento de Geologia, Universidade Federal do Rio de Janeiro, Av. Athos da Silveira Ramos, 274, Cidade Universitária-Ilha do Fundão, 20.941-916, Rio de Janeiro, Brazil. herminio.ismael@yahoo.com.br

2. Departamento de Ciências Biológicas, Universidade do Estado do Rio Grande do Norte, Av. Professor Antônio Campos, s/n, 59.610-090, Costa & Silva, Mossoró, Brazil.

Time and spatial resolutions are major themes in Paleontology and can be inferred using sedimentologic, stratigraphic and taphonomic data. Concerning taphonomy, the presence, for instance, of taxa with atypical taphonomic features in fossil assemblages can indicate higher levels of temporal- and/or spatial-mixing, and, consequently, a poorer resolution. This work attempts to show that the identification of such atypical taxa within a given fossil assemblage or across several assemblages can be attained by the joint application of some common multivariate techniques. We used three Quaternary vertebrate accumulations from Brazilian tank deposits (Jirau, 1405 specimens; Curimatãs, 118 specimens; Lage Grande, 220 specimens). Several taphonomic attributes – amount of specimens, physical integrity, weathering stages, abrasion, rooting, trample marks, tooth marks and color – were scored as absence and presence for each taxon in those assemblages. The resulting data matrix was submitted to cluster (Q-mode) and correspondence analyses using the Dice's similarity coefficient and, then, an ANOSIM test was applied to the taxonomic clusters found in the cluster analysis. All analyses were performed using the software PAST version 2.17. Well-defined taxonomic clusters were obtained for Jirau and Curimatãs assemblages in contrast to the more pectinate dendrogram obtained for Lage Grande. The ANOSIM-test values calculated for each assemblage are: Jirau – R=0.31, p<0.001; Curimatãs – R=0.9, p<0.001; Lage Grande – R=0.86, p=0.14. The lower R value in Jirau indicates a high taphonomic heterogeneity among the taxa of this assemblage, suggesting a low paleontological resolution (time and space). This is reinforced by the results of the correspondence analysis indicating that a larger amount of taxa with diverging taphonomic signatures occurs in this site. Inversely, the high taphonomic homogeneity suggested by R values for Lage Grande and Curimatãs assemblages can indicate a high paleontological resolution. The amount of taxa with atypical taphonomic features is: Jirau – 9 taxa (53% of the total); Curimatãs – 2 taxa (14.3% of the total); Lage Grande – 1 taxon (14.3% of the total). Interestingly, the species *Equus* (*Amerhippus*) *neogaeus* and *Hippidion principale* have atypical taphonomic signatures in two assemblages (Jirau and Curimatãs). Further analyses would be necessary to show if those two taxa are regional-scale atypical taxa in Pleistocene deposits of northeastern Brazil. This analysis shows that the paleontologic resolution and paleoecologic fidelity can vary regionally across tank deposits and reinforces, in a broader context, the importance of applying multivariate analyses in order to recognize patterns that may pass unnoticed in more qualitative taphonomic studies.

FOSSIL-DIAGENESIS AS AN INDICATOR OF PALEOENVIRONMENTAL CONDITIONS: INDICATIONS OF ARIDITY AT THE TRIASSIC-JURASSIC BOUNDARY

Carina Colombi[1] and Raymond R. Rogers[2]

1. Conicet – Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan.

2. Geology Department, Macalester College, 1600 Grand Avenue, Saint Paul, MN 55015, USA. rogers@macalester.edu

Permineralization of vertebrate fossils is typically a story of calcite and Fe-rich mineral paragenesis. Detailed study with a focus on a broad range of minerals using scanning electron microscope (SEM) has revealed a more complex history of diagenesis related to paleoclimate and tectonics. Eight paleovertebrate assemblages from the Ischigualasto and Marayes Basins, ranging in age from Middle Triassic to Lower Jurassic, were analyzed. Five different diagenetic pathways were discerned, and compared with sedimentologic, pedogenic and macro-scale taphonomic studies. The bones from Middle Triassic Chañares Formation (Ischigualasto Basin) are characterized by minor alteration at the microscale, and precipitation of Fe-rich minerals, presumably during a short interval of anaerobic decay. Permineralization ceased when bone voids filled with secondary apatite. The paucity of authigenic minerals potentially reflects the impermeable nature of host smectite-rich volcaniclastic sediment. Bones from the Upper Triassic La Peña and Cancha de Bochas Members of the Ischigualasto Formation (Ischigualasto Basin) are characterized by calcite and Fe-rich minerals, and this is consistent with recovery from oxidized calcic paleosols. A second stage of calcite precipitation was also documented, and this presumably reflects interactions with phreatic solutions after burial. This diagenetic history is consistent with a seasonal semiarid climate, and also potentially reflects low rates of sedimentation during the early burial stage. In contrast, fossil bones from the Upper Triassic Valle de la Luna Member (Ischigualasto Formation) and those recovered from the base of Los Colorados Formation (Ischigualasto Basin) are characterized by advanced bone alteration and a thick coating of Fe-rich minerals, indicating potentially longer anaerobic decay under humid conditions. It is also important to note that the fossils from the Valle de la Luna Member are permineralized with silica and barite, and this possible reflects volcaniclastic input in the uppermost Ischigualasto Formation. Interestingly, fossil bones from the base of the Los Colorados Formation also show evidence of halite precipitation, which is consistent with a return to arid conditions. This trend is also evident in the top of the Los Colorados Formation (Norian), where halite is accompanied by dolomite and rare sulfates in bone voids. Remarkably, fossils from the contemporaneous Quebrada del Barro Formation (Marayes Basin) also preserve halite and dolomite, which suggests widespread aridity played a role in bone fossilization during this time. This study of bone diagenesis from eight vertebrate fossil assemblages is consistent with other lines of evidence that suggest an increase in aridity across the Triassic-Jurassic boundary.

PRESENT-TIME WHALE CARCASSES VS. WHALE FOSSILS: THE PRESENT IS NOT KEY TO THE PAST

Raúl Esperante[1]

1. Geoscience Research Institute, Loma Linda, California 92350, USA.
resperante@llu.edu

A common premise in earth sciences is that processes and rates of sedimentation and decay of organisms in the past were similar to those observed today. Therefore, the study of decaying organisms in the present should provide clues to explain the processes of decay and fossilization in the past. Observations in modern seafloor settings indicate that preservation of fossil whales may not be explained by the processes of decay and sedimentation associated with modern whale falls. These whale falls create complex micro-environments with a high diversity of fauna feeding on the actual carcass or on the organic substances in the associated sediment. Although published studies claim that whale falls supply sustenance for decades, this study shows that they are quickly destroyed by both macro- and micro-scavengers in a matter of a few months to a few years, regardless of depth and degree of oxygenation of the water. The soft tissue is rapidly removed by macro-vertebrates in a period of a few weeks and the bones are colonized by *Osedax* polychaetes, which bore into the bones and feed on the enclosed lipids. Tanner crabs, sea cucumbers and other organisms feed on the skeletons and quickly destroy them. Evidence of borings and removal of bone tissue by scavengers is found in both large and small bones, and is more pronounced in the upper, exposed parts of the skeleton than in the partially buried sections, but nevertheless the entire skeleton is destroyed in a relatively short time. In contrast, most fossil whales show excellent preservation. Although evidence of limited activity of the bone-eating polychaetes *Osedax* has been found in cetacean bones, the fossil bones show a uniform degree of preservation regardless of the size, and both the upper and lower surfaces are well preserved, lacking evidence of the extensive scavenging by *Osedax* worms and of removal of bone by vertebrates or macro-invertebrates that occur in modern carcasses. In conclusion, modern whale carcasses on the seafloor are rapidly scavenged and show a high degree of deterioration over a short period of time. Under current rates of deposition in the ocean their likelihood of fossilization is very small, and therefore they may not be good, comparative models to explain the preservation of fossil whales. Observations in modern seafloor settings indicate that fossilization of whales is highly unlikely. This means that preservation of fossil whales in marine sediments may involve processes not observed in modern environments.

TAPHONOMY OF THE OLDEST COMMUNAL LATRINES FROM THE TRIASSIC CHAÑARES FORMATION (LA RIOJA, ARGENTINA): PALAEOECOLOGICAL AND PALEOCLIMATE CONSIDERATIONS

Lucas E. Fiorelli[1], Eloisa Argañaraz[2] and Julia B. Desojo[3]

1. Centro Regional de Investigaciones Científicas y Transferencia Tecnológica (CRILAR - CONICET), Entre Ríos y Mendoza s/n., 5301, Anillaco, La Rioja, Argentina. lucasfiorelli@gmail.com

2. Centro de Investigaciones Paleobiológicas (CIPAL), Av. Vélez Sarsfield 299, 5000, Córdoba, Argentina.

3. CONICET - Sección Paleontología de Vertebrados, Museo Argentino de Ciencias Naturales ''Bernardino Rivadavia'', Av. Ángel Gallardo 470 C1405DJR, Buenos Aires, Argentina.

Defecation spots are extremely rare in the fossil record because dung is frequently consumed by coprophagous, destroyed by termites and/or decomposed by microorganisms. Naturally, feces require exceptional and particular fossilization conditions to avoid being destroyed by these natural recyclers and their preservation involve special conditions. Moreover, herbivorous coprolites can provide unique information about paleoecological and paleoclimatic conditions of ancient ecosystems. Recently, several megaherbivorous dicynodont communal latrines composed of thousands of *in situ* coprolites have been reported from the Middle-Upper Triassic Chañares Formation in La Rioja province, northwestern Argentina. This formation was deposited in an alluvial to fluvial-lacustrine environment that received copious amounts of ash. In this volcanic palaeoenvironment, gravity flows of ash-mud buried and entombed the fossil vertebrate fauna in massive levels and volcanogenic concretions that typify the lower member of the unit. Here we recapitulate the discovery of the dicynodont communal latrines and describe in detail the biostratinomy and fossil diagenesis assessing paleoenvironmental and paleoclimatic conditions of Ladinian-Carnian Chañares Formation. The communal latrines (biogenic concentrations) could represent multiple "fossil censuses" and fit into the Johnson's model 1 ("census assemblage"), with a "clump type" geometric accumulation and an "intrinsic" biogenic concentration which imply gregariousness. The autochthonous coprolites preserve their original positions and show pristine surfaces with low proportion of broken samples: some display weathering in the upper surfaces (desiccation cracks before burial) with smooth lower ones. In general, coprolites lack evidence of bioturbation, physical reworking, corrosion or erosion, implying a rapid burial by catastrophic sedimentation ("*in mass* deposition"). However, constant and copious volcanic ash rains may have also covered the dung heaps preserving *in situ* the communal latrines. Nevertheless, the thanatocenosis and time-averaging were virtually zero. A paleogeographic reconstruction of westernmost Gondwana during the middle-late Triassic has located Chañares nearly to 40° south latitude, inside a subtropical dry fringe. Some taphonomic features (like weathering desiccation, differential coprofabric) and sedimentary structures may suggest seasonal conditions in a semi-arid paleoclimate, characterized by long dry periods and short wet seasons with general regionally warm temperatures. Moreover, the variation in coprolite shapes (spheroid to flat-round) and their coprofabrics could indicate diet seasonal changes. The temporal and spatial resolution of the coprolite deposits in the fossil communal latrines can supply information regarding the paleobiology and behaviour of kannemeyeriiform in Chañares Formation and provide more information to the paleoflorists, paleoecology, and paleoclimates of western margin of Gondwana during Triassic times.

TAPHONOMY OF *CAMPINASUCHUS DINIZI* (MESOEUCROCODYLIA: BAURUSUCHIDAE) FROM THE LATE CRETACEOUS OF MINAS GERAIS, BRAZIL: IMPLICATIONS FOR PALEOECOLOGY

Thiago da Silva Marinho[1,2], Hermínio I. de Araújo-Júnior[3] and Agustín G. Martinelli[2]

1. Instituto de Ciências Exatas, Naturais e Educação (ICENE), Universidade Federal do Triângulo Mineiro (UFTM), Av. Dr. Randolfo Borges Jr. 1700, Univerdecidade, 38064-200, Uberaba, Minas Gerais, Brazil. tsmarinho@icene.uftm.edu.br

2. Centro de Pesquisas Paleontológicas L. I. Price, Complexo Cultural e Científico de Peirópolis (CCCP/UFTM), Bairro Peirópolis, Uberaba, Minas Gerais, Brazil.

3. Universidade Federal do Rio de Janeiro, Programa de Pós-Graduação em Geologia, Instituto de Geociências, CCMN, Cidade Universitária, Ilha do Fundão, Av. Athos da Silveira Ramos, 274, Bloco G, 21941-916 Rio de Janeiro, RJ, Brazil.

Campinasuchus dinizi is a mid-sized baurusuchid crocodyliform known from the Late Cretaceous Adamantina Formation strata at the "Fazenda Três Antas" Paleontological Site, Campina Verde municipality, Minas Gerais state, Brazil. Several well-preserved and articulated specimens have been collected from the same outcrop and stand out due to the quantity and skeletal completeness. The fossils are preserved in reddish fine- to coarse-grained sandstones, which commonly enclose carbonatic nodules. Some levels record periods of higher energy events, as evidenced by the occurrence of conglomeratic sandstones containing igneous clasts and sandstone intraclasts. The paleoenvironment is interpreted as distal alluvial fans and alluvial plains, related to seasonal floods in a semi-arid hot climate. The specimen here studied (CPPLIP 1237) is a disarticulated subadult *Campinasuchus dinizi* represented by an almost complete post-cranial skeleton and almost complete skull with 195 mm in maximum length. The skeleton was preserved in a reddish fine-grained sandstone layer without sedimentary structures, overlapping a carbonatic coarse-grained sandstone layer. Brief comparisons with other specimens of *C. dinizi* collected from the same layer were performed in order to refine the knowledge on the paleoautoecology of this species. Only the bones exposed recently due to erosion show signs of weathering or abrasion, but some of the elements present minor cracks and fractures, possibly produced by grass roots. Most of the bones are preserved in the block as collected in field. Bones represented in the specimen are: skull and mandible in occlusion; cervical, thoracic, lumbar, sacral and caudal vertebrae; cervical and thoracic ribs; scapular and pelvic girdle elements; forelimb and hindlimb elements; and few osteoderms. Excepting the skull, mandible and some few articulated vertebrae, most of the elements are disarticulated, mixed and completely displaced. Despite the degree of articulation, the association between the bones suggests that the skeleton is autochthonous. The occurrence of several autochthonous individuals of *C. dinizi* in floodplain strata is intriguing; however, it is feasible when the hypothesis that Bauru Group crocodyliforms would be burrow dwellers (like some extant crocodilians) is considered. The occurrence of complete and articulated or semi-articulated specimens of *Campinasuchus* often found in pairs and associated to egg remains suggests that *C. dinizi* was a burrow dweller. The interpretation based on the taphonomic mode of most specimens of *C. dinizi* allows the interpretation of the fossiliferous layer of "Fazenda Três Antas" as an obrution deposit and, consequently, their fossiliferous content as a less time-averaged assemblage.

HISTOLOGY AND TAPHONOMY OF THE EXTINCT EQUID *HIPPARION ZANDAENSE* FROM TIBET (FIRST APPROACH)

Cayetana Martínez-Maza[1], Deng Tao[2], María Teresa Alberdi[1], Shi-qi Wang[2] and Yolanda Fernández-Jalvo[1]

1. Museo Nacional de Ciencias Naturales (CSIC), José Gutiérrez Abascal 2, Madrid, 28006, Spain. yfj@mncn.csic.es
2. Institute of Vertebrate Paleontology and Paleoanthropology (CAS), 142 Xizhimenwai, Beijing, 100044, China.

The analysis of long bone histology has been proven to be basic data source of developmental processes and life history traits of vertebrates. The study of the faunal assemblage from the Zanda Basin (Tibet) offers an exceptional opportunity to analyze a critical moment, the biological response to environmental changes during the uplift of the Tibetan Plateau. More specifically, the microscope analysis of a sample of *Hipparion zandaense* (4.6 Ma, middle Pliocene) showed that the histology is characterized by a reticular fibrolamellar bone tissue with a discernible growth mark partially obscured by secondary osteons. This growth mark or line of arrested growth (LAG) indicates that these specimens are more than one year old and show a seasonal growth. The comparison with the histology of other *Hipparion* species suggests a similar life history pattern conditioned by the availability of food during unfavorable seasons. Histological analyses under light microscope showed, however, that some of the specimens bear diagenetic modifications consisting of a dense black region penetrating the cortical bone. Analyses of the histological sections under the scanning electron microscopy (SEM) and energy dispersion spectrometry (EDS) to detect chemical composition resulted to identify two types of bone diagenesis. One of the specimens showed the entire cortical intensively affected by typical terrestrial bacteria (linked to the soil quality). In contrast, other samples showed a characteristic peripheral bioerosion related to continental aquatic environments (lake or calm river streams). Here, we present preliminary taphonomic results of the extinct three-toed horse *Hipparion zandaense* from the Pliocene/late Miocene Zanda Basin at the northern foothills of the Himalayas. Interpretation of these data from histological and taphonomic viewpoints complements and increases the general information on the site environment and repercussions on the life history of *Hipparion zandaense*, originally obtained by each of these disciplines in isolation.

LEFTOVER PREY REMAINS: A NEW TAPHONOMIC MODE FROM THE LATE MIOCENE (CERRO AZUL FORMATION) IN CENTRAL ARGENTINA

Claudia I. Montalvo[1], Rodrigo L. Tomassini[2] and Renata Sostillo[3]

1. Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, Av. Uruguay 151, Santa Rosa, 6300, Argentina. cmontalvo@exactas.unlpam.edu.ar

2. INGEOSUR-CONICET. Departamento de Geología, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, 8000, Argentina.

3. INCITAP-CONICET. P.O. Box. 186 Correo Argentino, 6300 Santa Rosa, La Pampa, Argentina.

The Cerro Azul Formation (La Pampa Province, Argentina) comprises a rich vertebrate fauna corresponding to the late Miocene (Huayquerian Stage/Age), which includes numerous and diverse mammal remains. Taphonomic analysis of micromammal fossils recovered from Estancia Ré locality evidence that the faunistic assemblage is characterized by: high density of remains in small area; high taxonomical diversity; high MNI; high percentage of juvenile individuals; high frequency of disarticulated remains; high frequency of cranial remains; better preservation of several portions of cranial and postcranial remains; high breakage degree in all skeletal elements; presence of remains with spiral and stepped fractures; presence of remains with tooth marks; absence of remains with evidence of corrosion produced by digestion; and lack of remains with evidence of abrasion. The taxonomic representation shows predominance of one taxon (*Paedotherium minor*, Notoungulata). These features indicate the activity of a predator which accumulated the micromammal remains. Considering this, comparisons with other assemblages recovered from the Cerro Azul Formation in Telén and Caleufú localities (La Pampa Province), also interpreted as produced by predator activity, were made. According to their taphonomic characteristics, assemblages from Estancia Ré, Telén and Caleufú are defined as microfossil bonebeds that differ from any accumulation of feces and pellets produced by modern predators (nocturnal and diurnal raptors and carnivorous mammals). However, due to their anatomical representation, degrees of breakage of the remains and the presence of tooth marks, they can be interpreted as accumulations of uneaten prey remains. This involves that the predator performed a selective use of certain portions of the body prey and discarded others at the same time. The type of predator involved cannot be determined with certainty, although the presence of tooth marks in some remains and the presence of coprolites in Telén and Caleufú suggest that it could be a carnivorous mammal. Similarities in the accumulation mechanism and patterns of preservation, coupled with similarities among the sedimentary contexts involved, support the recognition of a taphonomic mode that includes the three assemblages denominated “leftover prey remains”.

CHEMOSYNTHESIS–BASED COMMUNITIES ON CRETACEOUS PLESIOSAURID BONES: DISTRIBUTION PATTERNS OF ASSOCIATED MOLLUSCS AND BORINGS

Kazuhiro Moriya[1], Robert G. Jenkins[2], Andrzej Kaim[3], Yoshitsugu Kobayashi[4] and Hiroki Echizenya[4]

1. Graduate School of Natural Science and Technology, Kanazawa University, Kakumamachi, Kanazawa, Ishikawa, 920-1167, Japan. trex.gr.gw@gmail.com

2. School of Natural System, College of Science and Engineering, Kanazawa University, Kakumamachi, Kanazawa, Ishikawa, 920-1192, Japan.

3. Instytut Paleobiologii PAN, ul. Twarda 51/55, Warszawa, 00–818, Poland.

4. Hokkaido University Museum, Kita 10, Nishi 8, Kita–ku, Sapporo, Hokkaido, 060–0810, Japan.

Marine vertebrate deadfalls support characteristic communities of deep-sea organisms which are cognate to vent and seep faunas. Organic matter contained in the deadfall bones serves as both a direct and an indirect source of nourishment for these communities. Hydrogen sulfides, generated during decay of the organic matter, support chemosynthetic ecosystems. The best known and researched are whale deadfalls known both from modern seas as well as from the Cenozoic deep water sediments. Prior to the appearance of whales in the Eocene, the Mesozoic seas were settled by marine reptiles and their carcasses could also support chemosynthesis–based communities. Actually such chemosynthetic associations had been found from Cretaceous plesiosaurid skeletons. However, the detailed distribution pattern of chemosynthetic animals and bioerosion structures of these occurrences has not yet been analyzed. Here, we examined the distribution patterns of chemosynthetic molluscs and micro- and macroborings around/on the plesiosaurid carcass. We observed the surface and a cross section of the plesiosaurid specimen embedded in sedimentary rock. Shells of abyssochrysoid gastropods are densely distributed around the plesiosaurid carcass, especially on its upper side. Several types of borings (e.g. micron-sized filamentous microborings and μm- to mm-sized rounded boring holes) occur on the surface of the bones. A concentration of these borings can also be observed on the upper side of the carcass. On the basis of the shapes and existence of pyrite, we have assumed that the filamentous borings might have been formed by sulfur-oxidizing bacteria. The shape of the rounded borings is similar to the shape of the borings made by modern bone-consuming polychaetes *Osedax*. The coherent distribution patterns of abyssochrysoid gastropods and microborings on the Cretaceous plesiosaurid bones indicate that these gastropods grazed on the bacterial mats similar to their modern counterparts. Both the abyssochrysoid gastropods and the borings are concentrated on the same side of the skeleton. Most likely this side was exposed over the sediment longer period than the lower side, allowing settlement of this biota.

PRELIMINARY TAPHONOMIC ANALYSIS OF THE LATE PALEOCENE MAMMALIAN FAUNA OF "FISSURE 1948/1949", ITABORAÍ BASIN, RIO DE JANEIRO STATE, BRAZIL

Lorena Passos[1], Hermínio I. de Araújo-Júnior[1] and Lílian P. Bergqvist[1]

1. Departamento de Geologia, Universidade Federal do Rio de Janeiro, Av. Athos da Silveira Ramos, 274, Cidade Universitária-Ilha do Fundão, Rio de Janeiro, 20.941-916, Brazil. lorenapfb@hotmail.com

The Itaboraí Basin (late Paleocene of Brazil) stands out as the sole representation of the early radiation of mammals after the K/Pg boundary in Brazil. The fossils were preserved in terrigenous deposits that filled fissures developed in calcareous pavements. The "Fissure 1948/1949" is one of the most important due to its high diversity; however, its taphonomy is barely understood. This work presents a preliminary taphonomic analysis of the taphocoenosis of "Fissure 1948/1949", seeking to contribute to the interpretation of taphonomic processes that controlled vertebrate preservation in the basin. Up to now, 457 specimens were evaluated, including 385 isolated teeth, 56 mandibles and 16 maxillae. The specimens are housed in the paleontological collection of Museu Nacional, at Rio de Janeiro, Brazil. The following taphonomic features were evaluated: taxonomic representativeness, weathering (using the Behrensmeyer's classification for bones and a parallel classification for teeth), abrasion, breakage, color, ontogenetic stages (based on tooth wear) and superficial modifications (insect bioerosion, rooting, trampling and corrosion). The material is assigned to 20 taxa, although the species *Colbertia magellanica* and *Tetragonostylops apthomasi* are the most abundant. Only Behrensmeyer's weathering stages 0, 1 and 2 were observed, with overrepresentation of the stage 0. The weathering stages A, B, C and D were observed in the teeth. Non-abraded fossils are dominant, but moderate-abraded ones also occur. Ochre is the only impregnating color observed in the material. Adult and subadult individuals are represented. The breakage pattern includes irregular, smooth and parallel fractures. Evidence of scavenging, trampling, rooting, insect bioerosion and corrosion are absent. The ontogenetic profile suggests a non-catastrophic mortality. The breakage pattern indicates that the specimens were broken during both biostratinomy and fossildiagenesis. The patterns of weathering and abrasion suggest that the thanatocoenosis experienced a short time span of subaerial exposure and transportation. These interpretations, associated with the absence of other biostratinomic features and the occurrence of just one impregnating color in the fossils, suggest that the "Fissure 1948/1949" taphocoenosis represents a less time-averaged assemblage. Thus, the taxonomic representativeness observed in this taphocoenosis can be similar to the diversity setting in Itaboraí during the late Paleocene. Finally, the taphonomic interpretations for "Fissure 1948/1949" are similar to those for "Fissure 1968", suggesting an evenness of the taphonomic processes through time.

THE UPPER JURASSIC OF BRAZIL: ALIANÇA FORMATION (JATOBÁ BASIN), A GOOD PALEOVERTEBRATE FAUNA REPRESENTATION

Marcia C. da Silva[1], Alcina M. Franca Barreto[2], Marise Sardenberg Salgado Carvalho[3] and Ismar de Souza Carvalho[3].

1. Universidade Federal de Alagoas (UFAL), Campus Arapiraca, Núcleo de Biologia, Av. Manoel Severino Barbosa, s/n, Bom Sucesso, CEP 57309-005, Rodovia AL-115, Km 6,5. Arapiraca, AL, Brazil. marciasilva.paleo@gmail.com

2. Universidade Federal de Pernambuco (UFPE), Centro de Tecnologia e Geociências, Departamento de Geologia, Av. Acadêmico Hélio Ramos s/n, Cidade Universitária, Recife, PE, 50740-530, Brazil.

3. Universidade Federal do Rio de Janeiro (UFRJ), Instituto de Geociências – UFRJ, Av. Athos da Silveira Ramos s/n, 21910-200, Rio de Janeiro, RJ, Brazil.

The Jurassic sedimentary record is scarce in Brazilian basins due to the unfavorable conditions prevailing sedimentation and pre-rift tectonics during this period in Gondwana. Extensive arid regions associated with fluvial and lacustrine environments resulted in reddish oxidized sandstones and shales. Therefore Jurassic fossils are also rare and are of extremely importance at national and international levels (even when they present high index of fragmentation). The typical fossil samples for this unity are scales, bone fragments, teeth, spines and osteoderms that belong to Hybodontiform sharks (*Planohybodus marki* and *Parvodus* sp.), fish (*Ceratodus*, *Mawsonia* and *Lepidotes*) and a crocodyliform. The Jatobá Basin Aliança Formation, northeast Brazil, provides an excellent fossiliferous potential when compared to other Brazilian basins, giving this unity a special interest for Jurassic paleovertebrate studies in the country. Recent surveys carried out in the basin (Pernambuco State) resulted in the finding of lots of bone fragments, isolated teeth, scales, head and dorsal fin spines and coprolites attributed mainly to fishes. Crocodyliform teeth and osteoderms, and a fragmentary egg shell were also collected. The fragmentary material allows the identification of new species and gives insights about the understanding of the regional dynamics during the period. The Jatobá Basin fauna is correlated with other basins in northeastern Brazil such as Brejo Santo Fm. (Araripe Basin); Bananeira Fm. and Serraria Fm. (Sergipe-Alagoas Basin); Aliança Fm. (Tucano-Recôncavo and Camumu Basins); Malhada Vermelha Fm. (Lima Campos Basin). It is also related to the Tacuarembó Fm. (Paraná Basin in Uruguay). In Brazil there is some disagreement between authors about stratigraphic position of this faunal association: most of them agree it belongs to the Upper Jurassic, but some attribute it to the Lower Cretaceous. However, the confirmation of Late Jurassic aged fossils attributed to the Jatobá Basin is enhanced by the association with ostracods *Darwinulla oblonga* and *Bisulcocypris pricei* which allowed the framework of the typical vertebrate fauna in the regional PETROBRAS biozone NRT-001 from the Dom João Local Stage (Upper Jurassic).

PRELIMINARY BIOSTRATINOMIC ANALYSIS OF FOSSIL CONCENTRATIONS FROM THE RIO DO RASTO FORMATION (MIDDLE-LATE PERMIAN), PARANÁ BASIN, BRAZIL

Adriana S. de Souza[1], Karine L. Azevedo[1], Andressa Paim[1], Cristina S. Vega[2] and Marina B. Soares[1]

1. Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, Porto Alegre, CEP 91.540-000, Brazil. dessapaim@gmail.com

2. Universidade Federal do Paraná, Centro Politécnico, Bairro Jardim das Américas, Curitiba, Caixa Postal 19001, Brazil.

The Rio do Rasto Formation is a Middle-Late Permian depositional sequence from the Paraná Basin which is divided, from the base to the top, into the Serrinha and Morro Pelado members. The Serrinha Member is typically represented by lacustrine facies related to wetter climatic conditions, overlying by the fluvial-lacustrine deposits of the Morro Pelado Member, with an increasing in occurrence of eolian sandstones towards the top, representing the most severe phase of aridity recorded in the Rio do Rasto Formation. The studied outcrop is located at Paraná State, Southern Brazil, and corresponds to the top of the Morro Pelado Member. The outcrop is about 30 m thick and presents a succession of predominantly red siltstones interbedded with metric layers of fine- to medium-grained sandstones. The fossils include plant remains, conchostracans, bivalves, paleonisciforms fish scales and bone elements of temnospondyl amphibians, in addition to vertebrate trace fossils. Vertebrate fossils generally are surrounded by a thick layer of manganese oxide, being diagenetically altered. Three different taphofacies were distinguished from the bottom to the top. Taphofacies I is composed by post-cranial temnospondyl amphibians of relatively small size, which occur disarticulated and fragmented, preserved in parallel-laminated and current-ripple cross-laminated red siltstone. The predominance of small bone elements, in addition to their preservational condition, suggests hydraulic sorting. Taphofacies II occurs in parallel-laminated siltstone and consists of large bone elements in association with smaller elements (temnospondyl amphibian skulls and jaws, a fish jaw) that occur disarticulated, with no signs of fragmentation and abrasion, indicating an environment of calm waters, without the action of currents and, therefore, the absence of transport. Taphofacies III comprises a combination of densely packed paleoniscid fish scales and bivalves, with entire and fragmented specimens, preserved in a centimetric layer of red siltstone, which occur throughout the extension of the outcrop. This taphofacies probably reflects an environmental change to a shallower lake, where materials have undergone reworking, and possibly indicating time averaging. The outcrop in question proved to be quite promising for paleontological studies, but the small sample size has not allowed a more detailed taphonomic analysis yet, so that future collections are necessary for a better understanding of these aspects.

PALEOHISTOLOGY, MINERALOGY AND GEOCHEMISTRY OF PLIOCENE MAMMALS FROM THE MONTE HERMOSO FORMATION (ARGENTINA): *PAEDOTHERIUM BONAERENSE* (NOTOUNGULATA, HEGETOTHERIIDAE) AS A CASE STUDY

Rodrigo L. Tomassini[1], Claudia I. Montalvo[2], Teresa Manera[3] and Graciela Visconti[2]

1. INGEOSUR-CONICET. Departamento de Geología, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, 8000, Argentina. rodrigo.tomassini@yahoo.com.ar
2. Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, Avda. Uruguay 151, Santa Rosa, 6300, Argentina.
3. INGEOSUR, San Juan 670, Bahía Blanca, 8000, Argentina.

The mammalian faunas from the South American Neogene are generally analyzed from a systematic and/or biochronostratigraphic perspective, but taphonomic studies are still scarce. In this contribution we describe and analyze mineralogical, geochemical and paleohistological characteristics present in hemimandibles of the micromammal *Paedotherium bonaerense* (Mammalia, Notoungulata, Hegetotheriidae). Remains were recovered from the floodplain deposits of the Monte Hermoso Formation (early Pliocene), at Farola Monte Hermoso locality (Buenos Aires Province, Argentina). Francolite is the main mineral component in all hemimandibles, evidencing compositional changes in the internal crystalline structure during fossil diagenesis. Similarities in the chemical composition between fossils and host rock would indicate that the enrichment of the remains with new elements was due to a direct exchange with the sediments where they were buried. Original bone microstructure shows good preservation, only affected by permineralization and microfissures. Osteons, vascular canals, osteocyte lacunae and canaliculi were recognized. Manganese and iron oxides are the most abundant minerals infilling microstructural features and microfissures. The dark color identified on the outer surface of some remains is related to manganese oxide precipitation. The obtained results allowed us to reconstruct the processes that affected the remains both before and after the burial, and interpret the different taphonomic histories. This detailed taphonomic analysis increases the knowledge of South American Neogene faunal communities from a novel perspective, different from the one traditionally considered and, on the other hand, also establishes a framework for the analysis of other micromammal assemblages with similar characteristics.

TAPHONOMIC IMPLICATIONS OF FISH TEETH AND SCALES IN THE IRATI FORMATION, PARANA BASIN, BRAZIL

Everton Wilner[1,2], Luiz Carlos Weinschütz[1], João H. Zahdi Ricetti[1,2] and Paulo Cesar Manzig[1,3]

1. Universidade do Contestado (UnC), Centro Paleontológico (CENPALEO), Av. Pres. Nereu Ramos, 1071, Mafra, 89300-000, Brazil. paulomanzig@geotematica.com

2. Universidade Federal do Rio Grande do Sul (UFRGS), Programa de Pós-Graduação em Geociências (PPGGeo), Av. Bento Gonçalves, 9500, Porto Alegre, P. Box 15001, 91501-970, Brazil.

3. Universidade Estadual de Campinas (UNICAMP), Programa de Pós-Graduação IEL-Labjor, Cid. Univ. "Zeferino Vaz", Campinas, 13083-970, Brazil.

An outcrop of the Irati Formation (succession up to 10 m thick), located at the BR 280 highway margin in Três Barras city, North Plateau Santa Catarina State (South Brazil), yields abundant teeth and polymorphological fish scales and rare less mineralized multi-element fish parts. This is especially evident in the best exposed portion of the outcrop comprising an 8 m thick interval of bituminous shales interbedded with clayey siltstones and ash layers. Regional correlations suggest that these ash layers are possibly related to eruptive cycles. The fossiliferous beds are characterized by high density of exceptionally preserved teeth and scales. These traits suggest low energy, albeit with sorting of the most resistant bioclasts, supporting the hypothesis of drowning of "Irati Gulf" due to limited water circulation during the last stage of marine ingression in this interior basin depocenter. A similar situation is documented in the Paraná Basin by the Serra Alta Formation. Results from this research suggest that dense fossil concentrations are possibly related to pyroclastic flows.

SYMPOSIUM

EVOLUTION OF SOUTH AMERICAN ENDEMIC UNGULATES

ORGANIZERS:

DARIN CROFT - GUILLERMO LÓPEZ

MOLECULAR PHYLOGENIES OF SOUTH AMERICAN MAMMALS FROM 'PALAEOPROTEOMICS'

Michael Buckley[1], Alfredo Carlini[2], Jorge Martínez[3] and Jaime Powell[4]

1. University of Manchester, Manchester Institute of Biotechnology, 131 Princess Street, Faculty of Life Sciences, Greater Manchester, M1 7DN, UK. m.buckley@manchester.ac.uk.

2. Museo de La Plata, Paseo del Bosque S/N, 1900 La Plata, Buenos Aires, Argentina.

3. Instituto Superior de Estudios Sociales-CONICET, Instituto de Arqueología y Museo-UNT, Tucumán-Argentina.

4. CONICET, Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Miguel Lillo 205, 4000 Tucumán, Argentina.

Proteomics, a technique with its origins in the late 1980s, has been increasingly applied to extinct faunal remains in recent years with the hopes that it will improve our understanding of the evolution of life on Earth. It has three obvious advantages over DNA methods: 1) several proteins, such as collagen, survive orders of magnitude longer (i.e., millions of years); 2) the methods are much easier to carry out and less prone to contamination; and 3) they are also much cheaper. Previously, proteomics analyses have been used to resolve the phylogenetic placement of an extinct mammal from Madagascar, the 'Malagasy aardvark,' which, following a century of debate, was given its own taxonomic order 'Bibymalagasia.' The collagen sequencing results obtained from proteomics placed it closest to the tenrecs and the grouping Tenrecoidea. Current research similarly applies these molecular methods to resolving the phylogenetic placement for several groups of South American mammals, including collagen sequencing results from endemic South American ungulates such as *Toxodon* (Notoungulata) and *Macrauchenia* (Litopterna) for which current phylogenetic placement on morphological criteria is still debated. We also make comparisons between results from various tissue types from other South American mammals of better understood phylogenies, including *Megatherium* and *Hippidion* to further explore the potential of proteomics techniques in the analysis of Late Quaternary faunal remains.

DIVERSITY OF NATIVE UNGULATES IN THE LATE OLIGOCENE OF WEST-CENTRAL ARGENTINA

Esperanza Cerdeño[1]

1. Paleontología, IANIGLA, CCT-CONICET-Mendoza. Avda. Ruiz Leal s/n,
5500 Mendoza, Argentina. espe@mendoza-conicet.gob.ar

Knowledge of South American Cenozoic mammals has increased during the last several decades thanks to many extra-Patagonian local faunas. For the late Oligocene Deseadan Mammal Age in particular, Patagonian assemblages (Scarritt Pocket, Cabeza Blanca, Gran Barranca, La Flecha) are still the most abundant and diversified. Nevertheless, faunas from Uruguay (Fray Bentos Formation, which also crops out in Argentina), Bolivia (Salla, Lacayani), central Chile (Abanico Formation), Brazil (Tremembé Formation) and Peru (Moquegua Formation, Santa Rosa) have provided interesting taxa that have begun to fill in the picture of the South American late Oligocene. In this context, the faunal association from Quebrada Fiera, in Mendoza Province, west-central Argentina, is shedding additional light on that scenario by contributing to a better understanding of Deseadan mammal distributions and the role of this area in a paleobiogeographic context. Aside from a small lizard and some birds (a phorusrhacid and small birds), the long list of mammals from Quebrada Fiera includes three carnivorous metatherians, two rodents, nine xenarthrans (two Pilosa, seven Cingulata) and many native ungulates (Pyrotheria, Litopterna, and Notoungulata). The 13 notoungulate species comprise more than 80% of ungulate species and represent eight families of both suborders, Typotheria and Toxodontia. Within Typotheria, Archaeohyracidae, Hegetotheriidae and Interatheriidae are relatively abundant whereas Mesotheriidae are notably scarce. The archaeohyracid *Archaeohyrax suniensis* is shared with the Salla fauna, in which mesotheriids, by contrast, are very abundant. The high diversity of hegetotheriids resembles Patagonian faunas, mainly by the presence of pachyrukhines, but some hegetotheriines are shared with Salla and Fray Bentos Fm. The interatheriid *Plagiarthrus clivus* also has Patagonian affinities. Among Toxodontia, a new notohippid, *Mendozahippus fierensis*, has been recognized along with a second, poorly known taxon. A new genus and species of leontiniid is recognized, sharing features with both Salla and Patagonian genera. Two toxodontids, *Proadinotherium* sp. and *Pronesodon* sp., and a new species of the homalodotheriid *Asmodeus* are the first Deseadan extra-Patagonian records of these families and genera. The notoungulates and the mammal assemblage as a whole of Quebrada Fiera include typical Patagonian taxa (at generic and specific levels) and species present in Bolivia and Uruguay, together with many apparently endemic species (at least six new species of six families). Thus, this unusual fauna from Mendoza and its latitudinal position appear to represent a nexus between two paleobiogeographic regions, the higher latitudes of Patagonia and the lower latitudes of sites such as Salla.

SOUTH AMERICAN ENDEMIC UNGULATES IN THE PLEISTOCENE OF THE PAMPEAN REGION (BUENOS AIRES PROVINCE, ARGENTINA): ECOLOGICAL INSIGHTS FROM STABLE ISOTOPES (DIET, COMPETITION AND PREDATION PRESSURE)

Martin Cotte[1], Francisco J. Prevosti[2], Leopoldo H. Soibelzon[3], Stefanie Bauriedl[1] and Hervé Bocherens[1]

1. Dept of Geosciences, University Tübingen, Hölderlinstr. 12, Tübingen, 72074, Germany. martin.cotte@student.uni-tuebingen.de

2. MuseoArgentino de CienciasNaturales, Av. Angel Gallardo 470, C1405DJR, Buenos Aires, Argentina.

3. Museo de La Plata, Paseo del Bosque, La Plata, B1900FWA, Argentina.

During the Pleistocene, South American endemic ungulates coexisted with ungulates of North American origin as well as with carnivorous species that may have preyed on them. The Pampean region (Buenos Aires Province, Argentina) has yielded very rich mammal assemblages of early Pleistocene (Ensenadan) and late Pleistocene (Lujanan) age including all these groups. We used carbon and oxygen isotopic composition of tooth enamel to reconstruct the food preferences and habitats of South American endemic ungulates, such as *Mesotherium*, *Macrauchenia* and *Toxodon* (open versus forested environments, wet versus dry). In addition, we compared their carbon and oxygen isotopic composition with those of coeval non-endemic ungulates, such as equids, cervids, and camelids, as well as proboscideans, to evaluate possible competition and niche partitioning among these ungulates. Our data show that all herbivores underwent a shift of approximately 1‰ in their carbon and oxygen isotopic values between the early and late Pleistocene that could correspond to a shift in climate. Furthermore, we found a wide spread of habitats and diets for both endemic and invading ungulates, ranging from pure C3 environments to mixed C3-C4 environments. There seems to be no clear niche partitioning between the ungulate species based on habitat choice. Most groups show broad ranges of habitat and diet indicating no direct competition between species of invading and endemic ungulates. Finally, the prey preferences of the predators, which include giant short-faced bears, large canids and saber-tooth cats, was evaluated using isotopic tracking to test if any group of endemic ungulate was preferentially preyed upon by some of these predators. Our data suggest that some predators preferred to hunt in specific environments. *Smilodon* seemed to be restricted to prey from wet areas with pure C3 environments while *Theriodictis*, a large canid, seemed to prefer prey from more arid areas with mixed C3-C4 environments. The short-faced bear *Arctotherium* presents isotopic values similar to those of *Smilodon* during the early Pleistocene. This suggests, at the very least, some dietary competition between both species. This information will help to better understand the final stages of their evolution in this region.

FIRST DIGITAL CRANIAL ENDOCASTS OF LATE OLIGOCENE NOTOHIPPIDAE (NOTOUNGULATA): IMPLICATIONS FOR ENDEMIC SOUTH AMERICAN UNGULATE BRAIN EVOLUTION

María T. Dozo[1] and Gastón Martínez[1]

1. Centro Nacional Patagónico (CONICET). Boulevard Brown 2915, Puerto Madryn, U9120ACD, Argentina.
dozo@cenpat.edu.ar

Notohippidae were middle-sized toxodonts with an early tendency toward hypsodonty and convergence with the Equidae. They have been recorded from the Eocene to the early Miocene. New findings in the Deseadan locality of Cabeza Blanca (Patagonia), the most complete skulls known for Notohippidae, have motivated new studies. We provide the first description of the cranial endocasts of *Rhynchippus equinus* (MPEF-PV 695) and *Eurygenium latirostris* (UNPSJB-PV-60) based on three-dimensional reconstructions extracted from high-resolution X-ray computed tomography imagery. We analyze the encephalization quotient (EQ) and infer the location of some functional neocortical areas. Although obvious differences are observed in the morphology of skull, the morphological analysis of the endocasts of *Rhynchippus equinus* and *Eurygenium latirostris* indicates that they were similar in size, proportions of the encephalic components, and neocortical design. The digital endocast of *Rhynchippus equinus* shows the rhinal fissure, other cerebral sulci and casts of arteries, and the dorsal sinus system, which is also distinguishable on the artificial endocast of the same specimen. The neuromorphology of the notohippids *Rhynchippus* and *Eurygenium* is similar to the morphology of the endocasts of *Proadinotherium*, *Adinotherium* and *Nesodon* from the Miocene. However these toxodontids show a relatively larger frontal lobe and apparently greater development of secondary sulci in both the frontal and temporal lobes. On the other hand, the neuromorphology of notohippids contrasts with the neocortical morphological patterns described for the brains of living ungulates (orders Perissodactyla and Artiodactyla). The brain of most modern ungulates shows a less pronounced forebrain flexion, favoring the presence of longitudinally arranged sulci but without showing a developed sylvian region. This more simplified pattern resembles the brains of Tertiary Artiodactyla and Perissodactyla from the Northern Hemisphere and proterotheriid litopterns from the South American Tertiary. The present study is the first to include an estimate of EQ for *Eurygenium latirostris*. The EQ estimate (between 0.584-0.633 and 0.613-0.669) is somewhat lower than the EQ of *R. equinus* (0.670-0.695 and 0.709-0.738), and both are consistent with those observed for other toxodonts such as *Adinotherium* (EQ = 0.78) and *Nesodon* (EQ = 0.62). Regarding the location of some functional neocortical areas, the expansion of the frontal lobe in Notohippidae may reflect acquisition of heightened tactile sensitivity in the front of the snout as recorded in the somatic sensory cortex of living ungulates. The bulging temporal lobe may reflect expansion of the auditory cortex, likely related to the marked enlargement of the middle ear chamber.

THE AUDITORY REGION OF THE MIDDLE EOCENE LITOPTERNA *INDALECIA GRANDENSIS* BOND & VUCETICH, 1983: ANATOMICAL AND PHYLOGENETIC APPROACH

Daniel A. García-López[1,2] and Judith Babot[3]

1. INSUGEO (CONICET-UNT), Miguel Lillo 205, San Miguel de Tucumán, CP 4000, Argentina. garcialopez.da@gmail.com

2. Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Miguel Lillo 205, San Miguel de Tucumán, CP 4000, Argentina.

3. Fundación Miguel Lillo, Miguel Lillo 251, San Miguel de Tucumán, CP 4000, Argentina.

The auditory region of Paleogene South American ungulates is poorly known, although efforts have been made recently in order to increase its knowledge. Most contributions have focused on notoungulates, given that this group is the most common and often best preserved in Paleogene levels. Nevertheless, limited information exists for Litopterna, Pyrotheria, and Astrapotheria. *Indalecia grandensis* is a small-sized litoptern recovered from the Lumbrera Formation in Salta Province, Argentina. Although some traits of the auditory region were mentioned in the original description of this taxon, this part of the skull has remained unstudied. Considering the increasing value of auditory traits in mammalian systematics and the fact that this is a well-preserved Eocene specimen, we present a detailed basicranial description and interpret the relevance of these characters in the context of South American ungulate phylogenies. Most comparative sources are representatives of Notoungulata, from which *Indalecia* diverges by the lack of a completely ossified bulla. Instead, an expanded ectotympanic covers the lateral part of the tympanic aspect of the petrosal and forms the floor of a short external auditory meatus. Another difference regarding known early-diverging notoungulates is the presence of a postpromontorial tympanic sinus that is well-separated from the stapedial fossa by a marked step and a poorly demarcated promontorium. On the other hand, several common traits are noted: presence of an expanded medial flange, large fossa for the tensor tympani muscle located laterally to the secondary facial foramen, and large tegmen tympani. The study of *Indalecia* also provides information about the pathway of some vessels, such as the internal carotid, the superior ramus of the stapedial artery, the arteria diploetica magna, and the occipital artery. The most important traits include evidence of a medial trajectory of the internal carotid and a passage between the squamosal and the tegmen tympani for the superior ramus of the stapedial artery. This latter character is interesting because it is found in early-diverging mammals, such as the non-placental eutherian *Zalambdalestes*. The inclusion of these and other craniodental features in a large data-matrix comprising notoungulates, astrapotheres, pyrotheres, litopterns, and basal mammalian taxa placed Indalecia as the sister-taxon of astrapotheres and notoungulates, not closely related to other Litopterna. Although basicranial characters are not among the synapomorphies that define the relationships of Indalecia, this result is concordant with the general similarities observed with at least Notoungulata, particularly for dental and petrosal features.

DEPICTING THE EVOLUTIONARY HISTORY OF XENUNGULATA (MAMMALIA)

Javier N. Gelfo[1,2], Guillermo M. López[1,2] and Mariano Bond[1,3]

1. División Paleontología de Vertebrados, Museo de La Plata y CONICET. Paseo del Bosque s/n B1900FWA, La Plata Argentina. jgelfo@fcnym.unlp.edu.ar

2. Cátedra Paleontología Vertebrados (Fac. Cs. Nat. y Museo, U.N.L.P.), La Plata, Argentina.

3. Cátedra Paleontología II (Fac. Cs. Nat. y Museo, U.N.L.P.) y CONICET, La Plata Argentina.

The South American native ungulates were very diverse and include at least five extinct orders; in two of these orders, all members have low-crowned cheek teeth and a bilophodont pattern: Pyrotheria (middle Eocene-late Oligocene) and Xenungulata (late Paleocene-early Eocene). Xenungulates were neither so diverse nor abundant as Notoungulata, Litopterna or even Astrapotheria. Their cheek teeth show an exclusive specialization comparable to extant Tapiridae (Perissodactyla), and their ecological niche was probably very different than that of other South American ungulates. Only the families Etayoidae and Carodniidae are recognized among xenungulates, and their relationships remain uncertain and need further discussion. Etayoidae are represented by *Etayoa bacatensis* from the late Paleocene of Colombia and *Notoetayoa gargantuai* from middle Paleocene of Patagonia, Argentina. Both are known from fragmentary jaws. *E. bacatensis* has an alveolus of a large and procumbent canine and a long diastema mesial to the p2, suggesting the absence of p1. These features, not present in Carodniidae, resemble the morphology of Trigonostylopidae Astrapotheria, but in contrast to them, the symphysis in *E. bacatensis* is not fused. Carodniidae include *Carodnia feruglioi* and a gen. et. sp. nov., both from the middle Paleocene, Patagonia and *Carodnia vierai* from the early Eocene of Itaboraí, Brazil. The afore mentioned new taxon from the lower levels of Cerro Redondo presents a primitive pattern with remnants of the trigonid structure mesial to the protolophid (metacristid and paracristid), a well-marked cristid obliqua and the development of a short entocristid. These characters agree with an older age of the bearing levels with respect to those of the classic '*Carodnia* Zone.' Other new specimens found in Patagonian outcrops of the Peñas Coloradas Formation indicate the presence of two jaw morphologies for remains that could be assigned *prima facie* to *C. feruglioi*. One is characterized by its robustness and the height of the mandibular body below the m3, whereas the other type has a more slender and gracile jaw. These morphological differences could be interpreted as sexual dimorphism, but there is no dental evidence to corroborate that the morphotypes belong to the same species. Summarizing, the monophyly of Xenungulata is here questioned on the basis of the exposed arguments.

ISOLATED LITOPTERNA POSTCRANIAL REMAINS FROM LA BARDA TUFF (EARLY EOCENE), PASO DEL SAPO, CHUBUT, ARGENTINA

Malena Lorente[1]

1. CONICET; División Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina. mlorente@fcnym.unlp.edu.ar

Isolated postcranial remains are often disregarded in mammal paleontology. Most paleontological studies are based on teeth, which are considered the better-preserved remains of ancient faunas. La Barda is one of two localities that comprise the Paso del Sapo fauna (Chubut, Argentina), the main early Eocene mammal assemblage from west-central of Patagonia. Until now, the mammals of La Barda were described by isolated teeth and osteoderms. Here, Litopterna remains were identified from a larger set of isolated postcranial remains from this locality. The postcrania were separated by morphological characters into two different morphotypes, and their sizes were correlated with litoptern teeth from the same locality. Morphotype 1 is represented by one large astragalus, 47% larger than the rest. Morphotype 2 groups: two tibiae, five well preserved astragali and two calcanei. The statistical model for the correlation (log(astragalar length) = 1.06 x log(trigonid width) + 1.16) was based on a sample of 62 extant and fossil mammals. Using the leave-one-out cross validation method, a percent error (PE%) was obtained with an standard deviation of 8.39%; a 99% confidence interval was used to accept or reject a possible relationship between dental and postcranial remains. Two species of *Asmithwoodwardia* (Protolipternidae) have been identified by teeth from La Barda. The dental size of both species shows a good correlation with the size of morphotype 2. The astragali are mostly litoptern-like, differing from Proterotheriidae and Macraucheniidae by the presence of a reduced flexor groove, a more triangular ectal facet, and a neck crest projecting from the head, a character present in *Tiuclaenus* (Kollpaniinae) and in the tarsus assigned to other Protolipternidae (e.g., *Miguelsoria*). The tibia and the calcanei also show some primitive features, such as a well-developed malleolus in the tibia and a single faced ectal facet and inverted drop-like sustentacular facet in the calcanei. A taxon not represented by dental remains seems to be the source of the largest, more derived morphotype 1 astragalus, which lacks a flexor groove, has a more C-shaped ectal facet and an anterior trochlear facet, as in later litoptern taxa. There is no dental candidate that can be correlated by size with this tarsal, which questions the common idea that dental remains are better preserved than bones and are a reliable taxonomic sample of ancient diversity.

ANCIENT PROTEIN SEQUENCING RESOLVES LITOPTERN AND NOTOUNGULATE SUPERORDINAL AFFINITIES

Ross MacPhee[1], Frido Welker[2], Jessica Thomas[3], Selina Brace[4], Enrico Cappellini[5], Samuel Turvey[6], Ian Barnes[4], Marcelo Reguero[7], Javier Gelfo[7] and Alejandro Kramarz[8]

1. American Museum of Natural History, New York, NY 10024, USA. macphee@amnh.org
2. Max Planck Institute for Evolutionary Anthropology, 04103 Leipzig, Germany.
3. University of York, York, YO10 5DD, United Kingdom.
4. Natural History Museum, London SW7 5BD, United Kingdom.
5. University of Copenhagen, DK-1165 Copenhagen, Denmark.
6. Zoological Society of London, London NW1 4RY, United Kingdom.
7. Museo de La Plata, B1900FWA La Plata, Argentina.
8. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", C1405DJR Buenos Aires, Argentina.

Recent speculations concerning the affinities of South American native ungulates (SANUs) assert that at least some members of this ?paraphyletic group are not laurasiatheres but are instead either sister to Afrotheria or part of a distinct clade that includes afrotheres. Testing of this controversial hypothesis is desirable, optimally with data independent of phenotypic interpretation. Such a test might come from molecular data using short DNA sequences as barcodes (cf. Barcode of Life), but all efforts to acquire such information from SANU fossils have so far failed. There is an alternative: backbones of proteins such as collagen are an order of magnitude more stable than DNA and therefore more likely to survive taphonomically. We screened 34 Pleistocene bone samples of *Toxodon* (Notoungulata) and *Macrauchenia* (Litopterna) for collagen and DNA. Autochthonous DNA was not recovered, but collagen yield was often excellent. Using soft-ionization tandem mass spectrometry we obtained >90% sequence coverage of COL1α1 and COL1α2 sequences (1057 and 1040 residues, respectively) on the 4 best samples (2 per taxon), yielding 21,428 matching spectra. Aligned fossil sequences were mapped onto a mammalian phylogeny based on collagen gene transcripts from available genomes and MS/MS collagen data obtained for this study or from the literature. Our collagen tree yielded conventional Afrotheria, Euarchontoglires, Xenarthra, and Laurasiatheria, in overall good agreement with recent genomic and phenomic phylogenies of Placentalia. The two SANU taxa invariably placed within Euungulata, as follows: (((*Toxodon*, *Macrauchenia*) (Perissodactyla))(Cetartiodactyla)). Thus representative notoungulate and litoptern taxa fall on this evidence within Laurasiatheria and adjacent to crown Perissodactyla, at the opposite end of the cladogram from Afrotheria. This is consistent with the longstanding view that at least some SANU lineages may have originated from northern archaic ungulates ("condylarths"). To further test SANU affinities and their possible monophyly (as so-called "meridiungulates"), analyses of representative Astrapotheria, Xenungulata, and Pyrotheria would be needed. With improvements in instrumentation and analytical procedures, proteomics may produce a revolution in systematics like that achieved by DNA genomics, but with the possibility of working on much deeper timescales.
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SOUTH AMERICAN NATIVE UNGULATES FROM BRAZILIAN INTERTROPICAL REGION

Ana Maria Ribeiro[1], Francisco R. Negri[2] and Leonardo Kerber[3]

1. Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Av. Salvador França 1427, Porto Alegre, 90690-000, Brazil. ana-ribeiro@fzb.rs.gov.br
2. Laboratório de Paleontologia, Campus Floresta, Universidade Federal do Acre, Estrada do Canela Fina, km 12, 69980-000, Cruzeiro do Sul, Acre, Brazil.
3. Programa de Pós-Graduação em Geociências, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, 91501-970, Porto Alegre, RS, Brazil.

Among Cenozoic mammals found in the Brazilian intertropical region, South American native ungulates of the Paleogene Itaboraí and Tremembé formations of southeastern Brazil are well known. In the Neogene, native ungulates are well represented in the Solimões Formation of the Acre basin, Amazon region. Notoungulata Toxodontidae from Acre River have been represented until now by: *Gyrinodon* and *Trigodon*; Litopterna have been represented by Proterotheriidae indet. and possibly Macrauchenidae. These taxa indicate a late Miocene age for the Solimões Formation. In the Upper Juruá River, the toxodontids are more diverse and represented by at least the following taxa: *Gyrinodon*; *Trigodon*; *Palaeotoxodon*; *Paratrigodon*; *Trigodonops lopesi*; *"Plesiotoxodon" amazonensis*; *Neotrigodon utoquineae*; and Nesodontinae indet. In addition to toxodontids, the Leontinidae *Purperia cribatidens* and Notohippidae indet. are also present. On the other hand, Astrapotheria are represented only by Astrapotheriidae *Xenastrapotherium amazonense*. In the Upper Juruá, some taxa indicate a late Miocene age, but others seem to indicate older ages, for example *"Plesiotoxodon" amazonensis*, *Purperia cribatidens* and Notohippidae, whose dental morphology is very similar to the toxodontid and leontiniid from the middle Miocene of La Venta, Colombia. The same can be observed with the astrapotheres. These native ungulates, together with other mammal taxa, seem to suggest that the Solimões Formation faunal assemblage represents several levels of different ages, each of which may be correlated with other fossil localities in the Amazon. Finally, in the Pleistocene, the diversity of ungulates decreases, but we can observe at least two species of toxodontids, *Toxodon* and *Mixotoxodon*, both recorded in the Amazon region and in northeastern Brazil, whereas in the latter region an endemic macraucheniid, *Xenorhinotherium bahiensis*, also occurs. [Contribution to CNPq/Universal-483156/2014-4; CNPq/PQ-312085/2013-3].

ANATOMY, SYSTEMATICS, AND FUNCTIONAL INFERENCES OF TARSAL REMAINS FROM MIDDLE-LATE EOCENE OF NORTHWEST ARGENTINA

Matías A. Armella[1], Daniel A. García-López[1,2] and M. Judith Babot[3]

1. Instituto Superior de Correlación Geológica (INSUGEO-CONICET), Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina. matiasarmella@yahoo.com.ar

2. Facultad de Ciencias Naturales e IML, Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina.

3. Fundación Miguel Lillo. Miguel Lillo 251, San Miguel de Tucumán, 4000, Argentina.

In recent years, Paleogene outcrops in northwestern Argentina have provided abundant information about the evolution of South American mammals during the early Cenozoic. This region constituted an important area of early diversification for several groups of native ungulates during the Eocene, especially notoungulates. Nowadays, most works derived from these findings are focused on cranial and dental anatomy, although in many cases the specimens were found in association with postcranial elements. These elements can provide crucial information for phylogenetic analyses and supply important clues about the paleobiology of taxa that inhabited the region. This study presents a series of postcranial remains (proximal tarsals) from the Geste Formation that crops out at Antofagasta de la Sierra, Catamarca Province, Argentina. Three calcanei and two astragali were described, compared with extinct and extant ungulates, and systematically determined. Moreover, anatomical features were interpreted in a functional context. One calcaneus studied was assigned to Isotemnidae (Notoungulata), based on the oblique orientation of the line that runs along the distal portion of the sustentaculum, a markedly wide groove for the deep digital flexor tendon, and the extensive peroneal fossa, among other features. The other two calcanei and an incomplete astragalus were referred to Interatheriidae (Notoungulata) due to the presence of a fibular facet that is oriented obliquely with respect to the longitudinal axis of the calcaneus, the presence of two concavities in the posterior and lateral portion of the fibular facet, and a long astragalar neck with a markedly spherical head. Another element analyzed was an astragalus referred to Litopterna. This assignment is based on the presence of a pulley-like tibial trochlea, tibial and fibular crests approximately symmetric, and a markedly oblique astragalar neck with a cylindrical head. This last feature is less conspicuous than Miocene litopterns such as *Lambdaconus* and *Tetramerorhinus*, and resembles that of some didolodontids, such as *Didolodus*. On the other hand, the functional study allowed inferring the association of these bones with different types of stances. Based on the direction of different articulation planes (e.g., metatarsal, astragalar head, astragalar condyle planes, etc.) we suggest that the tarsal elements correspond to digitigrade animals. The study of these tarsals provided useful information about distinctive postcranial features of early forms of the most representative groups of native South American ungulates, and is of great importance for a more integrative view of the Paleogene forms in the region.

MORPHOLOGICAL INTEGRATION OF NATIVE SOUTH AMERICAN UNGULATE MANDIBLES BASED ON 3D LANDMARKS

Guillermo H. Cassini[1,2], Nahuel A. Muñoz[3], Santiago Hernández Del Pino[4] and Sergio F. Vizcaíno[3]

1. División Mastozoología, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", CONICET, Av. Angel Gallardo 470, Ciudad Autónoma de Buenos Aires, C1405DJR, Argentina. gcassini@macn.gov.ar

2. Departamento de Ciencias Básicas, Universidad Nacional de Luján, Ruta 5 y Av. Constitución, Luján, 6700, Buenos Aires, Argentina.

3. División Paleontología Vertebrados, Museo de La Plata, CONICET, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.

4. IANIGLA, Centro Científico Tecnológico -CONICET- Mendoza, Av. Ruiz Leal s/n., 5500, Mendoza, Argentina.

South American native ungulates include several extinct lineages that evolved within the context of Cenozoic geographic isolation of South America. By the late Early Miocene Santacrucian Age, the three orders Notoungulata, Litopterna, and Astrapotheria were clearly differentiated. Recent studies, in an ecomorphological framework, highlighted a complex functional pattern related to habitat/diet and hypsodonty. In order to understand these complex relationships in an evolutionary context we used geometric morphometrics methods to evaluate the morphological integration of two of the primary functional units of the mandible: the alveolar region and the ascending ramus. Twenty seven mandibular three-dimensional landmarks were digitized. Principal component analyses (PCA), and two blocks Partial Least Squared analyses (PLS) were used to explore the patterns of covariation between these two modules. The PCA of tangent space coordinates resulted in the six PCs accounting for nearly 85% of variance with the three first PCs accounting for most of the 70% cumulative variance. The shape changes associated with the first eigenvector go from a robust, curved mandibular corpus and expanded coronoid and angular process on the negative end to a gracile, straight mandibular corpus and shrunken coronoid and angular process on the positive end. The PLS analyses show a very high RV coefficient (~0.73) and only the first pair of PLS were significant, explaining 88% of covariation. The shape changes associated with PLS1 were very similar to those of PC1 (angle between vectors: 5°). These results were consistent when the PLS was repeated on the independent contrast. These results indicate a strong morphological integration in these three orders. In the Astrapotheria and Litopterna we found a common pattern of covariation, which might be due to similar constraints (developmental, functional and/or biomechanical). Conversely, in the Notoungulata the dimensions displayed a clear distinction among species suggesting a slighty different pattern of covariation in the different families of the order. The PLS within the litopterns and notoungulates indicate that only PLS1 was significant, explaining ~93% and 87% of covariation and showing higher RV coefficients, 0.91 and 0.66, respectively. The fact that the three orders differ in their hypsodonty could shape the morphological covariation between the two modules. In addition, the different covariation patterns in notoungulates with respect to litopterns are in concordance with both the taxonomic and morphological diversity of the clade, particularly in the typotheres.

ANALYSIS OF INTRAMEMBRAL PROPORTIONS IN ENDEMIC SOUTH AMERICAN UNGULATES AND COMPARISON TO MODERN TAXA

Darin A. Croft[1] and Patrick Guder[1]

1. Case Western Reserve University, 10900 Euclid Ave., Cleveland, Ohio, 44121-1667, USA.
dcroft@case.edu

Prior to the Great American Biotic Interchange (GABI), the South American mammal fauna included several groups of ungulate-like mammals. Comprised of orders such as Astrapotheria, Litopterna, and Notoungulata, these endemic ungulates were all extinct by the end of the Pleistocene. Due to the lack of living members, these ungulates have been compared to a variety of more distantly related extant taxa; astrapotheres have been likened to rhinocerotids and hippopotamids; litopterns have been compared to equids, bovids, and camelids; and notoungulates (the most diverse group) have been compared to taxa ranging from rodents and leporids to rhinocerotids and hippopotamids. One aspect of endemic ungulate morphology that has not typically been taken into account in such comparisons are limb intramembral proportions. In this study, we explored how intramembral proportions of these endemic ungulates compare to those of their presumed modern analogs in order to determine which modern species had limb proportions most similar to extinct South American ungulates. We gathered length measurements of forelimb bones (humerus, radius, metacarpal III) and hind limb bones (femur, tibia, metatarsal III) from the literature for 25 species of endemic ungulates (10 families in 3 orders) and compared them to measurements of 365 species of extant mammals from 66 families and 18 orders. Two exploratory principal components analyses (PCAs) were conducted to assess variation among species. The first PCA utilized untransformed measurements to determine variation in absolute limb segment length and permit comparisons of overall size. The second PCA used standardized length measurements (i.e., residuals from regressions of length measurements on PC1 from a PCA of log-transformed data) to explore limb length variation independent of body size. We used ternary plots of forelimb and hind limb proportions to compare intramembral proportions among taxa. Our analyses indicate that the limb proportions of many endemic ungulates are unlike those of the species to which they have traditionally been compared. For example, notoungulates plot equally close to carnivorans and rodents (far from extant ungulates); astrapotheres plot far from all sampled taxa; and litopterns are generally more similar to carnivorans, suids, and rhinocerotids than bovids, camelids, or equids. Our study highlights the unusual anatomy of extinct South American ungulates and suggests that limb proportions should be taken into account along with body size and presumed dietary niche when describing the appearance and ecology of these species to non-specialists and the general public.

TOMOGRAPHIC AND FINITE ELEMENTS STUDY OF THE RADIO-ULNA OF *MACRAUCHENIA PATACHONICA*

Andrea Elissamburu[1], Nicolás Agüero[2], Ariel Ibarra Pino[2], Cecilia Prieto[3], Aníbal Márquez[2] and Adrián Cisilino[2]

1. CONICET. Cátedra de Anatomía Comparada, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, 64n°3 e/119 y 120, 1900 La Plata, Argentina. aelissamburu@gmail.com

2. División Soldadura y Fractomecánica, INTEMA, Facultad de Ingeniería, Universidad Nacional de Mar del Plata-CONICET, Av. Juan B. Justo 4302, 7600 Mar del Plata, Argentina.

3. Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Argentina.

Macrauchenia patachonica is a native South American ungulate, now extinct, belonging to the Order Litopterna. It is the last species representative of the order, with records from the Early Pliocene (Ensenadan) to the Early Holocene (Lujanian). Its geographic distribution is extensive and includes Argentina, Chile, Uruguay, Bolivia, Paraguay, Perú and part of Brazil. General morphology and dentition place it as a cursorial herbivore, with an estimated body mass of 1,100 kg. Previous studies of the appendicular skeleton have proposed that *M. patachonica* could run and swerved to elude predators. In the present work, morphology, function, and bone resistance of the radio-ulna of *M. patachonica* are analyzed to test and to interpret different locomotor hypotheses. The methodology includes tomographic analysis to interpret bone morphology of the radio-ulna, and 3D finite element analysis study to test hypotheses of bone resistance to body mass support, both in standing posture and demanding locomotors postures. Additionally, a 3D digital model of *M. patachonica* was made to calculate its body mass and centre of mass. General preliminary results show that the radio-ulna had an internal bone configuration that increases resistance to tension and compression in the cortical region to the medial diaphysis in transverse and anteroposterior directions. Additionally, the general structure of the radio-ulna resulted in more transverse resistance to forces that act on the third distal part of the diaphysis. These results suggest that the anterior limb could resist high tensions in all directions with a grater transversal resistance capacity during body mass support and locomotion. Future research will use finite elements analysis to test whether the distal transverse resistance is tolerated by the radio-ulna during all locomotor demands or if it is associated with specific muscular action on this bone region.

A NEW TOXODONT FROM THE RAIGÓN FORMATION (PLIO-PLEISTOCENE) OF URUGUAY

Brenda S. Ferrero[1], Gabriela I. Schmidt[1], María I. Pérez García[2,3], Ana M. Ribeiro[4] and Daniel Perea[5]

1. Centro de Investigaciones Científicas y de Transferencia de Tecnología a la Producción (CICYTTP-CONICET), Materi y España, Diamante, 3105 Entre Ríos, Argentina. brendaferrero@cicyttp.org.ar

2. Instituto de Formación Docente de Treinta y Tres. Consejo de Formación en Educación (ANEP). Manuel Lavalleja 1191, 33000, Treinta y Tres, Uruguay.

3. Centro Regional de Profesores de Maldonado- Consejo de Formación en Educación (ANEP). La Virgen y Alférez Cámpora, CP 20000, Maldonado, Uruguay.

4. Museu de Ciências Naturais, FZBRS, 90690-000, Porto Alegre, RS, Brazil.

5. Instituto de Ciencias Geológicas, Facultad de Ciencias, Iguá 4225, 11400 Montevideo, Uruguay.

The specimen FC-DPV-514 (Facultad de Ciencias, Paleontología de Vertebrados, Uruguay) from the San José Member of the Raigón Formation (Plio-Pleistocene) consists of a skull fragment with P3-M3, right mandible with i1 and m1-m3, and postcranial fragments. This specimen was referred to *Dinotoxodon paranensis* (originally described from "Mesopotamiense" late Miocene, Entre Ríos Province, Argentina) based on the ventral extension of the mandibular ramus. MLP 39-XII-2-8 (stored at Museo de La Plata, Buenos Aires, Argentina), from "Mesopotamiense", also shares this feature, but it is less marked than in FC-DPV-514, and its maximum height is at the m2 level. The m2 of FC-DPV-514 has a well-developed metaconid and a straight posterior edge. The entolophid of m3 is straight, the hypoconulid is longer than MLP 39-XII-2-8 and lacks a smooth labial groove opposite the ento-hypoconid fold. These differences contradict the assignation of FC-DPV-514 to *Dinotoxodon*. Moreover, FC-DPV-514 differs from other Miocene taxa in the ventral extension of its mandible: *Gyrinodon* and *Pericotoxodon* have the lower edge less marked than FC-DPV-514, whereas in *Hoffstetterius* this feature is the most developed. In *Gyrinodon* and *Hoffstetterius* the maximum height of the mandible is at the anterior region of m3, whereas in *Pericotoxodon* it is at the level of m2, and in FCD-DPV-514 it is at the posterior region of m3. Furthermore, in FC-DPV-514 the hypoconulid (m1-m2) is lingually extended as observed in *Toxodon* and *Pisanodon*, differing of *Gyrinodon*, *Pericotoxodon*, *Calchaquitherium*, and *Ocnerotherium* (m2). Although *Hoffstetterius* has the hypoconulid lingually extended, it is less marked in m1 and rounded in m2. Unlike FCD-DPV-514, *Haplodontherium* and *Trigodon* only show the ento-hypoconid fold in m1-m2, *Trigodonops* presents the meta-entoconid fold hardly developed in m1-m2, and it is barely developed only in m2 of *Mixotoxodon*. *Plesiotoxodon* and *Hemixotodon* differ from FC-DPV-514 in ectoloph morphology in M2-M3, the M2 has the anterior and posterior grooves well-developed, and they have an Y-shaped convergence. *Stenotephanos*, *Posnanskytherium*, *Hyperoxotodon*, *Hemixotodon*, and *Nonotherium* are smaller than FC-DPV-514, with a shorter and lingually extended paraconid. These morphological differences support the erection of a new toxodontid genus in Uruguay. FCD-DPV-514 belongs to a fauna from the Raigón Formation that includes the endemic *Giganhinga kiyuensis*, *Pronothrotherium figueirasi*, *Josephoartigasia* and the Plio-Pleistocene *Platygonus*. Moreover, the finding of *Glyptodon*, *Plaxhaphous*, and *Catonyx tarijensis* in this formation would indicate a Pleistocene age so it would be considered Pliocene-Pleistocene in age according to its faunistic content. [Contribution to PIP-CONICET-112-201101-01024; FCE-2011-6752; CNPq/PQ-312085/2013-3].

A NEW AND PECULIAR MORPHOTYPE OF SOUTH AMERICAN NATIVE UNGULATE

Guillermo M. López[1,2] and Mariano Bond[1,3]

1. División Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n°, La Plata, (1900), Buenos Aires Argentina. glopez@fcnym.unlp.edu.ar
2. Cátedra Paleontología Vertebrados (Fac. Cs. Nat. y Museo, U.N.L.P.), La Plata, Argentina.
3. Cátedra Paleontología II (Fac. Cs. Nat. y Museo, U.N.L.P.) y CONICET, La Plata Argentina.

The highly endemic terrestrial fauna and flora of South America is mostly a result of the geographical isolation of this continent for much of the last 65 my. In this context the herbivorous mammals were mainly represented by native ungulates (five orders of extinct mammals) and xenarthrans. The South American native ungulates developed different morphotypes many of which are convergent with those present in phylogenetically unrelated groups of mammals. Notoungulates, the most diverse group, include a wide variety of animals: rodent-like ones, rhino and hippo-like ones, and even some "chalicotherian-like" forms. The also varied litopterns include some "camel-like" taxa and functionally monodactyl "horse-like" ones. Astrapotheres are medium to very large mammals with tusks, some of them probably with a proboscis and perhaps semi-aquatic habits. Other ungulates such as pyrotheres are large-sized, elephant-like mammals with tusks, and xenungulates are large and comparable to tapirs. Here we report a new notoungulate recovered from the Divisadero Largo Formation (Mendoza province, middle Eocene?) which represents a novel and amazing morphotype so far unknown for this order. The specimen (MLP 87-II-20-40) consits of the anterior half of the skull (still unprepared) with both mandibles in occlusion that preserve two lower incisors, C-P4/c-p4 series of both sides, one broken M1 and one isolated m1. The most remarkable features observed in this skull are: (1) a strong shortening of the rostral region; (2) large orbits tending toward frontalization; (3) a relatively large cranial height; (4) robust mandibular rami with a long and fully fused symphysis. These peculiar features are reminiscent of a small primate, although according to an analysis of its anterior cranial proportions it would be ecologically comparable to some arboreal marsupials (e.g. phalangerids). Of what can be observed, the occlusal morphology of the molariforms is reminiscent of that of the putative oldfieldthomasiids of Divisadero Largo. Consequently, this new taxon is referred to the notoungulates and tentatively to the Oldfieldthomasiidae s.l. This taxon, probably arboreal, represents a new morphotype, so far unknown of native ungulates. Up to now, in the South American Paleogene, the mammals of presumed arboreal habits were restricted to the marsupials and especially to *Groeberia*, a form that has been compared favorably to some primates, and which until now is only known from the Divisadero Largo Formation. This new and peculiar small notoungulate illustrates the incomplete knowledge about the history of the Paleogene mammals outside Patagonia.

CRANIAL OSTEOLOGY OF THE LATE OLIGOCENE NOTOHIPPIDAE *RHYNCHIPPUS EQUINUS* AMEGHINO (MAMMALIA, NOTOUNGULATA) BASED ON THE MOST COMPLETE SKULL KNOWN FOR THE SPECIES

Gastón Martínez[1] and María T. Dozo[1]

1. Unidad de Investigación de Geología y Paleontología, Centro Nacional Patagónico (CONICET). Bvd. Brown 2915, Puerto Madryn, U9120ACD, Argentina. gmartinez@cenpat.edu.ar

Notohippidae is a family of medium-large notoungulates with complete dentition and early tendency to hypsodonty. They have been recorded from the Eocene to the early Miocene, being particularly diverse during the Deseadan SALMA (late Oligocene). Although *Rhynchippus equinus* is one of the most frequent Notohippidae in the fossil record, there are scarce data about cranial osteology other than the classical descriptions which date back to the early last century. In this context, the exceptionally preserved specimen MPEF-PV 695 (collected in outcrops of the Sarmiento Formation in Cabeza Blanca, Southeast of Chubut, Argentina) allowed us an exhaustive morphological review of the species facilitated by CT-scanning techniques. The specimen was imaged in its entirety and 3D reconstruction methods were carried out. Regarding general morphology, its narrow and elongated nasals and the moderate lateral expansion of the zygomatic arches resembles the slender rostral morphology of *Mendozahippus fierensis* and differs from that observed in *Eurygenium pacegmun*, *Eurygenium latirostris* and *Pascualihippus boliviensis*. In the basicraneal region, it is worth noting some relevant morphological data. At the level of the sphenoidal complex, a fossa interpreted as the origin of the tensor veli palatini muscle and the pterygoideus medialis is observed between the entopterygoid crest (pterygoid) and ectopterygoid crest (palatine and alisphenoid). The morphofunctional and osteological interpretation of this fossa represents an unexplored source of anatomical information among notoungulates. Internally, high resolution x-ray computed tomographic analysis revealed endocranial traits not previously observed such as the intracranial apertures of meatuses and foramina and their associated soft tissue. Regarding the ear region, petrosal morphology of MPEF-PV 695 is largely congruent with that described for the suborder Toxodontia (at least on the cerebellar aspect). However, some differences can be recognized when compared to *Adinotherium ovinum*, such as a wider but less pronounced subarcuate fossa (which houses the paraflocular lobe of the cerebellum) and a sharper crest between the subarcuate fossa and the internal auditory meatus. This crest is continuous with the strongly developed petrosal crest. In the occipital region, the petrosal is exposed as a strip of bone associated to the mastoid foramen. This description provides new anatomical data that extend the diagnosis of the species and should prove to be phylogenetically informative.

TERTIARY LITOPTERNS FROM URUGUAY

Daniel Perea[1], Andrea Corona[1] and Martín Ubilla[1]

1. Instituto de Ciencias Geológicas, Facultad de Ciencias, Iguá 4225, 1400 Montevideo, Uruguay.
perea@fcien.edu.uy

The Tertiary litopterns from Uruguay are represented by specimens from Fray Bentos Formation (Deseadan Stage/Age, Late Oligocene, Soriano department, southwestern Uruguay), Camacho Formation (Huayquerian Stage/Age, Late Miocene, San José department, southwestern Uruguay) and Raigón Formation (Chapadmalalan-Ensenadan Stages/Ages, Late Pliocene-Middle Pleistocene, San José department). Here is reported the finding of a new litoptern remain in the former unit, a left mandibular fragment with one emerging tooth preserved (FC-DPV-2811). It is difficult to determine a specific taxonomy because the material is too fragmentary. The Camacho Formation had yielded more complete litoptern remains. Among macraucheniids, some postcranial bones assigned with doubts to *Scalabrinitherium* sp. have been described in previous publications. In the present abstract we communicate the finding of new macraucheniid material from that unit, including a partial skull and mandible with nearly complete dentition and the nares preserved (LRC-176), a mandible (LRC-200), and a right pes without phalanges (LRC-668). The three specimens are similar in size to *Scalabrinitherium bravardi*, but the location of the nares in the specimen preserving this character resembles *Promacrauchenia*. Another recent finding in the Camacho Formation is an almost complete skull (FC-DPV-2570) of a proterotheriid with the rostral region including a right incisor, diastema, both P1-M3 series and part of the postorbital region not well preserved. It is a medium-sized proterotheriid differing from *Diadiaphorus majusculus*, *Anisolophus minusculus*, *Eoauchenia primitiva*, *Tetramerorhinus* spp., and *Lambdaconus colombianus* in many aspects of skull and dentition. On the other hand, some similarities with *Epitherium laternarium* and *Thoatherium minusculum* can be observed in the dentition and diastema. This specimen represents the first proterotheriid undoubtedly collected from the Camacho Formation. From the Raigón Formation, mandibular material associated with postcranial remains (FCDPV-267 and 268) were described as *Licaphrium* aff. *L. floweri* in a previous publication. This taxonomic assignment is under scrutiny in light of the latest available studies at the family level. According to this ongoing revision of Uruguayan Tertiary litopterns, it seems that a greater taxonomic diversity than recognized current should be assumed. Abbreviations: FC-DPV, Vertebrate Fossil Collection, Facultad de Ciencias, Uruguay. LRC: Luis Castiglioni Fossil Collection, Uruguay. [Contribution to the projects ANII FCE-2011-6752 and CSIC-C211-348].

SYSTEMATIC UPDATE OF LITOPTERNA AND NOTOUNGULATA (MAMMALIA) FROM THE "MESOPOTAMIAN" (LATE MIOCENE) OF ENTRE RÍOS PROVINCE, ARGENTINA

Gabriela I. Schmidt[1]

1. CICyTTP-CONICET, Materi y España, E3105BWA, Diamante, Entre Ríos, Argentina.
gschmidt@cicyttp.org.ar

The richness of fossil vertebrates from the base of the Ituzaingó Formation (Entre Ríos Province) has been known since the beginning of the XX century, and the fossiliferous levels were named "Conglomerado osífero" or "Mesopotamiense," whose fossils, especially the mammals, constituted the base of the so-called "mesopotamiense" fauna. Within it, two groups of native ungulates were revised: the Litopterna, represented by the families Proterotheriidae and Macraucheniidae, and the Notoungulata, represented by the families Toxodontidae and Interatheriidae. Many of the species identified in the "Mesopotamiense" fauna were previously poorly characterized and sometimes based on very incomplete specimens. In this sense, the study of many unpublished specimens has enabled updating the taxonomic diversity of the formation, emending or extending the diagnoses of recognized genera and/or species, and analyzing species relationships in a phylogenetic scheme (except for the Family Interatheriidae). Within Proterotheriidae (Litopterna), *Brachytherium cuspidatum*, previously considered a *nomen dubium*, was revalidated, and a sexual dimorphism was recognized for this taxon based on specimens with metric but no morphologic differences. Also, the species *Neobrachytherium ameghinoi* and *Proterotherium cervioides* were maintained while *Epitherium*? *eversus* was reclassified as *Diadiaphorus eversus*. In the case of the Family Macraucheniidae (Litopterna), *Scalabrinitherium bravardi* and *Oxyodontherium zeballosi* were recognized. Within each one, metric —but no morphologic— differences also led to the proposal of the existence of sexual dimorphism. Moreover *Paranauchenia denticulata*, *Promacrauchenia antiqua*, cf. *Promacrauchenia* and *Cullinia* sp. were recognized. Among Notoungulata, Toxodontidae is represented by *Dinotoxodon paranensis*, *Stenotephanos plicidens*, *Haplodontherium wildei* and cf. *Pisanodon*. This implies a remarkable reduction in the diversity of toxodontids previously established for the "Mesopotamiense". In the particular case of *Stenotephanos*, this was recognized as the valid name instead of the traditionally accepted *Xotodon*. Other taxa, such as *Toxodontherium compressum*, *Adinotherium*? *paranense*, *Berroia*? sp., *Toxodon protoburmeisteri* and *Dilobodon lutarius*, were considered as *nomina dubia* due to the fragmentary, poorly diagnostic material attributed to them. The Typotheria notoungulates of the Family Interatheriidae are represented by *Protypotherium antiquum* and *Munizia paranensis*, each taxon represented by one specimen.

PALEOGENE NOTOUNGULATES FROM GUABIROTUBA FORMATION, CURITIBA BASIN, PARANÁ STATE (SOUTH BRAZIL)

David D. Silva[1,2], Ana M. Ribeiro[2], Eliseu V. Dias[3] and Fernando A. Sedor[4]

1. Universidade Federal do Rio Grande do Sul, Avenida Bento Gonçalves 9500, Porto Alegre, 91509-900, Brazil. david.paleo@hotmail.com

2. Fundação Zoobotânica do Rio Grande do Sul, Avenida Salvador França 1427, Porto Alegre, 90690-000, Brazil.

3. Universidade Estadual do Oeste do Paraná, Unioeste, Campus de Cascavel, CCBS, Laboratório de Geologia e Paleontologia, Rua Universitária 2069, Cascavel, 85819-110, Brazil.

4. Museu de Ciências Naturais –UFPR, Coronel Francisco Heráclito dos Santos 100, Curitiba, 81531-990, Brazil.

The Notoungulata constitute one of the most conspicuous components of South America endemic fauna. The group has a stratigraphic range from the Paleocene to the Pleistocene and it experienced a great diversity of forms and sizes during the middle Cenozoic. We report the occurrence of Interatheriidae (Notopithecinae) and Henricosborniidae from a new Paleogene site of the Guabirotuba Formation, Curitiba Basin (City of Curitiba, State of Paraná, South of Brazil). The material is deposited at the collection of the Museu de Ciências Naturais, Setor de Ciências Biológicas of the Universidade Federal do Paraná, Curitiba, Paraná, Brazil. The interatheriids "notopithecines" are represented by a dentary fragment with p4 and root of p3, a right dentary fragment with m2, a left dentary fragment with m3 and a left dentary fragment with m3 talonid and their respective root. The teeth are brachydont; the p4 exhibits a postmetacristid and the molars show a well-developed metacristid. The "notopithecines" are basal members of family Interatheriidae and considered by some authors as a paraphyletic group. The genera *Notopithecus*, *Transpithecus*, *Antepithecus* and *Ignigena* are known from Casamayoran (middle Eocene), *Guilielmescottia* and *Punapithecus* are from Mustersan (middle-late Eocene), while *Johnbell* is known from Tinguiririican (late Eocene–early Oligocene). They are recorded for Argentina, Chile and with some doubts for Bolivia. The Henricosborniidae are represented by an incomplete mandible with p2-m1. The Guabirotuba specimen has a hypoconulid posteriorly projected and medially placed, and the entoconids situated posteriorly. The henricosborniids occupy a basal position within the Notoungulata. They are typical from Riochican (early Eocene) and Casamayoran (middle Eocene) SALMAs, but also occurs in Itaboraian (early Eocene). They are recorded for Argentina and Brazil. This record of "notopithecine" interatheriids is the northmost and the first for Brazil. Until present there is no absolute dating for the outcrop; however, based on the biochronologic range of henricosborniids and "notopithecine" interatheriids in other localities from South America, the age of the Guabirotuba fauna could be estimated as middle Eocene–early Oligocene.

A NEW PHYLOGENETIC INTERPRETATION OF THE NOTOPITHECINAE (MAMMALIA, NOTOUNGULATA)

Bárbara Vera[1]

1. Paleontología, IANIGLA, Centro Científico Tecnológico CONICET-Mendoza, Avenida Ruiz Leal s/n, 5500 Mendoza, Argentina. bvera@mendoza-conicet.gob.ar

The families Notopithecidae and Archaeopithecidae (Notoungulata) were created by Ameghino to include Eocene taxa from central Patagonia, Argentina. These extinct mammals have brachydont dentition and are among the smallest known notoungulates. The systematics of both groups is complex. Simpson established numerous synonyms and proposed a new rank for the notophithecids, regarding them as the Subfamily Notopithecinae, including the oldest and more generalized members of the Family Interatheriidae. Simpson also observed that they are morphologically very close to archaeopithecids, but he considered Archaeopithecidae to be separate from Notopithecinae. More recently, extra-Patagonian records have been described, including the notopithecine *Punapithecus minor* from the Geste Formation (Catamarca and Salta provinces, Argentina), and the basal interatheriids *Ignigena minisculus* and *Johnbell hatcheri* from the Abanico Formation (central Chile). The Interatheriidae, considered traditionally as a group of rodent-like notoungulates included in the Suborder Typotheria, have been the subject of several phylogenetic analyses focusing on the Interatheriinae; however, notopithecines, as well as archaeopithecids, have been practically neglected in most of them. A phylogenetic definition for Interatheriinae has been proposed, but no synapomorphies have been identified that unite Notopithecinae, which represents a paraphyletic assemblage and consequently is referred to as basal interatheriids. Concerning Archaeopithecidae, different authors have stated that they do not belong to Typotheria but rather constitute their sister group. The present revision of notopithecines and archaeopithecids yielded novel taxonomic modifications with respect to previous reviews. Based on these data, a phylogenetic analysis was conducted in order to examine for the first time the relationships of all taxa grouped under the name Notopithecinae. The results indicate that the Patagonian notopithecines (*Notopithecus*, *Antepithecus*, *Transpithecus* and *Guilielmoscottia*) form a monophyletic assemblage supported by three synapomorphies: I2>I3, P1 overlapped by C and P2, and asymmetric astragalar trochlea. *Acropithecus* appears as sister taxa of this group. On the one hand, this arrangement supports the main morphological differences observed between Notopithecinae and Interatheriinae; on the other hand, the exclusion of the Chilean basal interatheriids and *Punapithecus* from the new monophyletic group has biostratigraphic and geographic implications because both were considered to represent the latest record of the group (early Oligocene) and occurrences of the group outside Patagonia. This new phylogenetic interpretation for notopithecines supports their exclusion from the Interatheriidae and regards them as a family as originally proposed by Ameghino. Studies in progress will provide more data on the relationship of these "notopithecids" and archaeopithecids.

SYMPOSIUM

CRETACEOUS-TERTIARY PALAEOBIOGEOGRAPHIC CONNECTIONS WITH ANTARCTICA

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THE LATE CRETACEOUS FLORAS FROM NORTHWESTERN ANTARCTIC PENINSULA AND THEIR EVOLUTIONARY AND PALEOGEOGRAPHIC ROLE

Tânia Lindner Dutra[1], Bibiana Bastos[1], Thièrs Wilberger[1] and Cristine Trevisan[1]

1. Graduation Program in Geology, Vale do Rio dos Sinos University -UNISINOS
Av. Unisinos, 950, 93022-000, São Leopoldo, Rio Grande do Sul, Brazil. tdutra@unisinos.br

The end-Cretaceous floras from Antarctic Peninsula (AP) exhibit a distinctive composition, including elements that will play an important role in the evolution of the Cenozoic and modern floras from South Hemisphere. The partially continuous landmasses (Weddelian Province), the wet and mild climates and the tectonic activity that created altitudinal gradients, stimulated the appearance of some critical taxa in this region, allowing the survival of others, protecting them against the drier climates of the tropical areas. Most of these processes have large-scale effects on vegetation after the beginning of the Cretaceous when the typical early-middle Mesozoic decreased in importance (ferns and primitive gymnosperm groups, like Pteridospermophyta, Bennettitales, Cycadales, Gyngoales, Taxodiaceae and Palyssaceae), and opens space to the evolution of a new kind of forested vegetation. Yet the "modern" South Hemisphere conifer families (Araucariaceae, Podocarpaceae and Cupressaceae) and tree ferns are maintained, whereas the first angiosperms appeared in the understory. Until the end of the period, putative *Nothofagus*, Proteaceae, Elaeocarpaceae, Anacardiaceae and some laurophyllous flowering plants, occupy all the landscape of the northwestern AP, with a marked altitudinal distribution near the volcanic centers. Forms related to the modern *Papuacedrus* (Cupressaceae), *Phyllocladus* (Podocarpaceae), dubious Melastomataceae and Aquifoliaceae make their first appearance. After this, guided by the environmental changes resulting from the Gondwana fragmentation and consequent climate changes, those forests will influence the composition of austral vegetation. Taking the opportunity created by the subsequent favorable climates from the end of Paleocene - Early Eocene, they will make part of a broad subtropical to warm temperate rainforest biome that dispersed to South America and Australasia, only reduced with the arrival of the first cold conditions during the Paleogene-Neogene transition. Today *Papuacedrus* is exclusive from Papua-New Guinea, yet other Cupressaceae still lives in South America and the same genus is recorded there till the beginning of Eocene. *Phyllocladus* grows only in New Zealand, Tasmania, Papua-New Guinea and other eastern Pacific areas. The Melastomataceae are nowadays an important family of both mountainous and lowland tropical areas of South America and other southern continents and the fossils here found, if confirmed, could contradict the molecular clock approaches. The modern species of *Nothofagus*, one of main taxa in attest the importance of AP in the evolution of austral floras, is only absent from Africa and Madagascar. [CNPq, CAPES].

COMPREHENSIVE STUDY OF ANTARCTIC- PATAGONIAN PLANT DIVERSITY DURING THE CRETACEOUS-TERTIARY IS ESSENTIAL FOR UNDERSTANDING MODERN AMERICAN PLANT DISTRIBUTION

Maria A. Gandolfo[1] and Maria C. Zamaloa[2]

1. L. H. Bailey Hortorium, Department of Plant Biology, Cornell University, Ithaca, NY 14853, USA. MAG4@cornell.edu

2. Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires – IEGEBA (CONICET-UBA), Intendente Güiraldes 2620, C1428EHA Buenos Aires, Argentina.

In the Modern World the Northern Hemisphere (NH) is characterized by its continentality whereas the Southern Hemisphere (SH) is characterized by its oceanicity. This results in completely different scenarios for plant distributions, since the continentality of the north and oceanicity of the south have considerable effects on the corresponding climates. Moreover, equatorial zones worldwide show higher plant diversity that clearly decreases towards the poles indicating the presence of latitudinal diversity gradients. Interestingly, the SH is more diverse than the NH, in particular Patagonia, which is considered an area of high endemism. In general, peaks in diversity started with the beginning of the fragmentation of Gondwana during the Jurassic followed by the appearance of the angiosperms during the Cretaceous and increasing dramatically in the Tertiary (mostly during the Paleogene - Miocene). The fossil record indicates 1- that equatorial peaks in species richness are typical of terrestrial plants, 2- that diversity and equatorial peaks increased during the Cenozoic, and 3- that several vicariant events that occurred during the Neogene were fundamental for the creation of high diversity centers. Several biogeographical models and dispersion routes have been proposed for explaining diversity centers and the Gondwana pathway is frequently recognized while the North-South American connection is sometimes ignored. The main goal of this contribution is to present a comprehensive analysis of plant diversity for Patagonia and the Antarctic Peninsula from the Late Cretaceous to the Miocene. Although, the North-South America pathway is not strongly detected in the plant fossil record at this point a route from the NH is emerging as boreotropical elements (such as Ulmaceae, Juglandaceae, *Azolla*, Marsileaceae, and *Nelumbo*) were found in Cretaceous and Paleocene sediments of Patagonia while the Antarctic route allowed the movement of Gondwanan elements (such as Cunoniaceae, Myrtaceae, Nothofagaceae, Proteaceae, and Casuarinaceae) during the Tertiary. As the climate changed, some elements became extinct but others survived and are now members of the extant floras. Although today 98% of Antarctica is covered by ice, during the Cretaceous – Oligocene the Antarctic Peninsula vegetation was similar to the one found today at the Valdivian Forests of the west Patagonian Andes. The eastern vegetation of Patagonia is a typical steppe or grassland. Undoubtedly, both routes influenced the composition of the extant floras and are central for explaining modern austral vegetation and the high Patagonian endemism.

IMPLICATIONS OF THE EVOLUTIONARY STASIS OF *NOTIOLOFOS ARQUINOTIENSIS* (MAMMALIA) EOCENE OF SEYMOUR ISLAND, ANTARCTICA

Javier N. Gelfo[1]

1. División Paleontología de Vertebrados, Museo de La Plata. Paseo del Bosque s/n B1900FWA, La Plata, Argentina. jgelfo@fcnym.unlp.edu.ar

The Sparnotheriodontidae litoptern *Notiolofos arquinotiensis* was the most abundant terrestrial placental mammal in the Paleogene of Antarctica. This herbivorous mammal was a low-crowned browser, with lophoselenodont and bicrescentic lower teeth and a strong lophoselenodont ectoloph and bunoid lingual cusp in the upper molars. Phylogeny and paleobiogeographic evidence indicates a South American origin of Sparnotheriodontidae, and an allopatric speciation event for the origin of *N. arquinotiensis.* It was recorded exclusively in Seymour Island, through most of the La Meseta Formation allomembers, including from base to top, Acantilados II, Campamento, Cucullaea I, and Submeseta. Isotopic and paleomagnetic calibration of the La Meseta Formation suggests an evolutionary stasis for *Notiolofos* of at least 17.5 Ma. The analysis of the morphological stability displayed by paleospecies requires a profuse fossil sample through the stratigraphic succession. *Notiolofos* remains comprise neither complete dental series nor abundant teeth; its hypodigm joins isolated teeth from different loci and from distinct stratigraphic levels. The stasis hypothesis is here tested as opposite to the possibility of a wider and non-previously identified specific diversity of the Antarctic sparnotheriodontids. The materials available for *Notiolofos* were compared in their preservation, characters and dental occlusal areas to the more complete phylogenetic relative *Sparnotheriodon epsilonoides* and the North American *Meniscotherium chamense*. Despite there is not a direct phylogenetic relationship between *Notiolofus* and *Meniscotherium*, the morphological dental similitude between both suggests they could be interpreted as ecologically equivalent taxa. The analysis allows the reassignment of some *Notiolofos* teeth to other dental locus but not to consider a higher variation than previously described. The temporal scale of *Notiolofos* is appropriate to consider Court Jester hypothesis as the principal evolutionary force, so it could be expected that during this span, environmental change triggered speciation events. The present analysis indicates that there are no elements to justify the presence of different species through the stratigraphic sequence or to refute the morphological stasis in *Notiolofos*. In a reductionist perspective, this suggests a stability of the terrestrial physical conditions in West Antarctica during most of the Eocene, or at least, that any environmental change, particularly in climate and vegetation, was not enough to generate an evolutionary response.

NEW RECORDS OF CENOZOIC BENTHIC FORAMINIFERA FROM ANTARCTIC PENINSULA SECTOR OF WEST ANTARCTICA

Wojciech Majewski[1] and Andrzej Gaździcki[1]

1. Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland.
wmaj@twarda.pan.pl

Despite considerable efforts, our knowledge on pre-Quaternary foraminiferal communities from the Antarctic Peninsula sector of West Antarctica remains far from satisfactory. Up to quite recently, only a few reports have been published. Cretaceous-Paleocene foraminifera were described from Seymour Island, Oligocene planktonic and Miocene benthic foraminiferal assemblages were reported from King George Island (South Shetlands), and Miocene-Pliocene and Pliocene benthic assemblages from James Ross and Cockburn islands west off Antarctic Peninsula. Here, we are presenting foraminiferal finds from the lower Eocene La Meseta Fm. of Seymour Island, the lower Oligocene Polonez Cove Fm. of King George Island, and the middle Miocene of Weddell Sea, ~150 km east off Joinville Island, which fill some gaps in foraminiferal Cenozoic record from the Antarctic Peninsula region. At all three locations, calcareous, benthic foraminifera strongly dominate the assemblages. The two Paleogene benthic foraminiferal assemblages from Seymour and King George islands represent shallow-water biotas. They share a group of common species including *Gyroidina zealandica*, sister species of *Nonionella iridea* and *N. bradyi*, *Globocassidulina subglobosa*, *Lobatula* (*Cibicides*) *lobatula*, and *Eilohedra* (*Epistominella*) *vitrea*. These species belong to the most morphologically conservative Antarctic foraminifera, which seem to be present continuously in neritic Antarctic settings at least since the Eocene. The youngest (mid Miocene) assemblage from the Weddell Sea is much different, probably not in situ. It is dominated by specimens similar to Recent *Elphidium macellum* that is widespread in coastal Patagonia but absent in Antarctica. Also, some important elements of the recently described Eocene and Oligocene foraminiferal communities (e.g. abundant Eocene elphidiid foraminifera) show similarities to contemporaneous forms from Patagonia, testifying for faunal links between Antarctic Peninsula and Patagonia through much of Cenozoic.

GEODYNAMIC EVOLUTION OF THE SCOTIA ARC: THE FINAL BREAKUP OF GONDWANALAND AND ITS GLOBAL IMPLICATIONS

Andrés Maldonado[1] and SCAN GROUP

1. Instituto Andaluz de Ciencias de la Tierra, Consejo Superior de Investigaciones Científicas and Universidad de Granada, Spain. amaldona@ugr.es

The Scotia Arc, located between South America and the Antarctic Peninsula is a region of critical importance because of its role as a developing ocean gateway during Eocene-Miocene times, and because of its impact on global ocean circulation, with possible importance for Palaeogene-Neogene palaeoenvironmental change, early phases of development of Antarctic ice sheets, gene flow, and resulting biodiversity. The Scotia Sea is embraced by the tectonic arc and reveals a host of spreading ridges and small oceanic basins which allow reconstructing the growth patterns of this sea and of Drake Passage, located in the western region. The opening of the Scotia Sea and Drake Passage is a subject of considerable controversy. Drake Passage is widely recognized as key gateway that controlled Cenozoic water-mass circulation and climate in the southern hemisphere. The gateway permitted the gradual instauration of the Antarctic Circumpolar Current, which isolated Antarctica from the influx of warm currents from the north and intensified its glaciation. An initial interpretation attributed the climatic change and the development of the large Antarctic ice sheets to the opening of Drake Passage, although additional hypothesis attributed the Eocene/Oligocene climate change and the subsequent Cenozoic glaciation of Antarctica to variations in the concentrations of greenhouse gases. A dense geophysical data set collected in the southwestern Scotia Sea is presented and evidences for the occurrence of oceanic crust that is older than previously reported are shown. The initial tectonic fragmentation of the South America-Antarctic Bridge, followed by oceanic spreading, was characterized by jumping of the spreading centers. An Eocene spreading center in the SW Scotia Sea was the precursor for the opening of the basin. A model with four tectonic evolutionary phases is proposed: Phase I, Pacific subduction –Paleocene to middle Eocene; Phase II, eastern Ona back-arc spreading –middle to late Eocene; Phase III, ridge jumping and western Ona back-arc spreading –early Oligocene; and Phase IV, ridge jumping and WSR spreading –early Oligocene to late Miocene. The development of shallow gateways allowed an early connection between the Pacific and Atlantic oceans and initiated the thermal isolation of the Antarctic during the Phase II. Deep gateways that enhanced the full isolation of the Antarctica were developed in Drake Passage from the Eocene/Oligocene transition. A significant correlation is observed between the tectonics, stratigraphic units and major climate events, thereby indicating the influence of the local tectonic and paleoceanographic events of the southern oceans on the global evolution.

FOSSIL FLORA OF THE CHATHAM ISLANDS, EASTERN 'ZEALANDIA': A WINDOW INTO THE FOREST BIOME OF THE MID-CRETACEOUS SOUTH POLE

Chris Mays[1] and Jeffrey D. Stilwell[1]

[1]Monash University, School of Geosciences, Monash University, Victoria, 3800, Australia.
chris.mays@monash.edu

The Chatham Islands, New Zealand, provide a unique perspective of the polar forest biome during the mid-Cretaceous global greenhouse (palaeolatitude ~ 70–80° S), when eastern Zealandia was attached to the West Antarctica sector of Gondwana. The palynological assemblage supports a Cenomanian-Turonian (~ 98–90 Ma) age for the ~ 400 m thick succession. The examined lithostratigraphic unit, the Tupuangi Formation, was deposited in a fluviodeltaic system; lithological and palaeopedological evidences suggest that the local depositional environments associated with the macrofloral remains were deltaic floodplains. Diverse macrofloral fossil assemblages were found on numerous hydromorphic palaeosol horizons, often associated with well-established root systems and *in situ* trunks, or entrained in overlying fine sandstone facies. This macroflora consisted of prevalent conifers, locally abundant angiosperms and ginkgos (*Ginkgoites*), and uncommon free-sporing plants, including non-vascular plants (marchantiophytes and bryophytes), herbaceous lycopsids and ferns (*Adiantites*, *Cladophlebis* and *Sphenopteris*). The fern leaf and spore assemblage comprised a lower diversity and abundance than coeval localities of the Southern Hemisphere, including eastern Australia, the Antarctic Peninsula and mainland New Zealand. Quantitative microfloral data reveal intermittent overabundances of monospecific fern spores, but these were likely caused by the localised re-establishment of riparian fern taxa after disturbance of the floodplain environment. In contrast to the relatively depauperate fern component, the high conifer pollen diversity and abundance is unparalleled for mid-Cretaceous assemblages of the Southern Hemisphere, and consists almost exclusively of Araucariaceae, Cupressaceae and Podocarpaceae. The conifer-dominated assemblage is likely due to the relatively cooler, drier climate associated with the extremely high palaeolatitude. Furthermore, the palynology hints at a previously unreported microfloral subprovince, characterised by a very high abundance of cupressaceous pollen. A combination of macro-, meso- and palynofloral fossil remains indicate a well-established coniferous forest with a ginkgo-angiosperm understory, and subsidiary ferns, seed-ferns, lycophytes and non-vascular plants. This assemblage represents the highest southern latitude flora of the mid-Cretaceous studied to date, and thus provides a crucial biogeographic and ecological end-member during one of the most extreme global greenhouse regimes in geological history.

A NEW LOOK INTO THE ANTARCTIC COOLING AND THE DISTRIBUTION OF SOUTHERN MARINE BIVALVES

Fernanda Quaglio[1], Huw J. Griffiths[2], Katrin Linse[2], Rowan J. Whittle[2], Silvio S. Nihei[3] and Marcello G. Simões[4]

1. Universidade Estadual Paulista, UNESPetro, Av. 24-A, 1515, Rio Claro, SP, 13506-900, Brazil. quaglio@gmail.com
2. British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK.
3. Universidade de São Paulo, Instituto de Biociências, São Paulo, 05508-900, Brazil.
4. Universidade Estadual Paulista, Instituto de Biociências, Distrito de Rubião Júnior, Botucatu, 18618-000, Brazil.

The Antarctic cooling is associated to several environment-related changes occurred in the Cenozoic, including: atmospheric CO_2 drop during times of orbitally-induced decline in the polar seasonality, tectonic isolation of Antarctica from Australia and South America, and reorganization of marine and atmospheric currents. Major tectonic changes included the opening of the Tasmanian Gateway (Late Eocene to Early Oligocene) and the Drake Passage (Late Eocene to Early Oligocene), which are key Southern Ocean gateways, tied to the origin of the Antarctic Circumpolar Current. Both cooling and opening of oceanic gateways are believed to have shaped the biotic evolution of the southern regions throughout the Cenozoic to the Present-day. Previous studies link the origin of modern Antarctic marine fauna to the geographic isolation of Antarctica, to the Cenozoic cooling, or both. This study shows, by analyzing an extensive dataset of bivalve genera with an innovative paleobiogeographic approach, that the main southern marine biogeographic provinces were defined as early as the beginning of Paleogene because of tectonic causes. Along the Cenozoic, the faunal differences were sharpened, probably due to climatic cooling, as indicated by the coupling of the faunal similarity curve to the global temperature trend. Our results have important implications for potential warmer marine environments.

UPPER CRETACEOUS–?PALEOGENE STRATIGRAPHY AND VERTEBRATE PALEOECOLOGY OF VEGA ISLAND, ANTARCTICA: PALEOGEOGRAPHIC, PALEOCLIMATIC, AND SEQUENCE STRATIGRAPHIC IMPLICATIONS

Eric M. Roberts[1], Matthew C. Lamanna[2], Julia A. Clarke[3], Jin Meng[4], Eric Gorscak[5], Joseph J. W. Sertich[6], Patrick M. O'Connor[5], Kerin M. Claeson[7], Nathan B. English[1], Christa J. Placzek[1], Jodie Kilpatrick[1] and Ross D. E. MacPhee[8]

1. School of Earth and Environmental Sciences, James Cook University, Townsville, QLD 4811, Australia. eric.roberts@jcu.edu.au
2. Section of Vertebrate Paleontology, Carnegie Museum of Natural History, 4400 Forbes Ave., Pittsburgh, PA 15213, USA.
3. Department of Geological Sciences, University of Texas at Austin, 1 University Station, C1100, Austin, TX 78712, USA.
4. Department of Paleontology, American Museum of Natural History, Central Park West at 79th St., New York, NY 10024, USA.
5. Department of Biomedical Sciences, Heritage College of Osteopathic Medicine, Ohio University, Athens, OH 45701, USA.
6. Department of Earth Sciences, Denver Museum of Nature and Science, 2001 Colorado Blvd., Denver, CO 80205, USA.
7. Department of Biomedical Sciences, Philadelphia College of Osteopathic Medicine, Philadelphia, PA 19131, USA.
8. Department of Mammalogy, American Museum of Natural History, Central Park West at 79th St., New York, NY 10024, USA.

In 2011, as part of a cruise sponsored by the U.S. National Science Foundation to the James Ross Basin, Antarctica, our team carried out fieldwork on Vega Island during a two-week period of mostly favorable weather. The project involved investigating the paleontology and sedimentology of each of the Upper Cretaceous units exposed on the island, with a focus on the capping Sandwich Bluff Member of the López de Bertodano Formation. Although this unit is one of the richest sources of end-Cretaceous vertebrate fossils in Antarctica, it is also one of the least sedimentologically and stratigraphically characterized units in the basin. Detailed facies and stratigraphic analyses of the Sandwich Bluff Member were conducted alongside intensive prospecting for fossil vertebrates and stratigraphic assessment of historic paleontological localities on Vega Island. This effort, coupled with the acquisition of new strontium isotope data, have led to a revised stratigraphy for the Sandwich Bluff Member and the precise stratigraphic placement of important terrestrial and marine vertebrate fossil localities within it. Most significantly, this work resulted in the recognition of a new sequence boundary near the top of the Sandwich Bluff Member, which is overlain by a 6 m-thick, matrix-supported, pebble-cobble conglomerate of probable alluvial origin. A thin stratal package above the conglomerate demonstrates a rapid return to marine conditions. A similar stratigraphic pattern is well documented at the top of the López de Bertodano Formation and the base of the overlying (Paleocene) Sobral Formation on Seymour Island in the southern part of the basin. Although no fossils were recovered to constrain the age of the upper 10–15 m of the succession on Vega Island that preserves the newly recognized upper sequence boundary, strata below this level can be confidently placed within the *Manumiella bertodano* interval zone, which extends to a short distance below the K–Pg boundary on Seymour Island. Hence, based on sequence stratigraphic and lithostratigraphic evidence, we propose that the uppermost 10–15 m of the succession on Vega Island may encompass the Cretaceous–Paleogene boundary together with a few meters of the Paleocene Sobral Formation. In addition, this presentation will briefly discuss the presence and implications of 'dropstones' in Upper Cretaceous strata of the James Ross Basin, as well as new strontium isotope dating and preliminary taphonomic investigations of Antarctic Cretaceous fossil wood and bone via synchrotron Fourier transform infrared (FTIR) analysis.

PALEOCENE FORESTS AND CLIMATES OF ANTARCTICA: SIGNALS FROM FOSSIL WOOD

Laura Tilley[1], Jane Francis[2], Vanessa Bowman[2], Alistair J. Crame[2] and Fiona Gill[1]

1. University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, United Kingdom. eeljt@leeds.ac.uk
2. British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom.

During the greenhouse world of the Paleocene, Antarctica was covered in forests, even though the continent was situated over the South Pole. Fossil wood is abundant in marine sequences of Seymour Island, Antarctica. The wood originated from forests that once grew on a volcanic arc now represented by the Antarctic Peninsula and then floated as driftwood on the ocean before eventually sinking into the ocean sediments and becoming permineralised. Fossil wood has been systematically collected from Paleocene marine sequences of Seymour Island and has been studied in order to reconstruct the forest composition and evolution of the vegetation throughout the Paleocene. The exact location of the wood was recorded on a measured stratigraphic section so that preservation type, taxonomy and climate data derived from the wood could be put into a stratigraphical and environmental context. Trees that lived in the forests included *Nothofagus*, Myrtaceae, *Weinmannia*, *Araucaria*, *Phyllocladus* and podocarp conifers. These tree types can be found in cool temperate forests in Chile and New Zealand today. Analysis of tree rings, angiosperm vessels and specific gravity have been used to reconstruct climate in which forests grew during the Paleocene. Mean growth ring analysis shows a trend towards narrow growth rings in the early-mid Paleocene, which suggests cooler climates. Mean sensitivity calculated from tree ring width generally shows growth under an equable climate. Vulnerability Index (VI) and Mesomorphy Index (MI) have been calculated using angiosperm vessels as an indicator of water availability, and more precise MI values indicate sufficient water availability. Specific gravity has been linked to a plants adaption to water availability in its environment as well as growth strategy. Most of the fossil wood types show medium specific gravity (0.40–0.75) values, which is expected for temperate forests. Podocarpaceae and Araucariaceae fossil wood shows high specific gravity values similar to their modern relatives, suggesting that they had a similar life habit. Investigating these factors is essential for understanding how sensitive vegetation was to climate change.

PALEOGENE ANTARTIC LAND MAMMALS: THEIR BIOGEOGRAPHIC RELATIONSHIPS AND THE FINAL BREAK-UP OF GONDWANA

M. Alejandra Abello[1], Paula Posadas[1], Edgardo Ortiz-Jaureguizar[1], Javier N. Gelfo[2], Laura Chornogubsky[3] and Marcelo Reguero[2]

1. CONICET, Laboratorio de Sistemática y Biología Evolutiva, Museo de La Plata, Paseo del Bosque s/n, (B1900FWA) La Plata, Argentina. mabello@fcnym.unlp.edu.ar

2. CONICET, División Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n, (B1900FWA) La Plata, Argentina.

3. CONICET, Sección Paleontología de Vertebrados, Museo Argentino de Ciencias Naturales, Av. Ángel Gallardo 470, Buenos Aires, C1405DRJ, and Departamento de Ciencias Básicas, Universidad Nacional de Luján, Ruta 5 y Avenida Constitución, Luján, 6700, Buenos Aires, Argentina.

The Paleogene land fauna of Antarctica is exclusively known from outcrops of the La Meseta Formation (Eocene to Oligocene) from Marambio/Seymour Island (Antarctic Peninsula). The faunal association includes several mammalian groups as ungulates (Sparnotheriodontidae and Astrapotheria), marsupials (Polydolopidae, Derorhynchidae and Microbiotheria) and non-therian mammals (Sudamericidae and Dryolestoidea). This taxonomic composition is similar to that of some Paleogene land mammal assemblages from the southernmost part of South America (i.e. Patagonia), thereby, several hypotheses were proposed to account for the biogeographic history of the Antarctic taxa, as well as for the timing of the paleogeographic events that could be implied in the shaping of the Antarctic land mammal association. To identify the biogeographic events (dispersion, vicariance) that could explain the observed distribution patterns of Antarctic land mammals, we selected those groups for which a phylogenetic hypothesis was available. Dispersal-Vicariance analyses were performed with RASP software for therian mammals (i.e. ungulates and marsupials). The analysis of Astrapotheria and Sparnotheriodontidae yields a widespread ancestral distribution, including South America and Antarctica, since the lower Paleocene up to middle-late Paleocene, when a vicariant event took place. In contrast, Polydolopidae marsupials show a distribution restricted to Patagonia during the lower and middle Paleocene and a dispersal event from Patagonia to Antarctica followed by a vicariance, both of them during the late Paleocene. The three analyses resulted in a congruent vicariance during late Paleocene when the ancestral distributions along Patagonia and West Antarctica were fragmented by the rise of a barrier leading to the geographic isolation and differentiation of Patagonian and Antarctic lineages. In absence of evidence of geographic barriers other than the emerging Drake Passage, the fragmentation of the ancestral range could be explained by the earlier stages of rifting and stretching crustal thinning in the opening of this seaway. From the results obtained we could conclude that the biogeographic histories of sparnotheriodontids and astrapotherians were different from those of polydolopids, but all of them support the hypothesis of an early stage (late Paleocene) in the paleogeogeographic event leading to the development of a shallow epicontinetal sea which eventually led to the opening of the Drake Passage.

NEW GIANT PENGUIN BONES FROM ANTARCTICA: SYSTEMATIC AND PALEOBIOLOGICAL SIGNIFICANCE

Carolina Acosta Hospitaleche[1]

1. CONICET and División Paleontología Vertebrados, Museo de La Plata. Facultad de Ciencias Naturales y Museo (UNLP), Paseo del Bosque s/n, B1900FWA, La Plata, Argentina. acostacaro@fcnym.unlp.edu.ar

A tarsometatarsus (MLP 12-I-20-116) and a fragmented humerus (MLP 12-I-20-288) of striking dimensions assigned to *Palaeeudyptes klekowskii* were collected in the DPV 13/84, Marambio (Seymour) Island, Antarctica. They come from the middle Eocene- earliest Oligocene Submeseta Formation, equivalent to the uppermost part of the former La Meseta Formation, according to new stratigraphic proposal. Body mass and body length (maximum measurements from the tip of the toes to the end of the bill, with the neck and legs outstretched) were calculated. The most conservative values were used for diving duration estimations. The 91.3 mm long tarsometatarsus is the most massive tarsometatarsus known for *Palaeeudyptes* (59- 82.4 mm), constituting the largest one ever described. Subtle differences were obtained by using each measurements selected for calculations. The tarsometatarsal width indicates a body mass of 114.38 kg and 2.01 m long, whereas the anteroposterior width points toward a body mass of 116.21 kg and 2.02 m of total length. It seems an extremely high value for both calculated parameters. Nevertheless, given that the living Emperor penguin reaches 46 kg in weight and 136 cm in length –equivalent to near 116 cm in height–, and its tarsometatarsus is only about 50 mm long, the estimated values based on an almost double sized tarsometatarsus are not beyond the expected assessment. Assuming that the humerus proportions are not sensitive to significant intraspecific variation, it seems possible to calculate an approximate length of 259.2 mm for the MLP 12-I-20-288 on the basis of the measurements taken in the co-specific MLP 11-II-20-07, and scaling its size from the width of the proximal epiphysis. Dimensions of the humerus are also huge, although these values are only estimates and cannot be taken as absolute. The most conservative values were here taken for further paleobiological calculations in order to prevent overestimations. The tarsometatarsus would belong to a penguin with high diving skills, capable of making longer breath-hold dives than other heavy animals. It was estimated that regular dives take 16.6 minutes duration (with potential and maximum dives of 40 minutes). These approximations are consistent with the generalized idea that Antarctic large penguins were piscivores. They had probably used pursuit diving techniques for the capture of large fish. Gigantism would confer it certain advantages for survival within the colony, a more effective defense against predators, and greater ability to catch prey.

CRETACEOUS EVIDENCE OF ASTERALEAN-LIKE POLLEN IN ANTARCTICA

Viviana D. Barreda[1], Luis Palazzesi[1,2], Maria C. Tellería[3], Eduardo Olivero[4] and Felix Forest[2]

1. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN-CONICET), Ángel Gallardo 470 (C1405DJR), Buenos Aires, Argentina. vbarreda@macn.gov.ar
2. Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3DS, UK.
3. Laboratorio de Sistemática y Biología Evolutiva (LASBE), Museo de La Plata, Paseo del Bosque s/n (1900) La Plata, Buenos Aires, Argentina.
4. Centro Austral de Investigaciones Científicas (CADIC-CONICET), B. Houssay 200, 9410 Ushuaia, Tierra del Fuego, Argentina.

Asterales is an order of flowering plants that includes the highly diverse Asteraceae —daisy family— along with ten other phylogenetically related families. Asterales appear to have originated in the Cretaceous, but no fossils from this period have been found to date to support this assumption regarding the origin of this group. Here we report new Asteralean-like fossil pollen grains from Antarctica that shed new light on the early evolution and diversification of Asterales. We recovered these specimens from Campanian/Maastrichtian sediments of the Santa Marta, Snow Hill Island and Lopez de Bertodano formations, on the James Ross and Vega islands, in Antarctica. We scored 75 binary pollen characters from 4 fossil forms and 55 extant species chosen to represent all families and tribes in Asterales. We conducted parsimony analyses to assess the phylogenetic position of each fossil using a highly supported molecular phylogenetic tree as backbone constraint. Our phylogenetic analysis places the new fossils within the early-diverging branches of Asteraceae and its sister Calyceraceae and Goodeniaceae. These fossils display some but not all the synapomorphies of the crown group, and hence leading us to infer that these fossils might represent members of the stem lineage. We reveal that some Asteralean lineages evolved in Antarctica during the Cretaceous, survived the K–P global extinction event, and radiated into the world's highest latitudes of Gondwana by the Paleogene.

MICROPALEONTOLOGICAL ASSEMBLAGES FROM EKELÖF POINT (UPPER CRETACEOUS) OF SOUTHEAST JAMES ROSS ISLAND, ANTARCTIC PENINSULA

Andrea Caramés[1], Cecilia R. Amenábar[1,2], Alessandra Santos[3] and Andrea Concheyro[1,2]

1. Instituto de Estudios Andinos Don Pablo Groeber-CONICET, Universidad de Buenos Aires, Departamento de Ciencias Geológicas. Intendente Guiraldes 2160, C1428EGA, Ciudad Universitaria, Buenos Aires, Argentina. amenabar@gl.fcen.uba.ar

2. Instituto Antártico Argentino, Balcarce 290, C1064AAF, Buenos Aires, Argentina.

3. ITT FOSSIL, Instituto Tecnológico de Micropaleontologia, Universidade do Vale do Rio dos Sinos, Brazil.

A micropaleontological analysis of a sedimentary succession from the Rabot Formation (Upper Cretaceous) at Ekelöf Point, southeast of James Ross Island, Antarctic Peninsula, is here presented. This unit was dated as late Campanian-early Maastrichtian, based on ammonites and dinocysts. The study is based on the analysis of foraminifera and palynomorphs from six fossiliferous samples of a stratigraphic section (*ca.* 200 meters of thickness). This consists of dark grey siltstones and claystones alternating with very thin indurated tuff levels and yellow claystones. At the top of the section a condensed horizon with concretions containing trace fossils interpreted as a maximum transgressive event is recognised. The foraminifera assemblage is characterised by benthic species. Except one sample, with only five specimens of the calcareous *Gavelinella sandidgei* (Brotzen) and one indeterminate fragment, the other ones are mainly composed of agglutinated species (70-80%). *Bathysiphon,* the most common genus in the section is dominant in different samples. *Reticulophragmoides* aff. *jarvisi* (Thalmann), *Rzehakina minima* (Cusman and Renz) and the calcareous species *Gavelinella sandidgei* are also common. Furthermore, taxa from the following genera were recognised: *Haplophragmoides*, *Reophax*, *Ammodiscus*, *Karreriella*?, *Recurvoides*, *Dentalina*, *Lingulonodosaria* and *Lagena*. Although a few samples are suitable for suggesting only tentative conclusions, epibenthic foraminifera are dominant and the agglutinated ones dominated by species with tubular morphology suggest a tranquil bathyal palaeoenvironment. It is noteworthy the taxonomical change in a sample just below the concretional level with a dominance of *Spiroplectammina chicoana* together with deeper infauna (*Reophax*). Considering that *Spiroplectammina* is a genus characteristic of shelf and marginal marine environments, a decrease in water-depth or a down-slope transport of shelf foraminifera could be possible explanations of such change. Palynomorphs are abundant in all levels and consist of dinocysts, pollen and spores in variable amounts. The continental palynomorphs represents 21 to 72% of the whole assemblage and indicate a continuous terrestrial influx to the marine basin. The dinocyst assemblage is dominated by peridiniacean taxa including *Isabelidinium cretaceum* (Lentin and Williams), *Isabelidinium* spp. and *Isabelidinium*/*Manumiella* complex, which are common in proximal marine environments. Palaeoenvironmental interpretations based on foraminifera are consistent with sedimentological studies which indicate an outer-shelf palaeoenvironment, evidenced by a monotonous sedimentary succession produced by sediment fallout with occasional ash fall from a volcanic arc. The dominance of peridinacean cysts and the continuous terrigenous input can be explained by the existence of a short shelf where the material quickly runs down the slope and would be deposited in the deep marine environment.

TETRAPODS FROM THE SNOW HILL ISLAND FORMATION (LATE CAMPANIAN-EARLY MAASTRICHTIAN), JAMES ROSS ISLAND, ANTARCTICA: TAPHONOMIC AND DEPOSITIONAL SETTINGS

Zulma Gasparini[1], Marcelo Reguero[1,2], Marta Fernández[1], Rodolfo A. Coria[3], Eduardo Olivero[4], José O´Gorman[1], Ari Iglesias[5] and Juan J. Moly[1]

1. Museo de La Plata, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, B1900FWA, Argentina. zgaspari@fcnym.unlp.edu.ar

2. Instituto Antártico Argentino, Balcarce 290, Buenos Aires, C1064AAF, Argentina.

3. CONICET / Museo Carmen Funes / Instituto de Investigación en Paleobiología y Geología, Universidad de Río Negro, Isidro Lobo 516, General Roca, 8332, Argentina.

4. Centro Austral de Investigaciones Científicas CADIC-CONICET, B. Houssay 200, Ushuaia, 9410, Argentina.

5. Instituto de Investigaciones en Biodiversidad y Medioambiente INIBIOMA-CONICET, Quintral 1250, San Carlos de Bariloche, 8400, Argentina.

The Snow Hill Island Formation (SHIF) constitutes the basal unit of the transgressive part of the NG Sequence (upper Campanian-lower Maastrichtian), which exposes extensively in the James Ross and Vega islands, James Ross Basin, northeast of the Antarctic Peninsula. The shallow marine sediments of the SHIF comprise two members: the upper Campanian Gamma Member and the lower Maastrichtian Cape Lamb Member. The SHIF yields mosasaurs, elasmosaurids, and dinosaurs, and contains the most diverse Mesozoic tetrapod assemblage recorded from Antarctica. At Santa Marta Cove (SM), James Ross Island the Gamma Member contains the holotype of the tylosaurine *Taniwhasaurus antarcticus* and a number of indeterminate elasmosaurid plesiosaurids. Additionally, three non-avian dinosaurs, represented by *Antarctopelta oliveroi*, *Trinisaura santamartaensis*, and an isolated sauropod vertebra, have been collected in this member. At The Naze (TN, James Ross Island) and Cape Lamb (CL, Vega Island) localities, from outcrops of the Cape Lamb Member, new non-aristonectine elasmosaurid and mosasaurids were recovered, identified as cf. *T. antarticus*, cf. *Hainosaurus* sp., and Tylosaurinae indet. (CL). Additionally, partial skeletons assigned to a hypsilophodontid (CL), a dromeosaurid (TN) and an ornithopod (TN) non-avian dinosaurs and few avian dinosaurs (CL, charadriiforms) were recovered from this member. Close scrutiny of the fossil assemblages and stratigraphic horizons indicates that at least two different subsets of articulated skeletons are present throughout the Gamma Member and have different taphonomic histories (including bone abrasion, scavenging, completeness, and sorting). Thus, allochthonous skeletons transported from continental fluvial systems are differentiated from autochthonous skeletons that were buried by the same bearer stratigraphic horizon. Taphonomic and depositional settings were analyzed in: 1) articulated skeletons of marine reptiles from SM, TN and CL (*Taniwhasaurus*; a new genus and species of elasmosaurid and several other elasmosaurid skeletons) with evidence of having been scavenged by hexanchid sharks and nautilods; and 2) dinosaurs recovered articulated from the same horizon of SM (*Trinisaura santamartaensis* and *Antarctopelta oliveroi*), associated to abundant plant debris share distinctive taphonomical history characterized by preservation of articulation and with no evidence of scavenging by hexanchid sharks on carcasses. Other isolated bones of dinosaurs (i.e. a sauropod vertebra), were found floating (not *in situ*) and from different stratigraphic horizons. Complete stratigraphic and taphonomic analyses of vertebrates are now available for the upper Campanian-lower Maastrichtian Snow Hill Island Formation, being possible better correlations through the Upper Cretaceous of West Antarctica with other Gondwanan areas.

THE FORAMINIFERA *ANTARCTICELLA* AND *CYCLAMMINA* FROM THE MIOCENE CAPE MELVILLE FORMATION OF KING GEORGE ISLAND, WEST ANTARCTICA

Andrzej Gaździcki[1] and Wojciech Majewski[1]

1. Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland.
gazdzick@twarda.pan.pl

The Miocene (~22 Ma) Cape Melvile Formation consists of glaciomarine strata ~150 m thick that are exposed on Melville Peninsula (King George Island, South Shetlands). They contain a rich, predominantly invertebrate fauna that has a relatively deep-water, outer-shelf character, making it one of the most significant Miocene biotas know from West Antarctica. Microfossils include benthic calcareous and arenaceous foraminifera of at least 50 species. The most abundant agglutinated species is *Cyclammina cancelata* Brady. It can be easily distinguished from other representatives of this genus by its larger size and broadly rounded periphery with usually fourteen chambers in the final whorl. Large population of this foraminifer of over 1000 well-preserved specimens allowed for paleobathymetrical interpretation. According to recently observed water-depth related variations in test width and diameter of *C. cancelata* living population, the Cape Melville Fm. was likely deposited in a relatively deep sea ~1000 m water depth. In the studied strata, an intriguing foraminifer, *Antarcticella antarctica* (Lackie and Webb), was recognized for the first time in the Antarctic Peninsula area. This species was described from the late Oligocene to mid Miocene of the Ross Sea as a planktonic form, but subsequently it has been interpreted as of benthic habitat. The presence of *Antarcticella antarctica* in the South Shetlands adds to the dispersal reconstruction of this biostratigraphically important taxon across the Southern Hemisphere.

UPPER CRETACEOUS MACROFLORAS, JAMES ROSS ISLAND, ANTARCTIC PENINSULA

Ari Iglesias[1], Marcelo A. Reguero[2,3], Rodolfo A. Coria[4] , Eduardo Olivero[5] and José P. O´Gorman[2]

1. Instituto de Investigaciones en Biodiversidad y Medioambiente INIBIOMA-CONICET, Quintral 1250, San Carlos de Bariloche, 8400, Argentina. ari_iglesias@yahoo.com.ar
2. Museo de La Plata, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, B1900FWA, Argentina.
3. Instituto Antártico Argentino, Balcarce 290, Buenos Aires, C1064AAF, Argentina.
4. CONICET; Museo Carmen Funes; Instituto de Investigación en Paleobiología y Geología, Universidad de Río Negro, Isidro Lobo 516, General Roca, 8332, Argentina.
5. Centro Austral de Investigaciones Científicas CADIC-CONICET, B. Houssay 200, Ushuaia, 9410, Argentina.

We analyze macrofloras from the north part of the James Ross Island at the Santa Marta and Snow Hill Island formations, Marambio Group, James Ross Basin. At the upper section of the Beta Member of the Santa Marta Formation, well preserved petrified trunks, charcoalified wood, and twists, leaves and seeds compression were collected. Leaves and seeds of angiosperms, podocarps and *Araucaria* are preserved with other plant debris in large calcareous nodules within fine-grained sands, escaping from bioturbation and taphonomical destruction. Some twists are preserved with attached large leaves of podocarps and *Araucaria*. Woody angiosperm leaves are quite diverse, with medium sizes (notophyll) and entire margins. Complete, small heteromorph ammonites in several orientations are generally associated with the plants, whereas inner-shelf coquina beds with charcoal are observed at the top of the unit. The ammonite assemblages indicate that this plant level is early-mid Campanian in age. At the Santa Marta Cove, the Snow Hill Island Formation shows less abundant plant debris. Small calcareous nodules in different levels have preserved diverse angiosperm and conifer woods. In some cases, the specimens conserved the external cortex of branches and twists with 3D leaf scar arrangement. Some large podocarp leaves were collected preserving stomata arrangement on the surface. The ammonite assemblages indicate a lateCampanian – early Maastrichtian age for these plant levels. Facies analysis suggests the evolution of a progradational deep-water delta system. Plant remains may be transported seawards by deltaic currents from the continental areas of the Antarctic Peninsula. Systematic and taphonomic studies of these plants and other transported fossils (i.e. vertebrates) give evidence about how high-latitude continental environments were in Antarctica in places that today are permanently covered by ice.

A REVIEW OF THE LATE CRETACEOUS MOSASAUR FAUNA OF NORTHEAST BRAZIL

Isabela Lima[1], Tatiane Silva[1], Iru Iakovisky[1], Adelino A. Carvalho[1] and Roberto Candeiro[1]

1. Universidade Federal de Uberlândia - Campus Pontal, Laboratório de Geologia, Rua 20 n° 1600, Ituiutaba, 38304-402, Brazil. isabelalima92@outlook.com

The Late Cretaceous of northeast Brazil is among one of the few South American places that preserve a rock record that documents mosasaur remains. This is a critical period for distribution of mosasaur related to final opening of South Atlantic Ocean. In post-Cenomanian time, Mosasaurinae and Plioplatecarpinae have been recorded in the marine deposit exposed along the northeast Brazil coastline. The oldest-known specimen of a Brazilian mosasaur has been assigned to Mosasaurinae indet. and is from the Cenomanian Alcântara Formation (São Luís Basin). Two isolated teeth originally assigned to *Platecarpus* sp. come from the late Turonian and Turonian-Coniacian Sergipe Basin (the Cotinguiba Formation?). While they exhibit general plioplatecarpine traits such as lateral fluting and/or medial striation of the crown, marginal tooth morphology is strongly conserved within the subfamily, and recent studies also indicated the range of *Platecarpus* to be no older than 85 Ma. These teeth therefore can be referred at best to Plioplatecarpinae gen. et sp. indet. *Plioplatecarpus* sp. is known from the Campanian Calumbi Formation (Sergipe Basin). The Maastrichtian Gramane Formation, which yielded the most representative Brazilian mosasaurid record, is represented by *Carinodens belgicus* Woodward 1891, Plioplatecarpinae gen. et sp. indet., and Mosasaurinae gen. et sp. indet. These mosasaur-bearing units ranging in duration approximately from 100 Ma (Cenomanian) to 65 Ma (Maastrichtian) serve as a unique and important reference point to further our understanding of mosasaur diversity and distribution patterns both in time and space, in the ancient South Atlantic Ocean in particular and in the Southern Hemisphere in general.

OLIGOCENE BENTHIC FORAMINIFERA FROM THE POLONEZ COVE FORMATION OF KING GEORGE ISLAND, WEST ANTARCTICA

Wojciech Majewski[1] and Andrzej Gaździcki[1]

1. Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland.
wmaj@twarda.pan.pl

Abundant benthic foraminifera are described for the first time from Oligocene strata of the Antarctic Peninsula sector of West Antarctica. They come from deposits of prograding fan-delta front of the lower Oligocene Low Head Member of the Polonez Cove Formation, which are exposed in some cliffs and nunataks of King George Island. Despite being collected from eight different sites, the foraminifera reported constitute a single diverse assemblage strongly dominated by calcareous species, belonging to *Cibicides* along with *Globocassidulina*, *Ammoelphidiella*, *Discorbis*, *Melonis*, *Lobatula*, *Gyroidina*, and *Pullenia*, as well as miliolids and unilocular calcareous foraminifera, enriched in foraminifera with robust tests. This assemblage does not correspond with any known modern Antarctic foraminiferal community, but it shows some links with Patagonian assemblages, suggesting different environments during the early Oligocene than in Recent Antarctica. Its general taxonomic composition and the enrichment in robust tests fit well into the shallow-water environment interpreted from geological data. Despite presence of some characteristic Antarctic taxa, for example species of the extinct *Ammoelphidiella*, the assemblage from the Polonez Cove Fm. is difficult to correlate biostratigraphically with a particular part of the foraminiferal record from the Ross Sea. Apparently, a strong environmental imprint on the shallow-water foraminiferal assemblage from the Oligocene of King George Island overshadows long-term evolutionary changes.

NEW NON-THERIAN MAMMAL FROM MARAMBIO (SEYMOUR) ISLAND IN WEST ANTARCTICA: FIRST MERIDIOLESTID OUTSIDE SOUTH AMERICA

Agustín G. Martinelli[1], Laura Chornogubsky[2], M. Alejandra Abello[3], Francisco J. Goin[3] and Marcelo A. Reguero[3,4]

1. Departamento de Paleontologia e Estratigrafia, Universidade Federal do Rio Grande do Sul. Ave. Bento Gonçalves 9500, Agronomia, 91501-970, Porto Alegre, RS, and Centro de Pesquisas Paleontológicas L.I. Price, CCCP/UFTM, BR-262, Km 784, Bairro Peirópolis, 38001-970, Uberaba, MG, Brazil. agustin_martinelli@yahoo.com.ar

2. CONICET-Sección Paleontología de Vertebrados, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia". Av. Ángel Gallardo 470, C1405DJR, Buenos Aires, and Departamento de Ciencias Básicas, Universidad Nacional de Luján. Ruta 5 y Av. Constitución, 6700, Luján, Buenos Aires, Argentina.

3. CONICET-División Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n (B1900FWA) La Plata, Argentina.

4. Instituto Antártico Argentino, Balcarce 290, C1064AAF Buenos Aires, Argentina.

The *Cucullaea* I Allomember of La Meseta Formation (Early Eocene to ?early Oligocene), Marambio (Seymour) Island, Antarctic Peninsula contains most of the terrestrial mammals, including non-therian gondwanatheres, metatherians, and eutherians recorded in Antarctica. This composition reflects a strong paleogeographical link between the Paleogene faunas of Patagonia and West Antarctica. A small isolated tooth (MLP 91-II-4-3) was found in locality IAA 1/90 from *Cucullaea* I Allomember and was originally interpreted as a possible third upper molar from a bat or an "insectivore" because of its zalambdodont appearance, and then more broadly assigned to Mammalia *Incertae sedis*. We present here an alternative interpretation, considering MLP 91-II-4-3 as a right lower molar of a non-therian Dryolestoidea, possibly being a member of the clade Meridiolestida. The crown is dominated by three cusps and a distolingual talonid cusp. The protoconid is flanked mesially by the paracristid and distally by the metacristid, which reach the paraconid and metaconid, respectively. Both crests form an acute angle, without a clear notch at mid-way. The labial wall of the protoconid is convex whereas the lingual face is slightly concave. The paraconid is worn out and lower than the metaconid. The flexid is notorious and forms a "v" shaped notch between paraconid and metaconid. The protoconid and metaconid are similar in height. The metaconid connects by a crest with the talonid. The talonid has a hook-like disto-lingual projection with a large cusp, slightly bent lingually, and an accesory more labially placed cuspule. The mesial cingulum starts as a thin ridge below the paraconid and becomes wider on its ventrolabial trajectory. It is unknown if the cingulum continues on the labial slope of the protoconid. A portion of a root is preserved below the paraconid-protoconid and it seems to be transversely wide. The crown morphology of MLP 91-II-4-3 closely resembles that of the meridiolestidans *Barberenia* and *Brandonia* from the Late Cretaceous of Patagonia (Los Alamitos and Allen formations). Meridiolestida is a diverse group of dryolestoids recorded mostly from Patagonian Cretaceous outcrops, which survived the Cretaceous/Paleocene boundary with the youngest representative of the clade (*Necrolestes*) from early Miocene. If proven correct, our hypothesis would expand the distribution of the Meridiolestida to West Antarctica, representing the second non-therian mammal from this continent. Thus, it would agree with previous inferred scenarios that show West Antarctic faunas more closely related to those of Patagonian Paleogene than to any other one from the Southern Hemisphere.

ORIGIN OF MODERN ANTARCTIC ICE-FISHES (TELEOSTEI, NOTOTHENIOIDEI) AND THE IDENTITY OF EOCENE FISH REMAINS FROM SEYMOUR ISLAND, ANTARCTICA

Thomas Mörs[1], Andrea Engelbrecht[2], Jürgen Kriwet[2], Cathrin Schwarz[2] and Marcelo Reguero[3]

1. Department of Palaeobiology, Swedish Museum of Natural History, P.O. Box 50007, SE-104 05 Stockholm, Sweden. thomas.moers@nrm.se

2. Department of Palaeontology, University of Vienna, Althanstr. 14, 1090 Vienna, Austria.

3. CONICET; División Paleontología de Vertebrados, Museo de La Plata, Paseo del Bosque s/n, B1900FWA La Plata, Argentina.

The modern Antarctic fish fauna is highly endemic and well-adapted to the polar conditions and geographic peculiarities of the Southern Ocean, which is geologically the youngest ocean and forms about 10% of the world's ocean surfaces. Continental ice sheets, cold polar waters delimited by the Antarctic Polar Frontal Zone (45-60°), the circum-Antarctic current, as well as shelf and upper slopes that are isolated from other shelf areas are characteristics of modern Antarctica. The development of the circum-Antarctic current is generally related to the opening of the Tasmanian Gateway between Australia and Antarctica during the Palaeogene, with deep-water circulation being established at about 31 Ma ago. The Drake Passage between South America and Antarctica opened perhaps as early as 33 Ma ago; it was certainly open to deep-water flow, deeper than 2000 m, by 29 Ma and the thermal isolation of Antarctica was complete. A benthic association that lacks skeleton-breaking (durophageous) forms but also epipelagic predators (this niche is filled by cephalopods today) characterizes the fish fauna inhabiting this extreme habitat today. Notothenioid teleosts that dominate the modern Antarctic fish fauna have evolved special features to cope with the extreme environmental conditions. Generally, the evolution of these fishes is linked to the development of the powerful Antarctic Circumpolar Current. However, recent analyses show that major high latitude cooling and the onset of Cenozoic glaciation predate the development of this current suggesting that adaptive traits in notothenioids probably started earlier then the development of glaciation, if the attribution of a single Eocene fossil skull to notothenioids, which was used to calibrate molecular clocks, is correct. The transition from a typical open marine fish fauna including diverse chondrichthyan associations to the modern, mostly benthic notothenioid-dominated fish fauna thus must have occurred in the Palaeogene after the K/T boundary event. However, more recent molecular analyses suggest that adaptation of fishes to polar conditions and subsequent evolution of notothenioids occurred prior to 24 Ma by directional selection and geographic isolation. Nevertheless, isolated fish remains from Eocene strata of Seymour Island recently were interpreted as relicts of notothenioids reiterating previous hypotheses. Here, we present a re-evaluation of Eocene Antarctic fossil teleost remains including abundant jaw elements and otoliths based on morphological comparisons of selected extant Antarctic fishes employing non-invasive micro-CT techniques for 3D visualization of skeletal and otolith structures. Our results are discordant with previous interpretations indicating that evolution of notothenioids must have occurred later.

TWO NEW SPECIES OF NON-ARISTONECTINE ELASMOSAURIDS (PLESIOSAURIA; SAUROPTERYGIA) FROM THE WEDDELLIAN PROVINCE AND THE ORIGIN OF THE ARISTONECTINAE

José P. O'Gorman[1,2]

1. División Paleontología Vertebrados, Museo de La Plata, Universidad Nacional de La Plata, Paseo del Bosque s/n., B1900FWA, La Plata, and CONICET, Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina. joseogorman@fcnym.unlp.edu.ar

The elasmosaurids from the Weddellian province (Patagonia, Western Antarctica and New Zealand) comprises the distinctive large skulled aristonectine (*Aristonectes*, *Kaiwhekea*) and the more typical small skulled non-aristonectine elasmosaurids. Here two new non-aristonectine elasmosaurids from the Weddellian Province are commented. The nov. sp. 1 (MLP 93-I-5-1, Museo de La Plata, Argentina) comes from Vega Island, James Ross Archipelago, Antarctica, lower Maastrichtian Cape Lamb Member of the Snow Hill Island Formation. The nov. sp. 2 (MLP 71-II-13-1) comes from Lago Pellegrini, Río Negro, Patagonia (upper Campanian-lower Maastrichtian Allen Formation). The nov. sp. 1 is one of the few Late Cretaceous elasmosaurids from the South Hemisphere whose postcranial anatomy is well-known. The nov. sp. 1 is distinguished from other elasmosaurids by the following combination of characters: cervical region with 54 vertebrae with elongated centra, dumbbell shaped articular faces and lateral ridge present in the anterior and middle part of the neck but absent in the posteriormost cervical vertebrae; scapula with ventral ramus bearing a strong ridge in the anteromedial corner of its dorsal surface; ilium shaft, with expanded distal end, divided in two parts forming an angle of 140° opening anteriorly; humerus with anterior knee and prominent posterior projection with accessory posterior articular facet. The nov. sp. 2 shares with the nov. sp. 1 the humeral morphology (humerus with anterior knee and prominent posterior projection with accessory posterior articular facet) but differs from the nov, sp. 1 in its distinctive small body size (about 3.7 m long), more elongated cervical centra, caudal parapophysis laterally projected and presence of pelvic bar. Preliminary phylogenetic analysis places the nov. sp. 1 and nov. sp. 2 within a clade that includes the Late Cretaceous Weddellian aristonectine elasmosaurids, *Aristonectes* and *Kaiwhekea*. This indicates a close relationship between Aristonectinae and non-Aristonectinae Late Cretaceous Weddellian elasmosaurids and reinforces the hypothesis of the Weddellian origin for the Aristonectinae.

SYMPOSIUM

USING TRACE FOSSILS TO UNDERSTAND EVOLUTIONARY TRENDS

ORGANIZERS:

CLAUDIA MARSICANO - LUIS BUATOIS - GABRIELA MÁNGANO

This Symposium is dedicated to the memory of Dolf Seilacher (1925-2014), who can be rightly regarded as the Father of modern Ichnology. His work has been hugely influential in both ichnology and paleobiology. He will be missed.

RELICT ECOSYSTEMS AT THE DAWN OF THE PHANEROZOIC REVOLUTION

Luis A. Buatois[1], Guy M. Narbonne[2], M. Gabriela Mángano[1], Noelia B. Carmona[1,3] and Paul Myrow[4]

1. Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, SK S7N5E2, Canada. luis.buatois@usask.ca
2. Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, Ontario K7L 3N6, Canada.
3. CONICET-UNRN, Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, Isidro Lobo y Belgrano, (8332) Roca, Río Negro. Argentina.
4. Department of Geology, Colorado College, Colorado Springs, Colorado 80903, USA.

The earliest Cambrian was a time of dramatic biological and sedimentary changes, including the replacement of Proterozoic-style microbial matgrounds by Phanerozoic-style bioturbated mixgrounds. However, Ediacaran-style matground-based ecology persisted into the earliest Cambrian. Our study in the type section of the basal Cambrian in Fortune Head, Newfoundland, Canada reveals widespread microbially induced sedimentary structures (e.g., wrinkle marks, gas domes) and typical Ediacaran-type matground trace fossils (e.g., grazing trails). Ediacara-type body fossils (e.g., *Palaeopaschichnus*) are present immediately below the top of the Ediacaran but are strikingly absent from the overlying Cambrian succession, despite optimal conditions for their preservation, and instead the microbial surfaces are marked by the appearance of the first abundant arthropod scratch marks (*Allocotichnus dyeri*) in the stratigraphic record. This combination of a microbial matground-based ecology, and the appearance of new body plans and associated locomotion mechanisms, actually resulted in a peak in diversity of animal-matground interactions during the Fortunian. These features imply that the disappearance of the Ediacara biota represents an abrupt evolutionary event that corresponded with the appearance of novel bilaterian clades, rather than a fading away due to the gradual elimination of conditions appropriate for Ediacaran preservation.

USING THE TRACE FOSSIL *OPHIOMORPHA* AS A GUIDE TO UNDERSTANDING CALLIANASSID EVOLUTIONARY TRENDS

H. Allen Curran[1], Renata G. Netto[2], Koji Seike[3], Zain Belaústegui[4] and Francisco M. W. Tognoli[2]

1. Department of Geosciences, Smith College, Northampton, Massachusetts 01063, USA. acurran@smith.edu
2. Programa de Pós-Graduação em Geologia, UNISINOS, 93022-000, São Leopoldo RS, Brazil.
3. Atmosphere and Ocean Research Institute, University of Tokyo, 277-8564 Kashiwa, Japan.
4. Departament d'Estratigrafia, Paleontologia i Geociències Marines, Universitat de Barcelona, Martí i Franquès s/n, 08028 Barcelona, Spain.

Ophiomorpha is one of the most distinctive and best known invertebrate trace fossils, consisting of a lined, branching shaft and tunnel burrow system that is distinctly pelleted on the exterior surface and smooth on the inside. Outside burrow diameters typically are 1-3 cm, and shaft/tunnel segments can reach lengths of 10s of centimeters. Based on close similarity with modern burrows, *Ophiomorpha* is interpreted as the dwelling burrow of callianassid (ghost) shrimp (Decapoda: Axiidea: Callianassidae) which are globally distributed and represented by ~200 modern species, mainly at tropical to temperate latitudes. *Ophiomorpha* typically occurs in sandy facies of both siliciclastic and carbonate strata and is common from the early Mesozoic onward, with some reported occurrences in the late Paleozoic. Its presence is considered diagnostic for marine shallow subtidal to beach lower foreshore paleoenvironments, including tidal flats and shoals of lagoons and bays, although at least one ichnospecies of *Ophiomorpha* is characteristic of deep water settings. The common occurrence of *Ophiomorpha* with onset of the Mesozoic marine revolution is an indicator of the role of callianassids as a dominant component of shallow-marine endobenthic faunas and an important generator of bioturbation. Ichnologists recognize several ichnospecies of *Ophiomorpha* based on exterior morphology and distribution of the wall-forming pellets, but this strategy has real limitations. By contrast, zoologists emphasize overall burrow architecture as the most important character of callianassid burrows, with the different architectures recognized as being species specific. Burrow systems from different genera and species, identified from casts, are quite varied and include forms that are shaft-dominated, spiral, broadly U-shaped, and combinations of U- and spiral shapes, among others. Reflecting their largely fossorial lifestyle, the greater part of a callianassid exoskeleton is weakly calcified, with parts of the first pereiopod usually the only remains preserved as fossils. Thus, our knowledge of the lineages of this important group of marine decapods is limited. By placing more emphasis on reconstructing the architecture of *Ophiomorpha* burrow systems, ichnologists may be able to contribute to the understanding of evolutionary trends within the Callianassidae. Examples of Pleistocene fossil burrow systems from the Chuí Formation (siliciclastic), Brazil; Rice Bay Formation, Bahamas; Miami Limestone, south Florida, USA; and Miocene units of the Camp de Tarragona Basin, NE Spain (allcarbonates) offer promise in this direction. In addition, preliminary studies to assess the burrow systems of the callianassid *Sergio mirim* are underway along modern beaches of the southern Brazilian coast.

THE ROLE OF BIOTURBATION DURING THE CAMBRIAN EXPLOSION

María G. Mángano[1] and Luis A. Buatois[1]

1. Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, SK S7N5E2, Canada. gabriela.mangano@usask.ca

The rapid appearance of bilaterian clades at the beginning of the Phanerozoic is one of the most fascinating topics in macroevolution. However, the role of bioturbation and the complex feedbacks between diversification and ecological interactions during the Cambrian explosion are still poorly understood. A systematic and comprehensive analysis of the trace-fossil record of the Ediacaran-Cambrian transition clearly points to two major evolutionary breakthroughs (1) the Fortunian diversification event, and (2) the Cambrian Stage 2 agronomic revolution that marks the establishment of a Phanerozoic-style ecology. In contrast to the prevailing view that diversification of animals and infaunal colonization were roughly coincident during the Cambrian explosion, a detailed, database analysis indicates that the presence of a wide array of metazoan behaviors preceded the establishment of a modern infaunal ecologic structure (i.e. mixground ecology), indicating a decoupling of cladogenesis and the major shift in benthic ecology. High ichnodiversity and ichnodisparity by the Fortunian imply a wide repertoire of behavioral strategies and body plans indicating that a major phase of the evolutionary radiation occurred earlier than suggested according to the classic Cambrian explosion scenario. The establishment of vertical-dominated ichnofabrics recording the activities of a suspension-feeder infauna triggered a major change in benthic ecologic structure during Cambrian Stage 2, improving the delivery of nutrients and oxygen into the sediment, increasing the complexity of the trophic web, and ultimately coupling the benthos and plankton. Both phases were accompanied by different styles of ecosystem engineering, but only the second one resulted in the establishment of the Phanerozoic-style ecology. In turn, the suspension-feeding infauna may have been the ecologic drivers of a further diversification of deposit-feeding strategies by Cambrian Stage 3, favoring an ecological spillover scenario. Trace-fossil information strongly supports the Cambrian explosion as a real event, but allows for a short time of phylogenetic fuse during the terminal Ediacaran-Fortunian.

THE EARLY DIVERSIFICATION OF AMNIOTES ON LAND: THE ROLE OF ICHNOLOGY IN THE GONDWANAN CONUNDRUM

Claudia A. Marsicano[1] and Veronica Krapovickas[1]

1. Departamento de Ciencias Geológicas, IDEAN-CONICET, Facultad de Cs. Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, Pab. II, C1428 EHA, Buenos Aires, Argentina. claumar@gl.fcen.uba.ar

It has long been known that during the Permian a major transition occurred in terrestrial tetrapod faunas: the radiation of amniotes on land. Early Permian faunas, dominated by temnospondyl amphibians together with early amniotes, changed during the Middle-Late Permian with the onset of much diverse and complex terrestrial amniote faunas. These changes in diversity and occupancy of continental environments are fully documented by the well-known paleotropical Laurasian faunas. In contrast, little is known about the early history of amniotes in the Southern Hemisphere. Basically all the information available comes from Permian beds at several high latitude localities in southern Africa and South America, where some clades of terrestrial synapsids along with parareptiles are well documented as early as the Middle Permian (Wordian-Capitanian). Before that time, the evolutionary history of amniotes in Gondwana remains elusive, as their skeletal record is very scarce. The only exception is a group of aquatic parareptiles, the mesosaurids, known from Artinskian (Early Permian) levels from southwestern Gondwana (southern Africa, Uruguay, Brazil). The mesosaurids has recently proved to be the earliest viviparous reptiles, an evolutionary novelty related to their fully aquatic mode of life. In this context, our current knowledge of the Gondwanan amniote fossil record suggests their sudden appearance by the Early Permian in high latitudes represented by an endemic group of specialized aquatic parareptiles. This is followed by a gap of information of ca. 10 Ma until the Middle Permian, when amniotes suddenly became diversified and abundant in the region, occupying different terrestrial ecological roles. Nevertheless, if the known amniote ichnological record is considered, a substantial different scenario is depicted. In the last years, tetrapod footprints have been described from putative Lower Permian (Sakmarian-Artinskian) strata of Argentina (Patquia and Yacimiento Los Reyunos formations). In all cases, the footprints were preserved in sandstone beds formed in dune field environments (dune and interdune deposits) revealing the presence of different groups of small-to-medium sized desert dwellers. Accordingly, the combination of the ichnological and skeletal record suggests that amniotes were already widespread in the high latitudes of Gondwana by the beginning of the Permian with a complex ecological structure, including the colonization of deserts as well as the aquatic habitats. This new scenario also implies that amniotes evolved in Gondwana significantly earlier than previously thought, probably in coincidence with the establishment of amniote-dominated land habitats in the Northern Hemisphere.

COUPLED PALEOGEOGRAPHIC PATTERNS IN LATE CRETACEOUS, SHALLOW-MARINE BODY AND TRACE FOSSILS FROM ANTARCTICA

Eduardo B. Olivero[1] and María I. López Cabrera[1]

1. Centro Austral de Investigaciones Científicas (CADIC-CONICET), B.A. Houssay 200, Ushuaia 9410, Tierra del Fuego, Argentina. emolivero@gmail.com

Late Cretaceous mollusks from the Marambio Group, James Ross Basin, NE Antarctic Peninsula, record a long cooling trend of seawater temperatures from the Coniacian/Santonian (~18C°) to the Maastrichtian (~8C°). Accompanying this trend are remarkable shifts in the biogeographic distribution of pelagic (ammonites) and benthic (bivalves) faunas. A strong biogeographical contrast is apparent between nearly cosmopolitan or Indo Pacific Santonian faunas and Southern Gondwana-restricted mid Campanian-Maastrichtian ones. The pelagic elements of the latter are characterized by radiation and dominance of the stenothermal kossmaticeratid ammonites and early extinction of the scaphitid, nostoceratid, and baculitid ammonites; and the benthic fauna by the early extinction of inoceramid and most trigoniid bivalves. Here we document and discuss accompanying changes in fossil behavior, expressed by complex spreite burrows that are mostly restricted to southern high-latitudes. The 3 km-thick Marambio Group records a variety of deltaic, estuarine, storm-influenced, and shelfal fine-grained deposits bearing ichnological suites characteristic of the proximal and distal *Cruziana* ichnofacies. Typical Upper Cretaceous ichnogenera that are well-known elsewhere in the world include: 1) for the proximal and archetypal *Cruziana* ichnofacies, *Asterosoma*, *Chondrites*, *Nereites*, *Ophiomorpha*, *Phycodes*, *Phycosiphon*, *Planolites*, *Rhizocorallium*, *Rosselia*, *Schaubcylindrichnus*, *Scolicia*, *Taenidium*, *Teichichnus* and *Thalassinoides*; and 2) for the distal *Cruziana* ichnofacies, the addition of large specimens of *Stelloglyphus*, *Zoophycos*, and restricted horizons with graphoglyptids. Among these a distinctive group of complex spreite burrows appears at different times with increasing diversity and dominance, including *Paradictyodora antarctica* (Santonian); *P. antarctica* and *Tasselia ordamensis* (late early Campanian); *P. antarctica*, *T. ordamensis*, and *Euflabella singularis* (mid Campanian); *P. antarctica*, *T. ordamensis*, *E. singularis* and *Euflabella multiplex* (late Campanian); and *P. antarctica*, *T. ordamensis*, *E. singularis*; *E. multiplex*, *Euflabella radiata*, *Patagonichnus stratiformis* and *Patagonichnus thalassiformis* (Maastrichtian). These complex spreite burrows are shallow-tier fodinichnia, but some of their producers were also trophic generalists, living on detritus from the burrowed sediment, fresh detritus from the surface, and bacterial gardening. Except for *T. ordamensis*, which is poorly known outside Antarctica and Tierra del Fuego, the rest of these spreite burrows appears to be restricted to southern high paleolatitudes. By the Late Cretaceous, the James Ross Basin was already positioned at its present latitude of about S64° and we hypothesize that high paleolatitudes, resulting in strong seasonal variations in primary production, and cooling, both favored the appearance of specialized strategies and behaviors offering a causal explanation for the observed concurrent paleogeographical restrictions in the pelagic and benthic faunas and trace fossils.

ICHNOLOGY OF SAUROPODOMORPH NESTS FROM PATAGONIA INDICATES EARLY JURASSIC ORIGIN OF HERD-LIVING AND BREEDING SITE FIDELITY

Roger M.H. Smith[1], Claudia A. Marsicano[2], Diego Pol[3] and Adriana C. Mancuso[4]

1. Iziko South African Museum, PO Box 61, Cape Town, 8000, South Africa. rsmith@iziko.org.za
2. IDEAN (UBA-CONICET), Universidad de Buenos Aires, Ciudad Universitaria, Pabellón II, C1428 DHE Buenos Aires, Argentina.
3. CONICET Museo Paleontológico Egidio Feruglio, Av. Fontana 140, Trelew 9100 Chubut, Argentina.
4. IANIGLA (CCT-CONICET), Adrián Ruiz Leal s/n, Parque Gral. San Martín, 5500 Mendoza, Argentina.

The Late Triassic/Early Jurassic Laguna Colorada Formation of Patagonia contains a unique sub-polar fossil assemblage dominated by the basal sauropodomorph *Mussaurus patagonicus*. This taxon was originally described from 8 well-preserved post-hatchling specimens associated with unbroken eggs and shell fragments found at the Laguna Colorada type section. A new detrital zircon date for the egg-bearing interval at this site of ±192.57 Ma is contemporaneous with the *Massospondylus* eggs with embryos recently described from South Africa. Our collecting at the original *Mussarus* site yielded 25 partial *Mussaurus* skeletons of six different ontogenetic stages, from embryonic to adult, associated with several complete "nests" of un-hatched eggs. The taphonomic signature is of an attritional accumulation of a stable (non-migratory) population living at this site year-round. The skeletons and egg clusters occur in three distinct horizons within a 3 m-thick sequence of mottled light reddish- brown/olive-grey massive siltstone. The host sediment is interpreted as wind transported loessite deposited around a floodplain lake under a seasonally dry climate. Eggs are all of similar dimensions and slightly ovoid in shape. The shell lacks discernable columnar structure, and is notably thin (±2 mm). Pores are evident on the outer surface as small inverted cones linked by shallow sinuous grooves. Pore densities do not vary within or between eggs. From compression breakage patterns of complete eggs and stacked shell fragments of hatched eggs, we infer that eggs were left open to incubate. The spacing of the nests suggests a common breeding ground rather than a colony, and the repeated occurrence of nests and skeletons through the 3 m-thick interval indicates year-on-year breeding at this site. Field observations and X-ray imaging of 5 complete nests confirms that 24-27 eggs are arranged in 2 or 3 layers within elongate depressions or trenches with an irregular bottom profile. These depressions appear to have been purposely excavated into semi-consolidated loess and as such they qualify as nest structures. The attitude and juxtapositions of the eggs within the nest hollows suggest that they were laid in repeated episodes of 3-4 at a time. To date the oldest record of nest digging and site fidelity has been from Late Cretaceous titanosaur sauropods. Our new ichnological evidence from Laguna Colorada Formation strongly indicates that sauropodomorphs of sub-polar Gondwana were practicing herding, nest digging and breeding site fidelity as far back as the Early Jurassic, at least 100 Ma earlier than previously thought.

THE RISE OF WOOD-BASED METABOLISM IN LATE TRIASSIC INSECTS

Leif Tapanila[1]

1. Department of Geosciences and Idaho Museum of Natural History, Idaho State University, Pocatello, 83201 USA. tapaleif@isu.edu

Macroscopic wood borings are prevalent in Late Triassic conifers of the Chinle Formation in Utah and Arizona, USA. Since their initial description in the 1930s, Triassic wood borings have received only slight attention. Preservation of borings is primarily restricted to the xylem tissues, and includes evidence of at least 4 distinct morphologies that contain frass. *Paleobuprestis* are girdling boreholes that spiral along the circumference of the trunk. Averaging 1.5 cm wide and only 0.4 cm high, these borings may extend for more than 200 cm as a single, continuous trace fossil that represents the consumption of >100cm^3 of wood, presumably by an individual tracemaker. *Paleoipidus* is a curved radial boring with a distinct biconvex cross-section oriented to the grain of the wood. New material of *Paleoipidus* shows a characteristic meniscate pattern of frass fill. A new unnamed boring that forms an irregular pattern of tunnels in rotted wood contains subhexagonal frass pellets, but is known only from one specimen. *Xylokrypta* is a U-shaped excavation with an enlarged chamber possibly to protect its tracemaker during pupation. This ichnotaxon is widespread in the Chinle Formation, and commonly co-occurs with fungal infestations in the wood. Several previously described borings are junior synonyms, or represent pseudoborings. Surveys of the Chinle Formation show a patchy distribution of borings, both spatially and stratigraphically. Investigations of these macroscopic trace fossils point to early xylotrophic behaviors in insects, which should only increase in abundance and diversity through the Mesozoic with the diversification of wood-boring insect clades.

COMPETITION BETWEEN MIXED-LAYER AND TRANSITIONAL-LAYER INHABITANTS – A MODERN PERSPECTIVE

Andreas Wetzel[1]

1. Geologisches Institut, Universität Basel, Bernoullistrasse 32, CH-4056 Basel, Switzerland.
andreas.wetzel@unibas.ch

The bioturbated zone comprises the mixed layer near the sediment surface and the transitional layer below that is characterized by distinct traces. Commonly the mixed layer is up to a few centimeters thick. Ideally it has a homogeneous appearance while indistinct biodeformational structures are produced by shallowly burrowing organisms. The organisms producing the mixed layer utilize the organic matter close to the sediment surface and thereon. Small-sized organisms, meio- and microfauna, occur in high abundances and distort the sediment fabric indistinctly. Macro-organisms produce fairly large biodeformational structures that appear like sediment eddies, but also deeper within the sediment if the benthic food content is so high that a behavioral specialization is superfluous. Furthermore, a homogeneous appearance is favored by a very soft to soupy sediment consistency. Therefore, the thickness of the mixed layer also depends on the environmental settings that need to be considered when the mixed layer is analyzed over geological time spans. On the long term the mixed-layer producers got the ability to burrow a little deeper. Similarly, burrows produced by the inhabitants of the transitional layer exhibit a tendency to behavioral evolution. Besides a trend to explore increasingly deeper intervals within the seafloor they expanded their behavioral programs to supplement their limited resources, including: (1) Temporary feeding directly on the sediment surface and/or (2) taking benthic food from the sediment surface to store it in a cache. The construction of deep caches located in the anoxic sediment zone is quite effective as the organic matter is not exposed to oxygen there. On the long-term, the number of ichnogenera increased that show one of these behavior programs; for instance, the producers of some *Nereites* or *Scolicia* feed temporarily on the sediment surface and the producers of *Zoophycos* or *Thalassinoides* construct and utilize caches. Consequently, the vertical extent of the mixed layer is determined by two long-term strategies of the burrowing organisms. The inhabitants of the mixed layer tend to vertically expand their habitat, but deep burrowers take food resources from the mixed layer. Due to the competition for food, mixed-layer inhabitants respond flexible and rapid on environmental changes. Observations in the modern suggest that after environmental disasters small-sized organisms recover more rapidly than organisms living deeper in sediment. Therefore, after severe biological crises the mixed layer might have expanded for some time.

CHANGING DIVERSITY AND INTENSITY OF MARINE MACROBORING THROUGH THE PHANEROZOIC

Mark A. Wilson[1]

1. Department of Geology, The College of Wooster, Wooster, Ohio 44691, USA.
mwilson@wooster.edu

A boring in the biological sense is an excavation in a hard substrate by an organism. A macroboring is a boring easily seen with a naked eye or hand lens. Borings are a major part of the phenomenon of bioerosion of hard substrates, especially carbonate rocks, shells, bone and wood. More than 25 marine macroboring ichnogenera are described from the Phanerozoic, each representing a distinct behavior on or in a substrate. Most are domichnia produced by filter-feeding organisms such as bivalves, annelids and sponges. Some macroborings are produced by predation, and others made by grazing activities of mollusks and echinoderms. Boring organisms may use mechanical means to drill, grind or rasp away the substrate; others employ chemical compounds to dissolve or soften hard substrates, particularly carbonates. Bioerosion began in the Archaean, but the first macroborings appeared in the Early Cambrian. The major diversification of macroborings occurred as part of the Ordovician Bioerosion Revolution (OBR). Six additional macroboring ichnogenera appeared, representing a diversity of behaviors. There was also a multi-fold rise in the amount of boring, with some substrates showing an intensity of boring not seen again until the Jurassic. The OBR was a function of the Great Ordovician Biodiversification Event (GOBE) that increased the types and abundances of boring organisms as well as the diversity and numbers of shelly substrates to bore. This was also a peak Calcite Sea time with extensive carbonate hardgrounds. The diversity of macroborings continued to increase but at a lesser rate through the Paleozoic. The rate of bioerosion, estimated from the number of borings, decreased after the Ordovician to head upwards again in the Jurassic. Macroborings declined dramatically with the Permian extinctions. Triassic macroborings are rare but show an increase in diversity with the introduction of additional grazing traces. The Jurassic saw a recovery of macroboring diversity and abundance that continued into the Cretaceous and Cenozoic. Again, these increases track the faunal diversification and the return of Calcite Seas. The renewed abundance of corals and other large calcareous organic substrates also added to the material available for boring. During this Mesozoic and Cenozoic interval is an increase in the depth and complexity of borings. Marine macroboring history is ultimately a function of the broad patterns in evolution plus an overprint of physical factors such as the availability and composition of hard substrates.

THE MERMIA ICHNOGUILD IN UPPER PALEOZOIC GLACIAL-POSTGLACIAL DEPOSITS OF WESTERN ARGENTINA: COLONIZATION STYLES IN FRESHWATER HIGH-LATITUDE SETTINGS

Pablo J. Alonso-Muruaga[1], Luis A. Buatois[2] and Carlos O. Limarino[1]

1. CONICET - IGEBA. Departamento de Ciencias Geológicas, Universidad de Buenos Aires, Pabellón 2, Ciudad Universitaria, C1428EHA, Buenos Aires Argentina. pablojoaquin3@yahoo.com.ar

2. Department of Geological Sciences, University of Saskatchewan, Saskatoon, Canada.

Upper Paleozoic rocks in the Southern Hemisphere contain an extensive record of the Gondwana glaciations and the associated postglacial transgressions. These glacial events and related deglaciation episodes have strongly affected benthic communities inhabiting terrestrial, freshwater, and coastal ecosystems, and therefore constraining the colonization in these areas. In western Gondwana, particularly in those basins located along the western active margin of the supercontinent, glacial and postglacial deposits are widespread, involving continental, transitional and marine settings. In this context, the occurrence of trace-fossils in a wide variety of environmental settings of similar age provides an opportunity for reconstructing and comparing ecosystems, and to explore evolutionary trends related to the Gondwana Glaciation. The upper Paleozoic Paganzo Basin of Western Argentina contains an extensive record of the glacial event that affected Gondwana during the Late Carboniferous. The basin is divided in two major areas: an eastern zone dominated by continental environments and a western one with increase marine influence. Upper Carboniferous glacigenic units in this basin contain distinctive trace-fossil assemblages commonly preserved in fine-grained postglacial deposits. This ichnofauna is present in subaqueous lacustrine facies of the Agua Colorada and Malanzan formations in the Eastern zone, and fjord deposits of the Guandacol Formation in the Western zone. The ichnofauna is characterized by the dominance of a moderately diverse assemblage of non-specialized grazing trails, simple feeding traces, together with some arthropod trackways and fish trails. These biogenic structures are representatives of the *Mermia* ichnoguild, which characterizes subaqueous freshwater settings, particularly in the late Paleozoic. The occurrence of the *Mermia* ichnoguild in both postglacial lake and transitional (e.g. fjords) deposits of western Argentina reveals the persistence of the same colonization styles, involving a similar use of the ecospace (surface and shallow surface), bauplan and trophic types in a wide spectrum of subaqueous freshwater settings. This also suggests that the colonization of relatively deep fjord ecosystems was synchronic with the colonization of fully lacustrine environments in high-latitude settings by the Carboniferous. Subsequent changes linked to the Mesozoic Lacustrine Revolution involved increased infaunalization and a faunal turnover in both lake-margin and fully lacustrine settings.

CARNIVORE COPROLITES FROM THE UPPER TRIASSIC SANTA MARIA 2 SEQUENCE OF SOUTHERN BRAZIL: PALEOBIOLOGICAL IMPLICATIONS

Marina Bento Soares[1] and Voltaire D. Paes Neto[1]

1. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul (UFRGS). Av. Bento Gonçalves, 9500, Agronomia, CEP 91940-000, Porto Alegre, RS, CNPq 304143/2012-0, Brazil. marina.soares@ufrgs.br

A rich tetrapod fauna has been recovered from the top of Southern Brazil Santa Maria 2 Sequence of Norian age. This faunal set, assigned to the *Riograndia* Assemblage Zone (AZ), is mainly composed by very small tetrapods, such as non-mammaliaform cynodonts (*Brasilodon*, *Brasilitherium*, *Irajatherium*, *Riograndia*), rhyncocephalians (*Clevosaurus*) and procolophonids (*Soturnia*), among others. The fossils occur in massive or stratified sandy lenses interpreted as formed in a fluvial/deltaic system. More than 20 whitish ovoid coprolites, from 7 to 10 mm long, with a circular cross section, were found in the "Linha São Luiz" outcrop in the same stratigraphic level of the aforementioned tetrapods. Eight coprolites were selected for analysis of chemical composition, coprofabric and inclusions. X-ray diffraction analysis has indicated phosphatic levels consistent with carnivore coprolitic materials. Thin sections of some specimens show a massive copofabric lacking laminated structures and bearing abundant sand grains and bone remains. The fragmentation degree of the bone inclusions suggests the coprolites were produced by carnivorous capable of chewing bone. The presence of sand inside the coprolites phosphatic matrix is suggestive of fossorial adaptations of its producers. In this case, the animals used the tip of the snout for excavation, with the mouth acting as an efficient tool, sometimes with the use of the lower incisors to aid in breaking up soil. Therefore, soil ingestion, as well as the evacuation of sedimentary particles mixed with feces, was common practices. Although it is difficult to assign coprolites unequivocally to a specific producer, their sizes can be an indicator of the size of the producer. In this case, the coprolite sizes are in accordance with the sizes of the small tetrapods from the *Riograndia* AZ, which are up to 100 mm long. All these lines of evidence indicate that the non-mammaliaform cynodonts may be the potential producers of the coprolites. This is corroborated by a sectorial postcanine dentition with a more precise pattern of occlusion that allows a better bone chewing; and features suggestive of fossoriality like a robust humerus (e.g. *Irajatherium*) and a hypertrophied rodent-like lower incisor 1 (e.g. *Riograndia*). These cynodonts, with a more efficient masticatory apparatus than sauropsids (e.g. procolofonids and rhynchocephalians) and fossorial adaptations may have produced these coprolites. These carnivore coprolites constitute an important source of new data that are contributing to the elucidation of paleobiological aspects of the *Riograndia* AZ.

ICHNOLOGY OF THE MARINE MEMBER OF THE MIOCENE-PLIOCENE RIO NEGRO FORMATION OF ARGENTINA: AN UPDATE

Noelia B. Carmona[1], Juan J. Ponce[1], Andreas Wetzel[2], Constanza Bournod[3] and Diana Cuadrado[3,4]

1. CONICET, Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, General Roca. 8332, Río Negro, Argentina. ncarmona@unrn.edu.ar

2. Geologisch–Paläontologisches Institut, Universität Basel, Bernoullistrasse 32, CH-4056 Basel, Switzerland.

3. CONICET, Instituto Argentino de Oceanografía, CC 804, 8000, Bahía Blanca, Argentina.

4. Departamento de Geología, Universidad Nacional del Sur, San Juan 670, 8000, Bahía Blanca, Argentina.

The Mio-Pliocene Rio Negro Formation consists of three members; a lower continental member, the middle marine member and an upper continental member. In this study we focus on the middle marine member which is strongly affected by bioturbation. Sedimentologic and ichnologic analyses of this member allowed the recognition of tidal flat, tidal-bar, upper, middle and lower shoreface-offshore transition deposits, recording a complete transgressive–regressive cycle. The tidal-flat facies that occurs at the base of the marine member is reworked by abundant *Arenicolites* and *Skolithos*, and also presents extensive microbially induced sedimentary structures (MISS). Large *Ophiomorpha* colonized the sandy strata in the tidal-bar facies, being a typical representative of the *Skolithos* ichnofacies. These shallow deposits pass upwards into lower-shoreface-offshore transition deposits with representatives of the archetypal *Cruziana* ichnofacies. These deposits are fully bioturbated by deposit-feeder structures, such as *Asterosoma*, *Helicodromites*, *Nereites*, *Scolicia*, *Siponichnus*, *Teichichnus*, and *Thalassinoides* and burrows of chemosymbiotic organisms such as *Chondrites.* Some relict tempestites can also be observed in this part of the member, having low bioturbation intensity, with specimens of *Teichichnus*, *Cylindrichnus*, *Scalichnus* and other unidentifiable equilibrium/escape structures. Upwards there is a shallowing trend, with upper shoreface deposits and tidal flats at the top. In the upper shoreface, bioclastic levels erode the finer deposits below, producing firm ground surfaces that are colonized by *Thalassinoides*-producers. The upper shoreface deposits are colonized mainly by crustaceans, which produce large *Ophiomorpha* burrows that are associated to brooding structures (e.g. *Maiakarichnus*). Finally, on top of this member, tidal flat deposits with MISS, bird tracks and large desiccation cracks occur. The development of the Modern Evolutionary Fauna from the Jurassic onwards, led to important ecological changes in the marine communities, with the dominance of mollusks, crustaceans and echinoids in the benthic communities. Interestingly, these are the same groups that were identified as the dominant trace-makers in the studied Mio-Pliocene, both in the shallower and in the deeper marine settings. These results agree with previous studies in other Cenozoic successions from Patagonia, which suggest that the establishment of the Modern Evolutionary Fauna is clearly reflected by the ichnologic record.

RECONSTRUCTING THE MIDDLE MIOCENE PALEOENVIRONMENT OF QUEBRADA HONDA, BOLIVIA, USING ICHNOLOGY AND PALEOPEDOLOGY

Angeline M. Catena[1] and Darin A. Croft[1]

1. Dept. of Anatomy, Case Western Reserve University, 10900 Euclid Ave., Cleveland, OH 44106-4930, USA. Angeline. Catena@gmail.com

Although the Neotropics are home to exceptional levels of mammalian diversity, there are few fossil-producing localities with which to study the history of these diverse and unique faunas. La Venta, Colombia, and Quebrada Honda, Bolivia are well-sampled, contemporaneous (12-13 Ma; late middle Miocene) Neotropical fossil-producing sites that preserve the remains of many nonvolant mammals (59 and 30 genera, respectively). These two localities have almost no mammalian genera in common, which could reflect different climates and/or habitats. However, unlike La Venta, the paleoenvironment of Quebrada Honda has not been investigated in detail. In this study, paleopedology and ichnology are used as independent lines of evidence to elucidate the habitat of Quebrada Honda. The paleosols of Quebrada Honda are weakly to moderately developed; features of the paleosols include a silty claystone- to silty sandstone-based lithology, slickensides and calcareous nodules. The paleosols appear to represent Entisols and Inceptisols that formed in proximal and distal floodplains, respectively. The ichnofossil suite present in Quebrada Honda paleosols includes *Coprinisphaera, Cellicalichnus, Psilonichnus, Macanopsis* and *Palaeophycus*. These ichnofossils are interpreted as dwelling and breeding structures that were primarily produced by solitary arthropods such as beetles, bees, and spiders. Rhizoliths are also abundant in the paleosols and range from small, branched mm-scale rhizohaloes to tapering, dcm-scale rhizocretions. The small, branched rhizohaloes are interpreted as roots from grasses or small plants, whereas the large, tapering rhizocretions are interpreted as taproots of medium-to-large plants, such as shrubs and trees. Based on the characteristics of the paleosols and the ichnofossils, the paleoenvironment of Quebrada Honda is interpreted as a mixture of seasonal grasslands and savannahs located proximal to alluvial systems. The inferred habitat of Quebrada Honda contrasts with that of La Venta, which has been reconstructed as a mixture of river-associated tropical forests and successional stages thereof. Our initial findings indicate that dissimilar habitats could account for some of the differences between the mammal faunas of Quebrada Honda and La Venta. Ongoing isotopic studies of this site should help refine this paleoenvironmental interpretation and provide constraints on the elevation of the site during the late middle Miocene.

FAUNAL DIVERSITY THROUGH COPROLITE ANALYSES: A CASE STUDY OF THE MIDDLE/UPPER PERMIAN, RIO DO RASTO FORMATION OF BRAZIL

Paula C. Dentzien-Dias[1], Ana Emilia Q. de Figueiredo[2] and Marina B. Soares[3]

1. Laboratório Oceanografia Geológica, Instituto de Oceanografia, Universidade Federal do Rio Grande, Av. Itália Km 8, Rio Grande, CEP 96201-900, Brazil. pauladentzien@gmail.com

2. Universidade Federal do Piauí, Campus Amílcar Ferreira Sobral, BR 343 Km 3,5, Floriano, CEP 64800-000, Piauí, Brazil.

3. Departamento de Paleontologia e Estratigrafia, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves 9500, Porto Alegre, Caixa Postal 15.001, 91501-970, Brazil.

The Rio do Rasto Formation (Paraná Basin) is well-known by its diverse vertebrate fauna. In the last years, up to 800 coprolites were collected in one outcrop in the lacustrine facies of the Rio do Rasto Formation (Middle/Upper Permian) in Southern Brazil. The material ranges from 0.6 cm to 13.5 cm long. A wide variety of morphotypes occurs, including heteropolar and amphipolar spiral forms and a new kind of heteropolar coprolite referred to as “edge”, which has the whorls grouped in the very end of one pole and the knot, which has in one of the poles a series of interlaced layers. All of them contain fragments of bones and fish scales, as well as crystalline apatite, and therefore are assigned to carnivores. Surface marks and adhesions occur in all types of coprolites. An impression of a shell was found on the surface of a coprolite, and impressions of plants occur only in one coprolite. A small amphipolar coprolite contains a cavity with smooth margins; this cavity is 1.5 mm wide and 1.4 mm deep. This small hole is interpreted as an invertebrate burrow. One larger cylindrical coprolite has two smashed areas, which show different deformation, one is in the middle of the coprolite and the other is at the end of it. The deformation probably was caused by an animal, and that explains why the coprolite was not smashed in its surface. These deformations were probably produced by the feet of an aquatic tetrapod. Lack of decomposition and absence of a flat undersurface indicate that the coprolites were expelled and crushed inside the water, siltic lacustrine substrate, and rapidly buried. In one thin section of a heteropolar coprolite, a cluster of 93 small oval-elliptical smooth-shelled structures, interpreted as Cestoda tapeworm eggs. Most of the eggs are filled by pyrite and some have a special polar swelling (operculum), suggesting they are non-erupted eggs. This is the earliest fossil record of tapeworm parasitism of vertebrates, suggesting a timeline for the evolution of cestodes. These discoveries show that the fossil record can be better understood through coprolites analyses. A wide variety of vertebrates and invertebrates lived in the lakes of the Middle/Upper Permian in southern Brazil and its fossilized feces show that the biodiversity of these paleoenvironments was even higher. These unusual preservations are rare in the geological record and these are the oldest ones reported.

INVERTERBRATE INFAUNAL COLONIZATION OF INCLINED HETEROLITHIC STRATIFIED (IHS) DEPOSITS DURING THE LATE MESOZOIC

Davinia Díez-Canseco[1], Luis A. Buatois[2], M. Gabriela Mángano[2], Margarita Díaz-Molina[1] and M. Isabel Benito[1]

1. Universidad Complutense-IGEO, Jose Antonio Novais 2, Madrid, E28040, Spain. daviniadiezcanseco@ucm.es
2. University of Saskatchewan, 114 Science Place, Saskatoon, SK S7N5E2, Canada.

Inclined heterolithic stratified (IHS) deposits of the Upper Cretaceous Tremp Formation (South-Central Pyrenees, Spain) are interpreted as deposited in point bars of tide-influenced channels. These deposits show an example of widespread colonization of the infaunal ecospace, as recorded by trace fossils. The dominant elements are meniscate trace fossils typical of the *Scoyenia* Ichnofacies, namely *Taenidium-Beaconites*. *Planolites* and *Palaeophycus* are also present, illustrating a poorly developed aquatic suite. Colonization of IHS deposits is marked by abundant and penetrative burrowing, resulting in an ichnofabric typically characterized by high index of bioturbation and dominance of mid- to deep tiers. In addition, over-crossing suites are common, indicating prolonged colonization windows. A comparison of the trace-fossil record of tide-influenced deposits at the fluvial-marine transition through geologic time suggests that colonization has varied significantly from Palaeozoic to Mesozoic times, mainly reflecting a progressive increase in burrowing abundance and penetration. Elements of the *Scoyenia* and *Mermia* Ichnofacies are recorded in tide-influenced settings from the Late Palaeozoic, particularly in the innermost freshwater zone of estuarine valleys, as indicated by arthropod trackways, superficial grazing trails and shallow feeding structures. However, since the Mesozoic, coincident with the Mesozoic Lacustrine Revolution, the *Scoyenia* Ichnofacies became dominated by deeper-tier meniscate trace fossils, impacting on the colonization styles of tide-influenced point-bar deposits. As a consequence, the shallow-tier elements of the *Scoyenia* Ichnofacies (e.g. arthropod trackways) are easily obliterated in these deposits during Mesozoic-Cenozoic times, as well as previously emplaced suites. Likewise, examples of Mesozoic and Cenozoic transitional deposits show composite ichnofabrics, where a brackish-water ichnofacies is overprinted by the widespread development of meniscate trace fossils of the *Scoyenia* Ichnofacies. Analysis of evolutionary trends of the *Scoyenia* Ichnofacies in deposits of tide-influenced channels suggests that the widespread infaunal colonization of IHS deposits is mainly a Mesozoic event. On other hand, this study allows to infer that the composite ichnofabrics of the IHS deposits of the Tremp Formation reflect the obliteration of a previously emplaced aquatic suite by the elements of the *Scoyenia* Ichnofacies. Analysis of macroevolutionary trends is essential to understand composite ichnofabrics, particularly in post-Paleozoic marginal-marine deposits.

ICHNOLOGY OF THE UPPER ORDOVICIAN WINNIPEG FORMATION OF SASKATCHEWAN, CANADA: EVALUATING THE IMPACT OF THE PALEOZOIC FAUNA IN ICHNOFACIES MODELS

Javier Dorador[1], M. Gabriela Mángano[2], Luis A. Buatois[2] and Francisco J. Rodríguez-Tovar[1]

1. Departamento de Estratigrafía y Paleontología, Universidad de Granada, Fuente Nueva s/n, Granada, 18017, Spain,
2. Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, SK S7N 5E2, Canada. gabriela.mangano@usask.ca

The ichnology of the Upper Ordovician Winnipeg Formation of southeast Saskatchewan (Canada) has been analyzed based on the study of five cores at the Saskatchewan Subsurface Geological Laboratory. This formation is approximately 70 m thick in the study area, and is dominated by sandstone, albeit with the intercalation of some mudstone-rich intervals. The Winnipeg Formation records sedimentation in wave-affected, relatively low-energy, shallow-marine settings during an overall transgression. These deposits host trace-fossil assemblages belonging to the *Skolithos* and *Cruziana* Ichnofacies, displaying a variable bioturbation index (BI 0-5). Overall, eleven ichnogenera have been recognized, namely *Arenicolites*, *Asterosoma*, *Cylindrichnus*, *Diplocraterion*, *Palaeophycus*, *Phycosiphon*, *Planolites*, *Rosselia*, *Skolithos*, *Teichichnus*, and *Thalassinoides*, together with escape trace fossils and borings restricted to a discontinuity surface. Contrasting with post-Paleozoic shallow-marine examples, ichnodiversity of these assemblages and the complexity of the tiering structure are much lower, reflecting the contrasting characters of the Paleozoic and the Modern Evolutionary Fauna. Some of the burrows (e.g. *Thalassinoides*) produced by archetypal tracemakers of the Modern Evolutionary Fauna (e.g. decapod crustaceans), although locally present, are not dominant in the Winnipeg Formation. Interestingly, bioturbation intensity reaches locally post-Paleozoic levels. The most popular trace-fossil models used for paleoenvironmental interpretations are based on the study of Mesozoic rocks. Our study shows that calibration of these models with respect to geologic age is essential, particularly in the case of ichnological studies of cores aiming to differentiate fully marine and brackish-water deposits.

VERTEBRATE BURROWING ACTIVITIES AT THE PERMO-TRIASIC TRANSITION IN SOUTHERN AFRICA

Vincent Fernandez[1,2], Fernando Abdala[2], Kristian Carlson[2], Robert Gess[2] and Bruce Rubidge[2]

1. European Synchrotron Radiation Facility, 71 rue des martyr , Grenoble, 38000, France. vinfernand@gmail.com
2. Evolutionary Studies Institute, University of the Witwatersrand, Yale road, Johannesburg, 2000, South Africa.

The Karoo Basin of Southern Africa has provided numerous examples of vertebrate burrowing behaviours in the strata spanning the Permo-Triassic (PT) boundary. The abundance of these underground shelters was therefore interpreted as an evidence of their importance to provide stable environments protecting their inhabitants from harsh climatic conditions consecutive to the PT mass extinction event. A few burrow diggers have been identified from fossilized burrow casts, notably cynodonts. It seemed logical to view burrowing behaviours as a key strategy to survive the extinction event. However this interpretation is weakened by the few numbers of identified burrowers compared to the numbers of burrow morphologies and sizes discovered. Secondly, an underground lifestyle was also ascertained for other taxa from older units of the basin which need to be taken into consideration in order to understand the evolution of burrowing strategy prior to the mass extinction event. Using new approaches, we investigate fossilized burrow casts, notably using X-ray tomography, to expand our knowledge on fossoriale lifestyle during this time. This technique allows us to explore the content of burrow casts, aiming to discover, and possibly identify, vertebrate remains. By keeping the sedimentological infill intact, we preserve taphonomical information, essential to discriminate taxa as burrowers or opportunistic inhabitants. In this work we present the latest results of this project, focusing on various types of burrows from different geological formations. We present a new burrow type from the Late Permian and early conclusions on the presumable burrow maker and discuss implications regarding burrowing as a survival strategy at the end of the Paleozoic.

INVERTEBRATE TRACE FOSSILS ON VERTEBRATE COPROLITES FROM THE UPPER CRETACEOUS MARÍLIA FORMATION (BAURU GROUP) OF UBERABA (MINAS GERAIS STATE, BRAZIL)

Heitor Francischini[1], Voltaire D. Paes Neto[1], Agustín G. Martinelli[1,2], Marina B. Soares[1], Cesar L. Schultz[1], Thiago Marinho[3], Mara L. F. Ferraz[2] and Vicente P. A. Teixeira[2]

1. Universidade Federal do Rio Grande do Sul (UFRGS), Avenida Bento Gonçalves, 9500, Agronomia, Porto Alegre, Rio Grande do Sul, 91540-000, Brazil. heitorfrancischini@hotmail.com

2. Centro de Pesquisas Paleontológicas L. I. Price, Complexo Cultural e Científico de Peirópolis (CCCP/UFTM), BR-262, Km 784, Peirópolis, Uberaba, Minas Gerais, 38039-755, Brazil.

3. Instituto de Ciências Exatas, Naturais e Educação (ICENE), Universidade Federal do Triângulo Mineiro (UFTM), Avenida Getúlio Guaritá, 159, Abadia, Uberaba, Minas Gerais, 38025-440, Brazil.

The Paleontological Site "Ponto 1 de Price" (19°43'24.6''S / 47°44'45.4''W) is an important and historically known outcrop located near the Peirópolis town (Uberaba County, Minas Gerais State, Brazil). The succession in this locality has been referred to the Maastrichtian Serra da Galga Member of the Marília Formation (Bauru Group, Paraná Basin). The outcrop includes a caliche (carbonate-cemented claystone) layer at the base, followed by a cyclic succession of cross-bedded fine- to coarse-grained sandstones and conglomerates, recording deposition within a fluvial system. The sandstone beds contain isolated (e.g., eggshells, teeth, turtles shells, bones remains and coprolites) and semi-articulated elements (e.g., the peirosaurid *Uberabasuchus* and the titanosaur *Trigonosaurus*) of several groups, such as fish, anurans, turtles, crocodiliforms and dinosaurs, and invertebrate trace fossils (aff. *Arenicolites* and *Skolithos*). Contrarily, the conglomerates only contain fragmentary remains. We report here the discovery of non-oriented bierosion structures, consisting of concave, long, rod-like shape borings with a length mean of 8.6 mm, width of 2 mm and a depth of 2.8 mm (n=9). These ichnofossils are preserved in elypsoid to irregular carbonate-rich structures, which are interpreted as vertebrate coprolites. The presence of cracks crosscutting the trace fossils in some coprolites suggests that they dried and desiccated after the production of the borings. Therefore, the presence in both sandstones and conglomerate facies indicates that the vertebrate-feces should have already been lithified before their transportation and deposition. The trace fossils are randomly located, concentrated on one hemisphere of the coprolite, commonly forming clusters where one trace fossil could overlaps another, and be absent on the opposite sides. They resemble the shape of *Petroxestes pera* Wilson & Palmer and *Cubiculum ornatus* Roberts *et al.*, made by marine boring bivalves and continental osteophagous insects, respectively. Despite *P. pera* is produced on carbonate rocks (or hardgrounds) and *C. ornatus* on bones, the aforementioned ichnofossils were made in a fecal matrix, possibly by an insect in the pupation period (e.g. dung flies or beetles). In some specimens, sub-transversal lines (bioglyphs) are preserved and can be interpreted as excavation and accommodation traces before the pupation. Thus, the ichnological record from the Marília Formation is extended, encompassing not only invertebrate burrows and vertebrate coprolites, but also the pupation marks here reported, representing the first record of Pupichnia in Brazil and the first occurrence of this behavior on a coprolite surface.

THE INVASION OF DESERTS: AN ICHNOLOGICAL PERSPECTIVE

Verónica Krapovickas[1], M. Gabriela Mángano[2], Luis A Buatois[2] and Claudia A. Marsicano[1]

1. IDEAN-CONICET – Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria Pabellón II, 1428 Buenos Aires, Argentina. vkrapovickas@gl.fcen.uba.ar

2. Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, Saskatchewan, S7N 5E2, Canada.

The transition from water to land and the consequent invasion of terrestrial ecosystems encompass some of the most significant events in the history of life. Among all terrestrial settings, deserts are one of the most extreme environments on Earth to be conquered, being hot and dry with greatly fluctuating surface temperatures. Consequently, deserts were one of the most difficult environments to be conquered by multicellular life, and possibly the last one to be colonized. Surprisingly, the invasion of deserts is one of the only events of the terrestrialization process that has not been studied systematically. By the elaboration of a comprehensive database that summarizes all life known in eolian deposits from the Cambrian to the Recent, we propose a summary of colonization trends and evolutionary turnovers in deserts. The first phase in the colonization of deserts coincides with the initial phases of terrestrialization during the early Paleozoic (Middle Cambrian-Silurian), and involves incursions into adjacent coastal dunefields by nearshore marine animals (phase 1). It is documented by large trackways produced by amphibious arthropods, although it is unlikely that these animals would have remained for long periods of time in coastal deserts. The colonization of inland deserts began as early as the Middle Devonian, involving fluvial-habitat animals that temporarily or permanently entered inland desert dunefields (phase 2). Among the earliest true inland desert inhabitants were stem-group arachnids or arachnids, together with myriapods. Currently, there is no evidence of plant colonization of deserts in Devonian times. Winds may have brought small detrital particles that served as a food resource for these early desert inhabitants. The first steps in the invasion of deserts by plants dates to the Middle Pennsylvanian when plants colonized stabilized deflation surfaces within coastal deserts, having been apparently incapable of colonizing and stabilizing mobile eolian dunes. Tetrapods are generally considered to have colonized most land habitats and diversified into many new modes of life further away from the water during the Carboniferous. Presumably, by the Early Permian tetrapods were present in desert on a global scale (phase 3). The ichnogenus *Chelichnus* is recorded in all desert ichnoassemblages with tetrapod footprints, and it is essentially the only ichnotaxon present. During the Mesozoic inland deserts experienced a major exploitation of the infaunal ecospace as reflected by the appearance of more varied behavioral patterns of sub-superficial structures (phase 4). Finally, during the Neogene modern desert communities were established (phase 5).

GLACIAL TRACE FOSSIL ASSEMBLAGES: SIMILARITIES AND BIOTIC CHANGES THROUGHOUT THE PHANEROZOIC

Renata G. Netto[1], Luis A. Buatois[2], M. Gabriela Mángano[2] and João Henrique Dobler Lima[1]

1. PPGeo, Universidade do Vale do Rio dos Sinos–UNISINOS, Av. Unisinos 950, 93022-000, São Leopoldo RS, Brazil. nettorg@unisinos.br

2. Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, Saskatchewan, S7N 5E2, Canada.

Recent ichnologic analysis of glacial environments, initially thought to be fossil-poor, has provided significant information about the inhabitants of ancient glacial settings. Glacial environments are subject to drastic oscillations in climate, resulting in immense melt water discharges during deglaciation periods and changes in the land surface of glaciated regions. The impact of these phenomena in the distribution, abundance and, evolution of biota through time is now evaluated. Arthropod trackways, shallow horizontal burrows made by worm-like organisms and fish trails dominate late Paleozoic glacial and periglacial trace fossil assemblages preserved in terrestrial and glaciolacustrine settings, while glaciomarine ichnofaunas from fjords are highly impacted by melt water discharge. As a consequence, freshwater conditions prevail in some fjord settings during deglaciation, allowing for the establishment of suites ascribed to *Mermia*, *Scoyenia* or mixed *Scoyenia-Mermia* ichnofacies. Under brackish-water conditions, suites illustrate the impoverished *Cruziana* ichnofacies. The *Skolithos* ichnofacies is typically suppressed, most likely due to water turbidity. Comparisons can be made between the ichnoassemblages of the Paleozoic Gondwanan strata and those of Cenozoic deposits. The replacement of the merostomate and 'myriapods' trace fossils in Paleozoic assemblages by trace fossils of subaquatic crustaceans in Cenozoic glaciolacustrine deposits reflects a faunal turnover because most merostomate arthropods went extinct by the end of Paleozoic. Despite the changes in tracemakers due to evolution, archetypal ichnofacies and ecological niche occupation remain similar between the Paleozoic and Cenozoic glacial deposits, which are an indication of the conservative nature of benthic faunas in glacially affected settings.

EARLY SAUROPODOMORPH FOOTPRINTS IN THE LATE TRIASSIC OF EAST GREENLAND

Grzegorz Niedźwiedzki[1], Niels Bonde[2], Błażej Błażejowski[3], Mateusz Tałanda[4], Andrzej Wolniewicz[5] and Tomasz Sulej[6]

1. Department of Organismal Biology, Evolutionary Biology Center, Uppsala University, Norbyvägen 18A, 752 36 Uppsala, Sweden.

2. Zoological Museum (SNM), Universitetesparken 15, 2100 Copenhagen Ø and Fur Museum (Museum Salling), 7884 Fur, Denmark. Nielsb.pal@gmail.com

3. Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland.

4. Department of Paleobiology and Evolution, Biological and Chemical Research Centre, University of Warsaw, Żwirki i Wigury 101, 02-089 Warszawa, Poland.

5. Department of Earth Sciences, South Parks Road, Oxford OX1 3AN, UK.

6. Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland.

The hunt for very early sauropodomorphs (including their footprints) in the Late Triassic of East Greenland involved expeditions by several Harvard (1988–2002), Danish (2012), and Polish-Danish (2014) teams. Only briefly, rounded, 'elephantine-like' footprints of a quadrupedal animal have been described by the Harvard team in 1995 and referred to prosauropods (the most common dinosaurs in the bone record of the Fleming Fjord Formation), while many tridactyl theropod footprints have been described in great detail by Gatesy and coworkers in 1999. During the Polish-Danish expedition numerous large (about 30–50 cm long), oval-shaped structures similar to earliest Jurassic sauropodomorph tracks were found in two localities in the lower-middle and sandy dominated part of the Malmros Klint Member at the MacKnight Bjerg (west of the Carlsberg Fjord). The most intriguing are very narrow trackways of oval-shaped prints from two animals of different size walking parallel, possibly representing the earliest evidence of gregarious behaviour in sauropodomorphs. Similar tracks, also organized in a narrow-gauge trackway indicative of a large quadruped animal with strong heteropody (pes larger than manus), have been described from the Late Triassic of Europe, South Africa, and North America (*Eosauropus*). In all newly discovered specimens, the pedal imprints are oval and elongate, possess a long axis and are without distal claw impressions. The Malmros Klint Member specimens are very similar to the Early Jurassic sauropodomorph footprint *Parabrontopodus* because both are large in size and organized in a narrow-gauge trackway. Further study of the large and oval–shaped tracks could provide new information about the morphology of the manus and pes of Late Triassic sauropodomorphs, as well as information about the size and ecological behaviour of these dinosaurs.

THE FREQUENCY OF TERRESTRIAL INVERTEBRATE-BONE INTERACTIONS: A PRILIMINARY CASE SUMMARY

Alexander H. Parkinson[1]

1. Evolutionary Studies Institute & School of Geosciences, University of the Witwatersrand, Private Bag 3, Wits, 2050, South Africa. palaeoparky@gmail.com

This study examines reported cases of terrestrial invertebrate-bone interactions spanning the period Triassic to early Pleistocene. Publications examined include 38 peer-reviewed and 2 unpublished papers, which detail 57 cases of insect-bone interactions. Evidence suggests that insect-bone interactions originated in the Triassic (2 cases) and showed a steady increase throughout both the Jurassic (11 cases) and Cretaceous (13 cases). Immediately after the KT extinction event and for the following 30 million years there is an absence of reported cases. The next reported instance dates to the Oligocene and only a further 3 cases are reported up to the end of the Miocene. In the last 5 million years 27 cases have been reported: 12 cases from the Pliocene, 11 from the Plio-Pleistocene and 4 in the Pleistocene. This presentation aims to initiate debate in relation to this distributional phenomena and prompt more extensive research efforts and collaborations. This branch of taphonomic investigation is still in its infancy and in order to undertake a more thorough and rigorous examination of this distributional phenomena the following is proposed that future neo-ichnological research be directed at resolving the problem of causal agent differentiation and modification type variability, with further efforts directed at formulating a standardised descriptive framework. It is believed that by following these directives, it would facilitate broad-scale comparative studies aimed at testing the impact of the Cretaceous-Tertiary extinction event on carrion feed communities at 65 million years ago.

PROTRACTED DEVELOPMENT OF INFAUNAL SEDIMENT MIXING: IMPLICATIONS FOR SUBSTRATE EVOLUTION AND EXCEPTIONAL TRACE FOSSIL PRESERVATION IN EARLY PALEOZOIC MARINE SHELFAL ENVIRONMENTS

Lidya G. Tarhan[1] and Mary L. Droser[2]

1. Department of Geology and Geophysics, Yale University, 210 Whitney Ave, New Haven, CT 06511, USA. lidya.tarhan@yale.edu.
2. Department of Earth Sciences, University of California-Riverside, 900 University Ave, Riverside, CA 92521, USA.

The radiation of burrowing metazoans in the early Phanerozoic dramatically altered the properties of marine sediments, an event commonly referred to as the "Cambrian substrate revolution" or "agronomic revolution." The advent of infaunalization and biogenically-mediated sediment mixing profoundly impacted the development of Phanerozoic biogeochemical cycling—including nutrient fluxes, organic carbon burial, seafloor oxygenation—and benthic ecology. However, the timing of the development of infaunal mixing has, historically, not been well constrained. Mixing has long been assumed to occur at the Precambrian–Cambrian boundary with the appearance of the index fossil and three-dimensional burrow *Treptichnus pedum*. We present new ichnological, stratigraphic and taphonomic data, from a range of lower to middle Paleozoic siliciclastic successions spanning four paleocontinents, suggesting that shelfal sediments in the early Cambrian were essentially unmixed. Moreover, we demonstrate that even as late as the Middle–Late Silurian, nearly 120 million years after the Precambrian–Cambrian transition, infaunal mixing of shelfal sediments had still not attained modern reworking intensities. These data indicate that in spite of concurrent advances in infaunalization, mixed layer development was a protracted process, challenging assumptions that mixing occurred with the first appearance of three-dimensional burrows and holding important implications for the advent of Phanerozoic-style paleobiological and paleoecological complexity and modern-style biogeochemical cycling.

NEW AVIAN TRACKS FROM THE NEOGENE OF NORTHWEST ARGENTINA

David E. Tineo[1,6], Leandro M. Pérez[2,6], Paula Bona[3,6], Marcos A. Comerio[4,6] and Jorge I. Noriega[5,6]

1. Centro de Investigaciones Geológicas, Universidad Nacional de La Plata. Calle 1 (644), B1900FWA, La Plata, Argentina.
2. División Paleozoología Invertebrados, Museo de La Plata. Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.
3. División Paleontología Vertebrados, Museo de La Plata. Paseo del Bosque s/n, B1900FWA, La Plata, Argentina. paulabona26@gmail.com
4. Instituto de Estudios Andinos "Don Pablo Groeber", Universidad Nacional de Buenos Aires. Ciudad Universitaria, Pabellon II, C1428ZAA, Buenos Aires, Argentina.
5. CICYTTP, Materi y España s/n, E3105BWA, Diamante, Argentina.
6. CONICET, Argentina.

The Argentinean trace fossil record of vertebrate footprints is abundant and profusely studied; however, the one referred to Aves is particularly scarce and less known. Although there are some studies on avian fossil footprints, there are few descriptions and taxonomical assignations. Here we describe a new ichnotaxon that is ascribed to bird activity. Footprints were found at the Río Iruya section (62 Km NW from San Ramón de la Nueva Orán city, Sierras Subandinas Australes), from lower levels of the Guandacay Formation (≈ Río Guanaco Formation; Mio-Pliocene). They are preserved as convex hyporeliefs in brownish-grey pebble to boulder conglomerates overlying reddish - reddish brown mudstones and very fine-grained sandstones. The new ichnotaxon is defined based on a trackway consisting of three well-preserved tridactyle footprints. This track presents a stride of 96 cm long, a track width of 13.6 cm, a step angle of 178° and a femoro-acetabular height of 65.2 cm, approximately. Footmarks present a mean length of 16.3 cm, a mean width of 10.9 cm and the following combination of characters: rhomboidal overall outline with a width/length ratio of 0.67 and the minor axis posteriorly displaced; thick digits (D) broader in their middle sector; DIII longer than DII and DIV, respectively; continuity between DIII and the rounded meta-basipodial distal end; DII - DIV internal angle of 62°; DII and DIII with a tapered outline and a well-defined knuckle and mark of claws at the ungueal phalanges; ungueal impression of DIII externally curved and DIV with an oval outline noticeably separated from the meta-basipodial distal end. The presence of a single knuckle by digit, the orientation of the DIII ungueal impression and the absence of a DI (hallux) suggest that these footprints could have been generated by a Rheidae, differing from those referable to other similar sized birds (e.g. Phorusrhacidae). The presence of probable rheid footprints was mentioned for the stratigraphic units outcropping at Quebrada del Yeso (Mio-Pliocene) in La Rioja Province and at the paleo-ichnological site of Pehuen-Co (late Pleistocene) in Buenos Aires Province.

UPPER JURASSIC DEPOSITS AND ICHNOFOSSILS OF TRANSBAIKALIA (RUSSIA)

Elena S. Vilmova[1]

1. North-Eastern State University, 13 Portovaya Street, Magadan, 685000, Russia.
Udokania@mail.ru

Upper Mesozoic continental deposits form intermountain troughs of Transbaikalia are characterized by complex facies patterns highly controlled by the climatic and tectonic framework. The section of the Upper Jurassic Undino-Dainskaya series, in particular, the Ukureiskaya suite (Duraleiskaya trough, South-Eastern Transbaikalia) is one of the most interesting and complete sections. The section of the Ukureiskaya suite (about 1000 m) consists of three subsuites: lower, middle and upper. The lower subsuite (530 m) consists of a cyclic alternation of medium- to- coarse-grained yellowish tuffs and tuffaceous siltstones and mudstones. The finer-grained deposits of the upper part of the section contain remains of Notostraca - tadpole shrimps (*Prolepidurus sewija*), Ephemeroptera - insect mayfly (*Proameletus caudatus*) and Crustaceans - Lynceidae (*Palaeolynceus stschukini*). Numerous sinusoidal trails (*Cochlichnus anguineus*) occur as epirelief in tuffaceous siltstones where they are locally associated with *Proameletus caudatus*. Some specimens grade into trails assigned to *Helminthopsis* and *Helminthoidichnites*. *Treptichnus*-like and *Entradichnus*-like burrows are rare. The middle subsuite (150-170 m) consists of cyclic alternations of terrigenous sediments, including yellowish tuffs with thin conglomeratic lenses, plant detritus and large woody remains in the lower interval and thin-bedded tuffs with the remains of mayflies and different trace fossils, such as *Myrowichnus*, *Planolites*, *Arenicolites* and *Treptichnus*? in the upper part. The upper subsuite (about 200 m) comprises siltstones, mudstones and sandstones. The iron-stained infilled *Myrowichnus*, rare *Entradichnus* and isolated needles and seeds of coniferous occur in siltstones of the lower part of the section. The association of invertebrate body and trace fossils is recurrent in different sections (e.g. Olov and Kulinda troughs) of the Ukureiskaya suite. However, the ichnofossils are still poorly studied and their significance in paleoenvironmental reconstruction underexplored. Integration of sedimentologic and ichnologic evidence indicates sedimentation in continental settings, encompassing terrestrial and shallow lake environments affected by tectonic and volcanic activity.

SYMPOSIUM

RESEARCH AND MANAGEMENT OF PALAEONTOLOGICAL UNESCO WORLD HERITAGE SITES

ORGANIZERS:

MELISSA GREY - DEBORAH SKILLITER

CELEBRATING FIVE YEARS OF RESEARCH AT THE JOGGINS FOSSIL CLIFFS UNESCO WORLD HERITAGE SITE, NOVA SCOTIA, CANADA

Melissa Grey[1] and Deborah Skilliter[2]

1. Joggins Fossil Institute, 100 Main St. Joggins, NS B0l 1A0 Canada. curator@jogginsfossilcliffs.net
2. Nova Scotia Museum, Department of Communities, Culture and Heritage, Halifax, NS, B3H 3A6 Canada.

The Joggins Fossil Cliffs, a Carboniferous coastal section within the Bay of Fundy, has recently celebrated its fifth anniversary as a UNESCO World Heritage Site. The Cliffs represent the finest example in the world of the terrestrial tropical environment and ecosystems of the Pennsylvanian (Late Carboniferous). The Site is co-managed with the province of Nova Scotia: all fossils in Nova Scotia legally belong to the province and collecting is only allowed with a Heritage Research Permit. The Joggins Fossil Institute (JFI) works in partnership with the Nova Scotia Museum (NSM) to manage the most comprehensive collection of Carboniferous fossils that is housed at the award-winning interpretive and research centre in Joggins. JFI houses a collection of Joggins fossils that is on loan from the province. JFI and NSM share curatorial responsibilities for the collection and training of new staff on curatorial practices and care and handling of the collection. The province has provided a specialized, site-specific database that allows JFI staff to catalogue new material as it is collected and share these records with a central server. The Joggins Fossil Cliffs has a long history of scientific research with more than 100 site-specific publications in over 150 years. Recent research has become broader, reaching far beyond the broad categories of paleontology, geology, and historical study. Inscription on the World Heritage List and its close proximity to the Fundy Biosphere Reserve has also made the Site of interest to economists, biologists, and geographers. Highlighted here are very recent studies (recently published or in progress) that span the broad range of research at the Site: from trace fossil taxonomy to bird migration to regional economic impacts of a World Heritage Site. Much of this work has been undertaken by Maritime institutions that include universities and provincial and federal governmental departments. While research from the past 150 years has made large strides in our understanding of the Late Carboniferous, many questions remain to be resolved and interest in the site is clearly expanding into new fields.

THE BURGESS SHALE AS PART OF THE UNESCO CANADIAN ROCKY MOUNTAIN PARKS WORLD HERITAGE SITE

Todd L. Keith[1], Jean-Bernard Caron[2-4] and Jim Mamalis[5]

1. Parks Canada, Lake Louise, Yoho & Kootenay Field Unit, P.O. Box 99, Field, British Columbia, V0A 1G0, Canada.
2. Department of Natural History-Palaeobiology, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, M5S 2C6, Canada. jcaron@rom.on.ca
3. University of Toronto, Department of Ecology and Evolutionary Biology, 25 Willcocks Street, Toronto, Ontario, M5S 3B2, Canada.
4. University of Toronto, Department of Earth Sciences, 25 Russell Street, Toronto, Ontario, M5S 3B1, Canada.
5. Parks Canada, Lake Louise, Yoho & Kootenay Field Unit, P.O. Box 213, Lake Louise, Alberta T0L 1E0, Canada.

Located within Yoho National Park in British Columbia, Canada, the original Burgess Shale site yields the most remarkable assemblage of "middle" (Series 3, Stage 5) Cambrian soft-bodied fossils known to this day. Discovered by Charles Walcott 105 years ago, this site provides an exceptional window into the early evolution of marine animals in the time following the Cambrian Explosion. The Burgess Shale was inscribed on the UNESCO World Heritage List in 1980, and was subsequently incorporated into the Canadian Rocky Mountain Parks World Heritage Site in 1984. Burgess Shale-type fossils are now known from more than a dozen localities within Yoho and Kootenay national parks. The first recorded discoveries of fossils now recognized as Burgess Shale-type were made in the nineteenth century from the "Trilobite Beds" on Mount Stephen, a few kilometres south of today's Walcott Quarry. Field activities have been most extensive around these original localities with new fossil horizons discovered below and above the Walcott Quarry and around Mount Stephen, especially in the last three decades of the twentieth century. The expeditions conducted since 2008 by the Royal Ontario Museum have concentrated on less-known stratigraphic equivalents, culminating in the discovery of an extraordinary new fossil site near Marble Canyon in 2012. This site possesses a fossil assemblage most comparable to that of the Walcott Quarry, but includes many new species, suggesting that the known diversity of the Burgess Shale community will continue to increase with more fieldwork. Parks Canada is responsible for protecting this component of the World Heritage Site while also providing access for scientific research and public education. Management strategies include land use zoning, restricted access, surveillance and monitoring, guided educational opportunities, and scientific research review. Law enforcement with respect to these sites is given a high priority by Parks Canada. Efforts include remote monitoring with state-of-the-art equipment and techniques, as well as intensive investigations of fossil thefts and trafficking. Future research provides the potential for the discovery of new organisms and new fossil sites that will continue to expand our understanding of this unique period in earth's history. The identification of new fossil sites provides opportunities for exciting new learning experiences, but it also increases the challenge of protecting a growing list of remote sites that are an irreplaceable part of our unique global heritage.

PALEOPARKS—THE PRESERVATION AND CONSERVATION OF FOSSIL SITES WORLD-WIDE: A WORKSHOP

Jere H. Lipps[1]

1. John D. Cooper Archaeological and Paleontological Center, Santa Ana, California 92701 USA and Museum of Paleontology, University of California, Berkeley, California 94720 USA. jlipps@berkeley.edu

Although many outstanding fossil locations have been protected by World Heritage Sites, national parks, monuments and reserves, state and provincial parks, GeoParks, local governments or non-profit organizations, as well as some private individuals, thousands of worthwhile and important fossil sites around the world remain unidentified and unprotected. Many of these are endangered by development, construction, collecting by professionals, amateurs and commercial collectors, and vandalism, yet all sites are places of primary data for researchers, educational opportunities for schools and the public, and recreational areas. Small local sites to national or international areas that protect paleontological treasures are essential, if we are to preserve and understand the history of life on Earth and to provide materials for scientific research now and in the future. The protection of fossil-bearing strata has a long history extending back hundreds of years, but much remains to be done and no worldwide effort to bring them all together has been attempted. The International Palaeontological Association (IPA) thus established a PaleoParks Initiative (http://ipa.geo.ku.edu/index3.html) to protect endangered sites, and to catalog and make public established parks of any nature that protect fossils in the ground, as well as key places protecting “living fossils”. IPA has 15 aims and goals and a web site for documenting both established and proposed sites at http://ipa.geo.ku.edu:591/PaleoParks/. The goals include the encouragement of local professional and amateur paleontologists to protect their important sites, to include them in the IPA database, to provide support for the protection and designation of sites, and to assist in the development of research, educational and recreational uses of the sites. The designation of PaleoParks needs the participation of experts who know and understand the importance of particular fossil sites. South America has many excellent fossil sites, both protected and unprotected, and this workshop will identify many of these. Previous IPA-sponsored meetings and workshops discussed these problems, successful solutions, and PaleoParks goals and aims. A published ebook documented ten examples of PaleoParks (http://paleopolis.rediris.es/cg/CG2009_BOOK_03/), and another volume is in progress.

TALAMPAYANATIONAL PARK: TRIASSIC LIFE REFUGE

Adriana C. Mancuso[1] and Andrea B. Arcucci[2]

1. IANIGLA, CCT-CONICET, Mendoza, Adrián Ruiz Leal s/n, Parque Gral. San Martín, 5500 Mendoza, Argentina. amancu@mendoza-conicet.gov.ar
2. Área de Zoología, Universidad Nacional de San Luis, Chacabuco 917, 5700 San Luis, Argentina.

Triassic life has been widely documented in the rocks of the Ischigualasto Villa-Union Basin. During the 1940's, the first palaeontologic discoveries were performed by Frenguelli, Groeber and de la Mota who conducted geological studies in the area. The first paleontological studies in this Basin were about non-mammalian therapsids, published by Cabrera. Subsequently, between the end of the 1950's and 1980 several groups of paleontologists led by Osvaldo Reig, Rosendo Pascual, Alfred Romer and Jose Bonaparte from different Argentinean and American institutions (Universidad Nacional de Tucumán, Museo de la Plata and Harvard University) performed field work and established background knowledge about the Triassic biota and its context from the main sites within this basin. These extraordinary discoveries captured public attention and triggered government actions about the necessity to include palaeontological heritage in a legal setting. This process began with the creation of protected areas, first in the form of provincial parks (Talampaya provincial park and Ischigualasto provincial park). First, the Talampaya site was proposed as part of the National park system, and later, together with Ischigualasto as a UNESCO World Heritage site because they include the most complete record of Triassic biota in Gondwana. The stratigraphy of the basin includes rocks of the Early Triassic with a scarce palaeontological record but that document the oldest post-Permian events in the region, including two completely different groups of tetrapods, basal archosaurs and different groups of therapsids. The Middle Triassic tetrapod biota of the Chañares Formation is very well documented and comprises: (1) a low species richness, high abundance of therapsids; and (2) a taxonomically diverse but low abundance of archosauriforms. The Middle Triassic invertebrate and plant records from Los Rastros Formation include excellent examples of *Dicroidium* Flora and Ipswich Microflora. Finally, the biota of the Late Triassic was documented in the Ischigualasto and Los Colorados Formations with the report of the oldest carnivorous and herbivorous dinosaurs like *Herresaurus*, *Eoraptor* and *Pisanosaurus*, among others, with the top of the sequence including *Zupaysaurus*, *Riojasaurus*, *Coloradia* and the oldest and most complete turtle *Palaeochersis talampayensis*. The increasing number of researchers and tourists that visit the area every year shows that even though some conservation issues persisted, the actions taken to protect this amazing site from different organizations were positive for both the science and social development of the region.

RECOGNISING SITES OF INTERNATIONAL PALAEONTOLOGICAL INTEREST: GLOBAL GEOPARKS AND WORLD HERITAGE

Patrick J. McKeever[1]

1. Division of Ecological and Earth Sciences, UNESCO, 1 rue Miollos, 75732 Paris cedex 15, France.
pj.mckeever@unesco.org

Presently, there are two mechanisms by which sites of internationally important palaeontological heritage can gain formal international recognition. Since 1972, the World Heritage Convention allows UNESCO to grant World Heritage status to those sites which are deemed as being of such outstanding universal value as to form part of the common heritage of humanity. As of June 2014, there are 981 World Heritage Sites in 160 countries. Of these 981 sites however, only 14 are inscribed partially because of their palaeontological interest while a mere 9 are inscribed solely because of their palaeontological interest. Since 2004, UNESCO has endorsed areas of international geological heritage significance with a sustainable economic development plan through the Global Geoparks label. As of June 2014, there are 100 Global Geoparks in 30 countries many of which include sites of palaeontological interest. Using examples, this presentation will discuss the challenges of getting sites of palaeontological interest onto the World Heritage list and will outline steps being taken by UNESCO and its advisory bodies to ensure a more representative record of the evolution of life on Earth on the World Heritage list. Similarly, using examples from both Global Geoparks and World Heritage Sites, this presentation will give examples of how site managers of both labels are bringing the wonders of the fossilized record of life to the general public. It will also demonstrate how these sites are not only engaged in educating local communities about their palaeontological heritage but assisting them in understanding their importance and the need for their conservation.

KONĚPRUSY REEF COMPLEX IN THE DEVONIAN OF THE CZECH REPUBLIC: ITS NATURAL HISTORY, SIGNIFICANCE AND FUTURE

Michal Mergl[1], Stanislava Vodrážková[2] and Lenka Ferrová[2]

1. Centre of Biology, Geosciences and Environmental Sciences, Faculty of Education, University of West Bohemia in Plzeň, Klatovská 51, Plzeň, 30619, Czech Republic. mmergl@cbg.zcu.cz

2. Czech Geological Survey, Klárov 3/131, Prague, 18821, Czech Republic.

The Koněprusy reef complex is a unique phenomenon in the Devonian of the Prague Basin, some 25 km SW of Prague, the capital of the Czech Republic. It occupies a small 4 x 2 km sized area, truncated in NE by an overthrust and passing laterally into deeper-water limestone units. The accumulation of coarse bioclastic material began at the top of a submarine tectonically-based elevation in the Lochkovian. In the Pragian, a reef with unusually high biotic diversity existed. About 500 species of brachiopods, crinoids, corals, bryozoans, trilobites, bivalves, gastropods and other invertebrate groups have been described from the massive white Koněprusy Limestone since the 19th Century. It is the locality of hundreds of Barrande's types, and the type locality of numerous widespread Devonian genera. The top of reef was eroded in late Pragian and lower Emsian. In late Emsian, the new unit called the Suchomasty Limestone was deposited on the truncated and weakly karstified top of eroded Koněprusy Limestone. The Suchomasty Limestone consists of red-, pink- or grey-coloured bedded sediments, having diverse, generally small-sized, mostly crinoid, brachiopod, gastropod and trilobite fauna; corals and bryozoans are very rare. In the Eifelian, the light-grey Acanthopyge Limestone was deposited in the area above the Suchomasty Limestone. The fauna of the Acanthopyge Limestone is characterised by smooth small-sized spire-bearing brachiopods, fragile coral and trilobite fauna. The dark limestone beds form the top of the Acanthopyge Limestone. These beds correlate with the Chotec event. The last limestone bank above the "dark" sequence bank is thought to be Givetian in age. The overlaying siltstone, which contains plant remains, terminates a stratigraphic sequence in the area. The reef is also famous for the neptunian dykes filled by Suchomasty and Acanthopyge limestones. Conodont and dacryoconarid stratigraphy has been well-studied and is focused to the Emsian-Eifelian-Givetian succession. At present, the reef limestone is strongly karstified, with the Koněprusy caves open to the public. The area is the target of many geological field excursions. It is the pivot-point of palaeontological research of the Czech Devonian. Despite the significance of the reef, a huge open-cast mine destroys part of the reef every year. The danger of total destruction of this reef, which has only marginally protected localities, is a lamentable reality.

MANAGEMENT OF THE MESSEL PIT FOSSIL SITE (EOCENE, GERMANY), AND THE UNKNOWN DIVERSITY STILL BURIED IN THE ROCK

Krister T. Smith[1], Sonja Wedmann[1] and Stephan Schaal[1]

1. Dept. of Palaeoanthropology and Messel Research, Senckenberg Research Institute, Senckenberganlage 25, 60325 Frankfurt am Main, Germany. krister.smith@senckenberg.de

The Messel Pit, Germany's first UNESCO World Natural Heritage Site, provides an exceptional view of a middle Eocene terrestrial ecosystem. The water column of this ancient maar crater lake was stratified, and the lower water column anoxic, which not only led to the preservation of organic remains (like fossil fuel precursors, epidermal scales) but also hindered scavenging, resulting in fossils of astonishing completeness. Large numbers of plants, insects, and vertebrates continue to be recovered. The scientific importance of Messel also lies in the fact that it records the time immediately after the Early Eocene Climate Optimum, when global temperatures reached their sustained, Cenozoic acme. Understanding community organization and ecosystem processes at Messel may shed light on ongoing changes in the present day. Excavations have been conducted by Senckenberg and other institutions each year since 1975. The state of Hesse, which owns the Messel open cast mine, contracts with Senckenberg concerning fossil excavations and management. Federal mining law applies, and many regulations must be followed. Senckenberg is responsible for the general operation, maintenance and protection of the Messel Pit. This includes water drainage, because water must continuously be pumped out of the pit to stabilize its slopes and to secure access to the fossiliferous sediments. To ensure security of visitors and personnel, the stability of the slopes is monitored regularly. A perimeter fence around the pit provides protection against trespassers and illegal excavation and needs regular inspection and maintenance, as do the roads and trails. One of the salient questions facing managers of an important fossil site such as Messel is: when does the expenditure of material and personnel no longer justify the cost? One measure of scientific return for paleontological excavations could be new species. Ecological theory provides a way to estimate the number of unknown species likely to be present in an assemblage. We use this theory to extrapolate the diversity of different groups preserved at Messel. The diversity of fossil squamates (lizards and snakes) and insects has not yet plateaued, and continued excavation is likely to reveal many new species. If the return on investment is taken to be species new to science, then investment at Messel should remain "profitable" for some time. Naturally, the recovery of previously known species also has scientific value, as does the study of long temporal sequences, and this value must also be taken into consideration in long-term site management.

SYMPOSIUM

EVOLUTION OF PHOTOSYNTHESIZING ORGANISMS- FROM MICROBIOTA TO PLANTS

ORGANIZERS:

MALGORZATA MOCZYDLOWSKA-VIDAL - VIVI VAJDA

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MORPHOLOGY OF THE MESOPROTEROZOIC EUKARYOTIC MICROFOSSILS AS A REFLECTION OF THEIR INTRACELLULAR COMPLEXITY

Heda Agić[1], Małgorzata Moczydłowska[1] and Leiming Yin[2]

1. Department of Earth Sciences, Uppsala University, Villavägen 16, 752 36 Uppsala, Sweden. heda.agic@geo.uu.se
2. Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 39 East Beijing Road, Nanjing 210008, China.

Mesoproterozoic is a time of increasing diversity of microscopic life and appearance of intricate new cell morphologies. First eukaryotes may have evolved around 2.4 Ga, but the first microbiota with intricate sculpture and ornamentation are found in the younger, 1.8.-1.6 Ga successions worldwide. Such microfossils were uncovered from the Ruyang Formation in Shanxi, China and Roper Group, Northern Territories, Australia, dating back to 1.6-1.0 Ga ago. Some of these unicellular organic-walled fossils share characters with Ediacaran and Phanerozoic fossils, as well as extant green microalgae. Key characters among some Precambrian acritarchs are acetolysis-resistant vesicle with multi-layered walls; vesicle ornamentation by diverse processes that are produced during cyst formation; and excystment openings for the release of gametes or daughter-cells. Combination of these morphological elements, also present in extant phytoplankton, reflects the fossils' protective function as reproductive cysts, indicating that complex life cycles and reproduction were well under way in Mesoproterozoic. Several case studies of microfossil morphology likely induced by intrinsic eukaryotic mechanisms are presented. Distinctive vesicle wall composed of the primary layer reinforced by polygonal platelets in Mesoproterozoic taxa *Dictyosphaera* and *Shuiyouisphaeridium*, as well as the sophisticated vesicle-wall patterning on the fossil sphaeromorphs *Valeria* and younger *Cerebrosphaera* would have required a certain degree of complexity for their formation, as observed in the present day analogues among eukaryotic protists. This suggests the activity of the key eukaryotic organelles and cellular mechanisms and signalling for the cyst formation. Considering that Golgi apparatus and the endoplasmatic reticulum are the organelles regulating eukaryotic secretory pathway and synthesis of biopolymers used in cell-wall construction, they would have been required for the complex morphology observed in these Precambrian taxa. Therefore, the presence of GA and ER in the eukaryotic cell is inferred at the minimum age of 1.6-1.4 Ga. Similarly, morphology of acritarchs of the Cambrian galeate plexus, namely openings with opercula, is likely induced by the activity of the LFA organelle (lid-forming apparatus) as in the extant dasycladalean alga *Acetabularia*. Additionally, several new morphotypes from the Ruyang Formation are presented. These unicellular fossils bear a velutinous outer membrane surrounding an internal sphere, which suggests a protective function of a reproductive or a resting cyst. Cyst-like morphology varies in disparity, but its key features are consistent through Mesoproterozoic, Neoproterozoic and early Palaeozoic.

DINOFLAGELLATE EVOLUTION FROM THE FOSSIL PERSPECTIVE: A STORY WITH HOLES IN IT

Robert A. Fensome[1], James B. Riding[2] and Graham L. Williams[1]

1. Natural Resources Canada, Geological Survey of Canada (Atlantic) Bedford Institute of Oceanography P.O. Box 1006 Dartmouth, Nova Scotia B2Y 4A2, Canada. Rob.Fensome@NRCan-RNCan.gc.ca

2. James B. Riding, British Geological Survey, Keyworth, Nottingham NG12 5GG, UK.

Dinoflagellates first appear in the fossil record in the Middle to Late Triassic, although molecular phylogenetic and biogeochemical evidence suggest that they originated in the early Paleozoic or even the Proterozoic. Regardless of other evidence, the early Mesozoic record of dinoflagellate cysts strongly indicates a real radiation, during which critical aspects of modern dinoflagellate morphology, such as furrows and distinctive tabulation types, became established. Modern gonyaulacoid and peridinioid tabulations, which are characterized by five or six series of plates, became stabilised during the Middle to Late Jurassic, as was recognized by paleontologists during the latter half of the twentieth century. Molecular phylogenetic studies have upheld the gonyaulacoids as a unified branching clade, but distinguish several distantly related clades among modern peridinioids. The latter is surprising given the striking stability in the tabulation of fossil peridinioids and the disparity in patterns requires an explanation. Perhaps the fact that the last non-calcareous fossil peridiniacean genus, *Palaeocystodinium*, became extinct in the Neogene provides a clue. After the major early Mesozoic radiation reflected in the fossil record, individual lineages went through phases of stability and phases of experimentation in aspects of their morphology, perhaps most notably in archeopyle development. Examples of archeopyle experimentation episodes occurred among gonyaulacaceans in the Middle Jurassic, palaeoperidinioids during the middle Cretaceous, and wetzelielloids during the Early Eocene. Recognition of these episodes and their tempo can be very helpful biostratigraphically. But for the full story of dinoflagellate evolution, we need collaboration between biologists and paleontologists and the integration of molecular, anatomical and fossil evidence.

TIMING OF THE ORIGIN OF PLASTID AND EVOLUTIONARY HISTORY OF CHLOROPHYTA BY MICROFOSSIL RECORD

Małgorzata Moczydłowska[1] and Heda Agić[1]

1. Department of Earth Sciences, Uppsala University, Villavägen 16, 752 36 Uppsala, Sweden.
malgo.vidal@geo.uu.se

The origin of plastid in eukaryotes and the minimum age of this event based on microfossil record are indirectly inferred by recognizing green algae among organically preserved, unicellular microfossils other than cyanobacteria. Single primary symbiosis of cyanobacterium established algae and led to divergence of Archaeplastida, including Chlorophyta. The reproductive cysts of extant microalgae share characters derived from their early green algal ancestors. The genetic inheritance and eventually its phenotypic expression are universally shared. Similarly, the enzymes binding specific compounds in photosynthesis evolved from cyanobacteria and are present in all photosynthesising organisms since the Archean. Molecular clock analyses suggest that primary plastid was established by c. 1.5 Ga, whereas by fossil record c. 1.8 Ga (*Leiosphaeridia*) or 2.1 Ga (*Grypania*). The fossil record of stem group eukaryotes without assignment to living groups is at 2.1 Ga by carbonaceous compressions (*Grypania*), however, the recognition as an alga is not excluded, and it would provide the minimum age of the origin of plastid. Spheroidal microfossils (*Leiosphaeridia*) with multilayered cell-wall and trilaminar sheath structure that is the algal character of Chlorophyceae are documented throughout the Proterozoic into Cambrian. Because of the presence of this character and interpreted as algal cysts, some leiosphaerids show record of chlorophyceans persistently since 1.8 Ga. Microfossils with phycoma-like morphology suggesting prasinophycean affinity are known at minimum age of 1.4–1.2 Ga (*Pterospermopsimorpha, Pterospermella, Simia, Tasmanites*). Microfossils of the Proterozoic to Cambrian ages assessed by body plan, ornamentation, excystment structure, cell wall resistance and ultrastructure, and internal bodies defined by their own walls, are recognized as algal zygotic cysts and phycomata by comparison with extant green algae. Internal bodies are a part of reproductive cysts, resembling those known in Chlorophyta. They are inferred to be endocysts containing zygote, if single, or offspring cells, if multiple, in sexual and asexual generations of ancient taxa of the classes Chlorophyceae and Prasinophyceae. Based on the earliest occurrence of microfossils with morphologic characteristic of a zygotic cyst, multilayered cell-wall structure indicative of the primary and secondary wall, and with an internal body in the *Dictyosphaera-Shuiyousphaeridium* plexus, the sexual reproduction is evident at c. 1.4-1.2 Ga. It became common in the Neoproterozoic (*Cymatiosphaeroides, Trachyhystrichosphaera, Vandalosphaeridium*, *Tanarium, Asterocapsoides, Ancorosphaeridium*, *Densisphaera*), and the Cambrian (*Skiagia, Polygonium*). The divergence of Chlorophyta from the lineage of Chloroplastida occurred at the minimum age of 1.8 Ga, and the origin of primary plastid prior to this time.

THE EVOLUTION OF EARLY PALAEOZOIC MARINE PHYTOPLANKTON AT THE ACTIVE CONTINENTAL MARGIN OF WESTERN GONDWANA (ARGENTINA)

Claudia V. Rubinstein[1] and Victoria J. García Muro[1]

1. IANIGLA, CCT CONICET Mendoza, A. Ruiz Leal s/n, Parque General San Martín, Mendoza, M5502IRA. Argentina. crubinstein@mendoza-conicet.gob.ar

The southern South American margin of Western Gondwana was active from the Neoproterozoic to the Mesozoic, until the break-up of the palaeocontinent. In this context, during the early Palaeozoic, this margin was strongly affected by successive episodes of subduction and accretion of terranes. Consequently, the basins related to this margin had a complex geodynamic history that should have influenced diversity trends of marine organic-walled phytoplankton. The oldest marine phytoplankton assemblage, low in abundance and diversity and poorly preserved, comes from the Late Cambrian of the Cordillera Oriental, Central Andean Basin. The Early Ordovician displays a gradual increase of diversity during the Tremadocian, with the remarkable presence of the Gondwanan characteristic *messaoudensis-trifidum* acritarch assemblage in the Late Tremadocian. The highest Ordovician diversity corresponds to the Floian platform facies of the Central Andean Basin. The Middle Ordovician shows a progressive decline of diversity. However, it must be taken into account that the Dapingian and Darriwillian marine phytoplankton comes mainly from estuarine-deltaic facies of the outermost part of the proto-Andean foreland basin. The diversity dramatically diminishes during the Sandbian and Katian in coincidence with a thickening- and coarsening-upward succession related to the progradation of a deltaic system. The Hirnantian glacial-related deposits record a new peak in diversity throughout all the foreland basin systems of the Central Andean Basin. The peri-Gondwana volcanic arc deposits of the Famatina System yielded rich and diverse Lower to Middle Ordovician phytoplankton assemblages, even if they show noteworthy differences with coeval assemblages of the Central Andean Basin. The Ordovician of the Precordillera terrane, marked by its accretion to the Gondwana margin, yielded sparse and poorly diversified Middle to Late Ordovician phytoplankton assemblages. During the Silurian, the marine phytoplankton flourishes with an increase of diversity starting from the Llandovery in both the Precordillera and the Central Andean foreland basins. A new biostratigraphic scheme recently proposed for the Silurian deposits of the Precordillera allows the recognition of the Wenlock, highly questioned in this basin. The diversity of the marine phytoplankton during the Wenlock remains quite similar. The highest marine phytoplankton diversity of the whole Silurianis documented in the Ludlow of the Precordillera, particularly in shaly-predominant sediments that correspond to a low-energy open shelf environment. Towards the top of the Silurian succession, the transition to a storm-affected inner shelf and a shoreface is accompanied by a decrease of the diversity in the Pridolian as well as in the Lower Devonian.

NEW ORGANIC-WALLED MICROFOSSILS FROM PARANOÁ GROUP, MESOPROTEROZOIC, BRAZIL: ASSESSING AGE AND EVOLUTION OF EUKARYOTES

Evelyn A. M. Sanchez[1], Kathleen Grey[2], Małgorzata Moczydłowska[2], Dermeval A. do Carmo[1], Silane Caminha[3] and Carlos J. Alvarenga[1]

1. Instituto de Geociências, Universidade de Brasília, Campus Darcy Ribeiro, Brasília, DF, 70910-900, Brazil. eamsanchez@gmail.com

2. Department of Earth Sciences, Uppsala University, Villavägen 16, 752 36 Uppsala, Sweden.

3. Instituto de Ciências Exatas e da Terra-ICET, Universidade Federal de Mato Grosso, Av. Fernando Corrêa da Costa, Cuiabá, MT, 78060-900, Brazil.

A new microfossil assemblage, typical of the Mesoproterozoic age, was recovered from a shale bed in the Paranoá Group, São Domingos Hills, State of Minas Gerais, Brazil. Although only one sample was collected to test the palynological potential of the succession, it produced a new record of a diverse and well-preserved assemblage. The assemblage comprises abundant *Leiosphaeridia* spp., coenobium of cocoidal forms, *Turuchanica ternata*, fragments of microbial mats, *Schizofusa* sp. 1, *Tappania plana*, and *Dictyosphaera* sp. 1. Recovery of this assemblage sheds light on two different aspects: firstly, the well preserved microfossils record characteristics likely to improve understanding of evolutionary modifications and acquisition of eukaryote architecture, such as cytoskeletons and membranous organelles, and the subsequent divergence of eukaryotic clades during the Late Mesoproterozoic, which may include taxa like *Schizofusa, Dictyosphaera* and *Tappania*. Secondly, it helps to refine the age attributed to the Paranoá Group. This lithostratigraphic unit contains the stromatolites *Conophyton cylindricum* and *Jacutophyton* morphotype 1, forms abundant in Mesoproterozoic through Early Neoproterozoic successions worldwide, although the group *Jacutophyton* has a recorded range of between 542 and 2400 Ma and *C. cylindricum* has a range of between 542 and 1730 Ma, so these morphotypes provide only an approximate chronostratigraphic range for the Paranoá Group. A recent detrital zircon age suggested deposition between 1200 and 800 Ma. The presence of *Dictyosphaera* supports a Mesoproterozoic age for the Paranoá Group, and it is hoped that further biostratigraphic studies will refine the age, shedding new light on the knowledge of Brazilian Proterozoic successions, a time interval that is still poorly known in this country.

REEFS: PHOTOSYNTHETICALLY DRIVEN ECOSYSTEMS THROUGH TIME

George D. Stanley Jr.[1] and Jere H. Lipps[2]

1. Department of Geological Sciences and Paleontological Center, University of Montana, Missoula, Montana 59812 USA. george.stanley@umontana.edu

2. John D. Cooper Archaeological and Paleontological Center, Santa Ana, California 92701 USA; and Museum of Paleontology, University of California, Berkeley, California 94720 USA.

Photosymbiosis is an important evolutionary strategy among ancient and modern reef organisms. In nearly all calcifying reef metazoans, the calcification advantage and metabolic enhancement permit both the growth of reefs and their success in nutrient-poor, tropical environments. Here we assess the presence of photosymbiosis in reef fossils and then analyze its Phanerozoic history. This revised view of reef evolution challenges two traditional assumptions: 1) reefs were fragile, and 2) calcified metazoans were masters of reefs. Photosymbiosis through time likely explains the development and collapse of ancient reefs. Reefs were not fragile but were actually quite resilient as demonstrated by persistence during tectonic upheavals, warming/cooling cycles and major sea-level changes characterizing much of the Phanerozoic. This resilience reflects the adaptability and robustness of the metazoans, protistians, bacteria, and, in particular, of their algal symbionts. Living protistians, corals and bivalves possess seven or more clades of the dinoflagellate *Symbiodinium*; each adapted to different of light, temperature and other regimes. Bleaching on reefs, commonly regarded as the harbinger of death and failure, may actually be a driving adaptive force in symbionts. Phanerozoic reefs show long-lived megacycles and at least six major episodes of collapse, usually coinciding with mass extinctions. Following these, recovery intervals lead to new reef cycles. The causes include global warming or cooling, sunlight reduction, sea-level changes, ocean acidification, and eutrophication, any one or all of which would adversely affect the host-symbiont relationships. Post-extinction reef gaps may be geologically short or last up to 20 million years. After reef collapse, photosymbionts re-evolved independently, across a wide spectrum of unrelated reef-building organisms (corals, calcified sponges, bivalves, etc). Assessing the former presence of symbionts in ancient reef fossils is difficult because the alga do not preserve, so we use indirect criteria grounded in comparisons with modern counterparts. Examples are drawn from the Late Devonian calcareous sponge/coral associations, a wide variety of shelly organisms after the end-Permian event, end-Triassic coral/sponge reefs, and Late Jurassic and Cretaceous coral, sponge and bivalve associations. With the emergence of ecologically modern coral reefs, many examples of this theme appear. Photosynthetically driven reefs thus are complex, integrated ecosystems, evolved for resistance to shallow-water disturbances and variations. The one-celled symbionts, not the metazoans, are likely the real masters of the reef today and in the past.

SPORE ASSEMBLAGES REVEALING DELAYED EXPANSION OF VASCULAR PLANTS IN BALTICA – EVIDENCE FROM UPPER SILURIAN SUCCESSIONS FROM SWEDEN

Vivi Vajda[1] and Kristina Mehlqvist[1]

1. Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden.
vivi.vajda@geol.lu.se

Upper Silurian successions from Sweden occur both on the island Gotland, situated in the Baltic Sea, and in the southern province Skane. These sediments are generally near shore marine to intertidal lagoonal based on the low, but persistent occurrence of acritarchs together with the high relative abundance of spores through the main part of these successions. The Late Silurian Swedish spore assemblages are overwhelmingly dominated by cryptospores regarding relative abundance, reflecting a restricted catchment area with spores chiefly representing the local flora growing on delta plains. Coeval marine deposits are characterized by extreme conditions manifested by increase of cyanobacteria, cerebroid ooids and evaporite tracers combined with extinctions of conodont faunas and fish. These changes are not reflected in the terrestrial vegetation, which instead reflect a robust, well-established and stable early flora throughout the studied successions. When comparing the late Silurian assemblages from Sweden (Baltica) with coeval deposits from elsewhere, significant similarities occur at generic level for example with Avalonian assemblages, whilst the abundance data show major discrepancies in that most coeval assemblages on other paleo-continents are by the latest Silurian are strongly dominated by trilete spores regarding relative abundance. This implies that the major expansion of vascular plants did not occur until the Silurian-Devonian boundary in Baltica.

IN SITU CALCIFICATION IN AN ANOXYGENIC, PHOTOSYNTHETIC MICROBIAL BIOFILM FROM THE 3.33 GA JOSEFSDAL CHERT, BARBERTON, SOUTH AFRICA

Frances Westall[1], Barbara Cavalazzi[1,2], Axelle Hubert[1], Alexandre Simionovici[3], Laurence Lemelle[4], Kathy Campbell[1,5] and Jean-Gabriel Bréhéret[6]

1. Centre de BiophysiqueMoléculaire-CNRS, Orléans, France. frances.westall@cnrs-orleans.fr
2. Dipartimento di Scienze geologiche e ambientale, Università di Bologna, Italy.
3. Institut des Science de la Terre, Université Joseph Fourrier, Genoble, France.
4. Laboratoire des Sciences de la Terre, Université de Lyon, France.
5. Geology, School of Environment, University of Auckland, New Zealand.
6. Laboratoire GéoHydrosystèmes Continentaux, Université de Tours, France.

Fossilised biofilms created by photosynthesising microorganisms are among the oldest traces of life preserved on our planet and, indeed, are the most readily-identifiable, morphological signatures of ancient microbial life. Identification and interpretation of the biofilm/mat-like features is generally based on their morphological and behavioural similarity to modern photosynthetic microbial mats, as well as their occurrence in shallow water environments although younger (Proterozoic onwards) photosynthetic mats and stromatolites are often characterised by in situ calcification. We here document the first evidence of in situ calcification in a 3.33 Ga-old photosynthetic microbial biofilm from the Josefsdal Chert (JC) in the Barberton Greenstone Belt. Photosynthetic biofilms, preserved by precocious silicification, are common in the shallow water hummocky/swaley (HCS/SCS) facies of the JC and occur also, though more infrequently, in the shallower, tidalite facies. One particular example from the HCS/SCS facies is preserved in three dimensions over an area of a couple of mm2 on a bedding surface. FIB-sections cut vertically into through the mat were examined to determine the structure, texture, mineralogy and elemental composition of the biofilm. While the surface (1 µm) of the 10 µm thick biofilm consists of degraded kerogen, the underlying body of the mat has a granular texture due to the presence of 5-10 nm nanocystallites of aragonite embedded in a reticular organic groundmass. Organic S (as well as C and N) is present throughout the thickness of the mat, reaching 1% in the upper, non-calcified layer. Inorganic S in the form of sulphate is also present but in greater concentrations in the calcified part of the mat. These associations suggest degradation of the lower, dead part of the mat by sulphate reducing bacteria (SRBs). We conclude that the Josefsdal Chert Microbial Biofilm was formed by an anoxygenic consortium including photosynthetic organisms and SRBs. Thus, by 3.45 Ga when we have the oldest morphological biosignatures, photosynthetic microbes were already the primary producers providing an organic substrate for heterotrophs while the volcanoclastic sediments supported chemolithotrophs.

CYANOBACTERIA IN JURASSIC GEOTHERMAL DEPOSITS FROM PATAGONIA, ARGENTINA

Juan García Massini[1], Ignacio E. Escapa[2], Diego M. Guido[3], Kathy A. Campbell[4] and Alan Channing[5]

1. CONICET-Centro Regional de Investigaciones Científicas y Transferencia Tecnológica (CRILAR). Entre Ríos y Mendoza s/n° (5301) Anillaco, La Rioja, Argentina. massini112@yahoo.com.ar
2. Museo Paleontológico Egidio Feruglio, Av. Fontana 140. Trelew, (9100) Chubut, Argentina.
3. CONICET-UNLP, Instituto de Recursos Minerales, Calle 64 esquina 120, (1900) La Plata, Buenos Aires, Argentina.
4. Geology, School of Environment, University of Auckland, Auckland, New Zealand.
5. School of Earth and Ocean Sciences, Cardiff University, Wales, CF10 3YE, UK.

This paper describes morphologically variable, structurally preserved coccoid and filamentous cyanobacteria from Jurassic hot springs in Patagonia. Fossils are silicified and preserved in their original context in fossiliferous cherts from the two best known geothermal localities of La Matilde Formation (Bahia Laura Group) in the Deseado Massif, Santa Cruz, Argentina. Coccoid forms are represented by individual, spherical or nearly spherical cells arranged in up to three perpendicular planes forming morphologically variable, tri-dimensional colonies of numerous units that lived epibiotically on different organic substrates. Filamentous forms consist of individual trichomes of variable length and diameter that occur as isolated units in the chert matrix or grouped in dense clusters forming hemispherical or spherical colonies on decayed plant stems, roots and other organic remains. Based on the morphological, anatomical and habit variability displayed, the fossils resemble different taxa within extant Croococcales, Nostocales and Oscilatoriales, such as *Myxosarcina*, *Lyngbia* and *Rivularia*, respectively. This record is among the few known of structurally preserved cyanobacteria in *in-situ* and in-life position from Phanerozoic non-marine terrestrial paleoecosystems. The presence of cyanobacteria in the geothermal deposits from La Matilde Formation in the Deseado Massif is consistent with extreme physical and chemical parameters known in modern comparable settings. Most importantly, this record helps fill in the gap in the distribution of cyanobacteria in the geological record and provides a reference point for their evolution, structural diversity and roles in Mesozoic terrestrial ecosystems.

EIFELIAN-GIVETIAN DIVERSITY TRENDS IN PALYNOFLORAS OF NORTHWESTERN ARGENTINA

Sol Noetinger[1] and Mercedes di Pasquo[2]

1. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia"- CONICET, Av. Angel Gallardo 470, Ciudad A. de Buenos Aires, C1405DJR, Argentina. noetinger@macn.gov.ar

2. CICyTTP - CONICET, Dr. Matteri and España, Diamante, Entre Ríos, E3105BWA, Argentina.

This study aims to elucidate diversity trends during the Middle Devonian in northwestern Argentina through the characterization of palynological events. A dataset of spore genera counts from two boreholes (San Antonio x-1, Santa Victoria x-1), ranging in age from the Eifelian to Givetian, was analyzed. Several measures of diversity were compiled and contrasted with the composition of the floras. The Simpson, Shannon-Wiener and standing diversity indices together with Pielou and Hurlburt's evenness measures were calculated. The standing diversity reaches its maximum during the Eifelian and rapidly decreases towards the Givetian. This tendency is also supported by the other computed parameters. The floras, during the Eifelian, are composed of apiculate, cavate and boldly sculptured spores represented mainly by the genera *Apiculiretusispora*, *Grandispora* and *Verrucosisporites* respectively. The decline in the evenness, towards the top of the sections, is shown when the *Verrucosisporites* genus outnumbers in the assemblages. The domination of these specimens is a pattern seen in other parts of Gondwana during the same time frame. The increment of this particular genus, associated with filicopsids, co-occurs with the inception of *Geminospora lemurata* and *Biharisporites parviornatus.* These species have a well-defined onset worldwide during the late Eifelian–early Givetian and are known to have affinities with archaeopteridaleans. Both, marine and continental elements, sustain a marginal depositional setting, with minor shoreline shifts for both assemblages during the Eifelian. By the early Givetian there is a significant increase of marine components. The diversity analysis and inferred palaeoenvironment support a change in the conditions, that show a stressed domain during the late Eifelian–early Givetian, which led to the predominance of few existing species and the establishment of new ones in the flora.

BRYOPHYTES ASSOCIATED WITH THE CARBONIFEROUS - PERMIAN CLIMATE CHANGES IN THE PARANA BASIN, SOUTHWESTERN GONDWANALAND

Fresia Ricardi-Branco[1], Isabel Cortez Christiano de Sousa[1,2], Juliana Sampaio Costa[1] and Yelitza Leon Vargas[3]

1. Departament of Geology and Natural Resources, Institute of Geosciences, University of Campinas, Rua J. Pandiá Calogeras 51, Campinas, SP,CEP 13083-970, Brazil. fresia@ige.unicamp.br
2. Program of Post Graduate in Geosciences, Institute of Geosciences, University of Campinas, Rua J. Pandiá Calogeras 51, Campinas, SP, CEP 13083-970, Brazil.
3. Centro Jardín Botánico, Facultad de Ciencias, Universidad de Los Andes, Mérida, Apartado 52, La Hechicera, Venezuela.

The Paraná basin is located in South America, encompassing Brazil, Paraguay, Uruguay and Argentina. In addition, the upper Paleozoic record includes southern Africa as well. The basin has a huge plant fossil record generated due to the abundance and diversity of plant communities that have inhabited it over the Carboniferous and Permian. Among groups of fossil plants, there is an excellent bryophyte record, which has been used to establish correlations, to assess the diversity of this group in Gondwana, and to understand the phylogenetic bryophyte evolution. The earliest records of bryophytes (*Dwykea araroii*) correspond to the northwest portion of the basin in São Paulo state ◎Brazil (Campinas, Sorocaba and Salto outcrops). The records occur in pro-glacial deposits of the Itararé Group. Gametophytes and a possible pleurocarp sporophyte were ascribed to *D. araroii*. Megaspores (*Sublagenicula brasiliensis*) associated with *D. araroii* were recorded, thereby supporting the development of a community in wet environments. *Dwykea*also occurs in the Dwyka Group (Karoo Basin, South Africa), which is coeval with the Itarare Group. In the post-glacial record of the Rio Bonito Formation, we identified the presence of gametophytes from *Hepatisites iporangae* hepatic (Quiteria Outcrop) in Rio Grande do Sul state – Brazil. *Hepatisites iporangae* was preserved in a plant association interpreted to have been formed in a marshy pond. Finally, continental environments and subsequent aridization of the basin occurred in the Permian, as a consequence of the northward drift of Gondwana and Pangea. This phenomenon is recorded in the Passa Dois Group. Two species of bryophytes, *Yguajemanus yucapirus* (grouping gametophytes) and *Capimirinus riopretensis* (encompassing gametophyte with pleurocarp sporophytes), were described from the Teresina Formation (Rio Preto Outcrop) in Paraná state associated with a less dry period. The species are associated with the oogonia carophyte *Leonardo sialangeii*. The assemblage was related to bryophyte communities living near bodies of fresh or slightly brackish water, characterized by deposition of fine-grained material. The *D. araroii* pleurocarp sporophytes and *C. riopretensis* are the oldest described of this important group of embryophytes, reinforcing that pleurocarps had already diversified by the upper half of the Permian in Gondwanaland. At least both species could be included in the current Core Pleurocarps. [FAPESP 2013/11563-6].

SYMPOSIUM

COMPARATIVE PALAEOECOLOGY OF PHANEROZOIC EXTINCTION EVENTS

ORGANIZER:

RICHARD J. TWITCHETT

(WITH THE COLLABORATION OF LUKE MANDER - SILVIA DANISE)

SYSTEM-LEVEL ECOLOGICAL STATE SHIFTS IN MARINE MOLLUSC ASSEMBLAGES ACROSS THE END-CRETACEOUS MASS EXTINCTION

Martin Aberhan[1] and Wolfgang Kiessling[2]

1. Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity Science, Invalidenstr. 43, 10115 Berlin, Germany. martin.aberhan@mfn-berlin.de

2. GeoZentrum Nordbayern, Paleobiology, Universität Erlangen–Nürnberg, Loewenichstr. 28, 91054 Erlangen, Germany.

Mass extinctions provide the opportunity to study the ecological and evolutionary dynamics of the Earth system when exposed to critical stress. The end-Cretaceous mass extinction has been considered to represent a planetary-scale state shift of the global ecosystem. Under this scenario we expect a major reorganisation of the ecological composition of local and regional communities. As an essential component of marine benthic ecosystems, we analysed whether benthic marine mollusc assemblages exhibit distinct shifts in ecological attributes across the Cretaceous-Paleogene boundary. Based on our own field work and data from the literature, we analysed molluscs from four boundary sections in Antarctica, Patagonia (one onshore and one offshore section), and Texas. We characterised the constituent species of pre-extinction and post-extinction assemblages in terms of their mobility, feeding mechanisms, and life habit and analysed changes in the abundance of the various modes of life (MOLs) across the boundary. In particular, we tested whether (1) post-extinction assemblages indicate a symmetrical refilling of ecospace that was emptied through extinctions; (2) post-extinction assemblages represent an impoverished pre-extinction fauna without refilling of emptied ecospace; or (3) post-extinction assemblages constitute a fundamentally new assembly of functional groups. Of 18 unique MOLs in the pre-extinction assemblages none was lost across the boundary when all four localities are viewed jointly. Despite this general stability in the number of MOLs, significant shifts in relative abundance within MOLs are evident at all localities. These shifts are commonly expressed as decreases within previously top-ranked groups and increases in lower-ranked ones. Thus, we reject scenario (1). Likewise, post-extinction assemblages exhibit pronounced changes in rank positions and proportional abundances when compared with pre-extinction assemblages from which species that disappeared in the latest Maastrichtian have been removed prior to analysis, thus contradicting scenario (2). Ecological structure differs distinctly among localities in both the pre-extinction and post-extinction faunas as evident in pronounced interregional variability in MOL rankings. Nevertheless, congruent patterns emerge: Post-extinction assemblages have shifted to elevated proportions of motile and of infaunal molluscs, and the use of various trophic resources changed in unison, resulting in more complex post-extinction food webs. In conclusion, our analyses show that utilized ecospace differed significantly before and after the event, consistent with the idea of ecosystem regime shifts. Congruent ecological trends at all studied localities suggest common driving factors.

VERTEBRATE EXTINCTIONS NEAR THE GUADALUPIAN-LOPINGIAN BOUNDARY IN SOUTH AFRICA

Michael O. Day[1] and Bruce S. Rubidge[1]

1. Evolutionary Studies Institute, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050, South Africa. Michael.day@wits.ac.za

Over the last two decades, extinctions within several groups of marine invertebrates have been reported at or near the end of the Guadalupian stage of the Permian. The proximity of these extinctions has led to the proposal of an end-Guadalupian or Capitanian extinction event that shares a common ultimate cause, often suggested to be volcanism within the Emeishan Large Igneous Province. This has been extended to include the terrestrial extinction of dinocephalian therapsids within the Gamkan Land Vertebrate Fauna chron, although biostratigraphic, magnetostratigraphic and chemostratigraphic correlation of marine sequences with terrestrial ones have provided mixed results and prompted the suggestion that the marine extinctions post-date the dinocephalian extinction and have no terrestrial equivalent. The Karoo Basin of South Africa has provided the most complete record of terrestrial faunas from the Middle to Late Permian and has recently yielded radiometric dates that support a mid-Capitanian age for the dinocephalian extinction, which occurs between the *Tapinocephalus* and *Pristerognathus* Assemblage Zones (Gamkan LVF). Long-term collecting efforts from these two assemblage zones, within the lower Beaufort Group of the Karoo Basin, have demonstrated that the dinocephalian extinction is more complex than a single sudden event and that diversity was reduced over a stratigraphic interval of 100 m or more. All other higher tetrapod taxa were affected by reductions in generic richness, but simultaneously a few genera of dicynodont and basal therocephalian therapsids increased in abundance. In the aftermath of these extinctions, basal therocephalians disappeared in an environment of increasing generic richness, heralding the transition to a Late Permian fauna.

TERRESTRIAL TETRAPOD GEOGRAPHIC RANGE AND EXTINCTION DURING THE END-TRIASSIC CRISIS

Alexander M. Dunhill[1] and Matthew A. Wills[1]

1. Department of Biology and Biochemistry, University of Bath, Claverton Down, Bath, BA2 7AY, UK.
a.m.dunhill@bath.ac.uk

Triassic-Jurassic tetrapod taxa with larger geographical range sizes were more resilient to extinction than those with smaller ranges. More generally, there is a positive correlation between rates of per lineage geographic range size change and diversity change. However, these relationships weaken with increasing proximity to the end-Triassic mass extinction, breaking down altogether across the event. These observations support the theory that taxa with larger geographic ranges are more resilient to extinction than taxa with smaller ranges in normal times, but that this effect is diminished during global biotic crises. Although the fossil record of terrestrial tetrapods is notoriously patchy, the Late Triassic has one of the best Mesozoic terrestrial fossil records. Moreover, changes in geographic range correlate with changes in diversity much more strongly than any combination of putative sampling proxies. This study explores the applications of novel spatial analysis techniques to increasingly detailed data from the Paleobiology Database (PaleoDB). Such approaches have enormous potential for understanding spatial macroevolutionary patterns in the fossil record and may have far reaching consequences for modern and future conservation issues.

MESOZOIC MARINE CRISES AND ICHTHYOSAUR HISTORY: A NON-DIRECT RELATIONSHIP

Valentin Fischer[1,2]

1. Geology Department, University of Liege, Allée du Six-Août, B18, Sart Tilman, 4000 Liège, Belgium. v.fischer@ulg.ac.be
2. Earth and History of Life O.D., Royal Belgian Institute of Natural Sciences, 29 Rue Vautier, Brussels 1000, Belgium.

Marine ecosystems underwent several profound crises throughout the Mesozoic; many of them are correlated with supra-regional to worldwide anoxic events. The impact of these crises is relatively well understood among animals occupying lower trophic levels but their influence on top predators of that time, fishes and marine reptiles, remains unclear. The fossil record of marine reptiles is of fluctuating quality but thoroughly revised taxonomic and phylogenetic frameworks now allow assessment of the influence of past climatic and oceanic changes on these top predators, by quantifying their cladogenesis and extinction rates across selected intervals. Here, I focus on ichthyosaurs, a successful clade of marine reptiles that colonized marine ecosystems during most of the Mesozoic. The ichthyosaur record indicates relatively few severe turnovers and a non-direct relationship with environmental drivers, notably anoxic events. New fossils from France reveal the middle-late Norian extinctions did not eradicate the clade of whale-sized shastasaurid ichthyosaurs; similarly, the severe early Toarcian anoxic event, the end-Jurassic climate changes and several Cretaceous anoxic events did not impacted ichthyosaurs significantly, at least at the suprageneric level. On the other hand, severe turnovers or extinctions occurred during the latest Triassic and the Cenomanian and are coincident with a number of profound environmental and biotic changes. This indicates that unique drivers fail to explain the turnover patterns in ichthyosaur evolutionary history. Notably, oceanic anoxic events only impacted ichthyosaurs during the end-Cenomanian and did so during a period of intense climatic and biological upheavals. These major crises in ichthyosaur history are seemingly protracted over several million years and are probably best explained by a conjunction of causes. This is part of a wider project that will incorporate data from other contemporaneous groups to shed a new light on the general turnover patterns among marine top predators of the Mesozoic and the influence of ancient environmental changes in shaping their biodiversity.

FUNCTIONAL DIVERSITY OF MARINE ECOSYSTEMS AFTER THE LATE PERMIAN MASS EXTINCTION EVENT

William J. Foster[1] and Richard J. Twitchett[1]

1. Plymouth University, School of Geography, Earth and Environmental Sciences, Drake Circus, Plymouth, Devon. PL4 8AA. United Kingdom. william.foster@plymouth.ac.uk

The Late Permian extinction event was the largest biotic crisis of the Phanerozoic with up to 74% of benthic marine invertebrate genera becoming extinct. Understanding biodiversity changes through the Permian-Triassic interval requires more than just taxonomic richness data, however, especially when trying to investigate the impact of changing environments on biota. Paleoecological data used for investigating biodiversity changes through this interval include: alpha diversity, tiering, taxonomic dominance, and biosedimentary fabrics (e.g. ichnofabric index), with each providing a different perspective on the extinction and recovery. In this study we used two large, vetted genus-level databases of occurrences and range-through data for marine benthic invertebrates, compiled from the literature and supplemented by the Paleobiology Database. Each genus was assigned a score for its motility, feeding, and tiering using established methodologies. Changes in the functional diversity of the benthic fauna were assessed both temporally, through the Late Permian to Middle Triassic interval, and in different paleolatitudes, oceanic settings, and depositional environments. Despite the magnitude of the extinction event only one mode of life was completely eliminated globally. Using occurrence data alone overestimates the extinction magnitude and loss of functional diversity, due to sampling biases and the Lazarus effect. At local and regional scales, functional diversity was dramatically reduced in tropical ecosystems, but those at higher latitudes suffered less change, at least initially. Reef ecosystems and basinal settings were largely vacated across the boundary, but inner shelf settings were less severely affected. These differences further highlight the complexity of ecosystem response to the Late Permian extinction crisis and through the recovery period. The data also serve to highlight where gaps in knowledge of certain depositional settings or regions are biasing our understanding of key intervals in the recovery, such as around the Olenekian/Anisian boundary.

EXTREME FAUNAL ENDEMISM AS THE KEY INTRINSIC CAUSE OF THE LATE ORDOVICIAN MASS EXTINCTION

Jisuo Jin[1], David A. T. Harper[2], Peter M. Sheehan[3], L. Robin M. Cocks[4] and Leonid E. Popov[5]

1. Department of Earth Sciences, University of Western Ontario, London, Ontario N6A 5B7, Canada.
2. Department of Earth Sciences, Durham University, Durham DH1 3LE, UK. david.harper@durham.ac.uk
3. Department of Geology, Milwaukee Public Museum, Milwaukee, Wisconsin 53233, USA.
4. Department of Earth Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.
5. National Museum of Wales, Cathays Park, Cardiff, Wales, CF10 3NP, UK.

Previous studies on mass extinction events (MEEs) have focused mainly on the various extrinsic killing mechanisms, many of which remain hotly debated. Here we propose a '*mass extinction by insularization and kill*' (MEIK) model as the key intrinsic cause of the Late Ordovician MEE based on palaeoecological and palaeobiogeographical investigations of Ordovician brachiopod faunas of Laurentia and adjacent tectonic plates. During the Late Ordovician pulses of a first-order sea-level rise, the MEIK model demonstrates (1) migration of biodiversity hotspots from ocean to epicontinental seas and drastic increase in faunal endemism, 2) formation of continental-sized 'island faunas' such as the Laurentian cratonic brachiopods, resulting in the eventual loss of their inter-plate dispersal ability, and (3) mass extinction of highly specialized, endemic super-island faunas at the onset of the glaciation and draining of epicontinental seas. The quantitative data presented here for the first time suggest that during a major sea-level rise, global biodiversity epicentres shifted from the ocean to epicontinental seas and became genetically isolated, rendering marine shelly benthos intrinsically susceptible to rapid environmental change and mass extinction.

SIZE, SHELL-CRUSHING AND SURVIVAL: RESTRUCTURING OF VERTEBRATE ECOSYSTEMS AFTER THE END-DEVONIAN HANGENBERG EXTINCTION (359 MYA)

Lauren Cole Sallan[1]

1. University of Pennsylvania, 240 S. 33rd Street, Philadelphia, PA, 19104 USA.
lsallan@sas.upenn.edu

The end-Devonian Hangenberg event (359 Mya) marked one of the most severe extinctions in vertebrate evolutionary history, featuring the loss of 50% of major clades and over 90% of species in both marine and continental settings. This event restructured vertebrate ecosystems worldwide: Devonian communities dominated by armored placoderms and lobe-finned fishes gave way to Mississippian assemblages featuring the Modern triad of tetrapods, ray-finned fishes and sharks. Here I present results from two studies showing how major ecological characteristics of these communities (size, feeding behavior) changed across the extinction boundary, preventing simple replacement of lost lineages. A new compilation of vertebrate body sizes shows that nearly all major lineages experienced "Cope's Rule" size increases (minimum, maximum, mean and mode) over the entire Devonian (418-359 Mya). In contrast, clades and assemblages show dramatic reductions in size in the aftermath of the Hangenberg extinction. This represents the first evidence of a Lilliput effect on a global scale, and marks the beginning of a trend towards reduced body size in newly dominant, diversifying, possibly r-selected groups (ray-finned fish, sharks) that lasts for the Mississippian (359-323 Mya). Neither the Devonian nor the Mississippian trends coincide with changes in oxygen or temperature, suggesting they may have been driven by ecological pressures alone. New morphological data also suggests a strong shift towards shell-crushing (durophagy) predation among the dominant fish groups (ray-finned fish, sharks) in depauperate post-extinction ecosystems. Up to 70% of species in each early Mississippian assemblage were capable of durophagy based on jaw and tooth morphology, compared to less than 20% of species at later Devonian sites. This is coincident with likely predator-mediated changes in the records of brachiopods and crinoids, such as increased crushing damage and changes in defensive morphology. Thus, restructuring of vertebrate communities induced cascading effects in ecological connected taxa. Long-term size reduction and increased durophagy may be common in vertebrates recovering from mass extinction, as suggested by preliminary evidence from the early Triassic and early Cenozoic. Thus, assemblages of small-sized, shell-crushing fishes may be considered disaster ecosystems, perhaps as much a marker of severe mass extinction and turnover, or other unstable conditions, as losses in taxonomic diversity.

DROUGHT-INDUCED END-PERMIAN TETRAPOD EXTINCTIONS IN THE KAROO BASIN, SOUTH AFRICA AND THEIR IMPACT ON THE EVOLUTION OF MAMMALS AND ARCHOSAURS

Roger M. H. Smith[1] and Jennifer Botha-Brink[2]

1. Iziko South African Museum, PO Box 61, Cape Town 8000, South Africa. rsmith@iziko.org.za
2. National Museum, PO Box 266, Bloemfontein 9300, South Africa.

The southern part of the Karoo Basin of South Africa contains an almost complete stratigraphic record of the Permo-Triassic boundary (PTB). We have found 580 in-situ tetrapod fossils, mostly therapsids, in PTB exposures at three widely-separated locations in the southern Karoo Basin. Biostratigraphic ranges of the various taxa found in each of the sections reveal three separate phases of die-off within the same roughly 75 metre-thick stratigraphic interval. This interval also displays the same sequence of sedimentary facies, which we interpret as indicative of climatic drying, increased seasonality and the onset of an unpredictable monsoon-type rainfall regime. We interpret the biostratigraphic data as reflecting three phases of an ecologically-stepped mass extinction: Phase 1 (45–30 m below PTB datum) brought on by lowered watertables, which led to loss of shallow rooting groundcover in the more elevated proximal floodplain areas and the disappearance of the smaller groundcover-grazing herbivorous dicynodonts and their attendant small carnivores. Phase 2 (20–0 m below PTB datum), represents the main extinction that occurs in massive maroon/grey mudrock culminating in an event bed of laminated reddish-brown siltstone/mudstone couplets. This facies reflects progressively unreliable rainfall leading to vegetation loss in proximal and distal floodplain areas. Larger browsing dicynodonts and their attendant carnivores are confined to riparian vegetation along watercourses before finally disappearing. Phase 3 (25–30 m above PTB datum) occurs in massive maroon siltstone facies with sedimentological and taphonomic evidence of climatic aridity. Phase 1 and Phase 2 die-offs lasted 21 000 and 33 000 years respectively, separated by a short period of 7000 years where no disappearances are recorded. This was followed by 50 000 years of stasis before the final extinction phase, which lasted only 8000 years and removed all surviving Permian taxa. We propose that the recorded disappearances are real (rather than preferential preservation failure) and that they represent drought-induced die-offs moving progressively up the food chain as the terrestrial ecosystem collapsed; the latter most likely caused by volcanogenic greenhouse gas emissions and rapid global warming. The die-offs allowed drought-adapted archosauromorphs, therocephalians and cynodonts to occupy the small faunivore/insectivore niches of the Karoo floodplains. We propose that the behavioral and physiological adaptations to survive the climatic drying of the Early Triassic led to the rapid ascendency of archosaurs and ultimately mammals as well.

A COMPARISION OF BIVALVE FAUNAS FROM DIFFERENT HABITATS AND FACIES IN SOUTH CHINA DURING THE CHANGHSINGIAN (LATEST PERMIAN)

Tinglu Yang[1], Weihong He[1,2], Yang Zhang[1], Mingliang Yue[1], Huiting Wu[1], Yifan Xiao[1] and Shunbao Wu[1]

1. Faculty of Earth Science, China University of Geosciences (Wuhan), Wuhan, 430074, China.
lotin.yang@gmail.com

2. State Key Laboratory of Geobiology and Environmental Geology,
China University of Geosciences (Wuhan), Wuhan, 430074, China.

The end-Permian Mass Extinction is not only the most catastrophic extinction event during the Phanerozoic with around 90% of marine species eliminated but it also altered the ecological structure of marine benthic communities. It largely reshaped the bivalve world. However, the taxonomy of pre-extinction bivalve faunas from different habitats or facies is still poorly known owing to the lack of detailed research on bivalves from different habitats. Herein materials from four sections in South China are presented to discuss this problem. The bivalve fauna from deep-marine siliceous-rock facies (generally deeper than 200 metres) were collected from the Dongpan section,Guangxi, the Sangzhi section, Hunan, and the Duanshan section, Guizhou. The bivalve fauna from shallow-marine clastic-rock facies (about 100 metres deep) was collected from the Zhongzhai section, Guizhou. The Changhsingian bivalve materials from the carbonate platform facies are rarely recorded. So far as known, deep-marine facies is generally dominated by epifaunal bivalves, especially those epibyssate suspension feeders, e.g. *Hunanopecten*, *Euchondria*, *Etheripecten*, *Palaeolima* and *Paradoxipecten* during the Changhsingian. Among them, the genus *Hunanopecten* is the most widely distributed in South China. Nevertheless, our materials also indicate that there are still differences among deep-marine bivalve faunas from different sections (probably representing different habitats). Dongpan section yielded the most abundant fossil materials with 15 bivalve genera. The bivalve fauna is characterised by the dominance of *Euchondria fusuiensis*, an endemic species, and the genus *Hunanopecten*. The palaeoecological structure of this bivalve fauna is also quite complex in terms of the life position and feeding sources. Both epifaunal and infaunal forms commonly occurred in the Talung Formation at the Dongpan section and different kinds of feeders are recorded, such as epibyssate suspension feeders *Euchondria* and *Leptochondria*, infaunal mobile deposit feeders *Nuculopsis* and *Palaeoneilo* and endobyssate suspension feeders *Parallelodon* and *Tambanella*. In contrast, the bivalve fauna from the Talung Formation (slightly deeper than 200 metres) at the Duanshan section is characterised by the abundance of *Paradoxipecten*, co-dominating with *Hunanopecten*. Interestingly, a monotonous *Hunanopecten* fauna is recorded at the Sangzhi section (about 200 metres deep). Comparatively speaking, the occurrence frequency and population size of infaunal mobile deposit feeders, e.g. *Palaeoneilo* and *Astartella*, notably increased in shallow-water clastic-rock facies. Furthermore, some epifaunal recliners or swimmers, e.g. *Pernopecten*, are also quite active within this niche. These detailed records, therefore, indicate that the bivalve faunas varied with water depth and by particular habitats or ecological environments.

FLORAL PROVINCIALISM HINDERS CORRELATIONS OF PERMIAN PALYNOLOGICAL ASSEMBLAGES ACROSS GONDWANA

Natasha Barbolini[1], Marion K. Bamford[1] and Bruce Rubidge[1]

1. Evolutionary Studies Institute, Centre of Excellence: Palaeontology, University of the Witwatersrand, Private Bag 3, WITS, 2050 South Africa. natasha.barbolini@wits.ac.za

Historically the Gondwanan supercontinent was thought to have formed a unified and largely homogenous plant kingdom, but it is now apparent that several intra-gondwanan floristic provinces are in fact recognisable. Regional variation in the floras is particularly evident in the Permian with elevated levels of endemic taxa and this hinders global biostratigraphic correlations. Intra-gondwanan provincialism is reflected palynologically with, for example, several stratigraphically useful Australian species absent from other continents in Gondwana. These include *Dulhuntyspora dulhuntyi*, *Dictyotriletes aules*, *Protohaploxypinus rugatus* and *Bascanisporites undosus*. This is unfortunate because the Australian palynozones are calibrated against independently dated marine faunas, carbon isotopes, and radiometric dates, making them the current standard palynostratigraphic classification for the southern hemisphere. The absence of the above key taxa in other Gondwanan basins complicates correlations with the standard Australian type zones. To investigate whether palynological assemblages from South Africa could be successfully correlated to the Australian palynozones, 135 pollen samples were collected from Permian outcrops of the Main Karoo Basin (MKB). Samples were derived from the western region (west of the 24° E meridian), southern region (east of the 24° E meridian) and the north-east distal facies of the the Ecca and Beaufort groups. Standard palynological methods yielded 56 productive samples for correlation. The Permian western Australian palynozones are defined by the first appearance datum of a particular index taxon, in ascending stratigraphic order: *Pseudoreticulatispora* (*Converrucosisporites*) *confluens*, *P. pseudoreticulata*, *Striatopodocarpites fusus*, *Microbaculispora trisina* (*Granulatisporites trisinus*), and *Praecolpatites sinuosus*. Upon correlation with Karoo assemblages, it was found that these stratigraphically important taxa all appear in South Africa either earlier or later in the fossil record than in Australia, except for *P.confluens* which is not present in the Main Karoo Basin at all. Index taxa of the overlying Australian zones were not recovered from South Africa in this study. Therefore endemism and differing stratigraphic ranges of key palynomorph taxa impede successful correlation between the standard Australian biozones and South African rocks. This has highlighted the need for a new South African palynozonation to be set up according to the Australian practice of designating pollen zones based on the first appearance of key index taxa. Such palynozones are a more reliable and accurate way of correlating basin-wide formations than the current South African practice of defining and correlating abundance biozones.

RECORDS OF ANTARCTIC SEASONAL VARIATION PRESERVED IN BIVALVE SHELLS ACROSS THE CRETACEOUS/PALEOGENE MASS EXTINCTION

Joanna Hall[1], Alan Haywood[1], Stephen Hunter[1], Rob Newton[1], Jane Francis[2], Alistair Crame[2] and Liz Harper[3]

1. School of Earth and Environment, University of Leeds, West Yorkshire, LS2 9JT, United Kingdom. eejlh@leeds.ac.uk
2. British Antarctic Survey, Madingley Road, Cambridge, CB3 0ET, United Kingdom.
3. Department of Earth Sciences, University of Cambridge, Downing Site, Cambridge, CB2 3EQ, United Kingdom.

Studies of Antarctic paleoclimate evolution from Cretaceous greenhouse to modern icehouse conditions have highlighted the Late Cretaceous to Early Paleogene as a time of extreme seasonality on a scale unseen in modern temperate climates. This is often overlooked in interpretations of geochemical proxies which may result in misleading paleoenvironment reconstructions. Variations in seasonal temperatures are important to understand from both a biological and climatic perspective particularly in deep time where changes in temperature extremes have been postulated as a mechanism to drive patterns of evolution and extinction. Seymour Island in the James Ross basin of the Antarctic Peninsula is a prime location for study of polar environmental change in the early Cenozoic. It possesses the world's highest latitude marine exposures (65^{0}S) of the Cretaceous-Paleogene boundary sequence and the paleogeographic sensitivity to global climate change at this locality has been highlighted by a number of previous studies. Marine fossil material including bivalves and other molluscs is both abundant and remarkably well-preserved. Bivalve shells in particular serve as valuable multiproxy archives in the marine realm at latitudes where other groups such as corals and foraminifera are less abundant, recording numerous environmental signals such as temperature, water geochemistry and productivity via growth rate and geochemical variations in skeletal carbonate where original material is preserved intact. Bivalves of the genus *Lahillia* and *Cucullaea*, found in the pre-extinction and recovery fauna across the Cretaceous-Paleogene boundary sequence have been examined using a number of qualitative and quantitative techniques to assess preservation and potential for use as sclerochemical archives of seasonal climate information. High resolution stable isotope and trace element analysis results show trends related to visible annual growth banding in the valve and tooth which allow reconstruction of age and growth history of individual specimens. Here we present the results of preservation studies and initial high resolution analyses of shell material and discuss subsequent potential for reconstruction of seasonal geochemical trends through the stratigraphic sequence to yield new data.

BRACHIOPOD HIERARCHICAL DIVERSITY PARTITIONING IN THE LATE ORDOVICIAN–EARLY SILURIAN: RECOVERY PATTERNS AFTER THE LATE ORDOVICIAN EXTINCTION

Karen Halpern[1,2] and Diego Balseiro[1,2]

1. Centro de Investigaciones en Ciencias de la Tierra, Consejo Nacional de Investigaciones Científicas y Técnicas y Universidad Nacional de Córdoba, Av. Vélez Sarsfield 1611. X5016GCA, Córdoba, Argentina. karenhalpern@conicet.gov.ar

2. Centro de Investigaciones Paleobiológicas (CIPAL), Facultad de Ciencias Exactas Físicas y Naturales, Universidad Nacional de Córdoba. Av. VélezSarsfield 299, 5000, Córdoba, Argentina.

Brachiopod global diversity trend shows a negative excursion in the Ordovician-Silurian boundary. This sharp decrease in diversity, interpreted as the Late Ordovician Extinction, can also be recognized at regional scales when drawing diversity curves with raw data. Recent studies demonstrate the existence of important geographic variability in diversity trends during this interval. However, diversity patterns analyzed so far represent equatorial and subequatorial paleoplates, while diversity trends in high-latitudes are virtually unknown. We here analyze brachiopod standardized diversity trends in a hierarchical scheme (alpha, beta and gamma) from Late Ordovician to Early Silurian among 4 regions, namely Laurentia, Baltica, Avalonia and the Argentine Precordillera. Gamma diversity shows similar trends in Avalonia and Baltica, increasing from Lower Caradocian to the Ashgillian, diminishing towards the Rhuddanian and, after a slight increase in the Aeronian, dropping in the Telychian. In the Argentine Precordillera gamma diversity progressively decreases from the Upper Caradocian to the Rhuddanian. Meanwhile, in Laurentia gamma diversity trend records a continuous rise from Lower Caradocian through the Telychian. Alpha diversity, however, shows a different trend across the Ordovician-Silurian boundary. In all regions but Baltica, alpha diversity diminishes from the Upper Caradocian to the Ashgillian but then stays stable across the Ordovician-Silurian boundary until the Aeronian. Instead, Baltica shows a peak of alpha diversity in the Ashgillian, a slight decrease in the Rhuddanian and drops in the Aeronian. As it could be expected, beta diversity also shows geographic variation. The general pattern is that beta diversity decreases by 50% from the Ashgillian to the Rhuddanian, being the largest drop in beta diversity recorded at the Ordovician-Silurian boundary. On the contrary, Laurentia's beta diversity increases steadily from the Lower Caradoc to the Telychian. These diversity patterns suggest geographic variability in recovery dynamics, having migration and speciation different importance in each region. On the one hand, local communities in Baltica, Avalonia and Precordillera seem to have recovered their diversity based on migration, provoking a homogenization of the faunas and a subsequent beta diversity loss. On the other hand, local communities in Laurentia, most probably recovered their diversity based on higher speciation, and hence beta diversity increased. Moreover, our results also indicate a mismatch in the recovery at different geographic scales. While local communities recover quickly, at regional scale metacommunities can have a much protracted recovery interval.

CHANGHSINGIAN (LATEST PERMIAN) DEEP-WATER BRACHIOPOD FAUNA FROM SOUTH CHINA

Weihong He[1], Guang R. Shi[2], Yang Zhang[3], Tinglu Yang[3], Kexin Zhang[1], Shunbao Wu[3], Zhijun Niu[4] and Zongyan Zhang[5]

1. State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Wuhan 430074, P. R. China. whzhang@cug.edu.cn

2. School of Life and Environmental Sciences, Deakin University, Melbourne Burwood Campus, 221 Burwood Highway, Burwood, VIC 3125, Australia.

3. Faculty of Earth Sciences, China University of Geosciences, Wuhan, 430074, P R China.

4. Wuhan Institute of Geology and Mineral Resources, Wuhan 430205, P. R. China.

5. Nanjing Institute of Geology and Mineral Resources, Nanjing 200016, P. R. China.

In South China, tens of sections with continuous Permian-Triassic sedimentary successions have been studied. These sections have inspired many geologists for detailed research on the stratigraphy and palaeontology of the Permian-Triassic interval of South China, and the Permian-Triassic mass extinction, the Late Permian and Permian-Triassic brachiopod faunas of South China have been abundantly documented, as evident from several detailed taxonomic monographs. Most fossils in these monographs were mainly collected from shallow-water carbonate facies because brachiopods are usually more abundant in limestones and hence naturally have attracted more attention from geologists. Since the late 1970s, some articles about Late Permian deep-water brachiopods have been published. However, detailed knowledge of Late Permian deep-water brachiopods globally is still very limited. Also of note is that the taxonomic status and definition of some Late Permian deep-water brachiopod genera and species referred to in some previous publications have been confusing because of the lack of taxonomically important internal structures discernable only in well-preserved material. We recently collected more than 4000 brachiopod specimens from the Talung Formation (Changhsingian, latest Permian) of the marine deep-water facies of South China. Here we recorded 45 brachiopod species, assigned to 23 genera of seven orders (Productida, Spiriferida, Athyridida, Orthida, Orthotetida, Rhynchonellida, and Lingulida). From this fauna, we (He et al.) have proposed two new genera, *Chaohochonetes* and *Parapygmochonetes*; along with 9 new species: *Tethyochonetes rectangularis*, *Tethyochonetes*? *sinuata*, *Chaohochonetes triangusinuata*, *Neochonetes* (*Zhongyingia*?) *liaoi*, *Neochonetes* (*Huangichonetes*?) *wufengensis*, *Paryphella majiashanensis*, *Paryphella minuta*, *Parapygmochonetes parvulus* and *Meekella sparsiplicata*. Additionally, we also summarized the taxonomic composition, significant morphological features and palaeoecological implications of this deep-water brachiopod fauna and compared this fauna with the Permian-Triassic boundary (PTB) mixed brachiopod fauna of South China. The results revealed that the Changhsingian (latest Permian) deep-water brachiopod fauna of South China shares some common features with the PTB mixed brachiopod fauna, especially in terms of taxonomic composition and certain apparent morphological adaptations. This commonality is interpreted to indicate a time and a broad marine environment of widespread low oxygen supply and/or reduced trophic resources during the end-Permian life crisis in South China.

LATE PERMIAN *CLARAIA*- LIKEBIVALVE IN SOUTH CHINA, AND ITS EVOLUTIONARY SIGNIFICANCE BASED ON MORPHOMETRIC ANALYSIS

Yanhong Pan[1], Jingeng Sha[1] and Yaqiong Wang[1]

1. LPS, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China. yhpan@nigpas.ac.cn

The flat clam *Claraia* has long been recognized as a zonal taxon for the Early Triassic. Although there is no consensus on the use of the names *Claraia* and *Claraioides*, the Late Permian *Claraia* - like specimens have been reported from southern China and northern Caucasus. Consequently, two evolutionary theories on the Permo-Triassic *Claraia*-like species emerged. Fang proposed that there are two parallel evolutionary lineages within the P-T *Claraia*-like species, the *Pseudoclaraia-Claraia* lineage might have originated in the cool-water Boreal Realm of middle-high latitudes, and the *Claraioides* lineage originated in the early Wuchiapingian in the warm-water Cathaysian province, whereas after the end-Permian biotic crisis, the *Claraioides* lineage was wholly replaced by the *Pseudoclaraia-Claraia* lineage. Yang suggested that the Triassic *Claraia* evolved from the Permian *Claraia*, according to ornaments and occurrence. He studied the variation in byssal notches of *Claraia*, and pointed out that from early Changhsingian to the Induan, byssal notches became narrower, and gradually changed from being ventrally extended to being horizontally extended, and also supported that the Triassic *Claraia* evolved from Permian *Claraia*. While the chronostratigraphic distribution is out of debate, the principal issues in dispute concern the diagnostic features of these end-Permian *Claraia*-like species from southern China. The diagnostic features for bivalve fossils are usually limited to the morpho-features, such as ornamentation, size, shape, and orientation of the valves or a certain structure (e.g. byssal notch, as in *Claraia*). Admitedly our understandings of the morpho-features of extinct organisms have often been affected (biased) by at least two processes, one is the fossilization process, the other is artificial information collection process. For example, the shape of the valve is usually used as a diagnostic feature at species level, whereas distortion of the shape can be easily resulted by compaction, which is quite common during the fossilization process. Therefore, we applied Hangle Fourier analysis on the outlines of the right valves, and other independent features besides the shape of the right valve were also re-evulated considering the taphonomic and artificial biases. Besides the published end-Permian materials stored at the Nanjing Institute of Geology and Palaeontology and Chinese Geoscience University, the Early Triassic *Claraia*fossils published by Zhang are also examined. The results show that *Claraia* species had existed beyond the P-T boundary, while a wide morpho-gap existed between Fang's *Claraioides* type specimens and typical *Claraia* specimens. [Supported by UNESCO-IUGS IGCP Project 632].

IMPACT OF THE END-ORDOVICIAN MASS EXTINCTION ON POLYCHAETES: NEW DATA FROM THE BASAL SILURIAN VARBOLA FORMATION OF ESTONIA

Petra Tonarová[1,2], Olle Hints[2] and Mats E. Eriksson[3]

1. Czech Geological Survey, Geologická 6, 15200 Prague 5, Czech Republic. petra.tonarova@geology.cz
2. Institute of Geology, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia.
3. Department of Geology, Lund University, Sölvegatan 12, SE-223 62, Lund, Sweden.

Jawed polychaete worms represented a significant component of the Early Palaeozoic marine invertebrate communities, as shown by the abundance and diversity of their jaws (scolecodonts) in the sedimentary rock record. General comparison between the Ordovician and Silurian polychaete faunas indicate that they were relatively unaffected by the end-Ordovician mass extinction. However, whereas the Late Ordovician scolecodonts are relatively well known, especially in Baltoscandia, the Silurian records primarily cover the latest Llandovery through Ludlow interval, leaving the basal Silurian faunas virtually unknown. This obviously complicates the possibility of evaluating the effects of the event in closer detail. In this study we have documented scolecodonts from the basal Rhuddanian (lowermost Silurian) Varbola Formation, central Estonia. Altogether 25 samples, comprising more than 10,000 scolecodonts, were studied from the Velise drill core and Reinu Quarry. The abundance of scolecodonts is comparable to that recorded from Upper Ordovician strata, with approximately 300 specimens per kg of rock, but reaching over 2000 specimens/kg in some samples. The polychaete assemblage recorded is rather diverse, containing at least 18 genera and 30 species. As expected, the Rhuddanian assemblage is dominated by polychaetaspids (*Oenonites*) and mochtyellids (*Pistoprion*, *Vistulella*, *Mochtyella*). In some samples, paulinitids (*Kettnerites*) are common, accounting for up to 20% of the fauna. Other families, such asatraktoprionids, xanioprionids and tetraprionids, only comprise a few per cent each. The genus level composition is similar to that of the Late Ordovician faunas, but some differences are observed at the species level: many Hirnantian species are absent and several new species are first recorded in the Rhuddanian. Yet other species seem to have been unaffected by the extinction event. For instance, *Pistoprion transitans*, often predominant in Hirnantian strata, is very common also in the Varbola Formation where it accounts for up to 20%. These new data suggest that jawed polychaetes endured the end-Ordovician crises seemingly with no, or insignificant, loss in genus and higher level taxonomic diversity and also that a number of species crossed the Ordovician-Silurian boundary. It is possible, however, that some gradual changes in the assemblage structure are related to the Hirnantian event. Detailed analyses of the collection at hand will thus allow new assessment of the response, such as the timing, severity and recovery patterns, of polychaetes to one of the most severe biotic crises of the Phanerozoic.
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BENTHIC ECOSYSTEM DYNAMICS THROUGH THE TRIASSIC-JURASSIC OF SOUTHWEST UK

Richard J. Twitchett[1], Autumn C. Pugh[2], James Brown[3], L. Felipe Opazo[4] and Silvia Danise[3]

1. Natural History Museum, Cromwell Road, London, SW7 5BD, UK. richard.twitchett@gmail.com
2. School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK.
3. School of Geography, Earth and Environmental Sciences, Plymouth University, Plymouth, PL4 8AA, UK
4. Florida Museum of Natural History, Gainesville, Florida, FL32611, USA.

The Late Triassic mass extinction is the largest biotic crisis to have affected post-Palaeozoic ecosystems and is intimately associated with evidence for CO_2 rise and global warming. Some of the best records of the Late Triassic extinction event and its subsequent recovery are exposed in coastal successions of southwest UK. Previous ichnological analyses have concluded that post-extinction recovery was complete by the late Hettangian, but comparative studies of the body fossil record are limited. Here we present the first quantitative palaeoecological analysis of the macroinvertebrate fossil assemblages spanning the Rhaetian to Sinemurian of southwest UK, focussing in particular on the classic and historically important exposure of the Blue Lias Formation around Lyme Regis. Quantitative data were collected from limestones in the field using 50 x 50 cm quadrats placed on exposed bedding surfaces, and bulk samples of the intervening mudstone lithologies were processed and picked in the lab. All macroinvertebrate fossil remains were counted and identified as far as possible, and a range of palaeoecological analyses were performed. As expected, assemblages around the Triassic/Jurassic boundary have lower richness, diversity, abundance and evenness compared to those of the upper Hettangian. Most palaeocommunities are characterized by low-motility, surficial, suspension feeders but higher tier organisms and an increase in functional richness characterise the later stages of recovery. Benthic shelf sea ecosystems of the latest Rhaetian to earliest Hettangian, associated with evidence for high atmospheric CO_2 conditions, were quantitatively different from those of the later Hettangian in terms of their structure and function. There are, however, also significant shifts within individual biozones and even between adjacent beds. The earliest Sinemurian records low diversity, high dominance macrofossil assemblages that may reflect environmental changes at that time, but these assemblages are compositionally and ecologically different from those of the latest Rhaetian or earliest Hettangian and are associated with a diverse and even trace fossil assemblage, which includes large diameter and deeply emplaced burrows that are indicative of normal marine conditions. Where there is a stratigraphic overlap, the trends recorded in the Lyme Regis study are comparable to those recorded from other UK sites, despite differences in sampling methodology, and therefore do not simply reflect local conditions or biases.

RECOVERY FROM THE K/PG MASS EXTINCTION IN ANTARCTICA

Rowan J. Whittle[1], James D. Witts[2], J. Alistair Crame[1], Jon Ineson[3], Jane E. Francis[1] and Vanessa Bowman[1]

1. British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK. roit@bas.ac.uk
2. School of Earth and Environment, University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, UK.
3. Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10, DK-1350, Copenhagen, Denmark.

The modern Antarctic marine fauna arose following the Cretaceous-Paleogene (K-Pg) mass extinction event, and biotic recovery occurred throughout the Cenozoic Era. New detailed stratigraphic sequences linked with comprehensive fossil collections from Seymour Island, located on the Antarctic Peninsula (65°S), has enabled the study of biotic recovery from the K-Pg mass extinction event. This locality comprises one of the best exposed and most complete high latitude Cretaceous–Eocene sedimentary sequences anywhere in the world. Lithologies comprise marine sandstones and siltstones deposited in a back-arc setting in the James Ross Basin. Fossil assemblages on Seymour Island are well preserved and include marine invertebrates and vertebrates, as well as terrestrial plant material washed in from the nearby Antarctic Peninsula. The K-Pg boundary occurs between units 9 and 10 of the López de Bertodano Formation, which were deposited in a mud dominated mid-shelf environment. The boundary was previously identified from dinoflagellate biostratigraphy and an iridium spike, and is exposed in the field as a prominent scarp slope in a glauconitic horizon. A bed of disarticulated fish material occurs immediately above the boundary along with high numbers of the large infaunal suspension feeding bivalve *Lahillia*. The early Paleocene molluscan fauna found in Unit 10 of the López de Bertodano Formation was dominated by infaunal taxa; two deposit feeding bivalves, three suspension feeding bivalves, one deposit feeding gastropod and one predatory gastropod. The ranges of many of these taxa extend into the overlying Paleocene Sobral Formation. A radiation of new molluscan taxa occurred ~0.5 million years after the K-Pg event close to the contact between the López de Bertodano and Sobral formations. Infaunal and epifaunal carnivorous neogastropods became more prominent at this level. Overall, the fossil community of the lower to middle Sobral Formation was dominated by molluscs living in a shallow water environment. A further speciation event occurred in the lower part of the succeeding Eocene La Meseta Formation.

LIFE AND DEATH AT HIGH LATITUDES: A REASSESSMENT OF THE CRETACEOUS/PALEOGENE (K/PG) MASS EXTINCTION EVENT IN ANTARCTICA

James D. Witts[1], Rowan J. Whittle[2], Paul B. Wignall[1], J. Alistair Crame[2], Jane E. Francis[1,2] and Robert J. Newton[1]

1. School of Earth and Environment, University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, United Kingdom. J.Witts@leeds.ac.uk
2. British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom.

The Cretaceous/Paleogene (K/Pg) extinction of 66 Ma is a key event in Earth history, with extinction of many previously dominant terrestrial and marine groups providing a foundation for the subsequent evolution and expansion of the modern fauna during the Cenozoic. This event is likely unique among the 'Big Five' extinctions of the Phanerozoic due to the abundant geological evidence suggesting a catastrophic extra-terrestrial impact was the primary cause. The K/Pg event is well studied in the northern hemisphere, but the timing, effects, and even the magnitude of the extinction in the southern hemisphere are still relatively poorly understood. The highest southern latitude site for studying this interval is Seymour Island, Antarctica (65°S today, and during the Late Cretaceous). Here, an exceptionally thick and abundantly fossiliferous Maastrichtian – Danian (~70 – 65 Ma) section is preserved within a sequence of marine siltstones and sandstones deposited in a back-arc basin setting to the East of the Antarctic Peninsula. We have produced stratigraphic range data for major macrofossil groups (primarily ammonite, bivalve and gastropod molluscs), based on detailed new sedimentary sections and a comprehensive taxonomic reassessment of the fauna from the shallow marine sediments of the ~1000 m thick López de Bertodano Formation exposed on Seymour Island. Initial results show a stable Maastrichtian community, with an initial increase and subsequent fluctuations in the diversity of the molluscan fauna up-section, probably related to sea-level and other latest Cretaceous environmental changes, before a single pulse of extinction coincident with the K/Pg boundary as defined by dinoflagellate biostratigraphy and a previously recognised iridium (Ir) spike. These new data do not support claims for a double extinction pulse and allow us to examine possible latitudinal and taxonomic selectivity of this major mass extinction event based on material from a true high-latitude setting.

SYMPOSIUM

COEVOLUTION OF THE EARTH AND LIFE: THE ROLE OF THE PHYSICAL ENVIRONMENT IN SPECIES EVOLUTION

ORGANIZERS:

ERIN E. SAUPE - CORINNE E. MYERS

NEW TWIST TO THE GALÁPAGOS BIODIVERSITY "STORY" REVEALED THROUGH PALAEOGEOGRAPHICAL MODELING

Jonathan C. Aitchison[1] and Jason R. Ali[2]

1. School of Geosciences, University of Sydney, Sydney, NSW 2006, Australia. jonathan.aitchison@sydney.edu.au
2. Department of Earth Sciences, University of Hong Kong, Hong Kong SAR, China.

Based on the present-day physiography of the Galápagos, we constructed a series of high-resolution palaeogeographical models for the archipelago for the last 700 kyr. These models accommodate thermal subsidence of ocean-islands, climate-related shifts in global sea level, and associated sea-floor loading/unloading. Analysis indicates that the combined effects of all three processes resulted in major changes to the pattern of land and sea. In particular, several large islands and their satellites in the central and western parts of the archipelago regularly connected for periods of 5-10 kyr before becoming isolated for ~90 kyr. For the majority of reptile clades occupying the "core", specifically the snakes, lava lizards, land iguanas, and leaf-toed geckos, this has profoundly impacted their biogeographical distributions, and as a consequence how sub-species and species have formed. A critical feature of our 'oscillating-geography shaped biota' mechanism is that it is amenable to testing. We suggest that molecular-clock derived phylogenies for the land-bound reptiles of the Galápagos will be most meaningful if they are constructed with nodes set at the following ages: ~20, ~138, ~252, ~342, ~433, ~546 and ~630 ka. Each of these ages represents an instant when sub-populations became isolated on high ground due to rapid rises in sea level. Finally, we argue that the part of the Galapagos faunal suite is even more exceptional than is generally thought because the fluctuating geography process may have similarly fashioned the biology on just a small number of other ocean-island systems (e.g. Canaries, Cape Verde, Maldives), at least on the modern Earth.

CONTINENTAL GATEWAYS AND THE DYNAMICS OF MAMMALIAN FAUNAL CHANGE

Catherine Badgley[1]

1. Department of Ecology and Evolutionary Biology, University of Michigan, 1109 Geddes Ave., Ann Arbor, MI 48109, USA. cbadgley@umich.edu

Tectonic and eustatic changes interact with climatic gradients over earth history to open or close narrow "gateways" for the passage of seawater or organisms dispersing from one region to another. First recognized in the marine realm (e.g., the Panamanian Isthmus, the straits of Gibraltar), these gateways have continental counterparts, particularly where long mountain ranges and changing regional sea level either open or close corridors to dispersal of flora and fauna. For mammalian faunas, the interaction of open versus closed gateways with changing versus stable climate results in four alternative biogeographic modes of evolutionary and ecological change. Each mode corresponds to unique predictions about origination rate, extinction rate, faunal turnover, and change in ecological structure. For example, the combination of open gateway and climatic stability should result in low rates of immigration and extinction, elevated endemic speciation, and stable ecological structure. In contrast, an open gateway and changing climate should result in elevated rates of immigration and extinction, low rates of endemic origination, and changing ecological structure. Three examples from the mammalian fossil record provide tests of these macroevolutionary scenarios in response to interacting changes in tectonics, sea level, and climate. (1) In the Siwalik record of the Indian subcontinent, mammalian faunas show a peak of immigration and changing faunal proportions during a Middle Miocene interval of low sea level and open dispersal corridors. A Late Miocene interval of regional aridification coincided with elevated extinction rates and changing trophic structure. (2) Late Miocene faunas of the Iberian Peninsula show elevated extinction and origination rates and change in ecological structure during regional aridification, and increasing endemism following intensification of Alpine uplift that restricted dispersal into the Iberian Peninsula. (3) In the Quaternary record of the Cape Floristic Province, South Africa, glacio-eustatic fluctuations alternately connected and isolated the western and southern coastal plains, which were isolated by montane barriers from the continental interior. Ungulates show a series of range contractions and extinctions, especially among open-habitat species, consistent with contractions of coastal habitat area, particularly grassland habitats, during interglacial intervals. These examples illustrate ecological and evolutionary responses of mammalian faunas to changes in regional landscape history.

(HOW MUCH) DOES THE PAST MATTER? EVALUATING THE INFLUENCE OF HISTORY ON EXTINCTION RISK

Seth Finnegan[1]

1Department of Integrative Biology, University of California, Berkeley, CA 94720-3140, USA.
sethf@berkeley.edu

Understanding the factors that control the waxing and waning of taxa is one of the central research agendas of paleobiology. Until recently, however, relatively little was known about the characteristic geographic range trajectories of taxa through time. Recent analyses of marine invertebrates show that both species and genera tend to exhibit relatively symmetrical trajectories. That is, they attain their maximum geographic range approximately midway through their stratigraphic range. This pattern is consistent with several possible models of the drivers of range expansion and contraction. It has been suggested to provide evidence that taxa experience discrete, directionally driven 'rise' and 'fall' portions of their histories and that once their geographic ranges begin to contract, they tend to continue to contract. However, it is also consistent with expectations from a bounded random walk: even if the likelihood of increasing or decreasing geographic range at any given time remains constant throughout a taxon's history, it will on average take it as long to decline to extinction as it took for it to rise to its peak. These two models make different predictions regarding the determinants of extinction risk. Both predict that, in a given interval, taxa with geographic ranges that have contracted relative to the preceding interval will exhibit greater extinction risk than taxa with stable or increasing geographic ranges. However, under the random walk model, the increased extinction risk simply reflects the fact that taxa that have declined have, on average, more restricted geographic ranges than those that have not. Under the driven model increased risk results, in part, from a tendency for taxa that have recently declined to continue to decline. In the first case, only present geographic range is informative for predicting extinction risk, and in the second case, both present and past geographic range are informative. I analyzed the Paleobiology Database to evaluate the relative support for the driven and random walk models of extinction risk in each of 72 Phanerozoic stratigraphic stages. Models that include only geographic range within a stage as a risk predictor are significantly outperformed by those that include change in range from the previous stage in 45-80% of all stages, depending on statistical approach and model selection criteria. I will discuss temporal and taxonomic variation in these results and explore their possible relationship to changes in the physical environment through time.

SPECIES DIVERGENCE SHAPED BY THE INTERSECTS OF ECOLOGY AND CLIMATE CHANGE

L. Lacey Knowles[1]

1. University of Michigan, 1109 Geddes Ave., Ann Arbor, MI 48109-1079, USA.
knowlesl@umich.edu

Most species we study today have been subject to periods of rapid climate change of differing severity at some point in their past. The impact of rapid climate change, and specifically its genetic consequences, has been studied at large geographic scales (e.g., comparisons between low and high latitudes). In contrast, we have a limited understanding of the genetic consequences of rapid climate change for taxa within local communities beyond simply describing patterns of genetic variation within and between populations. Yet, such information about *how* climate change impacts species divergence is essential for understanding *why* patterns of genetic variation differ across a landscape and vary among species. With the application of recent developments at the molecular level, as well as computational advances, what is emerging is a story of how patterns of genetic variation are shaped by an intersection of species ecology and climate change. I will review the methodologies that are propelling this promising area of research through the testing of hypotheses by coupling genetic tests with ecological-niche models informed from paleoclimatic variables. By reference to three examples – results from an analysis of an endemic lizard from southwest Australia, montane sedges from the Southern Rocky Mountains, and montane grasshoppers from the Northern Rocky Mountains – I discuss how these insights are useful for understanding not only how the divergence process may differ among geographic regions, but also why members of communities may respond differently to climate change.

DECLINING VOLATILITY, A MACROEVOLUTIONARY PROPERTY OF DISPARATE SYSTEMS: FROM FOSSILS, TO STOCKS, TO THE STARS

Bruce S. Lieberman[1] and Adrian L. Melott[2]

1. Department of Ecology & Evolutionary Biology and Biodiversity Institute, University of Kansas, Lawrence, KS 66045, USA. blieber@ku.edu

2. Department of Physics and Astronomy, University of Kansas, Lawrence, KS 66045, USA.

There are structural principles pertaining to the behavior of systems that lead to similarities in a variety of different contexts. Documenting such overarching principles represents a rejoinder to the Neodarwinian synthesis. Here we elucidate an example of congruent behavior in very different systems: there has been a tendency for more volatile entities to disappear from systems such that the volatility in these systems declines. We specifically focus on origination and extinction rates in the marine animal fossil record, the performance of stocks in the stock market, and the characters of star systems. We consider the evidence that each is experiencing declining volatility, and the broader significance of this. Extensive evidence exists to suggest that declining volatility is a widespread phenomenon spanning and uniting the three disparate areas discussed. The broader question is why? One reason is that in each area we are dealing with historical entities. The more volatile entities are, the more likely they are to reach a zero point from which there can be no possibility of return. With taxa this point is extinction. With stars, once they explode, they are, for all intents and purposes, extinct, and with stocks, below a certain stock price, the firm becomes bankrupt and become again, for all intents and purposes, extinct. The predilection to reach a zero point is seemingly exaggerated during times of heightened variability, for instance, mass extinctions and stock market crashes, and for stars early in the history of the universe. The notion that volatility tends to decline is worth discussing in reference to themes Stephen Jay Gould emphasized. For instance, many evolutionary trends and the decline of the .400 hitter in baseball can be explained by declining variance with a constant mean. There is a general relationship between Gould's principle and the principle articulated herein, but declining volatility is different because in the case of origination and extinction rates in the history of life, not only do these seem to change less through time, but the rates themselves are also declining. Ultimately, one of the reasons the Neodarwinian synthesis remained incomplete was that it emphasized one biological discipline: population genetics. One way of extending the synthesis and making it more complete is by incorporating contributions from other disciplines. Building on that notion, identifying general patterns across various areas of scientific and intellectual inquiry is another means of helping to bring the evolutionary synthesis to fruition.

ASSESSING THE CONTRIBUTION OF ABIOTIC NICHES AND DISPERSAL LIMITATIONS TO SPECIATION AND EXTINCTION UNDER CLIMATE CHANGE USING SIMULATION STUDIES

Corinne E. Myers[1], Huijie Qiao[2], Erin E. Saupe[3], A. Townsend Peterson[4] and Jorge M. Soberón[4]

1. Harvard University, 26 Oxford St, Cambridge, MA 02138 USA. cmyers@fas.harvard.edu
2. Institute of Zoology, Chinese Academy of Sciences, 1 Beichen W Rd, Chaoyang District, Beijing 100101, P.R. China.
3. Yale University, 210 Whitney Ave, New Haven, CT 06511 USA.
4. Biodiversity Institute, University of Kansas, 1345 Jayhawk Blvd, Lawrence, KS 66045 USA.

Species' geographic distributions are constrained by three main factors: abiotic niche requirements, biotic interactions, and dispersal constraints. Interactions among these factors during times of environmental change impact patterns of speciation, extinction, and distributional dynamics. However, determining the relative contribution of each factor is challenging, in both the fossil and modern biological records. We applied simulation studies to assess feedbacks between abiotic niche breadth, dispersal capacity, and environmental change to isolate their impacts on patterns of speciation and extinction. Specifically, we tested three hypotheses: 1) species with narrow niche breadths have higher rates of speciation and extinction; 2) species with rapid and far-reaching dispersal capacity (relative to the rate of climate change) have reduced speciation and extinction potential; and 3) increased rate and frequency of environmental change inhibits evolutionary change. Species with large and small niche breadths (defined by temperature and water availability) were chosen from a phylogenetically and ecologically diverse group of 1710 extant plants with known physiological climate tolerances. Dispersal capacity was manipulated as maximum search distance (radius). Climate fluctuated between "warm" intervals equivalent to the last interglacial and "cold" intervals equivalent to the last glacial maximum mapped onto Eurasia. Rate, frequency, and length of climate stability were varied to produce "fast", "medium", and "slow" climate change scenarios. Speciation and extinction events were documented by building a virtual phylogeny for each simulation. Preliminary results suggest that speciation and extinction are indeed damped in taxa with greater dispersal capacity, even under differing rates of climate change. Under the most rapid climate change scenario, however, species with poor dispersal capacity experienced particularly high rates of speciation and extinction. Species with narrow niche breadths showed higher speciation and extinction rates compared to those with broader environmental tolerances, especially under rapid climate change, while species with broader niche breadths showed reduced speciation potential. Interestingly, in all simulations, speciation and extinction rates varied in tandem, which matches observations throughout much of the fossil record. These results support expectations from macroevolutionary theory, where species with higher dispersal capacity are less likely to experience speciation via allopatry, and specialist species are more sensitive to extinction and speciation pressures than generalists.

BIOTIC AND ABIOTIC FACTORS AS POTENTIAL DRIVERS OF SPECIALIZATION IN PHANEROZOIC MARINE INVERTEBRATES

Sabine Nürnberg[1] and Martin Aberhan[1]

1. Museum für Naturkunde - Leibniz Institute for Evolution and Biodiversity Science, Invalidenstrasse 43, 10115 Berlin, Germany. sabine.nuernberg@mfn-berlin.de

Abiotic and biotic factors have been invoked to explain patterns in marine diversity, extinction rates, and – though rarely – origination rates. Among other mechanisms, niche subdivision, i.e. increasing specialization, has been considered to promote high levels of diversity. Yet, the relationship between specialization, standing diversity, and abiotic environmental conditions has not been determined quantitatively. Here, we address whether temporal variation in habitat specialization in marine invertebrates is related to standing diversity and its fluctuations or, alternatively, to several abiotic variables such as sea level change, nutrient input, shelf redox conditions, and global climate. We use sampling-standardized occurrence data from the Paleobiology Database to estimate diversity and to determine habitat breadth of marine genera as a proxy for their specialization in three major invertebrate groups (brachiopods, gastropods, and bivalves) over the Phanerozoic. Habitat breadth of a genus is defined as a function of its realized ranges in water depth, substrate mineralogy, and grain-size of the substrate. Our time series consists of 83 intervals, most of which are equivalent to geological stages. To analyze the impact of environmental change on habitat specialization, we use a data set containing estimates of eustatic sea level and isotopic proxies for environmental variables, such as $\delta^{18}O$ (proxy for temperature), $\delta^{13}C$ (proxy for changes in the carbon cycle), $^{87}Sr/^{86}Sr$ (proxy for inorganic nutrient input), and $\delta^{34}S$ (proxy for organic nutrient input or shelf redox conditions). Our time series analyses on the global scale indicate that habitat specialization of marine invertebrates is positively correlated with standing diversity. Times of high diversity are linked with preferential origination of specialists, and the total fauna tends to be more specialized than in periods with low standing diversity. In contrast, we find no evidence supporting an abiotic control of specialization in marine genera. These findings suggest that diversity and specialization are interdependent, and that the overall level of habitat specialization in marine invertebrates and its fluctuations through time are driven by biotic interactions.

ANALYZING THE MACROEVOLUTIONARY DETERMINANTS OF EXTINCTION RISK USING ECOLOGICAL NICHE MODELING: A CASE STUDY USING PLIOCENE—RECENT ATLANTIC COASTAL PLAIN MOLLUSKS

Erin E. Saupe[1], Huijie Qiao[2], Jonathan R. Hendricks[3], Roger W. Portell[4] and Bruce S. Lieberman[5]

1. Biodiversity Institute and Department of Geology, University of Kansas, 1475 Jayhawk Boulevard, Room 120 Lindley Hall, Lawrence, KS 66045, USA. eesaupe@ku.edu

2. Institute of Zoology, Chinese Academy of Sciences, 1 Beichen West Road, Chaoyang District, Beijing 100101, China.

3. Department of Geology, San José State University, Duncan Hall 321, San José, CA 95192, USA, and Paleontological Research Institution, 1259 Trumansburg Road, Ithaca, NY 14850, USA.

4. Division of Invertebrate Paleontology, Florida Museum of Natural History, University of Florida, 1659 Museum Road, PO Box 117800, Gainesville, FL 32611, USA.

5. Biodiversity Institute and Department of Ecology & Evolutionary Biology, University of Kansas, 1345 Jayhawk Boulevard, Dyche Hall, Lawrence, KS 66045, USA.

Determining which species are more prone to extinction is vital for conserving Earth's biodiversity and for providing insight into macroevolutionary processes over time. Here, we utilized the exceptional record of Pliocene—recent Atlantic Coastal Plain mollusks, in conjunction with Ecological Niche Modeling and deep-time climate models, to test the relative effects of geographic range size and niche breadth on survivorship of species from the Pliocene to the present-day. We assessed the vulnerability of 93 bivalve and gastropod species to extinction as a function of both fundamental and realized niche breadths, as well as geographic range size. We additionally examined whether extinct species lost more suitable habitat during the Last Glacial Maximum (~21 Ka) than still-extant species. Contrary to our expectations, extant species did not have larger fundamental niche breadths than extinct species. By contrast, the realized niche emerged as a key predictor of extinction risk. Our results also reiterate the well-supported idea that geographic range size is a key predictor of extinction risk. Similarly, amount of suitable area lost during the Last Glacial Maximum predicted survivorship for the studied mollusks. A potentially intriguing aspect of these results is that fundamental niche breadth appears to be decoupled from geographic range size with regard to extinction risk. In essence, this suggests that occupied environmental breadth (i.e., the realized niche) provides a greater buffer against extinction than potential tolerance limits (i.e., the fundamental niche), with the degree to which species are able to fill their fundamental niches providing the measure of extinction risk. This information can be used not only to implement proper conservation policies as we face current extinctions, but also to understand the properties promoting or inhibiting extinction —and perhaps speciation— across evolutionary time.

HOW DO SPECIES INVASIONS AND ENVIRONMENTAL CHANGE CAUSE NICHE EVOLUTION? CONSTRAINING THE LINK USING PALEOENM

Alycia L. Stigall[1]

1. Department of Geological Sciences and OHIO Center for Ecology and Evolutionary Studies, Ohio University, 316 Clippinger Laboratories, Athens, Ohio, 45701, USA. stigall@ohio.edu

Environmental change, including both biotic and abiotic change, is the primary driver of evolutionary innovation and extinction. Adaptive responses to environmental change that result in morphological divergence are concentrated during speciation events, whereas most species exhibit morphological stability during the remainder of their existence. Understanding the mechanisms that control when a species does and does not demonstrate an adaptive response is, therefore, a critical component of understanding evolutionary dynamics. Recent syntheses of ecological niche modeling analyses suggest that individual species may conserve the parameters of their ecological niches over long intervals of time. Yet, niche conservation is not ubiquitous among all species or all environmental changes. Identifying the underlying basis for these variable responses is important for conservation efforts and requires comparing multiple clades and styles of environmental change. To examine this issue, niche stability was analyzed for a suite of marine invertebrates that inhabited the shallow epicontinental seas of the Cincinnati Basin in eastern North America during the Late Ordovician Period (Katian Age). Niche stability was assessed for a broad set of 21 taxa including: trilobites, brachiopods, echinoderms, mollusks, and bryozoans. These species and genera experienced environmental changes including sea level fluctuations and a wave of species invasions during nine time slices spanning approximately three million years. Niche models were generated with Maxent and stability was assessed via geographic, ecologic, and parameter similarity between time slices. Niche stability varied through time. The focal taxa exhibited high fidelity habitat tracking and niche stability in geographic and ecologic space during the Pre-Invasion Interval characterized by gradual abiotic (sea level) change. An adaptive response, as indicated by increased niche evolution, became more common during and after the interbasinal invasion event, the Richmondian Invasion. Species adjusted to the increased competition by altering aspects of their niche. Notably, surviving taxa contracted their niche into a subset of their previous niche parameters. Niche contraction is interpreted as an adaptive response to increased competition from invasive species, and it was employed most successfully by generalist taxa. Notably, patterns of niche evolution were congruent between clades, trophic group, and at both the specific and generic level. Adaptive response (stability vs. evolution) was related to the tempo, mode, or a combination of both aspects of environmental change. Biotic interactions played a key role in driving biotic divergence via habitat partitioning at the species level in this case study.

THE NESTING STRATEGIES OF THE TITANOSAUR DINOSAURS

E. Martin Hechenleitner[1], Gerald Grellet-Tinner[1] and Luca E. Fiorelli[1]

1. Centro Regional de Investigaciones Científicas y Transferencia Tecnológica de La Rioja (CRILAR-CONICET). Entre Ríos y Mendoza s/n, Anillaco (5301), La Rioja, Argentina. emhechenleitner@gmail.com

Titanosauria is a clade of huge herbivorous dinosaurs whose representatives are known on all the continents, including Antarctica. Evidence currently suggests that this diverse group of sauropods used a variety of nesting sites worldwide. The rarity and nature of these nesting sites, combined with their abundance of egg clutches and eggs, indicate that sauropod dinosaurs were potentially colonial nesters and migrated to the same locations ('nesting-site fidelity') to lay their eggs. Historically, studies on nesting sites have focused on egg systematics, including diagnosis of eggs and eggshells fragments, which has resulted in a parataxonomic classification scheme. This trace fossil parataxonomy creates serious problems for understanding the paleobiological aspects of reproduction, as this classification scheme does not meet biological and evolutionary criteria. To date, no investigation has focused on the ecological and geological basis for the selection of titanosaur nesting sites that are distributed worldwide. Observations were performed on a series of well-known Cretaceous nesting sites in Argentina, South Korea, Romania, India, France and Spain. Preliminary observations strongly suggest that titanosaurs did not use the classic 'sit-on-eggs' incubation strategy typical of most modern dinosaurs, and instead must have relied on external environmental heat for incubating their egg clutches. Taking into account clutch composition and geometry, the nature of the sediments and their properties, and eggshell structures and conductance, it appears that titanosaurs adopted nesting behaviors comparable to those displayed by modern megapodes. This family of birds displays wide and specific nesting strategies, such as burrow-nesting in diverse media and mound building, which could explain the lack of true nesting traces, despite the overwhelming abundance of egg clutches in these nesting sites.

DECOUPLING OF LOCAL AND REGIONAL DOMINANCE IN TRILOBITE ASSEMBLAGES (NORTHWEST ARGENTINA): NEW INSIGHTS INTO CAMBRIAN-ORDOVICIAN ECOLOGICAL CHANGES

Beatriz G. Waisfeld[1,2] and Diego Balseiro[1,2]

1. Centro de Investigaciones e Ciencias de la Tierra (CICTERRA), CONICET and Universidad Nacional de Córdoba, Av. Vélez Sarsfield 1161, X5016GCA, Córdoba, Argentina. bwaisfeld@com.uncor.edu

2. Centro de Investigaciones Paleobiológicas (CIPAL), Facultad de Ciencias Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Av. Vélez Sarsfield 299, 5000, Córdoba, Argentina.

Significant changes in the ecological structure of benthic marine communities took place in Cambrian and Ordovician times. These changes have been mostly addressed on the basis of local trends of richness and evenness, however, and despite that patterns of biodiversity are strongly scale-dependent, aspects beyond the local scale are still little investigated. Previous research in Cambro-Ordovician successions of the Cordillera Oriental envisaged largely intergrading, highly dominated trilobite communities with little spatial turnover among environments. In order to disentangle this ecological structure at different spatial scales we explore patterns of abundance, evenness, and occupancy of dominant taxa across the onshore-offshore profile, through three time intervals (Furongian, middle Tremadocian, middle-upper Floian). The analysis of local dominance at the regional scale shows single taxa overwhelming dominant in the Furongian and in the middle Tremadocian (*Parabolina* and *Leptoplastides* respectively) across different environments, but six different dominants in the Floian. In that interval only one taxon (*Famatinolithus*) attains high occupancy but seldom reaches high dominance. In contrast, at the local scale only the Furongian records highly dominated assemblages, whereas local dominance decreases in the middle Tremadocian and the Floian. Thus, when both scales of analysis are combined, an unexpected scenario becomes evident. Strongly dominated assemblages at local and regional scales are restricted to the Furongian, whereas middle Tremadocian assemblages are much less dominated at the local scale. The middle Tremadocian only mirrors the Furongian regionally, as most assemblages are dominated by the same taxon along the whole gradient. Dominance decreases during the Floian, accounting for more even assemblages at both local and regional scales. Interestingly, the important middle Tremadocian decrease in local dominance matches previous analyses of the local evenness trajectory. Evenness progressively rose during the Cambro-Ordovician but exhibited a significant step up in the middle Tremadocian without an associated increase in taxonomic richness. Overall, the middle Tremadocian appears as a pivotal interval in the organization of communities from the Cordillera Oriental when a dramatic change in ecological structure took place. The switch in dominance occurred at first in local communities but only later at the regional scale, implying a decoupling in local versus regional dominance structures. These results highlight the impact of different scaled perspectives in the way that ecological processes are understood, and suggest that the aggregation of patterns and processes developed at local and regional scales within the same region are also influential to unravel Early Paleozoic reorganization of marine communities.

SYMPOSIUM

ROTTEN FOSSILS? EXPERIMENTAL AND ANALYTICAL APPROACHES TO DECAY AND EXCEPTIONAL PRESERVATION OF SOFT TISSUES

ORGANIZERS:

MARK PURNELL - SARAH GABBOTT

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COMPARING THE TAPHONOMIC BIAS OF MINERALIZATION AND KEROGINIZATION ON A SIMILAR INSECT SOURCE POPULATION

Evan P. Anderson[1] and Dena M. Smith[2]

1. Department of Geological Sciences, University of Colorado Boulder, UCB 399, Boulder, CO, 80309-0399, United States. Evan.P.Anderson@Colorado.edu

2. Department of Geological Sciences, University of Colorado Boulder, UCB 399, Boulder, CO, 80309-0399, United States.

There are many different mineralogical pathways by which soft-bodied fossils may be preserved, but which pathways offer better preservation quality, and how does this impact the morphological, taxonomic, and ecological information that can be recovered from a soft-bodied fossil assemblage? Soft-bodied fossil deposits are difficult to compare quantitatively because they are often separated by vast spans of time and space, and they preserve different groups of animals and plants with different integuments. However, the Green River Formation of the Piceance Creek Basin of Colorado offers an unusual opportunity for just such a quantitative comparison: these middle Eocene marlstones preserve fossil insects as carbonaceous compressions (via keroginization) at most sites, but at one locality, known as the Paleoburn, they are preserved as iron oxides (likely representing oxidized pyrite). This study quantifies the preservation state of insects from both the Paleoburn and a Green River Formation carbonaceous compression site, the Anvil Points, in order to compare the taphonomic bias between two deposits preserved by different preservation pathways, but derived from similar original insect populations. We predicted that the carbonaceous compression site would preserve greater numbers of insects from orders characterized by delicate body plans (like the flies and wasps) and more fragile morphologies with greater fidelity than the Paleoburn. This is because keroginized fossils have the potential to enter the fossil record with only a minimum of microbial decay, whereas the Paleoburn insects were originally preserved in pyrite, which requires substantial bacterial activity in order to produce the chemical constituents necessary for mineralization. The samples we examined included approximately 230 insects from the Paleoburn and 480 insects from the Anvil Points. Each specimen was measured for body size, taxonomically categorized, and scored for the number of antennae and legs they had, as well as the preservation state of the head, eyes, antennae, thorax, wings, legs, and abdomen. Our predictions were largely verified: the majority of insects identifiable to order at the Paleoburn site were beetles, while the delicate flies were the most common order at the Anvil Points site. Preservation quality scores generally were also higher at the Anvil Points site, particularly for morphologies like wing and eye preservation quality. Nonetheless, it is worth noting that the major insect orders were all represented at both sites even though their relative proportions differed, and that although finer detail was often lost at the Paleoburn, gross morphology was nonetheless frequently preserved.

SEDIMENT EFFECTS ON THE PRESERVATION OF BURGESS SHALE–TYPE FOSSILS

Nicholas J. Butterfield[1] and Lucy A. Wilson[1]

1. University of Cambridge, Department of Earth Sciences, Cambridge, CB2 3EQ, UK.
njb1005@cam.ac.uk

Marine sediments are represented by a wide range of mineralogies and textures which impart a first-order control on early diagenesis, including the preservation of interred carcasses. The enhanced early Palaeozoic preservation of carbonaceous compression fossils in Burgess Shale-type biotas suggests secular variations in the chemistry of sediment-carcass diagenesis, a hypothesis that can be tested via actualistic taphonomy. Experimental burial of polychaete (*Nereis*) and crustacean (*Crangon*) carcasses in kaolinite, calcite, quartz, and montmorillonite over a four-month period demonstrates a marked effect of sediment mineralogy on the stabilization of non-biomineralized integuments – the first step in producing carbonaceous compression fossils. The greatest preservational effect was with *Nereis* buried in kaolinite (recovery of robustly preserved cuticles including parapodia, palps and tentacular cirri), whereas *Nereis* in montmorillonite returned only chaetae. These morphological responses were paralleled by levels of preserved protein. Similar but more attenuated effects were observed with *Crangon*. A distinct taphonomic pathway was observed in quartz, where both *Nereis* and *Crangon* rapidly produced a permeating black exudate; transient black stains developed around carcasses buried in montmorillonite. The interplay of differing carcass histologies and sediment mineralogies also affected system pH, oxygen content, and major ion concentrations, further complexifying individual taphonomic circumstances. The particular susceptibility of *Nereis* to both diagenetically enhanced preservation and diagenetically enhanced decomposition most likely derives from the relative lability of its collagenous cuticle – vs. the inherently more recalcitrant, chemically unreactive cuticle of *Crangon*. We propose a mechanism of secondary, sediment/mineral-induced 'taphonomic tanning' to account for the enhanced morphological preservation of certain substrates, a complementary phenomenon to the primary, biological tanning of, e.g., arthropod cuticle and polychaete chaetae. As in the case of industrial tanning, the retention of original morphology during this process will depend on particular combinations of tanning agents, system pH and ionic concentrations. Under other (more typical) circumstances, however, the presence of chemically reactive sediment is likely to accelerate decay. Such idiosyncratic effects on tissue recalcitrance undermine the phylogenetic significance of sediment-free decay series. In light of the marked effects of sediment mineralogy on fossilization, the early Palaeozoic window for Burgess Shale-type preservation may be related to a coincident interval of low pH, glauconite-prone seas.

THE PRESERVATION POTENTIAL OF CELL NUCLEI

John A. Cunningham[1,2]

1. School of Earth Sciences, University of Bristol, Bristol, BS8 1RJ, UK. John.Cunningham@bristol.ac.uk

2. Department of Palaeobiology, Swedish Museum of Natural History, 10405 Stockholm, Sweden.

The discovery that the cell contents of decaying prokaryotes can condense to form structures that resemble nuclei has led to skeptical treatment of reports of fossilized nuclei. This is particularly true when the structures in question originate from Precambrian rocks. However, this debate has been reinvigorated by recent reports of structures that are considered to be too consistent in size, shape, occurrence and volumetric relationships with the hosting cells to have been formed by cellular degradation. Some have argued that these structures are best interpreted as fossilized nuclei. On the other hand, critics have used three main lines of evidence to argue that the preservation potential of nuclei is vanishingly small and therefore to question their entire fossil record. Firstly, the nuclear membrane consists of two lipid bi-layers that are only a few nanometers thick, so it might be expected to decay very rapidly. Secondly, nuclei have never been fossilized in taphonomy experiments. Thirdly, if nuclei were preserved one might expect that they would be found alongside other organelles thought to have higher preservation potential. However, although hypotheses regarding the preservation potential of nuclei can be tested by experimental taphonomy, few experiments have been designed to investigate these issues. Here I present results from taphonomy experiments that aim to address this and to understand the circumstances required for nuclei and other organelles to become preserved in the fossil record. The findings indicate that nuclei can survive in decay experiments for several weeks and have higher preservation potential than previously recognized.

FROM LAB TO LAGERSTÄTTEN: DOES SEDIMENT TYPE BIAS THE PRESERVATION OF ANATOMICAL CHARACTERS?

Sarah E. Gabbott[1], Theo I. E. Beecroft[1], Duncan J. E. Murdock[1] and Mark A. Purnell[1]

1. Department of Geology, University of Leicester, University Road, Leicester, LE1 7RH, UK.
sg21@le.ac.uk

Our view of life from deep time, the anatomy of organisms and their phylogenetic relationships is contingent on our ability to see through the haze of uncertainty introduced by processes of decay and preservation. This is especially true of exceptionally preserved non-biomineralized organisms from Konservat-Lagerstätten. Rates of decay are clearly important in controlling what tissues survive into the fossil record but our recent work has shown that the sequence in which anatomical characters are lost during decay has the potential to significantly bias our reading of the fossil record through stem-ward slippage, where the most phylogenetically informative characters are decayed and lost more rapidly than characters shared by more inclusive clades, and correlated character decay. Our knowledge of these biases is derived from analysis of sequences of character decay in simplified experimental systems. This approach is important if we are to establish null models and then test how particular physical and biotic variables might enhance or degrade preservation potential, but the results so far beg an important question: what is the effect of sediment type? Recent work by Butterfield and Wilson has demonstrated the impact of sediments on the *rate* at which organisms decay, but can the presence of sediment affect the *sequence* of transformation and loss of anatomical features? We decayed experimental organisms in closed containers with different sediment substrates (kaolinite, mica, or bentonite) and compared rate and sequence of character transformation and loss against a null model (artificial sea water). Nineteen characters were observed and sampled destructively over a period of several months. Our results allow us, for the first time, to determine whether the sedimentary environment in which carcasses decay can significantly bias the suite of characters that become preserved. Integrating decay data from the lab with data on the modes of exceptional preservation in fossils is the next step in unravelling real phylogenetic signal from taphonomic distortion.

EXPERIMENTS WITH MICROBIAL MATS AND IMPLICATION IN FOSSIL PRESERVATION

Miguel Iniesto[1], Anabel López-Archilla[1], Karim Benzerara[2], Carmen Guerrero[1] and Ángela D. Buscalioni[3]

1. Departamento de Ecología, Facultad de Ciencias, Universidad Autónoma de Madrid, Darwin, 2, Cantoblanco, 28049 Madrid, Spain.

2. Institut de Minéralogie, de Physique des Matériaux, et de Cosmochimie (IMPMC). Sorbonne Universités - UPMC Univ Paris 06, CNRS UMR 7590, MNHN, 4 Place Jussieu, 75005 Paris, France.

3. Departamento de Biología, Facultad de Ciencias, Universidad Autónoma de Madrid, Darwin, 2, Cantoblanco, 28049 Madrid, Spain. angela.delgado@uam.es

Microbial mats are morphologically and physiologically complex benthic communities differing notably from single-layer biofilms. Taphonomic experiments have been mainly based on biofilms, primarily because mat communities require special growth conditions, and thus, long-term tracking. Here we describe the biostratinomic phases which relate to exceptional fossil preservation, and elucidate the interrelationships between corpse decay and microbial community activity. We investigated the preservation of extant fishes (*Paracheirodon innessi*, *Danio rerio* and *Carassius auratus*), frogs (*Hymenochirus boettgeri* and *Bombina orientalis*) and insects (*Musca domestica*) enclosed in microbial mats in a shallow lake (Salada de Chiprana, Zaragoza, Spain) and undertook controlled experiments with and without microbial mats with varying light, temperature, and water salinity in tanks. Carcasses were monitored at set intervals and observed for up to 60 months. Decomposition in experiments with mats was compared against decomposition in sediment without mats. A range of quantitative and qualitative data was collected to i) establish the time sequence of decay; ii) describe the microenvironmental changes accompanying the decomposition process (e.g. O_2 concentration and pH); iii) identify the in situ formation of precipitates, and iv) record the production of carcass molds. Several techniques were employed including MEB, RMI and TAC to explore biostratinomic alteration of body integrity and soft tissue preservation; MiniProfiler MP4 microelectrode system to measure chemical profiles; and X-ray Diffraction, Raman microscopy and FIB/MET to analyse bioprecipitates. Our results demonstrate that microbial mats have a significant effect on delaying decomposition. Fish and frogs maintained their external body integrity where mats were present for a few years, while corpses with no mat involvement were rotten after day 15. Exceptional preservation of internal organs was also evident where mats were involved; fish swim bladders remained identifiable after 5 years. Experimental data from the laboratory suggest that microbial mats aid fossil preservation by providing a rapid entombment process that generates a protective sarcophagus inside of which the oxygen and pH deplete until anoxic conditions are reached. Consequently decomposition is slowed during the first several days (day 7 to day 10). When pH recovers to basic conditions microbial mats also promote bioprecipitates which are able to produce body replicas. These processes have a coherent explanation related to the metabolic activity of the mat community.

EXPERIMENTAL STUDIES IN EDIACARAN PRESERVATION

Marc Laflamme[1], James D. Schiffbauer[2] and Simon A. F. Darroch[3]

1. Department of Chemical and Physical Sciences, University of Toronto Mississauga, Mississauga, Ontario, L5L 1C6, Canada. marc.laflamme@utoronto.ca
2. Department of Geological Science, University of Missouri, USA.
3. Department of Geology and Geophysics, Yale University, PO Box 208109, New Haven, CT 06520-8109, USA.

The fossil record is fickle and biased. Sites that preserve soft-bodied organisms, as opposed to typical fossil assemblages of bones, teeth, and shells, are exceedingly rare and truly exceptional. *Konservat-Lagerstätten* represent the richest source of anatomical information for extinct species, offer more complete views of diversity patterns in deep time, and ultimately can open a window into the workings of ancient ecosystems typically afforded only to biologists studying modern systems. Understanding the early evolution and diversification of the Metazoa, as written in the Ediacaran fossil record, is reliant on our understanding of the preservational constraints affecting the fossilization of soft tissues in Ediacaran *Lagerstätten*. A two-pronged approach has been the focus of recent attempts at unraveling the geobiological intricacies in Ediacaran preservation. On the one hand, advanced instrumentation such as environmental scanning electron microscopy (ESEM), energy dispersive X-ray spectroscopic elemental mapping analyses (EDS)x-ray, photoelectron spectrometry (XPS), and electron probe microanalyzer wavelength dispersive X-ray spectroscopy (EPMA-WDS), was performed on sectioned Ediacaran fossils, revealing the importance of clay minerals and the precipitation of iron sulfides such as pyrite in casting the external morphology of the organisms (Jim Gehling's "death-mask" preservation). On the other hand, decay experiments conducted under controlled laboratory settings allowed for investigations into the replication of soft-tissue preservation, which identified controls on rates of tissue decay and early mineralization. This combined two-pronged approach provides a conceptual framework for understanding the distribution of Ediacaran-style preservation in time and space, and will parameterize the paleoenvironmental settings and conditions where body fossils are preserved in the Neoproterozoic.

NON-INTEGUMENTARY MELANOSOMES CAN BIAS RECONSTRUCTIONS OF THE COLOURS OF FOSSIL VERTEBRATE SKIN

Maria E. McNamara[1,2], Jonathan S. Kaye[1], Mike J. Benton[1] and Patrick J. Orr[3]

1. School of Earth Sciences, University of Bristol, Queen's Road, Bristol BS81RJ, UK.
2. School of Biological, Earth and Environmental Sciences, North Mall, Cork, Ireland. maria.mcnamara@ucc.ie
3. UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4, Ireland.

The soft tissues of many fossil vertebrates preserve melanosomes – micron-scale organelles used to inform on original integumentary coloration and the evolution of visual signaling strategies through time. In extant vertebrates, however, melanosomes also occur in internal tissues, and hence melanosomes preserved in fossils may not derive solely from the integument. Here, by analyzing the internal tissues of extant and fossil frogs, we show that non-integumentary melanosomes are extremely abundant; they are usually localised to the torso in fossils but can also occur in the limbs, presumably due to dispersal during decay. Melanosomes from the body outlines of fossils cannot, therefore, reliably inform on integumentary coloration. Crucially, non-integumentary and integumentary melanosomes differ in geometry in both fossil and modern frogs and, in fossils, occur as discrete layers. Analysis of melanosome geometry, distribution and size-specific layering is required to differentiate integumentary from non-integumentary melanosomes and is essential to any attempt to reconstruct the original colours of vertebrate skin.

BEYOND THE BUCKET: TESTING THE EFFECT OF EXPERIMENTAL DESIGN ON RATE AND SEQUENCE OF DECAY

Duncan J. E. Murdock[1], Sarah E. Gabbott[1] and Mark A. Purnell[1]

1. Department of Geology, University of Leicester, University Road, Leicester, LE1 7RH, UK.
duncan.murdock@le.ac.uk

Experimental decay has revealed the potential for profound biases in our interpretations of exceptionally preserved fossils, with non-random sequences of character loss distorting the position of fossil taxa in phylogenetic trees. By characterising these sequences we can take account and compensate for this distortion and make better-informed interpretations of the anatomy and affinity of enigmatic fossil taxa. Equally, rate of character loss is crucial for estimating the preservation potential of phylogenetically informative characters, and revealing the mechanisms of preservation themselves. However, experimental decay has been criticised for poorly modeling the real conditions of exceptional preservation, and dismissed by some as unsophisticated 'bucket chemistry'. Here we test the effect of a range of experimental parameters on the rate and sequence of decay, using a range of animals from across the tree of life. By doing so, we are able to assess how robust the assumption is that the results of decay experiments are applicable to informing interpretations of a range of exceptionally preserved fossil taxa from diverse preservational settings. More specifically, using a series of iterative experimental designs, we systematically compare the rates and sequences of decay of both cuticularised and entirely 'soft' organisms rotting on different substrates, with different microbiological communities and, across a range of body sizes. Our results demonstrate the validity of using experimentally derived sequences of character loss as tools in anatomical and phylogenetic interpretation and analysis, and sheds light on the extent to which environmental variables need to be taken into account. With careful consideration of experimental design, driven by testable hypotheses, decay experiments are robust and informative – experimental taphonomy needn't kick the bucket just yet.

PROLONGED PRESERVATION OF SMALL CRUSTACEANS IN DIFFERENT CLAY COLLOIDS

Elena Naimark[1], Maria Kalinina[2], Alexander Shokurov[2] and Natalia Boeva[3]

1. Paleontological Inst. RAS, Profsouyznaya, 123, Moscow, 119017, Russia. naimark@paleo.ru.
2. Inst. of Physical Chemistry and Electrochemistry RAS, Leninsky prosp. 31, Moscow, 119071, Russia.
3. Inst. of Ore Geology and Minerology RAS, Staromonetny per. 35, Moscow, 119017, Russia.

Experimental burial of small crustaceans (nauplia of *Artemia salina* and adult specimens of *Daphnia sp.)* was carried out during 18 months in two types of clay sediment (kaolinite and montmorillonite) in fresh non-sterile water. In all cases, experimental remains were preserved much better than in the liquid phase above the sediment. A carcass extracted from the clay after 18 months still retained its shape and limbs with very fine anatomical details such as a filter comb, and sometimes the gut. The shape and limb morphology was retained after exposure of clay-exhumed remains to high pressure and temperature conditions (150ºC and 4 atm.). Enhanced preservation occurred in animals buried in kaolinite in comparison with animals buried in montmorillonite. In both clay sediments a decrease of the pH to 3.6-4.2 in the first two to three months occurred, after which a gradual increase to pH to 5.5 was recorded. Degradation of the remains formed a contrasting environment around every buried specimen in the sediment, although this affect was less clear in the montmorillonite; nevertheless, self-conservation of organics took place due to the low pH and tanning by Al-organic complexes. Chitin of the external integument appeared to be degraded in the case of *Artemia* nauplia, especially after thermo-pressure processing, but it persisted in the case of the remains in montmorillonite. We detected substitution of the surface integuments of both *Artemia* and *Daphnia* by clay derivatives, though the substitution was produced by different chemical elements in the two types of clays. In the kaolinite EDS/SEM-elemental mapping and spot analyses revealed kaolinite-like composition of the animals' surface along with carbon. In the montmorillonite a significantly higher ratio of Si (2-2.5 times) occurred in comparison with the clay sediment. The high content of Si became more evident in, for example, the thick shell of the *Artemia* eggs, in which this ratio, again, appeared to be the same magnitude. The thickness of the shell means that this result is unlikely to reflect a bias caused by deep penetration of the scanning beam to a silica (glass) template. We suggest that prolonged preservation of crustacean remains occurs in different clay colloids and that there is resistance to early diagenetic processes. Many fossils of the Burgess Shale Type, which are preserved as aluminosilicate carbonaceous films, show increased Si-content.

RECONSTRUCTING THE EARLY EVOLUTION AND MORPHOLOGY OF FOSSIL ENTEROPNEUSTS USING EXPERIMENTAL DECAY OF MODERN FORMS

Karma Nanglu[1,2], Jean-Bernard Caron[2,1] and Christopher B. Cameron[3]

1. Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, Ontario, M5S 2J7, Canada. karma.nanglu@alum.utoronto.ca

2. Department of Natural History Palaeobiology, Royal Ontario Museum, Toronto, Ontario, M5S 2C6, Canada.

3. Département de sciences biologiques, Université de Montréal, Montréal, Québec, H2V 2S9, Québec, Canada.

Decay experiments are becoming more widespread in the evaluation of the fidelity of the fossil record. These studies suggest that morphological characters do not decay randomly but follow a particular sequence of decay. Character interpretations of fossil specimens stand to benefit from an understanding of the timing and order of decay of phylogenetically informative characters. In this study we performed a decay experiment using the class Enteropneusta to assess the validity of anatomical interpretations of the Burgess Shale enteropneust *Spartobranchus tenuis* and to determine how the preservation of features compares with the sequence of character decay in extant analogues. We used three extant species, *Saccoglossus pusillus*, *Harrimania planktophilus* and *Balanoglossus occidentalis*, representing the two major families of Enteropneusta. Freshly-collected specimens were euthanized and incubated at 17°C over a time period of 5-10 days to observe the patterns of decay. Comparisons among decay sequences of the three species suggest that morphological characters decay in a consistent and predictable manner within the Enteropneusta, with minor variations among species and individuals. The collagen-based gill bars and nuchal skeleton were the most decay-resistant, and did not exhibit damage even at the most advanced stages of decay, whereas the gill pores and pre-oral ciliary organ were unequivocally the most decay-prone structures. The trunk and proboscis exhibited intermediate decay resistance. Decay patterns support the identification of the nuchal skeleton, gill bars, esophageal organ, trunk and proboscis in *Spartobranchus tenuis* and corroborate its harrimaniid affinity. The phylogenetic absence – rather than the taphonomic loss – of taxonomically informative characters, such as the genital wings and hepatic sacs, makes associations with other enteropneust families unlikely. The morphologically simple harrimaniid body plan can be seen, therefore, to be plesiomorphic within the enteropneusts. Discrepancies between the sequence of decay in a laboratory setting and other types of fossil preservation (i.e. in Mazon Creek specimens) also exist. These discrepancies are highlighted not to discredit the use of modern decay studies, but, rather, to underline their differences from actualistic taphonomy and the need to consider paleoenvironmental variables other than decay alone in a laboratory setting. Some of these variables, such as the time frame between death and early diagenesis, as well as pre- versus post-burial transport, are discussed relative to decay data from this experiment. Decay experiments reinforce the importance of a comprehensive understanding of decay timelines as a benchmark against which to describe fossil taxa and to understand the conditions prior to fossilization.

TAPHONOMY OF THE MONTCEAU-LES-MINES LAGERSTÄTTE (LATE CARBONIFEROUS, FRANCE)

Vincent Perrier[1] and Sylvain Charbonnier[2]

1. University of Leicester, Department of Geology, University Road, Leicester LE1 7RH, UK. vp110@leicester.ac.uk

2. Muséum national d'Histoire naturelle, Département Histoire de la Terre, CP 38, UMR 7207, Centre de Recherche sur la Paléobiodiversité et les Paléoenvironnements, 8, rue Buffon, 75005 Paris, France.

The Montceau-les-Mines Lagerstätte (Late Stephanian, Late Carboniferous) is located northeast of the French Massif Central. Situated at equatorial latitudes during the Pennsylvanian, this Lagerstätte, probably a freshwater environment, preserves a rich and diverse flora and fauna. The Montceau Lagerstätte displays exceptionally preserved fossils in the shales, where they are flattened, but the really remarkable material come from the nodules. The fossils from the nodules are exceptional for at least two reasons: the absence of major disarticulation of their body structure and the three-dimensional preservation of soft parts and extremely fragile cuticular structures. Decomposition in most Montceau fossils was minimal, indicating that the carcasses were protected from both mechanical and biochemical damage by their rapid burial, the anoxic conditions that prevailed in the sediment, and the lack of physically disrupting agents (e.g., scavengers, bioturbators). Most fossils from Montceau preserve their original three-dimensional form; even extremely fragile spherical syncarid eggs or poorly sclerotized insect nymphs were preserved in 3D. Such preservation was made possible by the combination of two main factors: 1- the early (bacterially mediated?) siderite precipitation created a protective microenvironment around the carcass, and through the nodule formation, prevented the compression of the fossils; 2- the phosphatization (apatite) of cuticles and soft-bodied features.

EXPERIMENTAL DECAY OF AVIAN INTEGUMENT: IMPLICATIONS FOR THE PRESERVATION OF SKIN IN THE FOSSIL RECORD

Christopher S. Rogers[1], Patrick J. Orr[2], Stuart L. Kearns[1], Michael J. Benton[1] and Maria E. McNamara[3]

1. School of Earth Sciences, University of Bristol, Wills Memorial Building, Queens Road, Bristol, BS8 1ND, UK. cr8392@bristol.ac.uk

2. UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4, Ireland.

3. School of Biological, Earth and Environmental Sciences, University College Cork, Distillery Fields, North Mall, Cork, Ireland.

The integument of extant birds is a complex organ; many of its distinctive ultrastructural features relate to the development and positioning of feathers. Whether such features can survive decay and be preserved in fossils - and thus indicate the presence/absence of feathers in dinosaurs - has not been investigated. This is especially surprising as fossilised integument is not uncommon in the geological record and previous reports of ultrastructural detail in fossil skin have informed on the organisms' biology. However, without taphonomic context we cannot hope to understand fossilised integument. Here, we investigate, for the first time, the physical taphonomy of avian integument during decay, with particular focus on the response of the feather bearing skin (pterylae), and the unfeathered skin (apterylae) to decay: do the adaptations of the skin to the presence of feathers influence its taphonomy? To test this, we degraded samples of integument of the zebra finch (*Taeniopygia guttata*) under controlled laboratory conditions and used scanning electron microscopy and histology to compare the ultrastructure of decayed and undecayed samples. Initial results indicate that while the pterylae and apterylae differ as to how they decay, this is secondary to differences between the dermis and epidermis. These separate from the underlying muscle during early decay. The dermis remains cohesive even when the epidermis disassociates into small irregular fragments (typically 200-600 μm long). Epidermal fragments become trapped within downy and body contour feathers close to the base of the rachis where plumulaceous barbules dominate. The profile of these epidermal flakes closely resembles that of the outer cortex of the feather rachis, which can also be shed and become trapped within the feathers of the animal. The results of this study will allow us to reliably recognise the presence of preserved avian skin that is likely to occur in the fossil record. This study provides context for any future discoveries of fossilised avian skin, allowing us to distinguish the preservation of pterylae and therefore the presence of feathers, as well as the degree of decay prior to fossilisation.

THE DIFFERENCE BETWEEN ABSENCE AND LOSS: PHYLOGENETIC ANALYSIS OF SOFT-BODIED FOSSILS REQUIRES VERY FEW ERRORS

Robert S. Sansom[1]

1. Faculty of Life Sciences, University of Manchester, Manchester M13 9PT, UK.
robert.sansom@manchester.ac.uk

Exceptionally preserved soft bodied fossils provide unique insight into many important evolutionary events, including the Cambrian explosion. The utility of fossils in these contexts is entirely dependent on their accurate placement in phylogenetic frameworks, yet intrinsic and widespread missing data make this problematic. The complex taphonomic processes of decay and preservation make it difficult to distinguish absence from loss; is a particular morphological character (e.g. appendage, tentacle or nerve) missing from a fossil because it was never there (phylogenetic absence), or just happened not to be preserved (taphonomic loss)? Complete taxa, both simulated and empirical, were subjected to data loss through the replacement of present entries (1s) with either missing (?s) or absent (0s) entries. Both cause taxa to drift down trees, from their original position, toward the root. Absolute thresholds at which downshift is significant are extremely low (2 entries replaced, 6% of present characters). The opposite threshold in empirical fossil taxa is also found to be low; two absent entries replaced with presences causes fossil taxa to drift *up* trees. As such, only a few losses interpreted as absences will cause fossil organisms to be erroneously interpreted as more primitive than they were in life. This observed sensitivity to coding presents a problem for all evolutionary studies that attempt to use exceptionally preserved soft bodied fossils to reconstruct rates of evolution or unlock sequences of morphological change. Stem-ward slippage, whereby fossilization processes cause organisms to appear artificially primitive, appears to be a ubiquitous and problematic phenomenon inherent to missing data, even when no decay biases exist. Absent characters therefore require explicit justification and taphonomic frameworks and data regarding decay patterns to support their interpretation.

EXPERIMENTAL TAPHONOMY AND RECONSTRUCTION OF FOSSIL COLOR

Jakob Vinther[1]

1. Schools of Earth Sciences and Biological Sciences, University of Bristol, Woodland Road, Bristol, BS8 1UG, United Kingdom. jakob.vinther@bristol.ac.uk

The study of fossil melanin has become a field of wide interest for its applicability for recognizing specific melanin bearing tissues and interpreting aspects of coloration in integumentary structures. Several approaches have been offered, which provide more or less direct ways to quantify the melanin content in a fossil and its melanin based coloration. In this talk I will review the strengths and weaknesses of these approaches and the progress made towards understanding the chemical alterations yielding the observed melanin residues. Several methods allow the melanin content in fossils to be quantified, but suffer from limited knowledge of the nature of the diagenetically altered composition of the chemically distinct eumelanin and pheomelanin. Ongoing experimental research has made significant advances in addressing these issues. The morphology of melanosomes has proven to be a valuable tool for assessing colors, irrespective of diagenetic alteration and shrinkage of the melanosomes. Black, grey, brown and iridescent can be assessed, and analysis of melanosomes is currently the strongest approach for color reconstruction. Proxies, such as tracing chelating metal complements in fossils using x-ray synchrotron scanning, are of little use as the signatures have no specificity to melanin and are affected by diagenetic alteration of the organic material, and by weathering. Mass spectrometric approaches in particular have proven particularly valuable for characterizing fossil and extant melanin. The potential for reconstructing fossil color has become a reality in the last 6 years, and will be a valuable tool in studies of ecology and evolution of animals in the next decades.

SYMPOSIUM

SAUROPOD DINOSAURS FROM GONDWANA: THE EVOLUTION OF GIANTS

ORGANIZERS:

BERNARDO GONZÁLEZ RIGA -
JORGE CALVO - MATTHEW LAMANNA

TITANOSAURS FROM THE UPPER CRETACEOUS MAEVARANO FORMATION OF MADAGASCAR: DIVERSITY, EVOLUTION, AND PALEOBIOLOGY

Kristina Curry Rogers[1]

1. Macalester College, St. Paul, MN, 55105, USA. rogersk@macalester.edu

Ongoing field exploration in the Mahajanga Basin of northwestern Madagascar has yielded two distinctive titanosaur taxa represented by hundreds of skeletal elements spanning hatchling to adult ontogenetic stages. Remains of *Rapetosaurus krausei* are among the most abundant fossils recovered from the Maevarano Formation. It is known from a wealth of well-preserved cranial and postcranial elements and has proven pivotal to ongoing revisions of titanosaur anatomy and phylogeny. It has also played a role in our understanding of osteoderm distribution and function within titanosaurs. A second, recently named titanosaur, *Vahiny depereti,* is currently known only from juvenile and adult cranial material, and comprises less than 10% of the total sauropod collection from the Maevarano Formation. Although *Vahiny* and *Rapetosaurus* co-existed in the same environment on the island of Madagascar, both share their closest taxonomic affinities with titanosaurs that lived elsewhere. Cranial material of *Vahiny* indicates close relationships with *Jainosaurus* (India), and *Muyelensaurus* and *Pitekunsaurus* (South America), while *Rapetosaurus* indicates closer affinities to *Isisaurus* (India) and *Nemegtosaurus* (Mongolia). Micro-CT scanning and traditional bone histological sampling of Malagasy titanosaurs yields a rich dataset for investigations of life history in these taxa, and allows testing of recent hypotheses that titanosaurs exhibit unique growth rates, distinctive bone tissue types, and/or truncated phases of active growth during ontogeny. The histological sample for *Rapetosaurus* includes an associated early juvenile postcranial skeleton (femur length = 19.5 cm) as well as an ontogenetic array of forelimb, hindlimb, and girdle elements. The largest sampled elements come from the largest *Rapetosaurus* individual known (femur length = 143.4 cm). Results indicate that highly vascularized fibrolamellar bone tissue with abundant vascularization and high osteocyte lacuna density characterizes primary growth in *Rapetosaurus* as in most other sauropods. However, even the smallest individual in the sample exhibits secondary remodeling that extends into the mid-cortex. By the time *Rapetosaurus* individuals are ~30% adult size, remodeling obliterates most primary growth signals in cortical bone. Expressed in Histologic Ontogenetic Stages (HOS), bone tissue in juvenile *Rapetosaurus* specimens is like that otherwise only observed in adult sauropods (HOS 12-14), and *Magyarosaurus,* thought to exhibit extremely reduced growth rate and diminutive adult body size. Hypotheses of insular dwarfism as proposed for *Magyarosaurus* are not valid in *Rapetosaurus*, for which large-bodied adults are known. Instead, alternative causative agents (e.g., biomechanical strain, blood calcium homeostasis) may be mediating the intense remodeling of bone tissue in the *Rapetosaurus.*

CONCAVO-CONVEX INTERVERTEBRAL JOINTS IN SAUROPODS AND CROCODYLIANS: DO THEY INCREASE FLEXIBILITY OR STABILITY?

John A. Fronimos[1] and Jeffrey A. Wilson[1]

1. University of Michigan Museum of Paleontology, 1109 Geddes Avenue, Ann Arbor, MI 48109-1079, USA.
jfronimo@umich.edu

Sauropod dinosaurs were the largest terrestrial animals, with highly elongated necks and tails held off the ground as cantilevers. The sauropod neck is composed of anteriorly convex and posteriorly concave (i.e., opisthocoelous) centra, a condition that appeared in the Late Triassic coincident with the appearance of large body size and neck elongation. This condition was retained in all members of the clade. Concavo-convex joints between centra have been proposed to either 1) enhance the range of motion of the vertebral column by permitting rotation or 2) stabilize the column against shear stress by nesting one articular surface within another and increasing their area of contact. If concavo-convex intervertebral joints facilitated a greater range of motion, then the most strongly convex condyles should occur in the most flexible regions of the vertebral column. If these joints stabilized the column, then the converse should be true. The American *Alligator* (*Alligator mississippiensis*) was chosen as the extant analog in which to test this hypothesis because crocodylians are the closest living relatives of sauropods that have comparable concavo-convex centra. Flexibility was measured in situ in an alligator using CT scans taken with the body manipulated to the maximum range of motion; these measurements were compared to the articular morphology of the same specimen after dissection. Results indicate that the most strongly convex condyles correspond to the least flexible parts of the spine, such as the anterior thoracic region. Conversely, the least convex condyles occur in the most flexible parts of the spine, such as the distal caudal region. It is therefore unlikely that concavo-convex intervertebral joints evolved to enhance flexibility. The most strongly convex condyles also have the greatest proportion of overlap by the cotylar rim, which permits less rotation and maximizes the depth of nesting and area of contact between the articular surfaces. This relationship is consistent with the hypothesis that concavo-convex joints between vertebral centra function primarily in resisting dislocation by shear stresses. It is probable that the early evolution and invariant retention of opisthocoelous cervical vertebrae in sauropods stabilized the elongate, cantilevered neck. The negative relationship between the degree of articular overlap and range of motion of intervertebral joints also suggests that the degree of overlap can provide useful insights into flexibility along the vertebral column in extinct taxa.

EXCEPTIONALLY-PRESERVED TITANOSAURS FROM MENDOZA PROVINCE, ARGENTINA, PROVIDE NEW DATA ON SAUROPOD PEDAL EVOLUTION AND DIVERSITY

Bernardo J. González Riga[1] and Matthew C. Lamanna[2]

1. Laboratorio de Dinosaurios, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Cuyo, Mendoza / CONICET-IANIGLA, CCT-Mendoza, Argentina. bgonriga@mendoza-conicet.gov.ar

2. Section of Vertebrate Paleontology, Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, Pennsylvania, 15213, USA.

The record of sauropod dinosaurs in South America is among the most important in the world, and includes around 52 species at present. The paleobiogeography of South American sauropods was influenced by geographical factors including the fragmentation of Gondwana and changes in sea level. Two evolutionary phenomena are particularly striking: (1) the replacement of diplodocoids by titanosauriforms during the early Late Cretaceous; and (2) the remarkable proliferation of titanosaurs throughout the Late Cretaceous. The pedal anatomy of lithostrotian titanosaurs has been poorly represented in phylogenetic analyses because complete pedes of these sauropods are extremely rare: only *Opisthocoelicaudia* (Mongolia), *Epachthosaurus* (Patagonia, Argentina), and the unidentified La Invernada titanosaur (Patagonia, Argentina) preserve this part of the skeleton in its entirety. Here we report two new titanosaurian species from the Coniacian–lower Santonian Plottier Formation, discovered by the first author in Mendoza Province, Argentina. Specimen UNCUYO-LD-301/302 (housed at Laboratorio de Dinosaurios, Universidad Nacional de Cuyo) is among the largest sauropod individuals yet found (humerus length = 1.79 m), and preserves a number of elements including a complete and articulated right pes. Its phalangeal formula is 2-2-2-2-0, and it shows a spreading metatarsus with a structure that is unique among Eusauropoda: metatarsals II–V are all short and similarly robust. Metatarsal IV is the longest, but metatarsal II to V exhibits little difference in length (less than 10 percent). Moreover, the proximal and distal ends of metatarsals I and II are wider than these metatarsals are long. The unguals of digits I–III do not show the 'sickle-shape' characteristic of other eusauropods. Specimen UNCUYO-LD-309 preserves both articulated pedes (phalangeal formula: 2-2-2-2-0) and has elongate and slender metatarsals and typically 'sickle-shaped' unguals. In the field, the articulated metatarsi of both specimens were inclined at 40 to 50 degrees, confirming a semi-plantigrade hind limb posture in these animals. The unguals were deflected laterally, as is observed in exceptionally-preserved titanosaur tracks discovered in the lower Campanian Anacleto Formation of Mendoza Province. These discoveries demonstrate that lithostrotian titanosaurs encompassed a greater pedal diversity than was previously appreciated. Furthermore, variation in the shapes and sizes of titanosaurian metatarsals and pedal phalanges and the progressive reduction of the phalanges provide data critical for informing phylogenetic analyses and evaluating morphofunctional and ichnological interpretations.

NEW TITANOSAURIFORM (DINOSAURIA: SAUROPODA) FOSSILS FROM THE EARLY LATE CRETACEOUS OF MOROCCO: IMPLICATIONS FOR SAUROPOD DIVERSITY AND PALEOECOLOGY ON THE AFRICAN CONTINENT

Matthew C. Lamanna[1] and Yoshikazu Hasegawa[2]

1. Section of Vertebrate Paleontology, Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, Pennsylvania, 15213, USA. lamannam@carnegiemnh.org

2. Gunma Museum of Natural History, 1674-1 Kamikuroiwa, Tomioka, Gunma 370-2345, Japan.

We describe two titanosauriform sauropod dinosaur fossils from the Cenomanian 'Kem Kem beds' of Morocco that collectively provide new insight into sauropod diversity and paleoecology in the early Late Cretaceous of continental Africa. Although the specimens pertain to the titanosauriform clade Somphospondyli, their precise systematic position(s) within that clade (as non-titanosaurian somphospondylans or basal titanosaurians) cannot be conclusively determined. One of the bones, a nearly complete, exquisitely-preserved anterior dorsal vertebra, is among the most anatomically informative titanosauriform elements yet recovered from the Late Cretaceous of continental Africa and the Arabian Peninsula. Comparisons with approximately coeval forms from the Bahariya Formation of Egypt—the titanosaurians *Aegyptosaurus* and *Paralititan*—suggest, but do not definitively demonstrate, that the vertebra does not belong to either of these taxa. Some early Late Cretaceous (Cenomanian–Turonian) somphospondylans from the African mainland appear strongly similar to one another: for example, the scapulae and humeri of *Paralititan* and *Angolatitan* share distinctive morphologies that may indicate a close phylogenetic relationship. By contrast, the femur of the only known titanosauriform partial skeleton from the Maastrichtian of continental Africa shows significant differences with an isolated titanosauriform femur from similarly-aged beds in Egypt, suggesting that at least two distinct lineages of these sauropods inhabited this landmass near the end of the Mesozoic. The second bone, an incomplete ischium, preserves little morphological information; nevertheless, the specimen is noteworthy in exhibiting numerous pits and grooves that we interpret as feeding traces left by a very large non-avian theropod. Previous works have proposed that at least some North African early Late Cretaceous theropods may have fed primarily on fishes; thus, the new traces are significant in demonstrating that sauropods were a food source for at least one such theropod as well.

COMMENTS ON A TITANOSAURID VERTEBRAL SEQUENCE ("SERIES A") FROM THE BAURU BASIN, BRAZIL

Elaine B. Machado[1] and Alexander W. A. Kellner[1]

1. Laboratório de Sistemática e Tafonomia de Vertebrados Fósseis, Departamento de Geologia e Paleontologia, Museu Nacional/UFRJ. Quinta da Boa Vista s/n, São Cristóvão, 20940-040 Rio de Janeiro, Brazil. kellner@mn.ufrj.br

Among the most important titanosaurid material from Brazil is one almost complete sequence of cervical vertebrae and some dorsal elements from the Upper Cretaceous of the Bauru Basin. This specimen was mentioned in the literature as "Series A" and now is being redescribed. The material belongs to the fossil collection of the Museu de Ciências da Terra (MCT 1487-R/ DNPM/CPRM). MCT 1487-R was collected by Lewellyn I. Price at the locality known as "Mombuca" (Minas Gerais State). The outcrop corresponds to the Marilia Formation (Maastrichtian age). The specimen is composed by a sequence of twelve cervical vertebrae (lacking the atlas) and three anterior dorsals. MCT 1487-R is a small subadult animal. MCT 1487-R presents a pre-epipophysis as reported in *Euhelopus*. Unlike *Brasilotitan*, MCT 1487-R lacks the anterior accessory articular surface near the prezygapophyses. The intraprezygapophyseal laminae are prominent and meet each other forming a wide "U shape", differing from the "V shaped" condition of *Brasilotitan*. MCT 1487-R also differs from *Brasilotitan* by the proportionally taller neural spine. The epipophyseal-prezygapophyseal lamina is similar to *Erketu* and *Uberabatitan*. The segmented postzygodiapophyseal lamina described in *Uberabatitan* is also present in MCT 1487-R (exceptin the 4th, 9th, 10th and 12th vertebrae,which have single lamina). MCT 1487-R and *Uberabatitan* differs in: the distal portion of the centrum which in *Uberabatitan*is concave or slightly flat in ventral view, while in MCT 1487-Ris convex; the posterior centroparapophyseal lamina is rounded and discrete in MCT 1487-R, contrasting to pointed condition in *Uberabatitan*; the tip of the neural spine in MCT 1487-R is convex and laterally expanded; and the prezygapophyses areshorter than in *Uberabatitan*. The major difference is the presence of acentropostzygapophyseal fossa in *Uberabatitan* (not noticed in the original description) which is absent in MCT 1487-R. *Aeolosaurus maximus* can be distinguished from MCT 1487-R by having the posteriorcentrodiapophyseal lamina at least 50% thicker than the postzygodiapophyseal lamina in the posterior cervicals, while in MCT 1487-R both laminae have almost the same thickness. *Trigonosaurus* differs from MCT 1487-R by having more robust and laterally expanded vertebrae. The prezygapophyses of *Trigonosaurus* are straighter, the neural spine is elevated, and the postzygapophyses are placed higher, while in MCT 1487-R the prezygapophyses are projected downward and laterally inclined. Although preliminary, those comparisons highlight some differences among those specimens, suggesting that MCT 1487-R represents a distinct taxon closely related with *Uberabatitan* and *Trigonosaurus* as well.

NEW PHYLOGENETIC CHARACTER SET SHEDS LIGHT ON THE LATE JURASSIC TO MID-CRETACEOUS EVOLUTION OF GONDWANAN SAUROPOD DINOSAURS

Philip D. Mannion[1] and Paul Upchurch[2]

1. Department of Earth Science and Engineering, Imperial College London, London, SW7 2AZ, UK. philipdmannion@gmail.com
2. Department of Earth Sciences, University College London, London, WC1E 6BT, UK.

Many aspects of the phylogenetic relationships of sauropod dinosaurs remain unresolved or controversial. Problems stem from ambiguous character definitions, high levels of homoplasy, missing data, and the heavy reliance on unrevised and non-augmented data sets that were generated over 10 years ago. As a first step towards the production of a thoroughly revised character set, we have created a data set of over 700 characters for 53 eusauropod taxa. This emphasises Diplodocoidea (29 taxa), but has representatives of non-neosauropods and Macronaria. Approximately 10% of these characters are entirely new, and many existing ones have been split into multiple characters, heavily revised, and/or rescored based on first-hand examination of specimens (43 taxa). Analysis of this data set in TNT, with *Shunosaurus* as the outgroup, produced 44 most parsimonious trees of length 2123 steps. The relationships of Flagellicaudata and Titanosauriformes are fully resolved and well supported, but resolution is lower around the base of Neosauropoda and for rebbachisaurids. Application of reduced consensus clarifies the positions of most taxa via *a posteriori* removal of highly incomplete forms. The results support many widely accepted aspects of eusauropod phylogeny, including the monophyly of Neosauropoda, Diplodocoidea, Flagellicaudata, Rebbachisauridae, Macronaria, Titanosauriformes and Titanosauria. However, the positions of some taxa or clades differ from those proposed by previous analyses. *Histriasaurus* is placed as the most basal rebbachisaurid, with *Amazonsaurus* and *Comahuesaurus* successively nested within basal Rebbachisauridae. Nigersaurinae is composed of the Afro-European taxa *Demandasaurus* and *Nigersaurus*, but also includes *Rebbachisaurus* and *Tataouinea*. There is evidence for several Argentinean taxa forming a limaysaurine clade. Within Titanosauria, *Epachthosaurus* is confirmed as a lithostrotian, rather than a basal titanosaur, and *Rapetosaurus* is more closely related to saltasaurids than to *Malawisaurus*, contradicting the largest previous analysis of titanosaur relationships. In a subsequent set of analyses, we have also explored the positions of enigmatic taxa from the Late Jurassic Tendaguru Formation of Tanzania. Although these fragmentary taxa degrade the overall phylogenetic signal, we are able to determine their approximate placements. The putative titanosaur *Janenschia* is recovered as a non-titanosauriform macronarian, whereas the sympatric *Australodocus* is the earliest known somphospondylan. A caudal sequence previously referred to *Janenschia* provides the first unambiguous evidence for a non-Asian mamenchisaurid. This new data set will form a platform for developing a greater understanding of the evolution of sauropod dinosaurs, in particular with regard to the impact of Pangaean fragmentation on their biogeographical history.

JURASSIC SAUROPODS FROM PATAGONIA AND SAUROPOD FAUNAL REPLACEMENT IN THE JURASSIC

Diego Pol[1], Oliver W. M. Rauhut[2] and José L. Carballido[1]

1. Museo Paleontológico Egidio Feruglio, Fontana 140, 9100 Trelew, Argentina. dpol@mef.org.ar
2. SNSB, Bayerische Staatssammlung für Paläontologie und Geologie, Richard-Wagner-Str. 10, 80333 Munich, Germany.

The main diversification of sauropod lineages dinosaurs happened during the Jurassic, but especially the pre-Late Jurassic sauropod record is still rather poor. Thus, the origin of the Late Jurassic and Cretaceous sauropod faunas is still poorly understood. In South America, pre-Cretaceous sauropod dinosaurs are mainly known from the Cañadón Asfalto Basin of Central Patagonia. Within this basin, two geological units have yielded sauropod remains, the Cañadón Asfalto Formation and the Cañadón Calcáreo Formation. From the latest Early to early Middle Jurassic Cañadón Asfalto Formation, two sauropod taxa have been described so far, the basal eusauropods *Patagosaurus* and *Volkheimeria*. Two further taxa of sauropods are represented by so far undescribed material. Phylogenetic analysis demonstrates that all of these taxa are basal, non-neosauropod sauropods, representing at least three distinct lineages. The Late Jurassic (Oxfordian-Kimmeridgian) Cañadón Calcáreo Formation has yielded two taxa of sauropods, the basal macronarian *Tehuelchesaurus* and the dicraeosaurid *Brachytrachelopan*. Furthermore, fragmentary remains indicate the presence of a brachiosaurid titanosauriform and a diplodocid. Thus, the taxonomic composition of the sauropod fauna from the Cañadón Calcáreo Formation is markedly different from that of the Cañadón Asfalto Formation, but remarkably similar to roughly contemporaneous faunas from the Morrison Formation of North America, various units in Europe, and the Tendaguru Formation of Tanzania. These records show that a sauropod assemblage formed by basal macronarians, basal titanosauriforms, and diplodocids had been established by the Kimmeridgian at the latest both in Gondwana and western Laurasia. The Middle Jurassic sauropod fossil record indicates that up to the Bathonian sauropod assemblages were dominated by basal eusauropods (non-neosauropodan sauropods), this indicates a rapid sauropod faunal turnover from the Middle to the Late Jurassic. Taking into account palaeogeographical reconstructions, this faunal replacement probably happened between the Bathonian and the beginning of the Oxfordian, in a geologically short period of less than five million years.

AN EVOLUTIONARY CASCADE MODEL FOR SAUROPOD DINOSAUR GIGANTISM: OVERVIEW, UPDATE AND TESTS

P. Martin Sander[1]

1. Steinmann Institute, Division of Paleontology, Nussallee 8, University of Bonn, Germany.
martin.sander@uni-bonn.de

Sauropod dinosaurs are a group of herbivorous dinosaurs that exceeded all other terrestrial vertebrates in mean and maximal body size and were the most successful herbivorous tetrapod clade. Abiological factors, such as global environmental parameters, that might have been conducive to their gigantism have not yet been identified. As such questions surrounding sauropods as living animals, their evolutionary success, and unique gigantic body size continues to fuel research. Contributions to this research program have come from many fields and can be synthesized into a biological evolutionary cascade model of sauropod dinosaur gigantism (sauropod gigantism ECM). This review focuses on the sauropod gigantism ECM, providing an updated version based on recent published evidence. The model consist of five separate evolutionary cascades (''Reproduction'', ''Feeding'', ''Head and neck'', ''Avian-style lung'', and ''Metabolism''). Each cascade starts with observed or inferred basal traits that either may be plesiomorphic or derived at the level of Sauropoda. Each trait confers hypothetical selective advantages which permit the evolution of the next trait. Feedback loops in the ECM consist of selective advantages originating from traits higher in the cascades but affecting lower traits. All cascades end in the trait ''Very high body mass''. Each cascade is linked to at least one other cascade. Important plesiomorphic traits of sauropod dinosaurs that entered the model were ovipary as well as no mastication of food. Important evolutionary innovations were an avian-style respiratory system and an elevated basal metabolic rate. Comparison with other tetrapod lineages identifies factors limiting body size.

THE SKULL OF THE TITANOSAUR *TAPUIASAURUS MACEDOI*: NEW INSIGHTS INTO TITANOSAUR FEEDING BEHAVIOR

Jeffrey A. Wilson[1], Alberto B. Carvalho[2], Diego Pol[3] and Hussam Zaher[2]

1. Museum of Paleontology & Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI, USA. wilsonja@umich.edu

2. Museu de Zoologia da Universidade de São Paulo, Serviço de Vertebrados, São Paulo, SP, Brazil.

3. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Museo Paleontológico Egidio Feruglio, Trelew, Argentina.

The recent discovery of a partial skeleton of the sauropod dinosaur *Tapuiasaurus macedoi* by Zaher and colleagues offers the first glimpse at the skull of a titanosaur from South America, where the greatest diversity of that group has accumulated since the late 19th Century. Surprisingly, although Titanosauria is the most diverse and late-surviving sauropod lineage, cranial elements are known for just over 20 of its 50+ genera—the vast majority of which are fairly fragmentary and restricted to the Late Cretaceous. Only four complete titanosaur skulls have been described to date; three of these are from the latest Cretaceous (*Nemegtosaurus*, *Rapetosaurus*, *Quaesitosaurus*), and the fourth, *Tapuiasaurus*, is from the Early Cretaceous (Aptian). Despite the ca. 70 Ma interval separating these Early and latest Cretaceous titanosaurs with complete skulls, phylogenetic analyses have recovered them as a monophyletic group called Nemegtosauridae. The hypothesis that *Tapuiasaurus* is more closely related to other nemegtosaurids than to other titanosaur genera is supported by features of the postcranial skeleton and cranial elements that are more commonly preserved (e.g., braincase); it implies a lengthy ghost lineage and that the peculiar morphology of the nemegtosaurid skull evolved early in the Cretaceous but is not primitive for Titanosauria. Here, we present further investigation of the skull anatomy of *Tapuiasaurus macedoi*, which improves its diagnosis and allows the interpretation of its feeding adaptations. The skull of *Tapuiasaurus* is approximately half a meter long and nearly half as tall. The dentigerous portion of the skull in *Tapuiasaurus* represents 28% its total length, which is slightly greater than in *Diplodocus* (17.5%) or *Nemegtosaurus* (20%). The values for these narrow-crowned forms differ significantly from those of broad-crowned forms (e.g., *Camarasaurus* = 50%), which have a comparable number of broad teeth, and from those of basal sauropodomorphs (e.g., *Plateosaurus* = 60%), which have a large number of medium-breadth teeth. Other similarities, which are independently derived, include the overall shape of the skull (braincase rotated posteriorly relative to the snout), elevated tooth replacement rates, and prominent vascular grooves on the dentigerous snout. Our study provides insights into the herbivorous adaptations that are shared by these narrow-crowned forms (diplocodoids, titanosaurs) and those that are unique to at least nemegtosaurid titanosaurs. We present a new hypothesis for titanosaur feeding, which supports modified version of the 'guillotine' hypothesis for titanosaur feeding forwarded a decade ago.

SAUROPOD DINOSAUR TRACKS FROM THE EARLY CRETACEOUS OF CHINA

Niels Bonde[1] and Eliza Estrup[2]

1. Zoological Museum (SNM), Universitetsparken 15, 2100 Copenhagen Ø and Fur Museum (Museum Salling), 7884 Fur, Denmark. Nielsb.pal@gmail.com

2. Geocenter Møns Klint, Møn, Denmark.

In 2011, large dinosaur tracks were found on a small clay surface (2.4 x 3.2 m) covered by ash in parallel-laminated lake sediments of the middle section of the Yixian Formation (Early Aptian) in Liaoning, China. The discovery, carried out by Eliza Estrup and the senior author, includes tracks clearly assigned to sauropod dinosaurs based on their shape and size, but that exhibit unusual traits. Morphotype 1 comprises two large and subcircularpes tracks that are about 45 cm in diameter; they have neither claw nor toe impressions. Two relatively small roundish tracks without claw impressions (ca. 25 cm) are preliminary assigned to manus prints. If so, the trackway is narrow. Morphotype 2 is represented by two other tracks, left and right close to each other; they have elongated shape (ca. 40 length, 25 cm width) and are characterized by the absence of toes or claw impressions with the antero-medial part separated from the rest, probably because the metatarsal one is inclined inwards while the others are vertical lateral to a big pad. There seem to be no toes, and probably pedal printsrather than manual prints are recorded. Both types are produced by sauropods walking on the metatarsals surrounding large pads and making narrow trackways. Morphotype 1 also exhibits manus prints without toes or claws. Morphotype 3 includes three pairs of smaller, ca. 20 cm roundish tracks, with the hindfoot stepping up in the forefoot, without traces of toes. If they are from one trackway, this is extremely wide, or the animal was turning and sliding a little. The record of sauropod skeletal parts in this formation only include teeth, but we have also seen four large cervical vertebrae in a local museum, apparently not yet published.On the same clay surface three other small tracks were found. One of them had four round toemarks and subcircular shape (ca. 17 cm) and was produced possibly by thyreophoran dinosaurs. The others are indeterminate.The findings described here comprise a new tracksite of sauropod and thyreophoran dinosaurs from the Early Cretaceous with anatomical data useful for more detailed ichnological and paleoecological studies.

DINOSAUR (TITANOSAURID) FOOTPRINTS FROM LATE CRETACEOUS INTERTIDAL SEDIMENTS OF NEW ZEALAND

Greg H. Browne[1] and Lucia Roncaglia[1]

1. GNS Science, 1 Fairway Drive, Lower Hutt 5010, New Zealand.
l.roncaglia@gns.cri.nz

Titanosaur Sauropod footprints from Late Cretaceous (Maastrichtian) intertidal sediments have been recognized at six sites in NW Nelson, New Zealand. These are the first evidence for dinosaurs in the South Island and the first dinosaur footprints recognized in New Zealand. The trace fossils are preserved both in cross section and plan view and range in size between 5 and 60 cm diameter. They are preserved in finely laminated carbonaceous ripple and parallel laminated sandstone and mudstone interpreted to represent intertidal sand and mud flats. They are associated with channelized sandstones and shoreface sandstones of this coastal estuary/beach paleoenvironment. Footprints occur as individual structures rather than tracks due to the limited extent of the outcrop exposures. Typically they are semi-circular in shape in plan view, and display one margin that is either characterized by small scale fractures, or by crenulated sand interpreted as the toe portion of the footprint, formed when the foot lifted from the sand. In cross section, they show deformed bedding features at the margin and below the structures, and either massive or brecciated sandstone/mudstone sediment infilling the footprint. One locality has rather poorly defined footprints in cross sectional view, with homogenized sediment infilling the footprint, and little deformation in sediments underlying the footprint. Such examples are interpreted as formed by sauropods which were either swimming or were partially supported in water. No hard parts have been recognized at the various sites, and this is thought to reflect the terrestrial oxidizing nature of these coastal environments. In New Zealand, a dedicated national dinosaur footprint exhibition started in June 2014, displaying replicas of these trace fossils at several museums throughout the country. Plans are also underway to save some of the footprint specimens from modern coastal erosion which threatens to destroy some of the examples.

NEW FOSSIL REMAINS OF *FUTALOGNKOSAURUS DUKEI* (SAUROPODA, TITANOSAURIA) FROM THE LATE CRETACEOUS OF NEUQUÉN, ARGENTINA.

Jorge O. Calvo[1]

1. Grupo de Transferencia Proyecto Dino, Ruta 51, km 65, Neuqué, and Cátedra de Introducción a la Paleontología, Facultad de Ingeniería, Univ. Nacional del Comahue, Buenos Aires 1400, (8300) Neuquén, Argentina. jocalvo@hotmail.com

Since 2000 the Futalognko quarry, at Barreales lake, has given a rich upper Cretaceous fauna and flora (Río Neuquén Subgroup, late Turonian – late Coniacian - Neuquen Province, Argentina). The most amazing material is one of the giantest sauropod ever found, *Futalognkosaurus dukei*. The type is based on an almost complete skeleton. Here we present new remains that were found in the paleontological site and assemblage of the holotype. The new materials include left femur, left fibula, left humerus, right ulna and radius, one metatarsal, one ungueal phalange, two metacarpal, one anterior caudal, one middle-anterior caudal and two haemal arches. The complete femur (198 cm) is robust, straight, with a prominent head as those present in other Titanosauridae. A slight lateral bulge stands out, as in other Titanosauriformes such as *Brachiosaurus, Chubutisaurus, Austrosaurus, Aegyptosaurus, Phuwiangosaurus* and most titanosaurs. The femoral head is small and it extends dorsally surpassing the greater trochanter. The tibial condyle is slightly smaller than the fibular one. A robust and short left humerus (156 cm) has the proximal end (60 cm) expanded approaching a 40% of the total length of the bone as that in *Saltsaurus, Neuquensaurus, Opishocoelicaudia* and *Argyrosaurs*, but different to *Mendozasaurus*. The proximal border, relatively straight as in *Mendozasaurus*, is different to the sigmoid type present in *Saltasaurus* and the convex border in *Titanosaurs colberti*. The deltopectoral crest is very prominent and reaches the middle of the shaft. The distal end shows prominent condyles (45cm). The ulna, radius and metacarpals are similar to those of other titanosaurs. In particular, the metacarpals (47 cm) exhibit slightly expanded ends, reduced diaphysis and have not convex phalangeal articular facets, like in all Titanosauria. The ulna (95 cm) is robust and straight; the proximal end (46 cm) is triradiate as in other Sauropoda. The radius (94 cm) is slender with expanded ends; the proximal ones, is flat and the distal one is slightly rounded. A slender fibula (114 cm) has an oval and flat proximal end. The middle anterior caudal body (length, 24 cm; width, 21 cm; height, 22 cm) is strongly procoelous with a robust but short neural spine (43 cm high), the prezigapophyses are directed posteriorly. The anterior caudal is similar to that described for the holotype (87 cm high). The new materials allow improving the knowledge of this giant Titanosauridae sauropod. [ANPCyT: 2011-2591-UNCo: 04/I082. Chevron SA, Pan American Energy].

LATE CRETACEOUS SAUROPOD DINOSAURS OF TRIÂNGULO MINEIRO REGION (MINAS GERAIS STATE, BRAZIL)

Caio Cesar de Faria[1], Lívia Motta Gil[2] and Carlos Roberto A. Candeiro[2]

1. Universidade Federal do Rio de Janeiro, Programa de Pós-Graduação em Geologia, Instituto de Geociências, CCMN, Cidade Universitária, Ilha do Fundão, Av. Athos da Silveira Ramos, 274, Bloco G, 21941-916, Rio de Janeiro, Brazil. caio_321@gmail.com

2. Universidade Federal de Uberlândia, Laboratório de Geologia, Avenida 20, 1.600 Bairro Tupã, Ituiutaba, Minas Gerais, Brazil.

In the Triângulo Mineiro region, the sauropod fauna from Late Cretaceous is quite representative and is restricted to Marília, Adamantina and Uberaba Formations. From the Adamantina Formation on the Uberaba City (late Maastrichtian) are known the titanosaurian *Trigonosaurus pricei*, *Baurutitan britoi* and *Uberabatitan ribeiroi*. Furthermore, occurrences assigned to Titanosauria indet., *Titanosaurus* indet, *Aeolosaurus* sp., *Aelosaurus* related and eggshells of Faveoloolithidae were also found in Uberaba region. The late Maastrichitian Marília Formation in Veríssimo area includes titanosauriform Titanosauria indet. and aeolosaurid *Aeolosaurus* sp. The records of Sauropods from Turonian-Santonian Adamantina Formation of Serra da Boa Vista Hill are composed by *Maxakalisaurus topai* and other fragments of Titanosauria. While the Adamantina and Marília Formations have several records of titanosaurs, the Campanian-Maastrichtian Uberaba Formation has a single occurrence, which is assigned as Titanosauria. The record of Triângulo Mineiro, even several, does not provide a definitive answer about the relationship with the Argentine titanosaurs, but shows taxonomic affinity with the titanosaur record of the Chubut and Neuquén groups from Argentinian Patagonia. Such affinity can be observed in the presence of the genus *Aeolosaurus* in Brazil and Argentina with three described species which represent an endemic group of South America. This genus, along with the Argentine species *Panamericansaurus schroederi*, *Rinconsaurus caudamirus* and *Overasaurus paradasorum*, and the Brazilian species *Maxakalisaurus topai* and *Gondwanatitan faustoi* are phylogenetically related and all included in Aeolosaurini clade after some authors. Aeolosaurini species from Argentina and Brazil are also chronoestratigraphically related and exhibit similar age. The descriptions of the Triângulo Mineiro species are from materials discovered in the last century and only few of this material have been recently revised and then assigned to new taxa. Thus, these two regions provide an insight about a possible ecological corridor during the late Cretaceous. This work emphasizes the necessity of taxonomic review of Brazilian titanosaurs and the increase of their phylogenetic and paleobiogeographic knowledge. The review of such materials from the Triângulo Mineiro region is a key to understanding the ecology of these animals during the Cretaceous of South America.

AN EARLY CRETACEOUS DINOSAUR FROM SOUSA BASIN, BRAZIL

Aline M. Ghilardi[1], Tito Aureliano[2], Rudah R. C. Duque[2], Édison V. Oliveira[2] and Alcina M. F. Barreto[2]

1. Universidade Federal do Rio de Janeiro (UFRJ), CCMN, Departamento de Geologia, Av. Athos da Silveira Ramos, 274, Bloco G, Ilha do Fundão, Rio de Janeiro, RJ, 21949-900, Brazil. alinemghilardi@yahoo.com.br

2. Universidade Federal de Pernambuco (UFPE), Centro de Tecnologia e Geociências, Departamento de Geologia, Av. Acadêmico Hélio Ramos s/n, Cidade Universitária, Recife, PE, 50740-530, Brazil.

Although a considerable number of dinosaurs are known from the Late Cretaceous deposits of Gondwana, its Early Cretaceous record is scarce. Herein is presented the first dinosaur bone found in the Lower Cretaceous Sousa Basin, NE Brazil. It is the oldest Cretaceous dinosaur body-fossil record in this country and one of the oldest Cretaceous dinosaurs from Gondwana. The Sousa Basin (Upper Jurassic-Lower Cretaceous), located in the Paraíba State, is included in the Rio do Peixe basin complex, well-known as a megatracksite. Its vertebrate ichnocoenosis includes chelonians and crocodyliforms trace fossils and hundreds of dinosaur tracks. Body fossils are rare and small, only occurring in the Sousa Formation. Until the present date, there had been no formal description of the tetrapod material, as no fossils had been previously documented for other lithostratigraphic units. The long bone here described is from the Rio Piranhas Formation (Hauterivian-Barremian/ early Cretaceous). It was found in the surroundings of the Sousa municipality, at the Lagoa do Forno site, inserted in a poorly consolidated and crudely stratified granule conglomerate associated with a braided-river deposition. Its main characteristics allow association with a sauropod fibula. The specimen (UFPE-7517) is 45 cm in length and has a general sigmoid shape. The extremities are more expanded than the diaphysis, the proximal end being slightly more expanded craniocaudally than the distal one, and flattened transversely. The distal end, despite some erosion, can be recognized as triangular in shape, a typical feature of titanosaurs. The lateral side was more eroded than the medial one, making it impossible to recognize the iliofibularis scar. This particular individual was estimated to be 5,8 m long, with no information on age or sex. The fibula outline, especially the curvature and diagonal line, is unmatched, which suggests it may represent a new taxon. More material is needed to establish further affinities. From the 491 individual dinosaur tracks known for the Rio do Peixe basins, 74 are attributed to sauropods. Previous literature suggested that these tracks could belong to Dicraeosauridae, Rebbachisauridae or, more likely, to early titanosaurs. Nevertheless, all tracks described until now had been associated with large sauropods, which is not the case of our specimen. Further analyses are needed to determine if it was a naturally small animal or a juvenile. The presence of this material brings relevant data for the understanding of not only the local dinosaurian fauna but also for the Early Cretaceous biogeography of dinosaurs.

EFFECT OF CARBON DIOXIDE CONCENTRATION ON THE DIGESTIBILITY OF POSSIBLE SAUROPOD FOOD PLANTS

Fiona L. Gill[1], Barry H. Lomax[2] and Jürgen Hummel[3]

1. University of Leeds, School of Earth and Environment, Leeds, LS2 9JT, UK.
2. University of Nottingham, School of Biosciences, Nottingham, LE12 5AA UK. barry.lomax@nottingham.ac.uk
3. University of Göttingen, Department of Animal Sciences, 37077 Göttingen, Germany.

During the Mesozoic, atmospheric carbon dioxide levels were elevated when compared to the present day, with estimates ranging from ~650 to ~1130 ppm. Elevated carbon dioxide leads to accelerates plant growth via the production of carbohydrates. These changes in turn may affect the fibre content, carbohydrate to protein ratio, secondary metabolite profiles and other properties related to digestibility. We therefore hypothesize that the elevated carbon dioxide levels during the Mesozoic may have resulted in variations to the digestibility of Mesozoic plants and that these changes may have cascaded up the food chain. To test this hypothesis we investigated the effect carbon dioxide had on the digestibility of living fossils plant species which are modern analogues to sauropod food. Plants were grown under a range of Mesozoic carbon dioxide concentrations (400 ppm, 800 ppm, 1200 ppm and 2000 ppm), with all other growth parameters held constant. The metabolizable energy content of the plants as a measure of digestibility was evaluated using the Hohenheim gas test. Data show that metabolizable energy content varied considerably between plant species, but no systematic changes as a function of carbon dioxide were found. Variations in diet quality available to sauropods throughout the Mesozoic may have implications for our understanding of sauropod digestion, energy requirements and potentially methane emissions.

REVISION OF THE HOLOTYPE OF *PATAGOSAURUS FARIASI*, A BASAL EUSAUROPOD FROM ARGENTINA

Femke Holwerda[1,2], Oliver Rauhut [1,3] and Diego Pol [4,5]

1. Bayerische Staatssammlung für Paläontologie und Geologie, Richard Wagnerstrasse 10, 80333 München, Germany. F.M.Holwerda@gmail.com
2. GeoBioTec, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Monte de Caparica, Portugal.
3. Ludwig-Maximilians Universität, München, Germany.
4. Museu Paleontologico Egidio Feruglio, Avenida Fontana 140, 9100 Trelew, Chubut, Argentina.
5. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) Buenos Aires, Argentina.

Patagosaurus fariasi is an early Middle Jurassic sauropod from the Cañadon Asfalto Fm., Patagonia, Argentina. Since its first description, it has been used in numerous phylogenetic analyses of sauropod dinosaurs. However, our current understanding of *Patagosaurus* is based on elements of several specimens, collected from two localities. Furthermore, at least one specimen of one of these localities is probably a different taxon. Therefore, a revision has been started of all *Patagosaurus* material, starting with the holotype PVL 4170, which is described and compared to other sauropods. The specimen has seven preserved cervical vertebrae, ten dorsals, the complete sacrum consisting of five sacral vertebrae, and caudals. Furthermore, the right ilium, pubis and the distal fused parts of the ischia, and the right femur are preserved. The cervicals are opisthocoelous, and neurocentral sutures are present, indicating that the animal was still growing. There is a prominent ventral keel, with two lateral fossae, as in *Amygdalodon*, *Lapparentosaurus* and *Spinophorosaurus*, but in contrast to *Cetiosaurus* and derived sauropods. Laterally, a shallow pleurocoel is present which is deeper cranially, as in *Spinophorosaurus* and *Lapparentosaurus*, and not as in *Cetiosaurus* and *Tazoudasaurus*. Cranially, the intraprezygapophyseal laminae do not meet, as in *Tazoudasaurus* and *Cetiosaurus*. The anterior and mid-dorsals are mildly opisthocoelous as in *Chebsaurus*. The dorsal neural spines are higher than the centrum, and have high neural arches with a wider distal dorsal end of the neural spine as in *Amygdalodon*. A ventral keel is present in anterior and mid-dorsals but not in posterior dorsals. Laterally only a small shallow fossa is present, as in *Cetiosaurus* and *Lapparentosaurus*. An infradiapophyseal fenestra below the transverse processes is present, as in *Barapasaurus* and possibly *Tazoudasaurus*. The caudals are amphicoelus, as in most basal sauropods. The ilium is highly arched and craniocaudally elongated. The pubis is twisted towards the medial plane. The femur is taphonomically deformed. The fourth trochanter is developed as a non-prominent posteromedial bulge. There is no prominent bulge on the proximolateral side as in titanosauriforms. After incorporation of this information in an existing data matrix for preliminary phylogenetic analysis, *Patagosaurus* emerges as sister taxon to *Cetiosaurus*, more basal to *Omeisaurus* and *Mamenchisaurus*, and more derived than *Barapasaurus* and *Shunosaurus*.

STUDY OF CERVICAL VERTEBRAE OF TITANOSAURIAN SAUROPODS: CONTRIBUTION FOR PHYLOGENETIC ANALYSIS

Leonardo D. Ortiz David[1,2] and Bernardo J. González Riga[1,2]

1. IANIGLA, CONICET, Centro Científico Tecnológico, Mendoza, Argentina.

2. Laboratorio de Dinosaurios, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Cuyo, Padre Contreras 1300, Parque General San Martín, (5500), Mendoza, Argentina. prof.leortiz@gmail.com

In sauropods, cervical vertebrae are one of most informative structures of the skeleton. They have been studied in detail in most diplodocids, brachiosaurs and camarasaurs. However, these elements have not been described yet in detail in titanosaurs, a group of sauropods that exhibit an amazing diversity in the cervical series. This study is focused on the anatomy of cervical vertebrae and their application in phylogenetic analyses. Cervicals show differences in size and shape. Some taxa show lateral expanded neural spines in cervicals, like *Isisaurus colberti, Mendozasaurus neguyelap, Bonitasaura salgadoi, Ligabuesaurus leanzai* and *Quetecsaurus rusconii*. However, the anatomical details of these structures are different and must be described with accuracy in the phylogenetic matrix. Fourth main distinct structural patterns are recognized: (1) *Mendozasaurus*-type, (2) *Ligabuesaurus*-type, (3) *Bonitasaura*-type, and (4) *Isisaurus*-type. In the first one (e.g., *Mendozasaurus, Futalognkosaurus*) a very wide neural spine is formed by lateral laminae that are not related to the spinopostzygapophyseal or the spinoprezygapophyseal laminae. The same lateral laminae are also present in *Quetecsaurus*, but they are less developed. In the second type, the huge neural spines of *Ligabuesaurus* are formed by splayed lateral spinoprezygapophyseal laminae. In the third type, *Bonitasaura* has a rhomboid-shaped neural spine forming a simple expansion of the distal spine without a clear contribution of anterior or posterior laminae. Therefore, the broad neural spine of *Bonitasaura* lacks the lateral laminae of *Mendozasaurus*. In the forth type, the neural spine of *Isisaurus* is linked with the spinopostzigapophyseal laminae. In the character matrix this morphology can be describe by three characters: (A) Lateral expansion of the neural spine: absent (0); present (1); (B) Lateral expansion formed by: lateral spinoprezygapophysial laminae (0); spinopostzygapophyseal laminae (1); lateral laminae (2); thickening without contribution of laminae (3); (C) Width of the neural spine: less than the 70 percent of the centrum width (0); between the 70 and 100 percent of the centrum width (1); more than the centrum width. This comparative study demonstrates that titanosaurs have a greater cervical diversity than was previously appreciated, a topic that is useful for phylogenetic analyses.

A DINOSAUR LOST AT SEA: A NEW TITANOSAURIFORM SAUROPOD FROM LOWER CRETACEOUS MARINE DEPOSITS IN AUSTRALIA

Stephen F. Poropat[1,2], Tony Thulborn[3] and Benjamin P. Kear[1]

1. Uppsala University, Villavägen 16, Uppsala, SE-752 36, Sweden. stephenfporopat@gmail.com
2. Australian Age of Dinosaurs Natural History Museum, Winton, 4735, Australia.
3. Kenmore, 4069, Australia.

Sauropod remains are uncommonly recovered from marine sediments. Consequently, the discovery of an articulated right forelimb in Australian Lower Cretaceous offshore sediments is unusual. Furthermore, it represents a new genus and species of sauropod from Australia, thereby adding to one of the most enigmatic continental dinosaur faunas worldwide. Australia's Cretaceous sauropod record has, to date, consisted of only two valid monospecific genera: the non-euhelopodid, non-titanosaurian somphospondylan *Wintonotitan wattsi*, and the much more derived lithostrotian titanosaur *Diamantinasaurus matildae*. A third monospecific genus, *Austrosaurus mckillopi*, established on incomplete presacral vertebrae in 1933, is now considered a *nomen dubium* (although a review of this taxon is underway). We describe a new species of sauropod based on KKF 601, a specimen held in the Kronosaurus Korner palaeontological museum which comprises: an incomplete right scapular acromion; the right coracoid; the right ulna; the right radius; right metacarpals III–V; and two right manual phalanges. A tree had grown between the scapula and the ulna, obliterating the humerus prior to the specimen's recovery. KKF 601 was recovered from upper Albian sediments of the Allaru Mudstone, near the town of Richmond in central-northern Queensland, by Mary Wade of the Queensland Museum in the mid-1990s. With respect to its phylogenetic position, KKF 601 can be assigned to Macronaria on the basis of the maximum proximodistal length of the longest metacarpal being greater than 45% that of the radius. Furthermore, the enlarged and elongate anteromedial process of the ulna (relative to the anterolateral process), and the unexpanded distal end of the same element, implies that KKF 601 pertains to Titanosauriformes. Cladistic analyses have suggested that this taxon represents a somphospondylan; however, the coracoid is much taller dorsoventrally than long anteroposteriorly (resembling brachiosaur coracoids), and lacks the undulating scapular contact observed in euhelopodids. It is likely that KKF 601 is relatively basal within Somphospondyli or Titanosauriformes. Based on comparisons with other taxa, the maximum length of KKF 601 is approximately ~10 m; thus, it is the smallest-bodied sauropod yet documented from Australia. Precisely how this sauropod limb came to be buried in marine sediments has not yet been determined; it seems likely that it was once part of a much more complete carcass that drifted away from shore following *post mortem* distension of the gut by decomposition gases. The consistent recovery of sauropods from Australian Cretaceous marine units is intriguing, and seems to imply their regular occupation of paralic palaeohabitats.

ON SOME NEW EARLY DINOSAUR FINDINGS FROM BRAZILIAN UPPER TRIASSIC (SANTA MARIA 2 SEQUENCE, *HYPERODAPEDON* ASSEMBLAGE ZONE)

Flávio A. Pretto[1], Cesar L. Schultz[1] and Max C. Langer[2]

1. Universidade Federal do Rio Grande do Sul, Instituto de Geociências, Setor de Paleovertebrados, Av. Bento Gonçalves, 9500 - Bloco J, Prédio 43127, Campus do Vale, Agronomia. CEP 91540-000, Porto Alegre, Rio Grande do Sul, Brazil. flavio_pretto@yahoo.com.br

2. Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo, Departamento de Biologia, Av. Bandeirantes, 3900. CEP 14040–901, Ribeirão Preto, São Paulo, Brazil.

The oldest unequivocal dinosaurs come from Upper Triassic strata, mostly from the Carnian Ischigualasto Sequence of Argentina and the biostratigraphically correlated *Hyperodapedon* Assemblage Zone of the Santa Maria 2 Sequence, Brazil. The Argentinean record comprises seven unambiguous taxa, including all major dinosaur lineages: herrerasaurids (*Herrerasaurus*, *Sanjuansaurus*), theropods (*Eodromaeus*), ornithischians (*Pisanosaurus*), and sauropodomorphs (*Eoraptor*, *Chromogisaurus*, *Panphagia*). Brazilian outcrops yielded a scarcer record, with only three taxa: the herrerasaurid *Staurikosaurus* and the sauropodomorphs *Saturnalia* and *Pampadromaeus*. Although early dinosaur findings in Brazil are less abundant, recent discoveries in the Sítio Janner outcrop (type-locality of *Pampadromaeus*) suggest that this might represent a collection bias. The new materials discussed here are deposited in the collection of Universidade Federal do Rio Grande do Sul (UFRGS-PV). One of the new specimens (UFRGS-PV-1240-T) includes humerus, femur, pubis, and five caudal vertebrae. The well-developed humeral deltopectoral crest and a concave emargination ventral to the femoral head suggest dinosaur affinities for the specimen, but its incompleteness precludes a more precise attribution. UFRGS-PV-1240-T is significantly larger than *Pampadromaeus* (the femur is 70% longer). A second, probably unrelated specimen (UFRGS-PV-1099-T) is represented by partial skull and mandibles and much of the postcranial skeleton, including trunk, sacral, and caudal vertebrae, and most of the pelvis and hindlimb. Haemal arches, fragmentary ribs, and gastralia are also associated with the specimen. Different degrees of neurocentral fusion are observed in the vertebrae. Caudal elements show complete co-ossification, whereas mid-trunk vertebrae still show signs of the neurocentral suture. This indicates that UFRGS-PV-1099-T may represent a young adult, as also hinted by the large size of the orbit (about one-third of the skull length). Several features suggest that UFRGS-PV-1099-T is a sauropodomorph dinosaur, including a short skull (less than two-thirds femoral length), femur and tibia/fibula of similar length, and teeth with coarse and large serrations. Other features, like the low dorsal iliac lamina and the symmetrical fourth trochanter of the femur, are unknown in other sauropodomorphs of similar age. However, these features may be present in *Guaibasaurus*, a younger (*Riograndia* Assemblage Zone, Norian) Brazilian taxon of uncertain affinities. A third specimen (UFRGS-PV-1257-T) also bears a symmetrical fourth trochanter in the femur. This individual may represent the same taxon as UFRGS-PV-1099-T, but further preparation and analyses are needed to test this hypothesis. Forthcoming studies will assess the affinity of these specimens, which could belong to an already known taxon, or represent new sauropodomorph species.

MID-CRETACEOUS TETRAPODS FROM NORTHERN MARANHÃO STATE, BRAZIL

Jéssica Alves Pereira Rodrigues[1], Carolina Alves Santos[2,3] and Carlos R. dos Anjos Candeiro[3]

1. Universidade Federal de Uberlândia, Av. João Naves de Ávila, 2121 - Santa Mônica, Uberlândia, 38408-100, Brazil. jessicaalvespereira94@gmail.com

2. Universidade Federal de Uberlândia, Av. João Naves de Ávila, 2121 - Santa Mônica, Uberlândia, 38408-100, Brazil.

3. Laboratório de Geologia, Curso de Geografia, Campus Pontal, Universidade Federal de Uberlândia, Rua 20, n. 1.600, Bairro Tupã, Ituiutaba, 38304-402, Brazil.

The Itapecuru Group (Albian age "Undifferentiated Unit" and Early Cenomanian Alcântara Formation) of Northern Maranhão State, Brazil, has produced an important dinosaur fauna. It is composed of sauropods and theropods and a possible ornithischian. The sauropod dinosaur fauna has been recorded from the Albian "undifferentiated unit" and includes the diplodocoid *Amazonsaurus maranhensis* and Titanosauria indet. Theropods, such as the spinosaurid *Oxalaia quilombesis*, *Sigilmassasaurus brevicollis*, *Carcharodontosaurus* sp., *Spinosaurus* sp., Dromaeosauridae indet., the abelisaurid cf. *Masiakasaurus*, and Baryonychinae indet., have been recorded from the early Cenomanian Alcântara Formation. The sauropod dinosaur fauna from the Alcântara Formation includes rebbachisaurid cf. *Limaysaurus* and Diplodocoidea indet. The dinosaur record from the Itapecuru Group is restricted to the Mid-Cretaceous, revealing the youngest occurrences of Carcharodontosauridae and Diplodocoidea in northern Brazil.

SYMPOSIUM

ORDOVICIAN BIOTAS OF GONDWANA: RESPONSES TO GLOBAL CLIMATIC AND EUSTATIC EVENTS, AND THEIR BIOGEOGRAPHIC RELATIONSHIPS WITHIN THE ORDOVICIAN WORLD

ORGANIZERS:

DAVID HARPER - ANDREI DRONOV

THE ARGENTINE PRECORDILLERA DRIFT HISTORY FROM TROPICAL LATITUDES AS SUGGESTED BY CONODONT Δ^{18}O PALAEOTHERMOMETRY

Guillermo L. Albanesi[1], Christopher R. Barnes[2], Julie A. Trotter[3], Ian S. Williams[4] and Stig M. Bergström[5]

1. CICTERRA-CONICET – Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Av. VélezSarsfield 1611, Córdoba, X5016GCA, Argentina. galbanes@com.uncor.edu

2. School of Earth and Ocean Sciences, University of Victoria, P.O. Box 1700, Victoria, V8W 2Y2, B.C., Canada.

3. School of Earth and Environment, University of Western Australia, Perth, WA 6009, Australia.

4. Research School of Earth Sciences, Australian National University, Canberra, ACT 0200, Australia.

5. School of Earth Sciences, Division of Earth History, The Ohio State University, 125 S. Oval Mall, Columbus, Ohio 43210, USA.

The allochthonous or parautochthonous Precordillera of central western Argentina is considered to be a large tectonic unit within the Cuyania Terrane. Its origin and palaeogeographic migration are somewhat controversial, with several models proposing different trajectories based on various lines of investigation of analytical data. Some studies have favoured the model that the Precordillera drifted from the southern margin of low-latitude Laurentia during the Late Cambrian-Early Ordovician, then migrated southward across the Iapetus Ocean, eventually to dock with, and receiving glaciogenic sediments from, high-latitude Gondwana in (Mid to) Late Ordovician. Alternative models have proposed that the Precordillera originated from the margin of a low-latitude segment of Gondwana then migrated southward toward high latitudes through episodes of major transform faulting in the Ordovician. The Precordilleran Late Cambrian-Ordovician stratigraphy and the palaeontology of many fossil groups (e.g. brachiopods, trilobites) have allowed palaeobiogeographic interpretations that support the Laurentian-Gondwanan model, in that the Precordillera faunas initially have Laurentian affinities during Cambrian-Early Ordovician, and then exhibit a transition to mixed assemblages that progressively include species typical of colder-water provinces (e.g., Avalonia, Baltica) by the Mid Ordovician (Dapingian-Darriwilian). Our study attempts to estimate the sea surface temperatures from the oxygen isotope compositions ($\delta^{18}O_{phos}$) of pelagic conodont species (phosphatic microfossils) collected from Laurentian and Precordilleran sequences. This aims to constrain potential palaeoclimate and palaeolatitudinal differences between these regions during the Early to Late Ordovician, and thus test the Laurentian-Gondwana palaeogeographic model. Theconodont $\delta^{18}O$ compositions were determined *in-situ* at high spatial resolution (30 μm spots) using the SHRIMP II ion microprobe at The Australian National University. Well-preserved, largely pelagic conodont species were selected from extensive and well-studied collections of latest Cambrian-Mid Ordovician age from the Precordillera, as well as from two Laurentian control sites in Texas and Alberta. Results show that the primary climate trend across all sites is consistent and shows a measureable and progressive change to cooler temperatures in the Precordillera after the early Darriwilian, which is consistent with the influx of cooler-water faunas. Unfortunately, the younger Ordovician Precordilleran cold-water clastics have few carbonates and conodonts. Despite this limitation of our $\delta^{18}O_{phos}$ record, the isotope data are consistent with the Laurentian-Gondwanan model for Precordilleran drift across the Iapetus Ocean, reflecting changes in oceanic temperature, circulation, and tectonism.

EARLY ORDOVICIAN CONODONT FAUNAS FROM NORTHWESTERN MALAY PENINSULA: DEPOSITIONAL ENVIRONMENTS AND REGIONAL CORRELATION

Atilia Bashardin[1], C. Giles Miller[2], Aaron W. Hunter[1,3] and Richard P. Major[1]

1. South East Asia Carbonate Research Laboratory, Department of Geoscience, University Teknologi Petronas, Seri Iskandar, Tronoh 31750, Perak, Malaysia. atilia.bashardin@gmail.com

2. Department of Palaeontology, Natural History Museum, Cromwell Road, London SW7 5BD, United Kingdom.

3. Department of Applied Geology, Western Australia School of Mines GPO Box U1987, Curtin University Perth, WA 6846, Australia.

We collected conodonts from the Lower to Upper Ordovician Kaki Bukit Limestone in Perlis State, Malaysia in the northwestern part of Peninsular Malaysia. Among the conodonts we collected were *Bergstroemognathus extensus*, *Drepanodus arcuatus*, aff. *Periodon*, *Serratognathus bilobatus*, and *Scolopodus striata*, which generally indicate an Early Ordovician age. The existence of *Drepanodus arcuatus* indicates the upper Tremadocian (Lower Ordovician) to Darriwillian (Middle Ordovician), whereas *Scolopodus striata* is known from the upper part of the *Paroistodus proteus* Zone to the *Baltoniodus norrlandiscus* Zone of the Lower Ordovician. *Bergstroemognathus extensus* and *Serratognathus bilobatus* are restricted to the Lower Ordovician. *Bergstroemognathus extensus* has been reported from a wide range of shallow- to deep-water marine environments worldwide, and *Serratognathus bilobatus* represents a relatively deep-water, mid-to-outer shelf environment. *Drepanodus arcuatus* has been identified from inner shelf to slope (or basinal) settings in other regions. Thus, the palaeoecology of this area can be interpreted as an outer shelf to slope, relatively deep-water environment. These conodont faunas correlate with faunas from other locations in peninsular Malaysia, southern and western Thailand, northern and southern China, and western and offshore Northern Territory, Australia. This indicates the close proximity of these areas at the time of deposition. Indeed, the South China Province, Shallow-Sea Realm, Temperate Domain has been characterized as a deep-water, shelf margin and slope environment.

ORDOVICIAN TRACE FOSSILS OF SIBERIA: RESPONSES TO CLIMATIC AND EUSTATIC EVENTS AND CONNECTION WITH GONDWANA, BALTICA AND LAURENTIA

Andrei V. Dronov[1]

1. Geological Institute of Russian Academy of Sciences, Pyzhevsky per. 7, Moscow, 119017, Russia.
dronov@ginras.ru

In recent years new data on the distribution of trace fossils in the Ordovician succession of the Siberian palaeocontinent have been obtained. Giant *Rusophycus* (32 cm x 20 cm) were reported from the Baykit Sandstone (Vikhorevian and Mukteian regional stages, Darriwilian) for the first time from outside the Gondwana palaeocontinent. A rich and diverse *Cruziana*/*Rusophycus* ichnocoenosis was found in quartz sandstones of the upper part of the Moyero Formation (Kirensko-Kudrinian regional stage, uppermost Darriwilian) on the northeastern margin of the Tungus basin. Appearance of these typical Gondwana trace fossils are associated with typical Gondwana lithologies and accompany the wide distribution of the "Nubian facies" in the Tungus basin. Invasion of these facies marks the destruction of the conditions of the previous warm-water carbonate platform and sea-level lowering probably coinciding with the beginning of a cooling event. The lithology and position of the Baykit Sandstone and its counterparts (between the warm-water and cool-water carbonate successions) are comparable to the lithology and position of the Upper Ordovician (Katian) Eureka Quartzite of Laurentia. Morphology of the Siberian *Cruziana* and *Rusophycus*, their size and claw formula suggests that they belong to a new ichnospecies probably endemic to the Siberian palaeocontinent. Trace fossils assemblages from the Darriwilian of the Irkutsk basin to the south of the Siberian platform also demonstrate closer affinity to Gondwana than to Baltica. The assemblages include *Polycladichnus* and *Teichichnus* in shallow-water settings and *Palaeophycus*, *Arthrophycus*, *Megagrapton*, *Phycodes* and *Cochlichnus* in relatively deep-water settings. Massive thick-bedded *Thalassinoides* ichnofabric identified in limestones of the Volginian regional stage (Upper Darriwilian) in the northern part of the Tungus basin is very similar to that described in Laurentia. That could be regarded as an independent evidence for near equatorial position of this part of the basin in the Darriwilian. From the Upper Ordovician of the Tungus basin bioerosion structures like *Trypanites* and *Balanoglossites* are reported for the first time. In the Ordovician of Baltica such traces appear much earlier in Floian and Dapingian strata but disappear when the palaeocontinent migrated into the tropics. In Siberia boring traces probably reflect the onset of cool-water conditions.

PALAEOBIOGEOGRAPHIC AFFINITY OF THE CUYANIA TERRANE OF ARGENTINA DURING THE ORDOVICIAN PERIOD

Stanley C. Finney[1]

1. California State University at Long Beach, 1250 Bellflower Blvd. Long Beach, CA 90840, USA.
Stan.Finney@csulb.edu

The Cuyania terrane of western Argentina, which includes the Argentine Precordillera with its extensive exposures of Cambrian and Ordovician strata, has been interpreted as an exotic terrane of Laurentian affinity. According to the widely accepted Laurentian microcontinent model, Cuyania rifted from the Ouachita embayment of Laurentia in the Early Cambrian, drifted across the Iapetus Ocean as a microcontinent, and docked with the proto-Andean margin of Gondwana outboard of the Famatina magmatic belt in the Mid to Late Ordovician. Evidence from conodonts, brachiopods, trilobites, and other benthic invertebrates has been presented in support of this palaeogeographic and geotectonic model. In particular, the presence of olenellid trilobites in Lower Cambrian strata of the Precordillera is widely cited as convincing evidence of the Laurentian affinity and origin of Cuyania. Furthermore, the interpretation of the evolving palaeobiogeographic affinities of benthic invertebrate faunas of the Precordillera from Laurentian to Gondwanan is widely cited as a definitive record of the migration of Cuyania. However, much of the palaeobiogeographic evidence cited in support of the Laurentian model has been misinterpreted, misrepresented, and ignored. A careful analysis of the evidence shows that it is more compatible with a parautochthonous Gondwanan origin of Cuyania, in which the close equatorial positions of Cuyania and Laurentia allowed for the dispersal of invertebrates by equatorial currents.

EARLY PALAEOZOIC BIOGEOGRAPHY AND PALAEOGEOGRAPHY: NEW FRAMEWORKS AND NEW OPPORTUNITIES

David A. T. Harper[1] and Thomas Servais[2]

1. Department of Earth Sciences, Durham University, Durham DH1 3LE, UK. david.harper@durham.ac.uk
2. UMR 8217 Géosystèmes, CRNS-Université de Lille 1, Cité Scientifique, 59655 Villeneuved'Asq Cedex, France.

The Early Palaeozoic was a critical interval in the evolution of marine life on our planet. Through a window of some 120 million years, the Cambrian Explosion, Great Ordovician Biodiversification Event, End Ordovician Extinction and the subsequent Silurian Recovery established a steep trajectory of increasing marine biodiversity that started in the Late Proterozoic and continued into the Devonian. Biogeography is a key property of virtually all organisms; their distributional ranges, mapped out on a mosaic of changing palaeogeography, have played important roles in modulating the diversity and evolution of marine life. Improved stratigraphic and taxonomic data together with more accurate, digitized palaeogeographic maps, have confirmed the central role of palaeobiogeography in understanding the evolution of Early Palaeozoic ecosystems and their biotas. The recent researches of some 130 authors from over 20 countries, on distributional and in many cases diversity data for all the major biotic groups plotted on current palaeogeographic maps (Geological Society Memoir 38, edited by Harper and Servais), has provided major advances in our understanding of Early Palaeozoic biogeography and palaeogeography. We have now a much greater potential to identify oceanic circulation and migrational patterns, zones of upwelling and species pumps and the phylogeography of the major animal groups.

DID ASTEROZOANS HAVE THEIR ORIGINS IN GONDWANA? NEW DATA FROM THE LOWER ORDOVICIAN OF FRANCE AND MOROCCO

Aaron W. Hunter[1]

1. Department of Applied Geology, Western Australian School of Mines, Curtin University, GPO Box U1987 Perth 6845 WA, Australia. aaron.hunter@curtin.edu.au

The Palaeozoic asterozoan fossil record is generally poor and heavily reliant on exceptional preservation. This has not only resulted in instability with regard to the taxonomic hypothesis but has meant that the asterozoan fossil record has a marked bias towards areas of more intensive study such as North America and the British Isles. In terms of Ordovician paleobiogeography these well studied areas where part of the Laurentia and Avalonia terranes, with the fossil record from these areas showing that the majority of taxa had diversified by the Late Ordovician. However, the record in terranes that were part of Gondwana have received relatively little study, despite some of the earliest documented Early Ordovician taxa being known from the Montagne Noire, Languedoc, southern France. A recent review of all the existing described taxa of asterozoans, with reference to this classic material, established 4 major taxonomic groupings that include the Stenuroidea, Somasteroidea, Ophiuroidea and the Asteroidea. In this analysis somasteroids where established as the best candidate for the most primitive of all the asterozoan taxa from which the other three taxa derived. New data from the Montgane Noire, France and Anti-Atlas, Morocco explore this hypothesis further and establish whether this origination and diversification could have taken place in Gondwana. We have found one of the earliest occurrences of a somasteroid asterozoan in the Upper Fezouata Formation of the Anti-Atlas of Morocco, which has characters consistent with the most primitive morphologies of the somasteroid *Chinianaster*, identified from the classic coeval Upper Tremadoc/Lower Arenig ?Floian Montagne Noire fauna. Examination, in the field, of echinoderm plates preserved in these Anti-Atlas sections, established that it was unlikely, unless due to preservational bias, that any other asterozoan echinoderms persisted at these levels. Reexamination of the Upper Tremadoc/Lower Arenig ?Floian Montagne Noire fauna from the Saint Chinian Formation in this study has shown that not only were somasteroids diverse at this time, but that the primitive ophiuroids *Pradesura* and a hudsonasteroid asteroid were also present. These derived taxa confirm that asterozoan diversification had already taken place by the ?Floian, matching our observations in the Upper Fezouata Formation of the Anti-Atlas of Morocco. Furthermore, in the Montagne Noire, the overlying upper Floian strata (Landeyran Formation) contains derived prostasterid ophiuroids, one of the earliest occurrence globally, supporting the evidence for the origination and diversification of asterozoans in Gondwana by the Early Ordovician.

THE CHANGING BIOGEOGRAPHICAL DISTRIBUTIONS OF ORDOVICIAN ACRITARCHS

Stewart G. Molyneux[1] and Thomas Servais[2]

1. Honorary Research Associate, British Geological Survey, Keyworth, Nottingham NG12 5GG, UK.
2. UMR 8217 Géosystèmes CNRS-Lille1, Université de Lille1, Villeneuve d'Ascq, 59655, France.
Thomas.servais@univ-lille1.fr

Analysis of Ordovician acritarch biogeography has shown that the amount of provincialism varied through the Ordovician, and that the biogeographical ranges of genera and species also changed. Distinct acritarch provinces can be recognized during the Early–Mid Ordovician (Floian–Darriwilian), one along the Gondwanan margin (Perigondwanan Province) and a second in Baltica (Baltic Province), although with some mixing of assemblages at low palaeolatitudes in South China and northwest Argentina. At other times, for example in the later Ordovician, provincialism seems to have been less marked, and only at the end of the Ordovician is there any suggestion that provincialism might have increased again. The reasons for such changes, from times of marked provincialism to less provincialism and back, are unclear, but must be related to the changing biogeographical ranges of individual species and genera. *Veryhachium* provides an example of a genus that originated at high palaeolatitudes on the margin of Gondwana during the Tremadocian, spread to lower palaeolatitudes on the Gondwanan margin and to Baltica during the Floian, and became widespread in the later Ordovician. Other genera also show expanding biogeographical ranges from the Early Ordovician onwards, although not always following the same path or spreading as widely as *Veryhachium*. In some instances, changes in biogeographical ranges are probably related to global climatic and/or eustatic events, such as the expansion of *Striatotheca* into intracratonic basins on Gondwana long after the genus appeared in Perigondwanan assemblages. In other cases, changes such as the expansion of the biogeographical ranges of genera and species along the Gondwanan margin seem to have been protracted and to have taken place over a period of several million years. Although the possible effects of sample bias cannot be discounted, the evidence suggests that this represents a time lag rather than being an artifact, and that expansion was a slow and gradual process.

MULTIDISCIPLINARY APPROACHES TO THE ORDOVICIAN STRATIGRAPHY IN CHINA AND THEIR IMPLICATIONS

Yuandong Zhang[1], Yongyi Zhen[2], Axel Munnecke[3] and Xu Chen[1]

1. LPS and LESP, Nanjing Institute of Geology and Palaeontology, Nanjing 210008, China. ydzhang@nigpas.ac.cn
2. Geological Survey of New South Wales, Londonderry NSW 2753, Australia.
3. GeoZentrum Nordbayern, Fachgruppe Paläoumwelt, Erlangen, Germany.

A multidisciplinary approach has been taken in the past years to refine correlation of the Ordovician System amongst the several constituent blocks of China, i.e. South China, North China, Tarim, Indochina and Sibumasu, which are all located in northeastern peri-Gondwana region. We focused on the transitional intervals across the base of Sandbian and across the Hirnantian, and have adopted integrated studies of graptolite, conodont, chitinozoan, acritarch and radiolarian palaeontology together with biostratigraphy, incorporated with a study of stable carbon isotope records. The studies turned out to indicate some unexpected disconformities within the Ordovician successions of several blocks: (1) Integrated graptolite and conodont biostratigraphy and carbon isotope stratigraphy suggest that an extensive gap is present between the Darriwilian and Sandbian strata, which is of unequal durations at different places, in the Yangtze Region, South China. A similar gap is also present within the same interval in the Bachu area of the platform-facies, as indicated by recent conodont biostratigraphic and chemostratigraphic studies. This gap, if further confirmed by evidence from the other blocks, may indicate a significant response of the peri-Gondwana region to a potential fall in global sea-level. (2) There is a significant positive excursion of carbon isotope values across the base of Hirnantian, followed by a large negative excursion in the early to mid Hirnantian, suggesting a possible burial and subsequent release of massive amounts of organic material in the transition interval of the early Hirnantian. A disconformity seems to be present at the base of the Hirnantian in the Upper Yangtze Region, as indicated by the development of conglomerates, and may represent a regional response to the global sea-level drop in the early Hirnantian. A similar disconformity may be present in Tarim and Sibumasu, too, as suggested by integrated biostratigraphy of graptolite, trilobite and chitinozoans, and sedimentological data.

FLOIAN (EARLY ORDOVICIAN) CONODONT BIOGEOGRAPHY, BIOFACIES, AND BIOSTRATIGRAPHY OF THE AUSTRALASIAN SUPERPROVINCE

Yong Yi Zhen[1] and Ian G. Percival[1]

1. Geological Survey of New South Wales, 947-953 Londonderry Road, Londonderry NSW 2753, Australia. yong-yi.zhen@trade.nsw.gov.au

The Floian Age was a critical interval during the Great Ordovician Biodiversification Event, particularly for conodont evolution. New data from Australia and South China obtained in recent years enable a comprehensive regional synthesis of the conodont biogeography, biofacies and precise biostratigraphic correlation of the Floian Stage across northern Gondwana to the Chinese microcontinents, and along the eastern Gondwana coastline to South America. Floian conodonts from the Australasian Superprovince, particularly those from shallow-water settings, exhibit a strong regional biogeographic signature, characterized by the occurrence of serratognathids and other endemics. In Australia, three conodont biozones, including the *Prioniodus adami–Serratognathus bilobatus* Biozone, *Oepikodus communis* Biozone, and the *Oepikodus evae* Biozone (=lower part of the *Jumudontus gananda* Biozone in equivalent shallow-water carbonate successions) are established. In South China, two parallel conodont zonations are recognised for Floian successions from the Yangtze Platform and the Jiangnan Slope, reflecting faunal differences mainly caused by variations in ecology, water depth and temperature. The *Serratognathus diversus*, *Prioniodus honghuayuanensis*, and *Oepikodus communis/Oepikodus evae* conodont biozones on the Yangtze Platform correlate respectively with the *Serratognathus bilobatus*, *Prioniodus elegans*, and *Oepikodus evae* biozones of the Jiangnan Slope, which tie into the Baltoscandian zonation. Using species of *Serratognathus*, *Prioniodus* and *Oepikodus*, the Floian Stage can be precisely subdivided and correlated across northern Gondwana and peri-Gondwanan plates and terranes, particularly among coeval rocks from Australia, South China, North China, Tarim Basin, Korea, Indochina, Subumasu, and Kazakhstan. Temporal and spatial replacement of conodont biofacies can be well demonstrated in the transgressive Floian successions of South China, where carbonate-dominated rocks of near-shore to slope settings are well preserved. Of the three zonal index species characterising Baltoscandian late Tremadocian–Floian successions, *Paroistodus proteus* was reported from outer-shelf settings in Western and Central Australia or slope settings in South China. *Prioniodus elegans* was restricted to the slope setting in South China and replaced by shallow-water forms like *Prioniodus honghuayuanensis* on the Yangtze Platform. *Oepikodus evae*, recorded only from the marginal platform and slope in South China or deep-water basins in eastern Australia, was apparently replaced by *Prioniodus amadeus*, *Oepikodus pincallyensis* and *Oepikodus communis* in the diverse shallow-water faunas of Australia. *Oepikodus communis*, the zonal index species for the middle Floian in North American Midcontinent faunas, extended to the late Floian in northern Gondwana. Occurrence of *Erraticodon patu* and *Scolopodus houlianzhaiensis* in the late Floian-Dapingian faunas from South America indicates some biogeographic connections with northern Gondwana and peri-Gondwana.

MIDDLE DARRIWILIAN TO LOWER SANDBIAN CONODONT ZONES AND GLOBAL CORRELATION OF THE ARGENTINE PRECORDILLERA

Guillermo L. Albanesi[1], Nicolás A. Feltes[1] and Fernanda Serra[1]

1. CICTERRA-CONICET, CIGEA, Museo de Paleontología, FCEFyN, Universidad Nacional de Córdoba, Av. Vélez Sarsfield 1611, X5016GCA Córdoba, Argentina. galbanes@com.uncor.edu

The Precordillera of San Juan Province in western Argentina is characterized by over 2,200 m thick Cambrian-Ordovician limestones, which were deposited cyclically on restricted to open marine platforms. The study areas are located southwest of Jáchal city including the Las Aguaditas Formation in the Los Blanquitos range and the Las Chacritas Formation in the La Trampa range. The sample section of the former unit involves the top strata of the San Juan Formation and the overlying Las Aguaditas Formation, which is 282 m thick. The second study section includes the uppermost 10 m of the San Juan Formation, the 60 m thick Las Chacritas Formation, and the 10 m thick Las Aguaditas Formation. Both sections span the mid Darriwilian to early Sandbian interval. A total of 10,400 identifiable conodont elements were recovered, including chronostratigraphic significant taxa such as: *Lenodus variabilis*, *Yangtzeplacognathus crassus*, *Baltoniodus variabilis*, *Eoplacognathus pseudoplanus*, *E. suecicus*, *Dzikodus tablepointensis*, *Histiodella sinuosa*, *H. holodentata*, *H. kristinae*, *H. bellburnensis*, *Microzarkodina hagetiana*, *M. ozarkodella*, *Periodon macrodentatus*, *P. zgierzensis*, *P. aculeatus* and *Pygodus anserinus*. On the basis of the conodont zones identified, the index species enable confident ties between sections. The *Y. crassus* Zone straddles the contact between the San Juan Formation and overlying units at both study sections, i.e., Las Aguaditas and Las Chacritas formations. The *E. pseudoplanus* Zone, which includes the *M. hagetiana* and *M. ozarkodella* subzones, was recognized in the upper half of the lower member of the Las Aguaditas Formation and intermediate strata of the correlative Las Chacritas Formation. The *E. suecicus* Zone was determined only in the upper Las Chacritas Formation, whereas the upper subzone of the *P. anserinus* Zone was identified in the Las Aguaditas Formation at both study sections. The fossil record verifies an important hiatus with regional geotectonic significance between the lower and middle members of the Las Aguaditas Formation at Los Blanquitos, which encompasses the *E. suecicus*, *Pygodus serra* and the lower subzone of the *P. anserinus* zones. In the La Trampa range, the hiatus suppressed the upper *E. suecicus* and the *P. serra* zones as well as the lower *P. anserinus* zones. The conodont records allow the establishment of a biostratigraphic scheme for the middle Darriwilian and lower Sandbian in the Argentine Precordillera, with controls over numerous well-studied localities of the Central Precordillera. Global correlation of the analyzed interval with sections from North America, China, Thailand, Australia and Baltoscandia is now consistently constrained.

COLOUR ALTERATION INDEX AND PALAEOTEMPERATURE OF CONODONT ASSEMBLAGES FROM NORTHWESTERN PENINSULAR MALAYSIA

Atilia Bashardin[1], C. Giles Miller[2], Aaron W. Hunter[1,3] and Richard P. Major[1]

1. South East Asia Carbonate Research Laboratory, Department of Geosciences, University Teknologi PETRONAS, Seri Iskandar, Tronoh 31750, Perak, Malaysia. atilia.bashardin@gmail.com

2. Department of Palaeontology, Natural History Museum, Cromwell Road, London SW7 5BD, United Kingdom.

3. Department of Applied Geology, Western Australia School of Mines, GPO Box U1987, Curtin University, Perth, WA 6846, Australia.

Colour alteration of conodonts provides information on thermal maturation levels (time-temperature history) and level of metamorphism for sedimentary rocks. Colour Alteration Index (CAI) values can be used as an indicator of source-rock maturity for hydrocarbon exploration; CAI 1.5–2.0 is at the upper margin of the oil window, CAI 4.5 is near the upper margin of dry gas production. CAI values can be used to understand regional thermal history. For example, they can be used to identify anomalously high temperature zones, which may be indicative of mineralized zones or high heat flow at plate margins. Conodonts were sampled and evaluated for CAI values from five locations in northwestern Peninsular Malaysia: (1) Lower Devonian, CAI=5, 290–300˚C (Kaki Bukit Limestone, Utan Aji, Perlis); (2) Lower Silurian, CAI=4, 170–180˚C (Mempelam Limestone, Langgun Island, Langkawi); (3) Middle Silurian to Lower Devonian, CAI=3, 105–110˚C (Mempelam Limestone, Langgun Island, Langkawi), these temperature values are above the oil production window but are low enough to suggest that dry gas formation; (4) Lower Triassic, CAI= 3, 105–110˚C (Kodiang Fm., Gunong Keriang, Bukit Kalong and Bukit Kechil, northern Kedah); and (5) Lower Triassic, CAI= 2, 25˚C (Kodiang Fm, Bukit Kalong and Bukit Kechil, northern Kedah), these values are very close to the upper margin for oil production. None of these conodonts is tectonically deformed. There is a general trend in these data of higher CAI values for older rocks, and all but the oldest samples are within hydrocarbon-generating time-temperature ranges. There have apparently been no thermal effects associated with the Triassic granite intrusions located approximately 100 km southeast of the study area.

CAMBRIAN AND ORDOVICIAN CALCAREOUS ALGAE, CYANOBACTERIA, AND ALGAE OF UNCERTAIN AFFINITY FROM THE ARGENTINEAN PRECORDILLERA: A REVIEW

Matilde S. Beresi[1] and Veronica A. Luchinina[2]

1. IANIGLA-CONICET/ CCT Mendoza, Av. Ruiz Leal s/n, 5500 Mendoza, Argentina. mberesi@mendoza-conicet.gob.ar

2. A.A. Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences, pr. Akademika Koptyuga 3, Novosibirsk, 630090, Russia.

Calcareous algae, cyanobacteria and algae of uncertain affinity are present in the Middle Cambrian and can be locally abundant in Lower-Middle Ordovician and Lower-Upper Ordovician carbonate platform successions in the Argentine Precordillera terrane, western Argentina. Outcrops of this terrane extend from 29° S to 33° S latitude, and correlative rocks are exposed near San Rafael City (35° S /68° 20′ W) in the south of the Mendoza Province. The *Renalcis* group, *Girvanella* (Cyanobacteria) and a few specimens of the genus *Solenopora* (Rhodophyta) were described from the Middle Cambrian shallow carbonates of the La Laja Formation (*Bolaspidella* Zone), and *Girvanella* mentioned from the Los Sombreros Formation, Precordillera of the San Juan Province. Also, *Girvanella* is common in the olistoliths of the San Isidro area, Mendoza, Precordillera. Several Ordovician (Dapingian-Darriwilian) calcified cyanobacteria (*Girvanella problematica*); algae of uncertain affinity (*Rothpletzella* sp., *Halysis monoliformis* and *Nuia sibirica*) were described from the shallow-subtidal carbonate platform of the San Juan Formation in the central and eastern ranges of the Precordillera of San Juan Province. Also, individual segments and fragments are assigned to Chlorophyta, Family Dasycladaceae (*Vermiporella*? or *Mastopora*?) and globular solid forms with an exterior dark film doubtfully referred to algae were mentioned from this formation. These morphological algal types of different sizes may account for 35% of the clasts in many thin sections from this formation, and are associated with distinct limestone textures. *Girvanella* and *Rothpletzella* are present as oncoids or intraclasts in algal oncoid grainstones and *Nuia* and *Girvanella* mainly in bioclastic-peloidal wackestones. In the deeper-water slope succession of the Las Aguaditas Formation (Darriwilian-Sandbian), Central Precordillera of San Juan, *Nuia* and *Girvanella* are the most common. In the San Rafael Block, Mendoza Province, a fragment of a dendritict hallus with lateral branches was recovered from the shallow clastic-carbonate facies of the Ponón Trehué Formation (Darriwilian-Sandbian). Its determination is in doubt. A new elongate algal septatet hallus with branches was recovered from clastic sediments of the La Cantera Formation (Sandbian) at the Villicúm Range, Eastern Precordillera of San Juan. It may be assigned to the Rhodophyta or to *Chabakovia* Vologdin. According to new interpretations, *Chabakovia,* in fact, characterizes different stages of the life cycle of algae of the genus *Epiphyton.* The near-equatorial position of the Precordillera during the Mid Cambrian and Early-Mid Ordovician favoured the diversification of these “floral” assemblages in the euphotic zone of tropical to warm-water carbonate platforms.

BIOSTRATIGRAPHIC SIGNIFICANCE OF ORDOVICIAN SPONGE SPICULES IN THE CUYANIA TERRANE AND THEFAMATINA BASIN, WESTERN ARGENTINA

Matilde Beresi[1], Ana Mestre[2], Susana Heredia[2] and Josefina Carlorosi[3]

1. IANIGLA-CONICET/ CCT Mendoza, Av. Ruiz Leal s/n, 5500 Mendoza, Argentina. mberesi@mendoza-conicet.gob.ar

2. CONICET-CIGEOBIO-Instituto de Investigaciones Mineras. Universidad Nacional de San Juan. Av. Libertador y Urquiza. CP: 5400. San Juan, Argentina.

3. Instituto Superior de Correlación Geológica (CONICET-UNT), Miguel Lillo 205, 4000 San Miguel de Tucumán, Argentina.

Well-preserved silicified sponge spicules were recovered from residues of conodont samples spanning the interval from the Lower-Middle to Upper Ordovician in the Cuyania terrane (Precordillera and San Rafael Block) and the Middle Ordovician of the Famatina basin, western Argentina. The Precordilleran spicules were recovered from carbonate samples of the San Juan, Los Azules, Las Aguaditas and Don Braulio formations. Also, they occurred in the Ponón Trehué Formation, San Rafael Block, in southern Mendoza. In the Famatina Range, they appear in the Loma del Kilómetro Member. The spicule assemblages occur during the intervals of several conodont biozones, spanning almost all the Ordovician Period. The poriferan taxa include desmas and non-lithistid spicules (Class Demospongea), octactinellids —sexiradiates and octactins— of the Class Heteractinida, hexactins of the Class Hexactinellida and root tufts. Octactinellid spicules were recovered from shallow-water carbonates of the San Juan Formation, at several fossiliferous localities in the Precordillera of San Juan, from the *Oepikodus evae* Zone. Also, hexactins occur at the same interval in the Pachaco section, Western Precordillera. *Dodecaactinellida,*?*Praephobetractinia* and *Sardospongia* (polyactinellide triactine spicules) in addition to octactines of the Eiffeliidae (*Chilcaia?)* of the Class Heteractinida were previously described. This faunule flourished on shallow-subtidal, warm-water platforms during the Dapingian-Darriwilian. Overlying the limestones of the San Juan Formation, in the black shale of the Los Azules Formation, hexactins are mentioned from the *Amorphognathus tvaerensis* Zone. The Las Aguaditas Formation, in the Central Precordillera, only contains siliceous hexactine spicules occurring in carbonates deposited in a deeper-water slope environment during the interval the *Pygodus anserinus*-*A. tvaerensis* zones (Darriwilian-Sandbian). We add herein the discovery of a single demospongiid lithistid tricranocladine spicule with irregular brachyome, of the Family Hindiidae (*Hindia*?), in the Huaco area from the *Yangtzeplacognathus crassus* Zone. Hexactins occur in the Upper Ordovician (*Hirnantia* Zone) of the Don Braulio Formation, Villicúm Range. This assemblage is related to faunules of sponges and bryozoans from the cool-climate belts of Gondwana. Non-lithistid demospongiid triactines, oxeas and hexactins were described from the *Pygodus serra* and *P. anserinus* zones (Darriwilian-Sandbian) of the Ponón Trehué Formation, San Rafael Block. Toward the north of western Argentina, in the Famatina basin, only simple small hexactine spicules restricted to clastic deposits of the Loma del Kilómetro Member were recovered from the *Baltoniodus navis* Zone (Middle Ordovician).

DIAGNOSTIC CHARACTERISTICS OF THE CEPHALOPOD *SINOCERAS CHINENSE* (FOORD)

Xiang Fang[1], Yun-bai Zhang[1], Ting-en Chen[1] and Yuan-dong Zhang[1]

1. Nanjing Institute of Geology and Palaeontology, CAS, No.39 East Beijing Road, Nanjing, 210008, China. royfangxiang@gmail.com

Sinoceras chinense is one of the most significant and dominant cephalopods in the lower Upper Ordovician of China. There are eight subspecies of *Sinoceras chinense*; some of them are fairly different from each other as shown in the description and plates in the literature. Moreover, some subspecies were reported in association with *Sinoceras chinense*, implying that the species need to be clarified taxonomically. Herein we restudy all the thirty-three published specimens of *Sinoceras chinense*, and conduct a Cluster Analysis and Principal Component Analysis based on six morphological parameters. The analysis indicates that the published specimens fall into three morphological groups: (1) *Sinoceras chinense chinense* Group, (2) *Sinoceras chinense eccentric* Group, and (3) non-*Sinoceras chinense* Group. Based on these results, we propose the diagnostic characteristics of *Sinoceras chinense*, and that the specimens of non-*Sinoceras chinense* Group should be renamed as they are significantly different from typical *Sinoceras chinense*.

TAXONOMIC REVIEW OF THE EARLY SPECIES OF THE CONODONT GENUS *BALTONIODUS* LINDSTRÖM AND ITS DISTRIBUTION IN THE ORDOVICIAN OF GONDWANA

Susana Heredia[1], Josefina Carlorosi[2] and Graciela Sarmiento[3]

1. CONICET- Instituto de Investigaciones Mineras (UNSJ). Libertador 1109, San Juan (5400), Argentina. sheredia@unsj.edu.ar
2. CONICET – INSUGEO Miguel Lillo 205, Tucumán (4000), Argentina.
3. Departamento de Paleontología, Universidad Complutense de Madrid, José Antonio Novais, Madrid (28040), Spain.

The Lower-Middle Ordovician strata of South America exposed in several localities in Northwestern Argentina and Peru provided large collections of conodonts. These conodont samples were collected in the following sections: Chaschuil, Gallinato Creek, Los Colorados, Lipan, Zenta and Espinazo del Diablo (Argentina) and Kimbiri (Peru). In this contribution new species of the genus *Baltoniodus* are proposed, noting the key conodonts *Baltoniodus pretriangularis* sp. nov., *B. triangularis* (Lindström) and *B. cooperi* sp. nov. These species document accurately the eponymous biozones and subzone for the conodont-bearing strata, being the *B. cooperi* Subzone defined for the first time in Gondwana suggesting the uppermost part of the *B. triangularis* Zone. The main goal of this contribution is to analyze morphological characters of the multielemental apparatuses of this species. We also interpret the evolutionary patterns of the early species of this genus. The early *Baltoniodus* apparatus was described for Baltica, China and Argentina. New findings of this genus in Lower-Middle strata of the South American sector of Gondwana allow description of a continuous record of the early forms of this genus, proposing to recognize *Baltoniodus* cf. *B. triangularis* previously described as *Baltoniodus pretriangularis* nov. sp. and the species *Baltoniodus cooperi* nov. sp. for the species *Baltoniodus navis*. Morphology of the processes of the P elements and distribution of denticles are the main characters that permit definition of the different species. In this contribution the constitution of the *Baltoniodus* apparatus is recognized confirming the inclusion of this genus in the Family Balognathidae.

TAXONOMIC REVIEW OF THE CONODONT GENUS *EOPLACOGNATHUS* BERGSTRÖM AND ITS STRATIGRAPHICAL RECORD IN THE ORDOVICIAN OF ARGENTINA

Susana Heredia[1], Ana Mestre[1] and Tatiana Soria[1]

1. CONICET- Instituto de Investigaciones Mineras (UNSJ). Libertador 1109, San Juan (5400), Argentina.
sheredia@unsj.edu.ar

The Middle-Upper Ordovician strata of Cuyania, exposed in several localities in Eastern and Central Precordillera and the San Rafael Block, provided large collections of conodonts. These conodont samples were collected in the following sections: La Tortuga, La Pola, Don Braulio, Las Chacritas, La Brecha, Cerro La Chilca, Las Aguaditas, and Los Amarillitos. The key conodonts *Eoplacognathus pseudoplanus, E. suecicus, E. robustus, E. lindstroemi* and *E. elongatus* document accurately the eponymous biozones and subzones for these conodont-bearing strata. The main goals of this contribution are to analyze morphological characters of P elements, including S and M elements as a part of the *Eoplacognathus* apparatus, and finally to focus on the inclusion of these conodont species in the Family Balognathidae. The Family Polyplacognathidae Bergström included three genera, *Polyplacognathus* Stauffer, *Eoplacognathus* Hamar, and *Cahabagnathus* Bergström. All these genera were characterized exclusively by bimembrate apparatuses. However, in 1990 S and M elements were reported in the apparatus of *Eoplacognathus pseudoplanus;* this finding carried out a changed in this genus name to *Lenodus pseudoplanus*, assigning the genus *Lenodus* to the Family Balognathidae. Also, the genus *Eoplacognathus* was kept in the Family Polyplacognathida which is characterized by having the apparatus with one kind of pectiniform element supporting three main processes and another kind of pectiniform element with three to four main processes. However, many authors still continue using the *Eoplacognathus pseudoplanus*, recognizing S and M elements for this species. Recently, S elements were recognized in the *E. foliaceous* apparatuses. In 1971 the *Eoplacognathus* apparatus was first described and defined as a subzonal key conodont, with only P elements. This original description is only based on the oral shape of the P elements. A review of the aboral side of the P elements of the different species showed that earlier species are scaphate and the later ones are planate. In the conodont collections studied here, early forms of *E. suecicus* also confirm the close relationship with later forms of *E. pseudoplanus*. In this contribution S and M elements of the *E.suecicus*, *E. robustus* and *E. lindstroemi* apparatus were recognized confirming the inclusion of this genus in the Family Balognathidae.

BOHEMIAN-TYPE OBOLIDS (LINGULATE BRACHIOPODS) FROM THE LOWER ORDOVICIAN (TREMADOCIAN) OF NORTHWESTERN ARGENTINA

Diego F. Muñoz[1,2] and Juan L. Benedetto[1,2]

1. Centro de Investigaciones en Ciencias de la Tierra, CONICET and Universidad Nacional de Córdoba. Vélez Sarsfield 1611, Córdoba, X5016GCA, Argentina. df.munoz@conicet.gov.ar

2. Centro de Investigaciones Paleobiológicas (CIPAL), Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba. Vélez Sarsfield 299, Córdoba, X5000JJC, Argentina.

Although linguliform brachiopods are a common component in the thick and continuous Upper Cambrian-Ordovician clastic successions of northwestern Argentina and Bolivia, to date they remain almost unknown. A few species from the Eastern Cordillera (Cordillera Oriental) were described and illustrated by H. J. Harrington more than eighty years ago and their taxonomic placement needs revision. Other forms have been mentioned in the context of taphonomic analyses on the 'lingulid shell beds' recorded from different localities of NW Argentina. In this study, we report well-preserved obolids from a succession of sandstones and siltstones referred to the Humacha Member of the Santa Rosita Formation, which according to the conodonts of the *Paltodus deltifer* Zone is of mid Tremadocian (Tr2) age. Rhynchonelliform brachiopods are dominated by *Nanorthis purmamarcensis* Benedetto and *Lipanorthis* spp. (unpublished). Lingulate brachiopods consist of acrotretids (not included here) and two species of obolids assigned to *Libecoviella* Mergl and *Leptembolon* Mickwitz. The former is represented by a new species relatively close to *Libecoviella ovata* (Havlíĉek). Like other 'westoniid-like' obolids, it possesses the characteristic external sculpture of zig-zag terrace lines, which has been interpreted as an adaptation to burrowing into the substrate. *Libecoviella* is typical of the upper Tremadocian and Floian strata of the Prague basin (Třenice and Klabava formations, respectively) and it has been reported recently from Australia. *Leptembolon* has been recorded in the same Bohemian formations, but together with other taxa it forms the *Thysanotos-Leptembolon* Association present in Baltica (Estonia) and a series of high-latitude terranes (e.g. Alborz, Perunica, Central Iran). The record of *Leptembolon* and *Libecoviella* in the high- to temperate-latitude Central Andean region confirms the peri-Gondwanan distribution of these genera.

FACIES OR CLIMATE-RELATED OCCURRENCES OF BALTIC ECHINODERM FAUNA IN THE ORDOVICIAN OF MOROCCO?

Elise Nardin[1], Bertrand Lefebvre[2] and Samuel Zamora[3]

1. Géosciences Environnement Toulouse (OMP), UPS, CNRS, IRD, 31400 Toulouse, France. elise.nardin@get.obs-mip.fr.
2. Laboratoire de Géologie, Terre, Planètes, Environnement, CNRS, Université Lyon 1, Villeurbanne, France.
3. Museo Geominero, IGME, 50006 Zaragoza, Spain.

Fossiliferous Ordovician strata (except the Dapingian) are well exposed along the Anti-Atlas Mountains in South Morocco. This region, located on the high latitude Gondwana margin, is interpreted as a large siliciclastic epicontinental sea, fluctuating from glacial-marine restricted environments (upper Second Bani Group, Hirnantian), a low energy ramp dominated by geostrophic currents (Zini Formation, late Floian; lower First Bani Group, late Darriwilian), a high energy storm dominated ramp (upper First Bani Group, late Darriwilian-earliest Sandbian; Upper Tiouririne Formation, mid Katian), to middle (Fezouata formations, Tremadocian-Floian) to deep shelf (Ktaoua formations, Sandbian-Katian). Most of the formations contain typical Ordovician faunal assemblages including soft-bodied taxa. Blastozoan echinoderms represent an important component of the Ordovician fauna, with the Moroccan specificity of abundant and markedly diversified diploporans. The last were supposed to reflect typical Mediterranean Province affinities, reaching their highest diversity during the Sandbian-early Katian interval. However the recent discoveries of the Baltic species of asteroblastid diploporans – *Asterocystis tuberculatus*, uppermost Lower Ktaoua Formation (late Ka1, lower Katian) and the *Asteroblastus* indet., Guezzart Member of the First Bani Group (mid Dw3, upper Darriwilian) – challenge this classical view. They coincide with intervals of moderate diploporan diversity and low endemism. They were collected in characteristic deposits interpreted as sandy storm-dominated proximal ramps. Because of their exquisite preservation and their fragility, both occurrences are supposed para-autochthonous, only transported by storm-currents from more a proximal zone. Pandemic rhombiferans, with a lower latitude provincial affinity, have also been collected at comparable levels of the lowermost Tiouririne Formation. The sporadic occurrences of lower latitude-affinities species of diploporans and rhombiferans might have been controlled by sea-level, oceanic circulation or climate changes. The upper Darriwilian deposits could correspond to the lower part of a local regressive sequence, lacking any global or local climatic event signal. The early Katian occurrence coincides with an interval of deepening followed by a strong (glacio-marine?) regression. The two occurrences might be controlled by different factors, such as an oceanographic current favoring progressive migration paths along the Gondwana margins (westward) during the Darriwilian and as a possible migration from the lower latitude regions (Baltica) enabled by a global transgression in the Katian associated with a change in oceanic circulation patterns.

THE CONODONT-GRAPTOLITE BIOSTRATIGRAPHIC SCHEME FOR THE LOWER ORDOVICIAN OF THE EASTERN CORDILLERA, NW ARGENTINA

Gladys Ortega[1,3], Guillermo L. Albanesi[1,2], Fernando J. Zeballo[1], Gustavo G.Voldman[1,2] and María E. Giuliano[1,2]

1. Museo de Paleontología, CIGEA, FCEFyN, Universidad Nacional de Córdoba, Av. Vélez Sarsfield 299, 5000 Córdoba, Argentina. gladyscortega@gmail.com

2. CICTERRA-CONICET, Argentina.

3. CONICET, Argentina.

The records of conodonts and graptolites in the Lower Palaeozoic of the Eastern Cordillera, Salta and Jujuy provinces are the best known from northwestern Argentine basins, and are herein organized to follow a chronostratigraphic scheme for the various recognized faunas. Recent studies on the historical geology of the Eastern Cordillera are based on sequence stratigraphy within sedimentologic and biostratigraphic frameworks. This has allowed us to verify the actual extent of the different facies, areally restricted and bounded by discontinuities and incised valleys. In this morphostructural unit, the major conodont and graptolite records are grouped into a sedimentary cycle controlled by tectonoeustatic factors of third and fourth order represented by the Santa Victoria Group (Upper Cambrian - Middle Ordovician), which is bounded by two major unconformities, named the Iruya at the base that separates the Meson Group, and the Ocloya, which separates it from the Upper Ordovician glacigenic deposits. In the complex palaeoenvironments of the Eastern Cordillera, the conodont and graptolite faunas evolved and their records are utilized for defining the following biostratigraphic units. The Tremadocian conodont zones are named in ascending order, from the chronostratigraphic Cambrian/Ordovician boundary, the *Iapetognathus, Cordylodus angulatus, Paltodus pristinus, Paltodus deltifer,* and the *Acodus apex* zones. Accordingly, the Floian is characterized by the *Acodus deltatus s.l.* zone, followed by the *Trapezognathus*? *primitivus* and *Gothodus andinus* zones. Similarly, the defined graptolite zones for the Tremadocian are the *Rhabdinopora flabelliformis parabola, Anisograptus matanensis, Rhabdinopora flabelliformis anglica, Adelograptus, Bryograptus kjerulfi, Aorograptus victoriae, Kiaerograptus supremus, Araneograptus murrayi,* and *Hunnegraptus copiosus* zones. The Floian is represented by the *Tetragraptus phyllograptoides, Tetragraptus akzharensis, Baltograptus* cf. *deflexus,* and *Didymograptellus bifidus* zones. Using the combined records of conodonts and graptolites in critical intervals, precise correlation ties for all named units are verified. In particular, the Tremadocian/Floian boundary coincides with the base of the *T. phyllograptoides* Zone and is close to the base of the *A. deltatus s.l.* Zone. The global standard schemes adopted in our study allow direct links withthe contemporary faunas of different continents with assemblages of the northwestern Argentine basins, and their distinctive palaeobiogeographic and evolutionary patterns in the Lower Ordovician.

AN EARLY INCURSION OF STROPHOMENOID BRACHIOPODS ONTO THE HIGH LATITUDE GONDWANAN SHELVES (MIDDLE ORDOVICIAN OF SPAIN)

Enrique Villas[1], Jaime Reyes-Abril[2] and Juan C. Gutiérrez-Marco[3]

1. Department of Earth Sciences, Zaragoza University, Pedro Cerbuna 12, Zaragoza, 50009, Spain. villas@unizar.es

2. Departamento de Geología General, Grupo TERRA, Universidad de los Andes, Núcleo La Hechicera, Edificio de Ingeniería, Mérida, 5101, Venezuela.

3. Instituto de Geociencias (CSIC, UCM), José Antonio Novais 12, Madrid, 28040, Spain.

Brachiopods of the order Strophomenida did not become relatively frequent on the North African-Mediterranean Gondwanan shelves until the late Katian, coinciding with the Boda warming event and the spreading of carbonate sedimentation across the region. During the Early and Mid Ordovician the dominant rhynchonelliformean brachiopods in the region were orthides, very often of endemic families, such as Drabovidae, Euorthisinidae and Heterorthidae. They thrived on siliciclastic platforms at high latitudes, making up brachiopod communities of low diversity. The first conspicuous strophomenide in the region is the plectambonitoid *Aegiromena mariana*, abundant in the upper Darriwillian of Iberia, Armorica and occasionally North Africa, where it frequently crowds many bedding planes. Besides this species, within an association where orthides are more diversified, *Dactylogonia*? *asturica* can occasionally be found, representing the other superfamily of the order, the Strophomenoidea. *D.*? *asturica* was first described from volcaniclastic rocks of the Cantabrian Zone, in northernmost Spain, but it has been recently reported from dispersed outcrops of shaly units in Central Spain. In lower horizons of Central Spain, mid Darriwilian in age, a new strophomenoid assigned also tentatively to *Dactylogonia* occurs within a brachiopod association adapted to dark muddy substrates. This association is dominated by endemic species and occasionally also endemic genera of the family Orthidae. Both species represent the first arrival of brachiopods of the superfamily Strophomenoidea to the high latitude Gondwanan shelves. The earliest strophomenoid settled there during the first stages of the mid Darriwilian transgression that drowned the platforms dominated since the Floian by the inshore clastic deposits of the Armorican Quartzite facies. Its arrival onto the Mediterranean margin of Gondwana coincided with the beginning of a major diversification of the superfamily Strophomenoidea in South China, at a time when it is poorly known from other palaeocontinents. Simultaneously, *Dactylogonia* dispersed throughout the equatorial belt of Laurentia, with at least five known species from the USA and Canada. Since it has not been recorded in the Middle Ordovician of any other tectonic plate or terrane, with the only possible exception of Iberia, some questions arise regarding the generic identity of the Spanish species and the dispersion routes of the strophomenoids during the late Mid Ordovician.

EARLIEST SILURIAN GRAPTOLITES FROM THE TARIM AREA, NORTHWESTERN CHINA

Wang Wenhui[1,2], Chen Xu[2] and Tang Peng[3]

1. School of Earth Sciences and Engineering, Nanjing University,163 Xianlin Road, 210023, Nanjing, China. wwhever@126.com

2. Key Laboratory of Economic Stratigraphy and Palaeogeography, Nanjing Institute of Geology and Palaeontology, 39 East Beijing Road, 210008, Nanjing, China.

3. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, 39 East Beijing Road, 210008, Nanjing, China.

Some of the Silurian black shales in the Tarim Basin have served as potential hydrocarbon source rocks. Studies on the graptolite fauna from these shales, together with conodonts and chitinozoans, permit a refined correlation of these rocks. Graptolites from the Kalpintag Formation occurred mainly in the thin and medium bedded, grayish-green, arenaceous mudstones that characterized the basal part of the Middle Member (of the Kalpintag Formation) in the Kalpin area, Xinjiang Province, Northwestern China. Graptolite specimens were collected from four time equivalent sections in the Kalpin region, namely the Tierekeawati section, the Dawangou-East section, the Sishichang section and the Dawangou section. Taxonomic and biostratigraphic reappraisal of the graptolite records has enhanced our knowledge of the lowest Silurian in the regions, and allows some conclusions: (1) The graptolite fauna contains 13 graptolite species attributed to five genera. Although no new taxa are present, approximately half of the species have not been previously recorded from this area. The graptolite species are: *Avitograptus avitus*, *Korenograptus laciniosus*, *Korenograptus* aff. *K. magnus*, *Persculptograptus* sp., *Normalograptus ajjeri*, *Normalograptus angustus*, *Normalograptus mirnyensis*, *Normalograptus parvulus*, *Normalograptus* aff. *N. wangjiawanensis*, *Normalograptus jerini*, *Normalograptus jideliensis*, *Paramplexograptus madernii* and *Paramplexograptus*? sp. (2) The faunal composition has long posed a chronostratigraphic problem, which has now been largely resolved, the fauna being interpreted as early Rhuddanian (early Silurian) in age. Taxa, which have important age implications, such as *Normalograptus jideliensis*, *Normalograptus jerini* and *Paramplexograptus madernii,* are found in this region, while typical Hirnantian taxa, such as *N. persculptus* and *N. extraordinarius* are absent. (3) Review and correlation of the Rhuddanian chronozones and global graptolite assemblages show that the present graptolite fauna can be roughly correlated with the *A. ascensus* to *P. acuminatus* biozones recognized in South China, Wales, Southwest Sweden, Austria, Bohemia, Poland and elsewhere.

A PRELIMINARY RESTUDY ON MICROPLANKTON PLANT ASSEMBLAGES FROM THE LOWER-MIDDLE ORDOVICIAN LUQUAN, YUNNAN PROVINCE

Kui Yan[1,2] and Jun Li[1]

1. Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 39, East Beijing Road, Nanjing, 210008 China. kuiyan@nigpas.ac.cn

2. State Key Laboratory of Palaeobiology and Stratigraphy, 210008, Nanjing, China.

Although Fang Xiaosi has studied microplankton flora from the Kunming-Luquan area in 1986, more detailed studies are needed to understand the biostratigraphic, palaeoenvironmental and palaeogeographic implications of this microplankton flora. The Guihuaqing Reservoir bank and Liujiang sections are located in Luquan County in the eastern part of Yunnan Province, and contain Lower-Middle Ordovician strata. The Lower-Middle Ordovician rocks from Luquan are subdivided into the Tangchi, Hongshiya, Qiaojia, and Daqing formations in ascending stratigraphic order. 41 samples were collected from the Tangchi, Hongshiya and Qiaojia formations that mainly consist of clastic deposits. The Hongshiya Formation is composed of reddish and greyish-green banded shale intercalated with sandstone, and the underlying Tangchi Formation consists of greyish-green shale intercalated with quartz sandstone, while the overlying Qiaojia Formation consists of greyish-green to greyish sandstone and shale intercalated with limestone. As a result, a moderately well-preserved and diverse acritarch and prasinophyte assemblages were recognized from these two sections in Luquan County. The palynomorph assemblage consists of 39 species assigned to 29 genera. The acritarch and prasinophyte assemblage is dominated by *Leiosphaeridia*, *Dactylofusa velifera*, *Rhopaliophora* and *Pterospermella* from the Tangchi Formation, *Ploygonium*, *Cymatiogalea/Stelliferidium*, *Coryphidium* and *Striatotheca* from the Hongshiya Formation, and *Polygonium*, *Cymatiogalea*, *Leiosphaeridia* and *Micrhystridium* from the Qiaojia Formation. The acritarch and prasinophyte assemblage from the Tangchi Formation including *Acanthodiacrodium angustum*, *Aureotesta clathrata simplex*, *Coryphidium elegans*, *Dactylofusa velifera*, and *Rhopaliophora* probably imply a late Tremadocian-early Floian age which correlates with the *messaoudensis-trifidum* acritarch assemblage. The presence of *Arbusculidium filamentosum*, *Coryphidium bohemicum*, *Ampullula*, and *Barakella* indicates that the Hongshiya and Qiaojia formations should correlate with the Floian-Darriwilian stages.

SYMPOSIUM

GEOCHEMISTRY AND THE STUDY OF BIOMINERALIZATION: A POWERFUL TOOL FOR PALAEONTOLOGICAL STUDIES IN THE XXI CENTURY

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This symposium is dedicated to the memory of Mena Schemm-Gregory, a young and promising brachiopodologist, well known and respected for her remarkable researches on brachiopod taxonomy, biostratigraphy and palaeoecology.

THE GEOCHEMICAL COMPOSITION OF ORGANIC-WALLED DINOFLAGELLATE CYST SPECIES FROM THE YORKTOWN FORMATION (PLIOCENE): EVIDENCE FOR DIAGENETIC OVERPRINTING

Kara A. Bogus[1*], Silvia Anglès[2], Kenneth Neil Mertens[3] and Lucy E. Edwards[4]

1. International Ocean Discovery Program, Texas A&M University, College Station, TX, USA. bogus@iodp.tamu.edu
2. Department of Oceanography, Texas A&M University, College Station, TX, USA.
3. Research Unit for Palaeontology, Ghent University, Gent, Belgium.
4. United States Geological Survey, Reston, VA, USA.

Understanding the formation and preservation of sedimentary organic matter (kerogen), the largest pool of organic carbon, is crucial to a holistic understanding of the global carbon cycle. Kerogen is challenging to study because it is heterogeneous in origin and composition, which makes it difficult to identify the biological, physical and chemical transformations it undergoes during diagenesis. However, by studying these changes in biologically identifiable particles of kerogen, such as dinoflagellate resting cysts (dinocysts), we have the potential to document how these changes affectkerogen as a whole. Recent work has begun to examine the (geo)chemicalcomposition of dinocysts in this capacity because they are widespread in marine settings and have a long, rich sedimentary record. However, little is known regarding the chemical composition and variability of dinocysts, and diagenetic changes of the macromolecule (called dinosporin) after burial are almost completely unknown. In this study, we used micro-Fourier transform infrared spectroscopy to analyze the composition of several species in two samples from the Yorktown Formation (Holland Ball Park core DEQ161-592; Suffolk, VA, USA), which is of Pliocene age. Our aim was to compare the composition and variability of dinosporin in the Pliocene specimens to modern specimens to identify diagenesis-induced chemical changes in the dinocyst walls. In general, chemical changes consistent with diagenetic overprinting were observed, including a loss of oxygen-containing functional groups, suggesting that chemical preservation of dinosporin in these samples is poor.

COMBINED TRACE-ELEMENT AND STABLE-ISOTOPE ANALYSIS OF SINGLE OSTRACOD VALVES: INSIGHTS INTO SHORT-TERM PALAEOENVIRONMENTAL VARIABILITY

Allan R. Chivas[1] and Laurent S. Devriendt[1]

1. School of Earth & Environmental Sciences, University of Wollongong NSW 2522, Australia.
toschi@uow.edu.au

The oxygen isotopes and elemental ratios of ostracods are widely used to reconstruct changes in palaeolimnologic variables that are, in turn, commonly related to Quaternary continental climates. Such data also provide information about the mechanisms and rates of calcification in controlled growth experiments of modern material. We review the field of ostracod chemistry before providing new data from experimental results and methods which allow a more detailed and robust interpretation. In addition to long-term environmental changes, ostracod geochemical proxies also constrain short-term environmental variations if sufficient single valves are analysed within specific stratigraphic horizons and provide an opportunity to reconstruct past changes in the seasonality and/or interannual variability of continental climates. However, multiple variables (e.g. salinity, temperature, alkalinity) potentially influence the short- and long-term variations of ostracod geochemical proxies. We present a new method to better constrain the environmental variables and apply the method to an ostracod fossil population that lived in a shallow tropical palaeolake (Lake Carpentaria, northern Australia) during the Last Glacial Maximum. The method allows comparison of trace-element and isotopic results from a single valve by dividing the ostracod valve into two sub-samples that are analysed separately. For *Cyprideis australiensis*, we demonstrate that when a valve is split to form an 'anterior' and a 'posterior' half valve of similar weights, the bulk composition of the half valves are representative of the whole-valve values (i.e. $\delta^{18}O$, $\delta^{13}C$, Na/Ca, Mg/Ca, Sr/Ca, Ba/Ca, Mn/Ca, Fe/Ca and U/Ca). Inferences about the seasonal/interannual variations in the palaeolake solute concentration, $\delta^{18}O$ value and water temperature are made from the relationships between the ostracod $\delta^{18}O$ value and Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca ratios of valves extracted from a single stratigraphic horizon representing about ten years of sedimentation. Future applications to multiple stratigraphic horizons should enable the reconstruction of changes in the seasonality and/or interannual variations of targeted limnologic variables.

MAGNESIUM ISOTOPES IN CALCITIC BRACHIOPODS: IMPLICATIONS FOR BIOMINERALIZATION AND CHEMICAL EVOLUTION OF PHANEROZOIC OCEANS

Juraj Farkaš[1], Uwe Brand[2], Karem Azmy[3], Adam Tomašovych[4], Jan Fietzke[5], Anton Eisenhauer[5], Michaela Francová[1], Martin Šimeček[1] and Ján Veizer[6]

1. Czech Geological Survey, Prague, 152 00, Czech Republic. juraj.farkas@geology.cz
2. Brock University, St. Catharines, L2S 3A1, Canada.
3. Memorial University of Newfoundland, St. John's, A1B 3X5, Canada.
4. Slovak Academy of Sciences, Bratislava, 84005, Slovakia.
5. GEOMAR, Helmholtz Centre for Ocean Research, Kiel, 24148, Germany.
6. University of Ottawa, Ottawa, K1N 6N5, Canada.

Magnesium isotope composition (δ^{26}Mg) of marine carbonates potentially can be used to constrain changes in the oceanic Mg cycle over geologic time. Brachiopod shells composed of diagenetically resistant calcite are particularly valuable archives of past variations in the isotopic composition of seawater. We present δ^{26}Mg (DSM3) data analyzed in different species of modern brachiopods with shells composed of (i) a relatively low Mg-content calcite such as *Terebratalia transversa, Terebratella sanguinea, Terebratulina septentrionalis, Liothyrella uva, Megerlina pisum;* (ii) an intermediate Mg-content calcite such as *Thecidellina congregate, Pajaudina atlantica;* and one with (iii) a high Mg-content calcite, *Novocrania anomala*. Sample locations of the species cover a global scale, thus representing major water bodies including the North and South Pacific, North and East Atlantic, Southern Ocean, and Mediterranean Sea. The mean habitat temperatures (HT) of these shallow-water brachiopods cover a wide range from cold (~0°C, Antarctica), through intermediate (~8 to 15°C, e.g., Friday Harbor, Doubtful Sound) to warm tropical settings (~29°C, Koror, Palau). Our results reveal an inverse correlation between δ^{26}Mg and δ^{18}O values in modern brachiopod shells ($R^2 = 0.43$; $p < 0.05$). However, the overall temperature sensitivity of δ^{26}Mg in brachiopod calcite is relatively weak (~0.01‰/°C), suggesting its use as a suitable archive for the δ^{26}Mg composition of paleo-seawater. Generally, the shells from tropical settings (HT of ~29°C) yielded the heaviest δ^{26}Mg (up to -1.77 ±0.07‰), whereas those from polar regions (HT of ~0°C) show the lightest (from 2.24 to -2.62 ±0.10‰). The shells from intermediate HT ranges (~10 to 20°C) are scattered around a δ^{26}Mg value of about -2.10 ±0.15‰, which is ~1.25 ‰ lighter compared to modern seawater ($\delta^{26}Mg_{SW}$ = -0.85 ±0.10‰). Interestingly, the brachiopod *Novocrania anomala* collected in the Mediterranean gave an extremely light δ^{26}Mg of -3.43 ±0.06‰, which corresponds to "Mg-isotope fractionation" between brachiopod calcite and seawater of about ~2.60 ‰. The latter bears some similarity with the estimated "equilibrium" Mg-isotope fractionation value between inorganic calcite and solution as determined in laboratory experiments by recent studies. We will discuss how δ^{26}Mg measured in modern shells with variable Mg content can be used to constrain biomineralization processes in brachiopods. Furthermore, we will present δ^{26}Mg record of fossil brachiopod shells spanning the Ordovician to Neogene with implications for the Mg isotope budget of Phanerozoic oceans, and the causative mechanism(s) behind the long-term oscillation of marine Mg/Ca ratios.

THE BLACK BOX TAXONOMIC EFFECT ON BIOGENIC CARBONATE: BIOMINERALIZATION PROCESSES CONTROL THE GEOCHEMICAL RECORD OF BRACHIOPOD CALCITE

Claudio Garbelli[1], Lucía Angiolini[1] and Uwe Brand[2]

1. Dipartimento di Scienze della Terra 'Ardito Desio', Università degli Studi di Milano, via Mangiagalli 34, 20133, Milano, Italy. lucia.angiolini@unimi.it

2. Department of Earth Sciences, Brock University, St. Catharines, Ontario, L2S 3A1 Canada.

Rhynchonelliformea brachiopods branched in the Cambrian, giving rise to two classes: the extinct Strophomenata and the extant Rhynchonellata. The two classes show differences in their body-plane and in the secretory mechanism of the shell. Strophomenata produced two or three layer shells with a primary layer of randomized granular calcite, a secondary layer of cross-bladed laminar calcite – eventually with pseudopunctae - and, at times, a tertiary layer of prismatic calcite. The secondary layer was highly variable in its structural units shape and organization. Rhynchonellata also have two- or three-layered shells, but their secondary layer consists of calcite fibers, which may be perforated by punctae. Secondary layer fibers are more uniform and less variable in terms of supra-structural organization. Furthermore, inter-crystalline space is limited in the secondary layer of Rhynchonellata, but higher in the laminar layer of Strophomenata. Our investigation reveals that, during the Permian, the two classes have important differences in their carbon isotopes and in the trace element contents (magnesium and strontium), but similar values for oxygen isotopes. The oxygen isotope composition of shells of the two classes collected in the same stratigraphic interval in the Lopingian of North Iran shows considerable overlap of $\delta^{18}O$ values. On the contrary, carbon isotopes are significantly different between coeval Strophomenata and Rhynchonellata. An evaluation of published data from Permian and Carboniferous brachiopods strengthens the thesis of a differentiation in $\delta^{13}C$ values between the two classes. Differences in the chemical composition of biominerals are usually confined into the black box of a "Taxonomic effect", supposing that there are underlying mechanismsinfluencing chemical composition. These underlying mechanisms are difficult to unravel, since they range from variability in physiological ability to differentkinetics. It is possible that Strophomenatasecreted shell calcite at a faster rate and this process may account for their different $\delta^{13}C$ andhigher magnesium and strontium contents. However, the different amount and composition of the organic matter of the Strophomenata may also play a role in shaping their more negative carbon isotope signature. Althoughwe do not have a definitive answer to explain the origin of these differences, this finding has important consequences on the study of Paleozoic seawater chemistry, because brachiopod shells represent one of the most important sources of data. Their different fabrics and classes should be carefully assessed and their $\delta^{13}C$ data should be adjusted when considering the reconstruction of Paleozoic global $\delta^{13}C$ carbonate-based seawater curves.

RARE EARTH ELEMENT IMAGING AND SPECTROSCOPY OF WELL-PRESERVED FOSSILS: FOSSILIZATION AND DIAGENESIS IN THE DJEBEL OUM TKOUT LAGERSTÄTTE (UPPER CRETACEOUS, MOROCCO)

Pierre Gueriau[1,2], Mathieu Thoury[2,3], Tatiana Séverin-Fabiani[2,3] and Loïc Bertrand[2,3]

1. CR2P, UMR 7207 CNRS-MNHN-UPMC, 8 rue Buffon, Paris, 75005, France. gueriau@mnhn.fr
2. IPANEMA, USR 3461 CNRS-MCC, BP48 Saint-Aubin, Gif-sur-Yvette, 91192, France.
3. SOLEIL synchrotron, BP48 Saint-Aubin, Gif-sur-Yvette, 91192, France.

Vertebrate fossil remains essentially consist of bones and teeth, which are preserved in sediments due to their high mineral content of bioapatite. The geochemical composition of these skeletal remains, in particular trace elements such as strontium and rare earth elements (REEs),are commonly used in palaeontological, palaeoenvironmental and taphonomic research, as their distribution and fractionation depend on fossilization and diageneticprocesses. In well-preserved fossils the presence of strontium, yttrium and REEs is attributed to their long-term isomorphous substitution within bone bioapatite and the authigenic apatite that finely replicate muscles or other soft tissues. We have recently shown that the distribution of these elements can be easily mapped at themicroscaleusing synchrotron-based X-ray fluorescence (S-XRF) scanning approaches. Processing of the collected spectra allows non-destructive local quantification of such minor and trace elements. Insight on their typical content opens new ways for palaeoenvironmental and taphonomic studies as differences in concentrations, sorption and/or substitution rates simultaneously reflect the connectivity of the environmental water network, local redox conditions, the specific surface area of the bioapatitenanocrystals and physico-chemical conditions and the properties of substituted apatite. We have used S-XRF to determine REEs composition, distribution and concentration in well-preserved fish and crustaceans from the DjebelOumTkoutLagerstätte (Upper Cretaceous, Morocco), and we have studied the speciation and preferential incorporation of the more informative elements using microscopic X-ray absorption near edge spectroscopy (μ-XANES) and UV-Visible luminescence spectroscopy. Results provide relevant information on the microscale fossilization and diagenetic conditions of this exceptional fossil locality.

URANIUM SERIES DATING HELPS TO RECONSTRUCT HISTORICAL PATTERNS OF CORAL MORTALITY IN THE KEPPEL ISLANDS, INSHORE SOUTHERN GREAT BARRIER REEF

Mauro L. Lepore[1,3], A. Rodriguez-Ramirez[2], T. Clark[2], G. Roff[1,3], J. X. Zhao[2] and J. M. Pandolfi[1,3]

1 School of Biology, University of Queensland, St Lucia, QLD 4072 Australia. maurolepore@gmail.com

2 Radiogenic Isotope Facility, School of Earth Sciences, University of Queensland, St Lucia, Queensland, 4072, Australia.

3 Australian Research Council Centre of Excellence for Coral Reef Studies, School of Biology, University of Queensland, St Lucia, QLD 4072 Australia.

Modern geochemical tools can now be used to reconstruct ecological and environmental baselines of coral reefs prior to and over the period since human impacts. Here we provide an example from the Great Barrier Reef (GBR) of an application of Uranium series (U-series) dating to constraining the timing of mortality in coral reef environments. There is mounting evidence linking coral reef decline in the inshore Great Barrier Reef to multiple stressors (e.g. increased runoff and climate change) since European settlement of Queensland (mid-19th century). However, causal relationships between reef degradation and natural/anthropogenic factors are still controversial because of the lack of ecological baseline data and historical understanding of past mortality events before the early 1980s, when regular monitoring programs began. Using high-precision U-series dating of corals from reef surface death assemblages, we reconstructed mortality patterns at 4 reefs from the Keppel islands region (southern GBR) adjacent to the Fitzroy River. Dates ranged from ~322 BC to ~2008 AD. Most corals returned ages around or after the onset of regular surveys of coral reefs on the GBR and some corals from Halfway reef dated around 2,000 years old. Density probability plots of U-series ages revealed peaks of mortality that coincided with periods of bleaching and flooding events. Branching acroporids were generally dominant in both live and death assemblages, and appear to have dominated coral reef communities at Halfway for at least the past two millennia. In contrast to lower latitude inshore reefs from the central GBR, no evidence of shifts in coral dominance was observed following European settlement. This study is a crucial starting point for developing a regional scale pre-European baseline of coral reefs in the southern GBR. Furthermore, it illustrates the role of geochemistry in helping to set sensible goals to manage threats to coral reef ecosystems.

TEMPERATURE AND OXYGEN ISOTOPIC COMPOSITION OF PHANEROZOIC OCEANS

Jan Veizer[1] and Andreas Prokoph[2]

1. University of Ottawa, Ottawa- Carleton Geoscience Center, Ottawa, K1N 6N5, Canada. jveizer@uottawa.ca
2. Speedstat, Ottawa, K1G 5J5, Canada.

A new Phanerozoic $\delta^{18}O$ database for 51,281 low-Mg calcite marine shells, referenced to the GTS2012 time scale, consists of 34,453 benthic foraminifera, 5,846 planktonic foraminifera, 5,226 brachiopods, 2,972 belemnites and 786 bivalves and is further differentiated into high- , mid- and low-paleolatitude subsets. In this massive compilation, there is almost a complete absence of measurements in the space between the upper envelope of the secular trend and the modern value for marine calcite at about 0‰ PDB. Any diagenesis - if involved - therefore shifted the oxygen isotopic composition downward from the Phanerozoic trend, not towards it, resulting in a somewhat diffuse lower envelope of the secular band. While it is still entirely feasible to argue the details, and sample reliability, within the band, the primary nature of the overall Phanerozoic secular trend should be beyond any reasonable dispute. The 6 (±1) ‰ magnitude of the latter can presently be explained by only two propositions: 1) the oceans became progressively warmer with increasing antiquity, or 2) they became more depleted in ^{18}O. Assuming modern value for oxygen isotopic composition of sea water, the earliest Paleozoic oceans would have been hot, with temperatures mostly within about 30-60°C range. Yet, the 700,000 measurements of ocean temperatures by the Argo program show that the overall span of modern ocean temperatures is from 0 up to about 30°C, capped at its upper limit via a likely thermostatic regulation by cloud formation. This range is evidently also the optimal temperature regime for marine biological communities that involve higher life. The preference of life for optimal conditions is a rule of nature, not an exception, and exceptions should not be therefore invoked to justify special pleadings invented solely for disposal of the unpalatable consequence of too hot oceans. The alternative approach is to accept that world ocean temperatures were buffered within 0 to 30°C range throughout the entire Phanerozoic and it was the oxygen isotopic composition of sea water that did evolve. The empirical paleotemperatures for the above taxa normalized this way cluster, with only very few exceptions, around the following modal values: planktonic foraminifera 23-25°C, brachiopods 19-25°C, belemnites 17-23°C, bivalves 19-23°C and benthic foraminifera 3-13°C.

SEASONAL ISOTOPIC PALAEOTEMPERATURES OF THE EARLY ALBIAN MADAGASCAR MARINE BASIN AND MESOZOIC SEAWATER STRONTIUM ISOTOPES RECORDED IN CEPHALOPOD ARAGONITE

Yuri D. Zakharov[1], Yasunari Shigeta[2], Peter P. Safronov[1], Olga P. Smyshlyaeva[1] and Sergei I. Dril[3]

1.Far Eastern Geological Institute of Russian Academy of Sciences (Far Eastern Branch), Stoletiya Prospect 159, Vladivostok 690022, Russia. yurizakh@mail.ru

2. National Museum of Nature and Science, 4-1-1Amakubo, Tsukuba, Ibaraki 305-0005, Japan.

3. Institute of Geochemistry of Russian Academy of Sciences (Siberian Branch), Favorsky Street 1a, Irkutsk 664033, Russia.

We investigated five Cretaceous cephalopod species from Madagascar for their isotopic geochemistry. Existing data on Phanerozoic Sr-isotope stratigraphy have been derived from whole-rock samples and calcitic fossils. Here, we focus on seasonal palaeotemperature fluctuations during the early Albian and some Mesozoic Sr-isotope oscillations using original data on isotopic composition of cephalopod aragonite in order tominimize the effects of diagenetic alteration. Palaeotemperatures have been determined on the basis of oxygen isotopic analysis of 178 aragonitic samples taken from species belonging to *Phylloceras,Eogaudryceras*, *Aconeceras*, *Puzosia*, *Desmoceras*, *Beudanticeras*, *Neosilesites*, *Cleoniceras*, and *Douvilleiceras*. Those obtained from aragonite, secreted by the animals while in the lower epipelagic and middle mesopelagic zones during the coolest season, range from 15.4 to 16.8°C, and from 11.8 to 12.0°C, respectively. Presumed spring/autumn palaeotemperatures obtained from aragonite secreted in the upper and lower epipelagic and upper and middle mesopelagic zones, are somewhat higher. Presumed summer palaeotemperatures, calculated for the upper and lower epipelagic, and upper mesopelagic zones range from 19.4 to 21.7°C, from 17.7 to 19.4°C, and from 14.4 to 16.1°C, respectively. Most of the investigated ammonoids inhabited the epipelagic zone, but representatives of four genera (*Phylloceras, Eogaudryceras, Eotetragonites,* and*Neosilesites*) prefer deeper, cooler conditions of the upper–middle mesopelagic zone.The following seawater Sr-isotope excursions are recognized in ammonoid aragonite within the Mesozoic: (1) earliest Olenekian (Hedanstroemi Zone) positive excursion in Arctic Siberia (0.708043), which is more prominent than that recently reported for the lower Maastrichtian Fox Hills Formation ofSouth Dakota; (2) late Callovian negative excursion on the Russian Platform (0.707429); (3) early Aptian (Volgensis–Schilovkensis Zone) negative excursion on the Russian Platform (OAE 1a – 0.707333); (4) early Albian negative excursion in Madagascar (0.707241–0707276); (5) late Santonian (Yokoyamai Zone) negative excursion in British Columbia (0.707281); (6) early Campanian (Chicoensis Zone) negative excursion in California (0.707198). This study supports the hypothesis that Madagascar was located in middle latitudes but within the tropical-subtropical climatic zone during early Albian time. Available carbon-isotope data allow us to assume a marked carbon-isotope stratification of the water column in the Madagascar area during the early Albian. Our preliminary data on Sr-isotope values in primary aragonite are consistent with those of calcite, suggesting the close correspondence in time between episodes of increased hydrothermal activity at ocean ridges, partly reflected in some negative Sr-isotope excursions, and sea-level rises more or less corresponding to OAEs. [Supported by a grant RSF 14-17-00035].

OXYGEN ISOPTOPES OF DENTAL BIOAPATITE: A PRECISION PROXY TO PALAEOENVIRONMENT

Živilė Žigaitė[1], Martin J. Whitehouse[2], Michael M. Joachimski[3] and Per E. Ahlberg[1]

1 Subdepartment of Evolution and Development, Uppsala University, Norbyvägen 18A, SE-75236 Uppsala, Sweden. zivile.zigaite@ebc.uu.se

2 Laboratory for Isotope Geology, Naturhistoriska Riksmuseet, Frescativägen 40, Box 50 007, SE-104 05 Stockholm, Sweden;

3 Geozentrum Nordbayern, University of Erlangen-Nürnberg, Schlossgarten 5, D-91054 Erlangen, Germany.

Oxygen isotopic compositions of dental bioapatites have gained wide recognition as paleoenvironmental proxies, first demonstrated on modern fish teeth by Longinelli and Nuti in 1973, and by Kolodny et al. in 1983. A major link between the $^{18}O/^{16}O$ ratios in aquatic ectotherm bioapatite and climate has been established through a number of works, including extensive $\delta^{18}O_{bioapatite}$ compilations through the Ordovician and Devonian by Trotter et al. (2008) and Joachimski et al. (2009). However, reliability of vertebrate bioapatite $\delta^{18}O$ as Palaeozoic seawater proxy was questioned after the discoveries of systematic taxon-specific offsets between autochthonous Palaeozoic conodonts and fish: the 2.5 ‰ $\delta^{18}O$ offset in Silurian was revealed by Žigaitė et al., 2010, and the 2.9 ‰ $\delta^{18}O$ offset in Carboniferous by Barham et al., 2012, both arguing it as a taxon-specific diagenetic overprint. Advances in analytical techniques and calibrations of phospohate $\delta^{18}O$ thermometer, most recently by Lécuyer et al. in 2013, together with the $\delta^{18}O$ analyses in a number of wild-caught shark species by Vennemann et al., 2001, followed by experimental studies of teleost teeth from monitored aquaria settings by Pucéat et al., 2010, have nevertheless defined the potential of modern aquatic vertebrate dental biomineral to reflect ambient seawater temperatures. Our recent work on modern captivity sharks applied *in-situ* $\delta^{18}O$ analysis within separate layers of shark dental tissues (enameloid and dentine), measuring all the oxygen components of fluorapatite with micrometer resolution. The analyses were carried out at NordSIM secondary ion microprobe facility (Stockholm Museum of Natural History, Sweden), and respective bulk $\delta^{18}O$ values of the 2. Phosphatic component of shark tooth bioapatite have been obtained by silverphosphate precipitations and high-temperature reduction mass-spectrometry (GeoZentrum Nordbayern, University of Erlangen-Nuremberg, Germany). All the measured oxygen isotope ratios revealed different intra- and inter-tissue variability for each tooth and for each shark species analysed: the parallel-bundled enameloid (PBE) and the tangle-bundled enameloid (TBE) both had high integrity in oxygen isotope ratios, while the dentine had larger variability and lower average $\delta^{18}O$, particularly those obtained by secondary ion microprobe. Both methods provided highly adequate and repeatable $\delta^{18}O$ values within the PBE and TBE. The biomineral of enameloid can be therefore recommended as a preferential target and biogeochemical reference for ambient aquatic environment, and most reliable biomineral proxy for palaeoclimate research.

BRACHIOPOD GEOCHEMISTRY: NEW INFORMATION FOR THE PALEOZOIC OF ESTONIA

Giuseppe Buono[1], Liisa Lang[1], Tõnu Meidla[1] and Leho Ainsaar[1]

1. University of Tartu, Geology Department, Ravila 14A, Tartu, 50411, Estonia.
gbuono.geo@gmail.com

In this study we report new data on $\delta^{13}C_{shell}$and $\delta^{18}O_{shell}$ (calciticbrachiopods, trilobites, corals), coupled withcorrespondent analyses of rock matrix ($\delta^{13}C_{rock}$), from Ordovician and Silurian of Estonia.Due to low resolution, most of the second-order stable carbon isotopic excursions, except for the Ireviken Event, are not well reflected in the new $\delta^{13}C_{rock}$ and$\delta^{13}C_{brach.}$ data. More interesting are the results from $\delta^{18}O_{brach.}$values. Most of the Ordovician values are generally higher than those reported in literature from other brachiopod data (especially from Laurentia and Southern Chinablocks). Silurian values (lower Sheinwoodian, upper Ludfordian, Pridoli) are similar to those reported for Gotland. Taking into account that $\delta^{18}O$ is susceptible to variousother environmental changes, interpretingthose values in terms of paleotemperatures may suggest the following: a) Katian high values support a cooling suggested by the Katian $\delta^{13}C_{rock}$ isotope excursions;b) Ordovician values point outa thermal latitudinal gradient when compared with those from Laurentia, which is in agreementwith paleogeography and brachiopod paleobioprovinces;c) during Silurian the isotopic values tend to be similar to those from Laurentia, which is also compatible with northward driftingof Balticapaleocontinent.Additionally, direct comparisonsfrom specimensfrom same bedsshow that $\delta^{13}C_{brach}$ is almost always heavierthan $\delta^{13}C_{rock}$(so as supported by literature). Tests with trilobites and corals show that $\delta^{13}C$ and $\delta^{18}O$ values are in a similar range to those obtained from brachiopods. Finally we will present additional data about sulphur isotopes ($\delta^{34}S_{brach}$).Fossil phosphatic shelled (lingulate) brachiopods, instead, show a variation in the apatite chemistry along shell lamination and their direct use for isotopic analyses should be handled with care. Infrared (ATR FT-IR) and energy dispersive spectroscopic (EDS) mapping of the cross sections of Furongianlingulate brachiopod *Ungula ingrica* shells show that the apatite in porous baculatelaminae differs from the apatite in compact laminae mainly by its higher carbonate anion and fluorine contents. Less pronounced differences appear also in the relative contents of various cations (Ca, Na, Mg). Additionalcrystallographic investigation with electron backscatter diffraction (EBSD) and electron probe microanalysis (EPMA) on the cross sections of calcitic brachiopods is currently in progress to investigate further their preservation, andtoassess the influence of crystallography on Mg^{2+} concentration and distribution in brachiopods calcite bio-minerals (with implications for Mg/Ca thermometry and for “vital effect”).

ESTONIRHYNCHIA ESTONICA: TAPHONOMY, DEFORMATION PATTERNS , PALEOECOLOGY, GEOCHEMISTRY, FUNCTIONAL MORPHOLOGY AND EVOLUTIONARY TRACTS INSIDE SUPERFAMILY UNCINULOIDEA (BRACHIOPODA)

Giuseppe Buono[1], Mena Schemm-Gregory[2] and Tõnu Meidla

1. University of Tartu, Geology Department, Ravila 14A, Tartu, 50411, Estonia. gbuono.geo@gmail.com

2. 1976-2013, last address: Centro de Geociências da Universidade de Coimbra, Largo Marquês de Pombal, P-3000-272 Coimbra, Portugal.

We examined more than 700 specimens of *Estonirhynchia estonica* coming from 24 localities from Silurian (from Adavere to Paadla stage, Llandovery *p.p.* to Ludlow *p.p.*) of Estonia, plus other uncinuloids (mostly also from Silurian Baltoscandian paleobasin). The study favored the identification of several morphotypes (distinguishable on the base of outline shape, ribs number width and length, umbo and foramen morphology) proofing a high phenotypic plasticity in *E. estonica*. The same is deducible from literature for its strict relatives *Plagiorhyncha* and *Spherirhynchia*, also found in the Silurian of the Baltoscandian paleobasin but in different temporal and facies setting. A distinctive taphonomic aspect of *Estonirhynchia* is a widespread evident to strong plastic deformation mostly localized in the anterior area. Additionally, dependent on age and locality, we also recorded breakage, dislocation, shell dissolution and/or replacement, shell perforations associated to pyrite crystal growth. Encrusting epifauna (bryozoans and serpulids) is rare and mostly localized in the anterior area, suggesting commensal relationship. Deformation pattern and distribution of epifauna, together with other anatomical features (in particular the commonly atrophied peduncle), suggests that: a) most of specimens was subject to an early diagenetic plastic deformationin life position in course of sediment compaction; b) *E. estonica* changed its life style during ontogenesis from benthic to semi-infaunal, as already suggested for its relative *Spherirhynchia*. *E. estonica* flourishing during Early Sheinwoodianstable isotopic (C and O) positive excursion (Ireviken event) recorded in Paramaja outcrop, in a dominated assemblage and in a sea level transgressive phase, proof as this species was able to thrive in “difficult” ecological environment. Considering Silurian Baltoscandian basin sea level evolution and features of uncinuloids there found, we suggest that this group gradually moved to the shallow-water environments, i.e. from relatively deep sea *Plagiorhyncha* (flatter and smooth) to the shallower *Estonirhynchia* (spherical, more ribbed, partially smooth), and then to *Spherirhynchia* (spheroidal, fully ribbed, geniculation and spines) adapted to high-energy environments. High phenotypic plasticity (so as blooming during transgressive sea level and stable isotopic positive excursion) of *Plagiorhyncha-Estonirhynchia-Spherirhynchia* lineage resembles that one of *Apringia-Soaresirhynchia-Stolmorhynchia* (Early Jurassic) within Basiliolidae (Permian-recent). This suggests that fast evolution and morphological adaptation to new colonized environments (phenotypic plasticity) may represent one of the determinant factors which favored rhynchonellid survival until today.

BIVALVE SHELLS AS FOSSIL ARCHIVES OF GLOBAL CHANGE: A TOOL TO INVESTIGATE SEASONALITY TOWARDS THE MIDDLE PLEISTOCENE TRANSITION

Gaia Crippa[1], Lucia Angiolini[1], Cinzia Bottini[1], Elisabetta Erba[1], Fabrizio Felletti[1], Christian Frigerio[1], Melanie J. Leng[2,3], Mariarose Petrizzo1[1], Gianluca Raineri[4] and Michael H. Stephenson[5]

1. Università degli Studi di Milano, Dipartimento di Scienze della Terra 'Ardito Desio', Via Mangiagalli 34, Milano, 20133, Italy. lucia.angiolini@unimi.it

2. NERC Isotope Geosciences Laboratory, British Geological Survey, Keyworth, Nottingham NG12 5GG, UK.

3. Centre for Environmental Geochemistry, School of Geography, University of Nottingham NG7 2RD, UK.

4. Riserva Naturale Geologica del Piacenziano, Via Scalinata Ospedale 4/6, Castell'Arquato, 29014, Italy.

5. British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK .

The Early Pleistocene is an epoch characterized by several climatic oscillations with obliquity as the dominant forcing parameter. The lower and upper boundaries of this time interval coincide with two important climatic events: the Northern Hemisphere Glaciation and the Middle Pleistocene Transition, the latter marking a world in which climate is dominated by eccentricity. The Mediterranean area was strongly affected by the Early Pleistocene climatic changes ; one of the most important biotic events is here represented by the appearance of the boreal guest *Arctica islandica* at the beginning of the Calabrian Stage, indicating significant cooling of the Mediterranean Sea. The Arda River marine succession, cropping out in Western Emilia, Northern Italy, has been shown to continuously covers this time interval, mainly based on nannofossils and foraminifers; it is also very rich in macrofossils, representing an ideal setting to study the climatic oscillations of the Early Pleistocene and understand how seasonality varies along the section using bivalves and their geochemical signature as archives of global change. We have undertaken sclerochemistry of pristine bivalve shells belonging to *Glycymeris inflata, Glycymeris insubrica* and *Arctica islandica* coming from several stratigraphic horizons from the Arda River succession. One of the main outcomes of these analyses is the recognition of an increase in the amplitude of the oscillation of the oxygen isotope record from the base to the top of the section. This suggests an increase in temperature seasonality during the deposition of the succession, which became more pronounced toward the Middle Pleistocene Transition. These results also offer the opportunity to unravel the interplay among the different factors affecting the oxygen isotope record, i.e. salinity, temperature and glacial advance and retreat.

DEVONIAN LINGULID BRACHIOPODS: TAXONOMY AND TAPHONOMY

Carolina Zabini[1,2] and Juliana de Moraes Leme Basso[2]

1. Universidade Tecnológica Federal do Paraná, UTFPR, Campus Dois Vizinhos. Estrada para Boa Esperança, km 4, Comunidade São Cristóvão, Dois Vizinhos, Paraná, PR 85660-000, Brazil. carolinazabini@utfpr.edu.br

2. Universidade de São Paulo, Instituto de Geociências, Rua do Lago-562 Cd. Universitária-São Paulo, SP, 05508-080, Brazil.

Devonian lingulid brachiopods from the Paraná Basin have been assigned to *Lingula* since they were first discovered. Integration of taphonomy and taxonomy allows a better understanding of the diversity of several fossil groups and diagenetic effects on their diagnostic featuresin a variety of lithologies. Identification of fossil lingulides to the generic and specific levels,now that *Lingula* itself is no longer considered a valid taxon for Paleozoic forms, is difficult because of the almost complete absence of preservable diagnostic features. Our study of Devonian lingulideshas allowed us to establish a correlation between their modes of fossilization and their corresponding depositional environments. Complete shells of two typical morphotypes occur in siliciclastic concretions in intervals relatedto maximum flooding surfaces of the highstandsystems tract. Several other morphotypes can be found as complete or fragmented, but flattened, specimens, occurring through the entire transitional offshore zone in both the transgressive systems and highstand systems tracts. The flattened specimens showed a variety of coloration related to weathering. Analyses using Raman and scanning electron microscopy demonstratethe chemical composition of the types of fossilization. The results point to two different kinds of fossilization: a) preservation within siliciclastic concretions of the original carbon and phosphorous composition; and b) preservation as flattened shells stained with recent minerals such as iron oxides. No preservation of carbonaceous films was detected, unlike that we found in a lingulide from the Hamilton Group (Middle Devonian) of New York State. With respect to morphotypes, flattened specimens show a variety of outlines due to deformation and this apparent diversity does not correspond to a real specific diversity. Only the two morphotypes present in the siliciclastic concretions recordreal lingulide diversity.

GLOBAL CORRELATION OF *OTOCERAS* BEDS IN LIGHT OF THE FIRST CARBON-ISOTOPE DATA ON THE PERMIAN–TRIASSIC BOUNDARY IN SIBERIA

Yuri D. Zakharov[1], Alexander S. Biakov[2], Sylvain Richoz[3] and Micha Horacek[4]

1. Far Eastern Geological Institute, Russian Academy of Sciences (Far Eastern Branch), Stoletiya Prospect 159, Vladivostok, 690022 Russia. yurizakh@mail.ru

2. Northeastern Complex Research Institute, Russian Academy of Sciences (Far Eastern Branch), Portovaya 16, Magadan 685000, Russia.

3. Karl-Franzens, Universität Graz, Heinrichstrasse 26, Graz, 8010 Austria.

4. BLT Wieselburg Research Center, Francisco-Josephinum, Rottenhauserstr. 1, 3250 Wieselburg, and Department of Lithospheric Research, Vienna University, Althanstr. 14, 1090 Vienna, Austria.

The Permian–Triassic boundary (PTB) interval at the Suol section (Verkhoyansk area, Siberia), hosting *Otoceras*-bearing beds, includes six carbon-isotope ($\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$) intervals (I–VI) which are traceable in several reference sections in Eurasia and North America. Interval I is characterized by uniformly elevated $\delta^{13}C_{org}$ values of the Posteventicum Subzone of the Imtachan Formation. Interval II, corresponding to the basal part of the Nekuchan Formation (the lower part of the Concavum Zone), shows a significant decrease in the $\delta^{13}C_{org}$ values. The higher beds of the Nekuchan Formation show two closely spaced negative $\delta^{13}C_{org}$ excursions (intervals III and IV, coinciding with the FAD of *Tompophiceras pascoei*). Interval V, comprising the lower part of the Pascoi Zone of the Nekuchan Formation, contains the third carbon-isotope minimum followed by beds with a significant $\delta^{13}C_{org}$ variation, and interval VI, corresponding to the middle part of the Pascoei Zone, is characterized by higher and less variable $\delta^{13}C_{org}$ values. These carbon-isotope patterns are traceable in several reference sections in the Tethyan (South China, Kashmir, Iran, and the Alps) and Boreal (Greenland, Norway, and Canada) realms. This provides grounds for assuming the PTB's position in the Suol section as being close to the carbon-isotope minimum of Interval IV. In the light of the new data, the upper Changhsingian in Siberia is proposed to correspond in range to the Concavum Zone, whereas the Griesbachian includes the Pascoei and Decipiens zones. Following the data from Norway, we correlate Interval I to stable climatic and geotectonic settings favourable for the development of gymnosperms in the Boreal realm. Interval II, which might reflect reduced productivity in the seas, is consistent with the gradual decrease in abundance and diversity of gymnosperms probably caused by intensification of the volcanic activity during the Changhsingian stage. However, the significant decrease of $\delta^{13}C_{org}$ values in intervals III and IV, characterized by the almost complete disappearance of gymnosperms in Norway, is most likely explained by the release of large volumes of CO_2 during the first two large phases in eruption of the Siberian Traps and/or by the proposed heating of marine sediments rich in organic matter at the very end of the Changhsingian. [Supported by grants RSF (14-17-00035) and RFBR (14-05-00011, 14-05-00217)].

SYMPOSIUM

CENOZOIC EVOLUTION OF TROPICAL-EQUATORIAL MAMMALS

ORGANIZERS:

PIERRE-OLIVIER ANTOINE - FRANÇOIS PUJOS

WESTERN AMAZONIA AS A HOTSPOT OF MAMMALIAN BIODIVERSITY THROUGHOUT THE CENOZOIC

Pierre-Olivier Antoine[1], Rodolfo Salas-Gismondi[1,2], François Pujos[3,4] and Laurent Marivaux[1]

1. Institut des Sciences de l'Evolution, cc64, Univ. Montpellier 2-CNRS-IRD, F-34095 Montpellier, France. pierre-olivier.antoine@univ-montp2.fr

2. Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru.

3. CCT-CONICET-MENDOZA, Mendoza, Argentina.

4. IFEA, UMIFRE 17 MAEDI/CNRS USR 3337 - America Latina, Lima 18, Peru.

Amazonia is the vastest South American natural region. Essentially covered by tropical rainforests and a complex river network, this area is today a major hotspot of biodiversity, notably for mammals. The pattern and timing of the settlement of the corresponding mammalian guilds remain widely unknown, due to the limited Cenozoic fossil record, especially for the Paleogene interval. Contrary to common beliefs, Cenozoic deposits from Western Amazonia contain a wide range of fossil mammals, most of them being highly relevant to test major evolutionary and/or biogeographic hypotheses. The earliest Cenozoic vertebrate assemblage from Amazonia, late Paleocene in age (~58Ma), was recently recovered from the Madre de Dios Sub-Andean Zone, Southeastern Peru. Regarding mammals, it includes only fragments of teeth. The oldest species-rich mammalian assemblage in Amazonia is CTA-27 (Contamana, eastern Peru; ~41Ma) with both endemic groups (gondwanatherians, marsupials, xenarthrans, and native ungulates) and early immigrants from other landmasses (rodents, bats). Another eastern Peruvian locality, Santa Rosa (?late Eocene-early Oligocene), yielded an equivalent mammalian guild. Two new localities, nearby Contamana, document the late Oligocene interval, with affinities to both Santa Rosa and Salla (Bolivia). In the Madre de Dios Basin, an early Miocene locality (MD-61) yielded the earliest platyrrhine primate from low-latitudes. By contrast, the middle-late Miocene interval is far more documented, with several faunas discovered over the last decades, from western Brazil (Acre, Juruá) and eastern/southern Peru ('Fitzcarrald Local Fauna', Madre de Dios). The mammalian guilds include marsupials, xenarthrans, native ungulates, caviomorph rodents, primates, bats, river dolphins, trichechid sirenians, and (disputed) North American immigrants. Younger faunas, late Pleistocene-Holocene in age, widely postdate the Great American Interchange(s), and accordingly include undoubted Northern invaders, such as perissodactyls, artiodactyls, proboscideans, carnivores, and muroid rodents, together with xenarthrans, toxodontids, and macraucheniids. Paleoenvironmental proxies point to the presence of tropical rainforests in Amazonia throughout the documented interval (late Paleocene-late Pleistocene), even if a drier episode is documented in the early Oligocene period. Western Amazonia also hosted a brief marine ingression during the late Paleocene. It experienced a much longer marine-influenced period during the Miocene, with the "long-lived Pebas megawetland system". Together with the Andean uplift, this Pebas system played a pivotal role in the biotic differentiation of southern/northern South American ecosystems and corresponding mammalian guilds prior to the Great American Interchange(s).

FIRST FOSSILS OF A PLATYRRHINE MONKEY FROM PANAMA PROVIDE EVIDENCE FOR MAMMALIAN DISPERSAL ACROSS THE CENTRAL AMERICAN SEAWAY IN THE EARLY MIOCENE

Jonathan I. Bloch[1], Aaron R. Wood[1], Aldo F. Rincon[1, 2], Emily Woodruff[1,3], Arianna R. Harrington[1, 3], Bruce J. MacFadden[1], Gary S. Morgan[4], David A. Foster[2], Camilo Montes[5] and Carlos A. Jaramillo[6]

1. Florida Museum of Natural History, University of Florida, Gainesville, FL 32611-7800, USA. jbloch@flmnh.ufl.edu
2. Department of Geological Sciences, University of Florida, Gainesville, FL 32611-7800, USA.
3. Department of Biology, University of Florida, Gainesville, FL 32611-7800, USA.
4. New Mexico Museum of Natural History, Albuquerque, NM, 87104, USA.
5. Geociencias, Universidad de los Andes, Calle 1A # 18A-10, Edificio IP, Bogotá DC, Colombia.
6. Smithsonian Tropical Research Institute, Box 0843-03092, Balboa, Ancon Republic of Panama.

While the northern-most distribution of South American monkeys (platyrrhines) today extends into the tropical forests of southern Mexico, this distribution is relatively recent, with mammalian interchange between South and Central America restricted by the Central American Seaway (CAS) for most of the Cenozoic. Despite geographic isolation, anthropoid primates arrived in South America from the Old World by the late Oligocene (*Branisella* from Salla, Bolivia; ~26 Ma). Until now, evidence for anthropoids in Central America prior to the rise of the Isthmus of Panama has been lacking, with acceptance of "rafting" on floating vegetation across the Atlantic as a mechanism for their dispersal into South America directly from Africa. Here we describe 7 isolated teeth of a new platyrrhine primate recovered from a tuffaceous mudstone in the Las Cascadas Formation in Panama that are similar to those of extant South American capuchin (*Cebus*) and squirrel (*Saimiri*) monkeys. Results from morphological phylogenetic analyses with molecular constraints that include the new taxon suggest a close relationship to crown platyrrhines, specifically cebids. A U-Pb radioisotopic date (20.93 ± 0.17 Ma) from 37 euhedral magmatic zircons in an ash layer directly associated with the anthropoid fossils, together with a diverse mammalian fauna consistent with the late Arikareean North American Land Mammal Age, indicates an early Miocene age. The new primate is the second oldest platyrrhine known and provides the first definitive example of mammalian dispersal between South and Central America prior to the beginning of the Great American Biotic Interchange, supporting recent tectonic reconstructions that proposed a relatively narrow CAS in the Miocene. While early stages of biotic interchange across the CAS have been hypothesized for certain groups (amphibians, reptiles, freshwater fishes, and plants), lack of other South American terrestrial mammals in the Miocene of Central and North America might suggest that Primates were uniquely better suited to northward dispersal at this time. Alternatively, anthropoids might have had a wider, largely un-sampled, tropical New World distribution during the Paleogene than currently understood. Discovery of new fossils from the New World Tropics will be critical to addressing questions surrounding the origin, dispersal, and early evolution of South American monkeys.

NEW FOSSIL MAMMALS FROM THE NORTHERN NEOTROPICS (URUMACO, VENEZUELA; CASTILLETES, COLOMBIA) AND THEIR SIGNIFICANCE FOR THE LATITUDINAL GRADIENT IN DIVERSITY AND THE GREAT AMERICAN BIOTIC INTERCHANGE

Juan D. Carrillo[1], Alfredo A. Carlini[2], Carlos Jaramillo[3] and Marcelo R. Sánchez-Villagra[1]

University of Zurich, Paleontological Institute and Museum, Karl Schmid-Strasse 4, Zurich, 8006, Switzerland. juan.carrillo @pim.uzh.ch

2. División Paleontología de Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, B1900WFA, Argentina.

3. Smithsonian Tropical Research Institute, 9100 PANAMA CITY PL, Washington DC, 20521-9100, USA.

The Great American Biotic Interchange (GABI) refers to the faunal exchange between North and South America around the time of closure of the Central American Seaway, an event that modified the mammal fauna of both continents. Unfortunately, current hypotheses about diversity dynamics during this migration event have been mostly based on data from temperate sites. We present new data from the Urumaco succession in Venezuela and from new sites at the Guajira Peninsula, northeastern Colombia, which together comprise a sequence of faunas expanding from the early Miocene to the early Pliocene. These faunas, due to their age and geographical location, serve to characterize the Neotropical mammal community before and after GABI's migrational intervals. Studies of several taxonomic groups involve different teams of researchers. In Urumaco the greatest diversity of mammals is in the xenarthrans, with at least 20 species representing Mylodontids, Megalonychids, Megatherines, Glyptodontids, Pampatherids and Dasypodids. Different species provide insights into the re-ingression from North America, taxonomic affinities with megalonychids otherwise present in the Caribbean islands, and the record in these northern latitudes of 'basal' forms recorded in earlier deposits of higher latitudes of the continent. Among rodents, the revision of both new dental and postcranial remains and their variation revealed that several species must have existed, including *Phoberomys pattersoni*, *Eumegamys* sp., and *Neoepiblema* sp. Among the 'meridiungulata', cranial remains of toxodonts suggest the presence of forms with plesiomorphic features unexpected for animals at this geological age. Astrapotheres include cranial remains from Castilletes representing the oldest record of Uruguaytheriinae in the tropics, whereas materials from the Urumaco sequence are postcranials and suggest a different locomotory style that the southern taxa from which postcrania is known. The oldest procyonid carnivores from the northern neotropics are recorded based on dental remains, from Castilletes and Urumaco (San Gregorio Fm.), both of affinities with genera recorded so far from Argentina. We complement field data by compiling and analyzing the composition of late Neogene mammal assemblages in the Americas by computing the percentage of both native and migrational faunas across a latitudinal gradient. Migrations started in the late Miocene (~10 Ma), but most exchange occurred after the early Pliocene (~5 Ma). In tropical South America migrants are first recorded in the Pliocene, whereas in temperate South America there are some records of North American migrants during the late Miocene and Pliocene, but it is not until the Pleistocene when migrants became common.

EVOLUTION OF THE HYDROGEOGRAPHY OF NORTHERN SOUTH AMERICAN RIVERS

Carlos Jaramillo[1], Ingrid Romero[1,2], Germán Bayona[3] and Jaime Escobar[1,4]

1. Smithsonian Tropical Research Institute, Panama. jaramilloc@si.edu
2. Seton Hall University, NJ, USA.
3. Corporación Geológica Ares, Bogotá, Colombia.
4. Universidad del Norte, Barranquilla, Colombia.

It has been argued that during the early and middle Miocene (22 to 15 My ago) the Amazon region and northern South America was either a giant lake, a shallow sea connected to the Caribbean, or a complex system of extensive floodplains. The main reason for all the controversy is that the geologic history in most of the rocks of Amazonia is highly condensed, with the last 20 My represented by only ~ 300 meters of rock. Much of the geologic history therefore is missing. One avenue to solve this problem is to study adjacent basins with higher subsidence rates where the rock record is more substantial. Many studies have suggested that the Miocene floodings of Amazonia came from the Caribbean via the Llanos of Colombia. We studied a sediment core (Saltarin) in the Llanos Basin, which have higher sedimentation rates that any site in Amazonia. Seventy nine palynological samples were analyzed and ~ 600 palynomorphs were identified. We applied maximum likelihood to estimate the age of the core using FAD, LAD and relative abundances of key taxa found in the fossil record of Saltarin, indicating that the core spans the entire Miocene (22 to 6 Ma). We used a salinity index to establish timing, duration and frequency of marine floods or freshwater lake developments. We identified five independent marine events, mainly during the early and middle Miocene, lasting from 200 Ky to 1 My, underscoring that northwestern Amazonia was covered by a shallow ocean during the Miocene, but those events were short-lived, rather than a continuous marine occupancy of Amazonian landscape over tens of millions of years. What happened to rivers during those flooding events is still a puzzle we are investigating. Did those flooding events had a lasting effect on the evolution of terrestrial clades? A flooding would have drastically reduced the population size of thousands of species across many different clades, as well as segmented populations that once were connected. It would be expected that those events, or at least those that last enough time, would be seen across DNA-phylogenies of many taxa, both plants and animals. However, it rarely has been detected with the exception of some riverine taxa that have relatives in the Caribbean. This is a puzzle that would like to solve in the coming years. By the onset of the late Miocene, marine incursions ceased, and fluvial deposition dominated the Llanos Basin. Although the Andes cordilleras had a positive relief by then and there was an incipient Amazon drainage, there were still drainages connecting rivers across the Andes, even until the middle Pliocene, connections that we are still attempting to understand.

AGE OF THE TARIJA FAUNA, BOLIVIA: IMPLICATIONS FOR *EQUUS* DISPERSAL AND CALIBRATION OF GABI 3

Bruce J. MacFadden[1]

1. Florida Museum of Natural History, University of Florida, Gainesville, Florida 32611, USA.
bmacfadd@flmnh.ufl.edu

The highly fossiliferous badlands in the Tarija basin, southern Bolivia, have produced a classic Ensenadan mammalian fauna representing the height of the Great American Biotic Interchange (GABI). Although traditionally accepted to be middle Pleistocene (0.78-0.126 Ma) in age, a recent study of supposedly interbedded radiocarbon ages has advocated for a younger age (Lujanian SALMA; 0.126-0.011 Ma) for the Tarija Fauna. In contrast, here a recently published radioisotopic determination of 0.76 ± 0.03 Ma is described for an ash within the Tolomosa Formation, which contains the Tarija Fauna. This geochronological calibration point corroborates a fission-track age and magnetostratigraphic correlation from the 1980s recording the Jaramillo subchron and Bruhnes-Matuyama boundary within the Tarija fossiliferous sequence. A biostratigraphic study of the equids confirms that horses (Family Equidae) are abundantly represented throughout the sequence at Tarija, including definitive evidence of the genus *Equus* (*insulatus*) at all fossiliferous levels recorded in the UF collections. Given the age of Tarija Fauna, these occurrences of *Equus* span an age range from 0.99 Ma to less than 0.76 Ma during the late early-middle Pleistocene, or Ensenadan SALMA. Over the past decade, refinements in geochronological calibrations indicate that GABI was actually a series of separate immigration events, or pulses, during the Pliocene and Pleistocene. Studies from the classic localities in Argentina, where the Pleistocene SALMAs are characterized, postulate that the genus *Equus* was part of GABI 4 that defines the base of the late Pleistocene Lujanian SALMA at 0.125 Ma. However, the biostratigraphic occurrences of *Equus* at Tarija demonstrably indicate an earlier arrival of this genus into South America during the middle Pleistocene Ensenadan at about 1 Ma, i.e., GABI 3. While the FAD of *Equus* in South America is earlier than previously accepted for the classic sequences in Argentina, the presence of the species *E. neogaeus* may still be an index fossil for the Lujanian SALMA.

MAMMALIAN EVOLUTION IN THE LATE EOCENE OF NORTHERN AFRICA: INCREASED SAMPLING RAISES NEW QUESTIONS

Erik R. Seiffert[1]

1. Department of Anatomical Sciences, Stony Brook University, New York, 11794-8081 USA.
erik.seiffert@stonybrook.edu

Terrestrial mammalian faunas of late Eocene or Priabonian age (~37 to ~34 Ma) are now known from three areas in northern Africa: Fayum (Egypt), Dur at-Talah (Libya), and Bir el-Ater (Algeria). The most productive sites — the Fayum localities BQ-2 and L-41 — have provided our most detailed insights into the nature of mammalian evolution in Afro-Arabia at the beginning and end of the Priabonian, respectively, while the Dur at-Talah localities DT1 and DT2 have yielded isolated teeth and jaw fragments of small mammals that appear to be intermediate in age between BQ-2 and L-41. From the limited evidence available, there are a few notable patterns of faunal change over the course of this interval: 1) in the earliest Priabonian of northern Africa, hyracoids were represented solely by morphologically conservative small-bodied forms, but by the late Eocene that group had achieved their all-time peak diversity, with considerable disparity in body mass and morphology; 2) early Priabonian hystricognathous rodents, hyracoids, and macroscelideans known from northern Africa had brachydont molars that lacked tall crests, but by the latest Eocene, relatively hypsodont members of each clade were present; 3) anomalurid rodents were common in northern Africa in the earliest Priabonian, but thereafter are known solely from equatorial areas; 4) embrithopods and elephantiform proboscideans have not been recovered from definitively Priabonian-aged beds in northern Africa, but are common in the earliest Oligocene of that region (*Moeritherium* and *Barytherium* are the only proboscideans known from the late Eocene of northern Africa); 5) caenopithecine adapiform primates were common and diverse in the Priabonian of northern Africa, but have not been found in older or younger beds on that landmass; 6) Tooth-combed strepsirrhine primates of Paleogene age have thus far only been documented in the Priabonian of northern Africa, and thereafter do not occur again in that region until the late Miocene; 7) anthracotheriid artiodactyls have not been recovered in the earliest Priabonian, but are known from the mid-Priabonian (~35 Ma) Dir Abu Lifa Member of the Qasr el-Sagha Formation in Egypt. The appearance of anthracotheriids is best explained by a mid-Priabonian dispersal from Asia, but the other appearances, disappearances, and morphological changes listed above are more difficult to explain. Paleontological sampling in other parts of Afro-Arabia will be required to determine which patterns are the result of *in situ* evolution in northern Africa, and which are due to immigration from other parts of that landmass.

PALEOGENE CINGULATA FROM THE GUABIROTUBA FORMATION, CURITIBA BASIN, PARANÁ, BRAZIL: TAXONOMY AND BIOCHRONOLOGY

David D. Silva[1,2], Edison V. Oliveira[2] and Fernando A. Sedor[3]

1. Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves 9500, Porto Alegre, 91509-900, Brazil. david.paleo@hotmail.com

2. Universidade Federal de Pernambuco, Av. Acad. Helio Ramos s/n, Recife, 50740530, Brazil.

3.Museu de Ciências Naturais –UFPR, Coronel Francisco Heráclito dos Santos 100, Curitiba, 81531-990, Brazil.

The record of Paleogene cingulates in Brazil consists only of *Eocoleophorus* from the Taubaté fauna (late Oligocene) and of *Riostegotherium* from Itaboraí (early Eocene). New Paleogene cingulates from Guabirutuba Formation, Curitiba Basin (State of Paraná, South of Brazil), are reported. The material is housed at the collection of the Museu de Ciências Naturais, Setor de Ciências Biológicas of the Universidade Federal do Paraná (MCN-SCB-UFPR), Curitiba, Paraná, Brazil. The specimens recovered up to now include isolated osteoderms, teeth and some postcranial materials. Based on the ornamentation of the osteoderms we identified the following taxa: Family indet., *Eocoleophorus* n. sp. and *Machlydotherium* sp.; Family Dasypodidae, *Utaetus* cf. *U. buccatus*, *Utaetus* sp., *Amblytatus* sp., *Meteutatus* aff. *M. lagenaformis*, *Archaeutatus* sp., *Prozaedyus* aff. *P. planus*, and Stegotheriini indet. In Patagonian Argentina, the age of *Utaetus* cf. *U. buccatus* ranges from the middle to late Eocene Casamayoran SALMA; that of *Meteutatus* aff. *M. lagenaformis* ranges from the middle-late Eocene Casamayoran (Barrancan Subage) up to the late Oligocene Deseadan SALMA. Regarding *Machlydotherium*, its latest record is in the "La Cancha" levels of Gran Barranca (Tinguiririan SALMA, early Oligocene) in Patagonia. *Eocoleophorus* is a genus described originally from the late Oligocene (Deseadan) of Brazil. The new species is clearly more basal than the type species, with movable osteoderms without anterolateral figures and scarce pits (foramina). Based on the presence of *Utaetus* cf. *U. buccatus* and other taxa we estimate the age of the Guabirotuba fauna as middle Eocene to early Oligocene (Casamayoran-Tinguiririan SALMAs).

PALEOGENE METATHERIA FROM THE GUABIROTUBA FORMATION, CURITIBA BASIN, PARANÁ, BRAZIL: TAXONOMY AND FAUNA CORRELATION

Eliseu V. Dias[1], Edison V. Oliveira[2], David D. Silva[3,4] and Fernando A. Sedor[4]

1. Universidade Estadual do Oeste do Paraná – Unioeste, Campus de Cascavel, CCBS, Laboratório de Geologia e Paleontologia, Rua Universitária 2069, Cascavel, PR, 85819-110, Brazil. eliseu.dias@unioeste.br
2. Universidade Federal de Pernambuco, Av. Acad. Helio Ramos s/n, Recife, PE, 50740530, Brazil.
3. Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves 9500, Porto Alegre, RS, 91509-900, Brazil.
4. Museu de Ciências Naturais – Universidade Federal do Paraná, Av. Coronel Francisco Heráclito dos Santos 100, Curitiba, PR, 81531-990, Brazil.

Previous records of Paleogene metatherians in Brazil are from Taubaté (late Oligocene) and Itaboraí (early Eocene) faunas. Remains of three metatherians coming from a new South American Paleogene fauna from Brazil are reported here. The fossils were collected in an outcrop of the Guabirotuba Formation (Curitiba Basin) in Curitiba, State of Paraná, south of Brazil. The material is deposited at the paleontological collection of the Museu de Ciências Naturais, Setor de Ciências Biológicas of the Universidade Federal do Paraná, Curitiba, Paraná, Brazil. The first specimen is a partial dentary with p1-m2 of a large sparassodont, identified as belonging to *Patene*, a genus previously described for Eocene faunas from Itaboraí, Central Patagonia and Peruvian Amazonia (Santa Rosa). The Guabirotuba specimen is more derived and larger than *Patene simpsoni* and it shows well-developed paraconids and reduced metaconids. As in *P. simpsoni*, the talonids are not strongly reduced. A second form is represented by an incomplete dentary with p3-m1, identified as a basal polydolopimorph, having a more generalized pattern with a small p3, but exhibiting potential derived features shared with *Epidolops* and *Roberthoffstetteria*, such as paraconid and metaconid placed close to each other, and talonids with a reduced and centrally placed hypoconulid. The third form is represented by an incomplete dentary of a juvenile, identified as the polydolopimorph *Wamradolops*, described originally from the Paleogene Santa Rosa fauna of Peru. The presence of *Wamradolops* in the Guabirotuba fauna constitutes an element of correlation with the Santa Rosa fauna, which has been dated as Eocene to early Oligocene. The inferred age (middle Eocene – early Oligocene) as provided by metatherians is in agreement with other elements of the Guabirotuba fauna and the record of *Wamradolops* expands its paleogeographical distribution to the Paleogene of Eastern South America.

DIVERSITY OF LATE QUATERNARY CAVIOMORPH RODENTS (RODENTIA: HYSTRICOGNATHI) FROM THE SERRA DA CAPIVARA, NORTHEASTERN BRAZIL

Leonardo Kerber[1], Elver L. Mayer[1], Ana M. Ribeiro[2] and María G. Vucetich[3]

1. Programa de Pós-Graduação em Geociências, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, 91501-970, Porto Alegre, RS, Brazil. leonardokerber@gmail.com

2. Seção de Paleontologia, Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Av. Salvador França, 1427, 90690-000, Porto Alegre, RS, Brazil.

3. División Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.

Quaternary fossil rodents of Brazil have been studied since the 19th century. However, the results are meager compared to the richness and diversity of the group. Publications about these fossils from northeastern Brazil are rare, although they have increased in the last few years. Today, the rodents from northeastern Brazil are adapted to dry environments that are predominant in this region (Caatinga Biome). However, these environments have changed over the last thousand years and consequently the taxonomic composition of the fauna has changed accordingly. Here, fossil rodents (Hystricognathi: Caviomorpha) from the late Quaternary (late Pleistocene-early Holocene) of the southwestern State of Piauí, northeastern Brazil, are described. The material comes from archaeological/paleontological sites located in the region of the Serra da Capivara and it is housed in the paleovertebrate collection of the Fundação Museu do Homem Americano (FUMDHAM). The late Quaternary taxa include: *Galea* Meyen, *Kerodon rupestris* Wied-Neuwied, Hydrochoeridae indet., *Dasyprocta* Illiger, *Myocastor* Kerr, *Thrichomys* Trouessart, *Phyllomys* Lund, *Coendou magnus* Lund and a new taxon with chinchilloid affinities. The *C. magnus* and *Myocastor* material represents the northernmost records of these taxa. The unexpected presence of a new extinct taxon contributes to the understanding of the ancient rodent faunas from South America. Today, the studied area is located within the Caatinga Biome but some of the identified fossil taxa, such as Hydrochoeridae and *Myocastor*, indicate the occurrence of wetter environments than today and of permanent waterbodies during the late Pleistocene – early Holocene. [CNPq 141986/2011-5; CNPq; CNPq/Universal-483156/2014-4; CNPq/PQ-312085/2013-3].

POTAMARCHINE RODENTS (RODENTIA: CAVIOMORPHA: DINOMYIDAE) FROM THE NEOGENE OF SOUTHWESTERN AMAZONIA, BRAZIL

Leonardo Kerber[1], Francisco R. Negri[2], Ana M. Ribeiro[3], Maria G. Vucetich[4] and Jonas Pereira de Souza-Filho[5]

1. Programa de Pós-Graduação em Geociências, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, 91501-970, Porto Alegre, RS, Brazil. leonardokerber@gmail.com

2. Laboratório de Paleontologia, Campus Floresta, Universidade Federal do Acre, Cruzeiro do Sul, AC, Brazil.

3. Seção de Paleontologia, Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Av. Salvador França, 1427, 90690-000, Porto Alegre, RS, Brazil.

4. División Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.

5. Laboratório de Paleontologia, Universidade Federal do Acre, Rio Branco, AC, Brazil.

The fossil rodents from southwestern Amazonia of Brazil have been studied since the first half of the 20th century. Several caviomorph rodents were reported for the Neogene of this region, mainly neoepiblemids and dinomyids. Dinomyidae is a group of caviomorphs represented today by a single species, *Dinomys branickii* Peters. However, the group was much diversified during the Neogene. Potamarchinae includes primitive dinomyids with protohypsodont cheek teeth. Until recently the records of dinomyids in the Solimões Formation were predominantly based on few isolated teeth, which difficult a more accurate taxonomic identification due to the scarcity of diagnostic characters. Here, new remains, more complete than the ones previously reported, of dinomyids Potamarchinae from the Neogene of Southwestern Amazonia are described. The material is housed in the paleovertebrate collections of the Universidade Federal do Acre – Campus Floresta, Cruzeiro do Sul (UFAC-CS), State of Acre and Universidade Federal do Acre (UFAC), Rio Branco, State of Acre. The rodent specimens here reported were collected along the Juruá, Purus and Acre rivers during expeditions conducted by UFAC and UFAC-CS teams. Micro-CT images were employed to analyze the internal structures and to review 3D graphics of the specimens. New material includes: a dentary of *Potamarchus murinus* Burmeister and several isolated teeth of *Potamarchus* sp.; a palate with M1-M3 series assigned to a new species of *Potamarchus*; and a maxilla with P4-M1 interpreted as new genus and species of a potamarchine. These data suggest a higher diversity of dinomyids in lower latitudes than previously supposed. Potamarchines have a considerable variation on the occlusal surface of cheek teeth, mainly ontogenetic. This would be analyzed in a major review, including a phylogenetic analysis incorporating the taxa here described for a better understanding of these primitive Neogene dinomyids. [CNPq 141986/2011-5; CNPq/PQ-312085/2013-3; MCTI/UFAC (Campus Floresta): n° 01200.001631/2010-32].

IS THERE ANY TROPICAL INFLUENCE ON THE ORIGIN AND DIVERSIFICATION OF SLOTHS?

François Pujos[1,2] and Gerardo De Iuliis[3,4]

1. IANIGLA, CCT–CONICET–Mendoza, Avda. Ruiz Leal s/n, Parque Gral. San Martín, 5500 Mendoza, Argentina. fpujos@mendoza-conicet.gov.ar
2. IFEA, UMIFRE 17 MAEDI/CNRS USR 3337 - America Latina, Lima 18, Peru.
3. Dpt. of Ecology and Evolutionary Biology, Univ. of Toronto, Toronto, M5S 3G5, Canada.
4. Dpt. of Palaeobiology, ROM, Toronto, M5S 2C6, Canada.

Modern sloths are relatively small, slow-moving mammals utilizing a mainly suspensory posture in arboreal environments of the tropical rainforests of South and Central America and some Antillean islands. However, their fossil kin, generally referred to as ground sloths, displayed a much wider range of body size, diet, and locomotory modes, as well as a much broader geographic distribution. They colonized much of the Americas (including the West Indies) during the Neogene and Quaternary, extending from Patagonia to Alaska. In South America, the sloths, along with native South American ungulates, dominated the continent until about 10,000 years ago. An unresolved question in xenarthran evolution is the origin of current and fossil sloths. Although they are ultimately of South American origin, the factors and place are still uncertain. The diphyletic origin of the living tree sloths *Bradypus* and *Choloepus* has long been strongly supported. Many of their remarkable postcranial specializations (e.g. elongation of long bones, simplification of articular facets) are convergent and strikingly different from the condition in ground sloths, so that their relationship to other sloths (*Choloepus* as a megalonychid, *Bradypus* as the sister group to all other sloths) is based on skull characters. Abundant discoveries of new Neogene tropical localities (e.g., in Brazil, Colombia, Peru, and Venezuela) have not yielded fossil tree sloths. Instead, most tropical fossil lineages exhibit strong affinities with taxa present in other areas of the continent. Some peculiar tropical ground sloths, such as the mylodontoid *Octodontobradys*, are clearly not closely related phylogenetically to tree sloths. Large ground sloths, particularly among Megatheriidae and Mylodontidae, were apparently well suited to subtropical environments present in northern South America since the Neogene. *Megathericulus*, the oldest megatheriine genus (common in Patagonia and recently discovered in Peruvian Amazonia), was already a very large sloth of several hundred kilograms by middle Miocene times. The evidence indicating 1/ origin and diversification of current sloths is clearly related to tropical influence, 2/ the existence of great taxonomic, dietary, and locomotory diversity in ground sloths, the absence of fossil tree sloths, and of several sloth clades in the southernmost region of South America provides no suggestion of neither a tropical origin for ground sloths nor a strong tropical influence for the diversification of these large mammals.

SYMPOSIUM

FOSSIL ARTHROPODS AS LIVING ORGANISMS: MORPHOLOGY, PALAEOECOLOGY, DEVELOPMENT AND EVOLUTION

ORGANIZERS:

ALLISON C. DALEY - JAMES C. LAMSDELL

FIRST COMPARISON OF LATEST CRETACEOUS AND EARLY PALEOCENE INSECT DAMAGE IN THE SOUTHERN HEMISPHERE SUPPORTS A PATAGONIAN BIODIVERSITY REFUGIUM

Michael P. Donovan[1], Ari Iglesias[2], Peter Wilf[1], N. Rubén Cúneo[3] and Conrad C. Labandeira[4]

1. Department of Geosciences, Pennsylvania State University, University Park, Pennsylvania, 16802, USA. mpd187@psu.edu
2. Instituto de Investigaciones en Biodiversidad y Medioambiente INIBIOMA-CONICET, Universidad Nacional del COMAHUE, Quintral 1250, San Carlos de Bariloche, 8400, Argentina.
3. Museo PaleontológicoEgidioFeruglio,Av. Fontana 140,Trelew, 9100, Argentina.
4. Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20013, USA.

Most research on terrestrial ecosystems after the Cretaceous-Paleogene (K-Pg) asteroid impact comes from a relatively small area of the western USA, severely limiting our understanding of global extinction and recovery patterns. In that region, plants and associated insect-damage diversity decreased significantly at the K-Pg boundary, and specialized damage types (DTs) were disproportionately affected in the extinction. Here, we present results comparing insect damage on latest Cretaceous and early Paleocene fossil floras from coastal deposits in Chubut Province, Patagonia, Argentina, comprising the first study of its kind done outside the western USA. We compared ca. 850 leaf fossils from the latest Maastrichtian (67-66 Ma) part of the Lefipán Formation in northwestern Chubut to approximately 2000 leaf fossils from the early Danian Salamanca Formation, located ca. 360 km to the southeast (~50° south paleolatitude). Insect damage to both the Cretaceous and Paleocene floras (56 DTs each) is more diverse than in the western USA (49 Cretaceous and 44 Paleocene DTs from a much larger sample size) and includes many new associations. Examples of new DTs from the Lefipán Formation are spheroidal galls on primary veins surrounded by a wide rim of thickened woody tissue, and ellipsoidal to spheroidal galls composed of carbonized material with striated surfaces. The Paleocene Salamanca floras are also associated with high DT diversity, including 12 specialized DTs not found at the Lefipán localities, suggesting a more rapid recovery of insect herbivory in Patagonia compared to the western USA. Examples of new, Paleocen especialized DTs include concentric rings of piercing and sucking marks, mines, and galls on the oldest known *Agathis*. Comparisons of sampling-standardized DT diversity from the Cretaceous to Paleocene revealed a lower decrease than what has previously been observed in North America during the same interval.These results, combined with earlier work demonstrating minimal overall pollen extinction across the K–Pg boundary in the Lefipán Formation, support an emerging hypothesis that southern latitudes were buffered from the global environmental disaster after the end-Cretaceous impact. This buffering provided a refugium for associational diversity, as well as the survival of a long list of nominally Mesozoic plant and vertebrate clades.

THE RELATIONSHIP BETWEEN PHENOTYPIC PLASTICITY AND ENVIRONMENTAL CHANGE: IMPLICATIONS FOR LONGER-TERM MORPHOLOGICAL TRENDS WITHIN THE TRILOBITA OF THE CINCINNATIAN SERIES (LATE ORDOVICIAN)

Brenda R. Hunda[1] and Andrew J. Webber[2]

1. Cincinnati Museum Center, 1301 Western Avenue, Cincinnati, Ohio, 45203, USA. bhunda@cincymuseum.org
2. Cincinnati Museum Center, 1301 Western Avenue, Cincinnati, Ohio, 45203, USA.

Modern and fossil studies have shown that the distribution of variation within populations is not random with respect to geography and that environmental controls play a major role in these distribution patterns. It is well known that the foundation of macroevolutionary processes lies within minute intraspecific variation. However, a gap in our current understanding exists between documenting the nature of intraspecific variation within modern settings and the implications of these patterns for longer-term processes operating on the temporal scale of 10^3–10^5 years in the fossil record. This is particularly challenging in deep time studies, where the necessary controls on temporal resolution, geographic distribution, and environment are typically lacking. This study presents a high-resolution examination of geographic variation in morphology for the trilobite species *Flexicalymene granulosa* over a series of time slices within the Upper Ordovician Kope Formation. Trilobite specimens have been collected from coeval strata at four localities that span an environmental gradient. Together, these time slices facilitate the construction of quantified models of morphology and environment using geometric morphometrics and gradient analysis, respectively. This framework allows 1) an identification of the spatial component of morphological variation; 2) characterization of the dynamic interplay among geography, morphology, and environment; and 3) an assessment of how these variables operating over short time scales contribute to longer-term stratophenetic patterns. Previous analysis shows that a significant portion of the intraspecific morphological variation in *F. granulosa* is statistically correlated to quantified environment tied to water depth changes through time in the Kope Formation as a whole. Based on this model, the time-slice framework constructed here will be used to test the hypothesis that geographic patterns of morphology will align along environmental gradients. The predicted outcome for any single time slice would be a morphocline where distinct, yet overlapping, phenotypes vary laterally along the paleoramp according to preferred water depth. Results indicate that clines are persistent, dynamic and responsive to environmental shifts. Within this clinal regime novel morphologies do not appear and stratophenetic patterns mirror patterns of environmental change due to the dominant process of clinal translocation. Therefore, clines will not be the site of speciation unless environmental perturbation is severe enough to require adaptation rather than migration, or the steepness of the gradient changes sufficiently enough to reduce gene flow and promote isolation.

EVIDENCE OF THE PHEROMONE AND VIBRATORY COMMUNICATION IN THE FOSSIL CADDISFLIES (INSECTA: TRICHOPTERA)

Vladimir D. Ivanov[1] and Stanislav I. Melnitsky[1]

1. Department of Entomology, Faculty of Biology, St.-Petersburg State University, 199034, St.- Petersburg, Universitetskaya nab., 7/9, Russia. v--ivanov@yandex.ru

Processes of communication in insects use various channels: olphactory, visual, vibratory, and acoustic supported by specialized body structures. Adaptations of extant insect species are well studied with a bulk of published papers and books. Communication in fossil insects can be evidenced by homologous structures of their bodies showing the communicative organs. These structures are small and their remnants are visible mostly on fossils of high preservation quality. Trichoptera (caddisflies) have various adaptations for communication. The most widespread is pheromone olphactory attraction using sternal secretory glands on the abdominal segment V. Other adaptations include sternal abdominal projections for vibratory signaling and larger eyes combined with color patterns for visual communication. Fossil caddisflies provide evidence of such communication in the past. Sternal pheromone gland openings were found in some amber Trichoptera from the Eocene of Europe and in the Cretaceous *Dajella tenera* Sukatsheva from Siberia. The structure of gland openings in fossils matches that of corresponding structures in extant representatives of the same families. The antennal segments of fossils sometimes have well preserved specialized olfactory sensilla. Sternal abdominal projections for vibratory signaling are characteristic for some fossil Polycentropodidae, Rhyacophilidae, Hydrobiosidae, Beraeidae, and Goeridae from the European ambers and also for some Mesozoic Disoneuridae and *D. tenera*. Reliable communication evidence for Paleozoic Protomeropina basal to both Lepidoptera (butterflies and moths) and Trichoptera is lacking, although specialized wing coupling devices are sometimes interpreted as pheromone sources.

A NEW ARTHROPOD WITH AN INTRIGUING FEEDING APPARATUS FROM THE EMU BAY SHALE LAGERSTÄTTE, SOUTH AUSTRALIA

James B. Jago[1,2], James G. Gehling[2] and Diego C. García-Bellido[2,3]

1. School of Natural and Built Environments, University of South Australia, Mawson Lakes, SA 5095, Australia.
2. South Australian Museum, North Terrace, Adelaide, SA 5000, Australia. Diego.Garcia-Bellido@adelaide.edu.au
3. School of Earth and Environmental Science, University of Adelaide, SA 5005, Australia.

The Emu Bay Shale Lagerstätte (Cambrian Series 2, Stage 4), the best Burgess Shale-type biota in Australia, occurs on the north coast of Kangaroo Island, South Australia. Over 50 species are known, including trilobites and non-biomineralized arthropods, lobopodians, palaeoscolecids, hyolithids, brachiopods, polychaetes, vetulicolians, odontogriphids, nectocarids, sponges and chancelloriids. A common non-trilobite arthropod from this biota is the subject of this paper. The new taxon is up to 6 cm long, with a cephalic shield comprising about 30% of the exoskeleton. In most dorsally preserved specimens the cephalic margin is smooth, but in some there are three bilaterally-symmetrical pairs of small triangular spines on the central to posterior parts of the shield. A pair of small eyes is placed well forwards. The trunk comprises eleven segments that increase in length while narrowing posteriorly, each possibly bearing a pair of biramous appendages. The spatulate telson is very large, and constitutes 25–30% of the entire exoskeleton, proportionately longer than in similar taxa such as *Leanchoilia, Alalcomenaeus* or *Sanctacaris*. Up to six (three pairs?) of 3 mm-long rods bearing alternating inward-curving short and long spines are recognised in the cephalic shield. These are interpreted as components of a complex feeding apparatus, and they are not unlike the S2-elements of conodonts. A well-developed gut includes a stomach within the cephalic shield and extends to the base of the telson. In a few specimens there are identifiable fragments of the trilobite *Estaingia bilobata* (the most common species in the biota making up over 50% of the fauna) within the intestine; these fragments have sharp margins and extend almost right across the gut lumen. The species may have been a scavenger that ingested material already partly broken up by a larger predator/scavenger. Based on general morphology, but in the absence of diagnostic cephalic appendages (except the spinose rods), this taxon may belong to the leanchoiliids or the sanctacariids.

THE ARTIOPODAN ANCESTRY OF CHELICERATES REVISITED

David A. Legg[1]

1. Oxford University Museum of Natural History, Parks Road, Oxford OX1 3PW, UK.
david.legg@oum.ox.ac.uk

With over 113,894 described species, the chelicerates (sea spides, horseshoe crabs and arachnids) represent one of the most species-rich clades on Earth today, second only to their primary prey, the hexapods (insects). Understanding the origin and early evolution of chelicerates has proven to be a difficult and contentious pursuit. Although molecular clock analyses indicate an early Cambrian origin for this clade, body fossils of crown-group representatives are not recovered until the early Ordovician, although unequivocal chelicerate trace fossils are known from the late Cambrian. A diversity of putative chelicerate ancestors have been identified from Cambrian *Konservat-Lagerstätten*. Although traditionally aligned with artiopodans, particularly vicissicaudates, a group consisting of cheloniellids, aglaspidids and xenopods, more recent studies have regarded megacheirans ('short-great-appendage' arthropods) as the putative sister-taxon of Chelicerata, based primarily on the morphology of their frontal appendages. Few other features are shared between these taxa however, and similarities in frontal appendage morphology appear to be overstated. A restudy of selected vicissicaudates, namely *Sanctacaris*, *Sidneyia*, and aglaspidids, has revealed additional features, such as axial nodes, tripartite appendage exites, and antenniform and chelate anterior appendages, indicative of chelicerate affinities. An extensive phylogenetic analysis resolved vicissicaudates as the paraphyletic sister-taxon of Chelicerata, with *Sanctacaris* as sister-taxon to all other euchelicerates (horseshoe crabs and arachnids). The putative xiphosurans *Offacolus* and *Dibasterium*, resolved as successive plesions to crown-group euchelicerates. These taxa are notable for possessing elongate, antenniform chelicerae, whereas other euchelicerate possess short (< 4 podomeres) chelicerae. The elongate chelicerae of *Offacolus* and *Dibasterium* seemingly represent an intermediate stage in the evolution of chelicerate appendages from the more typically antennate anterior appendages of artiopodans (trilobites and vicissicaudates).

ORIGIN AND EARLY DIVERSIFICATION OF ARTHROPOD VISUAL SYSTEMS

Xiaoya Ma[1,2], Gregory D. Edgecombe[1] and Nicholas J. Strausfeld[3]

1. Department of Earth Sciences, Natural History Museum, London, SW7 5BD, UK. x.ma@nhm.ac.uk
2. Yunnan Key Laboratory for Palaeobiology, Yunnan University, Kunming, 650091, China.
3. Department of Neurosciences and Center for Insect Science, University of Arizona, Tucson, AZ 85721, USA.

Arthropod visual systems have fascinated evolutionary biologists for centuries, not the least because they are considered a key innovation of Arthropoda and a rich source of data for phylogenetic studies. Although the visual organs of major arthropod groups share some basic architectures, they are highly modified and specialized into many types, with different positions, numbers of elements, morphology, cytology and neuroanatomy. However, the origin and early evolution of these different types of arthropod eyes remain obscure. The oldest arthropod eyes trace to the early Cambrian (circa 520 mya), and exceptionally preserved Cambrian panarthropod fossils provide a rich and underexploited source of data pertaining to the origin and early diversification of arthropod visual systems. Comparative studies and phylogenetic analyses underpin a hypothesis that arthropod compound eyes orginated from a rudimentary compound eye, such as the multi-unit eyes from the Cambrian lobopodians *Luolishania longicruris* and *Hallucigenia fortis*. Detailed structures of anomalocaridid eyes reveal that compound eyes were already highly developed in the arthropod stem group at a common ancestor with Radiodonta. New observations on the visual organs of later-branching stem-group arthropods and of Cambrian crown-group arthropods demonstrate that the eyes of *Fuxianhuia protensa* resemble mandibulate apposition eyes, whereas the optics of the stem-group chelicerate *Alalcomaneaus* sp. share characters of *Limulus* apposition eyes, sensu Exner. Dichotomies of eye design in the Cambrian predict that arthropod lateral eyes evolved along divergent trajectories in Mandibulata and Chelicerata. Eye types, their morphologies and inferences about optical properties can provide detailed information about behavioral ecologies of early panarthropods and their environment. The innovations of visual system organization likely contributed significantly to arthropods' evolutionary success.

THE STEM-EUARTHROPOD HEAD PROBLEM; A PALAEOBIOLOGICAL AND DEVELOPMENTAL PERSPECTIVE

Javier Ortega-Hernández[1]

1. Department of Earth Sciences, University of Cambridge, Cambridge, UK.
jo314@cam.ac.uk

The head is widely regarded as the most informative tagma of the euarthropod body, and thus resolving its segmental organization is crucial for understanding the origins and phylogenetic relationships between all the major groups. The essence of the "(eu)arthropod head problem" consists of complications that arise when comparing the anterior segmental organization between phylogenetically and morphologically disparate representatives. The fossil record has played a key role in this debate; continuous research on exceptionally preserved organisms, coupled with significant changes in the conceptual and methodological approaches employed for the study of fossil taxa, have shifted paradigms in our understanding of the origin and early evolution of the euarthropod head. As a result, several different models that aim to reconstruct the segmental organization of various extinct groups have been suggested over the last two decades, each with different implications for understanding the early evolutionary history of the phylum as a whole. The aim of this contribution is to balance the alternative hypotheses for the anterior segmentation in Panarthropoda, with particular emphasis on the data available from extinct taxa. The application of a developmental biology context to the study of fossil taxa leads to the recognition of morphological landmarks that allow precise inferences on the segmental affinity of anterior appendages. Furthermore, recent morphological and palaeoneurological data clarify the structural organization of the anterior appendages in lobopodians, anomalocaridids, fuxianhuiids, bivalved Cambrian forms, megacheirans (short-great appendage euarthropods) and trilobites. These findings add up to an emerging view that feeding, or raptorial-like, appendages are not serially homologous in all Cambrian taxa; this conclusion carries implications for reconstructing the phylogenetic relationships of stem-group Euarthropoda, and implicitly the origins of the crown groups.

ON THE ORIGIN AND EARLY EVOLUTION OF TRILOBITES AND IMPLICATIONS FOR THE CAMBRIAN 'EXPLOSION'

John R. Paterson[1], Gregory D. Edgecombe[2] and Michael S. Y. Lee[3,4]

1. Earth Sciences, University of New England, Armidale NSW 2351, Australia. jpater20@une.edu.au
2. Department of Earth Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.
3. School of Earth and Environmental Sciences, University of Adelaide, SA 5005, Australia.
4. South Australian Museum, North Terrace, Adelaide, SA 5000, Australia.

Trilobites are arguably the most successful, diverse and morphologically complex (i.e., character-rich) group of animals that spanned most of Cambrian time, and indeed the Palaeozoic. Yet their origin and earliest evolutionary history still pose a conundrum that gave even Darwin some considerable angst, having made specific reference to them in the *Origin*. This problem relates to their first appearance in the fossil record some 20 million years after the beginning of the Cambrian, when these readily-preservable arthropods with calcitic exoskeletons materialised with an immediate abundance, diversity and geographic provincialism –patterns that seem difficult to reconcile with Darwin's ideas of gradualism. Later workers have reiterated Darwin's presumption that the patterns in early trilobite origination would have required a lengthy evolutionary history in the Proterozoic for which fossil evidence is wholly lacking. Furthermore, despite several decades of phylogenetic research on trilobites using mostly parsimony methods, there is still a rather poor understanding of the interrelationships between the major clades. This study represents a large-scale phylogenetic analysis of Cambrian trilobites using exemplar taxa from most families and a large set of morphological characters, including many that have been ascribed higher-level importance in trilobite classification, in an attempt to resolve relationships amongst all the earliest groups. Characters are preferentially sourced from fully articulated material with dorsal and ventral morphology and known ontogenies. This matrix is analysed using parsimony, as well as with maximum-likelihood and related Bayesian methods which simultaneously estimate tree topology, divergence dates and morphological evolutionary rates across branches. Unique derived characters (autapomorphies) are important for the latter methods, and were scored in these datasets. Ultimately, this study attempts to resolve one of Darwin's dilemmas by estimating the divergence times and rates of morphological change during the early evolution of trilobites. This in turn should provide further insight into debates concerning "slow fuse" versus "big bang" views of the Cambrian 'explosion'.

PALEOBIOTIC INTERACTIONS FROM EARLY CRETACEOUS SPANISH AMBER

Ricardo Pérez-de la Fuente[1], Enrique Peñalver[2], Antonio Arillo[3], David Peris[4], Alba Sánchez-García[4] and Xavier Delclòs[4]

1. Museum of Comparative Zoology, Harvard University, 26 Oxford Street, Cambridge, MA, 02138, USA. perezdelafuente@fas.harvard.edu
2. Museo Geominero, Instituto Geológico y Minero de España, Ríos Rosas 23, 28003 Madrid, Spain.
3. Departamento de Zoología y Antropología Física, Facultad de Biología, Universidad Complutense, E-28040 Madrid, Spain.
4. Departamentd'Estratigrafia, Paleontologia i Geociències Marines, Facultat de Geologia, Universitat de Barcelona, Martí i Franquès s/n, 08071 Barcelona, Spain.

The ability of fresh resin to encapsulate small portions of the paleoecosystem in a relatively fast and unaltered way, and to preserve them for millions of years, gives amber a paleobiological significance unmatched by any other fossiliferous material, explaining why amber inclusions are especially valuable for studying how organisms interacted in the past. Spanish amber, Albian in age (ca. 110 Ma), is one of the major sources of Cretaceous amber worldwide, and the second oldest known from which a diverse biota, especially insects, has been reported. About 3,700 bioinclusions have been discovered to date, and the study of direct paleobiotic interactions, both intraspecific and interspecific, is generating remarkable paleoecological, paleoethological, and evolutionary data. Intraspecific biotic interactions found so far in Spanish amber include a couple of mating biting midges belonging to the genus *Lebanoculicoides* Szadziewski (Diptera: Ceratopogonidae) and swarming microphorid flies (in nuptial flight). Both mating and swarming behaviors "frozen" in amber allow sex identification and to detect sexual dimorphisms and conspecific relationships. Research on interspecific biotic interactions is currently focused on plant-insect relationships, reflecting a paleoecosystem in which angiosperms were not yet prevailing ecologically. Pollination, mutualism, and a plant-insect mutual defense relationship have been discovered so far from Spanish amber. Regarding pollination, thrips classified in two species within the genus *Gymnospollisthrips* Peñalver et al. (Thysanoptera: Melanthripidae), were found with abundant gymnosperm pollen grains – likely belonging to a cycad or a ginkgoalean – adhered to specialized body setae. Although classically regarded as inefficient pollinators, modern thrips pollinate cycads, gnetophytes, and angiosperms. Pollen grains carried by the fossil thrips would have provisioned food for larvae, suggesting subsociality. As to mutual defense, animmature green lacewing, *Hallucinochrysa diogenesi* Pérez-de la Fuente et al. (Neuroptera: Chrysopoidea), was discovered carrying a dense accumulation of trichomes with affinity to the fern family Gleicheniaceae. Green lacewing larvae are voracious predators, and some gather and transport exogenous elements that provide camouflage from prey and predators and physical defense against the latter. In return for providing trichomes for the lacewing's protection, the fern would have benefitted from decreased herbivore populations through the predatory activity of the lacewing. Other interspecific biotic interactions recorded in Spanish amber include predation, the best examples of which are spider webs with trapped insects (one amber piece even preserving the araneoid that likely spun the web), and ectoparasitism, with erythraeid mites feeding from brachyceran flies.

IMAGING TECHNIQUES IN THE STUDY OF FOSSIL SPIDERS

Paul A. Selden[1]

1. Paleontological Institute, University of Kansas, 1475 Jayhawk Blvd, Lindley Hall, Rm 120, Lawrence, KS 66045, USA. selden@ku.edu

Spiders present particular problems for paleontologists. The vast majority are found in Cenozoic ambers, while most Mesozoic and Paleozoic finds are from Fossil-Lagerstätten deposited in water-lain sedimentary environments. Extracting morphological data of phylogenetic importance can be challenging because the details used to identify comparative extant spiders are commonly small and may not preserve well. Amber presents the lesser problem, unless it is opaque, in which case modern techniques such as synchrotron x-ray computed tomography can extract exquisite details. Among matrix-preserved fossils, different study techniques are necessary for the different facies in which spider fossils occur: these range through lacustrine volcaniclastics, mudstones, siltstones and carbonates, to estuarine and marine settings. Here, I review techniques used to extract morphological data from fossil spiders, giving some examples of amber preservation, but mostly concentrating on the wide variety of strategies used to visualize spider fossils in matrix preservation, including macrophotography, photomicrography, and scanning electronic microscopy. Using case studies, I show how the digital revolution in photography has allowed paleoarachnologists to observe morphological details which, until recently, would have been considered unpreserved or undetectable, thus enabling fossil spiders to be included in phylogenetic studies alongside their modern counterparts.

EXCEPTIONALLY PRESERVED ORDOVICIAN OSTRACODS WITH BROOD CARE

David J. Siveter[1], Gengo Tanaka[2], Úna C. Farrell[3], Markus J. Martin[4], Derek J. Siveter[5] and Derek E. G. Briggs[6]

1. Department of Geology, University of Leicester, Leicester LE1 7RH, UK. djs@leicester.ac.uk
2. BioGeos Japan Agency of Marine Science and Technology, 2-15 Natsushima, Yokosuka City, Kanagawa Prefecture, Japan.
3. Biodiversity Institute, University of Kansas, Lawrence, Kansas, 66045-7593, USA.
4. 371 Pawling Street, Watertown, New York 13601, USA.
5. Earth Collections, University Museum of Natural History, Oxford OX1 3PW, and Department of Earth Sciences, University of Oxford, South Parks Road, Oxford OX1 3AN, UK.
6. Department of Geology & Geophysics, and Yale Peabody Museum of Natural History, Yale University, P.O. Box 208109, New Haven, CT 06520-8109, USA.

Ostracod crustaceans are the most abundant fossil arthropods and are characterized by a long stratigraphic range. However, their soft-parts are very rarely preserved and the presence of ostracods in rocks older than Silurian was hitherto based on the occurrence of their supposed shells. Pyritized ostracods preserving limbs and *in situ* embryos, including an egg within an ovary and possible hatched individuals, are here described from rocks of the Upper Ordovician Katian Stage Lorraine Group of New York State, including examples from the famous Beecher's Trilobite Bed. This discovery extends our knowledge of the paleobiology of ostracods by some 25 million years, and provides the first unequivocal demonstration of ostracods in the Ordovician, including the oldest known myodocope, *Luprisca incuba*. It also provides conclusive evidence of a developmental brood-care strategy conserved within Ostracoda for at least 450 Myr.

LOBOPODIAN AND PENTASTOMID DISCOVERIES FROM THE HEREFORDSHIRE (SILURIAN) LAGERSTÄTTE

Derek J. Siveter[1,2], Derek E. G. Briggs[3], David J. Siveter[4] and Mark D. Sutton[5]

1. Earth Collections, University Museum of Natural History, Oxford OX1 3PW, UK. derek.siveter@oum.ox.ac.uk
2. Department of Earth Sciences, University of Oxford, South Parks Road, Oxford OX1 3AN, UK.
3. Department of Geology & Geophysics and Yale Peabody Museum of Natural History, Yale University, P.O. Box 208109, New Haven, CT 06520-8109, USA.
4. Department of Geology, University of Leicester, Leicester LE1 7RH, UK.
5. Department of Earth Sciences and Engineering, Imperial College London, London SW7 2BP, UK.

The Herefordshire Lagerstätte from the Welsh Borderland of the UK preserves a wide variety of invertebrates of mid-Silurian, Wenlock Series age (c. 425 Ma). The exceptionally preserved fossils are recovered through serial grinding, photographic, and computer rendering techniques which yield 'virtual fossils' in the round. Since its discovery some 20 years ago, this deposit has yielded a wide range of arthropods that have contributed much to our knowledge of the palaeobiology and early history of the phylum. They include a megacheiran, a pycnogonid, two synziphosurine chelicerates, a marrellomorph, a putative stem lineage crustacean, four myodocopid ostracodes, a phyllocarid, and a barnacle. We can now add Lobopodia and Pentastomida to these major arthropod groups, through the discovery of a new species of each of them. In the Palaeozoic lobopodians are best known from the Cambrian, from which there are almost 20 named species. Their record from other periods is very sparse. Only two lobopodians are recorded from both the Ordovician and also the Silurian; there are none from the Devonian, and only two or three species from the Carboniferous. The Herefordshire lobopodian is fully three-dimensional; it bears at least 9 lobopods and tuft-like sclerites. Pentostomida comprises c. 140 living species, all but four of which are parasitic in tetrapod (especially reptilian) or fish hosts. There are only eight fossil species of pentastomid known, each consisting of juvenile specimens whose hosts are a matter of speculation. We here report pentastomid specimens in situ, enodoparasitic in ostracods. This finding identifies the first verifiable host for a fossil pentastomid. In contrast to most modern hosts, it is a marine invertebrate. It is also the first record of a fossil pentostomid outside the Cambrian or Ordovician, and of possible adult fossil pentostomids.

RANGE OF FEEDING ADAPTATIONS OF *ANOMALOCARIS*, INCLUDING A NEW SPECIES FROM THE KINZERS FORMATION (EARLY CAMBRIAN OF PENNSYLVANIA), INDICATED BY THE FORMS OF SPINES ON THEIR FRONTAL APPENDAGES THAT WERE EMPLOYED IN FORAGING

Roger D. K. Thomas[1] and Katherine L. Oxman[1]

1. Franklin & Marshall College, Lancaster, PA 17604-3003, USA.
roger.thomas@fandm.edu

Anomalocaris has long been known from the Kinzers Formation, represented by frontal appendages of *A. pennsylvanica* and fragmentary specimens tentatively assigned to the same species. Now, a single frontal appendage, well preserved and distinctively different, has been discovered by ace-collector Kerry Matt. It undoubtedly represents a new species, characterized by long, delicate, paired ventral spines, without any development of accessory spines, attached to each podomere. This species is of particular interest, as it constitutes a morphological and functional end-member in one set of adaptations and a bridge to a substantially different mode of life. Among bottom-feeding species of *Anomalocaris*, now widely supposed to have preyed on infaunal worms, ventral spines attached to the frontal appendages commonly bear variably developed accessory spines, ranging from saw-tooth like forms to distally-bifurcating probes or pitchforks. Some podomeres in some species bear spines without accessories, but these spines are relatively short and stout, in contrast with the slender spines of the new species. We interpret all these types of anomalocaridid spines as a spectrum of adaptations to feeding on different substrates, ranging from forms evolved to probe in coarser sediment, or through superficial bacterial mats, to a set of spines designed and coordinated to sweep or rake loose, unconsolidated sediment in search of shallowly buried prey. Now, amazing fossils from Sirius Passet, Greenland, have been discovered and interpreted as a suspension feeding anomalocaridid, *Tamisiocaris borealis*. We see the new Kinzers Formation species as being transitional, morphologically and functionally, from bottom-feeding anomalocaridids to *Tamisiocaris*. The frontal appendages of the new anomalocaridid and *Tamisiocaris* share long, gradually tapering, slender spines that are all similar in length. Emergence of the suspension feeding mesh of *Tamisiocaris* from a species like ours would have required only expression of the pattern underlying development of accessory spines in other anomalocaridid species, in this case producing very tiny, closely spaced accessories that branch at a relatively high angle from each spine. Furthermore, it is reasonable to suppose that if a sediment sweeping or raking anomalocaridid were to evolve delicate accessory spines, it would have been capable of trapping and engulfing meiofaunal organisms in addition to infaunal worms, especially if the operation of its radial mouth involved suction, as has been suggested. So, the new species suggests the evolutionary path by which one or more anomalocaridids made the transition from the sea floor to mid-water suspension feeding.

ANOMALOCARIDID DIVERSITY IN THE EARLY ORDOVICIAN FEZOUATA BIOTA OF SOUTHEASTERN MOROCCO

Peter Van Roy[1], Allison C. Daley[2] and Derek E.G. Briggs[1, 3]

1. Department of Geology and Geophysics, Yale University, 210 Whitney Avenue, New Haven, CT 06511, USA. Peter.VanRoy@Yale.edu

2. Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS, U.K.

3. Yale Peabody Museum of Natural History, 170 Whitney Avenue, New Haven, CT 06511, USA.

Anomalocaridids are a major clade of stem arthropods, which, until recently, were considered to have disappeared after the middle Cambrian. While generally regarded to have been fierce apex predators, the wide morphological variation exhibited by the grasping appendages of different taxa is testimony to their ecological diversity; in fact, it was recently shown that the early Cambrian *Tamisiocaris borealis* from the Siriuspasset fauna of Greenland was a filter-feeder. The Fezouata Biota from the Early Ordovician of Morocco has provided the first undoubted post-middle Cambrian anomalocaridid record, and is home to at least four different taxa. The most conspicuous of these is a giant hurdiid reaching a length in excess of 2 m. In addition to abundant disarticulated material, consisting of central and lateral elements of the frontal carapace, bands of setal blades, and anterior appendages, several three-dimensionally preserved bodies are known from concretions. The latter have provided unequivocal evidence for the presence of a second set of lateral flaps in anomalocaridids, with the lower flaps being homologous to walking limbs. Exceptionally well-preserved anterior appendages show this giant taxon to represent another example of a suspension feeding anomalocaridid. Another, much rarer hurdiid is represented by a large isolated anterior appendage, which exhibits a specialised predatory morphology, being optimised for shredding soft prey. Other material includes disarticulated H- and P-elements of a *Hurdia*-like frontal carapace, several specimens of anterior appendages that show similarities to *Peytoia*, and the ventral spines of a smaller filter-feeding form. A handful of cephalic shields bear a resemblance to those recently described for the middle Cambrian *Anomalocaris canadensis* from the Burgess Shale of Canada. Articulated oral cones have so far proven to be extremely rare in the Fezouata Biota. However, a single minute, complete specimen with a diameter of only ca 4 mm belongs to either a miniature taxon, or a juvenile. The presence in the Fezouata Biota of at least four anomalocaridid taxa exhibiting widely differing, specialised appendage morphologies further underscores the ecological diversity and continued importance of this group in post-Cambrian Palaeozoic ecosystems.

INTEGRATION OF FOSSIL, PHYLOGENOMIC, AND DEVELOPMENTAL DATA TO SOLVE DEEP BRANCHING EVENTS IN PANCRUSTACEAN EVOLUTION

Joanna M. Wolfe[1]

1. American Museum of Natural History, Central Park W at 79th St, New York, NY 10024, USA.
jwolfe@amnh.org

The study of ontogeny as an integral part of understanding the pattern of evolution dates back over 150 years, but only recently have ontogenetic data been explicitly incorporated into phylogenetic homology statements. I developed approaches to incorporate data both from fossils and development, providing proof-of-concept that ontogeny does affect morphological phylogenetic reconstructions. This work focused on the Pancrustacea (crustaceans + hexapods), a clade with remarkable morphological disparity, comprising over half the world's described species (over 800,000 in total). Many possible sister-group relationships have been proposed. Using a concatenated molecular and morphological dataset, I dated the divergence of most major clades in the Cambrian. The only (and therefore oldest) likely Cambrian crown-group pancrustacean fossils are known from spectacular three-dimensionally phosphatized larvae from 'Orsten' type faunas, with impressively complete developmental sequences (but without unequivocal adult stages). These fossils have spurious placements in a traditional morphological analysis. Conserved synapomorphies in larvae may be overprinted later in development, obscuring phylogenetic signal. Therefore, each semaphoront (discrete larval or adult stage) is considered separately. Increased informativeness from larvae may apply to expressed genes, which promise to resolve deep phylogenetic questions, yet are susceptible to duplication and loss throughout evolution, resulting in trees potentially built from non-homologous genes. These alternative genes are expressed at different times in ontogeny, as they frequently play a role in development. Current work extends the semaphoront approach to phylogenomics, by sequencing transcriptomes of multiple semaphoronts of Decapoda, representing a broad sample of both species and metamorphic stages. Preliminary results suggest >50% of genes are differentially expressed between larval and adult semaphoronts within species, supporting the hypothesis of additional homologies in larval expression, which will provide synapomorphies allowing the reconstruction of the correct tree. Simulations suggest inclusion of morphology and/or expressed genes from multiple semaphoronts may have broader applications to other phylogenetic problems which may rely on ontogenetically variable homology statements.

BUTTERFLIES OF THE BENTHOS? SHIELD POSITION IN EARLY CAMBRIAN BRADORIID ARTHROPODS

Marissa J. Betts[1], Glenn A. Brock[1] and John R. Paterson[2]

1. Department of Biological Sciences, Macquarie University, Sydney, 2109, Australia. marissa.betts@students.mq.edu.au

2. Division of Earth Sciences, School of Environmental and Rural Science, University of New England, Armidale, New South Wales 2351, Australia.

Mode of fossil preservation and method of fossil recovery strongly influences our understanding of the way extinct organisms functioned. Bradoriid arthropods were abundant and diverse members of early Cambrian ecosystems and most life reconstructions display these animals with their shields open in a 'butterfly' configuration. Reconstructions are biased toward this arrangement due to the abundance of crack-out specimens preserved in the same 'butterfly' position (e.g. *Kunmingella* from China). In South Australia, abundant bradoriid specimens have been recovered from multiple stratigraphic sections measured through lower Cambrian (Cambrian Stages 3-4) carbonate dominated rocks in the Arrowie Basin. In contrast to crack-out specimens, the vast majority of complete specimens from South Australia derived from acid processing are preserved with shields folded along the midline and conjoined. The abundance of conjoined, closed (or mostly closed) specimens from the lower Cambrian Wilkawillina and Wirrapowie Limestones and overlying Mernmerna Formation suggests that most bradoriids were capable of withdrawing their appendages and tightly closing the shields, refuting the assumption that all bradoriids usually held their shields open during life. Degree of shield closure is likely to have been closely linked with morphological adaptations associated with specific lifestyles and palaeoenvironments and full closure of the shields may have occurred as a behavioural response to environmental and biological stress. Shields were often flexible and only weakly mineralised. The"hinge"in early Cambrian taxa lacks any complex articulating structures and is instead where the cuticle thins, allowing the shield to bend. Such simple, soft shields may not have required 'heavy duty' musculature (as in ostracodes) to open and close them (or to keep them closed). This may have resulted in a tendency for the shields to open post mortem, and the commonly preserved 'butterfly' position of many crack-out specimens may therefore be a characteristic of either dead individuals or exuviae. Consequently, the propensity for either closed or 'butterflied' shields in fossil assemblages is more likely to have been influenced by taphonomic factors rather than life attitude of bradoriids.

ONTOGENETIC TRAJECTORIES AND PHENOTYPIC INTEGRATION OF SEVERAL TRINUCLEOIDS (TRILOBITA) FROM ARGENTINA

Arnaud Bignon[1], Beatriz G. Waisfeld[1,2] and N. Emilio Vaccari[1-3]

1. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), CONICET, Universidad Nacional de Córdoba, Av. Vélez Sarsfield 1611, X5016GCA, Córdoba, Argentina. arnaudbignon@yahoo.fr

2. Centro de Investigaciones Paleobiológicas (CIPAL), Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Av. Vélez Sársfield 299, Córdoba, 5000, Argentina.

3. Universidad Nacional de La Rioja, Av. René Favaloro s/n 5300, La Rioja, Argentina.

Diverse, abundant and with a worldwide distribution, the trinucleoids constitute an opened window to describe the Earth during the Ordovician. Several formations of the Middle Ordovician from the Argentinian Precordillera have revealed a trinucleoid fauna preserved in silica. This exceptional preservation allows a precise and quantitative description of their ontogeny. Indeed, a vast scale of developmental instars is known in these species, from the protaspid (larval) to holaspid (adult) stages. This material is therefore remarkable to compare ontogeny and phenotypic modularity between close species. Morphological changes occurring during the development of two *Bancroftolithus* species, *B. pozensis* and *B. hughesi* are described using geometric morphometric methods. Thanks to these quantitative data we are able to compare the development of these species in order to recognize modifications of the ontogenetic trajectories. A preliminary analysis revealed a parallelism between the two species trajectories but at a different rhythm. Indeed, ontogenetic changes occurring during the meraspid and holaspid period of *B. pozensis* are significantly slower than the other species. Moreover the same change of trajectory happens during the early meraspid period for *B. pozensis* but only at the late meraspid for *B. hughesi*. The same trend is recognised in separate analyses for cephala and pygidia. The identification of this interdependence provides a clear pattern between the morphological features during ontogeny. Phenotypic integration is controlled by function and/or development. So understanding this organization is crucial to identify environmental constraints applied on a particular morphological area. These quantitative methods provide a precise framework of developmental relationships between morphological characteristics and between species. The results obtained here will be useful to study how environmental constraints may influence ontogenetic trajectory. As the trilobites studied are epibenthic, their survival depends on hydrodynamic conditions. Consequently, their shape is influenced by the water flow parameters. Thus we will model in 3D the trinucleoid morphology and analyse the water motion around the exoskeleton using Computational Fluid Dynamics simulations. Comparing hydrodynamic performances between juveniles and adults, we will be able to understand the control applied by the water flow dynamics on ontogenetic trajectory. Indeed, size changes during development imply a modification of hydrodynamic constraints. Ontogeny must consider these changes for the survival. The precise description of the developmental framework with the knowledge of the hydrodynamic constraints variation will offer an exceptional example of the control of an extrinsic parameter on ontogeny.

THE GIGANTISM OF THE CRETACEOUS CONCHOSTRACA FROM SOUSA BASIN, BRAZIL

Ismar de Souza Carvalho[1]

1. Universidade Federal do Rio de Janeiro, Departamento de Geologia, Av. Athos da Silveira Ramos 274 bloco F Cidade Universitária – Ilha do Fundão, 21.941-916 Rio de Janeiro – RJ, Brazil. ismar@geologia.ufrj.br

The Sousa Basin comprises an area of 1,250 km^2 in Northeastern Brazil and its origin is related to the South Atlantic Ocean opening during the Early Cretaceous. The main lithologies in the Sousa Basin are clastic rocks. They are subdivided into the Antenor Navarro, Sousa and Rio Piranhas formations. In the Sousa Formation (comprised of mudstones, siltstones, sandstones, marls and limestones), a large amount of big-sized conchostracans Palaeolimnadiopsidae (*Palaeolimnadiopsis reali*) are found. The specimens reach 4.5 cm in length, which represents an anomalous size for conchostracans. Living species inhabit fresh alkaline waters (pH between 7 and 9), usually in well-oxygenated environments that determine the morphological aspects of their shells. Then the proliferation of an abundant big-sized fauna requires specific physical-chemical characteristics of the water. Chemical analyses of the rocks of the Sousa Formation allow the evaluation of the geochemical conditions in which these Cretaceous conchostracans lived. Larger specimens (average length of 30 mm) from Pedregulho appear in rocks with 6.4% of calcium, 1.8% of magnesium and 21.7% of silicon ions. This same species, in the Lagoa dos Patos locality, is smaller (average length of 20 mm), and the rocks that contain it have 1.0% of calcium, 1.6% of magnesium and 31.7% of silicon ions. The higher calcium and magnesium concentration in the Pedregulho locality could be one of the determining factors for the larger size of the specimens. The concentration of phosphorus is important as it allows the blooming of algae and other microorganisms and also has a direct relation in current lakes with their eutrophization. Once again, it is possible to notice that the occurrence of *Palaeolimnadiopsis reali* is related to a phosphorous nutrient-rich environment. The values for phosphorus ions in the Pedregulho and Lagoa dos Patos localities, both located in the Sousa Basin, are among the highest ones (0.17% and 0.10%, respectively) for the analyzed samples. The large-size of this species must be directly related to the availability of nutrients, in which phosphorus is one of the most important element. The enrichment of nutrients in the Sousa Basin is probably due to the tectonic activity during the Early Cretaceous when chemical elements were remobilized throughout hydrothermal solutions that fed into the lakes. This might have been responsible for the nutrient-enrichment and the maintenance of the alkaline pH allowing then, the blooming of the big-sized Palaeolimnadiopsidae conchostracans. [Supported by FAPERJ and CNPq].

TOWARDS A COMPLETE AND INTERNALLY CONSISTENT COMPENDIUM OF CODABLE CHARACTERS FOR TRILOBITE PHYLOGENETIC ANALYSIS

Melanie J. Hopkins[1]

1. American Museum of Natural History, Central Park West at 79th Street, New York, 10034, USA.
mhopkins@amnh.org

Most phylogenetic work on trilobites has been at low taxonomic levels. Aside from a handful of papers, higher-level phylogenetic analyses are underexplored, and as a result, phylogenetic relationships between clades are still largely unresolved. This reflects both the high within-taxon morphological variation in early trilobite clades, which makes taxon delimitation difficult, and high morphological diversity among later trilobite clades, which makes hypotheses of character homology across different groups difficult. Here, I address the latter problem. Using character matrices from an extensive selection of previously published phylogenetic analyses as a starting point, I have compiled an internally consistent and non-redundant list of characters that can be coded across a very disparate set of trilobites. This compendium attempts to accommodate different opinions regarding the morphogenetic origin of different character states and their potential homology across disparate groups of trilobites. Although ontogenetic characters have yet to be included, this list is currently at around 250 characters. More inclusive selections of taxa coded for the entire dataset will result in many constant but sensible characters, making the dataset more conducive to some Bayesian analyses. A small proportion of characters may also be treated as continuous for analyses in programs such as TNT. Initial phylogenetic analyses of select phacopid and asaphid trilobites from the early and middle Ordovician support the monophyly of many genera but some families may be paraphyletic or even polyphyletic in their current definition; confirmation of this awaits the inclusion of more taxa. In both groups, traits describing the course of the sutures and the pleural regions of the pygidium show higher levels of consistency. However, the degree of homoplasy in a number of traits varies between the two groups. A long-term goal of this project is to create a character list that could be used to describe and code any set of trilobite species for inclusion in a phylogenetic analysis.

CADDISFLIES (INSECTA: TRICHOPTERA) IN FOSSIL RESINS

Stanislav I. Melnitsky[1] and Vladimir D. Ivanov[1]

1. Department of Entomology, Faculty of Biology, St.-Petersburg State University, 199034, St.- Petersburg, Universitetskaya nab., 7/9, Russia. simelnitsky@gmail.com

Caddisflies (Insecta: Trichoptera) of fossil resins are known from 10 amber localities. They were found in the Miocene Dominican (14–23 Ma) and Mexican (20–28 Ma) ambers; in the Eocene (33–37 Ma) Baltic, Rovno and Saxon, and also in the Cretaceous Burmese (95–105 Ma), Canadian (71–83 Ma), New Jersey (86–94 Ma), Taimyr (95–112 Ma) and Tenessee (65–70 Ma) fossil deposits. The Late Eocene amber caddisflies in Europe are the best studied and found in three localities. All three localities have faunistic similarity and the same dominant elements distinguish them from any extant fauna of Trichoptera. The amber Baltic fauna comprises 211 known species of caddisflies (61 genera, 25 families), the Rovno fauna – 38 (20 genera, 9 families), and the Saxon amber – 20 (7 genera, 6 families). Notable rarity of widespread extant European families (Hydropsychidae, Hydroptilidae, Limnephilidae) is a characteristic feature of the fossils in the European ambers, while some faunal elements, such as species of the genus *Wormaldia* (Philopotamidae) and the family Polycentropodidae, resemble the Holocene faunas of Southeast Asia. Fossil caddisflies of the North American Miocene ambers resemble recent caddisfly fauna of this region. The Dominican amber comprises 33 species of caddisflies (15 genera, 11 families), and 4 species (4 genera, 4 families) have been found in the Mexican amber. Cretaceous fossil resin caddisflies have been found in five localities in Eurasia and North America: 3 species (3 genera, 3 families) in the Burmese amber, 7 species (6 genera, 6 families) in the Taimyr, 8 species (5 genera, 3 families) in the New Jersey, and each the Canadian and the Tennessee deposits have one species. The Cretaceous amber faunas differ from Eocene ones in having a more balanced number of Polycentropodidae, weak presence of Integripalpia, and putative absence of Plenitentoria. There were two extinct families (Electralbertidae and Taymyrelectronidae), and a number of taxonomically biased species in other families of the Cretaceous Trichoptera.

TESTING COPE'S RULE IN ASAPHIDS (TRILOBITA) BY USING COMPARATIVE METHODS

Facundo R. Meroi Arcerito[1,2], Karen Halpern[1,2], Emilia Sferco[1,2] and Beatriz G. Waisfeld[1,2]

1. Centro de Investigaciones Ciencias de la Tierra (CICTERRA), Consejo Nacional de Ciencia y Técnica (CONICET) y Universidad Nacional de Córdoba. Av. Vélez Sarsfield 1611, X5016GCA, Córdoba, Argentina. facundomeroi@hotmail.com

2. Centro de Investigaciones Paleobiológicas (CIPAL), Facultad de Ciencias Exactas Físicas y Naturales, Universidad Nacional de Córdoba. Av. Vélez Sarsfield 299, Córdoba, 5000, Argentina.

Asaphids are significant members of the trilobite Evolutionary Ibexian II Fauna. The family radiated during the early Tremadocian, and thrived worldwide during most of the Ordovician, until vanishing at the Late Ordovician mass extinction. Thus, the study of their paleobiology is paramount in understanding the diversification, extinction, and ecological replacement within Trilobita during this period. From Cambrian to Ordovician, Trilobita in general and Asaphidae in particular registered an important body size increment that has been interpreted by some authors as an example of Cope's rule. We have carried out a preliminary analysis that showed an increasing body size tendency through time in probably related asaphid species from NW Argentina (Cordillera Oriental, Western Gondwana). Here we present a more comprehensive analysis by using phylogenetic comparative methods to test for Cope's rule among asaphids. Being a cosmopolitan family, several taxa from Late Cambrian (Stage 10) to Early Ordovician (Tremadocian-Floian) records from around the world were included in our database, however, we have emphasized on asaphid taxa from NW Argentina (i.e. *Asaphellus*, *Notopeltis* and *Kayseraspis*), where the first stages of asaphid radiation can be traced throughout a few number of potentially closely related taxa. In order to assess if ancestor-descendant relationships bear a tendency in body size, we first conducted a phylogenetic analysis using parsimony in TNT that resulted in 6 most parsimonious trees of 197 steps; then, each tree was age calibrated considering LAD (Last Appearance Date) of each taxon. On the other hand, pygidium size was used as a proxy for estimating body size throughout an average geometric mean calculated for each species. Both data sets were contrasted by testing the individual fitting of three evolutionary models in R, namely Brownian motion, Brownian motion with a trend and White noise or stasis. Unlike previous reports, our results do not support any phylogenetic tendency in body size. At least at this taxonomic level, the observed body size increment does not follow Cope's rule. Instead, we find that the White noise model has a better fit to our data (Akaike weight= 0,9994), implying that species attributes have no phylogenetic signal and can be thought as independent draws from a normal distribution with stable means and variance across the time interval.

PHYLOGENETIC ANALYSIS OF ARGENTINIAN OLENIDAE (TRILOBITA, PTYCHOPARIIDA) FROM THE FURONGIAN AND ORDOVICIAN

Daniela S. Monti[1] and Vianana A. Confalonieri[1]

1. Instituto de Ecología, Genética y Evolución de Buenos Aires, Departamento de Ecología Genética y Evolución, FCEyN, UBA, Intendente Güiraldes 2160, Ciudad Universitaria, Buenos Aires, C1428EGA, Argentina.
danielamonti@ege.fcen.uba.ar

To evaluate the relationships between the Argentinian members of Olenidae Burmeister, a cladistic analysis was performed. A total of 20 species were included (eleven Triarthrinae, two Hypermecaspidinae, one Plicatolininae, four Oleninae and two Pelturinae). Seventy five characters were codified (55 of the cephalon, eight of the torax, eight of the pygidium and four of the entire exoesqueleton), of which 23 are quantitative (20 ratios and three meristic) and were all codified either as discrete (additives and non-additives) or as median. This latter statistic descriptor was elected because it has the advantage that is little affected by few high values in the frequencies analyzed. When continuous characters are treated as such, the standardization versus the use of the raw data were explored. The data matrices were analyzed with TNT version 1.1 applying maximum parsimony and implied weights as optimality criteria. Analyses with implied weighting were conducted by means of values for the concavity constant k= 5–16. Since several authors considered *Olenus* Dalman as the ancestral genus of Olenidae, the most parsimonious tree was rooted with *Olenus gibbosus* (Wahlenberg). With respect to the continuous characters codification, similar results were obtained when treated as discrete additives or as medians. When quantitative characters are codified as medians, application of implied weights criteria is more efficient than standardization of raw data for solving scaling problems. Regarding to the relationships of species, these are partially consistent with previous proposals based on direct morphological comparison and stratigraphy. *Parabolinella* Børgger is a monophyletic group and *Plicatolina scalpta* Harrington and Leanza is its sister group. *Triarthrus jachalensis* (Harrington and Leanza) is included in the genus *Bienvillia* Clark. The Thiarthrinae is paraphyletic, because it does not include *P. scalpta*. Both Oleninae and Pelturinae would not be monophyletic groups. While the genus *Angelina* Salter is a well-supported monophyletic group, *Parabolina (Neoparabolina) argentina* (Barrande) is more closely related to *Jujuyaspis keideli* Kobayashi than *Angelina*. On the other hand, *Leptoplastides marianus* (Hoek) is recovered as the sister group of Triarthinae. The two species of *Hypermecaspis* Harrington and Leanza form a monophyletic group but, unlike previous proposals, preliminary results show no relationship between this genus and the subfamily Thriarthtinae.

NEW RECORDS OF PYGOCEPHALOMORPHS FROM IRATI FORMATION, LOWER PERMIAN OF PARANÁ BASIN, SOUTHERN BRAZIL

Paula Giovana Pazinato[1], Heitor Francischini[1] and Renato Pirani Ghilardi[2]

1. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, UFRGS, 91501-970, Porto Alegre, RS, Brazil. heitorfrancischini@hotmail.com

2. Faculdade de Ciências, Departamento de Ciências Biológicas, UNESP, 17033-360, Bauru, SP, Brazil.

Pygocephalomorph crustaceans are one of most representative elements of Late Carboniferous and Early Permian aquatic communities in Europe and North America. In the southern hemisphere, the group has been known since the beginning of last century by specimens recorded from Early Permian marine and freshwater shales and limestones of the Karoo Basin (South Africa) and Paraná Basin (Brazil), being representatives, along with mesosaurids, from Gondwana's epicontinental sea, the Irati-Whitehill sea. Despite its frequent record, not much work has been done within the group since its original descriptions, dated from the early twenties and thirties. There are seven species described from the Irati Formation of the Lower Permian Paraná Basin, *Paulocaris pachecoi*, *Liocaris angusta*, *L. huenei*, *Pygaspis brasiliensis* and *P. quadrata*, currently undergoing revision by the authors. A new outcrop finding in southern Brazil brings out new specimens of exceptionally preserved impressions of pygocephalomorphs, expanding the record in the Paraná Basin. The new records comes from the Aceguá county area, southwestern Brazil, from an approximately 10 m high rock exposure intercalating black shale and limestone, containing at its basal portion mesosaurid bone beds and at the top a 0.5 m strata of horizontally laminated red thin sandstone where the crustaceans impressions occur, in association with conifer branches and insects. One pygocephalomorph morphotype is represented by several impressions of carapace in dorsal view and a few articulated specimens in ventral view. The total length is about 50 mm, with the carapace being about 30 mm, entirely covering the cephalothorax. The carapace outline has a hexagonal shape and is ornamented by small tubercles; only gastric spines are present, the dorsal carina is indistinct, the cervical groove is present and highly ornamented, and there is a small rostrum. On ventral view, eight thoracic sternites with biramous pereiopods are present. Abdomen reflexed under itself with five somites visible. The distinctive carapace indicates the specimens may be a new species. These new findings, currently under study, may shed some light on the problematic evolution of this group of crustaceans in Gondwana, particularly regarding its taxonomy and systematics.

LATE PALAEOZOIC PAOLIIDA IS THE SISTER GROUP OF DICTYOPTERA (INSECTA: NEOPTERA)

Jakub Prokop[1], Wieslaw. Krzemiński[2], Ewa Krzemińska[2], Thomas Hörnschemeyer[3], Jan- Michael Ilger[4], Carsten Brauckmann[4], Philippe Grandcolas[5] and André Nel[5]

1. Department of Zoology, Charles University in Prague, Vinicná 7, 128 43 Praha 2, Czech Republic. jprokop@natur.cuni.cz

2. Institute of Systematics and Evolution of Animals, PAS, Kraków, Poland.

3. Georg-August-University, Johann-Friedrich-Blumenbach-Institute for Zoology & Anthropology, Dept. Morphology & Systematics, Berliner Str. 28, 37073 Göttingen, Germany.

4. Clausthal University of Technology, Clausthal-Zellerfeld, Germany.

5. CNRS UMR 7205, CP 50, Entomologie, Museeum National d'Histoire Naturelle, Paris, France.

Paoliida is an insect group of highly controversial composition and affinities since Handlirsch's time. With a known record since the earliest Pennsylvanian paoliids are almost equal in age to the first indisputable evidence of Pterygota. Herein we consider the Paoliida as an undisputed neopteran clade. Based on our comprehensive study we propose a new delimitation of the insect order Paoliida *sensu nov.* on the basis of their specific wing venation characters. Paoliida is considered as a potential sister group of the Dictyoptera on the basis of the presence of well-defined anterior branches of CuA, with the same convexity as the median vein and a more pronounced concavity than the posterior branches of the same vein (synapomorphy). The polarities of the other characters shared by these clades are discussed. New diagnoses of the order Paoliida and the family Paoliidae are provided. In addition we consider the families Herbstialidae, Ideliidae, and Protoblattinidae as junior synonyms of Paoliidae. Paoliids display relatively high abundance in early Pennsylvanian ecosystems with surprisingly low morphological disparity in comparison to the other groups of neopteran insects well diversified from the Duckmantian/Bolsovian boundary. [Research support of bilateral project between the Grant Agency of the Czech Republic (No. 14-03847J) and Deutsche Forschungsgemeinschaft (No. HO 2306/12-1)].

OSTRACODS OF UPPER DEVONIAN (FM FLORESTA) FROM NORTHERN SOUTH AMERICA

Juan D. Quiroz Silva[1]

1. University of Caldas, Carrera 22a #75-30 Apt 701 Bloque 1 Barrio Milán, Manizales, 17001000, Colombia.
Juan.600924119@ucaldas.edu.co

In the northeast of Colombia, in the region known as the massif of Floresta, there is a continuous sedimentary sequence, composed of conglomerates (El Tibet Formation), quartzose sandstones, mudstones, sandy mudstones (Floresta Formation) in the middle, and with sandstones and mudstones red (Cuche Formation) on the top. The micropaleontologic potential of the unit is reflected in the abundance of macrofossils such as bryozoans, gastropods, brachiopods, trilobites, and corals which allows us to assign the sequence to the Floresta Formation of middle Devonian age. Fieldwork indicates that the Floresta Unit was formed in an open platform and is tectonically stable, followed by a continental sedimentation which marks a marine regression during the upper Devonian. On the other hand, preliminary micropaleontological data indicate that preservation is average and a high abundance. The association is dominated by *Welleria spp*. with muscular impressions that are well-defined, as also the union between their leaflets. Currently detailed studies of these ostracods are undergoing. Based on preliminary results, we provide new data on the paleoenvironment of the Floresta Formation and its relationship with "nearby" basins during the Upper Devonian.

THE ACTUAL STATUS OF TRIASSIC SPINICAUDATAN FAUNA RECORDS (CRUSTACEA: DIPLOSTRACA) IN WESTERN ARGENTINA

Lara V. Tassi[1], Oscar F. Gallego[1,2] and Ana M. Zavattieri[3]

1. Área Paleontología (Centro de Ecología Aplicada del Litoral—Centro Científico Tecnológico Nordeste—Consejo Nacional de Investigaciones Científicas y Técnicas), Casilla de Correo 128, 3400 Corrientes, Argentina.

2. Geología Histórica-Micropaleontología (Facultad de Ciencias Exactas y Naturales y Agrimensura—Universidad Nacional del Nordeste), Corrientes, Argentina. ofgallego@live.com.ar

3. Laboratorio de Paleopalinología (Instituto Argentino de Nivología y Glaciología y Ciencias Ambientales—Centro Científico Tecnológico—Consejo Nacional de Investigaciones Científicas y Técnicas), Casilla de Correo 131, 5500 Mendoza, Argentina.

The investigations of spinicaudatan group in Argentina began with Jones' contributions there in 1862 and were intensified after the 1990s, with numerous new taxa reported from different continental Triassic sedimentary sequences in western Argentina, largely in the Cuyo and Ischigualasto-Villa Unión basins and San Rafael Depocenter. The most important spinicaudatan records come from localities of the Río Mendoza-Cerro de Las Cabras and Potrerillos-Cacheuta sequences (Uspallata Group, Cuyo Basin) and from the Chañares, Ischichuca, Los Rastros and Ischigualasto formations (Agua de la Peña Group, Ischigualasto-Villa Unión Basin). All mentioned stratigraphic units represent an interval ranging from lower Middle (=Anisian) to early Upper (= Carnian) Triassic, which bears the greatest and most diverse Triassic spinicaudatan collection of Argentina. The families represented until now are: Euestheriidae (*Euestheria*) recorded in the Ischichuca, Los Rastros, Cerro de Las Cabras, Potrerillos and Cacheuta formations; Loxomegaglyptidae (*Triasoglypta* and *Loxomegaglypta*) from the Montaña, Ischichuca, Los Rastros, Ischigualasto, Potrerillos and Cacheuta formations; Ulugkemiidae (*Triasulugkemia*) known from the Ischichuca, Cacheuta and Potrerillos formations; Palaeolimnadiopseidae (*Endolimnadiopsis*) in the Potrerillos and Cacheuta formations and, Pemphilimnadiopseidae (*Challaolimnadiopsis*) from the Cerro de Las Cabras and Potrerillos formations. New findings include the first mention of three families: Fushunograptiidae (*Estheriellites*) recorded in both the Chañares and Cerro de Las Cabras formations; Polygraptidae (?*Dendrostracus*) in the Ischigualasto Formation; and Lioestheriidae (*Cornia*) in the Quebrada de los Fósiles Formation (Puesto Viejo Group, San Rafael Depocenter) referred to Early Triassic (Induan-Olenekian) age, constituting the oldest known species from the Triassic of South America, with affinities to Indian Permo-Triassic boundary species. Recently, an ichnofossil (*Diplopodichnus*?) in the Talampaya Formation (Early Triassic) (Ischigualasto Villa Unión Basin) was also found, which could be assignable to Spinicaudata and therefore indicate the presence of this group since the beginning of Triassic times. The comparisons between spinicaudatan faunas from Argentina and from other Triassic gondwanan strata (mainly Brazil, Chile, India and Australia) allow us to know the distribution of these forms, including its recovery, diversification and routes of dispersion after the Permo-Triassic extinction event. An increase in the size of the valve is observed in species from Early to Late Triassic, reflecting a trend of increasing body size for Argentinean specimens, as mentioned for other invertebrate groups. The morphologic variation and therefore the increase in the diversity of species during Triassic is evident in the spinicaudatan fauna record in Argentina, probably due to better climatic condition occurred towards the end of the Period.

INSECT MIMICRY IN THE MESOZOIC – FOSSIL EVIDENCE FROM CHINA

Yongjie Wang[1] and Dong Ren[1]

1. College of Life Science, Capital Normal University, 105 Xisanhuanbeilu, Haidian District, Beijing, P.R. China. wangyjosmy@yahoo.cn

Mimicry is an important defensive and foraging strategy among the extant insects, including morphological mimicry, behavioral mimicry, voice mimicry, and chemical mimicry. Insect mimicry originated from the longtime coevolution between insects and the environment, however, we have few understandings on the evolution of the insect mimicry. The rarity, limitation and incompleteness of fossil preservation become the key problem for studying the evolution of insect mimicry. In the Mesozoic Era, insects began a rapid evolutionary radiation, and evolved into many defensive strategies to adapt to the environments. We have been conducting research of the Mesozoic insect fossils for more than ten years, and trying to explore the diversity of insects in Mesozoic ecosystems. Based on our study, we have found more than 170 genera and 360 species from the well-known Jehol biota and Yanliao biota, including one new order and 17 new families, which provided us abundant material to study Mesozoic insect mimicry. We found the oldest pinnate leaf-mimicking insects, *Bellinympha filicifolia* and *B. dancei* from China. The insects had developed many morphological specializations to achieve the mimicry: elongate wings with undulating margin, disruptive pattern of coloration resembling leaf pinnae on the forewing, and distinctly thickened MP branches resembling a leaf rachis. *Bellinympha* with their pinnate leaf-like wings with disruptive maculations likely rested and fed on the terminal pinnae of the leaves, remaining motionless or swaying gently to resemble leaf movement in the breeze. In 2012, we again found a new insect mimicry from the Mesozoic of China: the multilobed leaf of a ginkgo plant, *Yimaia capituliformis* that bore a surprising similarity with a particular species of hangingfly insect *Juracimbrophlebia ginkgofolia.* It is the first time to demonstrate the coevolution between insects and gingko, and it also indicated a much more complex associations between insects and contemporaneous plants, implying there would be more insect mimicry in the Mesozoic.

MESOZOIC NEUROPTERA FROM CHINA

Yongjie Wang[1] and Dong Ren[1]

1. College of Life Science, Capital Normal University, 105 Xisanhuanbeilu, Haidian District, Beijing, P. R. China. wangyjosmy@yahoo.cn

Mesozoic Neuroptera exhibit highest species richness and morphological diversity in Northeastern China, suggesting it should have been a golden time for neuropterans in the Mesozoic Era. Up to date, 18 families, 42 genera and 56 species have been described in Mesozoic China, and mainly found in the Jiulongshan Formation and Yixian Formation. Based on morphological data, incorporating most fossil and extant families, the familial phylogenetic relationships of Neuroptera were re-constructed. Combining the fossil records of Neuroptera, the familial division time of Neuroptera was discussed. Four extinct families, Permithonidae, Archeosmylidae, Mesithonidae and Nevrorthidae constitute the stem-groups of Neuroptera, representing the earliest division of Neuroptera. The suborder Myrmeleontiformia is confirmed, and Saucrosmylidae, Kalligrammatidae, Panfiloviidae, Aetheogrammatidae and Grammolingidae are assigned to the suborder. The superfamily Chrysopoidea is corroborated, comprising of Limaiidae, Tachinyphidae, Allopteridae, Mesochrysopidae and Chrysopidae. According to the fossil records of Neuroptera, it is inferred the familial division of Neuroptera is likely to have occurred at the Middle Jurassic. The Mesozoic fossil lacewings exhibit some specialized co-evolution relationships with the contemporaneous plants and environments that have been lost in the Modern insects, e.g. the oldest pinnate leaf-mimicking insects, *Bellinympha filicifolia* and *B. dancei* reveal a specialized co-evolution of insects and gymnosperms. Other extinct groups: Kalligrammatidae, Grammolingidae and Saucrosmylinae show some special traits that are different from the modern neuropterans, e.g. extremely large body size, peculiar wing marks and special behavioral adaptation. These enigmatic insects implied the diverse living strategies of Neuroptera before adaptation of angiosperms. The research of Mesozoic neuropterans would promote our knowledge to understand the early evolutionary history of Neuroptera.

NEW *ARCHINEMESTRIUS* SP. OF NEMESTRINIDAE FROM THE MIDDLE JURASSIC OF INNER MONGOLIA, CHINA

Zhijun Zhang[1]

1. Dept. of Palaeontology, the Geological Museum of China, Yangrouhutong No.15, Beijing, 100034, China.
zhjzhgmc@hotmail.com

As a cosmopolitan group of Diptera, the fossil representatives of family Nemestrinidae have been successively enriched these recent years. About 3 genera and 3 species were recorded in the deposits of Cretaceous-Jurassic of China. One more species of the genus Archinemestrius was found recently in the Middle Jurassic Haifanggou Formation of Inner Mongolia Autonomous Region. The body of the new species is about 12 mm long, the proboscis is longer than head and at least reaching the coxae of midlegs, and the 1st tarsus of the hind leg is longer than the others combined. The wing is about 9.5 mm long and 3.0 mm wide. Veins C and Sc are obviously thickened; R_1 is about 3/4 of the wing length; R_{4+5} and M_{1+2} connect in one point; R_{4+5} is forked proximal of the R_1 apex, and just under the distal Sc; R_5 is ending behind the wing tip; d+p4 cell is broad; distal part of M_3 is shorter than M_{1+2}; A1 is obviously sigmoid waved; m-cu connect CuA to the forking point of M_3 and M_4; halter is 1.6 mm long, and basal part slightly shorter than swelled distal part. The new material differs from other species within Archinemestrius in the following combined characters: R_{2+3} slightly sigmoid waved, R_{4+5} and M_{1+2} connect with one point, d+p4 cell broad, distal part of M_3 shorter than M_{2+3}, A_1 obviously sigmoid waved, m-cu connect CuA to the forking point of M_3 and M_4. Through re-examining the holotype of Protonemestrius jurassicus, the 'long proboscis' is a actually a fragment of plant and the proboscis is at most reaching the coxae of the midlegs. However, a long proboscis is not the unique indicator for pollination, and the deeper throated flowers, that relatively derived group in angiosperms, appeared later during the Cretaceous. Therefore the new species could presumably feed on bennettitales and gnetaleans, sucking and licking the liquid exudates as some experts speculated.

SYMPOSIUM

PALAEONTOLOGY OF SUPERB FOSSIL LAGERSTÄTTEN OF CHINA

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EXCEPTIONAL MARINE FAUNAS IN SOUTH CHINA DOCUMENT RECOVERY FROM THE PERMO-TRIASSIC MASS EXTINCTION

Michael J. Benton[1], Qiyue Zhang[2], Shixue Hu[2], Zhong-Qiang Chen[3], Wen Wen[2], Jun Liu[2], Jinyuan Huang[2], Changyong Zhou[2], Tao Xie[2], Jinnan Tong[3] and Brian Choo[4]

1. School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK. Mike.benton@bristol.ac.uk
2. Chengdu Center of China Geological Survey, Chengdu 610081, China.
3. State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan), Wuhan 430074, China.
4. Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China.

The Triassic was a time of turmoil, as life recovered from the most devastating of all mass extinctions, the Permo-Triassic event 252 million years ago. The Triassic marine rock succession of southwest China provides unique documentation of the recovery of marine life through a series of well dated, exceptionally preserved fossil assemblages in the Daye, Guanling, Zhuganpo, and Xiaowa formations. New work shows the richness of the faunas of fishes and reptiles, and that recovery of vertebrate faunas was delayed by harsh environmental conditions and then occurred rapidly in the Anisian. The key faunas of fishes and reptiles come from a limited area in eastern Yunnan and western Guizhou provinces, and these may be dated relative to shared stratigraphic units, and their palaeoenvironments reconstructed. The Luoping and Panxian biotas, both from the Guanling Formation, are dated as Anisian (Pelsonian) on the basis of conodonts and radiometric dates, the former being slightly older than the latter. The Xingyi biota is from the Zhuganpo Formation, and is Ladinian or early Carnian, while the Guanling biota is from the overlying Xiaowa Formation, dated as Carnian. The first three biotas include extensive benthos and burrowing in the sediments, and they were located in restricted basins close to shore. Further, even though the Luoping and Panxian biotas are of similar age, their faunas differ significantly, reflecting perhaps palaeogeographically isolated basins. Between the time of the Xingyi and Guanling biotas, there was a major transgression, and the Guanling biota is entirely different in character from the other three, being dominated by pelagic forms such as large floating crinoids attached to logs, very large ichthyosaurs and thalattosaurs, and pseudoplanktonic bivalves, with no benthos and no burrowing. Phylogenetic study of the fishes and marine reptiles shows apparently explosive diversification among 20 actinopterygian lineages very early in the Early Triassic, but a later expansion of marine reptile groups, in the late Olenekian and early Anisian. This offset in diversification patterns is matched by comparisons of feeding guild categories and body size data. New research tools will shed considerable light on the phylogenetic and ecological implications of recovery of marine vertebrates in the Triassic.

A CRITICAL APPRAISAL OF THE FOSSIL RECORD OF THE EARLIEST ANIMALS AND THEIR EMBRYOLOGY

Philip Donoghue[1], John Cunningham[1] and Stefan Bengtson[2]

1. School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK. phil.donoghue@bristol.ac.uk

2. Department of Palaeozoology, Swedish Museum of Natural History, Box 50007, Stockholm SE-104 05, Sweden.

The c. 570 Ma Doushantuo biota of South China has yielded important fossils that include the oldest widely accepted record for the establishment of the animal evolutionary lineage, as well as a suite of specimens with alleged bilaterian affinity. However, the interpretations of all of these fossils have been criticized on the basis that interpretations of affinity are contingent on the presence of key biological structures that may be more readily interpreted as artifacts of diagenetic mineralization. Furthermore, these fossils are limited to the earliest stages of embryonic development, and the absence of equivalent adults has led to the suggestion that these simple clusters of cells may rather represent clusters of dividing bacterial cells. We attempted to discriminate among these competing hypotheses by first characterizing the mineral phases that replicate original biological structure versus later diagenetic void filling using Back Scattered Electron imaging, Electron Microprobe Analysis, Kikuchi Diffraction, and Synchrotron Radiation Tomographic Microscopy, demonstrating that those structures interpreted hitherto as evidence for derived animals are characteristic of void filling mineralization long after the original biological structures have decayed away. To discriminate between animal versus bacterial interpretative models we undertook decay experiment on modern animal embryos and giant bacteria. The taphonomy of the Doushantuo fossils is compatible with animal embryos, but not with bacteria. Furthermore, the fossilised remains of nuclei within the Doushantuo allow us to reject the bacterial model. It does not follow, however, that the animal model is correct, and attempts to maintain an animal interpretation have been substantiated on metazoan symplesiomorphies that are encountered among more universal clades. Unfortunately, the Doushantuo does not appear to provide the window on early animal evolution that we would all wish for, but it nevertheless records with great fidelity stages in the life cycle of eukaryotes that may include forms within the holozoan clade.

THE MIDDLE TRIASSIC LUOPING BIOTA: A TAPHONOMIC WINDOW ON FULL RECOVERY AND RADIATION OF MARINE ECOSYSTEMS AFTER THE PERMO-TRIASSIC MASS EXTINCTION

Shixue Hu[1], Qiyue Zhang[1], Changyong Zhou[1], Wen Wen[1], Jinyuan Huang[1], Tao Xie[1], Michael J. Benton[2], Zhong-Qiang Chen[3] and Brian Choo[4]

1. Chengdu Center of China Geological Survey, Chengdu 610081, China. hushixue@hotmail.com
2. School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK.
3. State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan), Wuhan 430074, China.
4. Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China.

The Middle Triassic Luoping Biota, from Luoping County, Yunnan Province, SW China, is a typical Konservat-Lagerstätte. A conodont-based age determination indicates that this biota lies within the *Nicoraella kockeli* Zone, which is assigned to the Pelsonian Substage of the Anisian Stage, Middle Triassic. The interval containing the exceptional fossils belongs to the Second Member of the Guanling Formation, which is widely exposed in large areas of Guizhou and Yunnan provinces, SW China. The depositional environment of the Luoping biota is interpreted as restricted intraplatform basins. Several such basins have been recognized from the Middle Triassic of east Yunnan, among which the fossils from the Luoping basin show higher diversity and better preservation. The Luoping biota is a mixture of marine animals, terrestrial plants and few terrestrial animals. Arthropods, fishes and marine reptiles are the most common and important component of the fauna. Associated fossils include bivalves, gastropods, ammonites, echinoderms, lingulid brachiopods, conodonts, foraminifers, and plants. The arthropods include crustaceans, millipedes and limulids. Among these, crustaceans are the most common and diverse group, represented by decapods (lobsters and shrimps), isopods, cycloids, thylacocephalans, conchostracans and ostracods. Fishes are also dominant and diverse, including more than 30 taxa, belonging to nine families of basal actinopterygians. Marine reptiles are one of the highlights of the Luoping biota, including ichthyosaurs, sauropterygians (pachypleurosaurs), rare archosaurs and prolacertiforms. The presence of diverse top predators, most notably the fish and reptile taxa, and the complex food web indicates that Luoping is a fully recovered ecosystem, some 10 Myr after the profound Permo-Triassic mass extinction. The Luoping Biota also documents the diversification of crustacean arthropods, neopterygian fishes, and marine reptiles. The emergence of new animal groups, in conjunction with the introduction of new trophic levels, implying the rebuilding of the marine ecosystems is coupled with ecological innovations, and finally led to the emergence of Mesozoic marine ecosystem. The development of a mature, typical Mesozoic marine ecosystem was achieved in the Middle Triassic, by the time of the Luoping Biota, approximately 10 Myr after the PTME.

X-RAY MAPPING OF PIGMENTARY COLOURS IN FOSSIL AND MODERN INSECTS

Maria E. McNamara[1,2], Emma R. Locatelli[1], Stuart L. Kearns[3], Sam Webb[4], Patrick J. Orr[2], Derek E.G. Briggs[1,5], Lin Qiu[1], Shuang Yang[1] and Zhengrong Wang[1]

1. Dept. of Geology & Geophysics, Yale University, New Haven, CT 06520, USA.

2. UCD School of Geological Sciences, University College Dublin, Dublin 4, and School of Biological, Earth and Environmental Sciences, North Mall, Cork, Ireland. maria.mcnamara@ucc.ie

3. School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK.

4. SLAC National Accelerator Laboratory, Stanford Synchrotron Radiation Lightsource (SSRL), Menlo Park, CA 94025, USA.

5. Yale Peabody Museum of Natural History, New Haven, CT 06520, USA.

Insect color patterns are key to our understanding of visual signalling strategies and their evolution. Many fossil insects exhibit spots, bands, and blotches defined by varying brown to black tones. This monotonal patterning resembles color patterns in extant insects, but its origins have not been investigated. In both fossil and modern feathers tonal patterning is associated with spatial distributions of eumelanin-chelated trace elements, especially Cu, but whether such a diagnostic suite of elements characterises pigmentary colour in insects is unknown. Here, we resolve these issues using synchrotron-X-ray fluorescence and electron dispersive X-ray mapping of diverse extant and fossil insects that exhibit colour patterning. Spatial variation in abundance of Cu corresponds to tonal variations in all the fossil insects analysed but none of the extant insects. Maturation experiments reveal that Cu is preferentially incorporated into melanin-rich cuticle regions from the sedimentary matrix during diagenesis, allowing the original patterning to be reconstructed in cuticles altered to black by the effects of elevated temperatures. Incorporation of diagenetic Cu into the cuticle is enhanced at elevated temperatures and in oxygenated conditions; at lower temperatures, cuticles transform to a uniform black hue and do not show spatial variations in Cu. A lack of patterning – and spatial partitioning of Cu – in some fossil insects may thus be a diagenetic artefact. Other elements, however, especially Na, K, Cl, Mn, and Ti, are correlated with melanin-rich cuticle regions in extant insects and with darker tones in all the fossils analysed. This primary chemical signature can reveal details of patterning not visible in hand specimen and is thus a novel diagnostic tool for reconstructing pigmentary colour patterns in fossil insects.

MESOZOIC MAMMALS FROM NORTHEAST CHINA – IMPLICATIONS FOR EARLY MAMMAL EVOLUTION AND PHYLOGENY

Jin Meng[1]

1. Division of Paleontology, American Museum of Natural History, Central Part West at 79th Street, New York, NY 10024, USA; and Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, 142 Xi-Zhi-Men-Wai St., Beijing, 100044, China. jmeng@amnh.org

The first Chinese Mesozoic mammal, *Manchurodon*, was reported in 1938. Since then, the record of Mesozoic mammals has grown slowly, with a total of 8 species documented in 1995. Beginning with the report of *Zhangheotherium* in 1997 and up to submission of this abstract in May 2014, 43 additional Mesozoic mammal species have been named during the last two decades. Most of these species came from the Yanliao (Daohugou), Jehol and Fuxin assemblages in Northeast China. The ages of the strata containing the three mammal assemblages are not precisely determined and may vary considerably, depending on dating methods, data sampling, stratigraphic division/correlation as well as definition of biotas. Roughly, they were considered to be 168-155 Ma, 130-120 Ma and <120-~110 Ma, respectively. Because the localities producing the three mammal assemblages overlap geographically, we thus have a unique opportunity to learn mammalian evolution from the Middle Jurassic to the end of Cretaceous, a critical period of time for mammal diversification, perhaps associated with radiations of other organisms, such as dinosaurs, birds, insects and angiosperms. It is quite remarkable that the Yanliao mammals (dominated by archaic groups, such as docodontans and allotherians) had already reached high diversity in species and disparity in body shape and locomotion. The Jehol mammals, mostly preserved in the lacustrine, volcanically influenced beds similar to those of Yanliao strata, are distinctively different from Yanliao species; they are generally more derived (dominated by eutriconodonts, symmetrodonts and cladotherians) and show a greater disparity in body size. The Fuxin mammals (dominated by multituberculates, eutriconodonts and eutherians) were preserved in sand- and mudstones with richly intercalated coal measures, and usually more fragmentary than fossils from the other two earlier assemblages. Fuxin mammals show some continuity with Jehol mammals, but still display a more derived faunal composition. Mammals from the three assemblages add significantly to the diversity of Mesozoic mammals; they show morphological and taxonomic changes during a period of *ca.* 60 Ma that are consistent with the general pattern recognized in mammalian evolution. The excellent fossils enable us to know a great deal of morphology for previously poorly known mammals, such as haramiyidans, to deepen our understanding in the classic study for mammal middle ear evolution by recognizing the transitional mammalian middle ear, and to encourage rigorous discussions about the divergence and higher-level phylogeny of the crown mammals.

PERMIAN VEGETATIONAL POMPEII OFFERS A WINDOW TO LATE PALAEOZOIC COAL FOREST ECOLOGY: WUDA TUFF FLORA AS A FOSSIL FLORAL LAGERSTÄTTE (INNER MONGOLIA, CHINA)

Jun Wang[1]

1. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China. jun.wang@nigpas.ac.cn

The Wuda Tuff Flora as a peat forming vegetation from the earliest Permian (ca. 298 Ma) of Inner Mongolia buried in volcanic ash has been called as a Chinese vegetational Pompeii. These deposits allow palaeoecologists to examine the Late Palaeozoic coal forest ecology in much the same way as neoecologists appraise modern environments. Apart from pilot field research on the entire 20 km^2 coal basin, about 1,500 m^2 of the forest have been reconstructed based on the actual location of individual plants. Six major plant groups comprise the flora, including lycopsids, sphenopsids, noeggerathialeans, ferns, primitive cycadophytes and coniferophytes. Most abundant were the marattialean tree ferns represented by species of *Pecopteris*. Herbaceous ferns include *Nemejcopteris feminaeformis*, *Cladophlebis*, and *Sphenopteris*. Lycopsids are represented by *Sigillaria* cf. *ichthyolepis*, tall pole-like trees. Sphenopsids include *Sphenophyllum*, a dwarf shrub, and a small *Calamites*. Noeggerathiales, an extinct spore-bearing group of uncertain systematic position, are small trees represented by species of *Tingia* and *Paratingia*. Gymnosperms include possible early representatives of the cycads, *Taeniopteris* and *Pterophyllum*, and *Cordaites*, trees that were early coniferophytes with a generally modern growth habit, except for the large strap-shaped leaves with parallel venation. In addition to the proportional taxonomic composition (diversity) and individual plant growth stature (whole plant biology), landscape heterogeneity (species – area curve), forest structure (e.g. ecological assembly, density of individuals) and vegetational recovery are detectable. There is one site where Noeggerathiales, for the first time are found to be dominant. This flora growing on peat is also taxonomically distinct from those growing on clastic soils in the same area and during the same time interval. Most interesting is that ontogenetic features of the individual taxa suggest that phenology developed. This Permian flora demonstrates both similarities and differences to floras of the same age in Europe and North America, and confirms the distinct character of the Cathaysian floral realm. Therefore, this flora will serve as a baseline for the study of other fossil floras in East Asia and the early Permian globally that will be needed for a better understanding of palaeoclimate evolution through time.

PALEO-CO_2 VARIATION TRENDS AND THE CRETACEOUS GREENHOUSE CLIMATE

Yongdong Wang[1], Chengmin Huang[2], Bainian Sun[3], Cheng Quan[4], Jingyu Wu[1,3] and Zhicheng Lin[5]

1. Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China. ydwang@nigpas.ac.cn
2. Department of Environmental Science and Engineering, Sichuan University, Chengdu 610065, China.
3. School of Resources and Environment, Lanzhou University, Lanzhou 730000, China.
4. Research Center of Palaeontology and Stratigraphy, Jilin University, Changchun 130026, China.
5. Oil and Gas Engineering Institute, Chongqing University of Science and Technology, Chongqing 401331, China.

The Cretaceous was one of the most remarkable periods in geological history, with a “greenhouse” climate and several important geological events. Reconstructions of atmospheric CO_2 using proxies are crucial for understanding the Cretaceous “greenhouse.” In this paper we summarize the major approaches for reconstructing CO_2 based on paleobotanical or geochemical data, and synthesize the record of CO_2 variations throughout the Cretaceous. The results show that atmospheric CO_2 levels remained relatively high throughout the Cretaceous, but were lower in the early Cretaceous, highest in the mid-Cretaceous and gradually declined during the late Cretaceous. However, this overall trend was interrupted by several rapid changes associated with ocean anoxic events (OAEs) and the end-Cretaceous event. New data on paleo-CO_2 levels from paleobotanical and paleosol evidence support not only the overall trends indicated by geochemical models, but provide more precise records of the short-term fluctuations related to brief episodes of climate change. Temporal resolution within the long quiet magnetic period in the middle Cretaceous is one of obstacles preventing us from a more comprehensive understanding of the CO_2 climate linkage. But new paleo-CO_2 determinations and climatic data from stratigraphic sections of sediments intercalated with datable volcanic rocks will allow a better understanding of the relationships between fluctuations of atmospheric CO_2, climate change, and geological events. [Supported by State Key Program of Basic Research of Ministry of Science & Technology, China (Grant No. 2012CB822003), the National Natural Science Foundation of China (Grant Nos. 41272010, 41302004), and the Team Program of Scientific Innovation and Interdisciplinary Cooperation of CAS].

A NEW CAMBRIAN BURGESS SHALE-TYPE BIOTA FROM THE "TSINGHSUTUNG FORMATION" AT BALANG, JIANHE COUNTY, GUIZHOU PROVINCE, CHINA

Zhao Yuan-long[1], Peng Jin[1], Yang Yu-ning[1], Loren E. Babcock[2], Yang Xing-lian[1], Robert Gaines[3], Sun Hai-jing[1], Wu Meng-yin[4], Yuan Jin-liang[5] and Zhang Pei-xing[1]

1. College of Resource and Environment Engineering, Guizhou University, Guiyang 550025, China. zhaoyuanlong@126.com
2. School of Farth Science Ohio State University,Ohio 43210, USA.
3. Geology Department, Pomona College, Claremont, CA 91711, USA.
4. Department of Political Education, Guiyang College, 550005 China.
5. Nanjing Institute of Geology and Palaeontology, the Chinese Academy of Sciences, Nanjing 210008, China.

The new Burgess Shale-type Jianhe Biota including soft-bodied fossils occurs in mudstone and fine-grained limestone of the mid-upper "Tsinghsutung Formation" of Cambian Series 2 Stage 4 at the Songshan Section in proximity to the Wuliu-Zengjiaya Kaili Formation containing the Kaili Biota, from Balang, Jianhe county, Guizhou province, South China. It contains biomineralized and nonbiomineralized remains representative of a variety of higher taxa, including anomalocariids, *Tuzoia, Isoxys, Redlichia, Olenoides, Leptomitella, Sphenothallus, Nisusla, Wronascolex, Sinoeocrinus, Wiwaxia*, and eight phyla (Porifera, Cnidarians, "Worms", Brachiopoda, Mollusca, Arthropoda [trilobites, large bivalved arthropods, bradoriids, other arthropods], Echinodermata, Algae and Problematic taxa). As with other Burgess Shale-type biotas, arthropods are the dominant group in diversity and abundance; 22 arthropod genera comprise 55% of the total diversity of the biota, while 7 brachiopod genera are present. Further collecting of the Jianhe Biota will shed light on abundance patterns and may reveal the presence of previously unrecognized taxa. The discovery of multiple classes is surprising in a formation previously known to yield only trilobites. The trilobites *Arthricocephalus* and *Protoryctocephalus*, which are found in the Jianhe Biota, also occur in Greenland, and provide an important basis for biostratigraphic correlation of the Balang and Tsinghsutung Formations. This ongoing research will contribute to the selection of a Global Stratotype Section and Point for Cambrian Stage 4. The Jianhe Biota provides an important record of soft-bodied diversity in South China that is located stratigraphically between the Balang Biota and the Kaili Biota. It provides further material for study of the Cambrian Explosion and of the co-evolution of complex life and the global environment.

THE JEHOL BIOTA, AN EARLY CRETACEOUS TERRESTRIAL LAGERSTÄTTE: NEW DISCOVERIES AND IMPLICATIONS

Zhonghe Zhou[1]

1. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China. zhouzhonghe@ivpp.ac.cn

The study of the Early Cretaceous terrestrial Jehol Biota, which provides a rare window for the reconstruction of the Lower Cretaceous terrestrial ecosystem, is reviewed with a focus on some of the latest progress. A brief introduction of various types of preservation and mechanism of the Jehol fossils is provided and the newly proposed definition of the biota based on paleoecology and taphonomy is accepted. New discovery of taxa of significance from the Jehol Biota is summarized, with an updated introduction of its diversity. The evolutionary significance of major biological groups (e.g., dinosaurs, birds, mammals, pterosaurs, insects and plants) is discussed mainly in light of recent discoveries. Both the global and local geological, paleogeographic and paleoenvironmental background of the Jehol Biota is reviewed, and is shown to have contributed to the unique composition, evolution and preservation of the biota, demonstrating widespread faunal exchanges between Asia and other regions, and confirming northeastern China as the origin and diversification center for a variety of Cretaceous biological groups. Despite some progress made on the reconstruction of paleotemperature during the time of the Jehol Biota, much more work is still needed to conclude a possible link between the remarkable diversity of the biota and cold intervals during the Early Cretaceous.

THE DIVERSIFICATION OF CICADOMORPHA FROM THE MESOZOIC OF NORTHEAST CHINA

Dong Chen[1], Yongjie Wang[1] and Dong Ren[1]

1. Key Lab of Insect Evolution and Environmental Changes, College of Life Science, Capital Normal University, Beijing 100048, China. chend317@163.com

Mesozoic Cicadomorpha from northeastern China are highly diverse, including abundant froghoppers, leafhoppers, planthoppers and their relatives (hoppers), which provide important evidence for the origin and early evolution of the clade. Representatives of various families are present, both extinct and extant. Procercopidae is a poorly known group, believed to be ancestral to the extant families of Cercopoidea. Procercopidae is the most abundant group in both Jurassic and Cretaceous strata. However, the taxonomic diversity of these froghoppers must be re-examined and future systematic revisions are needed. Recently, we have found mating behaviors in the fossil record of Procercopidea. The earliest Cicadoidea is the Tettigarctidae which appeared in the latest Triassic. Tettigarctidae was morphologically diverse and quite abundant in the Jurassic and Cretaceous. Some 23% of the fossil materials from northeastern China belong to Tettigarctidae, but so far, only 4 definitive species of Tettigarctidae are known. Palaeontinoidea are huge, moth-like insects, resembling a little, but not related to, singing cicadas, which were derived from Dunstaniidae during the Late Triassic, went into its most prosperous stage during the Middle Jurassic, and became extinct in the mid-Cretaceous. A combination of cryptic coloration and disruptive marking enhanced their camouflage. Hylicellidea are believed to be common ancestors of living Cicadomorphora, with a fossil record from Triassic to mid-Cretaceous. Their taxonomic diversity is still weakly recognized and needs further investigation. The remaining forms include some uncertain taxa and only a few Fulgoromorpha. The study of fossil Fulgoroidea from China is still at an early stage, but the number of new outcrops and specimens is increasing. However, they clearly differ from forms known from Europe and elsewhere in Asia. By analyzing the record of animals and associated plants fossil, palaeoclimatic data and palaeoecological data, the processes of evolution of Cicadomorpha and Fulgoromorpha could be traced and analyzed. Concurrent changes in both plants and flourishing predators limited the hopper's development and radiation during the Middle Jurassic to Early Cretaceous.

DISCOVERY OF *ANNALEPIS* FLICHE (LYCOPSIDA) FROM THE YANCHANG FORMATION (MIDDLE-UPPER TRIASSIC) OF THE ORDOS BASIN, NORTH CHINA

Shenghui Deng[1], Yuanzheng Lu[1], Xin Li[1] and Ru Fan[1]

1. Research Institute of Petroleum Exploration & Development PetroChina, Beijing 100083, China.
dsh63@petrochina.com.cn

Annalepis Fliche is a fossil genus of the Lycopsida that occurred in the Lower-Middle Triassic. It is significant in biostratigraphy and palaeoenvironmental interpretation due to its narrow stratigraphical range and strict environmental requirements. So far, only a few species have been recorded as *Annalepis*, but they have a wide distribution in the Northern Hemisphere, including France, Germany, Russia, Kazakhstan, Kyrgyzstan and China in Eurasia and North America. *Annalepis* first appeared at the base of the Induan of the Early Triassic, flourished in the Middle Triassic and possibly went extinct at the end of the Middle Triassic. We report in this paper a new discovery of *Annalepis zeilleri* Fliche and *A. ordosensis* sp. nov. from the middle part of Yanchang Formation of the Middle-Upper Triassic of the Ordos Basin, North China. In our collection, we have numerous specimens of *Annalepis zeilleri*, including 10 with *in situ* megaspores. They compare very well with the type materials from France in both the morphology of sporophylls and the *in situ* megaspores. The new species is characterized by the outlines and structures of its sporophylls. The sporophyll is composed of an inverted triangular basal part and a wide triangular upper part. Its ligular pit is elliptic in shape and transverse-oriented. Its sporangium is elliptic in form and large in size. The new species can be easily distinguished from the known species of *Annalepis*. They are associated with *Equisetites sarrani* (Zeiller) Harris, *Neocalamites carcinoides* Harris, *Annulariopsis annularioides* Huang et Zhou, *Danaeopsis fecund* Halle, *D. magnifolia* Huang et Zhou, *D. plana* (Emmons), *Symopteris zeilleri* (Pan), *S. megasora* sp. nov., *Asterotheca szeiana* (Pan), *Todites shensiense* (Pan) Sze, *Cladophlebis ichunensis* Sze, *Cl. kaoiana* Sze, *Cl. raciborskii* Zeiller, *Cl. stenophylla* Sze, *Thinnfeldia alethopteroides* Sze, *Th. rigida* Sze, *Th. rhomboidalis* Ettinshausen, *Linguifolium sinense* sp. nov., *Nilssonia orientalis* Heer, *N.* sp., *Nilssoniopteris* sp., *Otozamites shannxiensis* sp. nov., *Sphenozamites change* Sze, *Sphenobaiera* sp., *Glossophyllum shensiensis* Sze, *Swedenborgia cryptomerioides* Nathorst, etc. Its geological age is possibly Ladinian to Carnian of the Triassic. *Annalepis* is considered as a salt-tolerant plant and occupies coastal areas influenced by tides. *Annalepis* fossils are mostly preserved in marine-continental facies sediments and its palaeogeographic distribution is closely related to sea level change. Therefore, the appearance of *Annalepis* in the Yanchang Formation possibly indicates that the Ordos Lake was connected to the sea during the Ladinian and Carnian.

BROODING BEHAVIOR EVIDENCE OF *KUNMINGELLA DOUVILLEI* FROM THE LOWER CAMBRIAN CHENGJIANG LAGERSTÄTTE, YUNNAN, SOUTH CHINA

Yanhong Duan[1,2]

1. Life Science and Technology Department of Xinxiang University, JinSui Avenue Eastern, Xinxiang 453000, PR China.

2. Early Life Institute and Department of Geology and State Key Laboratory of Continental Dynamics, Northwest University, 229 Taibai Road, Xi'an 710069, PR China.

dyh6065@163.com

Arthropods are the most diverse group of animals and have been so since the Cambrian radiation. Bradoriids are small bivalved marine arthropods that are widespread in rocks of Cambrian to Early Ordovician age. From research of reproductive strategy of Cambrian fauna, the author recognizes that the bivalved bradoriid arthropod *Kunmingella douvillei* (Mansuy) is the most common species in the Lower Cambrian Chengjiang Lagerstätte, Yunnan, South China. Its soft anatomy has been discussed and reported based on well-preserved specimens in the Lower Cambrian Chengjiang Lagerstätte. However, as with other Cambrian arthropods, their reproductive strategy and reproductive behavior as well as brooding behavior are poorly documented. Rare specimens of *K. douvillei* preserved with eggs on the appendages have been reported and discussed. Our new collections confirm that the eggs were directly attached to the last three pairs of biramous appendages and verify the head-trunk boundary suggested by previous work. An exceptionally preserved new *K. douvillei* from the Cambrian Chengjiang Lagerstätte preserves eggs on its appendages, providing a unique view of parental brooding care in the invertebrate fossil record. It demonstrates a remarkably conserved egg-brooding reproductive strategy in *K. douvillei* over 520 Myr. The brooding behavior of *K. douvillei* was most probably related to its small body size, as in living crustaceans. The female *K. douvillei* could carry 50–80 eggs ranging from 150–180μm in diameter, possibly indicating brooding behavior and reproductive behavior as well as a K-reproductive strategy. Its ontogenetic and reproductive mode as well as brooding behavior may have been an adaptive strategy in response to increasing predatory pressure of the outside environment across the Ediacaran–Cambrian boundary. All three main directions of development in the life history of living marine invertebrates, namely planktotrophic larvae, lecithotrophic larvae, and brood care, must have evolved by Stage 3 of the Cambrian, and might even have been rooted in the Precambrian. This also provides conclusive evidence of a developmental brood-care strategy conserved within bradoriids for at least 520 million years.

EARLY CRETACEOUS COEVOLUTION BETWEEN CHANGES OF CONTINENTAL BASIN AND JEHOL BIOTA IN WESTERN LIAONING CHINA

Enpu Gong[1] and Lijun Zhang[1]

1. Department of Geology, Northeastern University, Shenyang, 110819, China.
gongep@mail.neu.edu.cn

Western Liaoning is located on the northern margin of the North China plate and the middle-eastern segment of the Yanshan tectonic belt. It was situated on the Pacific Rim active belt of the continental margin in the Mesozoic. Significant tectonic activity happened and thus a series of volcanic-sedimentary basins formed. The Yixian basin is one of many basins of that period. In the Early Cretaceous, a series of NNE-directed depressions, concave cracks and rift basins were formed. Volcanism was concentrated in the Yixian stage with the developing Jehol Biota, and reached its peak in the middle stage, and diminished in the Jiufotang stage. According to statistics of new genera from the Jehol Biota in western Liaoning, the vertebrate fauna represented by birds and dinosaurs reached its time of maximum radiation. The maximum radiation of birds, dinosaurs and mammals occurred during the time of strongest volcanism. The biggest radiation period corresponds to the Jianshangou bed (125 Ma) in Jehol Biota. This occurs at the same time as the violent phase of volcanic activity of Cretaceous in western Liaoning. The volcanism is large-scale, high intensity and persistent during the Yixian phase in western Liaoning and it made a huge impact on the environment. The event made the terrestrial ecological environment complex, where diverse organisms originated and evolved. Community succession is observed with environmental changes. Finally, the transition of the Yixian biota into the Jiufotang biota is gradual. [Supported by National Natural Science Foundation of China (No 41172003); the National Key Basic Research Program of China (No 2012CB821905). Contribution to UNESCO-IUGS IGCP Project 632].

A MULTIPROXY APPROACH TO RECONSTRUCTING THE ECOSYSTEM EVOLUTION OF LAKE SIHETUN (YIXIAN FORMATION, CHINA)

Manja Hethke[1], Franz T. Fürsich[1] and Baoyu Jiang[2]

1. Universität Erlangen-Nürnberg, GeoZentrum Nordbayern, Loewenichstr. 28, Erlangen, 91054, Germany. manja.hethke@fau.de

2. Nanjing University, State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, 163 Xianlin Avenue, Nanjing, 210046, China.

The volcanic Yixian Formation of western Liaoning (Barremian-Aptian) documents an exceptional time slice that witnessed the diversification of major clades. Previous work on this Early Cretaceous fossillagerstätte has centred on groups such as feathered dinosaurs and early birds, but little is known about the evolution of the lake's ecosystem. The trajectory of the lake ecosystem is identified by a multiproxy approach, designed to delimit the major physicochemical processes and biotic changes that shaped the lake. Sedimentological evidence indicates four well-defined developmental phases for Lake Sihetun, of which phases 2 and 3 yield most of the exceptionally preserved biota. While Phase 2 was marked by dysoxic bottom waters with episodic meromictic events, Phase 3 was entirely holomictic and governed by increased siltation and oxygen availability within the hypolimnion. Each phase imposed diverse constraints on fossil preservation, which are exemplified by studies of the biomineralization and fossilization of clam-shrimps (Branchiopoda: Spinicaudata), the most abundant faunal component of Lake Sihetun. Excellent cuticle preservation can be linked to oxygen-deficient, alkaline bottom waters (Phase 2), while mineralogical and structural preservation is severely reduced in more oxygenated waters (Phase 3). In addition, palaeoenvironmental interpretations have been hampered by taxonomic inaccuracy along with inadequate knowledge and oversimplification of the ecology of clam shrimps. The apparent high diversity of clam-shrimp taxa within the lake can be drastically reduced on the basis of intraspecific shape variation and the quantification of carapace ornamentation. It is revealed that a number of species of the genus-group *Eosestheria* follow an ontogenetic trajectory. They should be classified as junior synonyms of the valid species *Eosestheria middendorfii* (Jones). Analyses of ontogenetically and environmentally controlled variability within this clam-shrimp species sheds light on the population ecology of the species, which diverts from the standing interpretation. The identification of sexual dimorphism, based on a single cohort yielding egg clutches, has led to the development of a new protocol for the identification of the reproductive system of fossil clam shrimps (dioecious reproduction in case of *E. middendorfii*). The revision of the population ecology of *E. middendorfii* renders the palaeocommunity analysis of Lake Sihetun interpretable. It is based on an excavation that spans both phases 2 and 3. Four arthropod-dominated associations are identified, two of which are restricted to either phase. Notable faunal components are the clam shrimp *E. middendorfii* and the water boatman *Karataviella*.

DISTRIBUTION AND SIGNIFICANCE OF THE BENTHIC FORAMINIFERAL SPECIES *FAVOCASSIDULINA FAVUS* IN THE WESTERN PACIFIC DURING THE EARLY QUATERNARY

Baoqi Huang[1], Na Wang[1], Mengsha Chen[1], Jianghui Du[1] and Yaocheng Niu[1]

1. Peking University, 5 Yiheyuan Rd., Beijing, 100871, China. bqhuang@pku.edu.cn

Abundances of the benthic foraminiferal species *Favocassidulina favus* were compared from ODP Sites 807, 1143 and 1146 during the early Quaternary (2500-1600Ka). The results show that abundance of the species reached 15% in Site 807 and below 7% in Sites 1143 and 1146 of the South China Sea. The species continued to live in Ontong Java Plateau in the western Pacific during early Quaternary, but they occurred intermittently in the South China Sea (SCS) during 2500-2100 Ka, 1950-1830 Ka, and 1750-1600 Ka. Two water masses balanced at the low latitude, namely the Pacific Deep Water (PDW) and Upper Circumpolar Deep Water (UCDW). PDW and UCDW occupy approximately the same density (and depth) range in the Pacific, with UCDW flowing into the Pacific and PDW flowing out. PDW is marked by low temperature, oxygen and salinity; high nutrients, silica and "age". By contrast, UCDW had higher salinity, and lower silicate entering low latitudes from the south Pacific. Previous studies on this species show that it lived in waters deeper than 2600 m and bathed by UCDW. Combined with stable isotopes of oxygen and carbon of benthic foraminiferal species and *F. favus* studies, we conclude that variation in *F. favus* in the South China Sea indicates the balance of two waters masses UCDW and PDW at the low west Pacific latitudes. *F. favus* occurs in the SCS when the front of the UCDW reached at least 20°N and PDW-influenced areas shrank to the north of 20°N or more, which happened during about 2500-2100 Ka, 1950-1830 Ka, and 1750-1600 Ka. However, *F. favus* disappeared from the SCS when PDW expanded and its front crossed the equator into the south hemisphere, which happened at about 2100-1950 Ka and 1830-1750 Ka.

EXCEPTIONALLY PRESERVED ONTOGENETIC STAGES OF *PUNCTATUS* FROM THE LOWERMOST CAMBRIAN OF CHINA

Yong Li[1], Yajuan Zheng[1], Yunhuan Liu[1] and Junfeng Guo[1]

1. College of Earth Science and Land Resources, Key Laboratory of Western China's Mineral Resources and Geological Engineering, Ministry of Education, Chang'an University,126 Yanta Road, Xi'an 710054, P.R. China.
zyxy_1@chd.edu.cn

In south Shaanxi, China, the lowermost Cambrian Kuanchuanpu Formation contains not only abundant small shelly fossils but also metazoan eggs and embryos. Knowledge of these fossil embryos has increased dramatically, but relatively little information has been reported concerning the early ontogeny of ancient Metazoa. Although the developmental sequence of *Olivooides* has been reconstructed by Bengtson and Yue, some crucial developmental stages are still obscure and the embryos of early cleavage stages are uncertain. Accordingly, it has been difficult to reconstruct the relationship between *Olivooides* and *Punctatus*. Here, we report some new exquisitely preserved fossils of cleaving-stage embryos juvenile stage and hatched individuals of *Punctatus* from the Kuanchuanpu fauna. These new findings not only fill gaps in the *Punctatus* developmental sequence, but also reveal the relationships between *Olivooides* and *Punctatus*. All the characteristics of newly collected *Punctatus* hatchlings and the morphology of the hatched *Punctatus* suggest that it was not pelagic, but rather benthic. The exceptionally well preserved embryos and hatchlings of *Punctatus* provide important clues about the early evolution of metazoans in general.

AN ANNELID FROM THE LOWER CAMBRIAN GUANSHAN BIOTA, CHINA

Jianni Liu[1], Qiang Ou[2], Yicheng Wu[1], Jian Han[1], Guoxiang Jiao[1] and Tongjiang He[1]

1. Early Life Institute, State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University, Xi'an 710069, China. liujianni@126.com

2. Early Life Evolution Laboratory, State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China.

A fossil polychaete annelid *Guanshanchaeta felicia* gen. et sp. nov. from the Lower Cambrian Guanshan Biota (Cambrian Series 2, stage 4) is described. The new taxon has a generalized polychaete morphology with biramous parapodia, most of which preserve evidence of chaetae, an inferred prostomium bearing a pair of appendages, and a bifid pygidium. The polychaete, *Guanshanchaeta felicia*, is the first unequivocal annelid reported from the Lower Cambrian of China. This find expands the panorama of the Cambrian "explosion" exemplified by the Guanshan biota, which thus hints at a great stock of fossil annelids in the Chengjiang Lagerstätte and the Kaili biota. In addition, this new taxon adds to our knowledge of the morphology of early polychaetes, which suggests there was a substantial diversification of polychaete annelids in the Cambrian.

THE CAMBRIAN (STAGE 4) BALANG FAUNA FROM EASTERN GUIZHOU, CHINA

Jin Peng[1], Yuanlong Zhao[1], Haijing Sun[1], Qiaojie Yan[1], Yongqin Wen[1] and Zhen Shen[1]

1. College of Resource and Environment Engineering, Guizhou University, Guiyang, Guizhou 550025, China.
gzpengjin@126.com

The Balang Formation in eastern Guizhou is composed of gray, gray-greenish silty shale or muscovite-rich shale and mud rock. It was deposited in the slope facies juxtaposed between the Yangtze platform to the west and Jiangnan basin to the east. The middle and upper parts of the Balang Formation yield an important deposit of exceptional preservation. The Cambrian Balang Fauna contains fossils representing eight invertebrate phyla, including arthropods (such as trilobites, bradoriids, and large bivalved arthropods), sponges, coelenterates, brachiopods, priapulids, mollusks, stalked eocrinoids, algae, and a rich ichnofauna. The Balang Fauna also contains evidence for soft-part preservation. For example, fossils with nonbiomineralized exoskeletons (e.g., *Noraoia taijiangensis*, *Wronascolex*) and a hyolith specimen with intact helens and operculum also occur in the fauna. Among them, the eocrinoid *Guizhoueocrinus yui* and the trilobite *Redlichia* (*Pteroredlichia*) *chinensis* are the most common and characteristic taxa in the fauna. Preservation of unusually large quantity and high quality of articulated eocrinoids indicates that the fauna was smothered by obrution events. Based on trilobite biostratigraphy, the fauna is of the Qiandongian (Cambrian) Dunyunian Stage, which is age equivalent to the late Canglangpuan in Yunnan Province, China or Botomian in Siberia. The Balang Formation contains abundant *Redlichia* (*Pteroredlichia*) *chinensis* and is correlated with the lower part of the Ordian of the Cambrian of Australia, even with the lower part of lower Cambrian Henson Gletscher Formation of Greenland; that is, the position of the Balang Fauna correlates with those of the Guanshan Fauna and Emu Bay Shale Fauna. Finally, the Balang Fauna lies in the *Arthricocephalus chauveaui* Zone. Whereas the age-equivalent Guanshan Biota from Yunnan and Emu Bay Shale Fauna were deposited in shallow water settings, the Balang Biota was deposited in deeper water, shelf margin to slope facies. Its faunal elements are transitional between the Cambrian Series 2 Chengjiang Biota and Cambrian Series 3 Kaili Biota in South China. Nevertheless, the Balang Biota is again the most important shelf margin fauna in the Cambrian Series 2 of South China and contains direct ancestors leading to the Cambrian Series 3 Kaili Biota. Because the Balang Formation is distributed widely in eastern Guizhou, recent fieldwork shows the presence of the fauna in the middle to upper part of the formation, at 7 localities. However, its distribution and composition need more work.

THE ARTHROPOD FAUNA IN THE LUOPING LAGERSTÄTTE, CHINA: EVIDENCE FOR EPISODIC MASS MORTALITIES

Carrie E. Schweitzer[1], Rodney M. Feldmann[2], Shixue Hu[3,4], Jinyuan Huang[3,4], Changyong Zhou[3,4], Changyong Zhou[3,4], Qiyue Zhang[3,4], Wen Wen[3,4] and Tao Xie[3,4]

1. Department of Geology, Kent State University at Stark, 6000 Frank Ave. NW, North Canton, Ohio 44720, USA. cschweit@kent.edu

2. Department of Geology, Kent State University, Kent, Ohio 44242, USA.

3.Chengdu Institute of Geology and Mineral Resources, Chengdu, 610081, China.

4. Chengdu Center of China Geological Survey, No. 2, N-3-Section, First Ring, Chengdu 610081, China.

The Middle Triassic (Anisian) Guanling Formation crops out southeast of Luoping, Yunnan Province, China. Remarkable exposures, referred to as the Luoping Lagerstätten, contain a diverse array of arthropods, including decapod Crustacea, thylacocephalans, and mysids. Of the more than 20,000 fossils collected from the site, the majority are arthropods. Some of the earliest species of dendrobranchiate shrimp have been recorded from these rocks. The shrimp belong to the Aegeridae, an extinct family currently assigned to the Penaeoidea. The shrimp are remarkably well preserved and retain pleopods, the reproductive structures of the animals, as well as eyes, antennae, and other cephalic appendages. They are unusual in being preserved not only in lateral aspect but in dorsal and ventral views, which is atypical of shrimp in Lagerstätten. Lobsters from the Luoping locality are diverse and include two clawed lobsters and one achelate form. The lobsters are well-enough preserved to see details of the antennae, major chelae, and chelate pereiopods. All of these decapods appear to have been benthic; lobsters typically exhibit that lifestyle, and the shrimp have specialized third maxillipeds for raking the sediment in search of food. The most abundant, but less well studied to date, arthropods are thylacocephalans and mysids, both groups interpreted to be pelagic. Detailed mapping of bedding surfaces on which arthropods have been recovered indicates that accumulation and preservation of fossils was episodic. Some of the surfaces are overwhelmingly dominated by pelagic animals including thylacocephalans and mysids; either one or the other of the arthropods numerically swamp all other fossils. Fish are commonly found on all bedding surfaces. Mass accumulations of these pelagic crustaceans supports the hypothesis that mass kills occurred periodically. More normal, but sparse, accumulations of benthic fauna were observed on other mapped surfaces on which the pelagic arthropods are rare or totally absent. Interpretation of the episodic mass mortalities is currently under investigation. [Supported by National Science Foundation grant OISE-1126137, National Geographic grant 9128-12, and Chinese Geological Survey grants 1212011140051 and 1212011120621].

OLIGOCENE MICROFOSSIL RECORDS AS INDEX FOR QUANTITATIVE RECONSTRUTION OF VARIATION IN LAKE WATER DEPTH IN DONGYING DEPRESSION, SHENGLI OIL FIELD, CHINA

Xin Su[1], Xuan Ding[1] and Zhaixing Jiang[1]

1. China University of Geosciences, Xueyuan Road 29, Beijing, 100083, China.
xsu@cugb.edu.cn

A large-scale lacustrine beach-bar oil pool has been discovered recently in the Dongying Depression, Shangdong Province, and the beach-bar sequences in the upper fourth member (with an age of about 45 Ma to 42 Ma) of the Eocene Shahejie Formation (Es4s) in this area became one of the important exploration targets. However, their distributions and deposit environments were poorly studied. Lake water depth is an important factor for controlling the deposition and distribution of beach-bars. A micropaleontological study was carried out with the objective to obtain quantitative data of paleo-water depths during the deposit periods of the Es4s in the Dongying Depression. Efforts were made to collect and study a huge number of varied data on drilling, logging, stratigraphy, and microfossils from 100 wells made during last 50 years of exploration in this oil field. Cores from more than 50 wells were observed and 100 microfossil samples were collected and analyzed. This study presents quantitative water depth data retrieved from 46 wells which contain sediment sequences deposited during periods of lowstand systems tracts of Es4s, roughly 45 to 43Ma in the early Middle Eocene. The results showed that paleo-water depth in the Dongying Depression during that period ranged from 0 m along the lake coast to more than 30 m in the central deep lake region. Three features of variation of water depths in the studied area were recognized. (1) Deeper water depth, steeper and narrower lake slope are located in the northern area, whereas flatter and wider beach terraces covered by shallower waters were seen in the southern region. (2) Steeper and narrower lake slopes occurred closed to headlands of lake coasts. (3) Three NE-SW extending water zones dominated by different water depths, were recognized, a small shallow lake zone (about 6 m) along the Well Lai 9 to Well Wang 18 in the northern-east corner of the Dongying Depression, the largest and deepest zone in the central, and a very shallow bar region (<3.5 m) occurred in the southern-west area. These features were well correlated with abundant sedimentary data and evidence from previous studies, for example, delta deposits found in the northern deep waters and beach-bar in the southern areas. All correlations suggest that the data of quantitative water depths are reliable and with significance for depicting and understanding variations of sedimentary environments.

MICROFOSSIL RECORDS AND COURSE CHANGE OF PALEO-KUROSHIO CURRENT IN THE NANKAI TROUGH DURING THE LAST 1 MA

Xin Su[1], Xiao Duan[1,2], Ling Ling[1] and Fang Chen[2]

1. School of Marine Sciences, China University of Geosciences, Xueyuan Road 29, Beijing, 100083, China. xsu@cugb.edu.cn

2. Guangzhou Marine Geological Survey, Guangzhou, China.

During Integrated Ocean Drilling Expedition 315 in the Nankai Trough, a 100 m long sediment sequence that contains relatively abundant calcareous fossils and with an age of middle to late Pleistocene (1 Ma) was recovered in the upper part of Hole C0002D. Age constraint for the sequences was based mainly on calcareous nannofossil biostratigraphy in combination with several paleomagnetic stratigraphic data and plankton foraminiferal data (*G. ruber* (pink)). Data sets of UK37 and plankton foraminiferal oxygen isotopes were analyzed to constrain records of glacial-interglacial cycles, surface paleotemperature (SST) and paleosalinity (SSS). Records of these microfossil proxies vary in response to glacial-interglacial changes during the last 1 Ma. These records indicate that this region had been dominated by paleo-Kuroshio Current during five periods (MIS17, MIS13, MIS7, MIS5 and MIS1). The possible influence of the Northern Pacific Center Water Mass was seen during MIS16 and MIS11.

A NEW LISSAMPHIIBIAN ASSEMBLAGE FROM THE LOWER CRETACEOUS OF THE GREATER KHINGAN MOUNTAINS IN NE CHINA

Yuan Wang[1], Liping Dong[2], Min Wang[2] and Jiangyong Zhang[2]

1. Key Laboratory of Vertebrate Evolution and Human Origins of Chinese Academy of Sciences, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, 142 Xi-Zhi-Men-Wai St., Beijing, 100044, China. wangyuan@ivpp.ac.cn

2. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, 142 Xi-Zhi-Men-Wai St., Beijing, 100044, China.

The Early Cretaceous Jehol Biota distributed in western Liaoning, southeastern Inner Mongolia and northern Hebei has yielded attractive vertebrate fossils such as feathered dinosaurs, primitive birds and mammals, as well as early angiosperms. The amphibian fossils among them are no less appealing and are usually well preserved as articulated skeletons, even with skin impressions in some occasions. They can be referred to several primitive clades of the Anura (frogs) and the Urodela (salamanders), providing important evidence on the early evolution of modern amphibian groups. The Greater Khingan Mountains of northeastern China, in northeastern Inner Mongolia Autonomous Region and western Heilongjiang Province, had no documents of amphibian fossils in the past. The Lower Cretaceous of this region, however, exposed the same volcanic rocks as well as interbeded sedimentary deposits, and geological and paleontological surveys also have found the same invertebrate fossils as those of the Jehol Biota in western Liaoning Province, such as *Ephemeropsis*, *Eosestheria*, and a few isolated fishes. Recently, some new fossil localities have been found in the municipal regions of Hulunbuir of Inner Mongolia and Qiqihar of Heilongjiang, which have yielded fossil plants, fishes, amphibians, turtles, pterosaurs, birds and mammals. The amphibians include both frogs and salamanders, documenting their first co-occurrence in Mesozoic localities of China. This assemblage also represents the northernmost amphibian occurrences in China, extending the geographic range to approximately N49° in latitude for fossil lissamphibians. Preliminary study showed that the anuran fossils of the assemblage should represent one taxon, characterized by the presence of eight presacral vertebrae, three pairs of free ribs, V-shaped ossified parahyoid bone, and narrow sacral diapophyses. The tibiofibula is obviously longer than the femur, and the articulation between the sacrum and urostyle is bicondylar. This combination of characteristics is sharply different from that of the primitive crown-group anuran, *Liaobatrachus* (with four species known to date) from the Jehol Biota in western Liaoning, and is not seen in any other anuran taxa. We named a new taxon for these materials and suggested this frog may belong to a primitive clade of Neobatachia. The salamander fossils are not as well preserved as the frogs in the assemblage. They seem to be similar to the hynobiid *Liaoxitriton*, unearthed from the Jurassic and Cretaceous in southeastern Inner Mongolia and western Liaoning, in the skull and scapulocoracoid morphology. More material is needed to solve its systematic position.

THE "SUBHOLOSTEANS" FROM THE MIDDLE TRIASSIC LUOPING BIOTA, YUNNAN PROVINCE, SOUTH CHINA

Wen Wen[1], Shixue Hu[1], Qiyue Zhang[1], Michael J. Benton[2], Jinyuan Huang[1], Changyong Zhou[1] and Tao Xie[1]

1. Chengdu Center of China Geological Survey, Chengdu 610081, China. wenwen2020240@163.com

2. School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK.

After the end-Permian Mass Extinction, the recovery of marine fishes did not happen until the early Anisian because of the extreme environment in the early Triassic. The Lower Yangtze region witnesses a relatively continuous sequence of fish records. The fish fossils from the early Triassic assemblages in Chaohu and Jurong are less diverse and endemic. However, the Anisian Luoping Biota bears various fish fossils with high-quality preservation, consisting of basal actinopterygians, subholosteans, basal neopterygians as well as coelacanths. Subholosteans, as the transitional forms between paleoniscoids and neopterygians, have both primitive and advanced characters. The subholosteans in the Luoping Biota mainly include Perleidiformes and Peltopleuriformes. There are 5 genera published from Luoping, which belong to Perleidiformes, namely, *Luopingichthys*, *Luopingperleidus*, *Perleidus*, *Fuyuanperleidus* and *Diandongperleidus*. Besides, some other perleidid fish fossils have not been described yet. One of them can be ascribed to *Peltoperleidus* with characters as follows: small-size, medially fused frontal, parietal, one suborbital, articulation facet of the lower jaw located before the posterior orbital border, epaxial rays existed on the caudal fin, three rows of deepened flank scales. Two of them with deepened flank scales persisting in the caudal peduncle suggest *Altisolepis*. The Platysiagidae are perleidid fishes, including *Helmoleips*, *Platysiagum* and *Caelathichthys*, spreading substantially from early Triassic to early Jurassic. Three specimens can be ascribed to Platysiagidae, with dorsally broad preoperculum, maxilla with curved posterior plate, expanded interoperculum, ovoid medial gular and extended terminal axial scale. The dermohyal, one pair of extrascapulars, entirely segmented dorsal fin and anal fin make them more close to *Helmolepis*. Peltopleuriformes in Luoping mainly belong to *Peltopleurus*, *Habroichthys*, *Placopleurus* and *Peripeltopleurus*. *Placopleurus* becomes the most abundant. The well-preserved and diverse subholosteans in Luoping not only provide anatomical information for each type in detail, but also show closer relationship with the ichthyofaunas of western Tethys.

STABLE CARBON ISOTOPES OF MIDDLE JURASSIC LEAVES FROM THE TURPAN-HAMI BASIN, NORTHWESTERN CHINA

Liang Xiao[1,2], Xiangchuan Li[1], Yong Li[1], Junfeng Guo[1] and Wenlong He[3]

1. College of Earth Science and Resources and Key Laboratory of Western Mineral Resources and Geological Engineering Ministry of Education, Chang'an University, Xi'an 710054, China. youmu4@sina.com

2. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China.

3. College of Geology and Environment, Xi'an University of Science and Technology, Xi'an 710054, China.

Quantitative reconstruction of ancient environments and climates has been a major goal for studies in geobiology. Fossil leaves are increasingly used as indicators of palaeoenvironmental parameters such as temperature, and atmospheric CO_2 concentration. Stomatal frequency analysis has been established as a palaeophysiological proxy for past atmospheric CO_2 levels. It is demonstrated that the carbon isotope composition of leaf remains can also reveal ecophysiological information on a plant's response to past environmental change. In this study, stable carbon isotope compositions of fossil leaves from the Xishanyao Formation in the Turpan-Hami Basin, northwestern China, were measured to infer Middle Jurassic environmental conditions and ecophysiological features of plants. The compression fossil leaves of three genera, *Ginkgoites*, *Phoenicopsis*, and *Cladophlebis*, were selected to analyze on a MAT251 isotope ratio mass spectrometer. Isotopic values are reported in δ notation, relative to VPDB and expressed in permil (‰). Moreover, the stable carbon isotope composition of a reproductive organ assigned to *Stenorachis* was obtained in order to estimate whether the data are true. The carbon isotope compositions of three assemblages of leaves are -23.55‰, -22.18‰, -23.37‰, respectively, all of which are more depleted than *Stenorachis*. This indicates that the isotopic values of the three leaves are reliable. Among the three isotopic values, $\delta^{13}C$ of *Ginkgoites* is similar to that of *Cladophlebis*. However, there is a difference of $\delta^{13}C$ between *Ginkgoites*, *Cladophlebis* and *Phoenicopsis*, suggesting that *Ginkgoites* is little relative to *Phoenicopsis*. In order to decrease the influence of atmospheric CO_2 stable carbon isotope, the $\delta^{13}C$ is transfered into Δ, i.e. carbon isotopic discrimination. According to the formula: $\Delta=\delta^{13}C_{air}-\delta^{13}C_{plant}=a+(b-a)C_i/C_a$, Δ values of three genera are 17.95‰, 16.58‰, 17.77‰, respectively. Contemporarily, the C_i/C_a values, being a physiological index, are obtained, 0.60, 0.54, 0.59, respectively. The C_i/C_a value of fossil *Ginkogites* is similar to that of extant *Ginkgo*. The Middle Jurassic atmospheric CO_2 concentration was reconstructed to be 1770 ppmv, markedly higher than the extant atmosphere (Xiao et al.). This implies that the Jurassic plants modulated their C_i in response to a high C_a value at that time probably by increasing their photosynthetic rate aided by the prevailing higher temperature. [Supported by National Natural Science Foundation of China (No. 41202009, 41202008), State Key Laboratory of Palaeobiology and Stratigraphy (Nanjing Institute of Geology and Palaeontology, CAS) (No. 123112), and Special Fund for Basic Scientific Research of Central College, Chang'an University (No. 2013G3274021, 2013G1271101)].

EOCENE *PODOCARPIUM* (LEGUMINOSAE) FROM SOUTH CHINA AND ITS PHYTOGEOGRAPHIC IMPLICATIONS

Qingqing Xu[1], Jue Qiu[1], Zhekun Zhou[2] and Jianhua Jin[1]

1. School of Life Sciences, Sun Yat-sen University, Guangzhou 510275, China.
lssjjh@mail.sysu.edu.cn

2. Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun 666303, China.

Previous records indicate that the extinct genus *Podocarpium* A. Braun ex Stizenberger of the Leguminosae was extensively distributed in Eurasian sediments from the Early Oligocene to Pliocene. A new fossil species of this genus collected from the Eocene Changchang Formation of the Changchang Basin and the Youganwo Formation of the Maoming Basin of South China is described in this paper, and it is the oldest megafossil record up to present. Although extant, supposedly similar groups to *Podocarpium*, such as *Gilletiodendron*, *Tessmannia*, *Brachystegia*, *Cryptosepalum* and some species of the pantropical genus *Cynometra*, are distributed only in tropical and subtropical Africa, certain records of this genus have not been reported there yet. The ancestral population of this genus is supposed to have originated in East Asia, most probably in South China, in view of the distribution of megafossil records and related palynological data. Combining the paleoclimate changes and its occurrences, the paleobiogeographic pattern of *Podocarpium* through the Cenozoic of Eurasia is discussed. *Podocarpium* may have originated in the Eocene of South China. During the Oligocene, it was able to enter Europe. The existence of a widespread arid band between north and south China from the Paleocene to the Oligocene made it difficult for *Podocarpium*, a thermophilous and moisture-loving plant, to disperse northward. In the Miocene it spread extensively across subtropical to warm temperate areas in Eurasia and reached its peak after the arid band disappeared. Due to the influence of the Tibetan plateau uplift and climatic deterioration, the distribution of *Podocarpium* rapidly shrank and it finally became extinct in Eurasia during the Pliocene.

CALIBRATING THE TIME TREE OF ANIMALS

Qun Yang[1], Xiao-Yan Sun[1] and Jun-Ye Ma[1]

1. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 39 E Beijing Rd, Nanjing 210008, China.
qunyang@nigpas.ac.cn

Recent advances in dating divergences in the Tree of Life have witnessed rapid development of more sophisticated models in molecular phylogenetics, such that rate variation problems among organism groups and along the time axis have been tackled according to probabilistic models. But, progress has been less remarkable in fossil evaluation as calibration points in dating the tree or in formulating strategies of how to treat the calibration points regarding its probabilistic distribution. The accuracy of dating the divergences depends on both the adequacy of the molecular models and reliability of the fossil calibration. In this study, we experimented with fossil calibration schemes in Crustacea and Demospongia. We demonstrate that strategies in calibration and maximum constraints are most crucial in obtaining correct divergence time estimates. By applying fossil evaluation techniques (e.g., cross-validation, empirical scaling, check-point likelihood, and marginal posterior distribution) to 14 selected pancrustacean fossil appearance dates, we found that: (1) fossil calibrations screened using cross-validation criteria resulted in generally younger estimates than the fossil priors, indicating that cross-validation is not suitable in this study; this is found to be caused by the fact that fossil dates preferred by cross-validation are, in this case, worse calibration points by criteria using empirical scaling method; (2) one fossil date favored by empirical scaling has very wide distribution of its marginal posterior probability, most likely due to its wrong position in the tree. We found that the way in which maximum constraints for fossil calibration points were selected was most influential in the dating results of crustacean divergences. By applying the Marshall maximum bracket (Marshall, *The American Naturalist*) as a proxy for the maximum constraints in the fossil calibration and comparison with recent dating results (crustacean part only) (Wheat and Wahlberg, *Systematic Biology*; Rota-Stabelli et al., *Current Biology*), we found that relatively relaxed maximum constraints of fossil calibrations and a different fossil calibration strategy (e.g., a lognormal *versus* normal distribution for a fossil date applied) led to a deeper origin of fresh-water ecosystem represented by the divergence time of crown group branchiopods (ca. 498-511 Ma in this study *versus*~416 Ma in Wheat and Wahlberg or ~445 Ma in Rota-Stabelli et al). Similar analysis was conducted for Demospongia, resulting in a deeper time estimate for the origin of spongiose (instead of spicular) type demosponges as compared with other estimates.

FOSSIL PRIAPULID WORM *OTTOIA* FROM THE KAILI BIOTA, CAMBRIAN SERIES 3, SOUTH CHINA

Yuning Yang[1], Yuanlong Zhao[2] and Xingliang Zhang[1]

1. Early Life Institute and State Key Laboratory for Continental Dynamics, Department of Geology, Northwest University, Xi'an 710069, China. xzhang69@nwu.edu.cn

2. College of Resource and Environmental Engineering, Guizhou University, Guiyang 550003, China.

The fossil worm *Ottoia*, placed as a stem group of the phylum Priapulida because of its absence of synapomorphic features of the crown groups, plays a very important role in understanding of the early evolution of priapulids. So far, *Ottoia* is only known from the middle Cambrian Burgess Shale-type biotas in North America, e.g., the Burgess Shale in Canada, the Spence Shale and Marjum Formation in Utah, and the Pioche Formation in eastern Nevada. *Ottoia* was referred to its own family, the Ottoiidae, due to its distinctive characteristic of a cylindrical body showing radial symmetry in scalid-bearing introvert and bilaterally symmetrical annulated trunk with posterior bursa. *Ottoia prolifica* Walcott is at present the type and only known species of the genus. Here we report a new record of *Ottoia* from the middle part of the Kaili formation (Cambrian Series 3 and Stage 5) in the Wuliu - Zengjiayan section, located in Balang area, Jianhe County, Guizhou Province, China. 23 specimens in total can be refered to *Ottoia* on the basis of diagnostic characters of the genus, i.e. external radial symmetry in scalid-bearing introvert and curved annulated trunk with posterior hooks, as elucidated by Conway Morris. Our taxonomic study indicates that *Ottoia prolifica* and an uncertain species *Ottoia* sp. were identified among the material; it showed low diversity. The new specimens from the Kaili biota provide additional information on the anatomy of *Ottoia*, which includes fine linear structures on the annulated trunk, posterior retractor muscles and a possible polythyridium. Moreover, a small number of well preserved specimens show excavating posture, and remains in the posterior gut demonstrate that *Ottoia* was a kind of burrowing carnivorous animal that may have moved through sediment on all sides. The new occurrence of *Ottoia* in the Kaili biota represents a notable geographic and stratigraphic extension of this well known animal, and it shows minimal morphological change during its stratigraphic range through much of the traditional Middle Cambrian.

EVIDENCE OF EPIBOLY IN EMBRYOS FROM THE LOWER CAMBRIAN

Xiaoyong Yao[1,2] and Yong Li[1,2]

1. College of Earth Science and Resources, Chang'an University, No.126 YanTa Road, Xi'an, Shaanxi Province , 710054, China. yaoxy@chd.edu.cn

2. Geological Museum of Chang'an University, No.126 YanTa Road, Xi'an, Shaanxi Province, 710054, China.

Extraordinarily well-preserved fossil embryos recovered from the Lower Cambrian are known from both cleavage and gastrula stages; consequently, these have the potential to yield vital insights into developmental evolution at that time. Stellate specimens come from the Lower Cambrian Kuanchuanpu Member of the Dengying Formation at Ningqiang in southern China, showing a fuller sequence of fossilized developmental stages of epibolic gastrulation. The embryonic mechanisms have been compared with the modern pattern: The spreading or extension of cell sheets to close an opening is a common morphogenetic movement in modern epiboly, but also is observed in our fossils. Convergence occurs as cells actively wedge between one another along one axis, and thereby produce a pushing force on the transverse axis. Moreover, similar to purse-string-like contraction of marginal cells in modern animals, there is a "zigzag margin" contraction of the fossilized epibolic frontier to reduce their perimeter that pushes the margin forward; all of these hint that the embryonic mechanisms of modern embryos had evolved in the Lower Cambrian. These include global patterning, tissue-level and genetic mechanisms. Although there is no counterpart in modern animals, these fossil embryos possess epibolic gastrulation and radial symmetry, which suggests a cnidarian sea anemone affinity.

ON THE AFFINITY OF *QUADRAPYRGITES* AND *OLIVOOIDES* FROM THE EARLY CAMBRIAN OF SOUTH CHINA

Huaqiao Zhang[1] and Yunhuan Liu[2]

1. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China. hqzhang@nigpas.ac.cn

2. College of Earth Science and Resources, Chang'an University, Xi'an 710054, China.

Quadrapyrgites and *Olivooides* are microfossils reported with embryonic and post-embryonic stages from the early Cambrian small shelly fauna of South China. They share comparable morphology and development mode, and might be close relatives. Their development mode and systematic positions are hot topics in palaeoembryology and evolutionary biology in recent years, but are still under debate. Previous work on *Quadrapyrgites* focused mainly on morphology; the life cycle was depicted, but was far from being complete. Additionally, the affinity of *Quadrapyrgites* and *Olivooides* has not been clarified in light of the growth pattern and post-embryonic development. New material of *Quadrapyrgites quadratacris* from the lower Cambrian Kuanchuanpu Formation of Xixiang section, southern Shaanxi, South China provides clues for its growth pattern and post-embryonic development. The growth zone of hatched *Q. quadratacris* is situated at the oral end, and new terminal lobes are generated within the oral aperture. The terminal lobes are first in control of the opening and closure of the tubes, and later transferred to be crests, thus elongating the tubes. The post-embryonic development is characterized by a one-by-one addition of crests, and an ontogenetic sequence with crest number from one to seventeen is reconstructed. During the ontogeny, the apical part remains stable in size and morphology. The oral aperture is the only opening of the tubes, while a possible anus on the apical end does not occur. *Quadrapyrgites* was proposed to be the sister group of *Olivooides*, and now this is strengthened by the identical growth pattern and post-embryonic development. The comprehensive data from anatomy, growth pattern and post-embryonic development reject the stem-lineage cycloneuralian affinity for *Quadrapyrgites* and *Olivooides*, and instead support a coronate scyphozoan hypothesis.

FORAMINIFERAL ASSEMBLAGES FROM CORE ZKA4 AND IMPLICATIONS FOR RECONSTRUCTING THE LAST TRANSGRESSION IN EASTERN CHINA

Kexin Zhang[1,2], Yi Wei[1,2], Weihong He[1,2] and Zongyan Zhang[3]

1. State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Wuhan 430074, P. R. China. kx_zhang@cug.edu.cn
2. Faculty of Earth Sciences, China University of Geosciences, Wuhan, 430074, P R China.
3. Nanjing Institute of Geology and Mineral Resources, Nanjing 200016, P. R. China.

This paper documents 56 foraminiferal species in 38 genera (including nine undetermined species) from the Gehu and Rudong formations of Core ZKA4, drilled in the Jiangdu area of Jiangsu Province, eastern China. These foraminifers are characterized by abundant *Ammonia beccarii*, which spans the entire interval sampled from Core ZKA4. Foraminifers from Core ZKA4 are assignable to the *Ammonia beccarii* Zone. Further detailed analysis of the stratigraphic distributions of the foraminiferal species allows the recognition of three local stratigraphic assemblages, comprising in ascending order the *Ammonia beccarii* - *Orbulina universa* Assemblage (OUA), *Ammonia beccarii* - *Cribrononion subincertum* Assemblage (CBA) and *Ammonia beccarii* - *Lagena sreiata* Assemblage (LSA). In comparison with their counterparts elsewhere in China, these foraminiferal assemblages suggest a late Pleistocene and Holocene age for the Gehu and Rudong formations, respectively. Optically Stimulated Luminescence data indicate that the age of foraminifers from Core ZKA4 as a whole is about 14.2 ± 0.6 Ka. Thus, it is clear that these foraminifers inhabited an area that is now far distant from the coastal zone in eastern China, and that the area was flooded by a major regional marine transgression during the post glacial period of the last glaciation in the Holocene, the last such event so far recorded in eastern China. Furthermore, a regional correlation of the foraminiferal assemblages from Core ZKA4 has enabled us to reconstruct the intensity and spatial extent of this final marine transgression in eastern China.

EARLY TRIASSIC SEDIMENTARY SEQUENCES AND CORRELATION WITH CONODONT ZONATION OF MEISHAN D SECTION IN CHANGXING, ZHEJIANG PROVINCE, SOUTH CHINA

Kexin Zhang[1,2], Weihong He[1,2], Xulong Lai[1,2] and Haishui Jiang[1,2]

1. State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Wuhan 430074, P. R. China. kx_zhang@cug.edu.cn

2. Faculty of Earth Sciences, China University of Geosciences, Wuhan, 430074, P R China.

The Lower Triassic, consisting of the Yinkeng Fm., Helongshan Fm. and the lower part of the Nanlinghu Fm., is well developed at the Meishan D Section of Changxing County, Zhejiang Province, South China. The sediments in the Yinkeng Fm. are dominated by calcareous mudstones from the deep shelf environment and dark mudstones with horizontal bedding, rich in organic matter, and micro-grains of pyrite occur rhythmically. Anoxic and oxic beds occur alternately in the Yinkeng Fm. The Helongshan Fm. mainly consists of micrites from the open shallow-shelf carbonate-platform facies. The Nanlinghu Fm. consists of light grayish white micrites, formed by the gradual filling of a restricted to semi-restricted littoral – shallow basin after the late Early Triassic continual falling of sea level. Four third-order sequences are subdivided from the uppermost Changxing Fm. to the lower part of Nanlinghu Fm. of the Meishan D Section. Sequence one (Sq1) corresponds to the topmost Changxing Fm., Yinkeng Fm. and the basal Helongshan Fm. This sequence is from latest Changhsingian to early Griesbachian in age and covers these conodont zones, from the bottom upwards: upper *Clarkina yini-C. zhangi* zone, *Clarkina meishanensis* zone, *Hindeodus changxingensis* zone, *Clarkina taylorae* zone, *Hindeodus parvus* zone, *Isarcicella staeschei* zone, *I. isarcica* zone and lower *Clarkina tulongensis-C. planata* Zone. Sequence two (Sq2) corresponds to the Lower Member of the Helongshan Fm. and covers the conodont zones from the upper part of *Clarkina tulongensis-C. planata* zone to the lower part of *Neospathodus kummeli* zone. The age is equal to the late Griesbachian to earliest Dienerian. Sequence three (Sq3) is composed of the lower Upper Member of the Helongshan Fm. and covers the conodont zones of the upper *Neospathodus kummeli* zone and the *lower Neospathodus cristagalli-N dieneri* zone ascendingly. The age is equal to the early Dienerian. Sequence four (Sq4) is composed of the upper part of the Upper Helongshan Fm. and the lower part of the Nanlinghu Fm. and covers the conodont zone, namely, the upper *Neospathodus cristagalli-N dieneri* zone of the late Dienerian.

NOTHOSAUR FORAGING TRACKS FROM THE MIDDLE TRIASSIC OF SOUTHWESTERN CHINA

Qiyue Zhang[1], Wen Wen[1], Shixue Hu[1], Michael J. Benton[2], Changyong Zhou[1], Tao Xie[1], Jinyuan Huang[1], Brian Choo[3], Zhongqiang- Chen[4], Jun Liu[1] and Qican Zhang[5]

1. Chengdu Center of China Geological Survey, Chengdu 610081, China.
yxzqy@sina.com

2. School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK.

3. Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China.

4. State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan), Wuhan 430074, China.

5. Department of Opto-Electronics, Sichuan University, Chengdu 610065, China.

The seas of the Mesozoic (252-66 Myr ago) were remarkable for predatory marine reptiles, but their modes of locomotion have been debated. One problem has been the absence of tracks, although there is no reason to expect that swimmers would produce tracks. We report here seabed tracks made by Mesozoic marine reptiles, produced by the paddles of nothosaurs (Reptilia, Sauropterygia) in the Middle Triassic of the Luoping localities in Yunnan, SW China. These show that the track-making nothosaurs used their forelimbs for propulsion, they generally rowed (both forelimbs operating in unison rather than alternately), and the forelimb entered medially, dug in as the paddle tip gained purchase, and withdrew cleanly. These inferences may provide evidence for swimming modes, or it could be argued that the locomotory modes indicated by the tracks were restricted to such contact propulsion. Such punting behavior may have been used to flush prey from the bottom muds.

WORKSHOP

CRETACEOUS MARINE BIOTAS AND SEAWAYS IN GONDWANA

ORGANIZERS:
M. BEATRIZ AGUIRRE-URRETA - DARÍO G. LAZO

PALEOBIOGEOGRAPHIC PATTERNS OF GONDWANAN DECAPOD CRUSTACEANS

Rodney M. Feldmann[1] and Carrie E. Schweitzer[2]

1. Department of Geology, Kent State University, Kent, Ohio 44242, USA. rfeldman@kent.edu
2. Department of Geology, Kent State University at Stark, 6000 Frank Ave, NW, North Canton, Ohio 44720, USA.

Although decapod crustaceans, the shrimp, lobsters, and crabs, were first noted in the Southern Hemisphere by d'Orbigny and Darwin in the 1840s, relatively little research focused on the group in the region until the 1980s. Since then, extensive study of the decapods in New Zealand, Antarctica, and South America transformed records of occurrence from anecdotal notices incidental to other studies to focused attention to the group. Thus, it is now possible to undertake an evaluation of the paleobiogeography of Gondwanan decapods. The database is based upon 182 generic-level and 489 species-level records, the majority of which are from southern South America, New Zealand, and Antarctica. This distributional pattern is a result of the focus of research as well as the concentration of targets of opportunity based upon anticipated association of decapods with known diverse fossil benthic communities. Thus far, this emphasis on high paleolatitude regions has revealed numerous origins of taxa well outside lower latitude regions. Current intense study in Colombia, however, is documenting new brachyuran taxa that will significantly impact some current generalizations about points of origin and directions of dispersal of major clades. The overall composition and general richness of Gondwanan decapod faunas is somewhat different from that in Laurasian regions for a variety of reasons. There is a strong collecting bias based upon the observation that the group has been studied extensively in Europe and North America for about 200 years, whereas concentrated studies in the southern continents generally began in the latter half of the 20th Century. Further, the geologic occurrence of decapods in the two regions is quite different. Whereas the majority of European and North American fossil decapods are known from continental interior seaways and passive tectonic margins, Southern Hemisphere rocks containing rich decapod faunas are dominated by active tectonic margin occurrences and relatively small basins adjacent to relatively narrow continental shelves. These differences in faunal composition from southern to northern regions in the geologic past has ultimately resulted in an increase in global diversity owing to interchange of taxa from one hemisphere to another that was initially significant in the Early Cretaceous and continuing through the Eocene. Patterns of endemism appeared from increased isolation of southern continents as a result of plate tectonic activity. [Supported by NSF EF-0531670 and EAR 12060279].

CRETACEOUS ORGANIC-WALLED DINOFLAGELLATE CYSTS FROM THE SOUTHERMOST PART OF SOUTH AMERICA: PALAEOBIOGEOGRAPHIC AFFINITIES

M. Verónica Guler[1]

1. INGEOSUR – CONICET, Universidad Nacional del Sur, San Juan 670, 8000 Bahía Blanca, Argentina.
vguler@criba.edu.ar

Organic-walled dinoflagellate cysts have been useful for the Mesozoic biostratigraphy of southern South America, particularly for the Lower Cretaceous marine rocks which integrate the most important oil-systems of the Austral/Magallanes and Neuquén basins in Argentina and Chile. Diverse and well-preserved assemblages were recorded from the Springhill and Río Mayer formations deposited during the regionally-extensive marine episodes occurred in the late Valanginian–Albian time interval, related to the thermal subsidence stage of the Austral Basin. The Early Cretaceous dinoflagellate cyst assemblages from the Austral Basin show similarity with those of Australia and Antarctica. The sequence of the age-diagnostic dinoflagellate cyst events that define the biostratigraphy of the Austral Basin is nearly the same as those recorded in well-calibrated sequences of Australia and Antarctica. Also, the Australian dinoflagellate cyst zonation schemes are clearly applicable. Therefore, assemblages from the Austral Basin reflect strong austral palaeobiogeographic affinities, and support marine connections between southernmost South America, southern and western Australia, and Antarctica in the Early Cretaceous. During the Late Jurassic to Cretaceous the Neuquén Basin was a retro-arc depocentre developed under active convergence of the western margin of South America, connected to the Pacific Ocean. Dinoflagellate cyst assemblages from the late early Valanginian – earliest Barremian Agrio Formation, well dated by ammonoids and calcareous nannoplankton, closely resemble coeval assemblages from western Europe, exhibiting clear Tethyan affinity. Thus, dinoflagellate cysts constitute another evidence of the extensive exchange of marine biota between the Neuquén Basin and the Tethyan Realm, in agreement with the distribution of echinoids, bivalves and ammonoids. The Late Cretaceous dinoflagellate cyst record is limited to the late Campanian–Maastrichtian interval in the south of South America. Late Campanian– early Maastrichtian and late Maastrichtian assemblages from the Cerro Cazador and Calafate Formations, respectively, southwestern Patagonia (Austral Basin domain), compare well with those from southern Australia, New Zealand, Antarctica, Maud Rise, Kerguelen Plateau and Georgia Basin. Furthermore, in the north of Patagonia, the Jagüel and Pedro Luro Formations (Neuquén and Colorado Basins, respectively) yielded late Maastrichtian dinoflagellate cysts which have little commonality with those from the Calafate Formation. Hence, dinoflagellate cysts assemblages from the southernmost tip of South America would integrate the South Polar Province based on the south high-latitudes Maastrichtian dinoflagellate cyst distribution and denote oceanic connections with the circum–Antarctic regions during the latest Cretaceous.

CRETACEOUS HIGH-LATITUDE MARINE LAGERSTÄTTEN AND BIOTIC TURNOVER IN AUSTRALIA

Benjamin P. Kear[1]

1. Palaeobiology Programme, Department of Earth Sciences, Uppsala University, Villavägen 16, SE-752 36 Uppsala, Sweden. Benjamin.kear@geo.uu.se

During the Cretaceous, the Australian landmass was situated at high latitude (50°-85° S) with much of its present continental area inundated by a vast inland seaway. This trans-basinal incursion interconnected with ingressions from the Tethys and emergent Indian oceans, which at their zenith in the Aptian–early Albian (~125–110 Ma), formed shallow (<100 m deep) epiric corridors separating the exposed land surface into a series of islands. Only the southeastern continental extremity maintained a terrestrial rift valley complex adjoining Antarctica, and unusually, was also subject to freezing climates up until the middle-late Albian (~105 Ma). Today these extreme polar palaeoenvironments are evidenced by geochemical and sedimentary indicators of sea surface temperatures around 10°C and seasonal ice build-up along inboard coastal margins. Perhaps most surprisingly, the fossil biotas that once inhabited these settings are exceedingly rich, both in terms of diversity and the exceptional quantity and quality of their preserved remains. Indeed, the record of spectacular marine amniote skeletons numbers in the hundreds, and accompanies innumerable examples of actinopterygian and chondrichthyan fishes, pelagic cephalopods, and benthic macroinvertebrates. Such abundance highlights the Australian Early Cretaceous as one of the most productive Gondwanan marine lagerstätten sequences known worldwide. Furthermore, faunal surveys have identified a chronostratigraphically correlative succession of cold to warm-temperate water assemblages that seem to reflect a climate change coincident with a compositional turnover. This event manifests as a replacement of taxonomically prolific benthic mollusc communities, associated with cosmopolitan ammonites and plesiosaurian dominated vertebrate predator niches, by monotaxic *Inoceramus* beds, endemic heteromorph ammonites, and an explosive radiation of teleosts, lamniform sharks, and early chelonioid sea turtles. The drivers of this regional extinction-diversification event were obviously complex, and to some extent reflected global cladogenic patterns. However, polar warming coupled with regressive basin enclosure, stratification, and hypoxia probably affected local biotic modification. Certainly, by the latest Albian-Cenomanian (~100 Ma) complete retreat of the epicontinental system restricted shallow marine habitats to the continental shelves. Geologically brief windows into these Late Cretaceous ecosystems occur in the Santonian (~86–83 Ma) and mid-Maastrichtian (~70 Ma), during which time both benthic and pelagic faunal elements (primarily bivalves and ammonites) took on a pandemic Tethyan character but maintained some distinctive austral components indicative of palaeolatitudinally transitional temperate water conditions.

THE CRETACEOUS SEAWAY IN THE NORTH ATLANTIC REGION - A MOLLUSCAN VIEWPOINT

Simon R. A. Kelly[1]

1. CASP, University of Cambridge, West Building, 181a Huntingdon Road, Cambridge CB3 0DH, United Kingdom. simon.kelly@casp.cam.ac.uk

Although narrow and occasionally restricted, the North Atlantic Ocean was a well established seaway during the Cretaceous Period. The northern part of this ocean was one of the gateways to the Boreal Arctic Ocean. In the North Atlantic, the Jurassic-Cretaceous transition was represented by sea-level lowstand. With rising sea levels, shelf seas and the tropical zone reached their all-time greatest extents in Late Cretaceous, the subtropics extending to 40° latitude. The extensive chalk sea extended from southern USA to Kazakhstan. Northwards, siliciclastics characterized sedimentation towards the Arctic Ocean. Cretaceous sea and land temperatures from equator to the poles were higher and far more equable than today. On land and sea, polar ice caps did not exist; forested land and dinosaurs reached well into the Arctic and Antarctic. Molluscan faunal changes are documented here, principally ammonites, belemnites and bivalves, from eastern Greenland, British Isles, Europe, Svalbard, the Sverdrup Basin and the Russian Arctic. The emergence of the Anglo-Brabant massif at the Jurassic-Cretaceous boundary, with development of Purbeck and Wealden facies, generated oyster-rich lagoons and fluvio-lacustrine systems with unionid bivalves. It created a physical barrier for contemporary marine nekton which exhibit high provinciality. Boreal Berriasian (Ryazanian) craspeditine ammonite faunas of eastern England, the North Sea and eastern Greenland are isolated from Tethyan berriasellids of southern Europe. Difficulties with Jurassic-Cretaceous boundary correlation between Boreal and Tethyan regions must be resolved in the less obstructed seaway of the Caspian-Russian Platform area. By Aptian time a shallow seaway crossed England and during Late Cretaceous high sea levels allowed near global distributions for some taxa. Whether North Atlantic molluscan diversity really is greatest in the earliest Cretaceous and decreases in the Late Cretaceous, as sea levels rise and the degree of endemism falls, will be examined. Controls on the apparent lower diversity as one goes northward will be assessed. Early Cretaceous rifting defined narrow shelves to the northern North Atlantic seaway, which were maintained as fluctuating sea levels rose through the Cretaceous. Deep water mudstones characterize much of the Late Cretaceous sediment preserved in this area in contrast to more varied lithologies on the wide and shallow shelf deposits further south in Europe. The northern North Atlantic therefore may have a much depleted molluscan fauna. Final mention will be made of anomalous chemosymbiotic mollusca, such as those of methane seeps occurring with associated limestones, whose existence and global distribution have only recently become known and understood.

HIGH DIVERSITY AND EVOLUTIONARY RATES IN CRETACEOUS CORALS UNDER EXTREME ENVIRONMENTAL CONDITIONS

Hannes Löser[1]

1. Universidad Nacional Autónoma de Mexico, Instituto de Geología, ERNO, L.D. Colosio y Madrid S/N, Hermosillo 83250, Mexico. loeser@paleotax.de

There is a general assumption in the classical literature on coral evolution and taxonomy that the evolution rate was slow and ranges of genera were, therefore, long. A critical review of Late Jurassic to early Palaeogene coral genera distribution over time that is based more on (type) material than on the literature gives a different picture. On the one hand, the number of Cretaceous genera is lower than the literature proposes. For the considered time-span about 700 genera are reported in the literature, but the true number may be about the half. On the other hand, the critical ranges are much shorter than published ranges. Although the abundance of genera that co-existed decreases, the data permit establishing evolutionary stages and diversity patterns much better than before. Cretaceous corals experienced various abrupt faunal changes at the end of the Valanginian, early Aptian, Albian, Santonian and Maastrichtian. Smaller changes took place at the end of the Jurassic and Cenomanian. Any of these changes are characterised by the disappearance of coral genera and the appearance of new genera immediately or soon after. All stages are characterised by the dominance of various suborders, but a certain loss in suborder diversity can be noted towards the Late Cretaceous. Early Cretaceous corals were more or less cosmopolitan, but from the Cenomanian onward they became more provincial. So, with the opening of the Western Interior Seaway (WIS) during the Cenomanian, coral growth in North American and Caribbean shallow marine habitats was inhibited. After the closing of the WIS during the Campanian, coral growth recovered in the Western Atlantic and the Caribbean and developed rich faunas during the Campanian and Maastrichtian. However, there is a deep discrepancy in the taxonomic composition of the Tethyan and Western Atlantic/Caribbean shallow marine faunas at the species and genus levels. In the western and central Tethys coral growth in shallow marine habitats was interrupted only during the early and middle Turonian due to oceanic anoxic event 2 (OAE). Coral faunas did not recover before the late Turonian. From the late Turonian to the Campanian numerous rich faunas are known from the western and central Tethys, but they differ in their taxonomic composition. Shallow marine coral growth in the Western Pacific stopped during the late Aptian and did not recover before the Eocene. Eastern Tethyan Late Cretaceous faunas are mainly deeper marine or taxonomically poorly known.

BIOGEOGRAPHY OF SANTONIAN-MAASTRICHTIAN ANTARCTIC AMMONOIDS: PALEOCLIMATIC, PALEOENVIRONMENTAL AND PALEOGEOGRAPHICAL CONTROLS

Eduardo B. Olivero[1]

1. Centro Austral de Investigaciones Científicas (CADIC-CONICET), B. Houssay 200, 9410 Ushuaia, Tierra del Fuego, Argentina. emolivero@gmail.com

A distinctive biogeographic pattern of Late Cretaceous ammonoids from the James Ross Basin (Antarctica) is the progressive Campanian/Maastrichtian dominance and endemism of kossmaticeratid ammonites. This pattern has been explained in terms of progressive geographical isolation of Antarctica during the breakup of Gondwana. However, new geological, paleontological and paleoclimatic data from the James Ross Basin strongly suggests that, in addition, lowering sea-water temperatures and expansion of the shelf during the Santonian-Maastrichtian were the dominant controls in the distribution of the Antarctic mollusk faunas. The biogeography of the Antarctic Late Cretaceous ammonoids is characterized by a Santonian-early Campanian cosmopolitan/Indopacific fauna, followed by a late Campanian-early Maastrichtian radiation of endemic kossmaticeratids, and then by a late Maastrichtian restriction of this group. Accompanying trends are the last occurrence in the Campanian of several mollusk groups that are well represented in the Maastrichtian elsewhere in the world, such as inoceramid and most trigoniid bivalves, and the nostoceratid, scaphitid, and baculitid ammonoids. The progressive geographical isolation of Antarctica alone does not explain satisfactorily the early extinction of relatively warmer taxa and the general absence in Antarctica of Turonian-Coniacian kossmaticeratids. The Campanian/Maastrichtian dominance of the Kossmaticeratidae, concomitant with an Austral temperature decline in the sea water, supports the idea that kossmaticeratids were stenothermal ammonites, which flourished in Antarctica when the water masses had their preferred temperature and were displaced when a certain threshold temperature was reached in the late Maastrichtian. By the late Campanian, the last Antarctic inoceramids have a distinctive shell structure that probably reflects thermal stress. In Tierra del Fuego, deep-marine inoceramids disappear by the early Maastrichtian, concomitant with a marked change from anoxic-dysoxic to well-oxygenated bottom conditions. The local extinctions of relatively warmer taxa closely match temperature cooling trends in the southern oceans. The oxygenation event at the inoceramid extinction level in Tierra del Fuego probably reflects cooling and enhanced bottom ventilation, promoted by circulation of deep Antarctic waters. In the James Ross Basin, Turonian-Coniacian sedimentation took place mostly in deep-marine settings. The development of a shelf area started in the Santonian and stretched during the Campanian-Maastrichtian when the shelf extended for about 150 km into the Weddell Sea. Turonian-Coniacian kossmaticeratids are recorded in shelf deposits from Indopacific areas around Antarctica. They are particularly well-known from India, Madagascar and South Africa; thus, their general absence in the James Ross Basin may reflect the lack of suitable shelf habitats in Antarctica at that time.

ANDEAN CRETACEOUS MARINE BASINS AND SEAWAYS OF WESTERN GONDWANA

Víctor A. Ramos[1]

1. Instituto de Estudios Andinos Don Pablo Groeber, Universidad de Buenos Aires, CONICET, Buenos Aires, Argentina. andes@gl.fcen.uba.ar

The paleogeography of South America during the Cretaceous was controlled by the tectonic regime of the Andes and the absolute motion of the South American Plate. A change in the subsidence mechanism took place around the Early and Late Cretaceous boundary defining two stages. The western continental margin was dominated in the first stage by extension and tectonic subsidence related to subduction from the Early Jurassic up to the Aptian. Two seaways were opened at this stage: a northern Hispanic Corridor linked to the separation between the North and South American Plates, as a western extension of the Tethys, and associated with the birth of the Caribbean Sea; and a second seaway related to the early separation of Antarctic Peninsula from western Patagonia at about 160 Ma, which controlled the propagation of subduction toward the southern tip of South America. The southern sector of the South Atlantic started its opening at 132 Ma as the result of Western Gondwana break-up. The separation of Africa and the Agulhas Bank from the Malvinas Plateau attached to South America produced the first important flooding of the southeastern continental margin of South America in the Early Cretaceous. As a result of these seaways most of the sub-Andean basins of South America were flooded directly from the Pacific, but the continent interior developed large intracratonic continental basins isolated from the Atlantic Ocean. The northern and central Andes were dominated by marine environments connected with the Pacific until Aptian-Albian times with abundant black shale facies, which are oil sources of the sub-Andean basins. The southern Andes had important volcanism during the Early Cretaceous with restricted communications with the Pacific as for example the Neuquén Basin, with the only exception of the southernmost basins as the Magellan and the western and eastern Malvinas basins. Those basins benefit from better communications with the Pacific as well as with the Madagascar and the Tethys through the South African seaway. The tectonic regime changed after Albian times to the second stage when general contraction produced tectonic load subsidence in the newly formed foreland basins. A new sub-Andean shallow marine seaway from the Atlantic developed in Campanian-Maastrichtian times related to a regional tilting of the basins associated with important loading of the fold and thrust belts along the Andes.

CRETACEOUS BRYOZOANS FROM GONDWANA

Paul D. Taylor[1]

1. Department of Earth Sciences, Natural History Museum, Cromwell Road, London SW7 5BD, UK.
p.taylor@nhm.ac.uk

The Cretaceous was a critical period in the evolution of bryozoans, witnessing the appearance of many extant genera and families and the commencement of the cheilostome dominance that has persisted through to the present-day. Both cheilostomes and cyclostomes radiated significantly during the Late Cretaceous to attain previously unequalled levels of taxonomic diversity and morphological disparity. Almost all our knowledge of Cretaceous bryozoan faunas comes from the northern hemisphere, particularly western Europe and to a lesser extent south-eastern USA. Very few bryozoans have been described from Gondwana, especially from the Early Cretaceous, and equatorial faunas are similarly rare. However, diverse bryozoan faunas are known from the Campanian Igoda Formation of Eastern Cape Province, South Africa, and the Maastrichtian Ariyalur Group of Tamil Nadu, India, the former as yet only partially described. Smaller bryofaunas have been recorded from the latest Cretaceous of Madagascar, the Valanginian–Barremian Agrio Formation of the Neuquén Basin, Argentina, the mid-Cretaceous Bagh Beds of the Narmada Valley, India, and the Campanian–Maastrichtian Kahuitara Tuff of the Chatham Islands, New Zealand. Biogeographical analysis is hampered by our patchy knowledge and the need for taxonomic reappraisal. However, provinciality at genus level appears to be limited, which raises the question of how so many taxa with short-lived larvae were able to achieve such wide distributions. Relationships between Gondwanan Cretaceous bryozoans and the rich Cenozoic and Recent bryozoan faunas from Australasia, South America and Antarctica have yet to be investigated. Key questions include: (1) is it possible to trace any clades which today typify Austral and Antarctic bryofaunas back to the Gondwanan Cretaceous?; (2) was the pattern of cyclostome replacement by cheilostomes through the Late Cretaceous the same in Gondwana as in the northern hemisphere? (3) what was the pattern of bryozoan extinction in Gondwana during the KT event?

EARLY CRETACEOUS GASTROPODS FROM WEST-CENTRAL ARGENTINA: PRELIMINARY INTERPRETATION OF PALEOBIOGEOGRAPHIC AFFINITIES

Cecilia S. Cataldo[1]

1. Instituto de Estudios Andinos Don Pablo Groeber (IDEAN), Universidad de Buenos Aires-CONICET, Int. Güiraldes 2160 1° piso, Pabellón II Ciudad Universitaria, Buenos Aires, C1428EGA, Argentina. ceciliacataldo@gl.fcen.uba.ar

Previous work on the Cretaceous paleobiogeography of gastropods has focused on the differences between low-latitude and northern mid- to high-latitude associations. This is probably related to a bias of information towards septentrional gastropod faunas that reveals poorly documented austral associations. Besides, the global distribution of gastropods was usually discussed in terms of a three-fold scheme of major paleobiogeographic units originally proposed on the basis of the endemism of bivalve species and the limits of coral-rudist facies. An equivalent model based on Cretaceous gastropods at a global scale has not yet been proposed, although some distinct areas of endemism were recognized for the latest Cretaceous. Over the last years, significant progress has been made in the knowledge of the composition of the marine gastropod fauna from the Lower Cretaceous of the Neuquén Basin. So far, 26 species -belonging to 20 genera and 18 families- were recognized in the Mulichinco (Valanginian) and Agrio (Valanginian–Barremian) formations, and several new records are still under study. Alongside, the palaeoecology and palaeobiogeographic affinities of this fauna were explored for the first time. The main results of the latter topic are presented here. Amongst the studied species, at least nine are endemic to the Neuquén Basin. So far, only three species were also recorded in Chile, and other three seem very close to records from Peru, Venezuela and the Argentinian Austral Basin. Only one species shows records in a very distant region. Despite its endemic elements, at the genus level this association shows a predominantly Tethyan influence. Moreover, the Neuquén Basin shares family-level gastropod taxa with the other basins in the western margin of South America and the Antarctic Peninsula. These results point to a faunistic exchange through open seaways established during the Berriasian–Barremian between the Neuquén Basin and both neighboring—*i.e.* the western margin of South America and the Antarctic Peninsula—and remote regions—*i.e.* the Tethys Sea and northern Europe. Also, they are consistent with previous findings, based on the distribution of other benthic and nektonic invertebrates, which claim that the basin stayed connected with the open sea during the Early Cretaceous. The mixed nature of this gastropod association contrasts with the highly provincial Late Cretaceous–Paleocene southern gastropod fauna. In terms of water temperature, the mass occurrence of one nerineoid species could be indicating a brief episode of warmer conditions in the northernmost part of the basin during the late Hauterivian. [Contribution C-76 of IDEAN].

IMPLICATIONS OF RECENTLY FOUND EARLY CRETACEOUS XIPHOSURID TRACKWAYS FROM THE NEUQUÉN BASIN (WESTERN GONDWANA): EVIDENCE OF PALEOCOASTLINE CONTINUITY?

Diana E. Fernández[1]

1. Instituto de Estudios Andinos Don Pablo Groeber (IDEAN–CONICET). Departamento de Ciencias Geológicas-FCEN-Universidad de Buenos Aires, Ciudad Universitaria, Pabellón II, Buenos Aires, C1428EGA, Argentina.
elizabeth@gl.fcen.uba.ar

Recently reported xiphosurid trackways represent the first record of such trace fossils from the Early Cretaceous (worldwide) and the second Cretaceous fossil record of xiphosurids in the Southern Hemisphere. These trackways were found in the uppermost levels (interpreted as tidal flat facies) of the Agua de la Mula Member (late Hauterivian–early Barremian) of the Agrio Formation (Neuquén Basin). Based on the phylogeny and fossil record of xiphosurids and the age of these deposits, these trackways were interpreted as produced by members of the Subfamily Limulinae. The aim of the present work is to discuss the implications this finding might have in the reconstruction of marine seaways involving Western Gondwana. Recent xiphosurids (horseshoe crabs) are found in two regions of the world. Three species occupy coastal waters from India to Japan, and one is found along the North American Atlantic coastline from Maine to the Yucatan. The main large-scale limitations on the distribution of Recent horseshoe crabs are the extent of continental shelves (which define space availability), certain tidal regimes, and low temperatures. Although extant xiphosurids have planktonic larvae, their long-range dispersal is limited. Studies based on genetic analyses and the distribution of extant species, established that the divergence of the American species from the Indo-Pacific species took place approximately 135 million years ago, and the ancestor of the present species originated in the Mesozoic in Europe and migrated east and west. However, no palaeobiogeographic, migration or distribution studies on xiphosurids have been carried out using the fossil record. Only five Cretaceous limulid body fossils have been recorded, and two are of Early Cretaceous age: *Victalimulus mcqueeni* Riek and Gill from Victoria (Australia) and *Crenatolimulus paluxyensis* Feldmann *et al.* from Texas (USA). During that time, the Neuquén Basin was connected to the Pacific Ocean through an island arc chain to the west. The arrival of nektonic (and planktonic in larval stage) North Pacific and Tethyan faunas along the western South American margin has already been documented. The global palaeogeographic reconstructions of the Early Cretaceous (Hauterivian-Barremian) and the marine connexions of the Neuquén Basin supported by body fossil information suggest a marine seaway between this locality and the previously mentioned North American and Australian sites. Nevertheless, given the large-scale limitations on the distribution of Recent horseshoe crabs, a direct passage between the three localities would most likely imply a continuous palaeocoastline with relatively shallow waters, which has not been accurately documented.

CORAL BIOSTROMES FROM THE HAUTERIVIAN OF THE SOUTHEASTERN PACIFIC, NEUQUÉN BASIN, WEST-CENTRAL ARGENTINA

Ricardo M. Garberoglio[1] and Darío G. Lazo[1]

1. Instituto de Estudios Andinos "Don Pablo Groeber" (UBA-CONICET), Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón II, Ciudad Universitaria, 1428 Buenos Aires, Argentina. rmg@gl.fcen.uba.ar

Scleractinian corals flourished in the Jurassic when they reached a maximum diversity of around 500 genera. During the Berriasian-Valanginian the environmental conditions would not have been optimal for their development and thus a significant decline is recorded. The Hauterivian was a transitional interval between Jurassic and Cretaceous for the coral faunas worldwide. There was a rise in eustatic sea level in the early Hauterivian and scleractinian corals communities started to recover and reached a diversity of 54 genera of which 48 genera were new. Hauterivian coral faunas have been reported mainly from carbonate platforms of the Tethys region (Tunisia, Portugal, Spain, France, Italy, Germany, Poland, Carpathians, east of Balkans, Crimea, Georgia, Azerbaijan, Turkmenistan), with more than 100 species reported from the Paris Basin and Georgia. Low diversity coral faunas with less than 20 species predominated outside the Tethys region, mainly recorded from Tanzania, Jamaica, Peru and northern Chile. The Hauterivian of the Neuquén Basin (west-central Argentina) has yielded an abundant but low diversity coral faunas composed of six species that were described almost 100 years ago. However, new field works and detailed collections have added at least five species, which are currently under study. These corals are colonial forms and they developed on soft consistency seafloors under moderate siliciclastic input. Isolated coral biostromes are recorded at the base of shallowing upwards cycles that are composed by three successive facies: a basal transgressive mixed carbonate-siliciclastic facies that reach the maximum flooding zone and include the studied coral biostromes, followed by fine-grained clastic facies and capped by amalgamated sandstones showing a coarsening upwards trend. Biostromes have a few meters in thickness and can be followed laterally for several hundreds of meters. They are composed by ramose colonies, similar to those recorded in the Lower Cretaceous of Peru and Turkmenistan; or instead they are composed of short-termed coral successions composed of basal massive and platy corals succeeded by phaceloid and ramose forms, which resemble those recorded in some unfavorable regions of the Tethys such as Southeastern France, Eastern Spain or Bulgaria. Biostromes harbor a diverse encrusting and boring fauna and usually alternate with mollusk-dominated biofacies. The studied coral taxa show close affinities with Tethys coral faunas and suggest an open seaway through the Caribbean.

TAXONOMY AND PALAEOBIOGEOGRAPHICAL AFFINITES OF EARLY CRETACEOUS STALKED CRINOIDS FROM THE NEUQUÉN BASIN, WEST-CENTRAL ARGENTINA

Darío G. Lazo[1], Graciela S. Bressan[1], Ernesto Schwarz[2] and Gonzalo D. Veiga[2]

1. Instituto de Estudios Andinos "Don Pablo Groeber" (CONICET), Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón II, Ciudad Universitaria, C1428EGA, Buenos Aires, Argentina. dlazo@gl.fcen.uba.ar

2. Centro de Investigaciones Geológicas, Universidad Nacional de La Plata, CONICET, 1900 La Plata, Argentina.

The aims of the present work are to present a preliminary morphological description and palaeobiogeographical affinities of stalked crinoids recorded from the Lower Cretaceous of the Neuquén Basin, west-central Argentina. The studied specimens proceed from the Agrio Formation in two different stratigraphic positions and facies relationships. Most of them come from abundant crinoid beds alternating with cross-bedded sandstones recorded at the basal third of the Pilmatué (lower) Member of the Agrio Formation. These beds have been dated as late Valanginian by the associated ammonoids and trigonioid bivalves. Besides, there are two specimens preserved in a calcareous nodule recorded from dark-grey shales of the Agua de la Mula (upper) Member of the Agrio Formation and dated as late Hauterivian by the associated ammonoids. The studied crinoids have a long and slender heteromorphic stem. Nodals and internodals are petaloid in transverse section. The articulation between internodals is symplexy. Axial canal is narrow and rounded. Internodals are 6-7 in number. Nodal plates are twice as high as internodal plates. Calyx is cryptodicyclic, composed by five radial plates and five basal plates not forming a contiguous circlet. Articulation between primibrachials 1 and 2 is synarthrial and between secundibrachials 3 and 4 is straight cryptosyzygial. Arms are more slender toward distal ends, but almost uniform in diameter within each brachitaxis. They display isotomous branching with at least 6 bifurcations in line per ray. Pinnules are arranged in one alternating series. Maximum crown height is approximately 80 mm. The studied specimens has been identified as belonging to the genus *Isocrinus* Von Meyer (Family Isocrinidae, Suborder Isocrinina, Order Isocrinida) with small basal plates not forming a contiguous circlet, low columnals, large cirrus sockets as high as nodals and synarthry articulation between primibrachials 1 and 2. The genus has been previously recorded in the Lower Cretaceous mostly in the Northern Hemisphere from Germany, France, Poland, Russia and Japan. In the Southern Hemisphere, they are extremely rare and complete specimens are only reported from Antarctica and Australia and as far as we know no records from South America have been published so far. Therefore, the first finding of well-preserved stalked crinoids from the Early Cretaceous Agrio Formation in the Neuquén Basin is remarkably important in terms of crinoid evolutionary history and palaeobiogeography.

CRETACEOUS PLESIOSAURS FROM THE NEUQUÉN BASIN, WEST-CENTRAL ARGENTINA: AN UPDATED PICTURE OF OCCURRENCES AND PALAEOBIOGEOGRAPHICAL AFFINITIES

José P. O'Gorman[1,2], Dario G. Lazo[2,3] and Beatriz Aguirre-Urreta[2,3]

1. División Paleontología Vertebrados, Museo de La Plata, Universidad Nacional de La Plata, Paseo del Bosque s/n., B1900FWA, La Plata, Argentina. joseogorman@fcnym.unlp.edu.ar

2. CONICET. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina.

3. Instituto de Estudios Andinos "Don Pablo Groeber", Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón II, Ciudad Universitaria, C1428EGA, Buenos Aires, Argentina.

Cretaceous plesiosaurs from the Neuquén Basin, Argentina, have been abundantly recorded from different marine and marginal marine units. However, records from the Early Cretaceous are still scarce and poorly known in contrast to Late Cretaceous ones. Early Cretaceous plesiosaurs include elasmosaurids recorded from the Agrio Formation, encompassing the Valanginian-Hauterivian time interval. These materials include scattered postcranial elements, but they have been precisely dated by means of the associated ammonoid faunas. Specimens show two different taphonomic modes: 1] preservation embedded in dark-grey shales that consists of partially articulated postcranial skeletons found in situ and interpreted as a result of the sinking of dead vertebrate carcasses to a muddy and calm seafloor under oxic to suboxic conditions without further transport or reworking, and 2] isolated bones in shell beds that are weathered, abraded and heavily encrusted by small cementing oysters resulted from the reworking of previously settled vertebrate carcasses on the seafloor. Specimens from the Agrio Formation share features with the Aptian *Callawayasaurus colombiensis* of Colombia and the Aptian-Albian of Australia, and indeterminate elasmosaurids from the Albian of Canada and the Berriasian-late Albian of England such as elongated cervical vertebrae, and absence of dumbbell shaped articular faces. The presence of a marked lateral ridge is not frequent among the elasmosaurids cervical vertebrae of the Agrio Formation but it has been recorded among the Aptian-Albian Australian elasmosaurids. Elasmosaurids from the Agrio Formation show a complex of plesiomorphic (absence of ventral notch; circular articular faces) and apomorphic (elongated cervical vertebrae; lateral ridge, in one case) features. Elasmosaurids from the Agrio Formation differ markedly from the elasmosaurids recorded in the late Campanian-early Maastrichtian Allen and late Maastrichtian Jagüel formations of the same basin. These younger forms show apomorphic features (dumbbell shaped articular faces) and include both the endemic Weddellian aristonectinae and non-aristonectinae elasmosaurids.

SANTONIAN-CAMPANIAN GAUDRYCERATID AMMONOIDS FROM ANTARCTICA IN SPACE AND TIME: PALEOBIOGEOGRAPHICAL IMPLICATIONS

María E. Raffi[1] and Eduardo B. Olivero[1]

1. Centro Austral de Investigaciones Científicas (CADIC-CONICET), B. Houssay 200, 9410 Ushuaia, Tierra del Fuego, Argentina. eugeniaraffi@gmail.com

The widespread geographic distribution of the relatively light-ornamented gaudryceratid ammonoids have been considered as typical for an oceanic planktonic drifter mode of life (leiostracan ammonoids) and the long ranging stratigraphic distribution of gaudryceratid species as an indication of its relatively low evolutionary rate. As a consequence, gaudryceratid ammonoids have been rarely used in paleobiogeography and biostratigraphy. However, the stratigraphic and paleobiogeographic distribution of the Santonian-Campanian Antarctic gaudryceratids partly belies this concept. In the James Ross Basin, five successive species of the genus *Gaudryceras* characterize particular stratigraphic intervals during the Santonian-Campanian. *Gaudryceras* cf. *denmanense* (Whiteaves), Santonian; *Gaudryceras* sp. nov. B, early Campanian; *Gaudryceras* sp. nov. A, *Gaudryceras* cf. *varagurense* (Kossmat) and *Vertebrites* cf. *kayei* (Forbes), lower middle Campanian; and *Gaudryceras* sp. nov. C, upper middle Campanian. In addition, two new species of *Anagaudryceras* appear near the early-middle Campanian boundary in the Rabot Formation. This interval also bears *Metaplacenticeras* cf. *subtilistriatum* (Jimbo), *Hoplitoplacenticeras* cf. *plasticum* Paulcke and *Baculites subanceps* Haughton; which are restricted in the Indopacific region to the base of the mid Campanian. A striking biogeographical contrast is that while the Santonian-early Campanian *G.* cf. *denmanense*, *G.* cf *.varagurense* and *Vertebrites* cf. *kayei* show marked affinities with similar species from the Indopacific or North Pacific regions, the mid-late Campanian gaudryceratid species (*Gaudryceras* sp. nov. B, A and C and *Angaudryceras* sp. nov. A and *Anagaudryceras* sp. nov. B) are apparently restricted to Antarctica. Outside Antarctica the genus *Gaudryceras* is well-recorded up to the late Maastrichtian. This is in strong contrast with the Antarctic record, where most of the species of *Gaudryceras s.s.* disappear by the middle Campanian, with only few specimens recorded near the base of the late Campanian. Apparently, gaudryceratid ammonoids follow the same trend detected in the rest of the ammonoid fauna from Antarctica, which is characterized by a cosmopolitan or Indopacific fauna during the Santonian-early Campanian followed by a strongly endemic fauna during the middle Campanian-Maastrichtian. This major faunal change has been interpreted as reflecting a long cooling trend in sea water temperatures. While the local extinction of *Gaudryceras* is concomitant with the gradual cooling of waters, the possibility of bathymetric controls, *i.e.* the generalized shallowing of the basin during the middle Campanian-early Maastrichtian, cannot be ruled out.

WORKSHOP

LAKE BASIN TYPES AND THEIR FAUNAS

ORGANIZERS:

ELIZABETH H. GIERLOWSKI-KORDESCH
- CECILIA A. BENAVENTE

LACUSTRINE BIOTIC ASSEMBLAGES IN THE EARLY CRETACEOUS OF CENTRAL-WESTERN ARGENTINA: LA CANTERA AND LAGARCITO FORMATIONS

Andrea B. Arcucci[1], Mercedes B. Prámparo[2], Laura Codorniú[3], Paula G. Giordano[3], Gabriela Castillo Elías[1], Gabriela G. Puebla[2], Natalia Mego[2], María A. Gomez[1] and Evelyn Bustos Escalona[1]

1. Área de Zoología, Dep. de Bioquímica y Cs. Biológicas, Universidad Nacional de San Luis, Chacabuco 917, 5700, San Luis Argentina. andrea.arcucci@gmail.com

2. CCT CONICET Mendoza – IANIGLA, Av. Ruiz Leal s/n, 5500, Mendoza, Argentina.

3. CONICET Depto. de Geología, Universidad Nacional de San Luis, Av. Ejercito de los Andes 950, 5700 San Luis, Argentina.

The San Luis Basin (Early Cretaceous, Aptian-Albian, central-western Argentina) contains two formations, La Cantera and Lagarcito, with lacustrine facies with well-preserved fossils that could be considered as *Konservat-Lagerstätten*. The fossil record of the La Cantera Formation includes a variety of palynomorphs (pollen grains and spores) and plant remains (leaves, stems, reproductive structures like cones, seeds and flowers) from Bryophyta, ferns, Gnetales, Gymnospermae and Angiospermae. The palynoflora is dominated by aquatic forms (freshwater algae), which represent more than 80% of the total population. *Classopollis* and plicate grains (*Ephedra* type) are also abundant. Among the angiosperms, *Afropollis*, *Retimonocolpites, Stellatopollis, Clavatipollenites, Tucanopollis*, *Pennipollis* and *Asteropollis complex* are recorded. The bryophyte association constitutes one the most complete records of its type in Argentina. The association of fossil leaves and pollen grains from the La Cantera Formation is one of the most ancient and complete records of first angiosperms in South America, being Late Aptian in age. The Lagarcito Formation yielded a palynoflora dominated by gymnosperm elements (mainly polyplicate and rimulate grains). The aquatic forms are also abundant. *Reyrea polymorphus*, identified in the association, is an excellent marker for the Aptian-Albian of northern Gondwana. The arthropod remains in both units include Ostracoda and Conchostraca with several endemic species. The insects from the La Cantera Formation, though fragmentary, allow the identification of five different orders and three endemic species of aquatic insects, belonging to the Families Notonectidae and Corixidae, including the oldest member of the Anisopinae subfamily. The actinopterygian fishes were abundant in both paleolakes, but the associations show different taxonomic composition. The Pleuropholid fishes from the Lagarcito Formation are the only record of this rare group in Argentina and the second from South America. *Pterodaustro guinazui*, the only and unique species of Pterosauria from the Lagarcito Formation, is present with a collection of hundreds of bones. This occurrence is one of the few fossil accumulations of pterosaur remains worldwide from which it is possible to study the details of life history, parameters like growth patterns, and ontogenetic development. This high paleobiodiversity needs to be assessed with respect to sedimentology and lake type to understand the stratigraphic relationships between the two formations and the paleoenvironmental processes preserving these fossils.

TRIASSIC BIOTIC ASSEMBLAGES OF TWO PALEOLAKES OF ARGENTINA

Cecilia A. Benavente[1*], Adriana C. Mancuso[1] and Nora G. Cabaleri[2]

1. Instituto Argentino de Nivología Glaciología y Ciencias Ambientales (IANIGLA), CCT-CONICET-Mendoza, Avda. Ruiz Leal s/n, CP 5500, Mendoza, Argentina. cbenavente@mendoza-conicet.gov.ar

2. Instituto de Geocronología y Geología Isotópica (INGEIS), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Universidad de Buenos Aires, Ciudad Universitaria, C1428EHA Buenos Aires, Argentina.

The Triassic Cerro de las Cabras and Cerro Puntudo formations represent part of the continental sedimentary infilling of the Cuyana rift basin. The basin has two asymmetric half-grabens – the North containing the Cerro Puntudo sub-basin with the Cerro Puntudo Formation (CPF) and the South where the Potrerillos sub-basin and the Cerro de las Cabras Formation (CCF) are identified. Both units conform to alluvial-fluvial-lacustrine successions of rift basins including carbonates with abundant microbialites. Sedimentology reveals playa lake systems with sandflat, mudflat, palustrine, and lacustrine subenvironments affected by subaerial exposure and pedogenesis. Geochemistry indicates hydrologically open paleolakes (through lack of a covariant trend between C and O stable isotopes), with meteoric water supply through springs and precipitation. The CCF is an aggradational succession that corresponds to the evaporative facies association type, diagnostic of underfilled lake basins. However, the lakes model links underfilled lakes with persistently closed surface hydrology, though groundwater supply may be open here. The CCF shows a negative C isotope signature indicating biologic effects attributed to organic matter (OM) decomposer heterotrophic bacteria. There are abundant stromatolitic limestones and rhizohaloes-rhizoliths representing paleosols. The CPF is an aggradational-minor progradational succession, pointing to a fluctuating profundal facies association diagnostic of balanced-fill lakes. However, the restricted areal extent of these deposits cannot confirm this interpretation. The CPF shows less negative excursions of the C isotopic signature interpreted as algal blooms with increased photosynthetic activity. The CPF contains a microbialite assemblage reflecting an aquatic paleoecosystem with a simple trophic network, composed of filamentous and coccoid algae with Cyanophyta affinities that constitute primary producers with lithified structures through bio-mediated carbonate precipitation. Charophytes have been identified fulfilling the same task. Ostracodes (heterotrophs) fed from detritus and bacteria as OM decomposers. Terrestrially associated components were hygrophytes and arthropods from the *Skolithos*-*Scoyenia* ichnofacies. In both paleolakes, biotic assemblages are freshwater-saline tolerant, as in balanced-fill lakes. However, they present low diversity and moderate abundance due to shallow-ephemeral paleolakes with high alkalinity, common lake level fluctuations, and subaerial exposure. These attributes certainly constrained the opportunistic biotic assemblages in unstable settings. For the CCF, biota supports an underfilled lake. Its open hydrology shows that underfilled lakes may be closed to surface water supply but open to groundwater movement. More studies are required to determine if the CPF can be analyzed under the current lake model and if indeed it can be interpreted as a balanced-fill lake type as biota suggests.

THE ICHNOLOGIC SIGNATURE OF OVERFILLED, BALANCED-FILL AND UNDERFILLED LAKES

Luis A. Buatois[1] and María G. Mángano[1]

1. Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, SK S7N5E2, Canada. luis.buatois@usask.ca

The classification into overfilled, balanced-fill, and underfilled lakes provides a useful scheme to frame ichnologic observations. Overfilled lake basins host well-developed softground trace fossils (*Mermia* and *Skolithos* ichnofacies and the softground suite of the *Scoyenia* ichnofacies) that are useful to delineate parasequences and parasequence sets. Fluvial discharge into overfilled lakes typically generates density currents that provide oxygenation to the lake bottom, allowing the establishment of epifaunal and infaunal communities. Additionally, because these are freshwater lakes where no stress due to hypersalinity occurs, a relatively diverse benthos is commonly present. Land-plant-derived organic matter is the prime source of nutrients, favoring the development of a deposit-feeding benthic fauna in permanently subaqueous, low-energy zones. Firmground suites are rare because such large lakes usually do not experience desiccation. Balanced-fill lakes are characterized by abundant firmground trace fossil suites of the *Scoyenia* ichnofacies, but softground assemblages are usually of low diversity. Lowstand deposits contain abundant and widespread ichnofaunas, typically backfilled trace fossils and arthropod trackways of the *Scoyenia* ichnofacies. Lake hydrology is closed during lowstands and salinity usually increases, imposing a stress factor on the lake biota As a result, softground ichnofaunas are depauperate. Ichnofaunas from turbidite systems in balanced-fill lakes are less abundant and diverse than those from overfilled lake turbidites, if present at all. Freshwater conditions are common during transgressions, but dysaerobic conditions may prevail, imparting a stress factor on the benthic biota. In hydrologically closed lakes, the *Scoyenia* ichnofacies is widespread, but the *Mermia* ichnofacies is commonly absent. In underfilled lakes, the *Scoyenia* ichnofacies is associated with lowstand desiccated substrates. The density of arthropod trackways may be high, revealing tracked omission surfaces. Some of these omission surfaces may represent sequence boundaries expressed by co-planar surfaces of lowstand and subsequent flooding. Rapid changes in depositional conditions reflecting desiccation during vertical aggradation can lead to the formation of composite ichnofabrics that reflect successive bioturbation events. A simple checklist approach is of little use because none of these lake-basin types is characterized by specific ichnotaxa. In particular, we favor a combined ichnofacies and ichnofabric approach to the study of overfilled, balanced-fill, and underfilled lakes. This combined approach allows characterization of vertical changes of archetypal ichnofacies as a response to secular changes in depositional conditions (e.g. progressive shallowing), and delineation of palimpsest surfaces resulting from desiccation along lake margins.

LAKE TYPES AND SPECIATION RATES

Elizabeth H. Gierlowski-Kordesch[1]

1. Department of Geological Sciences, Ohio University, Athens, OH 45701, USA.
gierlows@ohio.edu

Three types of lake successions have been identified in the geologic record through sequence stratigraphic analysis and the identification of petroleum biomarkers. Each type of lake – underfilled, balanced filled, and overfilled – all are part of a spectrum of lakes with specific characteristics related to the hydrology and tectonics of lacustrine basin evolution. Underfilled lake basins contain aggradational sedimentary fill dominantly represented by saline to hypersaline deposits with a mostly closed hydrology and widely fluctuating lake levels from rainfall events and subsequent desiccation. Organic enrichment is dominated by microbial matter and there is a low diversity of invertebrate species. Overfilled lake basins contain progradational sedimentary fill dominantly represented by mixed fluvial and lacustrine deposits representing an open hydrology and stable lake levels. Organic enrichment is dominated by both terrestrial plant and lacustrine microbial matter and the diversity of invertebrates is "average". Balanced-filled lake basins contain both aggradational and progradational sedimentary fill representing both saline and freshwater facies with fluctuating lake levels through time, representing an alternation between closed and open hydrology. Organic enrichment is high and this represents the best quality of petroleum formation while the invertebrate species diversity is the highest of the three lake types. This is attributed to the changing geography and increase in niches related to the alternation in the lacustrine hydrology. During hydrologically closed conditions, fauna retreat to freshwater areas upstream and can speciate within the increased number of niches available. As more overfilled conditions return and lake level rises, the fauna can return to the lake when it is fresh, perhaps with a higher diversity of species after this geographic isolation. The best example of this is the high diversity of cichlid fish present in Lakes Victoria and Tanganyika, both balanced filled lakes, which contain a high number of endemic invertebrate and fish species. Different lake basin types clearly affect faunal diversity during the life of a particular basin. Observations on the evolution of life within these lacustrine basins through the Phanerozoic can give insight on the affects of tectonic and hydrologic changes on the form and function of lake fauna through time.

THE CRATO FORMATION FOSSIL INSECTS: WINDOW TO GEOBIOLOGICAL PROCESSES

Gabriel L. Osés[1], Setembrino Petri[1], Fabio Rodrigues[2], Douglas Galante[2], Márcia de A. Rizzutto[3], Adriana de O. D. Silva[4] and Mírian L. A. F. Pacheco[5]

1. Instituto de Geociências/Universidade de São Paulo, Rua do Lago 562, Cidade Universitária, São Paulo, 05508-080, Brazil. gabriel.ladeiraoses@gmail.com

2. Laboratório Nacional de Luz Síncrotron, Rua Giuseppe Máximo Scolfaro 10.000, Barão Geraldo, Campinas, 13083-970, Brazil.

3. Instituto de Física/Universidade de São Paulo, Rua do Matão 187, Cidade Universitária, São Paulo, 05508-090, Brazil.

4. Departamento de Física, Química e Matemática/Universidade Federal de São Carlos, Campus Sorocaba, Rodovia João Leme dos Santos (SP-264) Km 110, Bairro do Itinga, Sorocaba, 18052-780, Brazil.

5. Departamento de Biologia/Universidade Federal de São Carlos, Campus Sorocaba, Rodovia João Leme dos Santos (SP-264) Km 110, Bairro do Itinga, Sorocaba, 18052-780, Brazil.

The Crato Formation (Araripe Basin, Early Cretaceous, northeastern Brazil) is well known for its abundant and diverse palaeoentomofauna. Taxonomical, evolutionary, and palaeoecological studies record the evolution of social insects and the early stages of the co-evolution between insects and flowering plants. These fossil insects are exceptionally well-preserved, including tridimensional specimens with mineralized soft tissues. The interconnection among mechanisms and processes responsible for the preservation of these fossils will shed light on palaeobiological implications. To accomplish this objective, we applied high-resolution geochemical and imaging techniques. Raman spectroscopy analysis revealed the presence of amorphous hematite or limonite in the fossils, representing the possible alteration of pyrite. The application of XRF (with portable equipment and in high vacuum with synchrotron light sources) and EDS showed a higher concentration of iron, phosphorus, copper, and zinc in the fossils in contrast to the surrounding laminated limestones. This pattern of distribution of elements is interpreted as the enveloping of the carcasses by bacterial biofilms and the infestation of the inner part of the carcasses by bacteria, leading to anaerobic decay and mineralization of soft tissues during early diagenesis. In this process, the micro-organisms have fixed specific elements, leading to an early mineralization of the biofilms, the exoskeleton, and the cavities of the specimens. This process was important in controlling the preservation of soft tissues and the minimal compaction of the carcasses, accounting for tri-dimensional fossils. SEM photomicrographs also lend evidence for support on the role of bacteria in the preservation of the Crato Formation fossil insects, revealing the presence of fragments of biofilms covering and bonding mineral grains replacing the exoskeleton and the cavities of the fossils, which are infilled with micron-sized pseudomorphs of framboidal pyrite. This research highlights the processes of exceptional fossil preservation and establishes a geobiological model that accounts for the preservation of the Crato Formation fossil insects. This contribution is valuable in understanding the fossilization of organisms in similar palaeoenvironmental conditions within lake types in the geological record. [Funding agencies: CNPQ and FAPESP].

WORKSHOP

BURGESS SHALE-TYPE DEPOSITS AND THE ORIGIN OF MODERN ECOSYSTEMS

ORGANIZERS:
JEAN-BERNARD CARON - JEAN VANNIER

STEM TRIANGULATION: RARE BURGESS SHALE ARTHROPODS DIAGNOSED BY A COMBINATION OF MEGACHEIRAN, ARTIOPOD AND CHELICERATE CHARACTERS

Cédric Aria[1,2] and Jean-Bernard Caron[2,1]

1. Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, Ontario, M5S 2J7, Canada. cedric.aria@gmail.com

2. Department of Natural History – Palaeobiology, Royal Ontario Museum, Toronto, Ontario, M5S 2C6, Canada.

In the last 30 years, remarkable, yet uneven, progress has been achieved toward the resolution of the phylogeny of Arthropoda, including the earliest forms constituting the "stem" of the clade. A number of fossil morphotypes have been traditionally overlooked, however, often due to their poorer preservation or rarity. New or undescribed exceptionally well-preserved material of the understudied "habeliids" and mollisoniids collected by the Royal Ontario Museum from the Burgess Shale provides a wealth of new information and constitutes a basis for a thorough reinvestigation of these groups of animals. We notably describe previously unknown soft parts of *Mollisonia* Walcott and "*Habelia*" *brevicauda* Simonetta. "*Habelia*" *brevicauda* and "*Habelia*" *optata* Walcott possess long and slender endopods in the anterior portion of their bodies. The cephalic legs of "*H.*" *brevicauda* in particular are much longer than the trunk limbs, with no trace of exopods. There are at least six pairs, and some of them are possibly differentiated. "*H.*" *optata*, in contrast, shows frontally clustered limbs and secondary antennulate appendages which seem altogether attached to a pair of rami – a condition identical to that of *Sanctacaris* Briggs and Collins, and lending support to the idea that they are comparable to "great appendages." In addition, "*H.*" *optata* bears a series of large mandibular processes that are possibly modified gnathobases. The tailpiece is a fused pygidial plate adorned with spinose outgrowths of the kind present in e.g. the artiopods *Helmetia* Walcott and *Kuamaia* Hou. Such a pygidial plate is also characteristic of *Mollisonia*, but the genus seems to lack any "great appendage"; instead, the cephalon features at least three pairs of long, uniramous legs projecting antero-laterally, as well as a pair of small lobes at its anterior most end pointing forward. The latter are diagnostic of several stem bivalved arthropods, e.g. *Canadaspis* Walcott, and thus may constitute a character of phylogenetic importance. We discuss the implications of our interpretations for the disparity of "great appendages" and for the phylogenetic relationships among megacheirans, artiopods and chelicerates.

SHEDDING LIGHT ON THE TOMMOTIID STEM-BRACHIOPOD TRANSITION WITH MULTI-SCALAR X-RAY COMPUTED TOMOGRAPHY

Aodhán D. Butler[1], Russell Garwood[2], Michael Streng[1], Zhifei Zhang[3], Tristian Lowe[4] and Lars E. Holmer[1]

1. Department of Earth Sciences, Uppsala University, Uppsala, Sweden. aodhan.butler@geo.uu.se

2. University of Manchester, Manchester, UK.

3. Northwest University, Early Life Institute, Xi'an, China.

4. Manchester X-Ray Imaging Facility, Manchester, UK.

The fossil record of life on Earth is strongly biased towards organisms which have hard parts - biomineralised tissues such as shells, teeth or bones. Indeed, we now know that the event termed the Cambrian explosion, once thought of as the initial appearance of life, in fact partially results from the evolution of hard parts and their resulting sudden appearance in the fossil record. This event, 542 million years ago, is immediately preceded by the appearance of a group of problematic microfossils known as the small shelly fauna. Significant progress has been achieved tracing the origin and evolution of Brachiopoda to this plethora of lower Cambrian scleritome taxa. We aim to determine the characters suites linking these putative stem-Lophotrochozoa to crown brachiopods and other lophotrochozoans. This is achieved by comparing records of exceptional preservation, most conspicuously members of Lagerstätten such as the Burgess Shale type faunas, with more widespread Cambrian stem-brachiopods and small shelly fossils. This determination is crucial to reconstructing the brachiopod stem-group and in polarising character changes associated with the putative transition from scleritome organisms to crown-group brachiopods. Lab-based CT scanning has helped us to characterise the gross anatomy, micro-structure and histology of tommotiid SSF's, providing the basis for solving the placement of these enigmatic fossils on the tree of life. Major features critically examined include those of fossilised setae, structures commonly found across Lophotrochozoa. Exceptionally preserved examples of which can be found *in-situ* in both brachiopods and tommotiids implying a close affinity. The addition of 3D microCT and synchrotron tomography data provides novel information on ontogenetic growth trajectories and the arrangement of phosphatised shell structures including so-called 'acrotretid type' columns and the conformation of associated lamellae. CT scanning also reveals exceptionally preserved soft-tissues, such as lophophores, mantle canals and digestive organs otherwise not visible without destructive sampling of scientifically valuable fossils. Such new data facilitates further critical anatomical comparison of tommotiids including *Micrina, Sunnaginia* and *Eccentrotheca* with stem-group brachiopods such as *Mickwitzia, Heliomedusa* and *Setatella.* These suggested homologies are of phylogenetic significance, and shed further light on the early evolution and assembly of the lophotrochozoan body plan during the early Cambrian.

A CHENGJIANG-TYPE BIOTA FROM THE EARLY CAMBRIAN OF WESTERN CANADA

Nicholas J. Butterfield[1]

1. University of Cambridge, Department of Earth Sciences, Cambridge, CB2 3EQ, UK.
njb1005@cam.ac.uk

"Burgess Shale-type" preservation provides an unparalleled view of early Palaeozoic biology, including evidence of marked evolutionary conservatism in muddy dysaerobic environments. Even so, the palaeontological signatures of the early Cambrian Chengjiang and middle Cambrian Burgess Shale biotas are sufficiently distinct to recognize substantial faunal turnover, possibly associated with the Sinsk extinction event. The early Cambrian (Stage 3) Mural Formation, central Canadian Rocky Mountains, preserves a range of exceptionally preserved fossil taxa, several of which are otherwise known only from earlier 'Chengjiang-type' assemblages; e.g., *Vetulicola*, *Parapeytoyia* and *Heliomedusa*. As in the Chengjiang, these are accompanied by a background of longer ranging forms, including palaeoscolecid worms, *Anomalocaris* claws and gills, bivalved carapaces and other arthropods. The Mural mudstones contain occasional burrows and conformably overlie archaeocyath reefs, pointing to stagnant mid-shelf environments broadly comparable to those in Chengjiang. Even so, carbonaceous fossil preservationlies at the more recalcitrant end of the histological spectrum, resulting in substantially lower overall abundance and diversity. Mural *Vetulicola* is preserved primarily as isolated anterior carapaces which, depending on the level of exhumation, may or may not exhibit the longitudinal groove and serially repeated openings. Co-occurring *Combinivalvula* are recognized as the carapaces of small, presumably juvenile, *Vetulicola*. Unlike their Chengjiang counterparts, there is little three-dimensional preservation of soft part anatomy in Mural *Vetulicola*, though certain features can be inferred from the expression of associated cuticle. The phylogenetic relationships of Chengjiang-type vetulicolids are problematic due to the presence of taxonomically conflicting characters: whereas their segmented tail is directly analogous to the articulated exoskeleton of arthropods, thepaired anterior gills/gill-slits are similar to the pharyngeal apparatus of deuterostomes. The test for determining the true relationships of vetulicoliids lies in the relative likelihood of these organ-systems arising through evolutionary convergence. I will argue here that the arthrodial/exo-skeletal architecture (and concomitant ecdysal habit) is unique to the Ecdysozoa; by contrast, respiratory pores have evolved independently in all three of the bilaterian clades, including crown-group Ecdysozoa. On the basis of previous phylogenetic analyses, it is clear that vetulicolids cannot be convincingly placed in any extant ecdysozoan clade; however, there is an increasingly good case for transferring them from stem-group deuterostomes – the current consensus – to stem-group Ecdysozoa. The absence of *Vetulicola* in a wide range of exceptionally preserved Burgess Shale-type biotas in western Laurentia further attests to its global Stage 4 extinction.

ANOMALOCARIDID PHYLOGENY, MORPHOLOGY AND EVOLUTIONARY SIGNIFICANCE

Allison C. Daley[1] and Gregory D. Edgecombe[2]

1. Oxford University, Department of Zoology & Museum of Natural History, Oxford, OX1 3PS, UK. allison.daley@zoo.ox.ac.uk
2. The Natural History Museum, Department of Earth Sciences, Cromwell Road, London, SW7 5BD, UK.

Since they were pieced together in the 1980s to reveal some of the strangest animals of the Cambrian, the anomalocaridids have been described from every major Cambrian fossil Konservat-Lagerstätte and several smaller localities, and have been shown to have survived into the Ordovician. These stem-lineage arthropods exhibit a much wider range of morphologies and ecologies than previously assumed. Recent discoveries from China, USA, Morocco, Greenland and Canada have prompted a phylogenetic examination of their internal relationships and a need to revise their classification. Anomalocaridid diversity now includes at least 11 genera and nearly 20 species, eight of which are known from specimens showing relatively complete body preservation. Here we present the most complete phylogeny of anomalocaridid interrelationships to date, including every taxon known from at least a frontal appendage. The phylogeny recognizes two large clades: *Hurdia* and *Peytoia* exemplify a group in which the frontal appendages bear long ventral spines with pectinate auxiliary spines, whereas *Anomalocaris* and *Amplectobelua* belong to a second clade in which frontal appendages have short ventral spines. Re-examination of several controversial specimens has helped clarify enigmatic features of their morphology, enabling or prompting changes to coding of internal and external morphology. *Parapeytoia*, a Chengjiang taxon previously identified as an anomalocaridid with biramous gnathobasic limbs, is removed from Radiodonta and placed more crownward in the euarthropod stem-lineage. As has been suggested in other recent analyses, the Devonian *Schinderhannes*, previously interpreted as an upper stem-lineage arthropod, is instead an anomalocaridid in the clade with *Hurdia* and *Peytoia* based largely on appendage morphology. Re-examination of a full-body specimen of *Peytoia nathorsti* from Utah reveals that this animal has the gut diverticulae and preservation of musculature seen in *Anomalocaris canadensis*. Specimens from different localities are distinguished by unique preservation styles that each reveals details not necessarily seen elsewhere, and taken together this information allows for a highly detailed understanding of the morphology and phylogenetic relationships of the anomalocaridids.

UNDERSTANDING THE EARLY PHANEROZOIC TAPHONOMIC WINDOW: BURGESS SHALE-TYPE PRESERVATION, SEAWATER CHEMISTRY, AND THE CAMBRIAN EXPLOSION

Robert R. Gaines[1]

1. Geology Department, Pomona College, 185 E. Sixth St., Claremont, CA, 91711 USA.
robert.gaines@pomona.edu

Burgess Shale-type fossil assemblages provide a unique record of animal life in the immediate aftermath of the Cambrian explosion. While most soft-bodied faunas in the rock record were preserved via mineral replication of soft tissues, Burgess Shale-type preservation involved the conservation of whole assemblages of soft-bodied animals as primary carbonaceous remains, often preserved in extraordinary anatomical detail. It has long been recognized that the Cambrian is enriched in fossil lagerstätten relative to other intervals of geologic time. The signal of this early Phanerozoic 'Taphonomic window' for exceptional fossilization is dominated by abundant and widespread Burgess Shale-type preservation, which occurred on paleocontinents worldwide. This means of preservation resulted from a combination of influences, operating at both local and global scales, which acted to drastically slow microbial degradation in the early burial environment, resulting in incomplete decomposition and in the conservation of soft-bodied organisms, many of which are otherwise unknown from the fossil record. The operation and distribution of this type of exceptional fossilization in space and time was controlled by transient chemical conditions that were pervasive in the oceans during the Cambrian explosion, and by changes in the distribution of marine environments over the continents. Preservation of soft-bodied fossil assemblages required early sealing of the sediment-water interface by seafloor cements that served to isolate the burial environment from overlying seawater. Early seafloor cementation, which was pervasive in Burgess Shale-type deposits found globally, resulted from an elevated flux of continental weathering products to the oceans during the Cambrian and early Ordovician. While chemical conditions conducive to Burgess Shale-type preservation appear to have been maintained through the early Ordovician, Burgess Shale-type preservation declines prominently after the middle Cambrian. This decline coincides with a sharp restriction of outer shelf environments favorable to preservation, which were progressively displaced from continental crust by the expansion of carbonate platforms. Recent discoveries from late Cambrian and early Ordovician strata, however, suggest that Burgess Shale-type preservation persisted through this time interval wherever favorable facies developed. While Burgess Shale-type preservation occurred only under a specific set of local environmental conditions, transient seawater chemistry during the early Phanerozoic was the ultimate control over the 'Taphonomic window'. The enhanced flux of continental weathering products to the oceans, which facilitated early cementation at the seafloor, may also have played a role in stimulating the Cambrian explosion via enhanced delivery of limiting nutrients (Fe, P) to shallow marine environments.

EARLY CAMBRIAN STEM-GROUP CUBOZOANS FROM SOUTH CHINA

Jian Han[1], Shin Kubota[2], Guoxiang Li[3], Xiaoguang Yang[1], Degan Shu[1], Osamu Sasaki[4], Kentaro Uesugi[5] and Tsuyoshi Komiya[6]

1. Early Life Institute and Department of Geology and State Key Laboratory of Continental Dynamics, Northwest University, 229 Taibai Road, Xi'an 710069, China. elihanj@nwu.edu.cn
2. Seto Marine Biological Laboratory, Field Science Education and Research Center, Kyoto University, Shirahama, Nishimuro, Wakayama 649-2211, Japan.
3. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China.
4. Tohoku University Museum, Tohoku University, 6-3 Aoba, Aramaki, Aoba-ku, Sendai 980-8578, Japan.
5. Bioengineering Division, Osaka University Graduate School of Engineering Science, Machikaneyama-cho 1-3, Toyonaka 560-8531, Japan.
6. Department of Earth Science & Astronomy, Graduated School of Arts and Science, Tokyo University, 3-8-1 Komaba, Meguro-ku, Tokyo 153-8902, Japan.

Extant cubozoans are active swimmers and voracious predators characterized by a square shape, four bundles of interradial tentacles and complex eyes in the perradii. A few probable cubozoan fossils have been described from the famous Mazon Creek biota (Pennsylvanian) and the Middle Cambrian Marjum Formation of Utah but earlier possible representatives of the group are rare. Here we studied microscopic embryonic fossils from the phosphatic limestones of the Lower Cambrian Kuanchuanpu Formation in South China using computed microtomography (Micro-CT) and synchrotron radiation X-ray tomographic microscopy (srXTM). These embryonic fossils have numerous diagnostic features of extant cubozoans (e.g. claustrum, gonad-lamella, suspensorium and valarium supported by the frenulum) but also display several original characteristics unknown in the living representatives of the group, typically septum-derived lamellae and well-partitioned gastric pockets. They mainly differ from coeval stem-group scyphozoans in having one or two sets of frenula. However, some of the Lower Cambrian cubozoans are enclosed within a thin, flexible, chitinous periderm comparable to that of extant coronate scyphopolyps. This would indicate sessile habits contrasting with the pelagic lifestyle of modern cubozoans. The interradial arrangment of subumbrellar tentacles represents a synapomorphy for cubozoans. The Lower Cambrian embryonic fossils described herein that lack perradial sense organs most probably belong to the stem-group Cubozoa.

AN ANNELID FROM THE LOWER CAMBRIAN GUANSHAN BIOTA, CHINA

Jianni Liu[1], Qiang Ou[2], Yicheng Wu[1], Jian Han[1], Guoxiang Jiao[1] and Tongjiang He[1]

1. Early Life Institute, State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University, Xi'an 710069, China. liujianni@126.com

2. Early Life Evolution Laboratory, State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China.

The fossil polychaete annelid *Guanshanchaeta felicia* gen. et sp. nov. from the Lower Cambrian Guanshan Biota (Cambrian Series 2, stage 4) is described. The new taxon has a generalized polychaete morphology with biramous parapodia, most of which preserve evidence of chaetae, an inferred prostomium bearing a pair of appendages, and a bifid pygidium. The polychaete *Guanshanchaeta felicia* is the first unequivocal annelid reported from the Lower Cambrian of China. This finding expands the panorama of the Cambrian "explosion" exemplified by the Guanshan biota, which thus hints at a great stock of fossil annelids in the Chengjiang Lagerstätte and the Kaili biota. In addition, this new taxon adds to our knowledge of morphology of early polychaetes, which suggests there was a substantial diversification in polychaete annelids in the Cambrian.

RE-INTERPRETATION OF *OESIA DISJUNCTA* AS A CAMBRIAN ENTEROPNEUST (HEMICHORDATA)

Karma Nanglu[1,2], Christopher B. Cameron[3] and Jean-Bernard Caron[2,1]

1. Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, Ontario M5S 2J7, Canada. karma.nanglu@alum.utoronto.ca
2. Department of Natural History Palaeobiology, Royal Ontario Museum, Toronto, Ontario M5S 2C6, Canada.
3. Département de sciences biologiques, Université de Montréal, Montréal PQ H2V 2S9, Québec, Canada.

The phylogenetic position of the Burgess Shale worm *Oesia disjuncta* is contentious. Previous interpretations have ranged from a polychaete worm, tunicate, problematica, chaetognat and hemichordate. A chaetognath affinity was ruled unlikely, and the most recent hypothesis that it is a possible hemichordate remains unsubstantiated. Here, we redescribe the species using new and unpublished material from the Walcott Quarry as well as abundant and exceptionally well-preserved "oesid" material recently uncovered near Marble Canyon in Kootenay National Park by the Royal Ontario Museum. *Oesia* has a tripartite body plan shared with enteropneusts, with a proboscis, possible collar and trunk with a bulbous posterior end. Compared to another Burgess Shale enteropneust, *Spartobranchus tenuis*, the body of *Oesia* is more robust, shorter and wider. A particular feature of *Oesia* is the presence of thin perpendicular striations along almost the entire length of the trunk. The shape of these striations is consistent with enteropneust gill bars, but their numbers and extent suggest potential alternatives (i.e. possible gut or muscles). Features previously described as lateral fins in the chaetognath interpretation are reminiscent of the genital wings of enteropneusts in the family Ptychoderidae. If *O. disjuncta* is considered to be part of the stem or crown group of ptychoderids, co-existing in the Cambrian with the morphologically simpler enteropneust family of Harrimaniidae, it would push back the fossil record of this family by over 300 million years and provide unambiguous evidence that the two clades diverged earlier in time; the only other known ptychoderid fossil is the Upper Jurassic species *Mesobalanoglossus buergeri.* This re-interpretation has the potential to shed light on the complicated and heavily-debated phylogeny of the enteropneusts, as well as their relationships to other deuterostome phyla.

EXCEPTIONALLY PRESERVED CHENGJIANG FOSSILS RESOLVE EVOLUTIONARY TRAJECTORIES OF BRAIN AND NERVOUS SYSTEM TYPIFYING PANARTHROPODA

Nicholas J. Strausfeld[1], Xiaoya Ma[2] and Gregory D. Edgecombe[2]

1. Department of Neuroscience and Center for Insect Science, University of Arizona. Tucson, USA. flybrain@neurobio.arizona.edu

2. Department of Earth Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

Extant panarthropods comprise the most species-rich taxon, hallmarked by stunning morphological diversity. However, this applies less to their nervous systems. Just four ground pattern organizations typify Onychophora, Tardigrada, Mandibulata, and Chelicerata. When did these ground patterns evolve; how do they relate phylogenetically? The tools of cladistics trace the occurrence of neural characters across Panarthropoda, corroborating the monophyly of each type of central nervous systems, but the timing of their divergences has been impossible to determine. The question may, however, find resolution in the fossil record. Cambrian Lagerstätten provide a novel source of data about brain diversity during early stages of panarthropod radiation. Rare Chengjiang specimens resolve features such as eye structures and sensilla as well as vascular systems, cerebral ganglia, optic lobes, and ventral nervous system (VNS). Such features had been largely overlooked until recently, partly because nervous systems were considered unlikely to be preserved. Despite few previous records, fossilized neural tissue was first taken seriously by a description of the brain and sensory setae from the middle Cambrian arthropod *Waptia fieldensis* and was further clarified by observations of brain and VNS from an earlier Cambrian fuxianhuiid, which demonstrated that 520 million years ago a brain typifying extant mandibulate arthropods already equipped a morphologically simple stem arthropod. The identification of the brain, eyes and VNS in the megacheiran *Alalcomenaeus* sp. demonstrated the coeval presence of the ground pattern of the chelicerate brain and VNS. Subsequent identification of an onychophoran-like brain and pre-protocerebral frontal ganglia in a new Chengjiang anomalocaridid species, in conjunction with data from A*lalcomenaeus*, resolves a long-standing dispute regarding the segmental affinity of "frontal appendages" versus "great appendages," and substantiates some of the cladistic predictions about early brain evolution in Panarthropoda. This talk will review and discuss these discoveries and consider further explorations in a new field of study dubbed neuropalaeontology.

THE PALAEOECOLOGY OF BRACHIOPODS IN THE BURGESS SHALE

Timothy P. Topper[1], Lars E. Holmer[1] and Jean-Bernard Caron[2,3]

1. Department of Earth Sciences, Palaeobiology, Uppsala University, Villavägen 16, SE-75236, Uppsala, Sweden. timothy.topper@pal.uu.se.

2. Department of Natural History (Palaeobiology Section), Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, M5S2C6, Canada.

3. Department of Ecology and Evolutionary Biology, University of Toronto, 25 Willcocks Street, Toronto, Ontario M5S3B2, Canada.

Brachiopods are among the first animal phyla to emerge from the Cambrian explosion, their relative abundance making them one of the most important benthic filter feeders of the Cambrian. Despite representing a significant component of these early marine ecosystems, information regarding their adaptive morphologies and palaeoecology is very limited. One of the best opportunities to investigate these palaeoecological themes is the iconic Cambrian (Series 3, Stage 5) Burgess Shale Lagerstätte in Yoho National Park, western Canada. This remarkable assemblage of soft-bodied brachiopods, exquisitely preserved in life position, provides a means to establish the development of ecological interactions and life strategies at one of the earliest points in the evolution of complex marine benthic communities. Brachiopods are common members of the Burgess Shale community, frequently preserved exhibiting soft-parts, such as slender, flexible pedicles and long, delicate marginal setae. Brachiopods are attached to a variety of substrates, such as sponges (e.g. the cactus-like *Pirania*), disarticulated skeletal elements (e.g. trilobites, hyoliths) and other brachiopod specimens, indicating preservation in life position. Although predominantly attached to other sessile organisms, there are unique examples of brachiopods attached to motile creatures such as the stem-group mollusc *Wiwaxia*, representing the oldest unambiguous example of a facultative ectosymbiosis between a sessile organism and a free mobile benthic animal in the fossil record. There are numerous potential evolutionary advantages of such symbiotic associations, with brachiopods benefiting from ease of attachment, increased food supply, avoidance of turbid benthic conditions, biofoul and possible protection from predators. Brachiopods are also attached at a variety of heights above the substrate, suggesting that the partitioning of nutrient resources and strategies such as tiering, were well established by the 'middle' Cambrian. Brachiopods are usually thought to contribute little to the tiering complexity in the Palaeozoic, however the brachiopod community of the Burgess Shale indicates that brachiopods exploited and developed a more complex ecological structure in Cambrian benthic communities than previously thought.

SOPHISTICATED DIGESTIVE SYSTEMS IN EARLY ARTHROPODS: ECOLOGICAL AND EVOLUTIONARY IMPLICATIONS

Jean Vannier[1], Jianni Liu[2], Rudy Lerosey-Aubril[1], Jakob Vinther[3] and Allison C. Daley[4,5]

1. Université Claude Bernard Lyon 1, Laboratoire de géologie de Lyon: Terre, Planètes, Environnement, UMR 5276 du CNRS, bâtiment Géode, 2, rue Raphaël Dubois, 69622 Villeurbanne, France. jean.vannier@univ-lyon1.fr

2. Early Life Institute, State Key Laboratory of Continental Dynamics, Geology Department, Northwest University, Taibai Road 229, Xi'an, 710069, China.

3. University of Bristol, Departments of Earth Sciences and Biological Sciences, Woodland Road, Bristol, BS8 1UG, UK.

4. University of Oxford, Department of Zoology, South Parks Road, Oxford OX1 3PS, UK.

5. Oxford University Museum of Natural History, Parks Road, Oxford OX1 3PW, UK.

Ecdysozoans (molting animals) including priapulid worms, lobopodians and arthropods have been ubiquitous in marine communities since the Cambrian and are the most successful clade of present-day animals, inhabiting aquatic, terrestrial and aerial ecological niches. Their remarkable and rapid success raises the question of identifying which triggers and factors shaped their early evolutionary history. Studies based on genomic data and fossil evidence from Cambrian exceptional biota suggest a sister group relationship between arthropods and onychophorans (and possibly tardigrades), with at least some lobopodians occupying basal positions in an arthropod stem lineage of Cambrian fossil taxa that depicts the gradual acquisition of arthropod features. Palaeontological evidence has mainly focused on the evolution of external features, such as cephalization, arthrodization, and arthropodization, and discussed the degree to which these served as critical steps in the radiation of arthropods. The recent discovery of nervous and circulatory systems preserved in Cambrian arthropods demonstrates that internal anatomical systems also provide valuable information for understanding character evolution and the timing of otherwise elusive key innovations. Here we collate records of exceptionally preserved, complex digestive organs in new and previously described specimens of early stem group arthropods from the Early Cambrian Chengjiang (*Megadictyon* and *Jianshanopodia,* China) and Sirius Passet (*Pambdelurion*, Greenland) biotas, that have clear functional similarities to structures in modern crustaceans (e.g. branchiurans, phyllosoma larval stage of palinurid decapods) and in a variety of arthropod lineages from the Cambrian (e.g. *Opabinia, Anomalocaris, Isoxys,* naraoiids). Reniform structures acting as gut glands would have increased efficiency of food processing, allowing early arthropods to more easily digest large food particles (macrophagy). As animals themselves evolved and radiated, they created a food source (live prey and carcasses) that require denzymatic breakdown of complex molecules such as proteins and lipids. Acquiring the capability to extract energy from nutrient-rich animal matter more efficiently using specialized digestive organs may have given arthropods the considerable advantage of being able to maintain the higher energy demands of an active and mobile predatory lifestyle. This innovation may have contributed to the evolutionary success of the arthropods by allowing them to exploit more food resources and modes of life. Our study on digestive systems also emphasizes the importance of internal driving factors in the early steps of animal biodiversification.

HOW THE INTRODUCTION OF NEW FEEDING STRATEGIES COULD HAVE DRIVEN THE STRUCTURE OF EARLY CAMBRIAN FOOD WEBS

David Casenove[1]

1. The University of Tokyo, 4F, Bldg 10, Komaba Campus, Meguro-ku, Tokyo, 153-8902 Japan.
dcasenove@aless.c.u-tokyo.ac.jp

The rapid diversification event that occurred at the beginning of the Phanerozoic, known commonly as the "Cambrian Explosion", continues to puzzle paleontologists despite recent advances in the understanding of its possible biotic (genetic/ ecological) or environmental (sea level rise/ erosion of land masses) drivers. It is likely that several of these factors interplayed and are codependent. Among these factors, predation (*sensu lato*) is perceived as a strong biotic pressure shaping interactions between the various components of marine ecosystems as well as explaining the disparity of high-level body plans. In particular, the notion of "arms race" pertains to the increase of morphological disparity related to the complexification of feeding behaviors and notably the appearance of carnivory at the Proterozoic-Phanerozoic transition. Arms races have been described as being the result of either coevolution or escalation at the level of direct predator-prey interactions but such particular circumstances do not reflect the trade-offs experienced in community-wide interaction networks. The structure of food webs has been examined in relation to both predator/prey size ratios and foraging strategies. It appeared from these past studies that marine predators can occupy various trophic positions during their development and therefore that variation of size plays an important role in the distribution of links in food webs. In parallel, the transition from filter feeding to raptorial predation is generally associated with a decrease of the number of weak links which means that consumers tend to become trophic specialist. Therefore, an increase of size combined with the appearance of a diversity of foraging behaviors in the water column at the Proterozoic-Phanerozoic transition could have led to increasingly complex food webs in which predators could have exerted a stabilizing effect on their prey through the implementation of top-down cascades.

WIWAXIA SCLERITES, ACRITARCHS AND OTHER SMALL CARBONACEOUS FOSSILS (SCFS) FROM THE MIDDLE CAMBRIAN OF THE NORTHERN LLANOS BASIN, COLOMBIA: THE FIRST EVIDENCE FOR *WIWAXIA* OUTSIDE OF THE TROPICAL/SUBTROPICAL ZONE

Gareth M. G. Hughes[1], Felipe de la Parra[2], María C. Vargas[2] and Martin R. Smith[3]

1. PetroStrat Ltd., Tan-Y-Graig, Parc Caer Seion, Conwy, LL32 8FA, UK. gareth.hughes@petrostrat.com
2. Biostratigraphy team, Instituto Colombiano del Petróleo-Ecopetrol, AA 4185, Bucaramanga, Colombia.
3. Department of Earth Sciences, University of Cambridge, Cambridge, CB2 3EQ, UK.

The palaeogeographic range of the enigmatic mollusc-like organism *Wiwaxia* has been previously restricted to low latitude middle Cambrian deposits, its distribution reconstructed from recovery of sclerites and articulated body fossils. Here we provide the first documentation of *Wiwaxia* from South America, from the northern Llanos Basin, Colombia, which can be dated on the basis of co-occurring acritarchs to the lowerpart of the Drumian (Series 3 of the middle part of the Cambrian, ~504 Ma, corresponding to the *Ptychagnostus atavus* / *Tomagnostus fissus* Trilobite Zone). These sclerites constitute the first evidence of *Wiwaxia* at high latitudes (and outside the palaeotropics), representing a substantial expansion of *Wiwaxia*'s palaeogeographic range. The specimens, alongside other small carbonaceous fossils (SCFs), including acritarchs, were extracted from washed and dried wellbore cuttings using traditional palynological HF acid maceration techniques optimized for acritarch recovery and analysis. These techniques are routinely used in the hydrocarbon industry to extract palynomorph assemblages, but are typically considered too destructive for SCF recovery. However, we show that these methods confirm the potential suggested elsewhere for the routine recovery of fragile SCFs using standard palynological HF acid techniques, even from washed and dried wellbore cuttings. Furthermore, they allow straightforward calibration of recovered fossils with published acritarch biostratigraphic zonation schemes, and from this, correlation with trilobite zonation schemes. Importantly, wellbore cuttings could now play a key role in documenting the evolution and dispersal of complex animal taxa in the wake of the Cambrian explosion.

RECONSTRUCTING THE DIET OF CAMBRIAN ARTHROPODS: A CHALLENGE MET

Jean Vannier[1], Rudy Lerosey-Aubril[1] and Axelle Zacaï[2]

1. Université Claude Bernard Lyon 1, Laboratoire de géologie de Lyon: Terre, Planètes, Environnement, UMR 5276 du CNRS, bâtiment Géode, 2, rue Raphaël Dubois, 69622 Villeurbanne, France. jean.vannier@univ-lyon1.fr

2. Université de Bourgogne, Laboratoire Biogéosciences, 6, boulevard Gabriel, 21000 Dijon, France.

Reconstructing the diet of 500 million year-old animals presents a scientific challenge with important implications regarding the level of interactivity within early marine communities and the construction of the very first modern-style trophic webs. The exceptional preservation of fossils from several Cambrian Lagerstätten allows us to reconstruct important aspects of the feeding ecologies of early animals with astonishing accuracy, as exemplified by recent studies on carnivorous worms. Here we focus on the most diverse animals within Cambrian ecosystems, the arthropods, and present the first indications of their diets and feeding modes. The feeding ecology of *Sidneyia inexpectans*, an iconic element of the Burgess Shale bestiary, is inferred using three lines of evidence: the structure of its digestive system, an analysis of its gut contents, and the functional morphology of its appendages. The digestive tract of *S. inexpectans* is straight, tubular and narrow in the cephalic and thoracic regions, but stretches to form a large pouch in the abdomen. Anteriorly, four pairs of glands with internal tubular structures open into the digestive tract. These glands have equivalents in various Cambrian taxa (e.g. naraoiids) and modern arthropods. Their most obvious function was to digest and assimilate food. More enigmatic is the abdominal pouch of *Sidneyia* that has never been described in other fossil arthropods but closely resembles the stercoral pocket of some terrestrial arachnids (e.g. Aranea, Solifugae), whose primary function is to store digested food residuals (and excretory material) until defecation. A similar role can be inferred for the pouch-like structure in *S. inexpectans*, which effectively concentrates undigested skeletal elements. Analysis of these gut contents reveals that *Sidneyia* fed primarily on small trilobites and brachiopods. This arthropod was a durophagous carnivore with predatory habits, feeding on small invertebrates that lived at the water sediment interface. *Sidneyia* lacked prehensile frontal appendages. Its living or dead prey were grasped ventrally, macerated into ingestible fragments and conveyed to the mouth through the action of molar-like strongly sclerotized gnathobases positioned near the base of the trunk appendages. The enzymatic breakdown and assimilation of ingested food likely took place within the digestive glands. Undigested elements were transported through the digestive tract into the stercoral pocket. This storage of faeces suggests infrequent feeding. Extant horseshoe crabs provide the closest ecological analogue to *S. inexpectans.*

PEDUNCULAR ATTACHED SECONDARY TIERING ACROTRETOID BRACHIOPODS FROM THE CHENGJIANG FAUNA: IMPLICATIONS FOR THE ECOLOGICAL EXPANSION OF BRACHIOPODS DURING THE CAMBRIAN EXPLOSION

Haizhou Wang[1,2], Zhifei Zhang[1,3], Lars E. Holmer[2], Shixue Hu[4], Xiangren Wang[1] and Guoxiang Li[3]

1. Early Life Institute, State Key Laboratory of Continental Dynamics, Northwest University, Xi'an, 710069, China. elizf@nwu.edu.cn

2. Department of Earth Sciences, Palaeobiology, Uppsala University, Uppsala, 75236, Sweden.

3. LPS, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, 210008, China.

4. Yunan Geological Survey & Yunnan Institute of Geological Science, No. 87, Dongfeng Lane, East Dongfeng Road, Kunming, 650051, China.

Brachiopods are usually thought to contribute little to the tiering complexity from the Paleozoic to the Recent, mainly due to the fact that their recent representatives live primarily in lower tiers directly above or below the water–sediment interface. Here we present the first and oldest record of varied levels of secondary tiering in minute brachiopods attached by exceptionally preserved thread-like pedicles around the branched fronds of the algae-like *Malongitubus kuangshanensis* Hu. The specimens illustrated herein were recovered from the Chengjiang fauna (Series 2, Stage 3) in the Lower Cambrian Heilinpu Formation at the Kuangshan section in Malong County, Yunnan Province, southern China. The micro-morphology and oval outline of the attached brachiopods demonstrate that they can be assigned to acrotretoid brachiopods (Linguliformea, Lingulata, Acrotretoidea), described here as *Kuangshanotreta malungensis* gen. et sp. nov. This is the first report on the occurrence of acrotretoid brachiopods in the Lower Cambrian muddy deposits from southern China. The posterior margins of the *Kuangshanotreta* shells are invariably either in direct contact with, or directed towards, and then in situ attached to the algal frond of *M. kuangshanensis*, indicating a secondary tiering in the ecological structure of Early Cambrian brachiopods. The acrotretoid *Kuangshanotreta malongitubus*/algae association represents both the first and oldest evidence into the enigmatic paleoecology of the diverse acrotretoid linguliformean stock that comprises an important component of the Cambrian evolutionary fauna, and sheds light on medium-high levels of secondary tiering (+ 5 to + 10 cm) Cambrian soft substrate suspension-feeding communities. When compared to other Chengjiang brachiopods, the miniature morphology and concomitant weight reduction of the shell of K. malungensis may be a good adaption to a suspended epifaunal tiering life style. We infer that the diversification of micromorphic and miniaturized acrotretoids that occurred from the Middle Cambrian to Early Ordovician may be the result of the increased availability of habitable surfaces provided by high levels of tiering in new types of ecological spaces.

OLDEST GLOSSELLINE LINGULIFORM BRACHIOPOD WITH SOFT PARTS FROM THE LOWER CAMBRIAN OF YUNNAN, SOUTHERN CHINA

Haizhou Wang[1,2], Zhifei Zhang[1] and Lars E. Holmer[2]

1. Early Life Institute, State Key Laboratory of Continental Dynamics, Northwest University, Xi'an, 710069, China. haizhou.wang@geo.uu.se

2. Department of Earth Sciences, Palaeobiology, Uppsala University, Uppsala, 75236, Sweden.

Lingulella chengjiangensis Jin, Huo & Wang is one of the most abundant brachiopods from the celebrated Lower Cambrian Chengjiang Lagerstätte. A detailed study of abundant new well-preserved specimens clearly shows that their morphology and preserved soft anatomy differs widely from that of the linguliforms of the Subfamily Obolinae, including *Lingulella*. *Lingulella chengjiangensis* is herein re-described as the probable earliest member of the Subfamily Glossellinae, which was previously known only from the Ordovician, and is referred to the new genus *Eoglossa*. *Eoglossa chengjiangensis* differs from species of *Lingulella* in lacking a dorsal pseudointerarea, having an elevated ventral proparea without flexure lines and in the lack of pitting on the visceral areas of both valves. The detail study of the exceptionally preserved specimens of *Eoglossa chengjiangensis* also reveals that it bears a unique musculature, which includes a single umbonal scar and a pair of posterolateral scars on each valve. The material of *Eoglossa chengjiangensis* also permits a more detailed study of the pedicle giving further insights into the early diversification and life habit of the linguliform brachiopods.

OPEN SESSIONS

MACROEVOLUTIONARY STUDY OF THE SYNAPSID MANUS

Fernando Abdala[1,2], Susanna Kümmell[3], Marissa Fabrezi[4] and Virginia Abdala[5]

1. Evolutionary Studies Institute, University of the Witwatersrand, Private Bag 3, WITS 2050, Johannesburg, South Africa. nestor.abdala@wits.ac.za

2. National Research Foundation / Department of Science and Technology, Centre of Excellence in Palaeosciences, University of the Witwatersrand, Johannesburg, WITS 2050, South Africa.

3. Witten/Herdecke University, Germany.

4. Museo de Ciencias Naturales, Universidad Nacional de Salta, Argentina.

5. Instituto de Biodiversidad, CONICET- Universidad Nacional de Tucumán, Cátedra de Biología General, Facultad de Ciencias Naturales e Instituto Miguel Lillo, Argentina.

The road to mammalness is well represented by several fossils, members of the synapsid lineage, whose only living representatives are mammals. The oldest representatives of this lineage are known from 300 million years ago and represented by pelycosaur-grade forms that include the sail-backed *Dimetrodon*. Towards the Middle Permian (~270 millions of years ago) occurred the explosive emergence in the fossil record of therapsids, represented by several fossil lineages, some with a prolific record. These groups depict a comprehensive window into the evolutionary transition of a major lineage. We surveyed most of the evidence known of the manus in the synapsids, trying to identify macroevolutionary patterns represented in the lineage. To this end we assembled a data matrix of 39 characters of the manus and 72 taxa, including members of the 'pelycosaurs' and therapsids, the latter represented by biarmosuchids, dinocephalians, anomodonts, gorgonopsians, therocephalians, non-mammaliaform cynodonts, and basal representatives of mammaliaformes and crown mammals. We mapped the characters in a combined phylogenetic tree constructed in Mesquite®, integrating recent phylogenies of the different lineages of synapsids. There is a strong constraint concerning the number of digits in the synapsid lineage, with only one digger (Jurassic mammaliaform) that shows the loss of one digit. This contrasts with the frequent loss of digits in theropod dinosaurs (including birds) during the Mesozoic. The pattern of the manus is differentiated in the two main clades of 'pelycosaurs', with Caseidae presenting digits III and IV equally long, whereas digit IV is dominant in non-therapsid eupelycosaurs. In therapsids, ectaxony (larger metacarpal IV) is dominant, but lateral paraxony (larger metacarpals III and IV) is present in advanced dicynodonts of large body size. Mammaliaformes have a wide variation in metapodial axony, with at least four different patterns. The phylogenetically most basal record of the mammalian manual digital formula is in tapinocephalid dinocephalians. Absence of mammalian digital formula in therapsids is correlated with the presence of disc-like reduced phalanges in digits III and IV. These types of phalanges are represented in biarmosuchians, an anteosaurid dinocephalian, a basal anomodont, gorgonopsians and three non-mammaliaform cynodonts. The record of the manus in three specimens of the Early Triassic cynodont *Thrinaxodon* shows that these phalanges are constrained in number and location, having one in digit III and one in digit IV. In the contemporaneous cynodont *Galesaurus*, the constraint is relaxed, as one specimen lacks disc-like phalanges, whereas another has one element in digit IV.

THE PEDRA DE FOGO FORMATION (PARNAÍBA BASIN, BRAZIL): A NEW WINDOW INTO EARLY PERMIAN TERRESTRIAL ECOSYSTEMS FROM TROPICAL WESTERN GONDWANA

Kenneth D. Angielczyk[1], Juan C. Cisneros[2], Claudia A. Marsicano[3], Roger M. H. Smith[4], Martha Richter[5], Jörg Fröbisch[6], Christian F. Kammerer[6] and Rudyard W. Sadleir[1]

1. Field Museum of Natural History, 1400 South Lake Shore Drive, Chicago, 60605, United States. kangielczyk@fieldmuseum.org

2. Universidade Federal do Piauí, Bairro Ininga, Teresina, CEP 64049-550, Brazil.

3. Universidad de Buenos Aires, Ciudad Universitaria, Buenos Aires, C1428 DHE, Argentina.

4. Iziko: South African Museum, 25 Queen Victoria Street, Cape Town, 8000, South Africa.

5. Natural History Museum, Cromwell Road, London, SW7 5BD, United Kingdom.

6. Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung an der Humboldt-Universität zu Berlin, Invalidenstraße 43, Berlin, D-10115, Germany.

Permian fossils, including petrified wood, fish, and a fragmentary temnospondyl amphibian, were first discovered in the Pedra de Fogo (PFF) Formation of the Parnaíba Basin in the first half of the 20th century. Beginning in 2011, our team has conducted fieldwork in the PFF to study its age, depositional environments, and vertebrate faunas. The PFF accumulated in a large, shallow intra-continental sag basin. Paleoenvironments preserved in the basin range from a large, shallow epeiric sea to expansive alluvial plains and isolated playas within aeolian dune fields. Biostratigraphic correlations with rocks elsewhere in Brazil and Europe suggest that the PFF is late Early Permian (Kungurian) in age. Chondrichthyians and osteichthyians are the most abundant vertebrate fossils found near the basin's depocenter and include xenacanths, ctenacanths, paleoniscids, dipnoans, and the endemic eugenedontiform *Anisopleurodontis pricei*. The putative archegosaurid *Prionosuchus* also is known from this area. Temnospondyls dominate lacustrine deposits near the basin's eastern margin. The lacustrine assemblage includes a new tupilakosaurid-like dvinosaurian, a new trimerorhachid, and fragmentary remains of a rhinesuchid, the latter representing both the oldest and northernmost occurrence of the clade. The spectacularly preserved dvinosaurian skeleton shows that it was fully aquatic, with internal gills, a long flexible body, and delicate limbs. However, the skeleton is well ossified, and it was likely capable of powerful body movements for penetrating dense aquatic vegetation. The lacustrine community had a multi-level trophic network, with small temnospondyl faunivores, medium-sized temnospondyl and chondrichthyian carnivores, and apex predators like the rhinesuchid and large sarcopterygians. Primary consumers likely consisted of invertebrates and small fish, although these groups are currently unrepresented in the collecting localities. During the Permian, the Parnaíba Basin was located at relatively low southern latitudes. This fact, combined with its age, indicates that the PFF provides a new window into a previously unsampled time and place in the history of Gondwanan terrestrial ecosystems. The phylogenetic placement of the dvinosaurian and the very early occurrence of the rhinesuchid suggest that the Gondwanan tropics were an important cradle for temnospondyl biodiversity. Despite this rich emerging picture, paleontological exploration of the PFF has only begun. There is great potential for significant future discoveries that shed light on a new stage in the history of Gondwanan terrestrial ecosystems.

INSIGHTS ON TAXONOMY, PALEOZOOGEOGRAPHY AND BIOSTRATIGRAPHY OF ALBIAN OSTRACODA (CRUSTACEA) FROM THE SERGIPE-ALAGOAS BASIN, BRAZIL

Lucas S. Antonietto[1,2], Dermeval A. Do Carmo[1] and Gene Hunt[2]

1. Micropaleontology Lab, Institute of Geosciences, University of Brasilia, Darcy Ribeiro Campus, Brasilia, Distrito Federal 70.910-900, Brazil. antoniettols@gmail.com.

2. Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, 10th Street & Constitution Avenue NW, Washington, District of Columbia, 20560-0121, USA.

The Sergipe-Alagoas basin has one of the most complete, exposed lithological successions of the Cretaceous period in the continental margin of Brazil. It captures several phases of the evolution of the South Atlantic Ocean, including rift, gulf and drift. The Aptian-Albian Riachuelo Formation belongs to its gulf phase and it is subdivided into three members: Angico, Taquari and Maruim. Previous studies of this formation and those adjacent led to a finely dated biostratigraphy of the unit. Herein, the main objective is to expand the knowledge about the biodiversity, paleozoogeography and biostratigraphy of ostracodes from the Albian of the Sergipe-Alagoas basin, while reviewing the status of some of its zones and subzones. Thirty-four species were recovered from the present samples: *Cytherella besrineensis* (Bischoff), *Cytherella* sp. 1, *Cytherelloidea btaterensis* Bischoff, *C. knaptonensis* Kaye, *Bairdoppilata comanchensis* (Alexander), *B. pseudoseptentrionalis* Mertens, *Bairdoppilata* sp. 1, *Robsoniella* sp. 1, *Paracypris eniotmetos* Nicolaidis and Piovesan, *Kroemmelbeincypris symmetrica*? (Krömmelbein and Weber), *Liasina* sp. 1, *Bythoceratina amsittenensis* Andreu-Boussut, *B. reducta* (Gründel), *Bythoceratina* sp. 1, *Bythoceratina* sp. 2, *Patellacythere parva*? Weaver, *Phodeucythere*? sp. 1, *Asciocythere*? sp. 1, *Dicrorygmini* sp. 1, *Neocythere pseudovanveeni* (Gründel), *N. tenuis* Kaye, *Aracajuia antiqua*? Rosenfeld and Raab, *A. benderi* Krömmelbein, *Metacytheropteron* sp. 1, *Microceratina* sp. 1, *Microceratina*? sp. 2, *Quasihermanites*? sp. 1, *Protoveenia*? sp. 1, *Reticulocosta* sp. 1, *Brachycythere* sp. 1, *Algeriana*? sp. 1, *Sergipella viviersae* Do Carmo *et al.*, *Isocythereis* sp. 1, gen. et sp. indet. 1 and gen. et sp. indet. 2. Several species are common with faunas from Europe, the Middle East, North America and West Africa, indicating that the ostracods from the Sergipe-Alagoas basin share closer affinities with these distant faunas than with those in closer proximity in the Proto-South Atlantic region, such as the southernmost parts of South America and Africa. Several factors could explain these patterns of faunal similarity, including differences in ecological settings between the areas of the Proto-South Atlantic Ocean at north (arid-tropical) and south (warm temperate) of the Walvis ridge. Taxonomic studies also indicate that the subzone *Veenia guianensis*, in the zone *Aracajuia benderi*, should have its name changed, although it still depends on an ongoing review. The recently found higher diversity of the genus *Bythoceratina*, compared to previous materials from the basin, might also lead to name changes in the subzone '*Patellacythere*' sp. [GA E 27].

PALEOGEOGRAPHIC RECONSTRUCTION BASED ON PALEONTOLOGY: A CASE STUDY FROM THE APTIAN OF THE SOUTH ATLANTIC

Mitsuru Arai[1]

1. Petrobras/CENPES/PDGEO/BPA, Av. Horácio Macedo, 950, Rio de Janeiro, 21941-915, Brazil.
arai@petrobras.com.br, mitsuru.arai@gmail.com

Paleontological data obtained in recent years reinforce the hypothesis that Aptian marine sedimentation in the sedimentary basins of the Brazilian continental margin – except the Pelotas basin, the southernmost Brazilian basin – took place under the domain of waters coming from the north through the Tethys Sea (Central Atlantic). Tethyan waters could reach the basins of the Brazilian continental margin via the seaway then existing in the present-day region of northeastern Brazil. Here there are records in several basins, notably in the São Luís (Codó Formation), Araripe (Codó Formation) and Sergipe (Riachuelo Formation) basins. Despite irrefutable marine evidence~~s~~ – e.g., dinoflagellates, echinoids, foraminifera, molluscs and fishes, conspicuously present in the Araripe Basin – there are very few paleogeographic reconstructions that include the seaway, which is totally ignored in the international literature. The skepticism is even greater in relation to the Tethyan affinity, although the evidence has been well documented by molluscs and dinoflagellates, together with ammonoids in the Sergipe Basin. That skepticism may be due to the fact that, in tectonic and geodynamic terms, the opening of the South Atlantic indeed proceeded from south to north, at least in the part that extends from Argentina to the northeastern Brazilian state of Paraíba. On the other hand, recent geological discoveries have been supporting the “Tethyan Seaway” hypothesis. Among particular examples, we can mention: (1) recognition of Neocomian (ca. 140 Ma) marine sediments on the Romanche Fracture Zone, between northeastern Brazil and West Africa; and (2) recognition of granitic basement in the Rio Grande Rise. The former point shows that the Tethyan waters reached the Brazilian equatorial margin even in the earliest Cretaceous, and the latter point indicates that the physical barrier constituted by the “Microcontinent Rio Grande” effectively inhibited the free exchange of waters between the Pelotas and Santos basins. It is important to state that the putative incoming of Tethyan waters via the “Trans-Saharan Seaway” during this time must be rejected, because the Benoué Trough – the only possible point of communication outside Brazil – lacks any pre-Albian marine sediments. To conclude, this paper shows that the paleogeographic reconstruction (i.e., of paleo-coastlines) does not coincide with the reconstruction of the position of continental blocks with the present contours.

RECOGNIZING THE FIRST PATAGONIAN RODENT RADIATION

Michelle Arnal[1] and María G. Vucetich[1]

1. CONICET; División Paleontología de Vertebrados, Museo de La Plata. Paseo del Bosque s/n, 1900, La Plata, Argentina. michoarnal@fcnym.unlp.edu.ar

The South American fossil record suggests that caviomorphs rodents have been in the continent at least since the middle Eocene, and by the late Eocene – early Oligocene they were already differentiated in the four major clades (Octodontoidea, Cavioidea, Erethizontoidea, and Chinchilloidea) recognized for living species. Although the middle Eocene – early Oligocene caviomorph record is poorly known, this interval is considered a key moment for the evolutionary history of this group. This is inferred from the rich record of the Deseadan South American mammal Age (early – late Oligocene), recently well documented. In this work we performed a phylogenetic analysis for the early caviomorphs classically assigned to the Octodontoidea (including most of the recently described caviomorphs from Cabeza Blanca, late Deseadan of Chubut Province), in order to analyze their relationships with other caviomorphs, and to study the first caviomorph radiation in Patagonia. The analysis shows that the pre-Deseadan evolutionary history of Octodontoidea is still unknown, since its differentiation from the remaining caviomorphs is inferred to have occurred in the late Eocene, being the first undoubtedly recognized octodontoids late Oligocene in age. The analysis corroborates the hypothesis that *Llitun*, *Leucokephalos*, and *Migraveramus* are closely related to each other, forming a clade of Caviomorpha *incertae sedis*, which was very diverse in the Deseadan but left no descendants. Together with this group, the major octodontoid lineages that dominate the early and middle Miocene were also present in the Deseadan. *Acarechimys leucotheae* represents a basal octodontoid lineage closely related to some special basal octodontoids (*Dudumus*, *Caviocricetus*, and *Plesiacarechimys*). The assignation of this species to *Acarechimys* must be studied in a broader context. *Galileomys baios* is one of the most ancient representatives of the Acaremyidae, a clade of pre-Deseadan origin. In this analysis *G. baios* is not directly related to *G. antelucanus*; hence, their relationships must be studied in a broader acaremyid context. The new combination *Ethelomys loomisi* is here corroborated as an independent lineage from *Deseadomys arambourgi*. The analysis indicates that the early evolutionary history of Octodontoidea was characterized by a first radiation in pre-Deseadan times. At least two subsequent radiations, in pre-Chasicoan and pre-Montehermosan ages, apparently lesser in magnitude, led to modern "Echimyidae" and Octodontidae.

TAPHONOMY AND FAUNA OF A FLUVIAL CHANNEL SYSTEM IN THE LATE TRIASSIC OWL ROCK MEMBER, CHINLE FORMATION, ARIZONA, USA

Anna K. Behrensmeyer[1], Robin L. Whatley[2], William G. Parker[3], Suzanne B. McIntire[1] and Jahandar Ramezani[4]

1. Smithsonian Institution, National Museum of Natural History, Washington, D.C., USA. behrensa@si.edu
2. Columbia College Chicago, Chicago, IL, 60605 USA.
3. Petrified Forest National Park, P.O. Box 2217, Petrified Forest, AZ 86028 USA.
4. Department of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA 02139-4307 USA.

The Late Triassic Chinle Formation is widespread in southwestern North America and well known for silicified fossil trees and diverse terrestrial vertebrates. Our research in the Petrified Forest National Park (PFNP) has focused on fossil-bearing lithofacies of the Owl Rock Member, part of the upper Chinle Fm. From 2009-2012, we identified several fossiliferous intervals including a “White Channel Complex” (WCC), which yields abundant remains of phytosaurs, fish, amphibians, theropod dinosaurs, the archosaur *Revueltosaurus*, and the first basal, non-pterydactyloid pterosaur from North America. U-Pb geochronology constrains the Owl Rock Mb. at PFNP to the latest Norian and Rhaetian age within the span of Chinle-aged rocks in the park (ca. 228 to ≤ 208 Ma). The WCC is up to 3 m thick and represents infilling of contemporaneous anastamosing channels by volcaniclastic and reworked siliciclastic sediment including intraformational conglomerate. The WCC can be traced laterally over an area of ~8 km^2, contrasting with over- and underlying redbeds consisting of siliciclastic channel deposits and mudstones with variable paleosol development. The WCC therefore represents unusual depositional circumstances relating to sudden introduction of volcanogenic sediment into an established drainage system. This caused relatively rapid infilling of channels and contributed to preservation of vertebrate remains from animals that inhabited the channels and surrounding floodplain. Because of the highly fragile state of fossils in the WCC, surface collection and field excavation are not effective strategies for specimen recovery, and screen washing also proved destructive, in part because of salt precipitates in the matrix. We used an alternative collection method in which adjacent blocks of fossiliferous matrix were excavated from the WCC and later micro-prepared in the laboratory. A pterosaur dentary with 11 teeth as well as other delicate bones and teeth were discovered using this approach. Bones and teeth preserved in the WCC are typically fragmentary and range from small, fragile limb elements to decimeter-scale remains of archosauromorph crania, armor, and limbs. The assemblage includes highly rounded to pristine bones, scales, and teeth, many with well-preserved morphological detail. This indicates a complex taphonomic history involving early post-mortem biological processes and different scales of physical transport and time-averaging. Some areas of the WCC have multiple superimposed fossiliferous beds with abundant matrix-supported vertebrate remains. The aquatic, terrestrial, and aerial vertebrates of the WCC represent a para-autochthonous, relatively short-term sample of the paleocommunity that inhabited the anastomosing fluvial system.

THE CRINOID *SACCOCOMA* AND THE PELAGIC BIOMICRO-FACIES: A POWERFUL BIOSTRATIGRAPHIC MARKER TO DATE LATE JURASSIC SEDIMENTS IN THE WESTERN TETHYAN REALM

Mohamed Benzaggagh[1], Catherine Homberg[2], Johann Schnyders[2], Sonia Benadesselam-Mahdaoui[3], Saloua Razgallah[3] and Touria Hssaida[4]

1. University Moulay Ismail, Faculty of Science, Department of Geology, BP 11.102, Jbabra, Zitoune, Meknes, Morocco. benzaggagh@gmail.com

2. University Pierre-and-Marie-Curie, ISTeP, UMR 7193, Case 129, 4 place Jussieu, 75252 Paris Cedex 05, France.

3. University Tunis El Manar, Faculty of Science, Department of Earth Sciences, 1060, Tunis, Tunisia.

4. University Hassan II Mohammedia, Faculty of Science, Ben M'Sik, Avenue Cdt Driss El Harti, B.P. 7955, Ben M'Sik 20.800, Casablanca, Morocco.

The study of several hundreds of thin sections, from dozen of outcrops in three different paleogeographic domains: the External Rif Chain (Morocco), the Voconcian Basin (South-East France), and the Northern Tunisia area, has confirmed the importance of the pelagic microorganism associations to date the Late Jurassic deposits. Among those paleontological groups, the crinoid *Saccocoma*, which appears in the middle Oxfordian, show in the three basins a prominent apex at the base of the lower Tithonian substage (*Hybonotum* ammonite zone). *Saccocoma* dominates the pelagic microfauna until the top of the upper Tithonian. The careful examination of the skeletal elements in thin sections of this fossil group, previously considered as without stratigraphic value, allowed to define 47 groups on the basis of their section morphology. Most of these group sections have typical geometric shapes and occur in successive stratigraphic levels in the different investigated basins. Several of these sections are characteristic of a specific time interval, whether by their geometric shape or by their relative frequency. Thus, 7 biozones of the inventoried sections were defined for the upper Oxfordian-upper Tithonian interval. In addition, calcareous dinoflagellate cysts have been used to characterize 10 biozones in the same stratigraphic interval. The protoglobigerines, which are abundant in the upper Oxfordian and at the base of the Kimmeridgian (*Platynota* zone), are rare or absent in younger strata. In the External Rif and in the Northern Tunisian basins, the microfilaments show two levels of abundance, respectively in the *Divisum* and the *Beckeri* zones. They disappear at the top of the latter zone. *Chitinoidella* have been used to characterize the lower Tithonian-upper Tithonian boundary. The calpionellids, which appear at the top of the *Microcanthum* zone, are still abundant within the *Durangites* zone. *Globochaete,* often present, is really abundant only from the base of the lower Tithonian and higher up throughout the Tithonian. The radiolarians show erratic stratigraphic distributions. Using these various fossil groups together and their abundances, 12 biozones of association, well correlated with the ammonite zones have been defined. They correspond respectively to the upper Oxfordian-Kimmeridgian base (*Platynota* zone), the *Hypselocyclum* zone, the *Divisum* zone, the *Acanthicum-Eudoxus* zones, the *Beckeri* zone, the *Hybonotum* zone, the *Darwini-Semiforme* zones, the *Fallauxi* zone, the *Ponti* zone, the *Microcanthum* pro parte zone, the *Durangites* pro-parte zone, and the upper part of *Durangites* zone. This work is a contribution to a better and useful biostratigraphical zonation of the Late Jurassic in Tethyan basins.

SILICICLASTIC-CARBONATE RAMP, A HOSTILE WORLD FOR CARBONATE SHELF FAUNA? THE EXAMPLE OF A MIDDLE AND UPPER DEVONIAN PLATFORM

Arnaud Bignon[1-3] and Catherine Crônier[2]

1. CICTERRA, CONICET and Universidad Nacional de Cordóba, Av. Vélez Sarfield 1611, X5016GCA, Córdoba, Argentina. arnaudbignon@yahoo.fr

2. Université Lille 1, UFR Science de la Terre, UMR8217 GEOSYSTEMES, 59655, Villeneuve d'Ascq Cedex, France.

3. Department of Geology and Geophysics, Yale University, New Haven, CT 06511, USA.

During the Middle and Upper Devonian, the sedimentation on the continental platform of Ardenne Massif changed from a mixed siliciclastic-carbonate ramp (Eifelian), to a carbonate shelf (Givetian), to a detritic influx with local mud-mounds (Frasnian). Due to these changes, this ancient massif represents an open-air laboratory that can be used to understand the mechanics of the carbonate factory. In this study, we tested whether the modification of sediment influx induces a change in the ecosystem, and therefore significantly reorganized the biodiversity. We studied biodiversity fluctuations in trilobites using multivariate analyses. Four communities were identified: one restricted to the Eifelian, another to the Givetian, and two to the Frasnian. The Eifelian community occurs both in the ramp and carbonate (local reef developed on the ramp) facies without any significant difference in composition. The Givetian community occurs preferentially closer to barrier reefs, but persists during short periods of detrital input. The Frasnian communities show a strong relationship with their environment; one is found only in the reef systems, whereas the other flourishes exclusively in the lateral facies. During the Givetian, the Ardenne platform is characterized by brief comebacks of this mixed ramp. In order to highlight the effects of such environmental changes on the biodiversity, we analysed the distribution of megaguilds in the Mont d'Haurs section (Lower Givetian) through four successive formations. From studied microfacies, seven megaguilds and their associated environment are identified. Results indicate that the reef is well demarked from others carbonate shelf environments, whereas fore-reef, back-reef and ramp environments show no significant differentiation. Moreover, the distribution of megaguilds does not seem to be affected by the comeback of the siliciclastic-carbonate input. Indeed, the multivariate analyses show no particular distinction between the megaguild distribution associated with the carbonate shelf, and those corresponding to the mixed ramp. These studies illustrate that biodiversity fluctuations during the Middle Devonian of Ardenne is mainly a function of sea-level fluctuations, rather than modifications of the platform morphology. In the present case, changes in sedimentary supply do not imply a structural modification of the ecosystem and affect the biodiversity only at the community-type level.

MIDDLE MIOCENE BRACHIOPODS OF BULGARIA: SIGNIFICANCE FOR THEIR RECENT BIOGEOGRAPHY

Maria A. Bitner[1] and Neda Motchurova-Dekova[2]

1. Institute of Paleobiology, Polish Academy of Sciences, ul. Twarda 51/55, PL-00-818 Warszawa, Poland. bitner@twarda.pan.pl

2. National Museum of Natural History, 1, Tzar Osvoboditel bul, BUL-1000 Sofia, Bulgaria.

During the middle Miocene thick marine, extremely fossiliferous sediments were deposited in the Central Paratethys that developed as a relict of the ancient Tethys Ocean at the Eocene/Oligocene boundary and comprised the area from the present-day Austria and Poland to Ukraine, Romania and Bulgaria. Although of low diversity, brachiopods are common fossils in the middle Miocene deposits of the Central Paratethys. They are represented mostly by micromorphic forms, but large terebratulides, while rare, are also present. These associations display clear affinities with those known from the Mediterranean area, due to the fact that until the middle Badenian the Mediterranean, Indo-Pacific and Paratethys formed a system of well-connected basins with biota easily migrating between them. The characteristic feature of the Paratethyan brachiopod associations is the absence of thecideides and paucity of rhynchonellides. The newly discovered brachiopod assemblage from clayey detrital limestone of early Badenian age from north-western Bulgaria, the most southern part of the Central Paratethys, contains nine species belonging to nine genera, i.e. *Discradisca* sp., *Cryptopora lovisati* (Dreger), *Novocrania anomala* (Müller), *Megathiris detruncata* (Gmelin), *Argyrotheca cuneata* (Risso), *Joania cordata* (Risso), *Megerlia truncata* (Linnaeus), *Platidia anomioides* (Scacchi and Philippi), and *Minutella* sp. nov. Like other Paratethyan assemblages it is dominated by megathyrid genera, i.e. *Megathiris*, *Argyrotheca*, and *Joania* while *Discradisca* and *Cryptopora* are rare. The genera *Discradisca*, *Cryptopora* and *Megathiris* are noted for the first time from the Miocene of Bulgaria. The presence of the thecideide *Minutella* makes the Bulgarian assemblage unique among brachiopod assemblages of the Central Paratethys. This Recent genus is known today from the Indo-West Pacific Province and the West Atlantic, and its occurrence in the Miocene of the Paratethys explains well (similarly as in the case of *Discradisca*) the disjunct recent distribution of this genus as a Tethyan legacy.

NEW INSIGHTS INTO FUNCTION, BIOGEOGRAPHY AND EVOLUTIONARY HISTORY OF *LATONIA* BASED ON *LATONIA NIGRIVENTER* OSTEOLOGY STUDY

Rebecca Biton[1], Renaud Boistel[2], Vlad Brumfeld[3], Rivka Rabinovich[1,4] and Salvador Bailon[5]

1. National Natural History Collections, Institute of Archaeology, Hebrew University of Jerusalem, Jerusalem 91904, Israel. rebecca.biton@mail.huji.ac.il

2. IPHEP, UMR CNRS 7262, Université de Poitiers, 6 Rue Michel Brunet, Pineau, Poitiers 86022, France.

3. Department of Chemical Research Support, Weizmann Institute of Science, Rehovot 76100, Israel.

4. Institute of Earth Sciences, Hebrew University of Jerusalem, Jerusalem 91904, Israel.

5. Département Ecologie et Gestion de la Biodiversité, Muséum National d'Histoire Naturelle, UMR 7209–7194 du CNRS, 55 rue Buffon, CP 55, Paris 75005, France.

The Hula painted frog (*Latonia nigriventer*) is a relict species of a panchronic clade that was widespread in Europe from the Oligocene until the early Pleistocene. In 1996, the Hula painted frog was the first amphibian to have been officially declared extinct by an international commission (IUCN), but it was rediscovered in the Hula Nature Reserve (Hula Valley, Israel) in 2011. Following its reappearance, new morphological and molecular studies were carried out. The results strongly support a conclusion that the Hula painted frog is not a *Discoglossus* species, as previously assigned, but the only living representative of the fossil genus *Latonia*. The genus *Latonia* is well documented and described in the fossil record of Europe and Western Asia. Extant and fossil Pleistocene specimens from the Hula Valley, Israel, were examined using binocular incident-light microscope, X-ray microtomography and 3D visualization. In the paper we will describe the osteological characteristics of *Latonia nigriventer*, and will use them to reconstruct the ecology, evolutionary history and zoogeography of the *Latonia* group. According to the skull characteristics of *Latonia nigriventer* we will highlight *Latonia*'s apomorphies in terms of the skull function. We will also address the suggestion that *Latonia* and the sister group *Discoglossus* both originated from a common ancestor by heterochrony. Based on osteological characteristics of juvenile *Latonia nigriventer* we will try to clarify the evolutionary history of the *Latonia* group. The paper will conclude with references to the zoogeography of *Latonia nigriventer* and the relationship between the different species within *Latonia*: *L. vertaizoni*, *L. seifriedi*, *L. ragei*, *L. gigantea* and *L. nigriventer*.

QUATERNARY PALEONTOLOGY AND THE SIXTH MASS EXTINCTION CRISIS: THE MARIE-GALANTE ISLAND (GUADELOUPE, WEST-INDIES) SQUAMATES AS A CASE STUDY

Corentin Bochaton[1,2], Salvador Bailon[1], Raphaël Cornette[3], Ivan Ineich[2], Anne Tresset[1], Victor Sierpe[1] and Sandrine Grouard[1]

1. Muséum National d'Histoire Naturelle, Département Ecologie et Gestion de la Biodiversité, UMR 7209, 55 rue Buffon - CP 55, 75005 Paris, France. corenboch@gmail.com

2. Muséum National d'Histoire Naturelle, Département Systématique et Evolution, UMR 7205, Laboratoire Reptiles et Amphibiens - 57 rue Cuvier, CP 30, 75005 Paris, France.

3. Muséum National d'Histoire Naturelle, Département Systématique et Evolution, UMR 7205, Plateforme de morphométrie - CP 51, 55 rue Buffon, 75005 Paris, France.

Questions about the reduction of the biodiversity and human impact on the biosphere are some of the main concerns of our modern societies. However, this phenomenon did not wait our awareness, in the 20th century, to begin. In fact, the sub-fossil bone deposits, last remaining evidence of the past biodiversity, tell us that the actual crisis took sometimes roots in older periods. The West-Indies is a perfect area to study these perturbations thanks to the successive occupations of two culturally very different human populations: firstly the fishermen-hunter-gatherer-farmer Amerindians populations, then, since 1492, the European populations. Moreover, the islands are very interesting particular cases to study the biodiversity evolution trough time. Indeed, isolated geographic areas with vulnerable ecosystems which respond fast and strong to every environmental disturbance. This communication will be a study case of a small French Lesser-Antilles island: Marie-Galante (Guadeloupe). We will describe the evolution of the snakes and lizards biodiversity of the island since the late Pleistocene (30,000 BC) until nowadays, using a corpus of 7 sub-fossils deposits. Our main questions will deal with the characterization of the past Marie-Galante biodiversity and the impact on it of two kinds of phenomena: pre-anthropic disturbance like climate evolution during the Holocene/Pleistocene transition and anthropic disturbance with the arrival of Mesoindian then modern populations. To achieve this goal we are identifying the sub fossil squamate remains using traditional descriptive osteology and geometric morphometrics. Our study allows the identification of at least 4 taxa previously unknown on the island and gives information about the endemic or invasive nature of each taxon. It also shows the great stability and richness of the squamate fauna from late Pleistocene to Holocene, during all the periods preceding the first human population arrival. The impact of the Pleistocene/Holocene transition is maybe visible, with the extinction of a very small boid (*Boa* sp.) and perhaps another unidentified snake. With the Mesoindian populations (around 3000 BC), the first alien species (*Leiocephalus* sp. and *Iguana delicatissima*) arrived. Yet, the European colonization increased dramatically the introduction and extinction phenomena and from the 8 taxa present during the Pleistocene only two are still present on the island.

PALEOFLORISTIC AND PALEOENVIRONMENTAL ANALYSES OF THE SOROCAYENSE GROUP (TRIASSIC) IN NORTHERN CUYO BASIN, SAN JUAN PROVINCE, ARGENTINA

Josefina Bodnar[1,2], Ari Iglesias[2,3] and Carina Colombi[2,4]

1. División Paleobotánica, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n°, La Plata, B1900FWA, Argentina. jbodnar@fcnym.unlp.edu.ar

2. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.

3. Instituto de Investigaciones en Biodiversidad y Medioambiente (INIBIOMA), Universidad Nacional del COMAHUE-CONICET, Quintral 1250, San Carlos de Bariloche, R8400FRF, Argentina.

4. Área Paleontología, Instituto y Museo de Ciencias Naturales, Av. España 400 norte. San Juan, 5400, Argentina.

The infill of the northern Cuyo Basin (west-central Argentina) is arranged into the Rincón Blanco and Sorocayense Groups. In this study we propose a new sequence-stratigraphy of the Sorocayense Group, reinterpret the paleoenvironments, and analyze the floristic composition of fossiliferous levels. On the basis of the new information, we adjust the geological correlation and age of the lithostratigraphic units. We defined three tectosedimentary sequences. The Basal Sequence is represented by pyroclastic flows, alluvial fans and ephemeral fluvial systems. The Middle Sequence, including the Barreal and Cortaderita formations, is characterized by sediment gravity flow deposits and gravel-sand meandering, anastomosed and sandy braided fluvial systems, with the development of ponds/lakes, vertisols and calcisols. The Upper Sequence, comprising the Cepeda Formation, was deposited by distributary alluvial and ephemeral fluvial systems. We recognized eleven fossiliferous strata (EF), all of them identified in the Middle Sequence: EF1 and EF2 in the Barreal Formation, EF3-EF7 in the lower section of the Cortaderita Formation, and EF8-EF11 in its upper section. EF1 is constituted by corystosperm stumps, equisetacean axes and osmundacean leaves. EF2 bears leaves of Dipteridaceae (*Dictyophyllum* spp.), Ginkgoales (*Saportaea* spp.) and Corystospermaceae (*Zuberia* spp.). EF3 contains trunks and leaves of Corystospermaceae (*Rhexoxylon cortaderitaense, Johnstonia stelzneriana*), equisetacean axes, and leaves of Dipteridaceae. The EF4, EF5, EF6 and EF7 are characterized by the presence of Corystospermaceae (*R. cortaderitaense, Zuberia* spp., *Dicroidium* spp.), Peltaspermaceae (*Scytophyllum bonettiae, Lepidopteris stormbergensis*), Cycadales (*Pseudoctenis* sp.), Ginkgoales (*Sphenobaiera* spp.), Coniferales (*Cupressinoxylon zamunerae*) and Gnetales (*Yabeiella* spp.). EF8 is distinguished by the occurrence of Corystospermaceae (*Dicroidium* spp.), Peltaspermaceae (*S. bonettiae, L. stormbergensis, Pachydermophyllum papillosum*), Ginkgoales (*Sphenobaiera argentinae*) and Gnetales (*Yabeiella* spp.). EF9, EF10 and EF11 only show corystosperm fossils (*R. cortaderitaense*). Previous authors assigned the Barreal Formation to the early Middle Triassic CSD Biozone; the lower section of the Cortaderita Formation to the late Middle Triassic MBC Biozone and the upper section of the Cortaderita Formation to the Late Triassic OL Biozone. However, the paleofloras here studied exhibit diagnostic elements of MBC Biozone (i.e. *Yabeiella mareyesiaca, S. bonettiae, R. cortaderitaense*) in both sections of the Cortaderita Formation, and permit to assign them to the Middle Triassic. Correlations between the Sorocayense and the Rincón Blanco groups allow us to infer that: the Basal Sequence was accumulated during Early to Middle Triassic, the Middle Sequence is Middle Triassic in age and the Upper Sequence was deposited in the Late Triassic.

RELATIONSHIP BETWEEN ALISITOS ARC AND BISBEE BASIN EARLY CRETACEOUS CORAL FAUNAS SUGGESTS A MARINE COMMUNICATION IN NORTHWESTERN MEXICO

Oscar A. Bonilla González[1] and Hannes Löser[2]

1. CICESE, Carretera Ensenada-Tijuana 3918, Ensenada, 22860, Mexico.
obonilla@cicese.edu.mx

2. ERNO-UNAM, L.D. Colosio y Madrid S/N, Hermosillo 83250, Mexico.

During the Early Cretaceous, northwestern Mexico was characterised by the presence of a convergent margin between the Farallon oceanic plate and the North American continental plate. (Alisitos arc north and Guerrero composite terrane south). On the east side of what now would be the Peninsular Range batholith, then composed by a Palaeozoic-Mesozoic assemblage previously accreted, the Bisbee Basin (south-eastern Arizona and north-eastern Sonora) records sedimentation (fluvial deltaic to shallow marine; Bisbee Group) from Late Jurassic to Early Cretaceous times, originated by the north-west extensional faulting related to the opening of the Gulf of Mexico. Communication between both areas is disputed and not proven. Both the Alisitos Formation and the Bisbee Group encompass shallow marine Albian coral faunas. The coral fauna from the Bisbee Basin is well documented, but the Alisitos fauna was so far unknown. The taxonomic composition of the Alisitos coral fauna was determined and compared to other Early Cretaceous faunas world-wide. Almost 200 coral samples were taken from 13 localities of several limestone, sand, shale, marl, tuff and volcanic conglomerate layers from two sections (Arroyo La Cueva and Punta San Isidro), ca. 150 km south of Ensenada, Baja California. Coral specimens were prepared for thin sections in transversal and longitudinal orientations. Taxonomic classification until genus level is mainly based on the description of the principal skeletal elements, but species differentiation is based on a quantitative process measuring various morphological elements. The morphometric study was carried out using cluster analysis by checking the new findings against existing data of a sample database with corresponding morphometric data of type material. The Alisitos fauna is composed of 24 genera and 55 species. In comparison with other coral faunas, by presence/absence correlation and multi-dimensional scaling (MDS) visualisation, the Alisitos fauna shows the strongest affinities with the Bisbee Group coral faunas. It shares, moreover, the same pattern, *e.g.* a reduced set of genera and the absence of certain key families that are present in central Mexico. This relationship between the Bisbee Basin and Alisitos Arc coral faunas suggests a marine communication between mainland basins related to the opening of the Gulf of Mexico and the western margin of North American plate, at least, until Albian times.

EARLY–MIDDLE MIOCENE HIGH LATITUDE IGUANID LIZARDS

Santiago Brizuela [1] and Adriana María Albino[1]

1. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)-Departamento de Biología, Universidad Nacional de Mar del Plata, Funes 3350, B7602AYL Mar del Plata, Argentina. brizuela@mdp.edu.ar

The Santa Cruz Formation (early–middle Miocene) in the Santa Cruz province (Argentina) has produced an important and diverse high latitude (>50° S) squamate fauna. These squamates include colubrid snakes, and teiid and iguanid lizards from different localities: Killik Aike Norte, La Cueva, Monte León, and Monte Observatorio. Among the iguanids, only those from La Cueva have been briefly described by Ameghino as the extinct genus "*Erichosaurus*" with three recognized species. The validity of this genus and corresponding species has later been challenged. The better conserved and more systematically informative of these fossils remains are a maxilla (MACN A 2272) and a dentary (MACN A 5807). The maxilla presents a weak palatine process, a dorsally shallow premaxillary process, a dorsally flat posterior process with no jugal buttress, and absence of a labial offset dorsal to the posterior teeth. The dentary presents an extended fusion of Meckel's canal, an extended intramandibular septum with no lamella, an anteriorly extended splenial, and a coronoid without a developed anterolateral process. The dentition in both maxilla and dentary is pleurodont, with tricuspid teeth whose lateral outlines (mesial and distal) are parallel. The overall morphological homogeneity of these fossil remains and the particular combination of characters suggest affinities with Leiosaurini (Polychrotinae). Similar character states are also present in an unpublished partial hemimandible from a different site (Killik Aike Norte) further south in the province of Santa Cruz. This latter fossil differs slightly from the material of La Cueva in size and in the shape of the splenial. Other, poorly preserved materials from the localities Monte León and Monte Observatorio, also from the province of Santa Cruz, present characters compatible with Polychrotinae or Tropidurinae lizards, or cannot be distinguished from either. At the moment, there is no clear evidence to support the presence of an extinct iguanid lizard genus in the early–middle Miocene of the Santa Cruz Formation. The accompanying squamate fauna of colubrids and teiids suggests that the environment of the Santa Cruz Formation was warmer and probably more humid than that of today. Although extant colubrids and teiids do not extent, respectably, beyond parallels 44°S and 40°S, iguanids are presently well represented in Santa Cruz province.

THE TOMMOTIIDA – NEW INSIGHTS INTO AN ENIGMATIC GROUP OF EARLY CAMBRIAN LOPHOTROCHOZOANS

Glenn A. Brock[1], Christian B. Skovsted[2], Timothy P. Topper[3], Lars E. Holmer[3], Marissa J. Betts[1]and John R. Paterson[4]

1. Department of Biological Sciences, Macquarie University, Sydney, 2109, Australia. glenn.brock@mq.edu.au

2. Department of Palaeobiology, Swedish Museum of Natural History, Box 50007, SE-104 05 Stockholm, Sweden.

3. Department of Earth Sciences, Palaeobiology, Uppsala University, Villavägen 16, SE-75236, Uppsala, Sweden.

4. Division of Earth Sciences, School of Environmental and Rural Science, University of New England, Armidale, New South Wales 2351, Australia.

Tommotiids are the archetypical early Cambrian small shelly fossils (SSF). They represent the first group in the fossil record to produce a multi-component exo-skeleton composed of calcium phosphate. The organophosphatic, cone-shaped sclerites of tommotiids are millimetric in size and usually asymmetrical in shape with approximately equal numbers of sinistral and dextral forms in any collection, although bilaterally symmetrical sclerites are also present in some taxa. Tommotiid sclerites grew by basal/marginal accretion and internal septa are sometimes present. Based on the high variability of sclerites and rare documentation of ontogenetically fused specimens, most taxa are assumed to have built a scleritome made up of multiple sclerites and, in most cases, two or more clearly differentiated sclerite morphotypes can be identified. The systematics, scleritome construction and biological affinity of tommotiids have been extensively debated and to date, five families incorporating 20 genera have been described. Tommotiid taxa are mainly distinguished by the number and types of sclerite morphs and their often strongly developed surface sculpture. A large proportion of known taxa are well represented by abundant and exquisitely preserved material in lower Cambrian rocks of South Australia. In recent years, detailed investigation of tommotiid ultrastructure, geometric form, sclerite growth and the recovery of partially complete skeletal scleritome composites has shed new light on the phylogenetic relationships of this enigmatic group. The first partially articulated tommotiids were discovered in South Australia in the form of *Eccentrotheca helenia* and *Paterimitra pyramidalis*. The scleritome of *Eccentrotheca helenia* was revealed as a slowly expanding tube with a circular cross section constructed through "stacking" of ontogenetically fused sclerite rings. The tube is interpreted to have attached to hard substrates and both *Eccentrotheca* and *Paterimitra* are interpreted as a sessile, filter feeding, stem group lophophorates, strongly linked to the phyla Brachiopoda and Phoronida. Other tommotiids have as many as six distinct sclerite types and subtypes. Such sclerite variation is difficult to accommodate within a tubular (eccentrotheca morph) or bivalved (tannuolinid) scleritome model and these taxa (e.g. *Camenella*, *Lapworthella* and *Dalyiatia*) form a distinctive separate monophyletic tommotiid group known as the "camenellans". This would indicate that the tommotiids, at the very least, represent a paraphyletic group. Whilst details of the camenellan scleritome remain elusive, detailed morphological, ultrastructural and pathological investigation using frontier imaging techniques will help to determine the phylogenetic affinities of this clade and, in so doing, provide another important step in untangling the roots of the lophotrochozoan tree.

THE LATE MIOCENE INITIATION OF THE GREAT AMERICAN FAUNAL INTERCHANGE

Kenneth E. Campbell, Jr.[1]

1. Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, California 90007 USA. kcampbell@nhm.org

South America was an island continent for tens of millions of years during the Cenozoic prior to its being united with North America via a terrestrial link through the Isthmus of Panama in the Neogene. Once established, this terrestrial link facilitated the Great American Faunal Interchange. The interchange has long been considered to be primarily a Plio-Pleistocene event, wherein the establishment of a permanent terrestrial link at ~3.0 Ma allowed North American faunal components to disperse to South America, and *vice versa*. Vertebrates who made the crossing before the Plio-Pleistocene were thought to have done so as survivors of chance ocean-crossing events, that is, as "waifs and strays," or they made the crossing through a Central American island archipelago as "island hoppers." However, new data derived from paleontological discoveries, paleoceanographic research, and molecular divergence time estimates, along with a better understanding as to how North America and South America became linked in the Neogene, support the hypothesis that the Interchange actually began in earnest via terrestrial links in the late Miocene. An initial interchange pulse appears to have occurred as early as during an early late Miocene (Tortonian) sea level lowstand, although this pulse was probably preceded by earlier, individual events. Following the initial intercontinental faunal interchanges, sea level fluctuations probably served to pulse interchange events until a permanent terrestrial link was established at ~5.0 Ma. Early interchange vertebrates followed the Baudo Pathway, a route that took advantage of semi-mountainous terrain that stretched the length of the Panama-Costa Rica Arc long before the permanent emergence of the isthmian lowlands and the complete accretion of the Choco Terrane to Colombia. Further documentation of the late Miocene origination date for the terrestrial connection between North America and South America, and especially a more complete fossil record, will be of some significance to diverse fields of inquiry ranging from paleoceanography to molecular phylogenetics.

MORPHOLOGICAL ANALYSIS OF AN EARLY MIOCENE PALEOFLORA FROM TIERRA DEL FUEGO, ARGENTINA

Nicolás Caviglia[1]

1. Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, IEGEBA (CONICET-UBA), Intendente Güiraldes 2620, C1428EHA, Buenos Aires, Argentina. nicocavi09@gmail.com

The existence of fossil plants in Tierra del Fuego is known since the expedition of Charles Darwin on the Beagle. However, these paleofloras have been poorly studied. A new fossil leaf assemblage recovered from outcrops of the Cullen Formation, north Atlantic coast of Tierra del Fuego, is analysed. The specimens were found in three localities: Cabo Espíritu Santo, Arroyo Beta, and Cañadón de los Mineros. Recent radiometric K/Ar dating of the Cullen Formation produced an age of 19.3±0.7 Ma (early Miocene). Over two hundred pieces were examined. The analysis reveals the presence of fifteen foliar morphotypes. Five of them are related to *Nothofagus* Blume (Nothofagaceae), one to *Araucaria* Jussieu, and one to the Myrtaceae. A paleontological statistics analysis, including this flora and other previously described Miocene Patagonian floras was performed. A strong resemblance (Jaccard similarity index of 31 %) was observed between the Cullen paleoflora and the paleoflora of Barrancas Carmen Sylva, also in Tierra del Fuego. The presence, abundance and diversity of cold temperate taxa (Nothofagaceae), suggest that the early Miocene vegetation of northeastern Tierra del Fuego was alike the extant subantarctic flora.

TIMING IN THE EVOLUTION OF PENGUINS: A TOTAL EVIDENCE APPROACH

Martín Chávez Hoffmeister[1,2], Alastair Tanner[1] and Davide Pisani[1]

1. University of Bristol, Wills Memorial Building, Bristol, BS8 1RJ, UK.
glmfch@bristol.ac.uk

2. Universidad Austral de Chile, Valdivia, Chile.

The living penguins (Sphenisciformes, Spheniscidae) comprise nineteen species of wing-propelled diving seabirds. Their fossil record has revealed numerous Paleogene stem taxa that radiated and dispersed under greenhouse conditions. Nevertheless, modern penguins depend on relatively cold and stable conditions, and rises in sea surface temperature have negative impacts on polar and tropical penguins alike. Phylogenies from combined morphological and molecular data show the Paleogene penguins arranged in a time-congruent gradient leading to crown Spheniscidae, the modern penguins, which represents a clade. However, some aspects regarding the timing of the radiation of modern penguins and their geographical origins remain uncertain. Most molecular clock analyses (MCA) have used external calibrations or a reduced sample for penguins, whereas chronologies in combined phylogenies are mainly based in the stratigraphic range of fossil taxa and the minimization of ghost linages. As a result, molecular chronologies are often in conflict with those obtained from combined data, proposing a much earlier radiation for the crown group and identifying global cooling and the Antarctic ice-sheets as major drivers in their evolution. Only recently, internal calibrations have been used in MCA in order to reconcile both chronologies. These results suggest a more recent origin of modern penguins in agreement with the paleontological evidence; but it also suggests that the Antarctic cooling might have played a role in their diversification. Unfortunately, the positions of some calibrations used in this last analysis are controversial, and the age offered for the crown group root has been biased by a maximum constraint.In order to offer the most comprehensive chronology possible, here we present a Bayesian total-evidence analysis of the phylogeny of penguins. This method allows the incorporation of fossil taxa using morphological characters to infer their placement and calibrating the tree at the same time, avoiding fixing nodes. Our dataset includes over 350 morphological characters scored for 50 fossil and 24 extant taxa, along with molecular data from five nuclear and mitochondrial genes (~6400 bp) for the extant taxa. This integrated analysis also allows us to incorporate the fossil record in our ancestral area reconstructions. Our results change previous chronologies and provide new information on the relation between environmental changes and penguin evolution, both in the past and perhaps also in the future.

A VIRTUAL CRANIAL ENDOCAST OF THE LATE DEVONIAN LUNGFISH, *RHINODIPTERUS*, REVEALED BY TOMOGRAPHY (SARCOPTERYGII: DIPNOI)

Alice M. Clement[1] and Per E. Ahlberg[1]

1. Uppsala University, Norbyvägen 18A, Uppsala, 75236, Sweden.
alice.clement@ebc.uu.se

Lungfish, or dipnoans, are a group of lobe-finned fish with a history spanning over 400 million years, from the Devonian Period to the modern day. They are the closest living sister taxon to the tetrapods, and as such hold a unique position for comparative studies into the evolutionary origin of tetrapod morphology. Most Devonian lungfishes had heavily ossified endoskeletons, whereasmost Mesozoic and Cenozoic lungfishes had largely cartilaginous endoskeletons and are usually known only from isolated tooth plates or disarticulated bone fragments. There is thus a substantial temporal and evolutionary gap in our understanding of lungfish endoskeletal morphology, between the diverse and highly variable Devonian forms on the one hand and the three extant genera on the other. *Rhinodipterus kimberleyensis*, from the Late Devonian Gogo Formation of Australia, presents one of the most derived fossil dipnoan braincases known from which an accurate endocast can be made. Neural endocasts are character rich and can give insight into relative sizes of various regions of the brain. Palaeoneurology, the study of fossil brains and their related neural endocasts, is a field that has greatly benefited from recent advances in tomographic scanning technologies. Here we present the first virtual endocast of any lungfish, and only the third fossil dipnoan endocast illustrated. The endocast of *Rhinodipterus* has numerous similarities to that of *Chirodipterus wildungensis* Gross. In comparison with extant sarcopterygian fish brains, the endocast is reminiscent of the long and narrow brain of the coelacanth *Latimeria*; extant lungfishes have more bulbous forebrains. However, the labyrinth region strongly resembles that of the Australian lungfish *Neoceratodus*. Several trends in the evolution of the inner ears in dipnormorphs are identified and discussed: the narrowing and lengthening of the semicircular canals, the heightening of the superior sinus, and the expansion of the utricular recess.

LIVING + FOSSIL COELACANTHS ≠ LIVING FOSSIL COELACANTHS

Gaël Clément[1], Hugo Dutel[2], Camila Cupello[3], Paulo Brito[3] and Marc Herbin[4]

1. UMR CR2P CNRS-MNHN-UPMC/Paris 6, Département Histoire de la Terre, Muséum national d'Histoire naturelle, 57 rue Cuvier, 75231 Paris cedex 05, France. gclement@mnhn.fr

2. Laboratory for Evolutionary Morphology, RIKEN Center for Developmental Biology, Kobe, Japan.

3. Departamento de Zoología, Universidade do Estado do Rio de Janeiro. Rua Sao Francisco Xavier 524, Maracana, 20559-900, Rio de Janeiro, Brazil.

4. UMR 7179 CNRS-MNHN, Mécanismes adaptatifs des organismes aux communautés, Département Écologie et Gestion de la Biodiversité, Muséum national d'Histoire naturelle, 57 rue Cuvier, 75231 Paris cedex 05, France.

The living coelacanth *Latimeria* is a member of a group of vertebrates first recognized on the basis of fossils and found one century later to be extant. The group was thought to be extinct at the end of the Late Cretaceous (about 70 million years ago). The discovery of a living coelacanth offshore South Africa in 1938 came as a surprise for the scientific community and the public. *Latimeria* was even more sensational since its morphology appeared to be very similar to those of its extinct relatives. As a result, *Latimeria* was rapidly popularized as a 'living fossil'. Moreover, coelacanths were seen at this time as the closest relatives of tetrapods, and *Latimeria* as the direct 'descendant' of a group of sarcopterygian fishes (rhipidistians) supposed to be at the origin of dwelling vertebrates (tetrapods). In this context, the newly-discovered living coelacanth *Latimeria* was expected to allow a better understanding of the biology of rhipidistian fishes and of the fish-tetrapod transition during the Devonian. Since then, the phylogenetic analyses of morphological, molecular, and, more recently, whole genome data have shown that coelacanths are more distantly related to tetrapods than previously thought. Based on comparative anatomy and morphology, it is clear that the long-standing idea of coelacanths as living fossils (notwithstanding the oxymoron itself) is specious and wrong. We will show how paleontology questions the traditional view of coelacanths as a group that has experienced little anatomical and environmental changes throughout its evolutionary history. Then, we will present recent developmental data acquired on *Latimeria* using x-ray synchrotron microtomography, which emphasize the derived features of *Latimeria* and suggest that developmental heterochronies have played a key-role in the early evolution of the coelacanth anatomy.

INTRODUCTION TO MAPCIS, A POSSIBLE END EDIACARAN, EARLY CAMBRIAN IMPACT

Daniel P. Connelly[1]

1. MAPCIS RESEARCH, 4815 Covered Bridge Rd., Millville, NJ 08332 USA.
danielconnelly@comcast.net

This introduction to Massive Australian Precambrian/Cambrian Impact Structure (MAPCIS) will present a synopsis of the research to date for the palaeontological community. The introduction will show the evidence for the impact that has been published by this author and others since 1993. The evidence will include but not be limited to: geomorphology (concentric rings and tsunami deposits), mineralogy (nickel copper & PGEs), stratigraphy and dating (~ 542 Ma), possible impact melt (pseudotachylite breccia collected from impact center), deep subsurface anomalies on magnetic and gravity maps, and post impact rifting with volcanism. An emphasis will be on the possible connections between MAPCIS as an impact event and the Ediacaran extinction as well as the early Cambrian changes that lead to an Earth becoming increasingly hospitable to the development of life.

FLUCTUATING EXTINCTION SELECTIVITY IN GRAPTOLITES FROM VERY HIGH RESOLUTION SURVIVORSHIP ANALYSIS

James S. Crampton[1,2], Roger A. Cooper[1] and Peter M. Sadler[3]

1. GNS Science, P O Box 30368, Lower Hutt, NZ.
J.crampton@gns.cri.nz
2. School of Geography, Environment & Earth Science, Victoria University, P O Box 600, Wellington, NZ.
3. Department of Earth Sciences, University of California, Riverside, California 92521, USA.

Is extinction risk related to time since first appearance of a taxon ("taxon age")? This question is of particular relevance today as extinction rate increases because of human activities, but also because it relates to controls of long-term biodiversity dynamics in general. Based on studies of the fossil record, extinction risk has been inferred generally to be either independent of taxon age (the "Law of Constant Extinction" as in Red Queen evolution) or to be inversely related to taxon age (at least, at the genus level or higher). The latter pattern is assumed to reflect the expectation of increased species richness and geographic range with increased taxon age, properties that are likely to promote extinction resistance. Here we exploit a very high-resolution database of Paleozoic zooplankton to examine extinction selectivity in relation to taxon age. Our data comprise continuous (unbinned) time series of origination and extinction for 1802 of the most common graptoloid species over virtually the entire history of the group (Ordovician-Silurian, 74 m.y.). The time series derive from quantitative biostratigraphic analysis of 518, globally distributed stratigraphic sections, have an average time resolution of 37 k.y., and span several major extinction events including the Late Ordovician Extinction Event. We have examined age selectivity at the species level using logistic regression of cohort age *versus* proportion surviving for multiple cohort survivorship curves that intersect each of many time bins through the Ordovician and Silurian. We have analysed the data using imposed time bins varying from 0.25 m.y. to 1 m.y. in duration; our adopted results are robust to sensitivities related to time-binning protocols. Age-selectivity of extinction can be detected through about half of Ordovician and Silurian time, and occurs in short, sharp pulses separated by intervals during which no selectivity can be detected. During the Ordovician, with minor exceptions, extinction risk was inversely related to taxon age. In contrast, in the late Katian and Silurian, with an extinction rate significantly higher and more volatile than that of the Ordovician, age-selective extinction fluctuated between negative (favouring long-lived species) and positive (favouring short-lived species). The mechanism for this striking pattern is the subject of on-going investigation, but is likely to lie in global patterns of oceanic circulation, nutrient flux and temperature gradients, as previously inferred by us for species richness and extinction rate changes.

THE LUNG OF COELACANTHS (SARCOPTERYGII: ACTINISTIA): AN ANATOMICAL, ONTOGENETIC AND PALEONTOLOGICAL APPROACH

Camila Cupello[1,2], Gaël Clément[2], Marc Herbin[3], François Meunier[4], Hugo Dutel[5] and Paulo Brito[1]

1. Departamento de Zoologia, Universidade do Estado do Rio de Janeiro; R. São Francisco Xavier, 524, Maracanã - Rio de Janeiro - RJ - Cep 20550-900, Brazil. camila.dc@gmail.com

2. UMR CR2P CNRS-MNHN-UPMC/Paris6, Département Histoire de la Terre, Muséum national d'Histoire naturelle, 57 rue Cuvier, 75231 Paris cedex 05, France.

3.UMR 7179 CNRS-MNHN, Mécanismes adaptatifs des organismes aux communautés, Département Écologie et Gestion de la Biodiversité, Muséum national d'Histoire naturelle, 57 rue Cuvier, 75231 Paris cedex 05, France.

4. UMR 7208 CNRS-MNHN, Département des Milieux et Peuplements aquatiques, Muséum national d'Histoire natuelle, CP26, 43 rue Cuvier, 75231 Paris Cedex 05, France.

5. Laboratory for Evolutionary Morphology, RIKEN Center for Developmental Biology, Kobe, Japan.

A lung apparatus was already mentioned on the anatomical description of the first known living species of coelacanths (*Latimeria chalumnae*). Only recently a pulmonary system, composed of large and rounded ossified plates, was formally described in fossil coelacanths. However, the evolutionary history of this system in coelacanths still needs further anatomical, ontogenetic and paleontological studies. This work has as main objective to understand the lung of coelacanths (modern and fossils) by comparing the different ontogenetic stages of this organ and associated structures. Palaeozoic to Mesozoic coelacanths from various localities (marine to brackish and freshwater environments) were examined for comparing the lung structures. Concerning the extant coelacanth *Latimeria chalumnae*, histological analysis of the vestigial lung of adult specimens and three-dimensional reconstructions (from conventional and synchrotron tomography scans and magnetic resonance imaging) of embryos, juvenile and adult specimens were achieved. Some differences between the ossified lungs of coelacanth fossils were observed, as well as important variations between the anatomical structures of the vestigial lungs in different ontogenetic stages of the extant coelacanth *Latimeria chalumnae*.

BONE HISTOLOGY IN ISCHIGAULASTO FORMATION VERTEBRATES: IMPLICATIONS FOR THE ORIGIN OF DINOSAURIAN GROWTH PATTERNS

Kristina Curry Rogers[1], Ricardo Martínez[2], Oscar Alcober[2] and Carina Colombi[2]

1. Macalester College, St. Paul, MN, 55105, USA.
rogersk@macalester.edu

2. CONICET – Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan, San Juan, Argentina.

The Upper Triassic (Carnian-Norian) Ischigualasto Formation yields a vertebrate fauna that records the initiation of dinosaur evolution and includes basal members of the three dinosaurian subgroups (Ornthischia, Theropoda, and Sauropodomorpha). Significantly, the formation also includes a suite of non-dinosaurian tetrapods, including archosauromorphs, crurotarsans, and non-mammalian cynodonts that overlap with or differ from the earliest dinosaurs in body size, diet, and habitat. This wide taxonomic and ecological diversity of vertebrates, combined with the relatively short temporal span of the Ischigualasto Formation (~ 6 my) and well documented paleoenvironmental setting provide the prime context for investigating life history and growth rates across the fauna. In this study, we employ bone histology to test hypotheses that (1) the evolution of elevated growth rates evolved in archosauromorphs before the divergence of distinctive groups (e.g., Crurotarsi); and (2) that dinosaurs exhibited growth strategies that were distinctive (and possibly faster) than those of contemporaneous non-dinosaurian reptiles. Our sample consisted of mid-diaphyseal femoral cross-sections from terrestrial Archosauromorpha (*Scaphonyx),* aquatic Archosauriformes (*Proterochampsa, Chanaresuchus*), terrestrial Crurotarsi (*Sillosuchus, Saurosuchus*, *Trialestes*), terrestrial, potentially omnivorous Sauropodomorpha (*Eoraptor*), carnivorous Theropoda (*Herrerasaurus, Sanjuansaurus, Eodromaeus)*, and terrestrial, herbivorous Cynodontia (*Exaeretodon*). All of the sampled individuals are at the upper limits of known body size for each taxon, with the caveat that some species are known from material with little or no ontogenetic variation. There are not clear or consistent histological patterns among the sampled taxa from a phylogenetic or paleobiological perspective. For example, *Scaphonyx* records highly vascularized primary bone characterized by reticular fibrolamellar bone and a high osteocyte lacuna density punctuated by regularly spaced lines of arrested growth (LAG). In contrast, among sampled Crurotarsi, bone tissue ranges from lamellar to parallel to woven fibred, and is sometimes densely vascularized (*Chanaresuchus*) but is often more sparsely vascularized (*Trialestes*) with peripherally decreasing bone deposition. No bones exhibit an external fundamental system (EFS). Secondary osteons are rare and limited to internal cortex in *Scaphonyx, Exaeretodon,* and *Herrerasaurus.* Other taxa record medullary drift and remodeling in the form of endosteal lamellar bone (*Sanjuansaurus, Eodromaeus*). Of particular note are major transitions in growth pattern. For example, *Proterochampsa* records a pulse of rapid bone deposition with an abrupt change in the outer cortex demarcated by a LAG and subsequent increase in fiber organization and decrease in vascularity/osteocyte lacuna density. Preliminary results suggest that there are few aspects of early dinosaur growth that are distinctive from contemporaneous, non-dinosaurian vertebrates.

THE BADENIAN OYSTERS FROM MORAVIAN COLLECTIONS IN THE CZECH REPUBLIC

Lorenzo De Bortoli[1] and Šarka Hladilová[2]

1. Faculty of Education, Palacky University Purkrabská 2, Olomouc, 77140, Czech Republic.
lorenzo.de@upol.cz

2. Masaryk University, Faculty of Science, Institute of Geological Sciences, Kotlářská 2, Brno, 611 37, Czech Republic.

This work deals with the bioerosion structures in Badenian oysters of the Carpathian Foredeep in Moravia (Czech Republic), from museum collections, particularly regarding their systematics and taphonomic features. The oyster samples (Vlastivědné Muzeum of Olomouc and Muzeum Prostějovska of Prostějov) come from three main areas: Vienna Basin (VB), south part of Carpathian Foredeep in Moravia (SMCF) and middle part of Carpathian Foredeep in Moravia (MMCF); the most representative being Guntersdorf (VB), Luleč (SMCF), Slatinky, Laškov, Hluchov and Myslejovice (MMCF). More than twenty species of oyster taxa are represented in these samples. The oyster assemblage studied includes *Crassostrea gryphoides*, *Hyotissa squarrosa*, *Neopycnodonte navicularis*, *Ostrea crassicostata*, *Ostrea lamellosa*, *Ostrea* cf. *fimbriata*, and *Ostrea* spp. *Crassostrea gryphoides* dominates the assemblage (50%), followed by *Neopycnodonte navicularis* (17%), *Ostrea digitalina* (5%), *Ostrea fimbriata* (4%) and *Ostrea lamellosa* (9%). The oyster shells are well preserved, favored by their resistance to diagenetic processes, particularly in the case of the larger size oysters. The alterations are more evident along the areas affected by bioerosion structures, particularly borings and furrows along the entire extension of their shells with reticular, channel shaped and punctuate structures. The ichnofauna consists of *Entobia*, *Caulostrepsis*, *Meandropolydora* and *Gastrochaenolites*, suggesting the activity of barnacles, sponges, bryozoans, worms, gastropods and bivalves. *Entobia* is the most abundant boring ichnogenus (40-45%) in MMCF, SMCF and BV. Bioerosion structures on the oyster shells are more apparent in the central (zone V) and posterior (zone II) areas on the external side of the valves, and in the ventral area (zone III) on the internal side of the valves. Bioerosion activity could indicate several reworking episodes, related to burial and exhumation.

NEW REMAINS AND PRELIMINARY PHYLOGENETIC RELATIONSHIPS OF *NEUSTICEMYS NEUQUINA* (TESTUDINATA) FROM THE UPPER JURASSIC OF NEUQUÉN BASIN (ARGENTINA)

Marcelo S. de la Fuente[1], Juliana Sterli[2] and Marta S. Fernández[3]

1. CONICET-Museo de Historia Natural de San Rafael. Parque Mariano Moreno s/n, 5600, Mendoza, Argentina. mdelafu@gmail.com
2. CONICET-Museo Egidio Feruglio. Av. Fontana 140, 9100, Trelew, Argentina.
3. CONICET-Museo de La Plata. Paseo del Bosque, 1900, La Plata, Argentina.

Neusticemys neuquina (Fernández and de la Fuente) is a Tithonian sea turtle with an unusual pattern in the manus and pes characterized by a relative elongation of both the forelimb and hind limb, an elongation of pedal digit V, achieved through the elongation of the bones, as well as a moderate hyperphalangy. This species is recorded from lower Tithonian levels (*Virgatosphinctes mendozanus* Biozone) at Cerro Lotena to upper Tithonian levels (*Substeueroceras koeneni* Biozone) at Trincajuera of the Vaca Muerta Formation (Neuquén Province, Argentina). Up to date *N. neuquina* was only known from post-cranial remains of seven specimens, with cranial remains partially preserved in two of them, and with a lower jaw preserved in other two specimens. The discovery of a new specimen at Cerro Lotena (MACN Pv N105) with articulated remains of skull and post-cranium belonging to a subadult specimen enhances the previous knowledge of this species. To start exploring the phylogenetic relationships of *N. neuquina*, it was included in a data matrix built up by 102 characters and 240 taxa. The preliminary analysis suggests that *Neusticemys neuquina* is a stem Testudines closely related to *Solnhofia parsonsi* and *Thalassemys moseri* from the Upper Jurassic of Europe, and *Santanachelys gaffneyi* from the Lower Cretaceous of Brazil.

ECO-MORPHOLOGY OF THE EXTINCT "GIANT WALLABY" *PROTEMNODON*

Wendy den Boer[1], Nicolas E. Campione[1,2] and Benjamin P. Kear[1]

1. Palaeobiology Programme, Department of Earth Sciences, Uppsala University, Villavägen 16, SE-752 36 Uppsala, Sweden. wendy.denboer@geo.uu.se

2. Subdepartment of Evolution and Development, Department of Organismal Biology, Uppsala University, Norbyvägen 18A, SE-752 36 Uppsala, Sweden.

The extinct kangaroo (Marsupialia, Macropodidae) *Protemnodon* roamed the Australian mainland, Tasmania and Papua New Guinea during the early Pliocene to late Pleistocene. Despite their substantial size, which equaled that of the largest modern *Macropus* species, *Protemnodon* has historically been likened to a gigantic "wallaby", an informal term for diminutive macropodids that typically do not exceed ~15 kg. This presumed affinity is based upon dental features, although paradoxically, the elongate proportions of the skull, shortened tail, robust forelimbs, and compact pes are unique amongst macropodoids, and suggests an adaptive preference towards quadrupedal gaits and/or slow "pentapedal" progression employing the tail. Moreover, the low-crowned molar teeth, coupled with long legs and slender neck, additionally infer medium-level canopy browsing. These interpretations, however, are largely speculative and there has as yet been no explicit investigation into the locomotory capabilities of this morphologically distinctive taxon. This study therefore utilized a morphometric approach for reconstructing eco-morphology, with a Principal Component Analysis visualizing proportional measures of femur, tibia, and metatarsal IV length versus femoral circumference from a range of both extinct (12 specimens) and extant (35 specimens) macropodiforms. The results plotted Australian and New Guinean *Protemnodon* species with other large-bodied macropodids, including gigantic Pleistocene sthenurines and *Macropus* spp., along a size-correlated first principal component. Conversely, the second principal component shape vector of *Protemnodon* occupied a discrete morphospace with non-macropodiform australidelphian marsupials that utilize either walking or quadrupedal bounding gaits. This could imply that *Protemnodon* was a kangaroo lineage that regressed its capacity for hopping, and alternatively adopted a lifestyle akin to browsing placental ruminants, but used its hind limbs to rear up and gather forage from low-growing trees and shrubs.

ROCKS FOR CLOCKS: INTEGRATING MOLECULAR CLOCKS AND THE FOSSIL RECORD IN THE ESTABLISHMENT OF EVOLUTIONARY TIMESCALES

Philip C. J. Donoghue[1] and Rachel C. M. Warnock[2]

1. School of Earth Science, University of Bristol, Wills Memorial Building, Queens Road, Bristol, BS8 1RJ, UK. phil.donoghue@bristol.ac.uk

2. Department of Paleobiology, National Museum of Natural History, The Smithsonian Institution, Washington, Box 37012, USA.

Establishing the timescale of evolutionary history has traditionally been the remit of the paleontology but this role has been usurped utterly by molecular biology. Initially, the fossil record provided the gold standard against which the accuracy and precision of molecular clock analyses were measured. Some sense of the confidence of molecular clock estimates can now be derived from the manner in which they are now routinely used to assess the completeness of the fossil record. It is somewhat ironic, therefore, that fossil evidence remains the principal means by which molecular clock analyses are calibrated. However, approaches to fossil calibration have developed dramatically, particularly with the introduction of Bayesian inference into divergence time estimation. The fossil record provides hard minimum time constraints on lineage divergence events. Maximum time constraints are more difficult to establish. The conventional approach is to employ an arbitrary simple mathematical distribution to express the degree to which fossil minima approximate the true date of lineage divergence. Unfortunately, time priors have a pejorative impact upon molecular clock estimates, and the impact of arbitrary time priors is particularly disproportionate to the material evidence on which they are based. Alternatively, qualitative and quantitative approaches have been developed to capture the prior probability of divergence timing based on the frequency of fossil stratigraphic occurrence, fossil preservation/sampling rate, and their relation to variation in sedimentary facies. However, the relative performance of these methods is, like all aspects of divergence time estimation, very difficult to assess since we never know the true time of divergence. To this end, we have developed an integrated simulation approach to evaluating the accuracy and precision of molecular clock analyses.

COMPARING TAXONOMIC AND FUNCTIONAL CHANGE THROUGH TIME IN TERRESTRIAL VERTEBRATE PALEO-COMMUNITIES IN PLIO-PLEISTOCENE NORTHERN KENYA

Andrew Du[1,2], Anna K. Behrensmeyer[3] and Matthew B. Davis[3,4]

1. Hominid Paleobiology Doctoral Program, Department of Anthropology, The George Washington University, 2110 G St., NW, Washington, DC 20052, USA. andrewdu@gwmail.gwu.edu

2. Center for the Advanced Study of Hominid Paleobiology, 2110 G St., NW, Washington, DC, 20052, USA.

3. Department of Paleobiology, Smithsonian Institution, National Museum of Natural History, 10th St. and Constitution Ave. NW, Washington, DC, 20560, USA.

4. Department of Geology and Geophysics, Yale University, 210 Whitney Avenue, New Haven, CT 06511, USA.

The Koobi Fora Formation in northern Kenya produces an abundance of Plio-Pleistocene terrestrial vertebrate fossils, including those of early humans. Decades of geological work, radiometric dating, and accurate stratigraphic correlation in the region have provided excellent stratigraphic age control on the order of 10^5 years. This provides a unique opportunity to study ecological and evolutionary change through time on very fine time scales. Despite this, very few studies have looked at how paleo-communities in this region have changed through time from a taxonomic perspective (e.g., change in number of species), and none have done so from a functional trait perspective (e.g., change in number and distribution of dietary traits, such as carnivore versus herbivore). Our study seeks to remedy this by examining and comparing how fossil terrestrial vertebrate communities in the Koobi Fora Formation change through time taxonomically and functionally. We focus on the time period between 4.3 – 0.7 Ma. Data were obtained from the public Turkana Database which contains 13,548 published records of fossil vertebrate remains. For the taxonomic component of our fossil community analysis, we looked at richness, evenness, and abundance patterns at the species level. For the functional component, we collected data from the literature on six functional variables: body mass, diet, substrate (e.g., whether the organism was terrestrial, aquatic, arboreal, etc.), molar height (i.e., degree of hypsodonty), type of digestion (e.g., ruminant, foregut fermenter, hindgut fermenter), and habitat vegetation cover (e.g., closed, mixed, open). We then investigated how the number and distribution of traits within functional variables changed temporally, as well as conducted multivariate analyses (i.e., non-metric multidimensional scaling) to see how multi-dimensional eco-space shifted over time. Even when accounting for sample size differences using subsampling routines, results show taxonomic and functional community changes do not correspond and follow different trajectories. This may be due to functional community traits reflecting ecosystem functioning while taxonomic attributes reflect the role of historical contingency in community change. This study demonstrates that community response to ecological changes is a complex process, and taxonomic and functional characteristics must both be studied to gain a holistic view of how communities change over time.

MESOZOIC PLANT CUTICLES FROM THE CHINTALAPUDI SUB-BASIN (GANGAPUR FORMATION), PALAR BASIN (SRIPERUMBUDUR FORMATION), AND RAJMAHAL BASIN (DUBRAJPUR FORMATION), INDIA

Sarah Gonçalves Duarte[1], Neerja Jha[2], Harinam Joshi[2], Eliana Tavares[1], Mitsuru Arai[3] and Maria Dolores Wanderley[1]

1. UFRJ, 274, Athos da Silveira Ramos Av., University City, Ilha do Fundão, 21949-916, Brazil. Sarahpalino@yahoo.com.br

2. BSIP,53, University Road, Lucknow, 226007, India.

3. CENPES, 950, Horácio Macedo Av., University City, Ilha do Fundão, 21941-915, Brazil.

The study of fossil plant cuticles in palynological samples recovered from three cored boreholes (A, B, and C), located in the Andhra Pradesh (Gangapur Formation, Chintalapudi Sub-basin, Jurassic-Cretaceous), Tamil Nadu (Sriperumbudur Formation, Palar Basin, Upper Jurassic-lowermost Cretaceous), and Jharkhand (Dubrajpur Formation, Rajmahal Basin, Upper Jurassic-Lower Cretaceous) States, India are presented herein. Cuticles and palynomorphs were extracted by standard palynological practices in the Palynological Laboratory of the Birbal Sahni Institute of Palaeobotany (Lucknow, India). Fossil specimens were examined under a binocular microscope and photomicrographs were taken with a digital camera. Twenty seven morphotypes of fossil cuticles (occasionally presenting stomata, trichomes and secretory structures) and other tissues (*e.g.*, a plicate parenchyma) were recovered. The morphological analysis of cuticles, and associated palynomorphs, reflect the presence of different group of plants (Bennettitales, Coniferales, Ginkgoales, Polypodiales, Pteridospermales). Cuticles display, in occasions, distinct structures (*e.g.*, monocyclic stomata, secretory structures) that allow comparisons with some extant and fossil genera. We conclude that the study of well preserved fossil cuticles, and associated palynomorphs, allow to taxonomic inferences on the composition of the parent floras.

DISENTANGLING ROCK RECORD BIAS, COMMON-CAUSE AND REDUNDANCY IN THE FOSSIL RECORD

Alexander M. Dunhill[1,2], Bjarte Hannisdal[3] and Michael J. Benton[2]

1. Department of Biology and Biochemistry, University of Bath, Claverton Down, Bath, BA2 7AY, UK.
a.m.dunhill@bath.ac.uk

2. School of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol, BS8 1RJ, UK.

3. Centre for Geobiology, Department of Earth Science, University of Bergen, Allegaten 41, N-5007 Bergen, Norway.

The fossil record documents the history of life, but the reliability of that record has often been questioned. Spatiotemporal variability in sedimentary rock volume, sampling, and research effort especially frustrates global-scale diversity reconstructions. Various proposals have been made to rectify palaeodiversity estimates using proxy measures for the availability and sampling of the rock record, but the validity of these approaches remains controversial. Targeting the rich fossil record of Great Britain as a highly detailed regional exemplar, our statistical analysis suggests that a time series of outcrop area contains a signal useful for predicting changes in raw fossil richness, fossil collection counts, and formation counts. In contrast, collection and formation counts are information redundant with fossil richness, characterised by symmetric, bidirectional information flow. If this is true, the widespread use of collection and formation counts as sampling proxies to correct the raw palaeodiversity data may be unwarranted.

PALYNOLOGICAL EVIDENCE OF PALEOGENE–NEOGENE BIOZONAL AGE VARIATIONS IN SOME SECTIONS OF THE MFAMOSING MEMBER, ASU RIVER GROUP, NIGERIA

Joseph K. Ebigwai[1]

1. Department of Botany, University of Calabar, Calabar, Nigeria.
ebijoe4@gmail.com

The Asu River Group, a member of the Lower Benue Trough, is one of the most endowed solid mineral producing areas of Africa. However, published palynological information is scantily known in the area. Eighty-four ditch cutting samples were recovered from two wells of UNICEM Nigeria. Sixty five palynomorph species were recovered (43 pollen grains, 11 spores, and 11 dinocysts, together with acritarchs and other algal specimens). The strata are referred to the Paleogene–early Neogene based on the occurrence of *Retistephanocolpites* spp., *Magnastriatites howardi*, *Foveotricolporites crassiexinus*, *Psilatricolporites benueensis*, and *Cissus quadrangularis*. The Paleogene–Neogene boundary was defined by the first appearance of *Psilatricolporites molnae* and regular subsequent occurrences of *Retimonicolpites pluribaculatus* and *Trichotomosulcites* sp. Two depositional environments, continental and transitional were deduced, based on the relative abundance and diversity of the miospores and marine palynomorphs. Four biozones (A, B, C and D) were defined based on miospore distribution and abundance (especially those of *Monoporites annulatus* and *Zonocostites ramonae*). This study significantly contributed to the palynological knowledge of the Mfamosing Member, Asu River Group, and records the Paleogene–Neogene boundary in these horizons.

EVOLUTION OF THE AGATHIOID LINEAGE (ARAUCARIACEAE)

Ignacio H. Escapa[1], Peter Wilf[2], Santiago Catalano[3], Ari Iglesias[4] and Rubén Cúneo[1]

1. CONICET-Museo Paleontológico Egidio Feruglio, Avenida Fontana 140, Trelew, 9100, Argentina. iescapa@mef.org.ar

2. Pennsylvania State University, University Park, 16802, Pennsylvania, USA.

3. CONICET, Instituto Superior de Entomología, Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Calle Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina.

4. Instituto de Investigaciones en Biodiversidad y Medioambiente INIBIOMA-CONICET, Quintral 1250, San Carlos de Bariloche, 8400, Argentina.

The conifer family Araucariaceae has three extant genera: *Araucaria* and *Agathis*, both known since the 19th century, and *Wollemia*, a monotypic genus discovered twenty years ago in New South Wales. The araucarian genera have a primarily southern distribution, with most of the species endemically distributed in Australasia and Southeast Asia, especially New Caledonia, Australia, New Guinea, Borneo, and New Zealand, and two species of the type genus *Araucaria* endemic to South America. Morphological distinction among *Araucaria*, *Wollemia*, and *Agathis* is clear from numerous vegetative and reproductive features, such as the presence/absence of seed wings, scale ligule, and scale tissues covering the seeds. Phylogenetic relationships among Araucariaceae have been recently inferred from a combination of morphological and molecular features, which strongly support the existence of an “agathioid” clade whose living representatives are *Agathis* and *Wollemia*. *Araucaria* has a diverse macrofossil record that shows a cosmopolitan distribution during the Mesozoic. On the other hand, fossil representatives of *Agathis* and possible *Wollemia* are rare and predominantly confined to impressions and compressions of fragmented vegetative organs from Australia and New Zealand. A number of endemism theories had been developed due to the apparent absence of *Agathis* macrofossils in other Gondwanan regions. However, a well preserved *Agathis* macrofossil species of fully modern aspect, as well as dispersed pollen identical to that found in *Wollemia* and some *Agathis* species (*Dilwynites*), have been recently described from the early and middle Eocene of Patagonia, extending the past distribution of the agathioids greatly. In this presentation we discuss the origin and diversification of the “agathioid” lineage, whose evolutionary history during the Mesozoic has been obscure per decades. Interestingly, although the fossil record indicates that the lineage of *Araucaria* achieved its modern morphology by the early Mesozoic, new early Paleocene (Danian) vegetative and reproductive fossils from Patagonia indicate that the acquisition of the derived features of *Agathis* occurred much later (by the early Eocene) and was not complete even by the early Paleocene. In this context, Araucariaceae may represent one of the best-understood and documented southern conifer families in terms of direct fossil evidence for the character evolution of its main lineages, representing a unique opportunity to test the validity of molecular estimates of divergence times.

ICHNOLOGICAL, PALEONTOLOGICAL AND SEDIMENTOLOGICAL SIGNATURES OF A BASIN-WIDE TRANSGRESSION, MIDDLE MIOCENE PISCO FORMATION, PERU

Raúl Esperante[1], Thomas DeVries[2] and Orlando Poma[3]

1. Geoscience Research Institute, Loma Linda, California 92350, USA. resperante@llu.edu
2. Burke Museum of Natural History and Culture, University of Washington, Seattle, Washington 98195, USA.
2. Facultad de Ingeniería Ambiental, Universidad Peruana Unión, Ñaña, Lima, Peru.

Four basin-wide transgressions are recorded in the thick sequence of mostly siliciclastic sediments of the Pisco Basin in southern Peru. During the last of these transgressions in the middle Miocene, the Pisco Formation was deposited overlying marine siliciclastic sediments of the Chilcatay Formation. For this study, we examined the boundary between the Chilcatay and the overlying Pisco Formation at twenty localities widely distributed across the basin, and we measured in detail fifteen sections of the lower sequence above the boundary. The boundary layer, which marks the onset of the transgression, consists of phosphate pebbles containing numerousigneous boulders (both rounded and subrounded), carbonate-cemented lithoclasts, articulated bivalve shells (*Chione* sp., *Chionopsis* sp., *Eucrassatella ponderosa*, *Miltha* sp., *Glycymeris ibariformis*, etc.), gastropods (*Testallium cepa*, *Ficus* sp., *Olivancellaria* sp.), oyster shells (both fragments and entire shells), barnacles (both clusters and fragments of *Megabalanus*), fragments of petrified wood and charcoal, *Isurus* shark teeth, fish teeth and vertebrae, and abundant marine mammals (mostly disarticulated and articulated skeletons of Mysticete whales). The layer of phosphate pebbles (here called M1) is 5-20 cm thick and the matrix consists of sand, poorly cemented phosphate grains, or carbonate-cemented phosphate pebbles. Both lithoclasts and the phosphate pebbles are poorly sorted and show abundant bioerosion consisting of *Gastrochaeonolites, Caulostrepsis,* and *Trypanites* borings. In some places, isolated and scattered 'reefs' of serpulid polychaete worms also occur. Above this transgressive layer, a bed of fine sandstone was deposited containing *Thalassonoides, Gyrolithes,* and *Skolithos* burrows, characteristic of a *Cruziana* ichnofacies. The body fossil content consists of abundant skeletons of marine mammals, gastropods, bivalves, shark teeth and tree logs. The sedimentary succession continues with a fining-upward sequence of sandstones, siltstones, tuffaceous and diatomaceous siltstones and mudstones, with minor thin-bedded biogenic conglomerates, very thin-bedded phosphate pebbles, igneous boulders, and interspersed with thin-to-medium-bedded volcanic ash. Marine mammal and other vertebrate fossils are abundant throughout the entire sequence. Radiometric dating and mollusk biostratigraphy indicate that the deepening of the basin started in the middle Miocene and continued until the early Pliocene, with a few short intervals of minor regressions represented by very thin to thin layers of either phosphate pebbles with igneous boulders (similar to M1), or very thin to thin layers of pebbles of rip-up siltstones. The excellent degree of preservation and completeness of both marine mammal skeletons and invertebrate fossils indicate that rates of sedimentation must have been very high throughout the basin during deposition of the Pisco Formation sedimentary succession.

FUNCTIONAL MORPHOLOGY OF THE UNUSUALLY LARGE CRINOID STEMS OF *RHABDOCRINUS*? FROM THE UPPER MISSISSIPPIAN SLADE FORMATION, EASTERN KENTUCKY, USA

Frank R. Ettensohn[1] and Donald R. Chesnut, Jr.[2]

1. University of Kentucky, Lexington, Kentucky 40506, USA.
fettens@uky.edu

2. Kentucky Geological Survey, University of Kentucky, Lexington, Kentucky 40506, USA.

Large crinoid stems (pluricolumnals), up to 3 cm in diameter, are common in the crossbedded, oolitic calcarenites of the upper Mississippian (Viséan; middle Chesterian) Tygarts Creek Member of the Slade Fomation from the Appalachian Basin in eastern Kentucky, USA. The stems are round in cross section, crenulated at sutures, and segments of uniform diameter up to 1.5 m in length are known. Stem lumens, moreover, appear to have been infilled with calcite by the crinoids when alive. The stems have never been found with an associated calyx. Although only one stem segment with cirri has been found, the absence of more cirri from the fossil record suggests that the crinoids mostly lived unattached. However, a survey of literature for coeval late Visean crinoids from the Appalachian Basin revealed only one large crinoid with a stem of this size, *Rhabdocrinus largus*. So although only one isolated crown has been found in the basin, the stems probably represent a species of *Rhabdocrinus.* These stem segments are found in rocks that represent high-energy, migrating, oolite shoals. We suggest that these crinoids were ripped up and broken away from any stationary holdfasts or cirri by the high energies on the shoals, and may have been transported with calyces intact. The large stem size, crenulated sutures, and infilled lumens may represent adaptations that allowed the stem segments to act as resistant, short-term anchors on quiet to moderately active shoals. During times of major, high-energy, shoal migration, however, the unattached nature of these crinoids would have allowed them to be moved or perhaps locally broken without the risk of burying the calyx. Hence, the unattached nature of the stems, their ability to break and their large, thick, infilled nature may represent unique crinoid adaptations to life on high-energy, migrating shoals.

AN ATLAS OF BRAZILIAN MICROBIALITES: A VISUAL STANDARD FOR MORPHOLOGICAL DESCRIPTION AND A DOCUMENT OF PALEOPROTEROZOIC TO MODERN BRAZILIAN GEOLOGICAL HISTORY

Thomas R. Fairchild[1], Rosemarie Rohn-Davies[2] and Dimas Dias-Brito[2]

1. Universidade de São Paulo, Rua do Lago, 562, São Paulo, CEP 05508-080, Brazil. trfairch@hotmail.com

2. UNESP–Universidade Estadual de São Paulo, Campus Rio Claro, Brazil.

Supported by Petrobras and the Center for Geosciences Applied to Petroleum – UNESPetro, Rio Claro, Brazil, we are completing an atlas that documents the principal occurrences of Paleoproterozoic to modern Brazilian microbialites - predominantly stromatolites and oncolites. This book provides a visual standard for the description of microbialites and insights into the sedimentary history of Brazil over the past two billion years. Among the oldest Brazilian microbialites are columnar stromatolites in bioherms of 2.1 Ga of Fecho do Funil Formation, post-dating thick BIFs of the Quadrilátero Ferrífero (Minas Gerais). Early Neoproterozoic stromatolites (Vazante and Paranoá groups) in the Brasilia fold belt, central Brazil, may be coeval with occurrences in southeast Brazil (Itaiacoca Group) and on the Congo and West African cratons. Unbranched, conically laminated columnar stromatolites (*Conophyton)* are typical and in Brazil often exhibit an upward-shallowing tendency, with the appearance of branching (= *Jacutophyton*) and changes from conical to more gently convex lamination. Proximal settings are indicated by hummocky-cross-stratified beds of coated grains (including oncoids and microphytolites) and by extensive stratiform stromatolites. Changes in stromatolite morphology may reflect cyclic variations in local or possibly global sea level. Younger Neoproterozoic microbialite successions may be largely monotypical (Bambuí Group and Capiru Formation) or exhibit considerable variation within bioherms (Salitre Formation). Paleozoic continental denudation and peripolar latitudes were unfavorable for microbialites. Microbialites reappear, however, in Permian mixed carbonate-siliciclastic environments of the intracratonic Paraná and Parnaíba basins following Gondwana glaciation, as epeiric seas regressed and desertification of Gondwana began. Restricted conditions are represented by very large elongated stromatolites containing remains of aquatic mesosaurid reptiles along the margin of the same epicontinental sea in Brazil (Paraná basin, Passa Dois Group) and Namibia. Small stromatolites in small complex bioherms and biostromes are commoner in the Brazilian Permian. "Microstromatolites" encrusting shells and intraclasts in the Paraná basin represent recurrent opportunistic colonization of available hard substrates under stressful conditions. Later, as the Southern Atlantic began to open, microbialites, now cropping out in Northeast Brazil, developed in Cretaceous hypersaline continental waters. Thickly laminated, pseudocolumnar stromatolites in the Codó Formation may correlate with supposedly microbial "Pre-Salt" carbonates containing hydrocarbon reserves of southeastern Brazil. Modern mats and stromatolites in the Lake District of Rio de Janeiro provide analogues for ancient microbial carbonates.

VOLCANIC ASH AS A POTENTIAL CAUSE OF MASS KILLS OF CENOZOIC DECAPOD CRUSTACEANS IN ARGENTINA

Rodney M. Feldmann[1], Evin Maguire[1], Silvio Casadío[2] and Carrie E. Schweitzer[3]

1. Department of Geology, Kent State University, Kent, Ohio 44242, USA.
rfeldman@kent.edu

2. Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, Isidro Lobos y Belgrano, Roca, Río Negro 8332, Argentina.

3. Department of Geology, Kent State University at Stark, 6000 Frank Ave, NW, North Canton, Ohio 44720, USA.

Literature documenting the effects of modern volcanic ash falls on terrestrial plants and animals is voluminous; however the impact of ash falls on extant marine organisms is extremely limited. Work known to us refers primarily to recovery assemblages of marine microorganisms rather than describing the fate of benthic communities impacted by an ash fall. Because Andean volcanic activity has had a profound effect on marine and non-marine sedimentary deposits at least since the Cretaceous Period, Argentina is an ideal candidate as an area for defining criteria to test whether ash falls indeed do severely affect benthic organisms. A recent study by us on the decapod fauna of the early Miocene Monte León Formation in Santa Cruz Province provided strong evidence for a mass kill resulting from volcanic emanations. The decapods collected were representatives of *Chaceon peruvianus*, all of whom were fully articulated corpses oriented in a similar direction and all with their anterior regions elevated. The third maxillipeds, the outermost mouthparts, were opened wide and extended outward from the normal, relaxed position. This posture has been interpreted as resulting from suffocation in living crabs, and has been interpreted as suffocation of a large number of *Chaceon peruvianus* by volcanic ash in the Monte León Formation. Stratigraphically above the layer with crabs, the sediments contained less volcanic material and indicated subsequent successional recovery to a normal benthic community. Present study of the Puerto Madryn Formation exposed on Peninsula Valdés, Chubut Province, and anticipated studies in other Patagonian localities, will test the ubiquity of the effect of volcanic ash falls on benthic marine organisms. [Supported by NSF EF-0531670, Graduate Student Senate, Kent State University, and CONICET].

TETRAPOD SWIMMING/WADING TRACES IN LOWER CRETACEOUS MARGINAL-MARINE ENVIRONMENTS FROM PATAGONIA: DISTRIBUTION AND PALEOBATHYMETRIC IMPLICATIONS

Diana E. Fernández[1] and Pablo J. Pazos[1]

1. Instituto de Estudios Andinos Don Pablo Groeber (IDEAN–CONICET). Departamento de Ciencias Geológicas-FCEN-Universidad de Buenos Aires, Ciudad Universitaria, Pabellón II, Buenos Aires, C1428EGA, Argentina.
elizabeth@gl.fcen.uba.ar

During the past few years, the first integrated ichnological/sedimentological research of Lower Cretaceous, marginal-marine units from the Neuquén basin (Northern Patagonia, Argentina) has been carried out. Most of the ichnofossils included in those studies were invertebrate trace fossils. Only some were assigned to vertebrates (non-avian theropod dinosaurs, in particular). The aim of the present work is to communicate the presence of tetrapod swimming traces in two Lower Cretaceous units of this basin, to describe them and to inform of their use as paleobathymetric tools in a case study. The Neuquén Basin contains over 7000 m thick marine and continental deposits of Late Triassic to Paleogene age. The material analyzed in this work comes from two units: the Mulichinco Formation and the Agua de la Mula Member or Upper Member of the Agrio Formation (Mendoza Group). The first unit is a mainly clastic, marine to continental succession of early Valanginian age. Nearby the study area, the Mulichinco Formation comprises clastic and carbonate lithologies that have been interpreted as deposited in non-deltaic, open shallow marine environments. The second unit is a Late Hauterivian–Early Barremian mixed carbonate–siliciclastic marine and marginal-marine succession. In five localities, bi or tridactyl hypichnial marks composed of elongate, parallel, straight to slightly curved ridges were found. Some of the terminations are reflexed. The sets of ridges are 48 mm up to 18 cm in length, and 17 mm up to 9 cm in width. We have previously reported isolated material. Even though the specimens continue to be scarce, it is possible to acknowledge that they are more abundant than previously thought. Some are provisionally assigned to *Characichnos* Whyte and Romano, and are ascribed to the activity of swimming or wading tetrapods of relatively small size. During the last years it has been confirmed that shallow and/or marginal-marine environments where common in the studied units. In levels where the direct sedimentological evidence was inconclusive, the presence of these trace fossils allowed to infer shallower depositional settings.

DIVERSITY AND PALAEOECOLOGY OF EARLY DEVONIAN INVERTEBRATE ASSOCIATIONS IN THE TAFILALT (ANTI-ATLAS, MOROCCO)

Linda Frey[1], Carole Naglik[1], Richard Hofmann[1], Mena Schemm-Gregory[2], Jiři Frýda[3], Björn Kröger[4], Paul D. Taylor[5], Mark A. Wilson[6] and Christian Klug[1]

1. Palaeontological Institute and Museum of the University of Zurich, Karl-Schmid-Strasse 4, Zürich, CH-8006, Switzerland. linda.frey@pim.uzh.ch

2. In memoriam.

3. Faculty of Environmental Science, Czech University of Life Sciences, Kamýcká 129, Praha 6 Suchdol, 16521, Czech Republic.

4. Finnish Museum of Natural History, University of Helsinki, P.O.Box 44 (Jyrängöntie 2), 00014, Helsinki, Finland.

5. Department of Earth Sciences, Natural History Museum, Cromwell Road, SW7 5BD, London, United Kingdom.

6. Department of Geology, College of Wooster, Scovel Hall, 944 College Mall, Wooster, OH 44691, USA.

The Anti-Atlas of Morocco is famous for its highly fossiliferous and well-exposed Palaeozoic rocks. Superb exposures of Early Devonian outcrops and their high abundance of mostly well-preserved fossils yield the possibility of studying faunal associations in their stratigraphic context. We collected five invertebrate associations of Early Devonian age (early Lochkovian to early Emsian) including a very rich Pragian fauna with well-preserved macrofossils from the south-west of Jebel Ouaoufilal (Filon 12) in the Tafilalt. All faunas were examined for alpha diversity and ecospace utilization by identifying the macrofossils, counting their frequencies and grouping them to ecological categories of tiering, motility and feeding behaviour. Quantitative analyses of the data showed a strong increase in diversity from the early Lochkovian to the late Pragian followed by a slightly reduced diversity in the early Emsian in the Taouz area of the Tafilalt. The ecospace use was considerably extended during the Early Devonian and reached its maximum in the early Emsian. Especially, the abundance of benthic organisms was conspicuously high in the Pragian fauna and was significantly decreased in the early Emsian fauna. The increase followed by a decrease in species richness and the expansion of ecospace use may reflect regional environmental changes in the Early Devonian of the Tafilalt. In particular, the fluctuating benthic diversity led to the supposition that changes in oxygen content near the seafloor in combination with sea-level fluctuations occurred. These assumptions are supported by visible changes in the colour of sediments during the Early Devonian of the Tafilalt.

COMPLETENESS OF THE TETRAPOD FOSSIL RECORD ACROSS THE END-PERMIAN MASS EXTINCTION

Jörg Fröbisch[1], Neil Brocklehurst[1], Christian F. Kammerer[1], Antoine Verrière[1,2] and MarcusWalther[1]

1. Museum für Naturkunde Berlin, Leibniz-Institut für Evolutions- und Biodiversitäts forschung, Invaliden straße 43, Berlin, D-10115, Germany. joerg.froebisch@mfn-berlin.de

2. Institut des Sciences de l'Évolution de Montpellier, Place Eugène Bataillon - Université Montpellier 2, Montpellier, F-34095, France.

Our knowledge of the fossil record improves continuously, reflecting a well-documented pattern of biodiversity including several major mass extinctions throughout Earth's history. Nonetheless, it is well known that the fossil record is incomplete and distorted by gaps and biases. To study these phenomena, several means of estimating biodiversity patterns and the completeness of the fossil record have been proposed. To best understand the information carried by the fossil record, it is essential to apply multiple methods, as different measures assess different factors. Here we address the fossil record of major groups of tetrapods across the end-Permian mass extinction, applying a number of different estimation methods for biodiversity and two recently proposed measures of specimen completeness, i.e. the skeletal completeness metric (SCM) and the character completeness metric (CCM). SCM quantifies how complete the known skeletal material is for a taxon, whereas CCM measures the amount of phylogenetic information available for a taxon. Our analysis suggests that biodiversity estimates and completeness of Permian-Triassic terrestrial tetrapods are independent of one another, as they generally lack significant correlation, implying that the observed fluctuations in biodiversity are not driven by variations in completeness of the fossils or by taxonomic practices. Completeness is highest in anomodont synapsids, the most speciose, abundant, and morphologically diverse clade of Permian-Triassic tetrapods. They show a mean completeness over the entire time interval of 73.50%, with scores ranging from 60.12% to 86.63%. Completeness of cynodonts is slightly lower with a mean value calculated over the entire time interval of 50.30%, and scores ranging from 45.66% to 55.94%. The mean completeness of parareptiles through time is also fairly high (45-69%), compared to previously studied tetrapod clades, e.g. Mesozoic birds (37.04%) and sauropodomorph dinosaurs (29.03-40.42%). Clade-specific differences in Permian-Triassic tetrapods reveal no link between body size and completeness, with large-bodied, heavy pareiasaurs being virtually as complete (28-57%) as small, lizard-like procolophonoids (38-60%). However, our study confirms the impact of ecology on the completeness of the fossil record: for example, aquatic mesosaurs are better preserved (CCM and SCM >80%) than terrestrial taxa, the only possible exception being anomodonts. Yet, whether the anomodont pattern results from the unrivalled fossil record of the Karoo Basin or whether it is clade-specific remains to be tested. Finally, tetrapod completeness across the end-Permian mass extinction varies, with only procolophonoid parareptiles showing a decrease, whereas the completeness of anomodont and cynodont synapsids increases across the event.

ON THE STAPEDIAL ANATOMY OF NON-MAMMALIAFORM CYNODONTS

Leandro C. Gaetano[1] and Fernando Abdala[2]

1. Instituto de Estudios Andinos "Don Pablo Groeber" (UBA-CONICET), Int. Güiraldes 2160, Pab. II, Ciudad Universitaria, Ciudad Autónoma de Buenos Aires, C1428EGA, Argentina. lcgaetano@gl.fcen.uba.ar

2. Evolutionary Studies Institute, University of the Witwatersrand, Private Bag 3, WITS 2050, Johannesburg, South Africa.

The stapes is known in several non-mammaliaform cynodonts although it has only been cursorily studied. Here we thoroughly analyze the stapedial anatomy of several basal cynodonts in a phylogenetic framework. Non-mammaliaform cynodonts stapes has two crurae and a stapedial foramen. The fused crurae may extend into medial and/or lateral platforms reducing the stapedial foramen relative size. The presence of straight crurae is the basal condition and the most widespread among non-mammaliaform cynodonts; however, variations of this morphology are recognized in the gomphodonts *Langbergia*, *Trirachodon*, *Exaeretodon*, and some specimens of *Massetognathus*. The anterior crus is more robust than the posterior one in most of the cynodonts analyzed. The opposite situation is registered in *Exaeretodon*, some specimens of *Massetognathus*, *Probainognathus*, and *Morganucodon*. The crurae are subequal in *Scalenodon* and some specimens of *Galesaurus* and *Probainognathus*. A relatively small stapedial foramen is observed in the basal non-mammaliaform cynodonts *Platycraniellus*, *Procynosuchus*, and *Progalesaurus* whereas it is larger in gomphodonts. The stapedial foramen size is highly variable intraspecifically in *Galesaurus* and *Massetognathus*. *Procynosuchus* and *Thrinaxodon* only have a lateral platform, whereas the presence of a single medial platform is synapomorphic of a more derived clade including *Platycraniellus* plus Eucynodontia. *Galesaurus*, *Procynosuchus*, and *Thrinaxodon* share the presence of a lateral ossified portion of the stapes wider than the medial one whereas the opposite situation is synapomorphic of gomphodonts and also observed in *Platycraniellus*. Anterior and/or posterior projections medially and/or laterally are inconsistently present in some of the cynodonts studied. These projections are not related to the insertion of soft tissues as it has been interpreted. Some of the taxa analyzed (*Luangwa*, *Massetognathus*, and *Trirachodon*) bear a delicate flange-like triangular dorsal process on the dorsal surface of the posterior crus pointing dorsally or dorsomedially. Its presence is variable intraspecifically and among closely related taxa. This process cannot be readily homologized with the tympanic process of more basal synapsids. The morphology of the dorsal process is compatible with the insertion of a small ligament or perhaps the stapedial muscle. The presence of a cartilaginous extrastapes contacting a postquadrate eardrum is not supported by the evidence available. The inclusion of characters provided by the stapes in a total evidence data matrix (including cranial, postcranial, and dental characters), showed that they are phylogenetically informative. Our analysis results in a better understanding of the auditory system in basal cynodonts and its evolution, highlighting the variability of the stapedial anatomy, even intraspecifically.

LATE QUATERNARY HISTORY OF LAGUNA LLANCANELO, MENDOZA, ARGENTINA

Adriana García[1], Allan R. Chivas[1], Sabina D´Ambrosio[1,2] and Paul Conolly[1]

1. GeoQuEST, School of Earth & Environmental Sciences, University of Wollongong, NSW 2522, Australia. adriana@uow.edu.au

2. Instituto de Limnología de la Plata, CONICET, UNLP, La Plata, Argentina.

Laguna Llancanelo (35°38´S, 69°08´W) is an ephemeral saline lake located ~400 km south of Mendoza, and ~70 km east of the Andes, developed in the Huarpes depression. The lake is within the Llancanelo and Payunia back-arc volcanic fields, an area characterized by ~800 volcanic eruption sites which have been active between 2 Ma and 7 ka years ago, perhaps also, in more recent times. A multidisciplinary study of sediment cores from the lake is under way, with nine undisturbed long cores up to 10 m long collected in 2010 from the eastern and western margins, and representing at least the last 30 ka (the onset of Marine Isotope Stage 2) of the lake's history. Grain size analyses, X-Ray Diffraction/X-Ray Fluorescence analyses (at least three explosive volcanic events are clearly preserved in the lake) and micropalaeontological analyses (charophytes and plant remains) were performed on three long cores on both margins of the lake. The charophyte association before the Last Glacial Maximum (LGM)(~ 20 ka ago) is represented by oospores and gyrogonites of *Nitella* sp. 1, *Chara contraria*, *Chara* sp. 1 and 2, and oospores of *Sphaerochara* (= *Tolypella* sect. Rothia); this section also holds excellently preserved organic remains of emergent aquatic plants - probably Cyperaceae). During the LGM the species present are almost the same, albeit in different abundances; changing after the LGM to an association of *Nitella* sp. 1 and 2, *Chara vulgaris, Chara contraria* and *Chara* sp. 1. For the pre-LGM, a larger fresh waterbody is indicated by abundant freshwater taxa, and particularly large numbers of *Sphaerochara* sp.; conditions continuing during the LGM. The charophyte association changes before the start of the Holocene with the presence of saline-prone taxa - *Chara halina*, *C. hornemannii* and *Lamprothamnium* sp. -, and the presence of a few *Chara contraria* gyrogonites, indicating more saline and warmer conditions. The Holocene is characterized by increasing aridity, until reaching the present state, with abundant *Chara halina*, *C. hornemannii* and *Lamprothamnium* sp., and few *Chara* sp. 1. The Holocene section contains at least two large evaporative cycles. The hypothesis about the past larger size of the lake, has been proved for at least its pre-LGM stage with the identification of active palaeodrainage channels on the eastern side of the lake (on the western side, the watercourses are still active), while for the Holocene, the lake became substantially drier and subject to periodical subaerial exposure (increasing deflation, gypsum precipitation and higher salinity).

A NEW JURASSIC CHERT DEPOSIT WITH EXCEPTIONALLY PRESERVED PLANTS AND MICROORGANISMS FROM PATAGONIA, ARGENTINA

Juan García Massini[1], Ignacio E. Escapa[2], Diego M. Guido[4] and Alan Channing[3]

1. CONICET-Centro Regional de Investigaciones Científicas y Transferencia Tecnológica (CRILAR), Entre Ríos y Mendoza s/n, 5301 Anillaco, La Rioja, Argentina. massini112@yahoo.com.ar
2. Museo Paleontológico Egidio Feruglio, Av. Fontana 140, Trelew, 9100, Chubut, Argentina.
3. School of Earth and Ocean Sciences, Cardiff University, Wales, CF10 3YE, UK.
4. CONICET-UNLP, Instituto de Recursos Minerales, Calle 64 esquina 120, 1900 La Plata, Buenos Aires, Argentina.

Jurassic geothermally-related chert deposits in the Deseado Massif, Patagonia, Argentina, have been known for some time, but its associated biota has only been recently revealed in a limited number of localities. Here we report the discovery of a complex of Middle-Upper Jurassic epithermal siliceous deposits represented by fossiliferous cherts preserved in distal paleoenvironments within the geothermal system from La Bajada, northwestern Santa Cruz Province, Patagonia. These well exposed deposits represent a series of several distinct chert-bearing localities with different stages of community development. The deposits are in a volcanic setting and contain an exceptionally well preserved multitude of *in-situ* and transported silicified microorganisms and plants from middle latitudes in western Gondwana. The microorganism assemblage contains vegetative and sexual structures of fungi, fungus-like organisms, such as oomycetes, algae and other protists, cyanobacteria, and numerous remains of unknown affinity. Microorganisms are preserved isolated in the chert matrix or directly associated with plants and other organic remains in mutualistic, parasitic and saprotrophic engagements. Also present are crustacean and other arthropod parts and a large number of coprolites, which, along with the microorganisms, further reveal diversity and trophic relationships. The plant assemblage includes disarticulated as well as organically connected conifer, cycad, fern and sphenophyte organs, preserved *in-situ*, in-life position or transported. The assemblage includes numerous isolated sporangia and palynomorphs, such as saccate and monocolpate pollen, which are consistent with the plant taxa identified from larger remains. Paleoecological inferences are consistent with the development of freshwater settings variably influenced by geothermal activity. This record represents a unique window into the evolution and diversification of Mesozoic plant and microorganism biota. It provides base line data for an understanding of the composition, trophic interactions and, ultimately, the structure and dynamics of middle Mesozoic terrestrial ecosystems.

BRYOZOA OF THE UPPERMOST GERSTER LIMESTONE (LATE WORDIAN, PERMIAN), MEDICINE RANGE, NORTHEASTERN NEVADA, USA

Ernest H. Gilmour[1]

1. Eastern Washington University, Department of Geology, Cheney, 99004, USA.
egilmour@ewu.edu

Abundant bryozoas occur in the uppermost 33 meters of the Gerster Limestone (Permian) in a saddle directly east of the main Medicine Range section of the unit in northeastern Nevada, USA. The shaly limestone contains the conodont *Merrilina praedivergens* (late Wordian) that occurs in other sections of the uppermost Gerster Limestone. Five new species of bryozoans belonging to two new genera and three existing genera are described. The existing genera are *Dyscritella*, *Dyscritellina*, and *Ogbinopora*. Other species of bryozoans present were previously described from the Russian Far East; the Murdock Formation of the Leach Mountains of northeastern Nevada; and from the Gerster Limestone of the Medicine Range section. This is the first reported occurrence of *Ogbinopora* in North America. This bryozoan fauna represents a late middle Permian boreal fauna.

CRETACEOUS CONIFERS FROM "EL CHANGO" QUARRY IN CHIAPAS, MEXICO: DESCRIPTION AND A PHYLOGENETIC ANALYSIS

Ixchel González-Ramírez[1], Sergio R. S. Cevallos-Ferriz[1], Helga Ochoterena[2] and David S. Gernandt[2]

1. Instituto de Geología, UNAM, Av. Universidad #3000, Universidad Nacional Autónoma de Mexico, C.U., Distrito Federal, CP 04510, Mexico. ixgon2@ciencias.unam.mx

2. Instituto de Biología, UNAM, Av. Universidad #3000, Universidad Nacional Autónoma de Mexico, C.U., Distrito Federal, CP 04510, Mexico.

One of the major difficulties in studying ancient life is the incompleteness of the fossil record. This problem is particularly important because allometric relationships and organic correlation used to reconstruct ancient plants are poorly understood, making it difficult to achieve accurate fossil plant reconstructions. Currently, this commonly involves comparative and deductive processes that may lack explicit methodology and could lead to subjectivity and non-refutability. Systematic biology also has been criticized with similar arguments; however, this problem was solved through establishing an explicit methodology for comparing data and taxa: cladistics. Employing cladistics as a method for comparison of modern plants has many benefits which could be employed in the same way for fossils. These benefits include: providing a testable method to infer character states present on ancient taxa that cannot be observed directly on the fossils, allowing the reconstruction of ancient plants with more confidence; and enabling the establishment of phylogenetic hypothesis that include fossils together with recent specimens. Conifers are an interesting group that reached their major species diversity during the Mesozoic. Many fossils of conifers have been described all around the world, but only few of them have been reconstructed as whole plants. In the state of Chiapas, Mexico, a Cretaceous quarry named "El Chango" has been recently discovered. A great diversity of fishes, invertebrates, aquatic angiosperms and at least five different types of conifer fossils has been found here. The main goal of this work is to understand the diversity of ancient conifers that lived in Chiapas during Cretaceous times, using the fossil specimens found at "El Chango" quarry. We described the fossils found at the quarry using different methodologies. Conifer fossils correspond with branches from ultimate, penultimate and antepenultimate order, some of them including organic connections. Furthermore, due to the excellent preservation of the cuticle, extraction techniques were applied. We also performed a cladistic analysis that includes sampling of the recent conifers families, with special emphasis on Cupressaceae and Podocarpaceae. The description of these fossils and the use of cladistic analysis enable greater understanding of ancient plants based on comparative biology.

PRESERVATION POTENTIAL OF ORGANIC-WALLED ALGAE IN SHALLOW, FRESHWATER LAKES: A CASE STUDY FROM SOUTH-CENTRAL MISSOURI

Robert D. Haselwander[1] and Francisca E. Oboh-Ikuenobe[1]

1. Missouri University of Science and Technology, 1870 Miner Circle, Rolla, 65401, USA.
ikuenobe@mst.edu

Algae preserved in sediments provide a standard paleolimnological method for reconstructing past ecological conditions in lakes, including trophic status, lake level, and anthropogenic influence. Organic-walled algae, such as desmids and the colonial green alga *Botryococcus* have been used in some paleopalynological studies to derive similar information. The purpose of this study was to document the preservation potential of various algae in shallow lakes, and better model trophic status and anthropogenic impacts. In 2010, a 28.5 cm core from suburban Pine Forest Lake (N37°57’34.6”, W091°42’35.3”) and a 29 cm core from the Bray Area Nature Reserve Lake (N37°55’11.5”, W091°49’41.0”) in the Rolla quadrangle, south-central Missouri (USA), were obtained at a water depth of 1 m and evaluated for algae. Ecological monitoring of these lakes was undertaken over a one-year period, from 2012–2013, with one water sample taken during each season. Mineral acids used for standard palynological processing removed siliceous and calcareous algae (i.e., diatoms and many Synurophytes) from the sediment samples. Neither ultraplankton (algae < 5 μm) nor algae larger than 106 μm were observed. Results from both cores indicate that the green algae *Staurastrum* and *Pediastrum*, and the dinoflagellate *Peridinium* were strongly overrepresented in all sediment samples in comparison to the water samples. *Ceratium* and *Scenedesmus* were underrepresented in the sediments possibly because of poor preservation; however, *Scenedesmus* was only found to occur in Pine Forest Lake. The lakes yielded similar data trends, although Pine Forest Lake recorded a modest increase in algal abundance. Because of their geographical proximity to each other, most variables in the lakes studied (regional hydrology, lithology, climate) are similar. Thus, the moderate increase in algal abundance in Pine Forest Lake sediment and lake water samples is attributed to an anthropogenic mediated increase in trophic status due to lawn maintenance. This study has important implications for algae that are either over-represented or under-represented in sediment samples. For example, *Scenedesmus*, which is often correlated with high nutrient levels, is underrepresented in these sediments, while *Staurastrum*, often associated with relatively low nutrient levels, is over-represented in the sediments. Thus, a sediment sample with a high abundance of *Staurastrum* and a very low abundance of *Scenedesmus* may represent a lake system with a higher nutrient content than expected. When considering algal results in a paleopalynological study, understanding their preservation potential should increase the reliability of interpretations and lead to more accurate reconstructions of the aquatic environment.

ENIGMATIC SILICI-ORGANIC OBJECTS CONSERVED IN EARLY DEVONIAN ECHINODERM LAGERSTÄTTEN OF ARGENTINA AND BOLIVIA

Reimund Haude[1], Rainer Brocke[2], Till Heinrichs[3] and Walter Riegel[1]

1. Geowissenschaftliches Zentrum der Universität, Abteilung Geobiologie, Goldschmidtstr. 3, D-37077 Göttingen, Germany. rhaude@gwdg.de
2. Senckenberg Forschungsinstitut, Sektion Palynologie und Mikrovertebrata des Paläozoikums, Senckenberganlage 25, D-60325 Frankfurt/M., Germany.
3. Geowissenschaftliches Zentrum der Universität, Abteilung Angewandte Geologie, Goldschmidtstr. 3, D-37077 Göttingen, Germany.

Small silici-organic objects (SOs) of unknown origin occur locally in two Lower Devonian siliciclastic successions, which are geographically rather widely separated: the Talacasto Formation in the Argentinian Precordillera, and the Icla Formation in the Bolivian Eastern Cordillera. These SOs are uniquely associated with several obrution Lagerstätten of well-preserved parautochthonous echinoderms, and have not been observed, so far, in the highly bioturbated mudstones representing the background sedimentation of the two series. They are either irregularly sheet-like but mostly discoid in shape and consistently oriented parallel to the bedding. The wall is hard and bright completely enclosing dark contents. Qualitative EDX analyses show that the wall consists of silica (SiO_2), while the contents are organic (C). In discoid SOs with diameters of 0.2-7 mm the wall thickness varies proportional to the diameter. The internal surface of the wall is generally smooth, but some specimens show a pitted pattern reflecting the pustulous surface of the dark contents. In some cases the pits are separated by faint fissure-like lines implying a polygonal cellular structure of the contents. Some SOs are deformed by contiguous objects (e.g. shells and echinoderm skeletons), and compaction. All observations suggest that the discs were originally rather spherical, and probably originated from multicellular organisms with a soft and certainly translucent, possibly gel-like cover of (?)hydro-SiO_2, which was permeable for ionic mineral transfer. The pitted inner surface of the wall in some SOs could be related to hydrostatic pressure of its eventually expanding (growing?) outer cells of the organic contents. The association with echinoderms may indicate that the SOs represent reproductive (blastula?) stages of one of their taxa. More probably they are of algal origin, with a translucent envelope allowing photoautotrophic processes for the synthesis of organic compounds. Since the SOs share a common biostratinomic process with the echinoderms, their absence in the bioturbated mudstones would then indicate consumption by other organisms. The sheet-like SOs are interpreted as relicts of originally spherical but considerably larger specimens representing another type (or species?) than the discoid forms. Due to their larger size and relatively thinner wall they might have been already distorted during turbulent sedimentation. The palaeoecological significance and possible association of SOs with similar echinoderm Lagerstätten in other parts of Gondwana will be discussed.

THE FOSSIL RECORD OF BOID SNAKES CHALLANGES HYPOTHESES OF GONDWANAN VICARIANCE BIOGEOGRAPHY

Jason J. Head[1], Jonathan I. Bloch[2] and Patricia A. Holroyd[3]

1. Department of Earth and Atmospheric Sciences and Nebraska State Museum of Natural History, University of Nebraska-Lincoln, Lincoln, 68588-0304, USA. Jhead2@unl.edu

2. Florida Museum of Natural History, University of Florida, Gainesville, Florida 32611-7800, USA.

3. Museum of Paleontology, University of California, Berkeley, CA 94720, USA.

The phylogenetic relationships of extant boid snakes combined with their disjunct distributions in the New World tropics, Madagascar, and Pacific Islands have been recognized as an important example of vicariance biogeography resulting from Gondwanan fragmentation during the Cretaceous. There has been little historical data to support this hypothesis, however, and the fossil record of boids has not previously been examined in the context of historical biogeography of modern clades. Recent discoveries of cranial remains of the giant Paleocene boid snake *Titanoboa cerrejonensis* from northern Colombia and a new boine taxon from the middle Eocene Friars Formation in southern California, as well as reconsideration of previously described Cenozoic Eurasian boids, reveal a more complex phylogenetic and biogeographic history than inferred from extant taxa. Cranial elements of *Titanoboa* include marginal and palatal tooth-bearing elements, a partial suspensorium, and partial mandibles. The Friars Formation taxon is represented by a partial skeleton, including most of a skull. Phylogenetic analysis of boid snakes based on osteological characters and including fossils tentatively places *Titanoboa* as either a stem member of the boid clade, or as sister taxon to Pacific Island *Candoia*, and places the Friars Formation taxon within Neotropical Boinae. The presence of a stem boine snake in the South American Paleogene combined with potential crown taxa from the North American Paleogene and Eurasian Neogene, as well as the lack of a Cretaceous boid fossil record from any southern landmass, do not support hypotheses of Gondwanan endemicity and vicariance for the clade. Instead, the widespread distribution of fossil boids suggests histories of dispersal during the Paleogene with subsequent regional extinction in former Laurasian landmasses producing the geographic ranges of extant taxa. These results contradict biogeographic tempo and mode inferred from molecular data of extant boids, and demonstrate the necessity of the fossil record for reconstructing histories of extant taxa.

WHAT DO MICRO- AND SMALL VERTEBRATES FROM LAURASIA TELL US ABOUT TRIASSIC NONMARINE ECOSYSTEMS? INSIGHTS FROM THE UPPER TRIASSIC OF NORTH AMERICA

Andrew B. Heckert[1]

1. Department of Geology, Appalachian State University, ASU Box 32067, Boone, NC 28608-2067, USA.
heckertab@appstate.edu

Micro- and small vertebrates provide basic information on paleobiodiversity and paleoecology, and have been used extensively in studies of nonmarine sequences in much of the Cretaceous and Cenozoic. There has been less systematic collection and description of microvertebrates in lower Mesozoic strata. Such collections could, and should, be used to test hypotheses regarding both biostratigraphy and paleobiogeography. Because microvertebrate sites often yield greater diversity than large vertebrate quarries, they can also test these hypotheses across a wide range of taxa. As an example, the proposed latitudinal segregation of tetrapod assemblages across Triassic Pangea should be tested using microvertebrates, as recent studies have increased the number of shared taxa from different localities in the Chinle (southwestern USA) and Newark (eastern North America) basins. Furthermore, the near-total absence of Gondwanan microvertebrate assemblages may exaggerate differences between Gondwanan and Laurasian assemblages. This is important because Triassic sediments Pangea-wide document major evolutionary events, such as the origin of mammals and the diversification of lepidosauromorphs and archosauromorph sauropsids after the Permo-Triassic extinction. Major evolutionary lineages include sphenodontians and putative squamates (lepidosauromorphs) and numerous lineages of archosauromorphs, including representatives of various branches of crown-group archosaurs, including aetosaurs, sphenosuchians, crocodylomorphs, pterosaurs, silesaurs, and dinosaurs. Many of these taxa are known from small body size, and a growing number of genera can be recognized from fragmentary fossils, such as isolated teeth. Several of these taxa are now known to occur in multiple Laurasian basins, for example the enigmatic amniote *Colognathus* (Chinle, Newark, and Germanic basins), and the archosauriforms *Uatchitodon* and *Revueltosaurus* (Chinle, Newark). A parallel situation has developed in the Upper Cretaceous of North America, where several theropod taxa are known largely to entirely from teeth (e.g., *Richardestesia* spp., *Troodon*, *Sauronitholestes*, etc.) and various parties have developed extensive databases of measurements. Because of the increased ability to use computer software to acquire and analyze measurements of small specimens, increasingly quantified descriptions of microvertebrate remains are increasingly desirable. Future studies in the Triassic need to (1) strive to find similar taxa in other basins, especially in Gondwana; and (2) better quantify distinctive dentitions, not only the isolated teeth, but also the *in situ* dentitions of the numerous taxa known from small body size that may only be known from more fragmentary fossils elsewhere.

LATE OLIGOCENE MYSTICETES (CHAEOMYSTICETI) FROM BAJA CALIFORNIA SUR, MEXICO

Atzcalli E. Hernández Cisneros[1], Enrique H. Nava Sánchez[1] and Gerardo González Barba[2]

1. Instituto Politécnico Nacional-Centro Interdisciplinario de Ciencias Marinas. CICIMAR. Av. Instituto Politécnico Nacional s/n Col. Playa Palo de Santa Rita. Apdo. Postal 592, 23096, La Paz, B.C.S. Mexico. atz_nemesis@hotmail.com

2. Museo de Historia Natural de la Universidad Autónoma de Baja California Sur. Carretera al Sur Km 5.5. Apdo. Postal 19-B, 23080. La Paz, Baja California Sur, Mexico.

An important key assemblage to understand the evolutionary traits of Mysticeti clade and their relationship between stemward and crownward groups are Oligocene toothless mysticetes. Few specimens have been described for the genus *Mauicetus*, and for both families Eomysticetidae and Cetotheropsidae. It is known that there are many others undescribed specimens that support the great cetaceans diversity that started in the late Eocene to Oligocene, which originated the Neoceti group. Baja California Sur (BCS) is an important locality in the Oligocene cetacean paleontological framework and represents the southernmost record in North America. In the late Oligocene deposits of San Gregorio and El Cien formations in BCS, occur baleen whale fossils that show a significant diversity, including eomysticetids forms and various undescribed groups. The relationship with other Oligocene records from Oregon, and Washington, USA, as well as Vancouver, Canada is unknown. Actually, four craniums from the Museo de Historia Natural de La Universidad Autónoma de Baja California Sur (MNH-UABCS), are in preparation and description. Preliminary observations of the MHN-UABCS_EcSj1/29/141 show a juvenile cranium that retains a supraoccipital shield with a semicircular outline like some aetiocetids or archaeocetes forms, short and slightly thicker intertemporal region with a thin sagittal crest, two lobed prominence like fingertip on the posterolateral part of squamosal (perhaps homologous to squamosal prominence), triangular nasal bones elevated in its anterior end like Aetiocetidae, wide anteroposterior supraorbital process of frontal like *Yamatocetus*. The cranium, EcSj1/29/142, represents an adult form similar to *Yamatocetus*, with a long and wide mesorostral groove contrary to both *Eomysticetus withmorei* and *Yamatocetus canalicualtus*, thin nasal bones with a maximum breadth of 43.2 mm at its anterior end, the posterior end of the nasal bones are behind of posteriormost end of the ascending process of premaxilla, which is in line with the posterior half of supraorbital process and close to the temporal crest. The other two specimens ECSj5/06/31 and ECSj2/18/95 are considered as one group, perhaps a new family, based on a characteristic periotic bone that differs from *Eomysticetus*, *Micromysticetus* and *Mauicetus*. The periotic has a longer posterior process, a pars cochlearis with ovoid form in oblique position, the anterior process expands dorsoventrally and grows to cerebral direction, finishing in apical and fused form with the cranial wall by a very thin lamina. Now many anatomical details and phylogenetic relationships are uncertain, but these materials will give more knowledge to a better understanding of evolutionary patterns between mysticetes.

PALEOCLIMATE OF THE LIGORIO MARQUEZ FORMATION (EARLY EOCENE) AND THE CLIMATIC EVOLUTION OF *NOTHOFAGUS*

Luis F. Hinojosa[1,2], Francy Carvajal[1,2], Francisca Campano[1,2], Mirta Quattrochio[3], Harufumi Nishida[4], Kazuhiko Uemura[5], Atsushi Yabe[5], Aurora Gaxiola[2] and María Fernanda Pérez[2,6]

1 Laboratorio de Paleoecología, Facultad de Ciencias, Universidad de Chile.
lfhinojosa@uchile.cl

2 Instituto de Ecología y Biodiversidad (IEB), Chile.

3 Departamento de Geología, Universidad Nacional del Sur, Argentina.

4 Chuo University, Tokyo, Japan.

5 National Museum of Nature and Science, Ibaraki, Japan.

6 Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile.

Temporal and spatial succession of paleofloras in southern South America has been linked to climatic changes and the transition from a "greenhouse" to an "icehouse" during the Cenozoic, and to the contraction of the climatic belt toward boreal latitudes. The temporal and spatial succession of paleofloras fit well with the idea of taxa that tracked favoured habitats (niche conservatism) throughout the climatic change. The high global temperatures of the early Eocene provoked the expansion of the tropical and subtropical climatic belts toward high latitudes, exerting a selective pressure on cool temperate taxa. The early Eocene Ligorio Marquez Formation (LMF) is a continental clastic succession of fluvial channels, flood plains, and marsh deposits located in the border of Argentina and Chile (46° S). The fossils plants, including pollen and leaf remains, are diverse, highlighting the local presence of *Nothofagus*. We present herein the paleoclimatic reconstruction of the LMF using both coexistence approach and leaf physiognomy analysis, in the micro and macroflora. We compare our results with a climatic niche reconstruction on *Nothofagus* phylogeny. Our paleoclimatic estimate suggests mesothermal and wet environmental conditions, close to those of the modern *Brassospora* subgenus, but warmer than Eocene niche reconstruction. Finally, and considering in particular modern South American taxa, we propose the existence of a broader climatic niche of *Nothofagus* during the Eocene with a trend toward its narrowing as seeing today. Stabilizing selection would generate a reduction of niches since the Paleogene and the difference observed between fossil and extant *Nothofagus* territorial extent. [Contribution to FONDECYT # 1120215 and IMEB PO5-002; PFB-23].

MODELING CRANIAL BIOMECHANICS IN ARCHOSAURS USING 3D COMPUTATIONAL METHODS

Casey M. Holliday[1], Kaleb S. Sellers[1], Julian L. Davis[2] and Lawrence M. Witmer[3]

1. Department of Pathology and Anatomical Sciences, University of Missouri, Columbia, 65212, USA. hollidayca@missouri.edu

2. Department of Engineering, University of Southern Indiana, Evansville, 47712, USA.

3. Department of Biomedical Sciences, Ohio University, Athens, 45701, USA.

Accurately modeling cranial function in vertebrates remains a challenging yet important tool for ecologists, functional morphologists, and paleobiologists. Three-dimensional computational methods now offer new approaches for reconstructing jaw muscle anatomy and the cranial biomechanical environment so that evolutionary and functional hypotheses can be tested. Here we present several examples that reconstruct muscle forces, joint moments and bite forces in extant and extinct archosaurs using 3D modeling techniques. 1) We compared modeled bite forces in an ontogenetic sample of *Alligator mississippiensis* with published *in vivo* bite forces to validate whether the method is applicable to diapsid vertebrates. 2) We modeled bite forces and joint moments within the skulls of the non-avian dinosaurs *Tyrannosaurus rex* and *Edmontosaurus regalis* to test the sensitivity of input parameters with force estimates. 3) Using these latter taxa, we compared moments about joints implicated in cranial kinesis to identify functional patterns. These models will enable us to test for coevolution between bite force and dietary correlates in fossil archosaurs, estimate loading patterns within cranial joints, and determine patterns in jaw muscle anatomy and function among tetrapods.

A BIZARRE CRINOID FROM METHANE SEEPS IN THE UPPER CRETACEOUS (CAMPANIAN) PIERRE SHALE, SOUTH DAKOTA, UNITED STATES

Aaron W. Hunter[1], Neal L. Larson[2], Neil H. Landman[3], Jamie Brezina[4] and Tatsuo Oji[5]

1. Department of Applied Geology, Western Australian School of Mines, Curtin University, GPO Box U1987, Perth 6845 WA, Australia. aaron.hunter@curtin.edu.au.

2. Black Hills Museum of Natural History, PO Box 614 Hill City, SD 57745, USA.

3. Division of Paleontology (Invertebrates), American Museum of Natural History Central Park West at 79th Street, New York, NY 10024-5192, USA.

4. South Dakota School of Mines & Technology, 501 East Saint Joseph Street, Rapid City, SD 57701 USA.

5. Nagoya University Museum, Nagoya University, Furo-cho, Nagoya 464-8601, Japan.

Despite a rich and varied record, Mesozoic stalked crinoids are relatively rare in the Western Interior Seaway of North America compared to those found in Northern Europe. A unique example of Mesozoic stalked crinoid is described from cold methane seeps (hydrocarbon seep mounds also called “tepee buttes”) from the Upper Cretaceous (upper Campanian) of the Northern Great Plains of the United States; the first crinoids to be described from such an environment. The Late Cretaceous Western Interior Seaway has never before yielded any identifiable stalked crinoid remains. Nevertheless, there have been significant studies on both free living and stalked crinoids from other locations in the Upper Cretaceous of North America that provide a good basis for comparison. This distinct species is characterized by a tapering homeomorphic column with through-going tubuli, lacking any attachment disc. The arms are unbranched and pinnulate, with muscular and syzygial articulations. The unique morphology of the column justifies the establishment of a separate family. A new suborder is also proposed as there exists no corresponding taxon within the Articulata that can accommodate all the characteristics of this new genus. This new crinoid shares many features with other members of the articulates, including bathycrinids, bourgueticrinids and guillecrinids within the Order Comatulida, as currently defined in the revised Treatise of Invertebrate Paleontology. Reconstructing the entire crinoid using hundreds of semi-articulated and disarticulated (well preserved) fossils, reveals a unique paleoecology and functional morphology specifically adapted to living within this hydrocarbon seep environment.

FIRST RECORD OF CALLIPTERIDS IN SOUTH AMERICA (PERMIAN OF PARNAÍBA BASIN, NE BRAZIL)

Roberto Iannuzzi[1] and Max Cardoso Langer[2]

1. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves 9500, Porto Alegre, RS, 91.540-000, Brazil. roberto.iannuzzi@ufrgs.br

2. Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo, Av. Bandeirantes, 3900. Ribeirão Preto, SP, 14040-901, Brazil.

The callipterids (Peltaspermales) apparently originated in Europe around the Carboniferous-Permian transition. The group achieved a huge success, expanding into tropical regions worldwide during the Permian (*e.g*. Europe, North America, northernmost Africa, northern China, southeast Asia, and the Malay Archipelago), as well as to northern Pangaea (Siberia). Here we provide the first record of callipterids *sensu stricto* in Western Gondwana (South America). The fossil plants were collected from sediments of the middle-upper Pedra de Fogo Formation (PdF), Permian of the Parnaíba Basin, southeastern Maranhão, northeastern Brazil. The material can be attributed to the genus *Rhachiphyllum*, and specifically to *R. schenkii* (Heyer) Kerp. In addition, an *Autunia*-like fructification found in association with our specimens corroborates the peltasperm affinity of the PdF fossil plants. The presence of *R. schenkii* could indicate a Cisuralian age for the PdF, because this species has a short and well-defined stratigraphic range in Europe. Paleogeographically located in tropical latitudes, the callipterids of northeastern Brazil correspond to the southernmost Permian Gondwanan record of peltasperms. This may prove to be of great paleobiogeographic importance, because the callipterids are considered closely related to the Corystospermales, a group that dominated the *Dicroidium* flora in the Triassic of Gondwana. Finally, the record of *R. schenkii* in association with the fern genus *Pecopteris* in the PdF and in the *Pecopteris* Horizon of the Nahe Group, Saar-Nahe Basin, Germany, suggests the existence of a dispersion corridor extending from central Europe to northern South America during the earliest Permian. The widespread geographic distribution of *R. schenkii* can be explained by the occurrence of similar climatic conditions in northeastern South America and western tropical Pangaea (North America, Europe) throughout the Pennsylvanian-Cisuralian.

BELEMNITE STRATIGRAPHY OF THE LOWER CALLOVIAN OF THE EAST EUROPEAN PLATFORM: APPLICATION OF INFRAZONAL STRATIGRAPHY CONCEPT

Alexei P. Ippolitov[1] and Denis B. Gulyaev[2]

1. Geological Institute of Russian Academy of Sciences, Pyzhevsky lane 7, Moscow, 119017, Russia. ippolitov.ap@gmail.com

2. Interdepartmental Stratigraphical Committee (ISC) of Russia, 25-7 Chekhov St., 150054 Yaroslavl, Russia.

The main result of the Jurassic biostratigraphy of European Russia achieved during the last two decades is the development of high-resolution infrazonal ammonite scales. The theoretic concept of infrazonal stratigraphy, based on the study of successive evolutionary elements within a certain lineage and marking immigration events, seems to be applicable to other fossil groups. Belemnites, despite widely spread in the same deposits, until now did not allow detailed subdivision and consequently could not provide precise age determinations. According to most actual schemes the whole lower Callovian comprises a single belemnite zone, but the same interval can be subdivided into 4 ammonite zones, the upper two of which are subdivided into 5 subzones, and more than 22 successive biohorizons. During the 2011-2013 field seasons, the authors collected a huge number of belemnite rostra from many continuous sections in European Russia and Ukraine, together forming a full sequence of the lower Callovian, well-characterized by co-occurring ammonites. Material was studied biostratigraphically according to concept of biohorizons. The lower Callovian can be subdivided by belemnites into three parallel series of successive biohorizons, based on three different phyletic lines inside the boreal family Cylindroteuthidae, each covering certain interval and partly overlapping, so that in certain intervals only one line can be used, while in other intervals two or even three. The number of successive units for the whole lower Callovian is up to 14 biohorizons, which, in turn, can be grouped into 4 larger units (=zones), characterized by well-recognizable appearance of the whole complex. Moreover, it is possible to select biohorizons based on immigration events, which are usually well-correlated with similar events in ammonites, thus indicating important paleoceanographic and paleoclimatic events. The concept of biohorizons seems to be fully applicable to belemnites, allowing elaborate biostratigraphic scales, comparable in resolution with ammonite infrazonal scales. [Supported by RFBR grant no. 12-05-00380].

EARLY MESOZOIC VERTEBRATE ASSEMBLAGES FROM ETHIOPIA AND THEIR SIGNIFICANCE FOR GONDWANAN BIOGEOGRAPHY

Randall B. Irmis[1], Mark B. Goodwin[2] and Gregory P. Wilson[3]

1. Natural History Museum of Utah and Department of Geology & Geophysics, University of Utah, Salt Lake City, UT 84108-1214, USA. irmis@umnh.utah.edu

2. Museum of Paleontology, University of California, Berkeley, CA 94720-4780, USA.

3. Department of Biology, University of Washington, Seattle, WA 98195-1800, USA.

The traditional view of early Mesozoic non-marine vertebrate assemblages is that they were relatively homogenous through the end of the Jurassic Period, owing to the existence of the supercontinent Pangaea. This hypothesis has been challenged in recent years with the discovery of high provinciality among Middle and Late Triassic terrestrial ecosystems in both Laurasia and Gondwana, as well as the re-evaluation of Late Jurassic assemblages from the southern hemisphere, which display more evidence of a Gondwanan biogeographic signal than previously thought. Much of these key data come from moderate to high paleolatitude assemblages from Africa and South America. In contrast, the low paleolatitudes of Gondwana remain largely unsampled for the Late Triassic-Late Jurassic interval. Our recent work in the non-marine Upper Triassic Adigrat Sandstone and Upper Jurassic Mugher Mudstone of the Northwest Plateau in Ethiopia reveal that this record is a key low paleolatitude datapoint for understanding Gondwanan biogeography. In the Late Triassic, the presence of capitosauroid temnospondyls such as *Abiadisaurus* distinguish the Ethiopian record from the metoposaurid dominated low paleolatitude assemblages in Morocco and North America. The Late Jurassic record of Ethiopia is quite diverse, including hybodont and batoid elasmobranchs, actinopterygians, dipnoans, pleurodires, paracryptodires, solemydid turtles, non-eusuchian mesoeucrocodylian crocodyliforms, theropod dinosaurs, at least two taxa of ornithischian dinosaurs, and a "peramuran" mammaliaform. At the clade level, none of these occurrences reveal a Gondwanan biogeographic signal, suggesting that either it was only apparent at finer taxonomic levels, or that the initial breakup of Pangaea had not yet affected the composition of these ecosystems.

TEMPORAL CHANGES IN HOLOCENE OSTRACODE FAUNAS IN NORTH PACIFIC INTERMEDIATE WATER

Hokuto Iwatani[1], Moriaki Yasuhara[1], Delia Oppo[2], Yair Rosenthal[3] and Braddock K. Linsley[4]

1. School of Biological Sciences, The University of Hong Kong, Kadoorie Biological Sciences Building, Pokfulam Road, Hong Kong SAR, China. hokuto.iwatani@gmail.com
2. Woods Hole Oceanographic Institution, MS#23, Woods Hole, Massachusetts 02543, USA.
3. Institute of Marine and Coastal Sciences, and Department. of Geology, Rutgers, The State University, 71 Dudley Road, New Brunswick, New Jersey 08901, USA.
4. Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W, Palisades NY 10964, USA.

The North Pacific Intermediate Water (NPIW), defined as the water mass with salinity minima at depths between *ca.* 300 and 800 m, is widely distributed around the North Pacific Ocean. It is influential in the dynamics of the North Pacific subtropical circulation, thus it is important to comprehensively understand the NPIW behavior. However, its behavior throughout geological time is not well understood, in particular, for the low-latitude ocean. Therefore, we investigated temporal changes in paleoenvironments under the influence of NPIW in the low-latitude ocean during the last 15,000 years on the basis of high-resolution statistical analyses of the fossil Ostracoda (Crustacea) as an effective environmental indicator. For the investigation, we used a sediment core obtained from the southern part of Makassar Strait, the eastern Java Sea (site: 70GGC, water depth: 482 m, latitude: 3°34′S, longitude: 119°23′E). In the process, more than 100 ostracode species were recorded in the study sequences. To reveal the transition of the bottom water environment, we investigated fossil ostracode faunal composition and species diversity changes during the deposition of the study site. The faunal composition drastically changed from ca. 7,500 to 6,000 years BP. The species diversity rapidly increased between *ca.* 13,000 and 11,000 years BP. According to a previous study, using high-resolution proxy records from sediment cores in the Java Sea, intermediate water temperatures at 500 m depth decreased after *ca.* 6,000 years BP. Therefore, it is possible that ostracode faunal changes were associated with decreasing intermediate water temperatures. Moreover, the peak of the ostracode species diversity between ca. 13,000 and 11,000 years BP coincided with the Younger Dryas cold event (YD). The abrupt change in the species diversity in this interval appears connected to the YD. We conclude that the ostracode assemblage at this site is sensitive to climatic change and is very useful for the reconstruction of ocean environments of NPIW throughout geological time.

NEW DATA ON *OIKOZETETES* (MOLLUSCA: HALKIERIIDAE) FROM THE LOWER CAMBRIAN OF SOUTH AUSTRALIA

Sarah M. Jacquet[1], Glenn A. Brock[1] and John R. Paterson[2]

1. Department of Biological Sciences, Macquarie University, Sydney NSW 2109, Australia.
sarah.jacquet@students.mq.edu.au

2. Division of Earth Sciences, School of Environmental and Rural Science,
University of New England, Armidale, NSW 2351, Australia.

Determining the problematic affinities of Cambrian taxa with complex composite skeletons is complicated by the fact they usually occur as isolated sclerites in acid residues. *Konservat-Lagerstätten* provide a crucial reference to the arrangement of multi-scleritome reconstruction. An exemplar of this process is the discovery and description of the complete scleritome of *Halkieria evangelista* Conway Morris and Peel from the lower Cambrian Buen Formation, Sirius Passet in Greenland. Isolated sclerites had been well documented among the small shelly fauna, but the body plan of the original organism and the articulation of the sclerites were previously unknown. New silicified material from the lower Cambrian Flinders Ranges of South Australia preserves the three-dimensional structure of the original calcareous shell and their shell morphologies in some important molluscan problematica. A new species of *Oikozetetes*, *O. mounti* n. sp. is described from the upper Mernmerna Formation (equivalent to Cambrian Series 2) in the eastern Flinders Ranges, South Australia. Description of both shell morphotypes (morph A and B) from the same stratigraphic horizon favours the interpretation of a two-shelled scleritome for *Oikozetetes*. Identification of at least two types of halkieriid sclerite (palmates and siculates) in stratigraphic association with the *Halkieria*-like shells of *Oikozetetes* suggests that these elements are derived from the same scleritome. This provides evidence against previous suggestions that the Gondwanan species was aspiculate; the scleritome arrangement is interpreted to be similar to *Halkieria evangelista* Conway Morris and Peel and supports placement in the family Halkieriidae Poulsen. Comparison of modes of accretionary growth in *Oikozetetes* shell morphotypes to *Halkieria* shells and terminal plates in modern polyplacophorans, supports a scleritome model that places shell morphs A and B in posterior and anterior locations, respectively, along the axis of the body.

A CRETACEOUS SEA TURTLE DEAD FALL SUPPORTED CHEMOSYNTHESIS-BASED ECOSYSTEM

Robert G. Jenkins[1], Andrzej Kaim[2], Kazuhiro Moriya[3], Ren Hirayama[4] and Yoshinori Hikida[5]

1. School of Natural System, College of Science and Engineering, Kanazawa University, Kakuma-machi, Kanazawa City, Ishikawa, 920-1192, Japan. robertgj@staff.kanazawa-u.ac.jp

2. Institute of Paleobiology PAS, ul. Twarda 51/55, Warszawa, 00-818, Poland.

3. Graduate School of Natural Science and Technology, Kanazawa University, Kakuma-machi, Kanazawa City, Ishikawa, 920-1192, Japan.

4. Faculty of International Research and Education, Waseda University, Nishiwaseda 1-6-1, Shinjyuku-ku, Tokyo, 169-8050, Japan.

5. Nakagawa Museum of Natural History Institution, Yasukawa 28-9, Nakagawa Town, Hokkaido, 098-2625, Japan.

The period ranging from the Cretaceous to the Paleogene is pivotal in understanding the evolution of modern type chemosynthesis-based communities. Many molluscs living at hydrothermal vents and hydrocarbons seeps today have appeared during this period. Also the chemosynthesis-based ecosystems sustained by vertebrate- and wood-falls have appeared in the Cretaceous. Before origination of whales, chemosynthesis-based associations were developed on plesiosaurid carcasses, marine reptiles which flourished in the Cretaceous oceans. Although many marine reptiles were present in the Mesozoic seas, we were uncertain so far whether any other marine reptile carcasses could support chemosynthetic ecosystems. Here we document the chemosynthetic community found on a carcass of the Cretaceous sea turtle, *Mesodermochelys* sp. (Dermochelyidae; Chelonioidea) collected from the Upper Cretaceous Campanian deposits cropping out along the Nio river, Nakagawa Town, Hokkaido. Sediments surrounding the turtle yielded provannid gastropods and thyasirid bivalves, both known to be members of chemosynthetic communities. Those molluscan fossils characteristic for chemosynthetic ecosystems have also been found in Cretaceous hydrocarbon seep deposits and around plesiosaurid carcasses. This finding indicates that the chemosynthetic communities were supported not only by plesiosaurid carcasses but also by decomposing sea turtles. The sea turtles are a rare example of Cretaceous marine reptiles surviving the Cretaceous/Paleocene extinction event. Thus, it is reasonable to assume that sea turtle carcasses could continuously support chemosynthetic ecosystems throughout the K/Pg boundary.

FOSSIL RECORD OF THE CHEMOSYNTHESIS-BASED COMMUNITIES –WHAT WE KNOW AFTER 30 YEARS OF RESEARCH

Andrzej Kaim[1] and Robert Jenkins[2]

1. Institute of Paleobiology PAS, ul. Twarda 51/55, Warszawa, 00-818, Poland. kaim@twarda.pan.pl

2. School of Natural System, College of Science and Engineering, Kanazawa University, Kakuma machi, Kanazawa City, Ishikawa Prefecture, 920-1192, Japan.

The discovery of modern chemosynthesis-based communities prompted a quest among palaeontologists to look for their fossil counterparts in attempt to decipher the evolutionary history of these communities. The first fossil example of chemosynthesis-based communities has been identified in 1984 though the fossils derived from such ecosystems were long known in the literature awaiting proper interpretation. The knowledge of such communities has significantly increased in recent years. The early assumption that the hydrothermal vent invertebrate fauna is “a glimpse of antiquity” turned out to be largely incorrect. Many groups known from modern hydrothermal vents and cold seeps have immigrated into these environments relatively recently. The major problem in deciphering the evolution of chemosynthesis-based communities is the general paucity of hydrothermal vent deposits and poor preservation of vent fauna, which is diverse and highly endemic to its environment in modern vents. Much more common and better-preserved are fossil examples of the hydrocarbon seep communities. Although Palaeozoic seep fauna is usually badly preserved it seems that, unlike their modern counterparts, these early communities were dominated by dimerelloid brachiopods while molluscs were only subordinate. The knowledge on Mesozoic seep faunas greatly benefitted from well preserved silicified specimens found in several Cretaceous and younger seep deposits. The fossil wood-fall communities are uncommon but it seems to be clear that their emergence was related to the first appearance of xylophage in wood-boring bivalves. Earlier, Jurassic associations were apparently not supported by chemosynthesis and consisted of almost entirely different set of organisms. The fossil vertebrate-fall communities are not common but the fossil examples of whale-fall communities are known from a period shortly after the appearance of whales. In the Mesozoic the vertebrate-fall communities are represented by Late Cretaceous plesiosaur-fall associations, which are more similar to coeval seep faunas than to the later whale-fall faunas.

ASPIDIN: A BONE OF CONTENTION

Joseph N. Keating[1,2], Philip C. J. Donoghue[1] and Zerina Johanson[2]

1. School of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol, BS8 1RJ, UK. jk12521@bristol.ac.uk

2. Department of Earth Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

Living jawed vertebrates (Gnathostomes) primitively possess a complex mineralised skeleton constructed from bone, enamel(oid), dentine and cartilage. Such a skeleton is absent in their extant sister-taxon (cyclostomes), thus in order to understand the evolution of vertebrate mineralised tissues, we must instead consider the extinct taxa that reside on the gnathostome stem-lineage. Among these fossil fishes, the jawless heterostracans, anaspids and thelodonts are the stratigraphically earliest occurring and phylogenetically most primitive vertebrates with a homologous mineralised skeleton. As such, they have featured prominently in discussion about the evolutionary and developmental origins of vertebrate mineralised tissues. Unfortunately, rudimentary knowledge of the histological diversity among these groups, as well as lack of phylogenetic synthesis, has impeded insight into the plesiomorphic state of the vertebrate skeleton. The root of the problem is a lack of agreement concerning the nature of aspidin, an acellular tissue present within the dermoskeleton of heterostracans, and possibly also anaspids and thelodonts. Numerous conflicting hypotheses have been put forward to explain the microstructure and homology of aspidin, spilling into the wider debate on the primacy of cellular versus acellular bone. In order to resolve the nature of aspidin, we survey the structure of the dermoskeleton among heterostracans, infer the plesiomorphic heterostracan skeletal microstructure and compare it to the skeletal histology of anaspids and thelodonts. Our results indicate that aspidin is a type of acellular bone that exhibits osteon-like centripetal development about an extensive vascular system, forming an intersecting network of radial walls. These contain an orthogonal fabric of thread-like spaces, interpreted as cell migration tracts, which distort the mineral matrix. A second homogenous tissue, containing a meshwork of collagen fibres, develops via remodelling the centripetal tissue within the core of the intersecting radial walls. Our reappraisal of aspidin indicates that it is apomorphic with respect to heterostracans and falls within a spectrum of bone histologies exemplified by stem-gnathostomes.

NORTH AMERICAN MEGAFAUNAL EXTINCTION CONSISTENT WITH MAJOR COSMIC IMPACT AT YOUNGER DRYAS ONSET (12.8 KA)

James P. Kennett[1], Douglas J. Kennett[2] and Allen West[3]

1. Department of Earth Science, Marine Science Institute, University of California, Santa Barbara, CA 93106, USA. kennett@geol.ucsb.edu

2. Department of Anthropology, The Pennsylvania State University, University Park, 16802, USA.

3. GeoScience Consulting, P.O. Box 1636, Dewey, AZ, 86327, USA.

The cause of the late Pleistocene North American megafaunal extinction has been debated since the Argentinian excavations by Charles Darwin (Voyage of the Beagle, 1845). Remarkably, even then, he introduced possible causes by climate change, human hunting or some other catastrophe. The potential roles of climate change and/or human overkill have been much debated, with limited success. We have discovered widespread geological evidence for a major cosmic collision over the Northern Hemisphere at 12.8 ± 0.15 ka. Massive energy released from this impact caused major biomass burning and other severe biotic and environmental changes. A widely distributed sediment layer (Younger Dryas Boundary layer: YDB) contains an exotic assemblage of high-temperature melt products, including nanodiamonds, impact spherules, melt-glass, microtektites and other proxies, including a platinum peak in Greenland ice. The YDB cosmic impact hypothesis, as proposed by Firestone and colleagues, appears consistent in explaining at least three major anomalous events: 1) massive, abrupt extinction of many large mammals and birds; 2) abrupt disappearance of the Clovis Culture technology; and 3) abrupt cooling and associated major change in continental plumbing and ocean circulation. Near the end of the Pleistocene, at least 35 mammal and 19 bird genera became extinct over North America. Modern improvements in dating suggest these extinctions occurred abruptly at ~12.8 ka (11 radiocarbon kyrs). We tested this hypothesis by critically examining radiocarbon ages and extinction stratigraphy of these taxa. From a large data pool, we accepted only radiocarbon dates that have low error margins with preference for directly dated biological materials (bone, dung) using modern chemical purification techniques. These data show that 16 animal genera and several other species became extinct close to 12.8 ka, including the most common animals: horses, camels, mammoths and mastodons. Furthermore, the remains of extinct taxa are reportedly found up to, but not above, the YDB layer. The abruptness of this major extinction is inconsistent with the hypotheses of human overkill and climatic change. Extinction ages older than 12.8 ka for many less common species likely reflect the Signor-Lipps effect. The YDB impact layer has been located in northern South America by W. Mahaney and colleagues at the onset of Younger Dryas cooling, and the extinctions of South American megafauna are closely contemporaneous with those of North America. These observations suggest the need for high-resolution stratigraphic investigations in South America to test possible relations between the megafauna extinction and the YDB cosmic impact.

THE FIRST 3D RECONSTRUCTION OF ARCHAEOCYATHA (CAMBRIAN)

Adeline Kerner[1]

1. CR2P, UMR 7207 CNRS-MNHN-UPMC, Département Histoire de la Terre, Muséum national d'Histoire naturelle, Bâtiment de Géologie, CP48, 57 rue Cuvier, 75005 Paris, France. kerner@mnhn.fr

Archaeocyaths represent an extinct and exclusively Cambrian class of the phylum Porifera, close to the Demospongiae. Their skeleton is commonly preserved as carbonate within limestone, which excludes their mechanical or chemical extraction from the surrounding matrix. Therefore, their morphology has to be examined through thin sections. As a consequence the orientation of the section through the skeleton, which influences the description and identification of the specimen is poorly controlled or even random. Here, the first computed tomography and 3D visualization of Cambrian archaeocyaths from Morocco is presented. Computed tomography, a non-destructive and non-invasive method, facilitates the view inside rocks and fossils. The combination of computed tomography and paleontological data enable us to produce 3D reconstructions of these extinct organisms and to simulate the different orientation of thin sections. From the reconstructions, each structure can be virtually cut and the correspondence between the diverse shapes of one structure from the different sections orientation can be reported.

AN ACCOUNT OF THE UPPER SIWALIK RHINOCEROTIDS OF PAKISTAN

Abdul Majid Khan[1], Esperanza Cerdeño[2], Muhammad Akhtar[1], Muhammad Akbar Khan[1] and Khaled Siddiq[1]

1. Palaeontolgy Laboratory, Department of Zoology, University of the Punjab, Lahore, Pakistan. majid.zool@ pu.edu.pk

2. Paleontología, IANIGLA, CCT-CONICET-Mendoza, Argentina.

Fossil remains of Pleistocene rhinocerotids have been collected from three upper Siwalik localities of Gujrat, Jhelum and Mirpur districts (Pakistan), belonging to Tatrot and Pinjor stages of the Soan Formation (3.5–0.9 Ma). The sample includes well-preserved maxillary and mandibular fragments along with isolated teeth. The fossils collected from upper Siwalik sediments exposed near the Tatrot village in Jhelum district are identified as belonging to *Rhinoceros sivalensis.* The specimens collected from Pinjor of the Sar Dhok in Pabbi hills, Gujrat district are identified as belonging to *Rhinoceros sivalensis*, *Rhinoceros sondaicus* and *Rhinoceros unicornis.* The specimens from Pinjor of Jari Kas (33° 06.236N 73° 50.012E) in district Mirpur of Azad Jammu and Kashmir are identified as belonging to *Rhinoceros sondaicus* and *Punjabitherium platyrhinus.* The specimens of *Punjabitherium platyrhinus* in the present collection resemble morphologically and metrically to those known from the Pinjor of Gurha village near Chandigarh, India. *Punjabitherium platyrhinus* have hypsodont teeth with well developed large crochet and crista that may unite to enclose a medifossette. The characteristics shared by *Rhinoceros sondaicus* and *R. sivalensis* in the present collection include: a distinct crochet (more developed and rounded in *R. sivalensis*) that may unite with the protoloph to enclose a fossette, well-developed parastyle, no mesostyle and U-shaped anterior valley in the lower molars. However, *R. sondaicus* differs from the later species in having a well-developed paracone fold, development of crista in the premolars and complete absence of lingual cingulum (well developed in *R. sivalensis*). The protocone is constricted by anterior and posterior grooves in *R. sivalensis* whereas in *R. sondaicus* the protocone is unconstricted. Teeth dimensions of *R. sondaicus* are greater than those of the *R. sivalensis*. The upper D3 of *R. unicornis* is identical in occlusal morphology to the D3 in AMNH 39234 repository. The broken dentary and the molars contained therein show identical occlusal morphology and dimensions to those known from the upper Siwaliks of India. However, the fossil dentary and the dentition have slightly larger dimensions than the living *R. unicornis. Rhinoceros sivalensis* is well documented from the upper Siwalik Soan Formation from different localities in Chakwal, Jhelum and Gujrat districts of Punjab, Pakistan. However, the fossils of *Rhinoceros unicornis* and *Rhinoceros sondaicus* are reported for the first time from the upper Siwaliks of Pakistan and resulted in an extension of the known geographic range of these species into Pakistan. The collection of *Punjabitherium platyrhinus* from the upper Siwaliks of Pakistan however rejects Lydekker's opinion regarding the confined distribution of *P. platyrhinus* only in the typical Siwaliks of India near the Ganga and Jamuna rivers.

WHAT KIND OF DISTURBANCES DID MEGAQUAKE GIVE/ CREATE ON CONTINENTAL MARGIN ECOSYSTEMS DURING MARCH 11, 2011 TOHOKU EARTHQUAKE AND TSUNAMIS: MODERN ANALOGUE OF TEMPESTITES

Hiroshi Kitazato[1], Shiro Hasegawa[2], Christophe Fontanier[3] and Takashi Toyofuku[1]

1. Japan Agency for Marine-Earth Science and Technology, Natsushimacho 2-15, Yokosuka 237-0061, Japan. kitazatoh@jamstec.go.jp

2. University Museum, Tohoku University, 6-3 Aoba, Aramaki, Aoba-ku,Sendai 980-8578, Japan.

3. IFREMER, Centre Bretagne, ZI de la Pointe du Diable, CS 10070, 29280 Plouzané, France.

Among benthic ecosystems in the ocean, continental margins constitute very familiar habitats. There, huge amounts of organic and inorganic materials including those with an anthropogenic origin are transported/transferred from land areas to adjacent seas. For sure, continental margin habitats are mostly well-studied areas. This is true for foraminiferal faunas. There are two types of continental margin. The Northeast Atlantic Ocean is, for instance, bordered by passive margins where only exceptional earthquakes take place. Conversely, the Pacific Ocean presents seismic (so-called active) margins where recurrent and high-magnitude earthquakes are expressed. Are there any reliable differences between both margin ecosystems in terms of biodiversity? On March 11, 2011, huge earthquakes and tsunamis took place along the Northeast Japanese Margin. JAMSTEC has urgently focused its research activities on early disturbances impacting marine ecosystems, from the shoreline to the trench bottom. Distinct disturbances were recorded in the earthquake epicenter area, close to the Japan Trench. Fifteen days after the earthquake, dense nepheloid layers were developed due to turbidites or density flows. In the trench axis area, a large displacement of the seafloor (lateral amplitude of 50 m and vertical one of ~7 m) took place. This displacement area is likely the source of tsunami waves. Four months after the earthquake, remarkable deformations and disturbances affecting the seafloor were observed by submersible investigation. Large (biogenic? or sediments?) mounds with sea urchins and ophiuroids were found at 5,000 m deep sites. We judged that major turbidity currents swept benthic organisms away from slope areas to those hadal sites. In contrast to the very deep margin, continental shelf and upper slope areas were less disturbed. Of course, strong movements should have experienced even at upper slope areas. But, it may not often have taken place of down slope turbidites at the upper slope areas.

LATITUDINAL SHIFTS OF PALAEOZOIC MARINE INVERTEBRATE GIGANTISM AND GLOBAL CHANGE

Christian Klug[1], Kenneth De Baets[2], Björn Kröger[3], Mark A. Bell[4], Dieter Korn[5] and Jonathan L. Payne[5]

1. Paläontologisches Institut und Museum, Universität Zürich, Karl Schmid-Strasse 4, CH-8006 Zürich, Switzerland. chklug@pim.uzh.ch

2. Universität Erlangen, Loewenichstr. 28, D-91054 Erlangen, Germany.

3. Museum für Naturkunde, Humboldt-Universität zu Berlin, Invalidenstraße 43, D-10115 Berlin, Germany.

4. Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT, UK.

5. Department of Geological & Environmental Sciences, Stanford University, 450 Serra Mall, Building 320, Stanford, CA 94305, USA.

Since the Cambrian Explosion, giant marine invertebrate species have evolved iteratively in several groups. In the Palaeozoic, marine invertebrate gigantism was heterogeneously distributed through time and space; changes in maximum sizes show no clear relationship with atmospheric or oceanic oxygen and other environmental factors. Although gigantism has found an explanation for Carboniferous land invertebrates in the atmospheric oxygen peak, marine gigantism has not been studied empirically and explained comprehensively. By quantifying the spatiotemporal distribution of the largest representatives of some major marine invertebrate clades, we assessed links between ecological parameters and giant growth. These occurrence data suggest that temperature and latitude in combination with oxygen played important roles. Marine invertebrate gigantism developed in certain phases and regions with a greater number of extremely large species and their occurrences shifted independently from middle towards low latitudes during the Palaeozoic in all examined groups. This trend roughly coincides with the Late Devonian to Carboniferous cooling and regression as well as with a rise in atmospheric oxygen. This shows how global environmental changes can control the geographical distribution of organisms and that the optimal ecological requirements might differ depending on body size: extremely large organisms might react less flexibly to ecological changes.

THE PALEOGENE EUROPEAN FOSSILS OF CLEROIDEA (COLEOPTERA) AND THEIR BIOGEOGRAPHICAL RELATIONS TO RECENT FAUNA

Jiri Kolibac[1]

1. Moravian Museum, Department of Entomology, Hviezdoslavova 29a, Brno, CZ-627 00, Czech Republic.
jkolibac@mzm.cz

The beetle superfamily Cleroidea consists of 13 extant families containing over 10,000 species, distributed worldwide. Representatives of the Cleroidea are mostly predaceous, hunting for other insects on the bark of trees, in the galleries of wood borers or even within grass stems, but they also feed on vertebrate carrion. However, some cleroids are anthophilous, feeding on pollen grains, whereas more primitive members feed on fungi in decaying wood or forest litter. No extinct family has been described within Cleroidea to date, although an attempt was made to include the Mesozoic †Parandrexidae. In recent decades, 17 Paleogene European species have been described in Cleridae, three in Trogossitidae and three in Rhadalidae. All the species are classified within 16 genera, of which seven are extinct and nine extant. Most of the extinct records were made from the Baltic amber, while there is a single finding from the mid-Eocene limnic sediments of the Eckfeld Maar (Germany). As the author of this communication participated in describing most of the material and has studied all of it, a platform exists for evaluation from a biogeographical point of view. Climatic changes around the end of the Neogene were perhaps the reason for the disappearance of tropical and subtropical cleroid fauna from Europe. Although these beetles became dispersed across the warm areas of other continents, not one definite Tertiary fossil cleroid genus inhabits Europe today. Conversely, not one of the 23 recent, extant European genera of Trogossitidae, Cleridae and Rhadalidae is known from a definite fossil record. Species of the extant genera *Strotocera*, *Cymatodera*, *Pseudopallenis*, *Orthrius*, *Thanasimodes*, *Phyllobaenus*, *Lemidia*, *Prosymnus* (all Cleridae) and *Ancyrona* (Trogossitidae) known from the Paleogene are recently distributed in Central and North America, Africa, Madagascar, eastern and south-eastern Asia, northern Australia, and central Chile. On the other hand, recent relatives of the extinct genera †*Bilbotillus* (Cleridae), †*Promanodes* (Trogossitidae) and †*Aploceble* (Rhadalidae) inhabit Europe, the Near and Middle East, northern and eastern Africa, and New Zealand. Four Paleogene genera of Cleridae (†*Mitrandiria*, †*Zahradnikius*, †*Smudlotillus*, †*Aberrokorynetes*) are probably members of extinct lineages, since no recent relatives are known.

PHYLOGENETIC RELATIONSHIPS OF ARCHAIC UNGULATES BASED ON DENTAL, CRANIAL, AND POSTCRANIAL DATA

Peter E. Kondrashov[1]

1. A.T. Still University of Health Sciences, Kirksville College of Osteopathic Medicine, 800 W. Jefferson St., Kirksville, Missouri 63501, USA. pkondrashov@atsu.edu

Archaic ungulates or condylarthrs represent a poorly defined polyphyletic assemblage of Paleocene and early Eocene eutherians that are thought to be ancestral to several groups of ungulate mammals. The purpose of this study was a comprehensive analysis of dental, cranial, and postcranial anatomical data to establish interrelationships between major groups of archaic ungulates, perissodactyls, artiodactyls, proboscideans, and hyracoids. Cladistic analysis of 128 characters (34 upper dentition, 22 lower dentition, 30 cranial, 2 vertebral, 15 forelimb, and 25 hind limb) in 27 taxa produced two most parsimonious trees with tree length of 569 steps. The phylogenetic analysis strongly supported the concept of Altungulata, which in our analysis included Perissodactyla + Hyracoidea + Proboscidea (branch support [BS] = 8). Our cladistic analysis did not recover monophyletic "Phenacodontidae", instead phenacodontids formed a series of sister taxa to the Altungulata clade. The "Phenacodontidae" + Altungulata clade was well supported (BS = 8). *Procavia* showed close affinities to *Moeritherium* confirming the monophyletic Tethytheria (BS = 11). Pleuraspidotheriidae formed a well-supported clade (BS = 10) that was loosely associated (BS = 2) with the "Phenacodontidae" + Altungulata clade. *Rhynchocyon*, *Haplomylus*, and *Apheliscus* formed a monophyletic group (BS = 6), while *Hyopsodus* did not show close affinities to either of them and was loosely associated with the Pleuraspidotheriidae + Altungulata clade (BS = 2). *Diacodexis* did not show close affinities to acrtocyonids and formed a sister group to the macroscelidean clade (BS = 5). Periptychidae was the only archaic ungulate family that formed a well-supported monophyletic group (BS = 9). *Periptychus* and *Ectoconus* formed the crown group within the family with sister taxa being *Mithrandir*, *Hemithlaeus*, and *Anisonchus*. A weakly supported Conacodontinae included *Conacodon* and *Haploconus*. The basal-most taxon within the family was *Oxyacodon*. Family "Arctocyonidae" was not supported by our analysis since *Arctocyon* and *Loxolophus* formed a sister group (BS = 3) to Periptychidae (BS = 3), while *Arctocyonides* and *Chriacus* were loosely associated with the Periptychidae + *Arctocyon* and *Loxolophus* clade. Out of five archaic ungulate families included in our analysis only Pleuraspidotheriidae and Periptychidae proved to be monophyletic and were well supported, while monophyletic "Hyopsodontidae", "Phenacodontidae", and "Arctocyonidae" were not supported. "Arctocyonidae" and Periptychidae showed affinities toward each other.

RISE AND DEMISE OF THE LATEST KATIAN (ORDOVICIAN) CARBONATE MUD MOUNDS OF THE BODA FORMATION, CENTRAL SWEDEN

Björn Kröger[1], Jan Ove R. Ebbestad[2], David Gröbner[3] and Oliver Lehnert[4]

1. Finnish Museum of Natural History, P.O. Box 44 (Jyrängöntie 2), FI-00014 University of Helsinki, Finland. bjorn.kroger@helsinki.fi

2. Evolutionsmuseet, Uppsala Universitet, Norbyvägen 16, SE - 752 36 Uppsala, Sweden.

3. Intitut für Paläontologie, Universität Wien, Geozentrum, UZA II, Althanstraße 14, A - 1090 Wien, Austria.

4. Geozentrum Nordbayern, Universität Erlangen-Nürnberg, Fachgruppe Krustendynamik, Schlossgarten 5, 91054 Erlangen, Germany.

The Boda mounds are iconic. They are the textbook examples for *Stromatactis*-bearing micritic bioherms, and they are name-giving for the so-called "Boda Event", an extraordinary climatic interval in the advent of the Hirnantian glaciation and its associated extinctions. The faunal richness of the Boda mounds is famous, with hundreds of species of trilobites, brachiopods, and mollusks described. Until recently, little was known about the exact stratigraphic position of the growth interval of the mounds, about their geometry, and of the composition of its main builders. Based mainly on new chemostratigraphical data, the exact timing of the mound formation now can be constrained. New field observations provide evidence for the geometry of the mounds and its synsedimentary deformations. Additionally, based on new sedimentological analyses, the top importance of sponges and green algae in different intervals of the mound formation can be demonstrated. The demise of the mound growth coincides with a drastic sea level fall of several tens of meters and a sudden faunal depletion at the end of the Katian. The observed changes in the mounds ecosystem and in the sedimentological regime provide a unique record of the local and global changes in environmental conditions during this critical interval in earth history.

CRANIAL ONTOGENY OF THE BASAL CARNIVOROUS DINOCEPHALIAN *ANTEOSAURUS MAGNIFICUS* FROM THE SOUTH AFRICAN KAROO

Ashley Kruger[1,2], Bruce S. Rubidge[1,2] and Fernando Abdala[1,2]

1. Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, WITS 2050, South Africa. ashleykruger@gmail.com

2. National Research Foundation / Department of Science and Technology: Centre of Excellence in Palaeosciences, University of the Witwatersrand, Johannesburg, WITS 2050, South Africa.

Anteosaurs were the dominant terrestrial predators during the late middle Permian (~ 270 million years ago) and became extinct at the end of this period. The group was represented in Laurasia (China and Russia) as well as Gondwana (South Africa, and most recently, Brazil). Two genera of anteosaurs, *Australosyodon* and *Anteosaurus*, are represented in the two oldest biozones from the Beaufort Group of the South African Karoo basin, namely the *Eodicynodon* and *Tapinocephalus* assemblage zones. We describe the first, almost complete, juvenile skull of *Anteosaurus* (BP/1/7074), represented by cranial and mandibular elements. The mode of preservation has allowed for the first time a study of the internal morphology of the skull. A full computer-aided 3-D reconstruction of the skull enabled cranial measurements to be taken for an allometric analysis which included twenty-three measurements and eleven specimens of *Anteosaurus*. Positive allometry was found for four of the measurements suggesting fast growing in the temporal region, and a significant difference in the development of the post orbital bar and suborbital bar between juveniles and adults. A recent phylogeny retrieved *Anteosaurus* as the sister taxa to the Russian *Titanophoneus*, whereas *Syodon* has a more basal position among the anteosaurs. The cranial morphology of the juvenile *Anteosaurus* resembles that of the adult Russian taxa *Syodon*, in the absence of skull roof pachyostosis and lateral widening of the suborbital portion of the jugal. The general similarity of the cranial morphology between the juvenile *Anteosaurus* with that of the adult, phylogenetically more basal, *Syodon* is a possible representation of a peramorphic process in the cranial development of the African form.

DIGITAL ASSESSMENT OF NON-MARINE TRACE FOSSILS IN THE KAROO SUPERGROUP, SOUTH AFRICA

Desmond W. Krummeck[1] and Emerse M. Bordy[1]

1. Department of Geological Sciences, University Avenue, Upper Campus, University of Cape Town Rondebosch, Cape Town, 7701, South Africa. krmdes002@myuct.ac.za

Ichnology, the study of traces made by organisms in sediments, is a relatively young discipline that has been somewhat neglected in southern Africa, with few papers explicitly dedicated to the study of trace fossils. To date, no consolidated ichnotaxa database exists, and thus the temporal and spatial distributions of southern African trace fossils are unknown. This is in spite of the usefulness of ichnofossils in indicating the environmental conditions that influenced the behaviour of the trace-making organisms, including the survival strategies of organisms during and after environmental crises (*e.g.*, mass extinction events). Globally, a trend is emerging where the validity of ichnotaxonomic assignments are being reconsidered, to assess more accurately past biodiversities and ecological events. In this new trend, trace fossil morphology is the primary means for diagnosing and describing ichnotaxa. Trace fossils, which are three-dimensional (3D) objects, are conventionally described through two-dimensional (2D) media (*e.g.*, on paper). In the midst of a 3D scanning and modelling technological revolution, photogrammetry allows for the production of digital 3D models utilising low cost equipment and relatively low processing power. Digital trace fossils allow researchers to visualize and quantify the full morphology (*e.g.*, architecture, bioglyphs patterns) of a trace fossil, allowing for more accurate identification and comparisons of ichnotaxa. This project aims to undertake a large-scale analysis and re-assessment of ichnotaxa in the Triassic to Jurassic non-marine deposits of South Africa, and to refine the local and the global biodiversity patterns related to the two of the Mesozoic mass extinction events (*i.e.*, pre- and post-Triassic). Once a more consolidated picture of the trace fossil diversity is achieved, more quantitative analysis of ichnology in South Africa can commence. Furthermore, the South African ichnofossil database could then be integrated into the global database projects on ichnofossils (*e.g.*, Fossilworks, PalaeoDB) and facilitate the bringing of southern African ichnofossil research up to speed with international practises. Finally, the use of 3D models and low cost technologies will allow for efficient information transfer globally among researchers and to the public.

BIOSTRATIGRAPHY AND CHEMOSTRATIGRAPHY OF THE LOWER/MIDDLE TOURNAISIAN (MISSISSIPPIAN) LIMESTONES OF THE MORAVIAN KARST (MORAVIAN-SILESIAN ZONE; CENTRAL EUROPE, CZECH REPUBLIC): PRELIMINARY RESULTS

Tomas Kumpan[1], Jiri Kalvoda[1] and Jiri Fryda[2,3]

1. Department of Geological Sciences, Masaryk University, Kotlářská 2, 611 37, Brno, Czech Republic. kumpan.tom@gmail.com

2. Czech Geological Survey, Klárov 3/131, 118 21, Prague 1, Czech Republic.

3. Department of Environmental Geosciences, Czech University of Life Sciences, Kamýcká 129, 165 21, Prague 6, Czech Republic.

The Famennian to Visean carbonate sequence of the southern Laurussian margin – the Líšeň Formation – is well exposed in the southern part of the Moravian Karst (NE of Brno, Czech Republic). The Frasnian/Famennian, Famennian/Tournaisian and Tournaisian/Visean boundaries were determined there, both biostratigraphically and eventostratigraphically in several quarry sections. Our preliminary results on high-resolution stratigraphic studies on conodonts, foraminifers and inorganic carbon isotopes ($\delta^{13}C_{carb}$) from the lower/middle Tournaisian of the Lesní lom and Anaklety sections are presented herein. Complete succession of the early Tournaisian conodont zones *Siphonodella sulcata*, *S. bransoni*, *S. duplicata*, *S. hassi*, and *S. sandbergi*, and the foraminiferal zones *Tournayellina pseudobeata* and *Prochernyshinella disputabilis* were documented in the 23 m thick interval of calciturbidites of the Lesní lom quarry. *S. belkai*, the index conodont for the *S. belkai* Zone, recognized in Eastern Europe and the Urals, was documented from the *S. hassi* and *S. sandbergi* zones for the first time in the Moravian Karst. The FAD of *S. belkai* is just above the FAD of *S. hassi*, supporting interregional correlation of the bases of these eponymous zones. A 2 meters thick calciturbidite yielding abundant conodonts of the *S. quadruplicata* and the *S. crenulata* zones (lower/middle Tournaisian boundary), together with a foraminiferal association typical of the *Palaeospiroplectammina tchernyshinensis* Zone was studied in the Anaklety section. Two positive $\delta^{13}C_{carb}$ excursions (3 ‰) were measured from the *duplicata* and *hassi* conodont zones (*Tournayellina pseudobeata* and *Prochernyshinella disputabilis* foraminiferal zones respectively) in the Lesní lom Quarry. Foraminiferal association from the second peak interval correlates with the Upian Horizon in the Urals and may correlate with the association of MFZ2 from the Middle Hastière Formation (Namur-Dinant Basin; S Belgium and NE France), where the $\delta^{13}C_{carb}$ excursion was documented during our previous research. However, interregional correlation of both $\delta^{13}C_{carb}$ excursions requires further survey, due to the discrepancies in conodont biostratigraphy and the biostratigraphic scheme used in shallow-water facies successions of the Namur-Dinant Basin. [Contribution to P210/11/1891 –Czech Science Foundation].

CLADE HISTORY, SPECIES ECOLOGY AND EXTERNAL CAUSAL FACTORS INFLUENCE ARTHROPOD SURVIVAL AND RECOVERY DURING PALEOZOIC MASS EXTINCTIONS

James C. Lamsdell[1] and Paul A. Selden[1,2]

1. Paleontological Institute and Department of Geology, University of Kansas, 1475 Jayhawk Boulevard, Lawrence, KS 66045, USA. lamsdell@ku.edu

2. Palaeontology Department, Natural History Museum, Cromwell Road, London SW7 5BD, UK.

Mass extinctions are known to be extraordinary events during which the normal rules of natural selection do not apply. Evidence points to the operation of a different selective regime, one where clade-level properties are selected upon; however, it is still unclear whether survivorship rules apply across different extinction events, the consequences of differential responses in diversity and disparity during extinction events, and the factors governing subsequent recoveries. Here, we compare variations in diversity and disparity across three arthropod clades for two extinction events: the end-Ordovician (443 Ma) and the late Devonian (385–359 Ma). Our study reveals different patterns of morphospace loss between the two extinctions, with the end-Ordovician characterized by random morphospace loss while a marked migration in morphospace occurs in all three clades during the late Devonian. The nature of these migrations is mediated by species ecology; in one clade, generalists survive and morphospace occupation is reduced to a portion of its original area, while the survivors in the remaining clades are specialists and morphospace expands into previously unoccupied areas. Variations in diversity between the three clades, with two related groups experiencing major diversity loss during the late Devonian with no subsequent recovery and another undergoing an evolutionary bottleneck before further radiation in the Carboniferous, suggests that inherent properties of the clade can also influence how it responds to mass extinction events. Through comparing rates of character evolution and rates of origination and extinction in it is shown that clades with higher volatility fail to recover, remaining at low diversity. Differences in ecology appear to be causing the heightened levels of volatility, resulting in fewer surviving species from which to radiate and limiting the possibility for expansion into vacant ecospace. Ecology is, therefore, shown to be an important factor in mediating survival and recovery during the late Devonian. Furthermore it is shown to operate on multiple, sometimes contradictory, levels. It is shown that ecological factors, such as specialization, that influence responses in morphospace act independently of the ecological and historical factors that influence recovery.

NEW DEVELOPMENTS INTO EARLY DINOSAUR PHYLOGENY

Max C. Langer[1] and Jonathas S. Bittencourt[2]

1. Universidade de São Paulo, Av. Bandeirantes 3900, Ribeirão Preto, 14040-901, Brazil. mclanger@ffclrp.usp.br
2. Universidade Federal de Minas Gerais, Av. Antônio Carlos 6670, Belo Horizonte, 31270901, Brazil.

First attempts towards a comprehensive phylogeny of early dinosaurs confirmed previously suggested hypotheses of relationship, stressed points of disagreement among earlier studies, and also recovered clades not identified before. This is based on a new taxon/character matrix of 243 characters; all variable within the group of interest (i.e., Dinosauromorpha not consensually nested within Ornithischia, Sauropodomorpha, or Theropoda) and compiled from different sources. These were scored for a set of 40 early dinosauromorphs (36 of with based on first-hand examination of the specimens), including all Triassic representatives of the group known form more than scrappy remains (except for a range of uncontroversial sauropodomorphs), as well as some Early Jurassic members of both Theropoda and Ornithischia. Multiple MPTs resulted from a primary heuristic search using traditional TNT parameters (TBR; random seed = 0; 10,000 replicates; hold = 20), the strict consensus of which is highly polytomic. The only recovered clades were: 1– Lagerpetidae (including *Lagerpeton* and *Dromomeron*); 2– Dinosauriformes; 3– all dinosauriforms expect for *Marasuchus*; 4– Silesauridae (including *Silesaurus*, *Sacisaurus*, and *Diodorus*); 5– Ornithischia (including *Pisanosaurus*); 6– Herrerasauria (including *Herrerasaurus*, *Staurikosaurus*, and *Sanjuansaurus*); 7– the sauropodomorph lineage (including *Saturnalia*, *Panphagia*, *Chromogisaurus*, and *Pampadromaeus*); 8– a clade including *Tawa* and *Chindesaurus*. The latter is firstly identified here, including two putative theropods from the Norian of western USA, which share a unique tibial/tarsal anatomy. Furthermore, background data recovered from bootstrap analyses, majority rule consensus, and selective exclusion of more fragmentary taxa hints into the affinities of (1) *Eucoelophysis* to Silesauridae, (2) *Eoraptor* to Sauropodomorpha, and (3) *Guaibasaurus* to Theropoda. In addition, on a broader picture, silesaurids belong into the Ornithischia branch, whereas most other discussed taxa belong into the opposite (Saurischia) branch, as non-eusaurischians, including herrerasaurs, the *Chindesaurus*/*Tawa* clade, as well as *Eodromaeus* and *Daemonosaurs*. These hinted arrangements are very weakly supported and require a much more in depth evaluation. Yet, the identified uncertainties do not seem to artificially derive from the inclusion of incomplete taxa, but to reflect real discrepancy (highly levels of homoplasy) of the anatomical data. Indeed, better resolution may only be achieved with more and better described fossils, and more detailed phylogenies, as attempted here.

ONTOGENETIC VARIATION IN THE BRAINCASE OF *CLADOCYCLUS GARDNERI* (TELEOSTEI: ICHTHYODECTIFORMS) FROM THE ARARIPE BASIN, LOWER CRETACEOUS OF NE BRAZIL

Maria E. C. Leal[1], Rodrigo V. Pêgas[2], Niels Bonde[3] and Paulo M. Brito[4]

1. Universidade Federal do Ceará, Depto. de Geologia, Campus do Pici, Bloco 912, Fortaleza, CE, 60455-760, Brazil. castroleal@gmail.com

2. Museu Nacional/UFRJ, Quinta da Boa Vista s/n, São Cristóvão, Rio de Janeiro, RJ, 20940-040, Brazil.

3. Zoological Museum (SNM), Universitetsparken 15, DK-2100 Copenhagen Ø, and Fur Museum (Museum Salling), DK-7884 Fur, Denmark.

4. Universidade do Estado do Rio de Janeiro, Av. São Francisco Xavier 524, PHLC, Maracanã, Rio de Janeiro, RJ, 20550-013, Brazil.

The braincase of *Cladocyclus gardneri* from the Romualdo Member of the Santana Formation is redescribed, based on a new series of acid-prepared specimens that allows the recognition of different stages of ontogenetic development based mainly on neurocranial characters from the ethmoid, otic and occipital regions. Characters from the dermocranium and post-cranium were also used to establish the ontogenetic series. The criteria for identification and distinction between adult and younger specimens have been based mainly on the different degrees of fusion of the neurocranial bones, disregarding the relative size of the specimens. The bones suffering the main modifications observed in the developmental series are: 1) in the ethmoidean region the supraethmoid, lateral ethmoid, rostrodermoethmoid and the ethmopalatinee (the latter particularly in the articular sufaces for the hypoethmoid+vomer and palatine); 2) in the otic-occipital region the articular facet for the hyomandibular bone changes its shape, involving modifications in size and relative proportions of the sphenotic, pterotic, prootic, and intercalar. The latter undergoes marked changes during ontogeny; 3) concerning the dermal bones associated with the neurocranium, the hypoethmoid-vomer complex presents ontogenetic variation especially related to the size and shape of the articular surfaces for the premaxilla and ethmopalatine, and the parasphenoid changes its angulation in its median region under the posterior wall of the orbit; 4) together with this change in the parasphenoid angulation there is a change in the overall neurocranium profile, due supposedly to allometric growth. Our results present further evidence for maintaning *Cladocyclus ferus* from the Santana Formation as a junior synonym of *C. gardneri.* Failure to recognize probable variations and/or developmental features is still a common problem in studies of fossil fishes, which may be reflected in misleading diagnosis of taxa and, subsequently, in a large number of synonymies.

THE SAUROPODOMORPH HAND EVOLUTION: MORPHOLOGICAL CHANGES IN THE CARPUS

Juan M. Leardi[1]

1. CONICET, Instituto de Estudios Andinos "Don Pablo Groeber", Intendente Güiraldes 2160, Buenos Aires, C1428EGA, Argentina. jmleardi@gl.fcen.uba.ar

The structure of the anterior autopodium has always been considered one of the hallmarks of Sauropodomorpha. The main changes recognized in this structure are those associated with the modification of the first digit, which is strongly hypertrophied and its first phalanx rotated outwards and the loss of the ossification in carpal elements. The anterior autopodium is further modified in derived sauropods, as they lack any ossified carpal elements and the metacarpals adopt a columnar disposition. Besides the recognition of the absence of ossified carpals in derived sauropods (titanosauriforms) few studies on this transition were made, which is surprising considering the great fossil record of sauropodomorph anterior autopodia. The aim of this contribution is to evaluate the changes in the carpus of Sauropodomorpha trough the phylogeny of the clade. As the carpal elements are rarely preserved, this study is based mostly on articulated and well specimens where the complete anterior autopodium was preserved. The absence of ossified proximal carpals is widely distributed among sauropodomorphs, with the exception of *Efraasia* where the radiale, ulnare and a centrale are present. Basal sauropodomorphs like *Plateosaurus* show a reduction in the distal carpals, as the distal carpal 4 is the smallest one of the carpus unlike the large distal carpal 4 of basal dinosaurians (*Eoraptor* and *Herrerasaurus*), where it is the largest distal carpal. A similar reduction is observed on distal carpal 3. On the other hand, the distal carpal 1 is laterally expanded and as a proximolateral process that covers the proximal end of the distal carpal 2. Massopods also continue with the reduction of the distal carpal row, as the distal carpal 4 is absent in any known member of the clade (e.g., *Massospondylus*, *Adeopapposaurus*, *Seitaad*). The structure of the carpus of non-sauropod sauropodiformes is uncertain as no complete carpus has been recovered for these taxa. A higher reduction is observed in the distal carpal row of sauropods and eusauropods, as a medial large single distal carpal is known in derived taxa (i.e., *Camarasaurus*). Thus, a gradual reduction is evidenced in the elements of the carpus, starting with the proximal carpals and continuing from the lateral most to the medial distal carpals. Even though, this process seems not to be devoid of any homoplasies as the case of the chinese eusauropod *Shunosaurus* which has three distal carpals unlike other known members of this derived clade.

REVISION OF THE BASAL MESOEUCROCODYLIAN *MICROSUCHUS SCHILLERI* FROM THE BAJO DE LA CARPA FORMATION (UPPER CRETACEOUS, NEUQUÉN, ARGENTINA)

Juan M. Leardi[1], Lucas E. Fiorelli[2] and Zulma Gasparini[3]

1. CONICET, Instituto de Estudios Andinos "Don Pablo Groeber", Intendente Güiraldes 2160, Buenos Aires, C1428EGA, Argentina. jmleardi@gl.fcen.uba.ar

2. CONICET, Centro Regional de Investigaciones Científicas y Transferencia Tecnológica (CRILAR). Entre Ríos y Mendoza s/n., Anillaco, 5301, La Rioja, Argentina.

3. CONICET, División Paleontología de Vertebrados, Museo de La Plata, Paseo del Bosque s/n, La Plata, 1900, Argentina.

During Late Cretaceous times, Patagonia and the rest of Gondwana were inhabited by an astonishing fauna of crocodyliforms. After numerous studies a more complete idea of their phylogenetic relationships and evolutionary patterns was obtained, achieving important conclusions on biodiversity, distribution, paleobiology and paleoecology. However, the Argentinean taxon *Microsuchus schilleri* has been almost ignored. The type specimen of *Microsuchus* was recovered in the early 20's from the Cretaceous outcrops of the Bajo de La Carpa Formation, in the area where the campus of the University of Comahue is presently located. This specimen is represented by an articulated individual that has hindlimb and axial remains, although the preservation of the materials is far from optimal. Besides the lack of details in its remains, *Microsuchus* has several traits that allow us to recognize it as a valid taxon, such as: the presence of lateral bulge lateral to the prezygapophyses of the second sacral vertebra, elongated posterior zeugopodia, proximal caudal centra with triangular cross section, and rectangular dorsal osteoderms, among others. On the original description *Microsuchus* was assigned as a goniopholid based on the platycely of its vertebral centra, a character that is widely distributed among fossil crocodyliforms. A phylogenetical analysis using an expanded data matrix focusing on postcranial data was performed in which *Microsuchus* and another long-legged crocodyliform from the same locality, *Neuquensuchus*, were included. The position of *Microsuchus* is conflictive as it is depicted in a politomy as a basal mesoeucrocodylian, with its position as a neosuchian or notosuchian supported by a single synapomorphy on the different most parsimonious trees. Additionaly, *Neuquensuchus* is recovered well nested among notosuchians, unlike previous hypothesis. These findings further increase the crocodyliform diversity of the Candeleros Formation and emphasize the relevance of its fauna in studies of the diversification of mesoeucrocodylians and notosuchians. Furthermore, the occurrence of both *Microsuchus* and *Neuquensuchus* give evidence of a basal stack of basal mesoeucrocodylians with elongated limbs that was not previously reported for northern Patagonia.

NEW FOSSILIFEROUS SITES WITH GANOID FISH SCALES, COPROLITES AND AMNIOTA TEETH REMAINS FROM CONTINENTAL FORMATIONS (LOWER CRETACEOUS) OF THE SERGIPE-ALAGOAS BASIN, NORTHEASTERN BRAZIL

Alexandre Liparini[1], Cleciana Andrade dos Santos[2], Paulo R. Lima Aragão[2], Tayara Santos Chagas[2], Daniel Costa Fortier[3], Paula Camboim Dentzien-Dias[4] and Ana E. Quezado de Figueiredo[3]

1. Universidade Federal de Sergipe, Av. Marechal Rondon, s/n, São Cristóvão, CEP 49100-000, Brazil. alexandreliparini@yahoo.com.br

2. Universidade Federal de Sergipe, Av. Marechal Rondon, s/n, São Cristóvão, CEP 49100-000, Brazil.

3. Universidade Federal do Piauí, BR 343, Km 3,5, Floriano, CEP 64800-000, Brazil.

4. Universidade Federal do Rio Grande, Av. Itália, Km 8, Rio Grande, CEP 96201-900, Brazil.

Several small (0.5 to 4 cm long) vertebrate remains were collected from two new fossiliferous sites in the municipality of Japoatã and São Francisco, NE Sergipe, NE Brazil (Geographic coordinates, WGS 84, Site 1: 10°18'40"S, 36°53'30"W; Site 2: 10°19'40"S, 36°48'30"W). The rocks that crops out in northeastern Sergipe are related to the pre-rift and rift continental depositional supersequences of the Sergipe-Alagoas Basin. The Bananeiras, Serraria, Feliz Deserto, Barra de Itiuba and Penedo formations (fluvial, deltaic and lacustrine deposits) of this section may be neo-Jurassic and eo-Cretaceous in age. On Site 1 (Bananeiras Formation), one well preserved spiral coprolite, some well-preserved ganoid fish scales and several fragmentary unidentified vertebrate remains were found in a greyish to reddish friable massive mudstone. On Site 2 (Barra de Itiúba Formation), two incomplete conical teeth, some unidentified bone fragments and many ganoid fish scales were found in yellowish, consolidated mixed carbonate-siliciclastic silt to fine-grained sandstone. The spiral coprolite (LPUFS-5735) has a bullet shape; eight whorls comprised in half of it, without inclusions, and was classified as heteropolar (2.75 cm wide and 5.4 cm long). Both teeth found are conical and slightly curved. Their upper portion is not preserved and the pulp cavity, dentine and part of the enamel are observable. Tooth LPUFS-5737 has a nearly round base with a diameter of 0.7 cm. Several regular vertical and parallel smooth ridges are observed without any distinct carinae. Tooth LPUFS-5736 is "crocodiliform-like" in shape, not laterally compressed, with a diameter of 0.5 cm. Two unserrated blade like tenuous carinae, opposite to each other and lateral to the curvature of the teeth are present. The ganoid fish scales comprise basically two morphotypes: (i) quadrangular (2 to 4 cm), ornamented with grooves and ribs, characteristic of the dorsal region of the animal (e.g., CPO-0264, CPO-0265); and (ii) rhomboid to oval shape (0.5 to 1 cm), with reduced or absent imbrication zone and smooth ganoine layer, from the posterior region of the fish near anal and caudal fins (e.g., CPO-0266 to CPO-0270). Those scales were attributed to basal actinopterygian (Lepisosteiformes or Semionotiformes), as the most probable attributable genus, i.e. *Lepidotes*, may not form a natural group among their species. Most fossils of the Sergipe-Alagoas Basin are from the Upper Cretaceous marine sequences, comprising specially invertebrates. Therefore, the findings presented herein add new information to a less studied time interval (Jurassic-Cretaceous boundary) and to poorly known fossil groups (vertebrates) of the Sergipe-Alagoas Basin. [Financial Support: Magis/COPES/UFS].

EXTINCTION AND RADIATION

Jere H. Lipps[1]

1. John D. Cooper Archaeological and Paleontological Center, Santa Ana, California 92701 USA;
and Museum of Paleontology, University of California, Berkeley, California 94720 USA.
jlipps@berkeley.edu

The fossil record includes the six (five in the fossil record plus the Anthropocene) major mass extinctions, a number of intermediate level extinctions and many other minor ones. They are distinguished by the number of taxa (usually genera are counted) that were extinguished in relatively short geological intervals. All of these extinctions impact organisms in different systematic, functional, and ecologic groups, both on land and in the sea, thus suggesting some widespread cause with general impacts on many different biotas. A variety of causes has been suggested in the past, including physiological disruptions, dissolution of carbonate skeletons, failure of photosynthesis, rise of new microbes, and a host of other organism-related factors. Ecologic factors, of course, have also been suggested; for example, that the "niches" of organisms were eliminated, which means any or all attributes of species, and then reoccupied. Recent discoveries and analyses suggest that relatively sudden impulses of greenhouse gases (CO_2 in particular) warming terrestrial and marine climates resulted in the extinctions. But how? Certainly the organism-specific mechanisms may be involved but not as general causes. At a first order level, global warming events account for most observations. More specifically sudden greenhouse warming has its greatest effect through the constriction and elimination of major habitats and ecosystems in both marine and terrestrial ecosystems. When these are destroyed or changed, the organisms adapt or die. Radiations, which may take many millions of years, have been interpreted as the reoccupation of "empty niches" but that is wrong. Since the ecosystems changed or were eliminated, no old niches existed after an extinction. Instead, new ecologic opportunities developed where survivors could adapt and evolve through physical processes often interacting with biological ones, and these allowed the evolutionary radiations that followed extinction events. The time of these radiations is chiefly a measure of increasing ecologic opportunities and complexity. Three planets in the solar system, Venus, Earth and Mars, are greenhouse planets that have warmer climates than expected. Earth, because life persisted for most of its existence, preserves greenhouse variations through its fossil record. Earth-like planets in the galaxy and beyond with life and water would also record variations in extinctions and radiations, as well as evolutionary patterns in general, because of variations in the intensity of their greenhouse effects. Greenhouse effects should be a general phenomenon anywhere in the universe.

THE ROLE OF LAST GLACIAL CLIMATE ON THE DISAPPEARANCE OF LARGE MAMMALS FROM THE COASTAL PLAIN OF SOUTHERN BRAZIL

Renato P. Lopes[1]

1. Universidade Federal do Rio Grande do Sul. Programa de Pós-Graduação em Geociências. Av. Bento Gonçalves, 9500, 91501-970, Porto Alegre, RS, Brazil. paleonto_furg@yahoo.com.br

The exact causes of the extinction of large mammals (megafauna) at the Pleistocene-Holocene transition in South America are yet open to debate, but climate change, overkill and pathogens have usually been considered. Here are presented data from recent studies in the coastal plain of Rio Grande do Sul state, in southern Brazil, that point to climate change as a major influence on the disappearance of the megafauna in this area. The most studied fossiliferous outcrops in the area are found along the banks of Chuí Creek, and represent the last ~220 thousand years. The fossils of megafauna include at least 26 species, mostly large-bodied (>1000 kg) taxa (ground sloths, glyptodonts, toxodonts and mastodonts), while small and medium-sized are scarcer in comparison, seemingly due to taphonomic processes. These remains are found in fluvial facies, and electron spin resonance (ESR) ages on teeth show that most of the remains date back to the interval between ~50 and 30 thousand years, although some older remains have also been dated. Carbon (^{13}C) analyses on teeth of the toxodontid *Toxodon* and the gomphotheriid *Notiomastodon* suggest a savanna-like environment. These fluvial facies are overlain by a 1 meter-thick silty loam (loess) which underlies organic matter-rich sediments that represent wetland environments that began to develop after ~10 thousand years. Carbonate concretions and nodules are widespread in the loess; the only fossils found in it so far are one m2 of the camelid *Hemiauchenia paradoxa* and some fragmentary rodent incisors. The available ages indicate that the loess was deposited during the last glacial (marine isotope stage or MIS 2), an interval of widespread cold and dry climate as recorded in Uruguay and Argentina. The mineral composition of this loess points towards a Pampean origin, which is consistent with increased aeolian activity during MIS 2 in southern South America and with the ~750 km northwards shift of the cold and dry (Patagonian) environment, also consistent with other records. The disappearance of the megafauna, coincident with the deposition of loess, suggest that cold and dry conditions were unsuitable for these animals; besides the lower water availability, enhanced by increased continentality effect due to lowered sea-level (about -120 meters in comparison to today), changes in the composition of plant communities (e.g. reduction of C4 plants) would have forced the large mammals to disappear from this area, indicating that the disappearance of the megafauna was not a synchronous event at least on a regional scale.

CONTRASTING ENCRUSTATION PATTERNS ON TRIGONIOID AND PECTINID BIVALVES FROM THE EARLY CRETACEOUS OF THE NEUQUÉN BASIN, ARGENTINA

Leticia Luci[1]

1. Instituto de Estudios Andinos "Don Pablo Groeber", CONICET- UBA. Int. Güiraldes 2160, Ciudad Universitaria, Pabellón II, CABA - C1428EGA, Argentina. leticialuci@gl.fcen.uba.ar

Encrusting faunas provide exceptional opportunities for palaeoecological studies, since they preserve several key features, like absolute abundance and spatial relationships among individuals. The encrusting fauna of semiinfaunal trigonioids of the genus *Steinmanella* (lower Valanginian of the Mulichinco Formation and upper Valanginian-lower Hauterivian of the Agrio Formation) were compared to the large epifaunal pectinid *Prohinnites* (upper Valanginian, Agrio Formation). Both inhabited shallow normal marine settings. All of their encrusters were mapped, recording their type, size and position. The percentage of shells colonized by at least one encruster was calculated for both basibionts, along with their species richness and Pielow's Diversity Index. Mean of encrusters per valve were calculated and compared with an analysis of deviance. Each basibiont's valves were divided in zones to assess the distribution of encrusters by a generalized linear mixed model (GLMM). Percentage of valves encrusted was significantly ($p<0.0001$) higher for the pectinid (92.68%) than for the trigonioid (43.46%). Likewise, mean of encrusters per valve was higher in *Prohinnites* (19.34) than in *Steinmanella* (2.17; $p<0.0001$). Richness was greater in the pectinid (14 encrusting taxa) than in the trigonioid (10). Both encrusting communities were dominated by oysters (*Steinmanella*: 86% of encrusters; *Prohinnites*: 57.49%). Solitary organisms prevail over colonial ones in both bivalves, but colonial organisms are more diverse and abundant in the pectinid. Pielow's indexes are 0.33 (*Steinmanella*) and 0.56 (*Prohinnites*). GLMM results showed that encrusters preferred the corselet and escutcheon of trigonioid, and avoided the proximal third of the pectinid's valves. These results indicate that *Prohinnites* sustained a more diverse and abundant encrusting fauna than *Steinmanella*. This is likely due to the pectinid's epifaunal habit and its heavy, stable ample valves. Both communities correspond to the upper euphotic zone sclerobiofacies; however, in neither of them interactions are common among encrusters, and both are dominated by oysters. The gregarious behavior of oysters, coupled to a greater larvae input (they conformed bioherms in the Agrio Formation) were likely key for rapid colonization and coverage of available substrates, which gave them a head-start advantage over other encrusters. They were, however, unable to exclude other encrusters, which could settle on shells regardless of the oyster's presence. This pattern is consistently seen in other mollusks from the Agrio Formation, resulting in encrusting communities structured mostly by larval abundance and disturbance rather than by competitive interactions. Oysters settled early on and replenished themselves as serpulids and other encrusters followed. [Contribution C-77 of IDEAN].

LATE EOCENE "SOFT" SPONGE ASSEMBLAGE FROM SOUTHERN AUSTRALIA: RECONSTRUCTION AND SIGNIFICANCE AS REVEALED BY SPICULAR ANALYSIS

Magdalena Łukowiak[1]

1. Institute of Paleobiology, Polish Academy of Sciences, ul. Twarda 51/55, 00-818 Warszawa, Poland.
mlukowiak@twarda.pan.pl

Loose (disassociated) siliceous sponge spicules are common fossils, but they are poorly studied and there is still a large and unexplored potential in their geological record. Here I have applied spicular analysis, *i.e.* the study of loose siliceous sponge skeletal elements, to the late Eocene spiculitic rocks of southern Australia. Comparison of the fossil spicules with the spicules belonging to Recent representatives of the phylum Porifera has shown that the sponge assemblage was diversified and abundant. It revealed the presence of two "soft" sponge classes Demospongiae and Homoscleromorpha represented by taxa belonging to 9 orders, 26 families, 33 genera, and 43 species. Ecological preferences of Recent counterparts of the recognized taxa suggest that the studied assemblage is of shallow-water character and lived in a depth that may be estimated as no more than one hundred meters. On the other hand, the presence of lithistid demosponges, and rare hexactinellids, which are usually deep-water forms, may be explained by the peculiar chemistry of sea-water; *e.g.*, the higher than normal silica level that allowed these forms to invade shallow-waters. This supposition is supported also by larger size of spicules of many taxa of the studied Eocene sponges than their Recent counterparts. The comparison with the sponge assemblage from the same-age Oamaru Diatomite (New Zealand) interpreted as deep-water (because of numerous hexactinellid spicules, especially strictly deep-water Amphidiscophora, and absence of typical shallow-water demosponges) supports interpretation of the Australian assemblage as the shallow-water as well. Despite the fact that many taxa recognized in the Eocene of Australia occur today in waters around Australia or in adjacent areas, there is a group of sponges that are currently known only from distant geographical regions (*e.g.*, Azores, West Arabian Sea, and European waters). This peculiar distribution pattern fits the range of the ancient Tethys Ocean, and today's distribution of these taxa might be considered as the relict of the former Tethyan distribution. Although the comparison of the studied late Eocene sponge fauna with the Recent sponge fauna inhabiting southern Australian waters demonstrates great similarity at the order level, differences can be noted at the family and lower taxonomic levels as only about half of the Recent sponge families from Australia are present in the Eocene assemblage. However, considering all difficulties in taxonomic attribution of fossil spicules and the sampling bias, there is no dramatic change in "soft" sponge fauna composition in this area since the Eocene.

OPTICS AND PHYLOGENY: A GLIMPSE INTO THE PAST THROUGH COMPOUND EYES

Javier Luque[1,2] and A. Rich Palmer[1]

1. Department of Biological Sciences, University of Alberta, Edmonton, Alberta T6G 2E9, Canada.
luque@ualberta.ca

2. Smithsonian Tropical Research Institute, Balboa–Ancón 0843–03092, Panamá, Panamá.

Although light-sensing organs or groups of cells exist in many organisms, image-forming eyes are among the most spectacular of evolutionary innovations. They have allowed animals to spot predators and find prey, search for mates, and interact with their surroundings since at least the early Phanerozoic. Image-forming eyes are such a valuable adaptation that similar optical mechanisms have evolved independently in many higher taxa. But if such complex organs have evolved independently multiple times, how useful are optical mechanisms for reconstructing phylogenetic relationships? What does the fossil record tell us about the evolution of eyes in extant taxa? Crustaceans are an ideal group to explore these questions because they have a good fossil record and possess a great variety of optical designs. In extant crustaceans, four types of compound eyes are known: apposition, parabolic superposition, refracting superposition, and reflecting superposition. Each type has a distinctive external ommatidial arrangement and internal properties to focus light on the retina. Interestingly, three of these types are known in true crabs, or Brachyura, while most crustacean clades have only one type. Brachyurans have been divided into Podotremata (females with sexual openings in the legs) and Eubrachyura (females with sexual openings in the thorax), and although Eubrachyura is purported to be monophyletic, the monophyly of Podotremata is controversial. While 'lower' podotremes (*i.e.*, Dromiacea and Homoloida) share the plesiomorphic condition of 'mirror' (reflecting superposition) eyes with most anomurans, lobsters and shrimps, the optical mechanisms of 'higher' podotremes are still poorly known. If optical characters are consistent among podotremes, then podotremes likely evolved from a single lineage. However, if 'higher' podotremes share optical characters closer to Eubrachyura than 'lower' podotremes, Podotremata may not be a monophyletic group, but rather a grade of increasing morphological complexity through time. To understand the phylogenetic implications of different eye types, we investigated the distribution of optical mechanisms in fossil and extant podotreme crabs by evaluation of external and internal features, with special emphasis on 'higher' podotremes (*e.g.*, Raninoida, Etyoida, Cyclodorippoida, and a new lineage of enigmatic 'chimaera' crabs). We conclude that apposition/parabolic superposition eyes have existed in 'higher' podotremes since at least the Early Cretaceous, and that the distribution of eye types in true crabs supports a paraphyletic 'Podotremata'. Optical mechanisms offer much promise as valuable characters for resolving phylogenetic relations at different hierarchical ranks.

PATTERNS OF SPECIES CO-OCCURRENCE IN PLANT AND MAMMAL COMMUNITIES FROM DEEP TIME TO THE RECENT

S. Kathleen Lyons[1], Nicholas J. Gotelli[2], Anna K. Behrensmeyer[1], Kathryn L. Amatangelo[3], Antoine Bercovici[4], Jessica L. Blois[5], René Bobe[6], Matthew Davis[7], William Di Michele[1], Andrew Du[6], Jussi T. Eronen[8], Tyler J. Faith[9], Gary R. Graves[1], Nathan Jud[10], Conrad Labandeira[1], Cynthia Looy[11], Brian McGill[12], David Patterson[6], Richard Potts[1], Brett Riddle[13], Rebecca Terry[14], Anikó Tóth[1], Amelia Villaseñor[6], John W. Williams[15] and Scott Wing[1]

1. Smithsonian Institution, National Museum of Natural History, Washington, D.C., USA. Lyonss2@si.edu
2. Department of Biology, University of Vermont, Burlington VT, USA.
3. Environmental Science & Biology, The College at Brockport – SUNY, Brockport NY, USA.
4. Department of Geology, Lund University, Lund, Sweden.
5. School of Natural Sciences, University of California Merced, Merced CA, USA.
6. Department of Anthropology, George Washington University, Washington, D.C., USA.
7. Department of Geology, Yale University, New Haven, CT, USA.
8. Biodiversity and Climate Research Centre (BiK-F), Senckenberganlage 25, 60325 Frankfurt am Main, Germany.
9. School of Social Science, The University of Queensland, Brisbane, Australia.
10. University of Maryland College Park, College Park, MD, USA.
11. Department of Integrative Biology, University of California, Berkeley, Berkeley, CA, USA.
12. School of Biology and Ecology & Sustainability Solutions Initiative, University of Maine, Orono, ME, USA.
13. School of Life Sciences, University of Nevada-Las Vegas, Las Vegas, NV, USA.
14. Department of Zoology, Oregon State University, Corvallis, OR, USA.
15. Department of Geography and Center for Climatic Research, University of Wisconsin-Madison, Madison, WI, USA.

Understanding the structure, function, and dynamics of ecological communities is a central goal of ecology. Models of extant ecosystems hold that biodiversity is a buffer that helps stabilize ecosystem processes and services, but how does this play out over geological time? When viewed over the entire Phanerozoic, modern levels of diversity and species richness are a relatively recent phenomenon in terrestrial communities. Many Mesozoic and older communities are considerably less diverse than those of today and yet demonstrate patterns of species composition, dominance and diversity patterns, and architectures that parallel those of modern ecosystems. We analyzed the strength of species associations, in replicated plant and mammal communities from ~300 Ma to the present using Pairs analysis. This program uses matrix randomization and null model approaches to evaluate the non-independence of species pairs, which can be significantly aggregated or segregated, or not different from null expectations. We also analyzed several critical intervals including the Cretaceous/Paleogene boundary, the Paleocene-Eocene Thermal Maximum and the Pleistocene-Holocene transition. Aggregated pairs dominate from the Carboniferous (307 ma) to the early Holocene (10,000 bp). The pattern cannot be attributed to the effects of spatial or temporal grain and extent of sampling, or to simple taphonomic artifacts. Unlike other critical intervals which showed no change in the percent of aggregated pairs or in the relative proportions of aggregated versus segregated pairs, in a Quaternary fossil pollen sequence and two Quaternary mammal assemblages, there was a progressive shift towards more segregated pairs in recent times. This trend is also consistent with a meta-analysis of 54 contemporary assemblages representing many different groups of organisms, which are dominated by segregated species pairs. The trend towards fewer positive associations begins in approximately the Holocene, and may point to the increasing influence of anthropogenic effects over the past 10,000 years. These results suggest that the organization of contemporary and Quaternary plant and animal communities may differ from those of deeper time slices.

THE EARLIEST GRAPTOLITES (PTEROBRANCHIA) AND THEIR RECOGNITION

Jörg Maletz[1] and Michael Steiner[1]

1. Institut für Geologische Wissenschaften, FU Berlin, Malteserstr. 74-100, D-12249 Berlin, Germany.
yorge@zedat.fu-berlin.de

Graptolites belong to the most important Paleozoic fossils, but their origin and early evolution is barely known. One of the main reasons for the lack of a fossil record of early pterobranchs (Graptolithina and Cephalodiscida) is the problem of identifying the organically preserved remains of graptolites in fossil 'Lagerstätten' due to the lack of structural details in many fossil taxa. A better understanding of preservational modes and diagenetic and metamorphic effects is also needed for their recognition. The pterobranch tubarium is secreted from a gland on the cephalic shield of the zooid and represents a relatively durable scleroproteic material, but later geological processes can alter these tubarial structures considerably. Thus, special methods as the SEM Backscatter method may have to be used to demonstrate the pterobranch affinities of the remains. Earliest fragmentary remains of pterobranch tubaria occur in the middle Cambrian Stage 4 (latest early Cambrian), but it is impossible to assign them to the cephalodiscids or graptolitids. Pterobranch remains are widely distributed in the Drumian (Cambrian Series 3) with a considerable biodiversity. A number of taxa are present in the upper Cambrian Stage 5 (?*Ptychagnostus gibbus* Zone) in the Monegeeta and Heathcote faunas of Victoria, Australia. The taxa *Archaeolafoea longicornis*, *Mastigograptus monegettae*, *Archeocryptolaria skeatsi* and *Archaeocryptolaria recta* were initially described as hydroids but are here assigned to the pterobranchs. Even though strongly tectonized and partly covered by pressure shadow minerals, organic remains of a number of specimens show indications of fusellar construction. A number of specimens from the Wheeler Formation and equivalent strata of Utah (USA), previously identified as the alga *Yuknessia*, show fusellar construction and can be recognized as pterobranchs too. However, elemental mapping of these fossils shows that many of these specimens do not preserve original organic material. The fossils are replaced by secondary clay minerals due to metamorphic overprinting or are preserved as faint imprints in entrapping clay matrix. The original organic material may also have been lost during diagenesis and weathering. The recognition of pterobranchs, previously identified as algae, in the Cambrian Stages 4-5 urges a re-interpretation of the Cambrian food chain, hinting at the lack of eukaryotic algae as major primary producers in the early Cambrian ecosystems.

EVOLUTION OF EARLY ONTOGENETIC STRATEGIES AND HATCHING SIZE IN EARLY PALAEOZOIC NAUTILOIDS

Štěpán Manda[1] and Vojtěch Turek[2]

1. Czech Geological Survey, Praha 1, Czech Republic.
2. National Museum, Department of Palaeontology, Václavské náměstí 68, 115 79 Praha 1, Czech Republic. vojtech.turek@nm.cz

Nautiloids (externally shelled cephalopods with cone or cup-shaped apex possessing cicatrix) represent prominent part of marine Palaeozoic faunas with variety of early ontogenetic and adult strategies. Although nautiloids appeared in latest Cambrian, their diversification coincides with the Early Ordovician radiation. Fossil nautiloids consist of two prominent lines derived from ellesmerocerids: Oncocerida and Tarphycerida-Nautilida. In the oncocerid line (including discosorids) the size of the first chamber is highly variable. Basal oncocerids possessed endogastrically curved embryonic shell; straight and exogastrically curved forms are derived. Hatched individuals characterise cup-like shell with 1–2 phragmocone chamber/s; demersal habit is supposed. During growth shell morphology changed and a variety of morphotypes appeared (brevicones, cyrtocones, coiled forms) reflecting adaptation to demersal or nektonic modes of life. Early Palaeozoic oncocerids were more diversified than nautilids and convergence with nautilids appearing in several lines enhanced competition pressure. Tarphycerid-nautilid line exhibits more complex evolution of early ontogeny. Ordovician and Silurian tarphycerids group nektonic nautiloids with coiled shell. Hatched individuals had small curved shell probably with a single phragmocone chamber and very short body chamber, which indicate planktonic habit. In Late Ordovician–Silurian uranocerids body chamber was more capacious. Freshly hatched juveniles could be also planktonic. After reaching about a half of the whorl, active swimming and a mode of life similar with adults are supposed. Silurian-Devonian lechritrochoceratids share slightly curved thin-walled juvenile shell with radial riblets; several low air chambers and long body chamber suggest increasing swimming ability of juveniles. Middle Devonian–Permian nautilids include exclusively coiled nektonic forms. Their hatching phase is indicated by a nepionic constriction. Early-hatched individuals possessed curved shell, pointed apex and very low first chamber bearing transversal lines. Nektonic mode of life is supposed. Hatching individuals of Post-Palaeozoic nautilids had large coiled shell and resembled adults in their habits. Prolonged embryonic development in egg capsule and consequently increasing size of hatched specimens characterised evolution of nautilids from tarphycerids. No similar trend has been recorded in other externally shelled cephalopods. Prominent changes appeared in early ontogenetic strategies in the evolutionary lineage leading to *Nautilus*: from pelagic early stages and nektonic–demersal adults to nautilids in which hatched individuals looks-like miniaturised adults with similar mode of life. Accommodation of these novelties caused restriction of dispersion area and affected biodiversity development in nautiloids (demise from several niches since mid-Palaeozoic). In all pre-Triassic nautiloids the mode of life of early-hatched specimens differed from adults, which caused complex interaction between evolutionary lines.

THE FOSSIL CYCADS OF ARGENTINA: NEW TAXA, EVIDENCES AND RELATIONSHIPS ABOUT THEIR EVOLUTIONARY HISTORY

Leandro C. A. Martínez[1,2] and Analía E. E. Artabe[2]

1. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Avda. Ángel Gallardo 470, Buenos Aires (1405), Argentina. gesaghi@gmail.com

2. Facultad de Ciencias Naturales y Museo. División Paleobotánica, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata (1900), Argentina.

Cycads are an ancient and enigmatic group of seed plants, with a fossil record dating back to the Cisuralian of China and reaching a great diversity in the Mesozoic. In spite of having a diverse and continuous fossil record, cycads do not grow as a native plant in Argentina. Stems, leaves, reproductive structures, pollen and seeds are known from the Triassic, with a peak in the Late Cretaceous, to decline and became extinct in the Paleogene. The goal of this research is to show the diversity attained by Cycadales in Argentina, to understand the diversification of some clades (e.g., Encephalarteae) across the Cretaceous of Patagonia, and to infer the causes of their extinction in southern South America. The phylogenetic relationships among extant and fossil Cycadales were tested by cladistic analysis. Taxa with close affinities with the Cydadales, e.g., Nilssoniales (*Baikalophyllun*, *Nissoniocladus*), Lyginopteridales, Medullosales, and Bennettitales, were taken into account in our cladogram. Our analysis shows that most of Cretaceous Patagonian Cycadales belongs to Encephalarteae and their diversity could be correlated with a humid to xeric subtropical climate, analogous to those developed in Africa today. The extinction of cycads in Patagonia could be influenced by abiotic and biotic factors. The Andean uplift (forming a topographic barrier), and the temperature diminution (drop of atmospheric CO_2, inception of the Antarctic Circumpolar Current) caused a drastic climatic change (from humid and template to cold and dry). The extinction of animals (e.g., dinosaurs) produced alterations in seed dispersal strategies, limiting the migration of cycad to new areas. Furthermore, floristic changes involving the diversification of the Magnoliophyta, and the appearance of groups that compete by the same habitat (and even with a similar life-form as the palms), also constrained the cycad populations.

AN EARLY SILURIAN DYSAEROBIC FAUNA FROM EASTERN KENTUCKY, USA: CHANGING PALEOZOIC PATTERNS OF DOMINANCE AND TROPHIC STRUCTURE IN DYSAEROBIC COMMUNITIES

Charles E. Mason[1], Frank R. Ettensohn[2] and R. Thomas Lierman[3]

1. Morehead State University, Morehead, Kentucky 40351, USA.
2. University of Kentucky, Lexington, Kentucky 40506, USA.
fettens@uky.edu
3. Eastern Kentucky University, Richmond, Kentucky 40475, USA.

Nearly all dysaerobic faunas are reported from upper Paleozoic (Devonian and later) rocks and are characterized by mobile, molluscan-dominated faunas that include deposit feeders, browsers and scavengers. These faunas also typically comprise low-diversity, high-abundance, juvenile-to-dwarf forms. In contrast, here we report what may be the first early Paleozoic dysaerobic fauna from the pyritic gray shales of the lower Silurian (Telychian) Estill Shale Member of the Crab Orchard Formation in eastern Kentucky. These shales were deposited in the subsiding Salinic foreland basin during a period of global sea-level rise and regional tectonic subsidence. Like other dysaerobic faunas, the Kentucky fauna exhibits low diversity and high abundance, and it is composed of juvenile or dwarf forms. However, unlike late Paleozoic dysaerobic faunas, this early Paleozoic fauna was dominated by sessile filter feeders, including brachiopods, bryozoans and crinoids. This fauna probably evolved in response to slow subsidence in the Salinic foreland basin. Although small size was probably a means to accommodate surface area/volume ratios in O_2-poor waters, filter feeding may not have been an effective means of feeding in deeper waters where transporting currents were apparently minimal or lacking. Such an early Silurian fauna may have been an initial attempt by filter feeders to adapt to deeper, dysaerobic, basinal settings, but it does not appear to have been successful in the longer term. By Devonian time, filter-feeding dysaerobic faunas had largely been replaced by mobile molluscan infauna, epifauna and nekton with lower oxygen needs and capable of living associated with muddy substrates.

A PERMINERALIZED ROYAL FERN WITH PRESERVED ORGANELLES FROM EARLY JURASSIC VOLCANIGENIC DEPOSITS OF SWEDEN

Stephen McLoughlin[1], Benjamin Bomfleur[1], Guido W.Grimm[1] and Vivi Vajda[2]

1. Department of Palaeobiology, Swedish Museum of Natural History, Stockholm, Sweden.
steve.mcloughlin@nrm.se

2. Department of Geology, Lund University, Lund, Sweden.

We present one of the most exquisitely preserved plant fossils yet discovered: a calcified rhizome belonging to a new species of royal fern (Osmundaceae) from the Korsaröd locality in the central Scanian volcanic province of southern Sweden. The specimen was entombed in a lahar deposit around 180 million years ago (Pliensbachian). Hydrothermal fluids then permineralized the rhizome *in vivo* at such remarkable speed and detail that many parenchyma cells preserve cytoplasm components including starch granules, nuclei, nucleoli and even chromosomes in different stages of cell division. Some parts of the stem's outer cortex contain cells bearing evidence of programmed cell death: shrunken cytoplasm and apoptotic nuclei. The Korsaröd fern fossil also yields evidence of a range of biotic interactions including the removal of cortical parenchyma from some outer petioles by herbivorous arthropods (probably oribatid mites) and emplacement of coprolites within excavated cavities. A few rootlets penetrating the petiole mantle have anatomies that differ from the royal fern and further contain associated fungi, indicating that the mantle around the presumably erect rhizome was being colonized by a separate, unidentified plant. Additional extraneous debris in the outer root mantle includes the remains of sporangia and possible megaspores, which are similar to taxa recovered from the lahar matrix. These discoveries collectively permit an exceptionally detailed palaeobiological and palaeoecological reconstruction of the Korsaröd fern and its local community. The anatomy of the specimen indicates close affinities with modern species of *Osmunda* and *Osmundastrum*; the significance of the fossil for the evolutionary history and classification of the modern Osmundaceae is currently being explored.

ON THE OCCURRENCE OF SECONDARY XYLEM IN FOUR DIFFERENT TAXA FROM RONQUIÈRES, A MIDDLE DEVONIAN LOCALITY FROM BELGIUM

Nicolas Momont[1], Philippe Gerrienne[1] and Cyrille Prestianni[2]

1. University of Liège, 17 Boulevard du Rectorat, Liège, 4000, Belgium.
Nicolas.Momont@ulg.ac.be

2. Royal Belgian Institute of Natural Sciences, 29 Rue Vautier, Bruxelles, 1000, Belgium.

Devonian plants evolved numerous innovations that increased the range of their growth potential, reproductive abilities and dispersal strategies. The secondary xylem (wood) is one of those innovations. It allows building the largest and the most impressive organisms on Earth. It also allows for a better water conduction, even in smaller growth forms. Secondary xylem is produced by a lateral meristem called vascular cambium. Vascular cambium evolved independently in multiple plant lineages, such as lycopsids, basal euphyllophytes, ferns *sensu lato* and lignophytes. In this presentation, we focus on the occurrence of four woody euphyllophyte taxa preserved as pyrite petrifactions in the mid to late Givetian (Middle Devonian) locality of Ronquières (Belgium). This outcrop is located 300 meters northeast from the contemporaneous Ronquières locality where the most diverse Middle Devonian flora from Belgium, including the proto-ovule *Runcaria*, has been described. Four types of plants, each with a distinctive anatomy, are represented. 1. Three axes include a protostele dissected into numerous primary xylem segments, with a ring of secondary xylem around every segment; these axes belong to cladoxylopsids. 2. Two specimens consist of a three-ribbed protostele surrounded by a layer of secondary xylem; they are attributed to the stenokolealean genus *Crossia*. 3. One large axis, approximately 12 cm across, comprises a eustele surrounded by secondary xylem; this axis is attributed to the archaeopteridalean progymnosperm *Callixylon*. 4. The last type consists of specimens of uncertain affinities with a multi-ribbed stele characterized by the presence of parenchyma and thick-walled cells among the primary xylem tracheids, and surrounded by secondary xylem. The wood of all those taxa will be described and compared in detail. The exceptional diversity of woody remains from Ronquières will hopefully help to characterize the secondary xylem traits across different euphyllophytes groups. It will also help to reconstruct the environment in which the turnover between cladoxylopsids and *Callixylon*/*Archaeopteris* forest was already perceptible, but also in which early seed plants evolved.

PALAECOLOGY OF SPINICAUDATANS FROM THE CAÑADÓN ASFALTO FORMATION (JURASSIC), ARGENTINA

Mateo D. Monferran[1], Oscar F. Gallego[1] and Nora G. Cabaleri[2]

1. Centro de Ecología Aplicada del Litoral, Universidad Nacional del Nordeste (CONICET-UNNE), Ruta 5 km 2,5, C.C.128, 3400, Corrientes, Argentina. monfdm@gmail.com

2. Instituto de Geocronología y Geología Isotópica, Universidad de Buenos Aires (CONICET-UBA), Ciudad Universitaria, C1428EHA Buenos Aires, Argentina.

Spinicaudatans ('conchostracans') or 'clam shrimps' are small branchiopod crustaceans that inhabit ephemeral, warm freshwater habitats with pH conditions from neutral to alkaline. They are easily recognizable by their short, laterally compressed bodies. However, their paleoecology has been poorly analyzed, and more work must be done to better understand the relationship between spinicaudatans and their environment. Therefore, our aim is to contribute to their paleoecological study and their importance. The Spinicaudatan fauna is present in the Cañadón Asfalto Basin, located in the extra-Andean region of the Chubut province (Patagonia, Argentina). The outcrops represent the most complete volcano-sedimentary continental Jurassic sequences of South America. Spinicaudatans are the most abundant invertebrate group recorded from the Cañadón Asfalto Formation and are present in both members (Las Chacritas and Puesto Almada). The methodology was based in the identification of species, the measurement of morphological parameters and the study of sedimentary characteristics in several localities. The Las Chacritas Member fauna is composed by the families Euestheriidae and Eosestheriidae, characterized by large (4.5–8.5 mm long) spinicaudatans such as *Euestheria volkheimeri* Tasch and Volkheimer, *Lioestheria patagoniensis* Tasch and Volkheimer and *Euestheria taschi* Vallati. These spinicaudatans are associated with lacustrine facies, interbedded with pyroclastic deposits and basalt flows. The lacustrine systems were the principal environment for the development of larger species/populations, although many levels show smaller individuals with narrow growth band and high growth line densities. In some levels the 'clam shrimps' are associated with ostracods and mollusks. On the other hand, the Spinicaudatan fauna from the Puesto Almada Member is composed by small forms (1-5 mm long) such as *Congestheriella rauhuti* Gallego *et al.* and *Wolfestheria smekali* Monferran *et al.*, where they are recorded in shallow, ephemeral, and shoreline water bodies occasionally with high-energy sedimentations. These species show lower density and wide few growth bands and moreover *C. rauhuti* appears in association with fishes which are their natural predators. In conclusion, the specimens present in each of the two members differ mainly in species and dimensions, which are probably related to environmental or ecological features. The populations of 'clam shrimps' were regulated by favorable (wide few growth bands) or unfavorable (narrow growth band) conditions as well as predators influence (fishes). The spinicaudatans played an important role in Jurassic ecosystems of Argentina and these results should provide important evidence to build upon for further studies on fossil 'conchostracans'.

MICROMORPH BRACHIOPODS FROM THE VISEAN (CARBONIFEROUS) OF NORTHWEST IRELAND

Bernard Mottequin[1], George Sevastopulo[2] and Eric Simon[1]

1. Royal Belgian Institute of Natural Sciences, Earth and History of Life, rue Vautier 29, B 1000 Brussels, Belgium. bernard.mottequin@naturalsciences.be

2. Department of Geology, Trinity College Dublin, Dublin 2, Ireland.

Micromorph brachiopods are usually overlooked due to the difficulties of extracting them from massive carbonate rocks. Therefore our knowledge of these forms is based mainly on silicified and acid-etched specimens, which are commonly exquisitely preserved. However, non-silicified minute brachiopods can also be obtained by surface collecting and disaggregation of bulk samples from weathered shale and limestone as is the case of a relatively diverse assemblage recovered from the Visean (late Asbian) Meenymore Formation, which is exposed in the Gleniff outlier, County Sligo, northwest Ireland. Much of this lithostratigraphic unit was deposited in restricted environments associated with tidal flats, with several horizons of stromatolites, dolomicrites and evaporites. The fauna from the Meenymore Formation of the Gleniff outlier is characterised by small fossils, including brachiopods, molluscs, notably ammonoids, nautiloids, gastropods and rostroconchs, a varied fauna of echinoderms (including microcrinoids, small blastoids, and the disarticulated ossicles of asteroids, ophiuroids, echinoids, holothuroids, cyclocystoids and ophiocistioids), and ostracodes and rare trilobites. Corals and bryozoans are extremely poorly represented in terms of both numbers of individuals and of taxa. Many of the fossils are encrusted with a micrite crust, which is probably microbial in origin. The brachiopod assemblage includes 14 micromorph species and juveniles of larger species, in which spire-bearers (Athyridida, Spiriferida and Spiriferinida) represent 40 % of the whole assemblage with six species but, in terms of numbers of specimens, the orthotetides, represented only by *Drahanorhynchus*, are the most abundant. Most of the species are left in open nomenclature as only few specimens shows internal features. Due to the good preservation of some delicate structures (*e.g.* spines in *Globosochonetes*, *Drahanorhynchus*, *Nucleospira*, and *Crurithyris*), it seems likely that the Gleniff assemblage represent an *in situ* accumulation, although time-averaged. The reasons for the large percentage of micromorph taxa of brachiopods in the Gleniff fauna, which is mirrored by the echinoderms, are difficult to explain. It is unlikely to be a consequence of abnormal salinity, because both echinoderms and brachiopods are largely stenohaline. What is notable about the fauna is that most of the sessile benthos were epifaunal suspension feeders confined to the lowest epifaunal tier of the spectrum of tiering.

VIRTUAL RECONSTRUCTIONS OF GROWTH TRAJECTORIES AND BUOYANCY OF SOME MAJOR PALAEOZOIC AMMONOID CLADES

Carole Naglik[1], Amane Tajika[1] and Christian Klug[1]

1. Palaeontological Institute and Museum, University of Zurich, Karl-Schmid-Strasse 4, 8006 Zürich, Switzerland.
Carole.naglik@pim.uzh.ch

Due to their accretionary shell growth, mollusks such as ammonoids are ideal to study evolutionary changes in ontogeny through time. But while they are studied for centuries now, some aspects of their palaeobiology remain poorly understood, especially when it comes to Palaeozoic ammonoids. Up to now, volumetric changes through ontogeny have not been quantified empirically although they bring additional information on growth, but most importantly, they contribute in the understanding of their buoyancy regulated by their phragmocones and gas-filled chambers. For the first time, we documented (1) volumetric growth of septa and phragmocone chambers in detail and (2) ontogenetic changes between major ammonoid clades. Additionally, our data allowed the reconstruction of (3) their hydrostatic properties, their (4) *syn-vivo* shell orientation and their (5) buoyancy. Standard methods were limited to two-dimensional data and volumes have been so far only estimated. In our material, CT-scans could not be used due to the too low contrast of absorption properties between the recrystallized shells and the carbonatic sediment matrix. Nevertheless, coupling grinding tomography and virtual three-dimensional reconstructions, we are now able to document volumetric changes in detail and ontogenetic changes between major clades throughout their early phylogeny. Although this method is destructive and requires working on abundant material, it provided very satisfying results and yielded data sets of various volumes. Three representatives of these ammonoid clades have been investigated with this method: the Middle Devonian agoniatitid *Fidelites clariondi*, the Middle Devonian anarcestid *Diallagites lenticulifer* and the early Carboniferous goniatitid *Goniatites multiliratus*. Our volumetric data show that growth trajectories are more similar among the most derived *Diallagites* and *Goniatites* compared with the more widely umbilicate *Fidelites*. We also noticed a good correlation between certain 2-D and 3-D parameters. In all three species, both volumes follow exponential trends with deviations in very early ontogeny and near maturity (mature modification in shell growth). According to our models, measurements and calculations, these specimens had aperture orientations of 19°, 64° and 125° during their lives, which roughly corresponds to the values obtained for such shell forms by means of theoretical shell models. Additionally, our calculations also confirmed that the shorter the body chamber, the poorer was the hydrodynamic stability of the animal.

NEOGENE MARINE MOLLUSCAN EVOLUTION IN THE SOUTHEASTERN PACIFIC

Sven N. Nielsen[1]

1. Instituto de Ciencias Ambientales y Evolutivas, Universidad Austral de Chile, Casilla 567, Valdivia, Chile.
sven.nielsen@uach.cl

Neogene marine mollusk faunas from Chile have been investigated since d'Orbigny and Darwin brought fossils to Europe. Mollusks constitute the most diverse and best known group of Chilean marine fossil invertebrates. Based on the latest estimate, there are about 580 Neogene species of gastropods and bivalves represented in collections, but some 200 of these are not formally described. This means that about one third of the collected species remain unpublished; most of them being small. Worse still, rarefaction analysis indicates that, even when including those undescribed species, our knowledge is far from complete even for the best known faunas. In addition to the mentioned gastropods and bivalves, there is one cephalopod species, about twelve species of scaphopods and few isolated polyplacophoran plates, all coming from lower Miocene units. Traditionally work concentrated on a few Miocene (Navidad Fm) and Pliocene (Coquimbo Fm) units without reaching consensus about their ages. The modern Chilean malacofauna is highly endemic with many monospecific genera. The roots of those, however, are not known and their place within the respective families and their sister taxa often not resolved. Many appear first in the lower Miocene units among a fauna of tropical to subtropical taxa with strong affinities to New Zealand faunas. It remains unclear where their origins lie as Oligocene faunas are completely unknown and those from the Eocene received little attention but seem to be completely different. Middle to upper Miocene units are little represented in collections and differences between lower Miocene and lower Pliocene faunas are huge, with Pliocene shallow water faunas containing an already high number of living species and New Zealand taxa having meanwhile disappeared. Most classic Pliocene faunas have a depleted diversity with only calcite-shelled taxa preserved. Some newly found faunas, still undated and undescribed, exhibit a rich diversity including aragonitic taxa. Quaternary faunas mostly equal the modern one with few exceptions reflecting warmer episodes where more tropical species were able to establish in northern Chile. Exotic taxa turn up also in Pleistocene faunas. In summary, we are far from having a complete picture of Neogene mollusks. Needed are monographs of several existing collections as well as newly collected material including small taxa. Macroecological analyses may be distorted by subestimating small-sized taxa, often representing specialized ecologies like parasites. Certain trends, however, like the exceptional modern inverse latitudinal diversity gradient of southern Chile, can be safely identified as a geologically very young feature.

PERMINERALIZED MATONIACEAE FERN FROM THE EOCENE CRANILAHUE FORMATION OF COCHOLGUE, CHILE

Harufumi Nishida[1,2], Kazuhiko Uemura[3], Kazuo Terada[4], Takeshi Asakawa[5], Atsushi Yabe[3], Toshihiro Yamada[6], Yuji Kurita[7], Luis Felipe Hinojosa[8] and Miguel Rancusi[9]

1. Chuo University, 1-13-27 Kasuga, Bunkyo, Tokyo, 112-8551, Japan. helecho@bio.chuo-u.ac.jp
2. Graduate School, University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo, 113-8654, Japan.
3. National Museum of Nature and Science, Tsukuba, Ibaraki, Japan.
4. Fukui Prefectural Dinosaur Museum, Katsuyama, Fukui, Japan.
5. Chiba University, Yayoi-cho, Chiba, Japan.
6. Kanazawa University, Kanazawa, Ishikawa, Japan.
7. Niigata University, Ikarashi 2 Nocho, Niigata, Japan.
8. Universidad de Chile, Santiago, Chile.
9. Colegio Compañía de María, Santiago, Chile.

The Matoniaceae is a leptosporangiate fern family consisting of only eight extant species classified into two genera *Matonia* and *Phanerosorus*. Although the species are limited in distribution to Indonesia, Borneo, New Guinea and southern Thailand, their ancestors are known worldwide during the Mesozoic mainly as leaf impressions or spore records. Fern phylogeny based on molecular and fossil data revealed that the family shares a clade with the Dipteridaceae, comprising one of primitive clades next to the Osmundaceae and the Hymenophyllaceae successively from the tree base. Paleophytogeography of the family shows rapid diversity decline after the Cretaceous, but its process and reason have not been clarified. Here we report a new evidence of *Matonia* based on permineralized rhizomes and other organs from the Eocene Cranilahue Formation exposed at the coast of Cocholgue (36˚35'S, 72˚58'W), north of Concepción, Chile. The materials are preserved in a silicified peat that was newly discovered during our field research in 2011. Microspcopic slides were made by using the peel technique. The rhizome is elongate, dorsiventral, about 7 mm in diameter, departing petioles at certain intervals, and has a tricyclic amphiphloic solenostele. The petiole has a C-shaped bundle with strongly incurved adaxial margins and wavy contour, which are characteristic of Matoniaceae. The tricyclic stele is only found in *Matonia*, while *Phanerosorus* has a dicyclic stele. Considering the depositional environment, it is reasonable to conclude that the silicified peat preserves *in situ* a plant assemblage developed on a peat bog. The fossil assemblage contains *Nothofagoxylon* wood, podocarpaceous twigs assignable to *Lepidothamnus*, and *Gleichenia* (ferns). These preliminary studies reveal a habitat similar to the present sphagnum bog found in a warm temperate region in southern Chile where the so-called Valdivian vegetation representing a mesophytic mixed forest is developed. The assemblage, however, shows an interesting combination of plants that prefer rather different habitats at present, such as warm for *Matonia* and cooler for *Lepidothamnus*. Reports on permineralized Matoniaceous fossils are rather scarce; only from Siberia and India (Jurassic), Japan (Upper Cretaceous), and Tasmania (lower Tertiary, but supposedly reworked from older strata). The present fossil is the first convincible report of permineralized *Matonia* from the Cenozoic of South America. [Supported by Kakenhi from MEXT, Japan, 18405013, 21405012, and 2570112 to H.N.].

LATE NEOGENE MAMMALIAN FAUNA OF NORTHEASTERN THAILAND

Yuichiro Nishioka[1]

1. Primate Research Institute, Kyoto University, Kanrin 41-2, Inuyama, 484-8506, Japan.
chicchaimon@gmail.com

Late Neogene mammalian fossils in Thailand are well-known from the Tha Chang sand pits that are located along the Mun River in Nakhon Ratchasima (= Khorat) Province, the northeastern region. Mammalian fossils from this location have been biostratigraphically compared with the Siwalik fauna from the Indian subcontinent and the Irrawaddy fauna from Central Myanmar. To date, four orders and 13 families of mammals were reported from the Tha Chang sand pits No. 8 and No. 10, including Primates (Hominidae); Artiodactyla (Anthracotheriidae, Hippopotamidae, Suidae, Giraffidae, Cervidae and Bovidae); Perissodactyla (Rhinocerotidae and Equidae); and Proboscidea (Deinotheriidae, Gomphotheriidae, Stegodontidae and Elephantoidae). Herein, I add several mammal taxa discovered in recent years, and review the biostratigraphic correlation with the Siwalik and Irrawaddy faunas. The primates contain *Khoratpithecus* that is known as a primitive orangutan from the middle/late Miocene of Myanmar and Thailand. This genus was recovered previously from sand pit No. 8. Various artiodactyl taxa include *Merycopotamus*, *Hexaprotodon*, *Sivachoerus*, *Selenoportax*, *Bramatherium*, and Cervidae gen. et sp. indet. Strictly, giraffid *Bramatherium* was found in sand pit No. 8 only, whereas hippopotamid *Hexaprotodon* and suid *Sivachoerus* were recovered primarily from sand pit No. 10. Several species belonging to *Selenoportax*, or ancestral oxen, occurred in both sand pits, but one species from sand pit No. 10 has more derived characteristics than another species from sand pit No. 8. The perissodactyls are represented by several genera of rhinos, such as *Aceratherium* and *Brachypotherium*, but these genera are absent in the fossil assemblage from sand pit No. 10. The proboscideans are common in the Tha Chang fauna, and most of them were classified as *Stegodon* (or *Stegolophodon*) and *Sinomastodon*, which usually indicates an age from the late Miocene onward. However, these genera were associated with Deinotheriidae that is the middle Miocene indicator in Asia, and also associated with *Elephas* that is the Quaternary member. As a result, the fossil assemblages from the Tha Chang sand pits include several faunas from different ages during the middle Miocene and the Quaternary. The age difference of these faunas probably depends on the location (or horizon) of sand pits, based on the composition of fossil mammals: the fossil assemblage from sand pit No. 8 is composed primarily of earlier members than 6 Ma, while that from sand pit No. 10 is closely correlated with the latest Miocene or early Pliocene (6–4 Ma) Irrawaddy fauna.

PLACODERMS FROM THE EARLY TETRAPOD-BEARING LOCALITY OF STRUD (BELGIUM, LATE DEVONIAN): EVIDENCE FOR A FISH NURSERY AND FOR CLOSE RELATIONSHIPS BETWEEN BELGIUM AND PENNSYLVANIA

Sébastien Olive[1,2], Gaël Clément[3], Edward B. Daeschler[4] and Vincent Dupret[5]

1. Palaeontology Department, Earth and Life History O.D., Royal Belgian Institute of Natural Sciences, Rue Vautier 29, Brussels B1000, Belgium. sebastien.olive@naturalsciences.be
2. Service de Paléontologie animale et humaine, Département de Géologie, Université de Liège, Allée du Six-Août, B18, Sart Tilman, Liège B4000, Belgium.
3. CR2P, UMR 7207 CNRS/MNHN/UPMC, CP 38, 57 rue Cuvier, F75231 Paris cedex 05, France.
4. Academy of Natural Sciences, Department of Biodiversity, Earth and Environmental Science, Drexel University, 1900 Benjamin Franklin Parkway, Philadelphia PA 19103, USA.
5. Subdepartment of Evolution and Development, Department of Organismal Biology, Uppsala University, Norbyvägen 18A, Uppsala SE 752 36, Sweden.

The Belgian tetrapod-bearing locality of Strud (late Famennian, Late Devonian) is mainly recognized for its *Ichthyostega*-like remains and the recent discovery of a putative complete insect. It has also yielded a diversified fauna and flora including early seed plants, crustaceans (decapods, conchostracans, notostracans and anostracans) and various vertebrate taxa (actinopterygians, acanthodians, sarcopterygians and placoderms). Three species of placoderms have been identified in this locality: the antiarch *Grossilepis rikiki*, and the arthrodires *Turrisaspis* sp. nov., and *Phyllolepis undulata*. Firstly, the age composition of the placoderm assemblage has been analyzed. *G. rikiki* displays a typical sensory line system pattern for juvenile or half-mature Bothriolepididae, like *Bothriolepis canadensis*. *P. undulata* is a widespread taxon from the Famennian of Belgium and the specimens found in Strud are clearly the smallest individuals found in whole Belgium, pleading for juvenile material in this locality. The median dorsal plates of *Turrisaspis* sp. nov. are similarly considered as juvenile material when compared with the Pennsylvanian species *Turrisapis elektor*. Taphonomic sorting is excluded because large remains of plants and sarcopterygians are found in the same fossiliferous layers. All placoderm forms found in Strud are thus considered as juvenile, inducing to consider Strud as a possible placoderm nursery. Secondly, the variability within the selected species of the genus *Phyllolepis* has been studied. A morphometric analysis of two dermal plates (centronuchal and anterior ventrolateral) of *Phyllolepis*, has been attempted in order to test the validity of the two *Phyllolepis* species previously described in Belgium: *P. undulata* and *P. konincki*. The species *P. undulata* is only considered valid because the size variation observed in these taxa is continuous. The material of *P. rossimontina* from the Red Hill locality (Pennsylvania, late Famennian) has been added to the study and displayed no significant differences with *P.undulata*. *P rossimontina* and *P. konincki* are thus proposed to be junior synonyms of *P. undulata*. Lastly, paleobiogeographical relationships between Belgium and Pennsylvania have been considered. Together with the genus *Turrisapis*, *Phyllolepis undulata* represents a taxon found both in Belgium and Pennsylvania. They increase the list of common taxa at generic or species levels between these localities, considered both as proximal environments. This induces to consider different hypotheses: 1) a non-marine link between Pennsylvania and Belgium during the late Famennian times, dealing with the Appalachian mountains, or 2) a relative tolerance to marine conditions and then a migration road along the northern margin of Rheic ocean.

ANCIENT BIOMOLECULES: TESTING HYPOTHESES FOR EARLY ECHINODERM PHYLOGENY

Christina E. O'Malley[1], William I. Ausich[2] and Yu-Ping Chin[2]

1. Stivers School for the Arts, 1313 E. Fifth Street, Dayton, Ohio, 45402, USA.
ausich.1@osu.edu
2. School of Earth Sciences, The Ohio State University, Columbus, Ohio, 43210, USA.

The Great Ordovician Biodiversity Event (GOBI) witnessed the divergence and radiation of numerous clades, including all five living classes of echinoderms, as well as at least ten additional class-level echinoderm clades. Several hypotheses have been presented for this early echinoderm phylogeny, with disagreement particularly on the position of crinoids relative to blastozoans and on the position of edrioasteroids relative to blastozoans and crinozoans. Here we test among competing hypotheses using biomolecules extracted from early and middle Paleozoic echinoderm fossils. Biomolecule solutions with "quinone-like" molecules were extracted from Paleozoic fossils, including an asteroid, blastoid, crinoid, diploporite, echinoid, and edrioasteroid. Solution composition was evaluated using fluorescence excitation-emission matrix spectroscopy (EEMS). The two blastozoans (blastoid and diploporite) have nearly identical EEMs, as do the two eleutherozoans (asteroid and echinoid). EEMs from crinoid are more similar to the blastozoans than other echinoderms analyzed, and edrioasteroids are dissimilar to all others. Thus, the ancient biomolecules are consistent with the hypothesis that blastozoans and crinozoans are members of a single clade.

COMPLEX LOBOPODIAN CLAWS SUPPORT RELATIONSHIP BETWEEN TARDIGRADA (WATER BEARS) AND EUARTHROPODA

Javier Ortega-Hernández[1] and Martin R. Smith[1]

1. Department of Earth Sciences, University of Cambridge, Cambridge, UK.
jo314@cam.ac.uk

The form-taxon Lobopodia encompasses a diverse range of Palaeozoic 'legged worms' known from numerous sites of exceptional preservation around the world. It is widely agreed that lobopodians occupy a deep phylogenetic position within Panarthropoda, that is extant Onychophora (velvet worms), Tardigrada (water bears) and Euarthropoda (arthropods). However, the evolutionary relationships of lobopodians relative to the former phyla remain controversial, mainly due to the lack of clear derived charactersjoining them with extant representatives. Here we present new data on a previously undocumented feature in the paired terminal claws of the middle Cambrian lobopodian *Hallucigenia sparsa* from the Burgess Shale (British Columbia, Canada), the presence of up to three nested exoskeletal moult elements, and demonstrate the same organization in the jaws and claws of extant Onychophora. A comprehensive cladistic analysis, informed by recent developmental data on the segmental head organization of extant panarthropods, strongly supports the homology of the complex terminal claws in *Hallucigenia* and Onychophora, indicating that hallucigeniid lobopodians belong to the onychophoran stem-lineage. The resultant character polarity also provides insights on the relationships between Tardigrada and Euarthropoda, and resolves a sister-group position between these phyla (*i.e.*, Tactopoda). This topology adds further support to recent neurological and musculoskeletal evidence joining these disparate phyla, and offers new insights on the morphology of the ancestral panarthropod.

Open sessions / Oral

A NEW BASAL SAUROPODOMORPH FROM SOUTH AFRICA WITH COMMENTS ON NON-SAUROPOD SAUROPODIFORMS

Alejandro Otero[1,2,3], Emil Krupandan[4], Anusuya Chinsamy-Turan[4], Diego Pol[2,5] and Jonah Choiniere[3]

1. División Paleontología de Vertebrados, Museo de La Plata, La Plata, Paseo del Bosque s/n, La Plata, Argentina. alexandros.otero@gmail.com

2. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.

3. Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa.

4. Biological Sciences Department, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa.

5. Museo Paleontológico Egidio Feruglio, Trelew, Argentina.

We present a new basal sauropodomorph from South Africa. The specimen (BP/1/386) was collected by A.W. Keyser from outcrops of the Late Triassic-Early Jurassic Elliot Formation, near the South African town of Zastron, between 1936-1946 and housed at the Bernard Price Institute of Johannesburg. This new medium-sized basal sauropodomorph, apparently recovered from a multi-specimen bone bed is represented by parts of the postcranial skeleton of at least three individuals, including cervical, dorsal, and caudal vertebrae; most of the forelimb, and part of the hindlimb. We hypothesize that three autapomorphies distinguish BP/1/386 from other basal sauropodomorphs, including: distal carpal I with proximally pointing tip on the palmar margin of its proximal surface, giving a triangular shape in palmar view, a strongly distally tapering craniomedial process of the ulna that is twice as long as the craniolateral process, and a trirradiate ascending process of the astragalus. The inclusion of BP/1/386 in a phylogenetic analysis places it within the group of sauropodomorphs more closely related to sauropods than to *Massospondylus* (i.e., Sauropodiformes), increasing the currently known diversity of the so-called ‘transitional forms’ leading to Sauropoda. Character mapping reveals the presence of several features that are common for taxa placed within the transitional branches basal to Sauropoda, and in this regard, BP/1/386 and other recently described non-sauropod sauropododiforms are interpreted as ‘transitional’ taxa that shed light on the origins of Sauropoda. These characters include: proximal width of first metacarpal more than 100% of its length, presence of a biceps tubercle and caudodistal tubercle of the radius, and strongly concave medial margin of metacarpal I. BP/1/386, together with the remaining transitional forms reported during the last decade, highlights the importance of Gondwanan taxa for the diversity and global record of the group and also for the evolutionary stages of the group related to the rise of sauropods.

A NEW OCCURRENCE OF THE MALVINOKAFFRIC FAUNA IN BRAZIL (PONTA GROSSA FORMATION, MATO GROSSO DO SUL): TAXONOMIC COMPOSITION AND PRESERVATION FEATURES

Mírian L. A. F. Pacheco[1], Bruno B. Kerber[2], Gabriel L. Osés[2], Pedro V. Buck[1], Sílvio Yuji[1], Jessica F. Curado[3] and Márcia A. Rizzutto[3]

1. Departamento de Biologia, Universidade Federal de São Carlos, Sorocaba, Rodovia João Leme dos Santos, 18052-780, Brazil. forancelli@ufscar.br

2. Instituto de Geociências, Universidade de São Paulo, Rua do Lago, São Paulo, 05508-080, Brazil.

3. Instituto de Física, Universidade de São Paulo, Travessa R, 187, São Paulo, 05508-900, Brazil.

An endemic invertebrate fauna characterized by low richness and abundance of individuals dominates the Pragian to early Givetian siliciclastic succession of Ponta Grossa Formation, Brazil. This fauna developed geographically and environmentally isolated at epicontinental seas of Gondwana and was very different in composition from their Laurasian counterparts. This unique fossil assemblage also occurs in South Africa, Malvinas (Falklands) and Bolivia, integrating the so-called Malvinokaffric realm. Here, we report a new occurrence of the Ponta Grossa fauna at Northern Maracaju Ridge, Mato Grosso do Sul, Brazil. By the means of paleometrical techniques we performed a geochemical analysis with the aim to understand some preservational processes for these fossils. The outcrops where the biota is found comprise successions of fine siltstones intercalated with shales grading upwards to fine to medium sandstones with hummocky cross stratification. Up to now, we observed brachiopods (*Australocoelia*, *Australospirifer*, *Schuchertella*, *Orbiculoidea baini*, *O. bodenbenderi*, *O. excentrica* and *Gigadiscina* sp.), calmoniid trilobites (*Calmonia signifer* and *Metacrypheus* sp.) and tentaculitids. All fossils occur as preserved hard parts, molds with remains of shell or as carbonaceous compressions. Spectroscopic techniques such as Energy Dispersive X- Ray Fluorescence (EDXRF) and Raman were performed in one specimen of *Australocoelia* (preserved as a mold with shell remains) and one specimen of *Orbiculoidea* (with preserved shell). The former showed a great influence of the sediment elements in the fossil spectra which may be due to the thinness nature of the remains, but, nonetheless, there are differences between the fossil and the rock. This fossil showed an enrichment of S, Ca, Mn and Fe in relation to rock matrix. The presence of calcium and manganese could be reminiscent of the brachiopod shell components. Sulphur and iron could be related to microbial decomposition preservation, but further analyses are necessary to corroborate this. The specimen of *Orbiculoidea* presented P, Ca, S, Sr and Y in greater concentrations compared to the rock matrix and Nd was detected only in the fossil. The P and Ca correspond to the phosphatic nature of the shell as confirmed by Raman spectroscopy (punctual and mapping analysis). Sr was probably related to Ca rates. Rare earth elements, such as Y and Nd, are common in apatite fossils and their occurrence in the orbiculoid shell raise possibilities to further geochemical studies (*e.g.* isotopic ones). In sum, these paleometrical analyses will shed new light in the preservation and compositional features as well as mineralogical characteristics of the Malvinokaffric fauna and will help to better understand the extinction of this fauna and its relation with the Kaĉák event.

4000 YEARS OF PALYNOLOGICAL RECORD AND PALEOCLIMATOLOGY IN LA PAZ BASIN, SOUTHERN GULF OF CALIFORNIA

Ludmila Hilham Palafox-Silva[1], Javier Helenes[1] and Juan Gabriel Flores-Trujillo[1]

1. Departamento de Geología, Centro de Investigación Científica y de Educación Superior de Ensenada, Carretera Ensenada-Tijuana No. 3918, Fraccionamiento Playitas, Ensenada, CP 22860, Baja California, Mexico.
jhelenes@cicese.mx

This work presents results of palynological analyses of core samples from laminated marine sediments in the southern part of the Gulf of California. Samples were processed following the conventional treatment, without oxidation and with *Lycopodium* markers. Changes in the abundances and composition of the marine and terrestrial palynomorph assemblages are related at a decadal scale with changes in the regional oceanographic and climatological conditions, and indicate variations in marine productivity (MP) and rainfall (RF) from 170 to 4,334 BP which are linked to changes in solar activity (SA) and the combination of the climatic forcings in the Pacific: the Pacific Decadal Oscillation (PDO) and El Niño–Southern Oscillation (ENSO). Considering the variability and characteristics of our data, we recognize six intervals and their relation to the climatic modulators: G (176 – 700 BP): high variability and values of MP and RF related with high SA, positive PDO and frequent El Niño events; F (700 – 1,100 BP): high variability and values of MP and medium values of RF related mostly to frequent La Niña events and tropical storms; E (1,100 – 1,900 BP): low variability and values of MP and RF associated with negative PDO conditions and low frequency of El Niño events; D (1,900 – 2,120 BP): low variability and high values of MP and RF related to high SA, positive PDO and frequent El Niño events; C (2,120 – 3,400 BP): low variability and medium values of MP and RF related to low SA and ENSO activity with frequent La Niña events; B (3,400 -– 3,800 BP): high variability with slight dominance of medium to high values of MP and RF related with high SA and negative PDO conditions; and A (3,800 – 4,334 BP): variability and slight dominance of medium to low values of MP and RF related to low SA, negative PDO conditions and low ENSO activity. In general the main modulator is solar activity, with the PDO dominating changes of MP and the ENSO being reflected in the variability of RF.

FIRST 3D RECONSTRUCTIONS OF THE BRAIN AND INNER EAR OF THE MONGOLIAN ANKYLOSAURIDS *TALARURUS* AND *TARCHIA* BASED ON CT SCANS

Ariana Paulina-Carabajal[1], Yuong-Nam Lee[2], Yoshitsugu Kobayashi[3], Hang-Jae Lee[2] and Philip J. Currie[4]

1. CONICET-Museo Carmen Funes, Plaza Huincul, Argentina. premjisaurus@yahoo.com.ar
2. Korea Institute of Geoscience and Mineral Resources, Daejeon, Korea.
3. Hokkaido Univerity, Hokkaido, Japan.
4. University of Alberta, Edmonton, Canada.

Ankylosaur braincase and endocranial morphology is in general poorly known, and only the cranial endocast and inner ear of *Euoplocephalus*, an ankylosaurid from North America, and the cranial endocasts of *Sauropelta* and another unnamed nodosaurid from Japan have been described in detail. The first 3D reconstructions of the brains and inner ears of the Mongolian Upper Cretaceous ankylosaurids *Talarurus* and *Tarchia* are presented here, based on the CT scans of two beautifully preserved skulls. The specimens were recovered by the Korea-Mongolia International Expedition, and were prepared and CT scanned in South Korea at the Hwaseong City laboratory and the Korea Institute of Geoscience and Mineral Resources (KIGAM). The general morphologies of the brains of the two Mongolian taxa resemble that described for *Euoplocephalus* in being anteroposteriorly short, and in having a globose forebrain, and large internal carotids that transversely enter the distal end of an elongated pituitary fossa. The size, number and disposition of cranial nerves (CN) I-XII are also similar. For example, all branches of CN V exit through a single foramen; CN VI does not enter the pituitary fossa, and there are two branches for CN XII even though they exit the braincase externally through a single foramen. In lateral view, the shape of the brain is slightly sigmoidal, with low angles between the hindbrain, midbrain and forebrain. The inner ear has a dorsoventrally short labyrinth with robust semicircular canals and an extremely elongate lagena, indicating that hearing was an important -if not the most important- sense, as in *Euoplocephalus*. Some differences can be observed in the brains of both taxa. *Talarurus* is characterized by the presence of a small, strongly-projected dorsal expansion that is not developed in *Euoplocephalus* or *Tarchia*. *Tarchia* in turn, is characterized by the presence of a flocculus. Within saurischian dinosaurs, the flocculus is present in theropods and absent in most sauropods except in *Spinosphorarurus*, and few rebbachisaurids. The presence of flocculus in *Tarchia* suggests some development of gaze stabilization, probably related to fast movement of the head and the club tail during alert or defense activities.

A NEW ECHINODERM LAGERSTÄTTE IN PORTUGAL: PRELIMINARY RESULTS

Bruno Claro Pereira[1], Pedro Pereira[2], Susana Machado[3], Jorge Carvalho[4] and Lia Mergulhão[5]

1. School of Earth Sciences, University of Bristol, U. K.; CICEGe, Universidade Nova de Lisboa, Portugal; Museu da Lourinhã, Portugal. glbmcp@bristol.ac.uk
2. DCeT, Universidade Aberta; Centro de Geologia da Universidade de Lisboa, Portugal.
3. Laboratório Nacional de Geologia, LNEG, Portugal.
4. EDM – Empresa de Desenvolvimento Mineiro, SA, Portugal.
5. Instituto de Conservação da Natureza e Florestas, ICNF, Portugal.

At the locality of Cabeço da Ladeira (Municipality of Porto de Mós in central Portugal; Lusitanian Basin), about ninety fossilized echinoderms remains were found in limestones dated at approximately 170 million years old (Bajocian, Middle Jurassic). The site was formerly a limestone quarry, inactive since approximately 2010. The fossils are located on the top surface of four of the layers, within a stratigraphic section of seven layers. Beautifully preserved echinoid, asteroid, crinoid and ophiuroid fossils can be seen at this site, many of which are museum-quality specimens and hold a high potential for becoming type specimens of new genera and species. As an example, a completely articulated *Heterocidaris* sp. and a *Rhabdocidaris* sp. were retrieved from that site. Also, among the specimens found, there is the first completely articulated ophiuroid from the Portuguese fossil record. The vast majority of the specimens are semi-articulated, showing all their ossicles in almost like-life position. Such excellent preservation probably resulted from cyclic storm events, as indicated by their preservation and distribution through the section, which suddenly killed and preserved these animals. The number and state of preservation of the fossils makes this locality unique in the Portuguese fossil record and rare in the international context in sections of Middle Jurassic age. Plans are being made to preserve the site and transform it into an open-air museum.

DIVERSITY AND PHYLOGENETIC RELATIONSHIPS OF THE SOUTH AMERICAN LATE MIOCENE-PLIOCENE CARDIOMYINE RODENTS (HYSTRICOGNATHI, CAVIOIDEA)

M. Encarnación Pérez [1], M. Guiomar Vucetich[2] and Cecilia M. Deschamps[2]

1. Museo Paleontológico Egidio Feruglio (CONICET), Av. Fontana 140, Trelew, U9100GYO, Argentina. mperez@mef.org.ar

2. Museo de La Plata (CONICET), Paseo del Bosque s/ n, 1900, La Plata, Argentina.

3. Museo de La Plata (CIC), Paseo del Bosque s/ n, 1900, La Plata, Argentina.

Cardiomyines were large terrestrial rodents closely related to the living capybaras and mocos. They inhabited large part of South America during the middle Miocene-Pliocene. Four genera were recognized: *Xenocardia*, *Procardiomys*, *Caviodon* and *Cardiomys*, with several species. A revision of the materials housed in different collections showed that one skull from the "Araucanian" (Andalhuala Formation, late Miocene) of Catamarca (Field Museum of Natural History, Chicago) catalogued as *Cardiomys ameghinorum*, a common species for the late Miocene, is in fact the first report of *Caviodon* for these deposits. This skull differs from those of other species of *Caviodon* because it is more robust, and its cheek teeth have relatively thin lobes with external fissures shallower than in *C. pozzi* (Chapadmalal Formation, late Pliocene, Buenos Aires) and *C. cuyano* (Aisol Formation, Pliocene, Mendoza), more transversal than in *C. australis* (Monte Hermoso Formation, early Pliocene, Buenos Aires), and deeper than in the three species (probably synonyms) *C. multiplicatus*, *C. bravardi* and *C. (L.) paranensis* ("conglomerado osífero" of the Ituzaingó Formation, late Miocene, Entre Ríos). In the Arroyo Chasicó Formation (Buenos Aires, early late Miocene) cardiomyines were represented by *Procardiomys martinoi*. A skull from the same locality found in the Museo de La Plata represents a second cardiomyine taxon for this unit. It differs from *P. martinoi* by the greater number of prisms in the M3 and the deeper external fissures of the cheek teeth. A phylogenetic analysis was performed to establish the relationships among these taxa and their affinities with other cavioids. The combined matrix includes 56 taxa, 124 morphological characters, and 4303 characters from DNA sequences. An equally weighted parsimony analysis was conducted using TNT 1.1. This analysis resulted in 25032 most parsimonious trees of 3281 steps. In the strict consensus the crown group shows a basal polytomy due to certain unstable fossil taxa that take different positions within Caviidae. The reduced consensus (ignoring the alternative positions of these species) retrieves as monophyletic *Cardiomys* and *Caviodon* supported by two unambiguous synapomorphies each one. Preliminary conclusions suggest that: 1) the diversity of this group of rodents during the late Miocene was higher than previously thought, 2) the geographic distribution of *Caviodon* is enlarged, 3) cardiomyines are confirmed to be more closely related to capybaras than to other Caviidae, and 4) *Caviodon*+*Cardiomys* are recovered as monophyletic.

CALCAREOUS NANNOFOSSIL, PALYNOLOGICAL AND SEDIMENTOLOGICAL DATA FROM THE EARLY MIOCENE MONTE LEÓN FORMATION AND THE LOWERMOST SANTA CRUZ FORMATION, SOUTHERN PATAGONIA, ARGENTINA

Juan P. Pérez Panera[1,2], G. Raquel Guerstein[3], M. Evelina Heredia[4], Ana Parras[5], Miguel Griffin[1] and Marta M. Paez[4]

1. CONICET – División Paleontología Invertebrados-Museo de La Plata, Paseo del Bosque s/n, La Plata, CP 1900, Buenos Aires, Argentina. perezpanera@gmail.com
2. Laboratorio de Bioestratigrafía. Área de Geociencias. YPF Tecnología S.A., Baradero s/n, Ensenada, CP 1925, Buenos Aires, Argentina.
3. INGEOSUR – CONICET. Departamento de Geología, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, CP 8000, Buenos Aires, Argentina.
4. Laboratorio de Paleoecologia y Palinologia. Universidad Nacional de Mar del Plata. Argentina.
5. INCITAP (CONICET-UNLPam). Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, Uruguay 151, Santa Rosa, CP6300, La Pampa, Argentina.

The Monte León Formation and the basal beds of the Santa Cruz Formation record micropaleontological and palynological information. When integrated with sedimentological data, this information allows the refining of paleoenvironmental reconstructions (and related sea level changes) in southern South America during the early Miocene. The studied sections (Restinga Norte, Cabeza de León and Cerro Monte León) are exposed in the southeastern area of the Santa Cruz Province. They yield dinoflagellate cysts (dinocysts), pollen, spores, calcareous nannofossils, silicoflagellates, and diatoms. The reconstruction of depositional environments suggests a basal transgressive interval represented by ca. 3 m exposed at the base of the Restinga Norte and Cabeza de León sections. This interpretation agrees with the high abundance and moderate diversity of dinocysts indicating an inner-shelf to nearshore environment. The nannofossil assemblages show a moderate to low abundance of *Coccolithus pelagicus*, *Reticulofenestra pseudoumbilicus pseudoumbilicus*, *R. pseudoumbilicus gelida*, *R. perplexa* and *Braarudosphaera bigelowii*. The overlying ca. 30 m exposed along the coastal cliffs of the Restinga Norte and Cabeza de León sections reflect a shallowing-up facies trend. The nannofossil assemblages show low to high abundance and an increased diversity compared to the underlying beds. The first record of silicoflagellates in the Monte León Formation is *Distephanus crux* (*sensu lato*), recovered from the basal levels of the Cabeza de León section together with abundant planktonic diatoms. These assemblages could indicate the presence of cool water originated by an upwelling event, which agrees with high concentrations of protoperidinacean dinocysts. Towards the top of this section the dinocyst assemblages reflect a restricted marine environment represented by *Lingulodinium hemicystum* and *Tuberculodinium vancampoae*. The upper ca. 40 m exposed at the Cerro Monte León section show a drop in dinocyst abundance and an increase of Chlorophyceae and hydrophytic taxa. These changes may indicate an increase of freshwater influx related to the coastline progradation. Rare nannofossils (*C. pelagicus*) were recorded in only one level. Pollen records in the Restinga Norte section suggest the development of a forest dominated by both Podocarpaceae and Nothofagaceae, while in the upper part of the Cabeza de León and Cerro Monte León sections it includes mainly pollen of Podocarpaceae. Herb/ shrub vegetation is underrepresented as well as the hydrophyta and *Pediastrum* sp. The nannofosil assemblage suggests an early to middle Miocene age. This agrees with the dinocysts and with the Burdigalian age based on $^{87}Sr/^{86}Sr$ isotopes (approximately between 17.5 and 18.5 Ma) previously reported for the sections.

DIGITIZATION OF THE FOSSIL INSECT COLLECTION FROM THE MUSEUM OF COMPARATIVE ZOOLOGY

Ricardo Pérez-De la Fuente[1] and Brian D. Farrell[1]

1. Museum of Comparative Zoology, Harvard University, 26 Oxford Street, Cambridge, MA, 02138, USA.
perezdelafuente@fas.harvard.edu

Insects are one of the main biological sources of environmental, ecological, and evolutionary information concerning life on land as archived in the geological record since *ca.* 400 Ma. Access to unearthed fossils, however, as generally occurs with specimens kept in biodiversity collections, is hindered by the fact that museum holdings can only be examined when physically visited or borrowed, not always possible, or only allow study of small fractions of the collections. To provide access to the paleobiological potential of fossil insects, the main collections from the United States are currently being digitized with the support of the US National Science Foundation, aiming to make them accessible through the internet not only to the scientific community but also to the general public, media, governments, etc. One of these fossil insect collections – a premier worldwide – is held in the Museum of Comparative Zoology (MCZ) at Harvard University. The collection is currently composed of about 30,000 catalogued insect fossils from all ages since the late Paleozoic, and approximately 3,200 are type specimens. About 80% of the collection is comprised of impression and compression fossils, and the remaining 20% is of amber inclusions. The most important holdings belong to the Wellington (early Permian) and Florissant (late Eocene) Formations, from which iconic fossils were described, *e.g.,* respectively, the largest virtually complete wing known from Paleozoic giant "dragonflies" (= griffenflies), which reached the wingspan of seagulls, or one of the most exquisitely preserved and complete butterflies fossilized as a compression. Imaging the specimens entails obtaining images using stacks of photographs taken at different depths of field so that the resulting composite image has the entire specimen sharply in focus. Additionally, 3-dimensional models generated from these image stacks are being obtained from some large rock fossils, allowing us to record not only their 3-dimensional morphology but also possible taphonomic deformations. The digitization of the MCZ's fossil insect collection will represent a major contribution towards illuminating the ecological and evolutionary responses to environmental changes of the past and will therefore provide critical data for understanding current biodiversity and the impacts of climate change.

A METHODOLOGY FOR MEASURING DENSITY OF FOSSIL LEAF VEINS BY THE LEAF GUI SOFTWARE

Ana Isabel Pérez-Maussán[1], Laura Calvillo-Canadell[2], Oswaldo Tellez-Valdez[3] and Carlos Martorell-Delgado[4]

1. Instituto de Geología, UNAM, Posgrado en Ciencias Biológicas, Ciudad Universitaria, Mexico City, 04510, Mexico. ebla4@hotmail.com
2. Instituto de Biología, UNAM, Ciudad Universitaria, Mexico City, 04510, Mexico.
3. Facultad de Estudios Superiores Iztacala, UNAM, Tlalnepantla, Mexico City, 54090, Mexico.
4. Facultad de Ciencias, Ciudad Universitaria, Mexico City, 04510, Mexico.

Venation patterns have been quantified in some extant taxa measuring characteristics of the veins such as density, angles between segments, thickness, number of branch points, and number of free terminations and/or loops. To get the statistics that explain the leaf venation, image segmentation algorithms were used. This method allows determining the position, width, and length of each vein segment and its connectivity to other segments. This study presents a methodology to measure venation patterns in fossil leaves based on the use of the Leaf Gui software. The proposed methodology aims to better suit the limitations that exist when working with fossil leaves and to allow a better measurement and understanding of vein characters. Photographs of approximately 200 Miocene fossil impressions from two towns in Mexico, San Esteban Tizatlán (~15 Ma) in Tlaxcala and Ixtapa (~13 Ma) in Chiapas were studied. The software Photoscape was used to improve the quality of the images and Photoshop to make the veins more evident (similar of how is done with the camera lucida), thus enhancing the contrast between the venation and the leaf blade and facilitating the measurement of the fossil impressions. The results of measurements with various processes of image modification both in extant and fossil leaves were compared statistically to define how fossil print images could be improved. The proposed methodology can be used in the future as a tool in numerical analysis (e.g. phenetic and / or climatic).

THE ORIGIN OF ARTHROPOD ZOOPLANKTON

Vincent Perrier[1], Mark Williams[1] and David J. Siveter[1]

1. Department of Geology, University of Leicester, University Road, Leicester, Leicester, LE1 7RH, United Kingdom.
vp110@leicester.ac.uk

Arthropods are a major component of the marine zooplankton and likely have occupied the water column since the early Cambrian, radiating and co-evolving with several major planktonic groups throughout the Phanerozoic. Examination of the fossil and molecular record of Phanerozoic arthropod zooplankton allows elucidation of the timing and strategies (*e.g.* anatomical pre-adaptation; planktonic larval stages) of major plankton colonisation events, and the feedbacks these events have elicited in marine environments and ecosystems (*e.g.* changes in the biological pump, development of suspension feeders). These data show that zooplankton involving arthropod groups have arisen independently many times, indicating the adaptability of the arthropod body plan to fundamental environmental change that includes intervals of prolonged ocean anoxia, and catastrophic collapses of the marine ecosystem.

MIDDLE EOCENE LAKE DEPOSITS FROM THE GIRAFFE PIPE CRATER, NORTHERN CANADA: A WINDOW ON FRESHWATER SPONGE EVOLUTION

Andrzej Pisera[1], Peter Siver[2] and Alexander Wolfe[3]

1. Institute of Paleobiology, Polish Academy of Sciences, ul. Twarda 51/55, Warszawa, 00-818, Poland. apis@twarda.pan.pl

2. Connecticut College, Botany Department, New London, Connecticut 06320, USA.

3. Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada.

The fossil record of freshwater organisms is usually less complete relative to marine counterparts, and sponges are a good example of such a situation. Today, freshwater sponges are a significant component of biotas in numerous freshwater habitats and are well studied worldwide, but their fossil history is poorly known. Marine sponges are documented since the Precambrian, but the earliest freshwater sponges do not appear in the fossil record until the Permo-Carboniferous of Europe. Mesozoic occurrences of these sponges are known from the Late Jurassic of USA, and the Lower Cretaceous of England and Patagonia. In this last region the oldest preserved gemmules (resting bodies of sponges) were found. More common freshwater sponges have been uncovered in Tertiary deposits, with records from Germany, Siberia, Japan, Chile and South Africa. Recently, middle Eocene (about 40 Ma old) lake sediments (laminated shales and massive organic mudstones) from a maar lake nestled within a kimberlite diatreme in northern Canada referred to as the Giraffe locality, have been discovered to contain a rich assemblage of siliceous microfossils, including diatoms, chrysophytes and euglyphids. In addition, these deposits contain a highly diverse association of freshwater sponge spicules, many of which display pronounced modern affinities. The sponges are represented exclusively by loose spicules; including numerous morphotypes of megascleres, amphidiscs, non-amphidisc gemmuloscleres, and microscleres. At least 8 distinct taxa can be identified based on spicule morphology, the most common belonging to *Ephydatia* (most probably the Recent species *E. facunda* Weltner), but also *Radiospongilla*, *Spongilla*, *Paleospongilla*, among other undiagnosed spicules. Most belong to the family Spongillidae Gray, but some belong to the family Potamolepidae Brien, know previously only from the Miocene of Japan. The diversity of the Giraffe sponge assemblage is the highest known in the fossil record and comparable with that of the present-day sponge fauna of all of Canada (15 species). Such high diversity indicates that radiation of freshwater sponges predates the middle Eocene, and that a rich, as of yet unknown, history of freshwater sponges exists. Due to its richness, diversity, and excellent preservation, the Giraffe Eocene sponge fauna is crucial in understanding the evolution of freshwater sponges.

STRATIGRAPHIC, TAPHONOMIC AND PALEOENVIRONMENTAL ANALYSIS OF THE DEVONIAN PIMENTEIRA FORMATION, PARNAÍBA BASIN, BRAZIL

Luiza C. Martins de Oliveira Ponciano[1] and Maria da Gloria Pires de Carvalho[2]

1. Universidade Federal do Estado do Rio de Janeiro, Departamento de Ciências Naturais, Laboratório de Tafonomia e Paleoecologia Aplicadas – LABTAPHO. Av. Pasteur, 458, sala 504, Rio de Janeiro, RJ, 22290-255, Brazil. luizaponciano@gmail.com

2. American Museum of Natural History, Division of Paleontology. Central Park West & 79th Street, New York, NY 100-24-5192, USA.

The distribution and mode of occurrence of the taphocoenoses of the Pimenteira Formation, including its Passagem Member (formerly assigned to the overlying Cabeças Formation), on the eastern border of the Parnaíba Basin, are used to reassess their paleoenvironmental settings. Previously regarded in the literature as tempestites (sandstone beds with HCS), these deposits are currently interpreted as the distal part of mouth-bar deposits, delta-front lobes, and the prodelta of a flood-dominated fluvio-deltaic system entering a shallow, epicontinental sea. According to this most recent depositional model, hyperpycnal flows originating from episodic flood events gave rise to transfer zones far more extensive than those of ordinary deltaic systems. These flows would have penetrated beyond the limits of the ancient littoral zone, reworking littoral to shallow-shelf bioclasts. The identification of these inundites in the Parnaíba Basin helps elucidate some puzzling issues, such as the occurrence of indisputable marine shelly faunas within strata bearing typical fluvial and fluvio-deltaic sedimentary structures. Taphofacies analyses have also been providing independent evidence in support of the sedimentation processes and depositional environments inferred from the lithofacies studies of the Devonian rock units in the Parnaíba Basin. The application of this flood-dominated fluvio-deltaic system predictive model has resulted in the discovery of new fossil localities and of additional fossiliferous levels in previously known sites. Formerly considered as restricted to the base of “tempestites”, Middle Devonian macrofossil assemblages of the Parnaíba Basin are now demonstrably more abundant and diversified in sandstones with sigmoidal clinoform structures (bearing asymptotic cross-stratification), in climbing-ripple cross-laminated and plane-parallel stratified sandstones and siltstones, and even in conglomerates. The taphonomic attributes of fossil invertebrates from the Pimenteira Formation and those from the Passagem Member (regionally restricted to the eastern border of the Parnaíba Basin) present very similar patterns, corroborating the interpretation of the latter as a proximal facies of the upper Pimenteira Formation (both dated palynologically as late early Givetian). Those units are unconformably overlain by sandstones and diamictites of the Cabeças Formation *sensu stricto*, of late to latest Famennian age. This regional unconformity accounts for the absence of late Givetian through early or middle Famennian strata in the eastern Parnaíba Basin. The geographically restricted distribution of the Passagem Member along the eastern border of the basin is consonant with the NW-oriented flood-dominated deltas in this region, where the distal-most marine deposits remained essentially shelfal.

TETRAPODS RISING: 3D RECONSTRUCTION AND FINITE ELEMENT ANALYSIS OF THE LOWER JAW ACROSS THE WATER-LAND TRANSITION

Laura B. Porro[1], Emily J. Rayfield[1] and Jennifer A. Clack[2]

1. School of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol, BS8 1RJ, United Kingdom. laura.porro@bristol.ac.uk

2. Department of Zoology, University of Cambridge, Downing Street, Cambridge, CB2 3EJ, United Kingdom.

The invasion of the land by vertebrates is a key moment in the history of life and necessitated dramatic skeletal evolution. Stepwise changes in lower jaw morphology across the fish-tetrapod transition were initially ascribed to a stronger lower jaw and increased bite force, shifts in feeding strategy (suction vs. biting), or constraints imposed by contrasting environments (aquatic vs. terrestrial). More recent work has suggested a disjunction between morphology and function in the lower jaws of early tetrapods. This study investigates the mechanical behaviour of the lower jaws of early tetrapods under feeding loads, utilizing taxa from the Late Devonian to Early Triassic. CT scans were segmented to remove matrix, separate individual mandibular bones, sutures and teeth, and repaired and retrodeformed to produce 3D computer models of the lower jaws of *Eusthenopteron, Acanthostega, Greererpeton, Crassigyrinus, Megalocephalus* and *Lydekkerina.* Applying the engineering technique of finite element analysis (FEA), models were scaled and simplified loads and constraints applied. Stress patterns and deformation regimes exhibited by early tetrapod jaws were compared to models of extant fish lower jaws, including pike (*Esox*) and eel (*Anguilla*), and to *Alligator*. Overall deformation of the lower jaw (including eversion of the working-side tooth row and dorsal bending of the balancing-side jaw ramus) and the distribution of tensile and compressive stresses were similar across most taxa. Higher stress occurred in the balancing-side ramus of more derived tetrapods, such as *Lydekkerina*, and in *Alligator*; in contrast, the working-side ramus of fish mandibles exhibited much higher stresses than the balancing-side ramus. These differences may reflect more efficient transfer of balancing-side muscle forces across the mandibular symphysis due to increasingly complex sutural morphology in later tetrapods compared to basal forms, such as *Eusthenopteron,* and living fish. Alternatively, lower stresses in the working-side ramus of later tetrapods may support the suggestion that morphological changes across the fish-tetrapod produced a stronger lower jaw better adapted for biting.

TSUNAMIS TRIGGERED THE LATE FRASNIAN KELLWASSER EXTINCTION EVENT

Edouard Poty[1], Julien Denayer[1,2] and Bernard Mottequin[1,3]

1. University of Liège, Unit of Animal and Human Palaeontology, Allée du 6 Août, B18, B 4000 Liège 1, Belgium. e.poty@ulg.ac.be

2. University of Queensland, School of Earth Science, St Lucia, Australia.

3. Royal Belgian Institute of Natural Sciences, Earth and Life History, rue Vautier 29, B 1000 Brussels, Belgium.

The long duration of the late Frasnian marine extinctions is related to the progressive decrease in the atmospheric oxygen rate, which had dramatic consequences on marine environments, and to the Upper Kellwasser Event, UKW (*Palmatolepis linguiformis* conodont Zone) at the Frasnian–Famennian boundary. The decrease in the atmospheric oxygen rate is suggested notably by the widespread development of brachiopods adapted to oxygen–depleted environments. In the proximal areas of the Namur–Dinant Basin (southern Belgium), apart from shales corresponding to the Lower Kellwasser Event, LKW (Upper *P. rhenana* Zone) and the UKW, levels of anoxic and dysoxic shales commonly occur, whereas in the most distal part of the basin, anoxic shales are known from the base of the Upper *P. rhenana* Zone to the Lower *P. triangularis* Zone, preventing the development of benthic fauna most of the time. The LKW corresponds to the maximum relative sea–level of the first of the two late Frasnian third–order sequences that were recognized both in shallow and deeper settings. The LKW had strictly no effect on the distribution of corals and brachiopods, except that they are locally and briefly absent when anoxic conditions prevailed. The UKW is responsible for the last Frasnian extinctions. It is widespread in the Namur–Dinant Basin and developed even in places where anoxic shales were previously absent since those of the LKW. Everywhere, the UKW rests on a 0.15 to 1 m–thick limestone bed with shaly intercalations. The particular structure of this carbonate bed is interpreted as the result of a series of at least seven tsunamis that triggered the input of anoxic–dysoxic waters in previously oxygenated environments. Isochronous levels related to tsunamis are known worldwide and are questionably related to a meteorite impact into the Palaeotethys Ocean. Therefore, the end Frasnian extinction is most probably related to both a series of tsunamis and the resulting spread of dysoxic and anoxic waters into areas that were already poorly oxygenated.

THE EARLIEST SEED PLANTS FROM GONDWANA: PALEOBIOGEOGRAPHICAL AND EVOLUTIONARY IMPLICATIONS BASED ON TOURNAISIAN (MISSISSIPPIAN) RECORDS FROM ARGENTINA

Cyrille Prestianni[1], Juan J. Rustán[2-4], Diego Balseiro[2-3], Emilio Vaccari[2-4], Andrea F. Sterren[2-3], Phillipe Steemans[5], Claudia Rubinstein[6] and Ricardo Astini[2]

1. Paleontology Department, Royal Belgian Institute of Natural Sciences, Rue Vautier 29, 1000 Brussels, Belgium. cyrille.prestianni@naturalsciences.be

2. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), CONICET-Universidad Nacional de Córdoba, Edificio CICTERRA, Av. Vélez Sarsfield 1611, Ciudad Universitaria X5016GCA, Córdoba, Argentina.

3. Centro de Investigaciones Paleobiológicas (CIPAL), FCEFyN, Universidad Nacional de Córdoba, Av. Vélez Sarsfield 299, 5000, Córdoba, Argentina.

4. Universidad Nacional de La Rioja, Av. René Favaloro s/n 5300, La Rioja, Argentina.

5. Unité de Paléobiogéologie, Paléopalynologie et Paléobotanique, Dpt. de Géologie, Université de Liege, B18/P40 Boulevard du Rectorat, 4000 Liege, Belgium.

6. Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales (IANIGLA), CCT CONICET-Mendoza, Av. Ruiz Leal s/n, Parque General San Martín, M5502IRA, Mendoza, Argentina.

One of the oldest known seed occurrences on Gondwana have been recognized in a new stratigraphic section located in Sierra de Las Minitas, La Rioja Province, western Argentina (Precordillera Basin). New palynological evidences indicate an early Mississippian (probably early Tournaisian) age for this new succession, instead of Late Devonian as previously reported. The two identified early seeds, *Pseudosporogonites* cf. *hallei* and *Warsteinia* were up to now considered to be restricted to the Devonian of Laurussia. This finding suggests a dispersal of earliest spermatophytes from Laurussia to Gondwana during Devonian/Tournaisian times, accounting for the Rheic Ocean (the sea-extension separating these two main landmasses) as a surmountable biogeographic barrier for continental biotas. This new information supports a weak impact of the Devonian/Carboniferous biotic crisis on earliest seed plant diversity. Alternative, contrasting biogeographic hypotheses dealing with the diachronic occurrence of early seed plants and the occurrence of Devonian-like herbaceous communities in cool high latitudinal regions, are being explored for explaining the recognized paleobiogeographical pattern. Based on preliminary evidences of niches differentiation and ecological dynamics probably affected by wildfires, Tournaisian Gondwanan plant communities from high latitudes are interpreted as being more complex than previously thought, and thus ecologically more similar to those reported from Laurussia. In addition, their discovery in a sedimentary environment associated with glacigenic deposits, shows that this new record might be linked to the coeval glacial age widely recorded elsewhere in Gondwana.

TAXONOMIC SIGNIFICANCE OF THE NEANOCONCH OF THE AMMONOID GENUS *GAUDRYCERAS* FROM THE UPPER CRETACEOUS OF ANTARCTICA

María E. Raffi[1] and Eduardo B. Olivero[1]

1. Centro Austral de Investigaciones Científicas (CADIC-CONICET), B. Houssay 200, 9410 Ushuaia, Tierra del Fuego, Argentina. eugeniaraffi@gmail.com

With its long stratigraphic record spanning the Albian-Maastrichtian, *Gaudryceras* de Grossouvre is considered a conservative ammonoid genus of low biostratigraphic importance. Three species group have been differentiated on the basis of the ribbing style of the adult shell. As this taxonomic character can only be applied to the adult shell, the classification of the juvenile shell is problematic. Juvenile and adult specimens of *Gaudryceras* from the Santonian-mid Campanian Santa Marta and Rabot formations, James Ross Basin, Antarctica, including *ca.* 60 specimens recovered in a thickness of 1,350 m, display a regular change in the ornamentation of the neanoconch. In well-preserved specimens, with the ammonitella and neanic phragmocone filled with sparry calcite, two contrasting ornamentation patterns of the neanoconch are distinguished: a) dense, seven or more, strong, simple, rectirradiate ribs, only found in Santonian-early Campanian specimens, and b) few, three or less, distant ribs, only found in late early and mid Campanian specimens. In both cases, the neanic ornamentation is abruptly replaced by fine, dense lirae and fine ribs typical for *Gaudryceras*. In combination with the ribbing style, degree of evolution and whorl section, five species of *Gaudryceras* are distinguished. *G.* cf. *denmanense* Whiteaves, with strongly ornamented neanoconch followed by prorsirradiate and straight ribs (Santonian); *Gaudryceras* sp. nov. B with strongly ornamented neanoconch followed by dense flexuous ribs; *Gaudryceras* sp. nov. A, with strongly ornamented neanoconch followed by distant flexuous ribs increasing in size at the body chamber; *Gaudryceras* sp. nov. C with less ornamented neanoconch followed by bifurcated flares; and *Gaudryceras* cf. *varagurense* with dense flexuous lirae followed by flexuous ribs. Although the genus *Gaudryceras* has been mentioned in the Coniacian-upper Campanian of Antarctica, its biostratigraphic importance was not fully appreciated. In ascending stratigraphic order we recognize four stratigraphic successive intervals characterized by different species of *Gaudryceras*: 1) *Gaudryceras* cf. *denmanense*, Santonian, lower part of the Santa Marta Formation; 2) *Gaudryceras* sp. nov. B, early Campanian, lower mid part of the Santa Marta Formation; 3) *Gaudryceras* sp. nov. A, mid Campanian, upper part of the Santa Marta Formation; and 4) *Gaudryceras* cf. *varagurense* and *Gaudryceras* sp. nov. C, mid Campanian-late Campanian, upper middle part of the Rabot Formation. Even though the significance of the variable ornamentation of the neanoconch for the juvenile mode of life is still under study, it clearly indicates a morphological feature of taxonomic importance.

BILATERALLY SYMMETRICAL CTENOCYSTOID ECHINODERMS FROM THE UPPER ORDOVICIAN OF THE UNITED KINGDOM: LONG-TERM PERSISTENCE OF A CAMBRIAN BODY PLAN

Imran A. Rahman[1], Sarah E. Stewart[2] and Samuel Zamora[3,4]

1. School of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol BS8 1RJ, UK. imran.rahman@bristol.ac.uk

2. Department of Natural Sciences, National Museum of Scotland, Chambers Street, Edinburgh EH1 1JF, UK.

3. Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington DC, 20013–7012, USA.

4. Museo Geominero, Instituto Geológico y Minero de España, C/ Manuel Lasala, 44 - 9º B, 50006 Zaragoza, Spain.

All extant echinoderms are characterized by pentaradiate symmetry; however, the earliest fossil representatives of the phylum are much more disparate in form, exhibiting four different types of symmetry. Perhaps the most intriguing of these extinct structures is the bilateral body form, which is exemplified by the ctenocystoids, a poorly known class that was long thought to be restricted to the Cambrian. Here, we report two species of ctenocystoid from the Upper Ordovician of the United Kingdom. These are *Conollia sporranoides*, which comes from the Balclatchie Formation of northwest Scotland, and *Conollia staffordi*, from the Mydrim Shale Formation of southwest Wales. Both these species comprise a small, elongate-ovoid theca, covered in fine spines and displaying perfect bilateral symmetry. They were most likely at least partly infaunal, burrowing through sediment in relatively deep-water environments. The discovery of ctenocystoids in the Ordovician extends the range of the group by approximately 40 million years, revealing the persistence and evolution of a body plan that was previously considered as exclusively Cambrian.

SOFT-TISSUE PRESERVATION IN A JUVENILE BLASTOID ECHINODERM

Imran A. Rahman[1], Johnny A. Waters[2] and Colin D. Sumrall[3]

1. School of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol BS8 1RJ, UK. imran.rahman@bristol.ac.uk

2. Department of Geology, Appalachian State University, Boone, NC 28608, USA.

3. Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996, USA.

Soft-tissue preservation is extraordinarily rare in fossil echinoderms, and hence many important aspects of their internal anatomy are poorly known or highly controversial. Here, phase-contrast synchrotron tomography was used to image the interior of a juvenile blastoid, gen. et sp. indet., from the Carboniferous of Xinxu, Guangxi, China. The results reveal, for the first time, the digestive system of a blastoid echinoderm, which comprises a simple, apparently undifferentiated, U-shaped gut. This is similar to the digestive system of modern crinoids, but less complex; because the specimen is a juvenile, perhaps equivalent to the pentacrinoid developmental stage in crinoids, it is possible that differentiation of the gut occurred later in ontogeny and that the gut of adult blastoids was like that of crinoids. However, further structural changes, *i.e.* the development of additional loops, are considered highly unlikely because these are established before the pentacrinoid stage in modern crinoids. Understanding the anatomy and development of the gut in blastoids could inform on the nature of the digestive system in the latest common ancestor of blastozoans, with significant implications for the evolution and phylogeny of early echinoderms.

BIOMECHANICAL EVOLUTION OF THE MAMMALIAN JAW JOINT AND MIDDLE EAR

Emily J. Rayfield[1], Stephan Lautenschlager[1] and Pamela G. Gill[1]

1. School of Earth Sciences, University of Bristol, Queens Road, Bristol, BS8 1RJ, United Kingdom.
e.rayfield@bristol.ac.uk

Of central importance to mammalian evolution is the transformation of bones forming the ancestral quadrate-articular jaw hinge into the two apomorphic mammalian middle ear ossicles, the malleus and incus, and the supporting ectotympanic ring. A key question concerns how the jaw hinge was able to remain viable and load-bearing during transformation into the vibratory ossicles of the ear, alongside the evolution of the apomorphic dentary-squamosal joint. Here we test the load-bearing capacity of the mandibular component of the jaw hinge in two Jurassic mammaliaform taxa, *Morganucodon watsoni* and *Kuehneotherium praecursoris*. Ordinarily *K. praecursoris* is considered more derived than *M. watsoni* (which also possesses a larger, more robust articular condyle), yet both taxa co-exist in the early Jurassic fissure-fill deposits of South Wales, United Kingdom. Component parts of the mandibles of each taxon were scanned using synchrotron radiation X-ray microtomography and micro-CT scanning. Jaw parts were digitally reassembled to produce a 3D composite mandible for each taxon. These models were used to generate 3D finite element reconstructions. Muscle insertion sites were identified, and muscle lines of action predicted. Analyses were performed to calculate the load experienced at the articular condyle during biting at different gapes and for varying muscle-force magnitudes. Both models are equivalent in surface area, and results show that for the same muscle force input, *K. praecursoris* generates a bite force that is only 57-65% that of *M. watsoni*. However it experiences a load at the condyle that is 15-31% greater than *M. watsoni*. When muscle forces are scaled to generate the same bite force (2N) in each model, *K. praecursoris* experiences nearly twice as much load at the articular condyle. Dissimilarity in performance between the two taxa is partly due to morphological differences at the condyle and in the jaw as a whole, but is also attributable to variation in muscle architecture. To fully understand the evolution of the mammalian jaw and middle ear, a detailed understanding of the functional and ecological performance of the skull is warranted.

REASSESSMENT OF THE SILURIAN PROBLEMATICUM *RUTGERSELLA* AS ANOTHER POST-EDIACARAN VENDOBIONT

Gregory J. Retallack[1]

1. Department of Geological Sciences, University of Oregon, Eugene, Oregon, 97403, USA.
gregr@uoregon.edu

Rutgersella is a problematic fossil from the early Silurian (Llandoverian) Lizard Creek Member of the Shawangunk Formation of New Jersey, initially interpreted as jellyfish by Johnson and Fox in 1968. This interpretation arose from its radial-pseudobilateral symmetry like the iconic Ediacaran fossil *Dickinsonia*, which was then considered a jellyfish. Sedimentology (flaser and linsen bedding), fossils (clams and eurypterids) and ichnology (including *Rosselia* and *Arenicolites*) at the Delaware Water Gap locality show that *Rutgersella* was a sessile organism of intertidal mudflats. *Rutgersella* was associated with pyritic intertidal paleosols like other Ediacaran fossils, such as *Aspidella terranovica* of Newfoundland. *Rutgersella* has been dismissed as pyrite suns, but petrographic examination shows that they were weakly pyritized, hollow, organic structures, with large hollow internal tubules, comparable with the Pflug's concept of Ediacaran Petalonamans. Less similar is Seilacher's quilted or "pneu" architecture, but Seilacher's Vendobionta is a useful taxonomic concept. *Rutgersella* thus shared symmetry, internal architecture, and intertidal paleoenvironments documented for Ediacaran fossils. As for Cambrian *Swartpuntia* and *Thaumaptilon*, and Devonian *Protonympha*, *Rutgersella* may be a post-Ediacaran vendobiont. The radial organization of *Rutgersella* recalls that of siphoneous green algae (*Acetabularia*, Dasycladaceae, Chlorophyta) in which coenocytic filaments finished on both sides radiate outwards from a central thread. No thread was seen in *Rutgersella* and its segments are finished on top but dissolve into filaments below. The radial structure of *Rutgersella* is also reminiscent of aggregating phases of cellular slime molds (Dictyostelia, Amoebozoa) and plasmodial slime molds (Myxogastria, Amoebozoa), but these are ephemeral and flimsy phases in the life cycle, unlike compaction resistant growth series of *Rutgersella*. Like *Rutgersella*, lichens such as *Xanthoparmelia plittsi* (Ascomycota, Lecanorales) have cortical-medullary tissue organization of filamentous hyphae, with a finished upper side and irregular lower side. The intertidal habitat of *Rutgersella* was comparable with living intertidal lichens such as *Verrucaria arctica* (Ascomycota, Verrucariales). Early Silurian palynofloras of Pennsylvania include large leiospheres of plausible glomeromycotan affinities, like Glomeralean vesicles from Ordovician rocks of Wisconsin, but no ascomycotan nor basidiomycotan spores. Current phylogenetic analyses of fungi and Precambrian fossils such as *Diskagma buttoni* are evidence for a Precambrian fossil record of lichenized Glomeromycota, and such affinities are also plausible for Silurian *Rutgersella*.

DENTAL WEAR AND DIETARY EVOLUTION OF EQUIDAE AND RHINOCEROTIDAE DURING THE QUATERNARY IN WESTERN EUROPE

Florent Rivals[1,2] and Adrian M. Lister[3]

1. ICREA, Barcelona, Spain.
florent.rivals@icrea.cat

2. Institut Català de Paleoecologia Humana i Evolució Social (IPHES), C. Marcel.lí Domingo s/n, Campus Sescelades URV (Edifici W3), 43007 Tarragona, Spain.

3. Earth Sciences Department, Natural History Museum, Cromwell Road, London SW7 5BD, UK.

In the last few decades, dietary ecological reconstructions have been used as powerful tools for gaining insight into local and global environmental trends. Ungulate tooth mesowear and microwear studies in particular serve as useful proxies for demonstrating the existence of geographical and/or temporal variability in diet and vegetation structure. Improvements in these techniques reveal patterns involving Quaternary vegetation and climatic structure as well as aspects of niche utilization. Pleistocene Equidae and Rhinocerotidae from about 20 Pleistocene localities in Britain spanning the last 2.6 Myr were sampled. The evolution of Equidae is characterized by an increase in hypsodonty through time. Tooth mesowear confirms the largely grazing habit of horses through the European Pleistocene. Tooth microwear also shows the same trend with some exceptions that suggest flexibility in the horse diet which might be related to seasonal shifts. Among the Rhinocerotidae, the low-crowned *Stephanorhinus etruscus* from two early Pleistocene localities showed dominant browsing feeding habits. In the late early and Middle Pleistocene, *Stephanorhinus hundsheimensis*, like its possible parent species *S. etruscus*, shows a browsing and mixed diet. The Merck's rhinoceros, *Stephanorhinus kirchbergensis* and the narrow-nosed rhinoceros, *S. hemitoechus*, co-occurring during the Middle Pleistocene, show different diets which indicate niche partitioning between the two species. According to mesowear and microwear patterns, *S. kirchbergensis* was browser or mixed feeder, which is supported by its longer limbs and brachydont teeth indicating more browsing habits. In contrast, *S. hemitoechus* samples indicate grazing and mixed feeding, a result supported by short and broad limb bones that suggest graviportal locomotion and higher hypsodonty, both indicating an adaptation to more open habitats than *S. etruscus* or *S. hundsheimensis*. These two species also show a high dietary flexibility. Finally, the Late Pleistocene wooly rhinoceros, *Coelodonta antiquitatis*, appears here as a pure grazer. Results indicate a greater plasticity in dietary behavior among forms with similar tooth crown heights and morphology than previously supposed. These results suggest that increased crown height is most likely an adaptation allowing species to expand their dietary breadth. That is, crown height augmentation may serve as a mechanism to allow a species to exploit new habitats and to expand its niche but not necessarily to shift exclusively to a new dietary regime.

THE SLOTTSMØYA MEMBER—A DIVERSE, UPPER JURASSIC BOREAL MARINE REPTILE LAGERSTÄTTE

Aubrey J. Roberts[1,2], Patrick S. Druckenmiller[3,4], Lene L.Delsett[2] and Jørn H. Hurum[2]

1. Ocean & Earth Science, The National Oceanography Centre, The University of Southampton, European Way, Southampton, SO14 3ZH, UK. ajr1g13@soton.ac.uk

2. The Natural History Museum, University of Oslo, Sars' Gate 1, Oslo, 0562, Norway.

3. University of Alaska Museum, 907 Yukon Drive, Fairbanks, Alaska, 99775, USA.

4. Department of Geology and Geophysics, University of Alaska Fairbanks, Fairbanks, Alaska, USA.

High latitude Late Jurassic–Early Cretaceous marine ecosystems are poorly known, primarily due to inaccessibility and lack of stratigraphic control. Since 2004, intensive fieldwork in the Upper Jurassic Slottsmøya Member of the Agardhfjellet Formation (Svalbard, Norway) has yielded abundant plesiosaurian and ichthyosaur remains, associated with a rich invertebrate fauna and carbonate seep deposits. These remains have been further incorporated into a high-resolution stratigraphic framework developed for the Slottsmøya Member, illustrating 12 million years of deposition in the marine Boreal Realm, spanning the Jurassic–Cretaceous boundary. The Slottsmøya Member preserves a diverse assemblage of marine reptiles; to date four endemic species of plesiosauroids, a new species of *Pliosaurus* and three new genera of ophthalmosaurid ichthyosaurs have been described. On-going research indicates that several other new plesiosaurian and ichthyosaurian taxa are also present. Preliminary phylogenetic analysis of the new ichthyosaur taxa has potential implications for the palaeobiogeography of the Svalbard ophthalmosaurids, which indicates a close affinity with other Boreal and Panthalassan ichthyosaurian taxa. In summary, the species-rich and endemic marine vertebrate assemblages of the Slottsmøya Member Lagerstätte demonstrate previously unrecognized diversity at high latitudes and provide important new data to current debates regarding faunal turnover at the Jurassic-Cretaceous boundary.

NEWLY DESCRIBED PERUVIAN ECHINOIDS: IMPROVEMENTS IN THE FOSSIL RECORD AND INSIGHTS ON PALEOBIOGEOGRAPHICAL PATTERNS AND AFFINITIES

Ryan O. Roney[1] and Colin D. Sumrall[1]

1. University of Tennessee, Department of Earth and Planetary Sciences, 306 EPS Building, 1412 Circle Drive, Knoxville, TN, 37996-1410, United States. rroney1@utk.edu

Our knowledge of South American, Cretaceous echinoids is incomplete and biased. The bulk of known echinoids from South America have been found in Peru and Brazil; however, a large portion of the Peruvian material housed in research collections remains undescribed. Description of this material will improve our knowledge of the South American fossil record of echinoids by providing a solid point of comparison for future finds in other countries. The incomplete state of this record is unfortunate because echinoids were important members of Mesozoic faunas during the fragmentation of Gondwana and can illuminate patterns of vicariance and dispersal between Laurasia, the Caribbean and South Atlantic. Presently, 34 Cretaceous echinoid taxa, including 26 genera, have been identified from Peru. More than half of the genera and one fifth of the identified species from Peru were collected by Harvey Bassler in the 1920s, and now are reposited in the Smithsonian Institution. These specimens were cursorily identified and cataloged in a 1966 publication by Bradford Willard, but no systematic descriptions were attempted at that time. Bassler identified 14 echinoid genera with five species level identifications. Among Peruvian taxa, 11 of these genera and four of these species are unique to Bassler's collection. With the increase in the known fossil record provided by the Bassler collection the affinities of the Peruvian Cretaceous echinoid fauna can be further linked to nearby contemporaneous basins. Here we describe the echinoid taxa in the Harvey Bassler collection. Revisions of original identifications and updates with modern synonymies are made based on comparisons with type material. This material shows affinity with fauna found in North America, North and West Africa, Europe, and other parts of South America; however, most of South America, especially the majority of the Southern Cone, remains unsampled. These data, in conjunction with material from Chile, suggest that a more complete study of South American Cretaceous echinoid faunas is warranted and may lead to insights about the paleobiogeographical patterns of vicariance and dispersal during the Mesozoic breakup of Gondwana.

COLONIZATION, PREVALENCE, AND CONTRIBUTION OF THE MICROBIAL WORLD TO FRESH WATER FOSSILIZATION

Vijay Sathe[1] and Varsha Kelkar-Mane[2]

1. Department of Archaeology, Deccan College Postgraduate and Research Institute, Pune 411006. India. vijay19sathe@gmail.com

2. Department of Biotechnology, University of Mumbai, Vidyanagari, Santacruz (E), Mumbai 400098. India.

Microbial world in a fresh water body especially a river or a lake does not have a constant supply of nutrients. Most of the times they have a feast or face a famine-like condition. Introduction of a dead animal to a water body changes this scene; saprophytes and heterotrophs predominate contributing significantly to the decay. Autotrophic organisms like cyanobacteria also find a substratum on the slow decaying animal bones and teeth. The intervention of the scavengers further changes this micro environment enabling solubilisation or precipitation of metal salts. The burial of the carcass in the soft sediments or soil shifts the aerobic conditions to anaerobic ones causing predominance of anaerobes. Anaerobes utilize sulphides, iron, and nitrates etc. as terminal electron acceptors converting them into compounds like hydrogen sulphide. These in-turn react with metal ions in the sediments producing insoluble metal sulphides that deposit on the 'fossil in the making", leaving its distinct colour. For example a fossil found in an environment rich in iron could possibly have red coloration, one rich in sulphide a brown-black coloration and so on. The metabolising microflora changes the pH of the microcosm resulting in further precipitation of the soluble salts in water. With a constant change in environment of the dead animal the microflora is replaced one after another, thus leaving the coloured deposits along with itself in the form of a film forming layers on the surface of the fossil. This hitherto unexplored aspect of biochemistry in tandem with taphonomic approaches to fossil record offers an opportunity to put forth and test this hypothesis with a few existing coloured fossils from the Narmada Basin (Central India), Manjra Basins (Western India), as well as from Kurnool caves in southern India. This work would weave microbial biochemistry with colours in fossilisation. There is also evidence of the presence of algal fossils on the limb bones of Pleistocene elephant and one is confronted with a challenge of reconstructing the microbiological environment of the fossil and its immediate surroundings which can have multiple implications in discussing the taphonomic history of bones in their initial phases of burial and diagenesis, generally so crucial to the future of skeletal assemblage as potential markers of palaeoecology.

DIVERSIFICATION OF MICROBIAL LIFE AFTER THE GREAT OXIDATION EVENT

Bettina E. Schirrmeister[1], Rachael Moore[1], Ella Nadian[1], Joachim Reitner[2] and Philip C. Donoghue[1]

1. School of Earth Sciences, University of Bristol, UK.
bettina.schirrmeister@bristol.ac.uk

2. Geobiology/Paleontology, Faculty of Geosciences and Geography, University of Göttingen, Germany.

The origin of life dates back as far as 3.8 billion years ago with the first prokaryotic fossils preserved in rocks from the paleoarchean Pilbara Craton, Western Australia estimated to be around 3.45 billion years old. Although bacterial remains have been found from various localities throughout the Precambrian, findings from the Archean and early Proterozoic challenge taxonomical identification. Among the few bacterial phyla that have been identified are cyanobacteria, photosynthesizing prokaryotes responsible for the "Great Oxidation Event" (GOE) over 2.4 billion years ago. Nevertheless, early occurrences of cyanobacteria are extremely controversial and far from being resolved. New strategies that may help to improve identification of those first indicators for life would further our understanding of the origin of life and possibly help to understand the causes for one of the greatest atmospheric changes in the history of Earth, the GOE. In this comprehensive approach Synchrotron Radiation X-ray Tomographic Microscopy (SRXTM) has been applied to study microbial communities from several Archean deposits, one early Proterozoic deposit shortly after the GOE, as well as, several modern stromatolitic mat and rock samples from different localities, including marine (Highbourne Cay, Bahamas), hypersaline (Shark Bay, Australia) and a soda lake (Lake Thetis, Australia) environment. Analyses of morphotype abundance and diversity indicate a strong increase and change of morphotype diversity after the GOE which is comparable to modern marine environments. Several of the larger taxa identified (10-20μm spheres and >8μm wide filaments) strongly resemble cyanobacterial taxa as found in modern mats. Comparison to phylogenomic data supports an early origin of multicellular Cyanobacteria and point towards a diversification of cyanobacterial morphotypes shortly after the GOE. Newly formed oxygenated habitats, shortly after the GOE, could have triggered a diversification of prokaryotic morphotypes adapting to those new enviroments.

A GLOBAL PERSPECTIVE OF THE TRIGONIIDA (BIVALVIA: PALAEOHETERODONTA), WITH A FOCUS ON THEIR MESOZOIC AND CENOZOIC REPRESENTATIVES

Simon Schneider[1] and Simon R. A. Kelly[1]

1. CASP, University of Cambridge, West Building, 181A Huntingdon Road, Cambridge CB3 0DH, UK.
simon.schneider@casp.cam.ac.uk

The Trigoniida Dall are a globally important group of dominantly marine Bivalvia, which had their acme during the Mesozoic, when they showed diversity equalin magnitude to extant cardioids, and played a similarly influential role in shallow marine communities. The anticipated revision of the bivalve volumes of the Treatise on Invertebrate Paleontology has fostered the authors' attempt on a global genus-level systematic arrangement for the Mesozoic and Cenozoic Trigoniida. Currently, classification is not based on rigid phylogenetic analysis, but on qualitatively defined apomorphies. Nevertheless, it allows for identification of several large palaeogeographically and stratigraphically well-constrained clades, e.g. the Myophoriidae, Minetrigoniidae or Nototrigoniinae. Other clades, in particular the Myophorellidae and Pterotrigoniidae are considerably less resolved and their subdivision is controversially discussed, mainly due to conflicting genus-level concepts. The previously reported circum-Pacific origin seems obvious for most of the larger Triassic clades of the Trigoniida. Subsequently, the break-up of Pangaea and later Gondwana created space for global expansion across shelf seas. At the same time, isolation forced more localized radiations of several groups. We present chronostratigraphic range charts for more than 100 genera currently recognized as valid, supplemented by palaeogeographic distribution maps for selected taxa. We further exemplarily discuss difficulties of generic assignment in the Myophorellidae, which affect species and genera that are highly abundant in southern Gondwana. Finally, we propose a revised classification for the Trigoniida that is put up for discussion.

THE MARINE TROPICAL AMERICAN TELEOST FAUNA RECONSTRUCTED FROM OTOLITHS; STATUS AND DEVELOPMENTS

Werner Schwarzhans[1] and Orangel Aguilera[2]

1. Ahrensburger Weg 103, 22359 Hamburg, Germany.
wwschwarz@aol.com

2. Universidade Federal Fluminense, Instituto de Biologia, Outeiro São João Batista, s/n°. CEP: 24020-141, Niterói, Rio de Janeiro, Brazil.

Miocene and Pliocene sediments of tropical America have proven to be rich in fossil otoliths. Teleost otoliths were obtained from locations in Ecuador, Panama, Costa Rica, Venezuela, Jamaica, Dominican Republic, Trinidad and NE Brazil. Shallow water environments are rich in Sciaenidae, Ariidae, Batrachoididae and Ophidiiformes, all groups with distinct South American centers of evolution. The fossil record shows that in the Neogene the diversity of these faunal elements was substantial and included lineages, which are now extinct or represent fishes not known any longer from South America. In the case of the Sciaenidae, genera which in the Recent are only known from freshwater environments exhibit multiple marine fossil records. And otoliths of Sciaenidae are morphologically very diverse and therefore particularly well suited to demonstrate the practical usage of otoliths for the scope of unraveling their evolution. In deep-water environments some extremely otolith rich sediments have been discovered. In two such cases from Panama nearly 1000 otolith specimens have been retrieved from just 500 g of bulk sediments each. The deep-water sediments are dominated by otoliths of the family Myctophidae, which is also the most abundant mesopelagic family in the Recent world oceans. The Myctophidae show changing patterns of evolution, fast during certain time periods, which offer prospects for regional and super-regional biostratigraphic purposes in the future. A recently published study by the authors represents a first stepping-stone for such development in respect to the knowledge base in South America.

DECAPOD CRUSTACEAN DIVERSITY AND ENVIRONMENTS THROUGH GEOLOGIC TIME

Carrie E. Schweitzer[1] and Rodney M. Feldmann[2]

1. Department of Geology, Kent State University at Stark, 6000 Frank Ave. NW, North Canton, Ohio 44720 USA. cschweit@kent.edu

2. Department of Geology, Kent State University, Kent, Ohio, 44242, USA.

Marine decapod crustacean diversity over geologic time follows a distinct pattern when examined by infraorder groups. Achelata (lobsters without claws), Gebiidae and Axiidea (mud and ghost shrimps) and Anomura (hermit crabs and relatives) have fossil records that have not changed much in terms of their percentage of the overall decapod fauna as compared to the modern fauna. Their environmental preferences through time, as exemplified by their enclosing rocks, are stable, consistent and congruent with current environments for the latter two groups. Achelata underwent an environmental change sometime in the Cenozoic from lower energy to higher energy, coral reef and rocky settings, but has maintained its relative diversity within Decapoda. The shrimp, including both the dendrobranchiate and pleocyemate groups, are strongly biased by the rock record. Nearly every occurrence is in shale or lithographic limestone. That said, their occurrence as a percentage of the decapod fauna is highest early in the decapod history and dropped markedly by the Holocene. Thoracotremata, the most derived crabs, including fiddler crabs and ghost crabs, increases in percentage late in geologic history, expectable as they first occurred late in geologic time. Most interesting is the relationship between the clawed lobsters which included several infraorders, the podotrematous crabs (the most primitive and first to evolve), and the heterotreme crabs, the most diverse and numerous marine crabs today. Clawed lobsters were by far the dominant members of the decapod fauna in the early and middle Mesozoic. They were being replaced by the podotrematous crabs by the Early Cretaceous. Podotremes were the most dominant group by the Late Cretaceous. The Heterotrematous crabs have dominated the marine fauna since the middle Eocene. When examining the environments these three groups inhabit, it is clear that they each inhabited a broad array of environments throughout geologic time. We propose that these three groups sequentially competed with and replaced one another as the dominant marine decapod group through geologic time. All three groups still exist in modern oceans; the clawed lobsters and podotremes have either become adapted to more specialized, narrow niches or tend to inhabit deeper water, offshore areas. [Supported by NSF grants EF-0531670 and EAR-1223206].

Open sessions / Oral

GEOCHEMICAL AND PALAEOMAGNETIC ANALYSIS OF THE LOWER ELLIOT – UPPER ELLIOT FORMATION TRANSITION (TRIASSIC-JURASSIC BOUNDARY) AT LIKHOELE MOUNTAIN, MAFETENG, LESOTHO

Lara Sciscio[1], Emese Bordy[1], Michiel de Kock[2] and Fabien Knoll[3]

1. Department of Geological Sciences, University of Cape Town, Cape Town, South Africa. l.sciscio@gmail.com

2. Department of Geology, University of Johannesburg, Johannesburg, South Africa.

3. School of Earth, Atmospheric & Environmental Sciences, University of Manchester, Manchester, UK.

The Triassic-Jurassic boundary (TJB) represents one of the five major mass extinctions of the Phanerozoic; and in South Africa and Lesotho, the TJB has been associated with the non-marine Elliot Formation which encapsulates part of the latest Triassic and early Jurassic within the main Karoo Basin. In attempt to accurately and precisely locate the TJB in southern Africa, palaeomagnetic and geochemical studies were carried out at several localities. This study reports on the results of the investigations at Likhoele Mountain (Mafeteng District, Lesotho) in order to provide a quantitative and exportable timescale for palaeontological data collected. Previous studies, at this site, have solely focused on palaeontological collections (e.g., type locality of *Lesothosaurus diagnosticus*) and therefore biostratigraphical evidence. Major and trace elements were analysed using x-ray fluorescence and induction-coupled plasma emission spectrometry. Provisional results show that the Elliot Formation at Likhoele can be subdivided into two geochemical units, based on the following ratios: K_2O/Al_2O_3, Al_2O_3/TiO_2, MgO/Al_2O_3 and Th/U. Results calculated using the Chemical Index of Alteration (CIA) method show a restricted but linear spread with low range of CIA values from 39 to 70 (av. 59). The low values are generally associated with coarser-grained clastic rocks, namely quartz- and feldspar-dominated, massive and laminated sandstones as well as massive conglomerates. The low and variable nature of these CIA values is interpreted to represent compositional differences based on variable climatic conditions in source areas and at the site of deposition. Palaeomagnetic timescale was constructed and constrained, and shows that the litho- and biostratigraphically defined lower and upper Elliot Formation (LEF-UEF) transition provisionally occurs during a period of normal magnetic polarity. The following three possible scenarios are currently our working hypotheses regarding the age of the UEF: (I) the UEF is Late Triassic (latest Norian-Rhaetian) in age; (ii) the UEF is Hettangian in age based on its faunal and ichnological content; (iii) the UEF is mid-Early Jurassic in age if the subaerial unconformity at its base is a large stratigraphic gap. In this latter case, the conformably overlying Clarens Formation is also late Sinemurian, but more probably Pliensbachian in age, as it precedes the radiometrically dated Pliensbachian-Toarcian Karoo basalts (Drakensberg Group ~183 Ma). Our provisional results in this on-going study tentatively suggest that the latter two are the most likely explanations.

A NEW SOUTH AMERICAN PALEOGENE FAUNA, GUABIROTUBA FORMATION (CURITIBA, PARANÁ STATE, SOUTH OF BRAZIL)

Fernando A. Sedor[1], Edison V. Oliveira[2], David D. Silva[3], Luiz A. Fernandes[4], Renata F. Cunha[4], Ana M. Ribeiro[5] and Eliseu V. Dias[6]

1. Museu de Ciências Naturais, Setor de Ciências Biológicas - Universidade Federal do Paraná, Campus do Centro Politécnico, Rua Cel. Francisco H. dos Santos n.100, Jardim das Américas – Curitiba, 81531-990, Brazil.
sedor@ufpr.br

2. Universidade Federal de Pernambuco, Av. Acad. Helio Ramos s/n, CEP 50740530, Recife, Brazil.

3. Universidade Federal do Rio grande do Sul, Avenida Bento Gonsalves 9500, Porto Alegre, 91509-900, Brazil.

4. Universidade Federal do Paraná, Curitiba, Campus do Centro Politécnico, Rua Cel. Francisco H. dos Santos n.100, Jardim das Américas – Curitiba, 81531970, Brazil.

5. Fundação Zoobotânica do Rio Grande do Sul, FZBRS, Porto Alegre, Avenida Salvador França 1427, 90690000, Brazil.

6. Universidade Estadual do Oeste do Paraná, UNIOESTE - Campus de Cascavel, CCBS, Laboratório de Geologia e Paleontologia, Rua Universitária 2069, Cascavel, CEP 85819-110, Brazil

The Paleogene vertebrate/invertebrate-bearing sites of Brazil are restricted to few units such as the Maria Farinha (early Paleocene), Itaboraí (early Eocene), Aiuruoca (Eocene-Oligocene) and Taubaté Formations (late Oligocene). A new Paleogene fauna is reported for the Guabirotuba Formation in Curitiba, Paraná State, South of Brazil. The Guabirotuba Formation belongs to Southeastern Brazil Cenozoic Rift System, a predominantly half-graben and horst system. The clastic succession comprises mudstones and arkosic sandstones with conglomerate facies and also presents calcrete horizons. It occupies an approximate area of 3.000 km^2 and has a maximum thickness of 90 m. The sedimentary facies indicate deposition by fluvial distributary systems and associated lakes, which took place under fairly humid climate conditions alternating with drier periods. The fossil materials studied here comes from an outcrop located near the border of Curitiba and Araucária municipalities in Paraná State, South of Brazil (25°30’30’’S, 49°20’30’’W) and are housed at the paleontological collection of Museu de Ciências Naturais of Universidade Federal do Paraná (MCN-SCB-UFPR), Curitiba, Paraná State, Brazil. This new Paleogene fauna is represented by invertebrate ichnofossils, Gastropoda, Osteichthyes, Amphibia (Anura), Testudines (Pleurodira), Crocodylia (Sebecosuchia), Aves (Phorusrhacidae) and Mammalia (Meridiungulata, Metatheria, Xenarthra). The Guabirotuba notoungulates are attributed to Interatheriidae, “Notopithecinae” (middle Eocene – early Oligocene) and Henricosborniidae (early – middle Eocene). A partial dentary of a metatherian mammal is identified as belonging to *Patene* sp.; this specimen represents a more derived form in relation to the early Eocene *P. simpsoni*, and a second form was identified as a plesiomorphic Polydolopimorphia. A third form, identyified as the Polydolopimorphia *Wamradolops*, constitutes an element of correlation with the Santa Rosa fauna, dated as Eocene to early Oligocene. The specimens of Cingulata include *Eocoleophorus* n. sp., *Machlydotherium* sp.; *Utaetus* cf. *buccatus*, *Utaetus* sp., *Amblytatus* sp., *Meteutatus* aff. *lagenaformis*, *Archaeutatus* sp., *Prozaedyus* aff. *planus*, and Stegotheriini indet. The new species of *Eocoleophorus*, is clearly more plesiomorphic than the type species (*E. glyptodontoides*). On the basis of the presence of *Utatetus* cf. *buccatus*, as well as other taxa, we preliminarily conclude that the time span of the Guabirotuba fauna, and thus of the Guabirotuba Formation, is middle Eocene to early Oligocene.

DESPERATELY SEEKING A PRESENT-DAY ANALOGUE: AFFINITIES OF *PALAEOCYPHONAUTES*, A SPANISH TRIASSIC FOSSIL RESEMBLING A GIGANTIC BRYOZOAN LARVA

Consuelo Sendino[1] and Paul D. Taylor[1]

1. Department of Earth Sciences, Natural History Museum, Cromwell Road, London SW7 5BD, UK.
c.sendino-lara@nhm.ac.uk

Laminated dolomites of late Ladinian age cropping out in the vicinity of Alcover, Tarragona, Spain, constitute a fossil *Lagerstätte* that contains a rich allochthonous assemblage of land plants and marine animals. The Alcover *Lagerstätte* was deposited in an anoxic and hypersaline setting in inter-reef depressions. There are obvious parallels with the younger Jurassic lithographic limestones from Solnhofen, Germany, although preservational fidelity at Alcover is inferior. Among the fossils found at Alcover there are three nominal species of the enigmatic genus *Palaeocyphonautes*, named by Vía Boada and Romero on account of its similarity to the cyphonautes larvae of some living cheilostome bryozoans. However, whereas cyphonautes larvae do not exceed 0.5 mm in size, individuals of the bell-shaped *Palaeocyphonautes* can be over 200 mm across. Upward scaling of a larval morphology to this degree is implausible. Seven specimens and one cast of *Palaeocyphonautes* in the collection of the Museo Geológico del Seminario, Barcelona, have been studied in order to evaluate the true affinity of this fossil. Most of these specimens possess a well-defined apical ring, and some have a notch in the opposite edge of the bell. Apparent 'elephant skin' texture over the surface of the holotype of *Palaeocyphonautes rugosus* suggests a role for microbial mats in the preservation of these fossils, which are believed to have been entirely soft-bodied. Numerous medusoid fossils co-occur with *Palaeocyphonautes* at Alcover. Although there are broad morphological similarities between *Palaeocyphonautes* and some modern medusoid scythozoans, as well as siphonophores (e.g. *Diphyes*) and salps, none of these living groups have yet provided a sufficiently close analogue to establish the true affinity of the problematical *Palaeocyphonautes*.

NEW TRIASSIC HORNED ARCHOSAURS FROM THE DENWA FORMATION, SATPURA GONDWANA BASIN, CENTRAL INDIA

Saradee Sengupta[1]

1. Geological Studies Unit, Indian Statistical Institute, 203 B. T. Road, Kolkata -700108, India.
to.saradee@gmail.com

Archosaurs, the dominant diapsids of the Triassic period, originated shortly after the Permian-Triassic mass extinction. It embraces present day birds, crocodilomorphs and several other extinct taxa of the Mesozoic Era, including dinosaurs. The Triassic archosaurs are recorded from all the continents throughout the world. In India, the terrestrial Triassic archosaurs are known from the Gondwana basins of Peninsular India. The middle Triassic archosaurs, namely prolacertids and prestosuchids are known from the Yerrapalli Formation of the Pranhita-Godavari (PG) Basin. The late Triassic archosaurs are known from the Maleri and the Dhramaram Formations of PG Basin and also from the Tiki Formation of the South Rewa Basin; these are represented by prolacertids and aetosaurs. Recently, a good number of Triassic archosaur fossil bones have been recovered from the Denwa Formation of the Satpura Gondwana Basin of central India. These new findings include few cranial and several post cranial bones. These bones were excavated from an undulatory area extending 5 m x 5 m with a thickness of nearly 1 m to 1.5 m. Most bones were recovered from red and green mudstones while few bones were excavated from green sandstones. The post cranial bones include cervical, dorsal, sacral as well as caudal vertebrae, scapulae, humerii, ulnae, ilia, femora, tibiae, fibulae and digit bones. Apart from maxillae and mandible the most interesting finding is the presence of horns of various sizes. These horns are ornamented, curving anteriorly and have orbital and post-orbital ridges. The detailed study of the anatomy, together with quantitative measurements of important parameters of postcranial bones, reveals the presence of two distinct morphotypes within this collection. However, whether the horns belong to both morphotypes or to any one of them is yet to be determined. A comparative study of both morphotypes with other Triassic archosaur specimens indicates that these archosaur bones belong to the clade paracrocodylomorpha under suchia. The axial skeleton of the new taxon or taxa shows similarities with poposauroidea but the appendicular skeleton shows similarities with loricata. The presence of different sized horns together with at least four right femora (size ranging from 24 cm to 28.8 cm) suggests that there were at least four individuals ranging from juvenile to adult. These semi-erect, carnivorous animals lived in groups and these new animals were the highest order consumers in the terrestrial Triassic community of Indian Gondwanaland.

A RE-INTERPRETATION OF THE AMBULACRAL SYSTEM OF *EUMORPHOCYSTIS* AND ITS BEARING ON THE EVOLUTION OF EARLY CRINOIDS

Sarah L. Sheffield[1] and Colin D. Sumrall[1]

1. The University of Tennessee, 1412 Circle Dr., Knoxville, TN 37912, USA.
ssheffi2@utk.edu

Recent debates over the evolutionary relationships of early groups of echinoderms have relied on evidence concerning morphological details of the feeding ambulacral systems. *Eumorphocystis* Branson and Peck, a Middle-Late Ordovician diploporan, has been a focus in these debates because it bears ambulacral features that show strong morphological similarity to early crinoid arms. Previously un-described and well-preserved specimens of *Eumorphocystis* from the Bromide Formation (Oklahoma, USA) have provided new data illustrating that composite arms bearing axial and extraxial components encasing a ceolomic extension are not unique to crinoids as previously reported. Recent studies have made it clear that early crinoid arms are composed of three layers of plates: uniserial brachial plates on the outer portion of the arm derived from the thecal wall (extraxial), biserial floor plate forming the food groove (axial), and ambulacral cover plates protecting the food groove (axial). The brachial and floor plates encapsulate a coelomic cavity that cores the arm and presumably the radial vessel. Later crinoids either lose or decalcify the floor plates leaving the ambulacral cover plates articulating directly to the brachial plates. Neither the triplate arrangement of early crinoid arms nor spaces for coelomic cavities has been previously observed in blastozoan echinoderms, although there is some similarity with the middle Cambrian *Dibrachicystis*. These new specimens of *Eumorphocystis* clearly show a similar triplate arrangement and a noticeable space within the arm that is interpreted to be the coelomic cavity. However, major constructional differences between the arm morphologies of the two groups, suggest that these are analogous structures. In *Eumorphocystis* the appendages mount directly off of the theca, the coelomic cavity appears to perforate the thecal wall, and the proximal food grooves are developed on alternating biserial plates, whereas in crinoids the arms are borne on radial plates, the coelom is positioned on the summit at the edge of the oral plates and the proximal food grooves are confined to oral plate sutures.These features of the ambulacral system of the early blastozoan eumorphocystids show significant homoplasy with protocrinid arms. This suggests that crinoid arms could have been derived from a specialized blastozoan ambulacral system that lost feeding brachioles. This, along with other features of crinoids, strongly suggests that crinoids are derived from within blastozoans.

NEW REMAINS OF *MAWSONIA* (ACTINISTIA: MAWSONIIDAE) FROM THE LATE JURASSIC-?EARLIEST CRETACEOUS OF URUGUAY

Matías Soto[1], Valeria Mesa[1], Daniel Perea[1], Pablo Toriño[1] and Andrés Batista[1]

1. Departamento de Evolución de Cuencas, Facultad de Ciencias, Iguá 4225, Montevideo, 11400, Uruguay.
msoto@ancap.com.uy

During the last decade, the sandstones included in the Batoví Member (Late Jurassic-?earliest Cretaceous) of the Tacuarembó Formation (Uruguay) have yielded abundant vertebrate fossils, of both aquatic and terrestrial organisms, includings hybodontid sharks, ginglymodian actinopterygians, mawsoniid actinistians, Testudinata, pholidosaurid crocodyliforms and theropod dinosaurs. As a result of recent fieldwork at the Bidegain Quarry (in the outskirts of the city of Tacuarembó, northern Uruguay) several interesting remains have been collected. Those remains include two basisphenoids, two opercula, one gular plate, one lacrimojugal and one angular, among others. The size, shape and, in particular, the ornamentation of the bones indicate they belong to the large extinct actinistian *Mawsonia* (Family Mawsoniidae), well known in non-marine deposits of northeastern Brazil and northern Africa. The Uruguayan occurrence represents the southernmost record of the family in the world. Almost all fossils are well preserved, non-abraded and complete. Fractures are present, but they are a result of post-burial processes. These facts, along with the discovery of articulated ganoid scales of ginglymodian fishes, indicate absence of transport and a rapid burial of the fishes. The majority of the actinistian bones came from the same stratigraphic level and were found in spatial association. Coupled with the absence of duplicated elements, it suggests that they belonged to the skull of a single, large-sized individual (2 to 3 meters long). The Bidegain Quarry locality mentioned herein includes the most complete and best preserved remains from the entire Tacuarembó Formation (including, besides actinistian bones, dipnoan tooth plated still attached to the corresponding bones), greatly contributing to the understanding of its vertebrate assemblage. Moreover, teeth from giant-sized theropods are only known from the Bidegain Quarry. Detailed taphonomic and sedimentological analyses in this locality will be undertaken.

OSTEOLOGY AND PHYLOGENETIC RELATIONSHIPS OF A NEW TURTLE FROM THE LATE JURASSIC-?EARLIEST CRETACEOUS OF URUGUAY

Matías Soto[1], Daniel Perea[1], Juliana Sterli[2], Valeria Mesa[1], Pablo Toriño[1], Guillermo Roland[1] and Jorge Da Silva[3]

1. Departamento de Evolución de Cuencas, Facultad de Ciencias, Iguá 4225, Montevideo, 11400, Uruguay. matiassoto1@gmail.com

2. Museo Egidio Feruglio, Av. Fontana 140, Trelew, 9100, Argentina.

3. Museo de Geociencias de Tacuarembó, Gral. Artigas 191, Tacuarembó, Uruguay.

Two years ago remains of a turtle were found in sandstones of the Batoví Member (Late Jurassic-?earliest Cretaceous) of the Tacuarembó Formation, Uruguay. These remains included a partial carapace external mold? and several associated shell bones, collected in an outcrop at Rincón de Giloca Lane, close to the locality where some gastropods were found in 1937. The estimated length of the carapace measured in a straight line is 18 cm. The fossil shows a unique combination of characters including: a large nuchal notch, a pair of anterior supernumerary scutes, the absence of a cervical scale, narrow neural plates (neural 1 being hexagonal, neural 2 rectangular, and neurals 3 to 6 inverted hexagonal), and an external surface ornamentation that is macroscopically smooth (with some thin linear ridges perpendicular to the margins of the plates) and microscopically composed of randomly distributed small pits. The first two characters resemble those seen in the solemydid *Naomichelys speciosa* from the Cretaceous of North America, although the ornamentation is markedly different. Neural plate morphology is similar to the one present in *Siamochelys peninsularis* (Late Jurassic of Thailand). This unique combination of characters (some of them present in either cryptodirans or pleurodirans) allows the recognition of a new genus and species. A review of different taxa with strong nuchal notches is presented. A phylogenetic analysis retrieved a politomy at the base of Testudines, but confirmed that the Uruguayan specimen (which behaves as a wildcard taxon) belongs to that clade. Additional remains are needed in order to clarify its phylogenetic relationships. The Uruguayan taxon is part of the *Priohybodus arambourgi* Assemblage Zone, which is of Late Jurassic–?earliest Cretaceous age. This is the first turtle to be discovered in South American continental deposits of that age, and thus increases the knowledge on the regional evolution of Mesozoic turtles. Taking into account the characteristics of the fossil assemblage and sedimentologic evidences, the inferred paleoenvironment includes permanent and ephemeral ponds and streams in semiarid-arid conditions (Batoví Member), passing upwards to hyperarid conditions (Rivera Member).

MEASURING PHYLOGENETIC CONSERVATISM OF EXTINCTION IN VERTEBRATES: DEEP-TIME SIGNALS AND METHODS

Laura Soul[1] and Matt Friedman[1]

1. Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN, UK.
lauras@earth.ox.ac.uk

Interactions between extinction risk, heritable traits that confer vulnerability, and phylogenetic relationships among taxa are an important focus of neontological research in extinction and conservation. The fossil record offers a unique deep-time perspective on these patterns that is unavailable to us from extinctions in recorded history alone. Unfortunately differences in time scale, the type of data available, and research intensity for different clades have so far made unification of neontological and palaeontological studies of extinction problematic. Here we present a study focussing on vertebrate groups, to determine whether phylogeny can be used as a proxy for extinction-linked, non-fossilising traits in the geological past. We used three metrics – Fritz and Purvis' D, Pearson's ϱ and Moran's I – to examine the pattern of phylogenetic clustering in extinction in three tetrapod groups (synapsids, temnospondyls and parareptiles) through the Permo-Triassic (P/T) mass extinction. In addition, given the potential for distortion of macroevolutionary patterns in the fossil record caused by poor sampling, we used simulations to test how robust the methods are to palaeontological data. By simulating 'true' phylogenies, then sampling them to represent time-scaled cladograms that we can reconstruct from the fossil record, we measured the degree to which measurements co-vary on true and fossil trees. Results show that there was a progressive shift towards more clustered extinctions leading into the P/T boundary, and all three clades show the most significantly clustered extinction at the boundary itself. This is in line with previous work on invertebrate groups. The results of the simulations indicate that strong phylogenetic clustering of extinction can be correctly identified when it is present, and that estimates tend to be conservative. However, we also found instances where results from the true trees and fossil trees were inconsistent. A measurement on a fossil tree can show significant phylogenetic clustering of extinction when the measurement on the true tree shows phylogenetically random extinction for the same time bin. Therefore, results must be interpreted with caution and in the context of long-term signals. Consistent selection against heritable traits over long timescales leads to a disproportionate loss in biodiversity. This occurred in the geological past and an increase in extinction intensity amplified the effect.

DECIPHERING THE ORIGIN OF PLANT SILICA BODIES: A NOVEL INVESTIGATION INTO THE EARLIEST PHYTOLITHS IN EARTH'S HISTORY

Charlotte Stephenson[1]

1. University of Hull, Department of Geography, Environment & Earth Science, Cottingham Road, Hull, HU6 7RX, UK. C.Stephenson@2013.hull.ac.uk

Phytoliths (plant silica bodies) are a result of the process by which plants deposit silica in an intracellular or extracellular location after absorbing it in a soluble state from groundwater. Phytoliths are used frequently in Cenozoic studies to answer a wealth of palaeoenvironmental questions; however, research has never before been conducted to establish when, where or why these phytoliths first evolved. Silica phytoliths in plants provide structural rigidity, as well as helping the plant to survive numerous abiotic stresses such as salt, nutrient imbalance, drought, radiation, high temperature, freezing and ultraviolet radiation. Phytoliths are also known to reduce the impact of biotic stresses i.e. pests and fungal diseases on plants. During the Devonian terrestrialisation plants developed a penetrative root system. Not only did these root systems have a major effect on weathering and pedogenic processes, but they had the potential to extract silica. Phytoliths also have the ability to sequester carbon. Phytolith Occluded Carbon (PhytOC) is a stable inert carbon fraction which remains in soils for long periods of time. Modern specimens show that PhytOC accounts for c. 37% of global long-term (millennial-scale) soil carbon accumulation. The 'Devonian Plant Hypothesis' discusses the processes by which Devonian terrestrialisation resulted in the decrease of atmospheric CO_2; a potential expansion of this theory could therefore incorporate the impact of PhytOC. Preliminary investigations present conclusive evidence for the development of phytoliths during the Devonian, with further research to be conducted in order to establish which plants produced these silica structures and why.

VARIABILITY IN THE PALEOECOLOGY OF *AUSTRALOPITHECUS AFARENSIS* – EVIDENCE FROM WORANSO-MILLE, ETHIOPIA AND LAETOLI, TANZANIA

Denise F. Su[1] and Yohannes Haile-Selassie[2]

1. Cleveland Museum of Natural History, 1 Wade Oval Drive, Cleveland, OH 44106, USA.
dsu@cmnh.org
2. Cleveland Museum of Natural History, 1 Wade Oval Drive, Cleveland, OH 44106, USA.

Australopithecus afarensis is one of the best-known early hominin species in the Pliocene fossil record with hundreds of specimens recovered thus far from penecontemporaneous sites in Ethiopia, Kenya, and Tanzania. Recent focus on reconstructing the paleoenvironments at these spatially disjunct sites by different researchers using multiple proxies has resulted in a better understanding of the paleoecology at each site. Interestingly, almost all sites are inferred to have had mosaic paleoenvironments, suggesting that *Au. afarensis* was adapted to a variety of habitats and utilized the different resources available in those habitats. However, there is no consensus definition of 'mosaicism' and it is likely that the type and level of 'mosaicism' varied from site to site, which has important implications for our understanding of *Au. afarensis* habitat use and preference. In order to explore this issue further, paleoenvironmental reconstructions at two contemporaneous *Au. afarensis* sites, Woranso-Mille, Ethiopia (3.57-3.82 Ma) and Laetoli, Tanzania (~3.6-3.85 Ma) are compared. In this study, ecological proxies derived from faunal presence and abundance data, dietary niche inferences using data from isotopes and dental morphology, and sedimentological data were examined. We focused on three Woranso-Mille collection areas – Aralee Issi (ARI), Mesgid Dora (MSD) and Korsi Dora (KSD) and Laetoli localities with fossiliferous horizons between Tuffs 5 and 7, as most fossils were recovered from these collection areas and localities. Locality-specific data were used to provide a fine-scale temporal and geographic resolution of the type of 'mosaicism' present at Woranso-Mille and Laetoli by comparing the locality-specific reconstructions to published composite reconstructions of the target collection areas and localities. The results indicate that Woranso-Mille and Laetoli represent different types of mosaic environments and that the distribution and proportion of vegetation across the landscape was likely very different between the two sites. These findings have important implications not only for interpreting *Au. afarensis* habitat preferences and how the species might have utilized available resources, but also for our understanding of mosaic environments at different temporal and spatial scales.

A NEW SPARASSODONTA (METATHERIA, MAMMALIA) FROM THE MIOCENE OF LA GUAJIRA, COLOMBIA

Catalina Suárez Gómez[1], Analía M. Forasiepi[2], Francisco J. Goin[1] and Carlos Jaramillo[3]

1. Museo de La Plata, Paseo del Bosque s/n, La Plata, B1900FWA, República Argentina. catasuarezg@gmail.com
2. IANIGLA, CONICET, Mendoza, Av Ruiz Leal s/n, Mendoza, 5500, República Argentina.
3. Smithsonian Tropical Research Institute, Balboa-Ancon, Panamá.

In 2009 the Smithsonian Tropical Research Institute initiated a series of field trips to prospect deposits in the northernmost areas of the La Guajira Peninsula in northern Colombia. As a result of these efforts, hundreds of fossil vertebrates have been collected, including reptiles, mammals, fishes, and birds. Here, we report the first record of a Sparassodonta (Metatheria, Mammalia) from the Castilletes Formation in the La Guajira Peninsula. Preliminary geochronological and stratigraphical data indicate that the age of the Castilletes Formation is ~ 17.5 to 14.5 My (early to middle Miocene). The Castilletes Formation was deposited in a very shallow marine environment intermixed with coastal plain environments. It is characterized by marly limestones, clays, calcareous and non-calcareous sandstones, and conglomerates. The specimen is represented by a left maxilla with the M1–M4 series and fragments of the lacrimal and jugal bones. The presence of four molars is indicative of its belonging to the Metatheria. Unlike most extinct and extant metatherians except borhyaenoid sparassodonts, it is relatively large-sized. At least one feature of its molars is diagnostic of Sparassodonta: the orientation of the preparacrista, which is anterobucally placed regarding the long axis of the tooth. Some characters shared by Hathliacynidae and Borhyaenoidea sparassodonts are also present in the specimen from La Guajira: 1) marked increase in molar size from M1 to M3; 2) fused metacone and paracone bases; 3) very low protocone. At least two characters are not shared with most other sparassodonts, probably representing autapomorphies for this taxon: on one side, presence of two lacrimal foramina instead of one; on the other, the jugal-maxillary suture shows a unique pattern, running dorsally sub-parallel to the frontal plane of the skull, centrally being sub-vertically displayed, while ventrally running sub-horizontally again. Preliminary comparisons suggest that the La Guajira specimen could be referred to the genus *Lycopsis*, a basal borhyaenoid not referable to the Borhyaenidae, the Proborhyaenidae or the Thylacosmilidae. Actually, the unusual jugal-maxillary suture of the La Guajira specimen is also present in *Lycopsis longirostrus*, from the middle Miocene of Colombia. Research in the La Guajira Peninsula offers the opportunity of increasing our knowledge about neotropical Neogene faunas and allows us to recognize aspects of the South American biota prior to the Great American Biotic Interchange (GABI). The specimen reported here constitutes the northernmost record of an extinct metatherian mammal in South America.

NEW DATA ON THE EARLY ORDOVICIAN STEMMED ECHINODERM FAUNA FROM ARGENTINA

Colin Sumrall[1], Marcelo G. Carrera[2] and Emilio Vaccari[20]

1. Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, USA. csumrall@utk.edu

2. CICTERRA-CONICET, Facultad Cs Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba X5016GCA, Argentina.

Two new echinoderm faunas have recently been collected from Lower Ordovician rocks of western Argentina. These include the Lower Ordovician limestones of San Juan Formation (Tremadocian-Darriwilian), San Juan Province and the siliciclastic Suri Formation (Floian-Dapingian) in Famatina Basin, La Rioja and Catamarca Provinces. The San Juan fauna includes several species of glyptocystitoid rhombiferans, some isolated blastozoan columnals and a few crinoid stems and holdfasts. The glyptocystitoid material though incompletely preserved includes three distinct cheirocrinid taxa. The first species bears a large cylindrical theca with numerous disjunct dichopores. The summit is poorly documented, but the ambulacra are confined to the thecal summit. These specimens bear typical cheirocrinid stems that taper distally. The second species known only from a few isolate plates is a cheirocrinid with large numbers of confluient dichopores. These plates are poorly documented but include radial plates demonstrating that the ambulacra are confined to the thecal summit. The final species is known from a few isolate plates from one locality. These plates bear multidisjunct dichopores, a feature known from only a few taxa. Non-glyptocystitoid blastozoan material and crinoid material is fragmentary and includes isolated columnals and holdfast structures. The Suri Formation, Lower Ordovician (Floian-Dapingian) at the Río Cachiyuyo locality, La Rioja and Chaschuil locality, Catamarca, has produced echinoderms assignable to several echinoderm clades. A single, partial glyptocystitid rhombiferan assignable to a new species of *Macrocystella* is preserved including a nearly complete stem and thecal base. Although the plating cannot be fully documented, the presence of corrugated plate surfaces that lack any evidence of pectinirhombs is consistent with assignment to *Macrocystella*. Ornamentation differentiates this species from other *Macrocystella* plates described from South America. Also present, in the Chaschuil area, are several specimens of large diploporitans with elongate globular thecae that conform to the Perigondwanan taxon *Ascocystites*. Specimens are preserved as internal molds and do not provide detailed information about the oral area, appendages and periproctal region. Finally a few specimens of thin, isolated thecal plates assignable to Blastozoa are also present. While the Suri Formation has taxa that have Perigondwannan affinities, the glyptocystitoid fauna from the San Juan Formation has taxa that are common members of Laurentian faunas consistent with data recovered for other invertebrate groups.

THE CARBONIFEROUS FAUNAS OF THE HUARACO FORMATION AT CORDILLERA DEL VIENTO, NEUQUÉN BASIN

Arturo C. Taboada[1], María A. Pagani[2] and Carlos O. Limarino[3]

1. Centro de Investigaciones Esquel de Montaña y Estepa Patagónicas (CIEMEP)-CONICET, Roca 780, Esquel, U9200, Chubut, Argentina. taboadaart@gmail.com

2. Museo Paleontológico Egidio Feruglio-CONICET, Av. Fontana 140, Trelew, U9100GYO, Trelew, Chubut, Argentina.

3. Departamento de Ciencias Geológicas-IGEBA, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires-CONICET, Ciudad Universitaria, Pabellón 2, Ciudad Autónoma de Buenos Aires, C1428EHA, Argentina.

New faunal assemblages were recently identified in outcrops of the Huaraco Formation surrounding the Andacollo locality at western flank of the Cordillera del Viento, Neuquén, Argentina. The Huaraco Formation of 700 m of maximum thickness is constrained between *ca*. 327 Ma (Serpukhovian) from rhyolites intercalated in the underlying Arroyo del Torreón Formation and *ca*. 288 Ma (Artinskian) from the overlying Huinganco Plutovolcanic Complex. The Huaraco Formation is mainly composed of shales, mudstones and fine- to medium- grained sandstones together with very scarce levels of coarse-grained sandstones and conglomerates. The stratigraphic analysis of the unit allowed recognizing four depositional sequences (DS), bounded by different types of incision surfaces, in which several transgressive-regressive cycles were found. Three main fossil-bearing intervals were located in the upper half of the sequence, the lower one included in the lower part of the DS 3, while the rest corresponds to the middle-upper part of the DS3 and the lower DS4. The lower assemblage is a low diverse brachiopod-dominant assemblage characterized by the plentiful occurrence of the brachiopod *Linipalus* sp. nov. associated with *Neochonetes granulifer* (Owen), *Leiorhynchus* sp., *Reticularia* sp., *Orbiculoidea* sp. and scarce Nuculidae bivalves. This association has some common elements with the warm-temperate *Marginovatia-Maemia* fauna from western Argentina of late Bashkirian-early Moscovian age, indicating the influence of warmer ocean currents southward reaching the Neuquén Basin. The second fossil-bearing horizon has coquinoid occurrences of *Tivertonia jachalensis* (Amos), scarce other brachiopods such as *Rhynchopora* sp., *Orbiculoidea* sp., *Lanipustula patagoniensis* (Simanauskas), more diverse bivalves such as *Phestia* sp., *Palaeolima* sp., *Nuculopsis* sp., *Palaeoneilo* sp., *Streblopteria* sp. and *Sueroa* sp., and the gastropod *Glabrocingulum* Thomas. Stratigraphically close, a third and uppermost fossiliferous horizon bears monospecific remains of *Septosyringothyris* sp. Most elements from these two last horizons were previously recognized in northern basins of western Argentina (San Rafael, Calingasta-Uspallata and Río Blanco basins) as taxa belonging to the temperate *Tivertonia-Streptorhynchus* fauna constrained to a Moscovian age. Its low diversity or impoverished expression in the Neuquén Basin could be interpreted as a cold-temperate faunal assemblage and related to the incoming of colder ocean currents from lower latitudes, where the psychrophilic *Lanipustula patagoniensis* thrived during the Serpukhovian-Moscovian time-span, represented by its record throughout the stratigraphic interval of *ca*. 1000 m thickness in the Pampa de Tepuel Formation, Tepuel-Genoa Basin, southern Patagonia. The Huaraco's faunal assemblages enrich the known paleobiogeographic scenario offering potential links to far-field faunas along the southwestern margin of Gondwana.

PREDATION PROXIES DURING THE EARLY MESOZOIC MARINE REVOLUTION: MORPHOLOGICAL CHANGE AMONG SHELLY BENTHOS DURING THE LATE TRIASSIC

Lydia S. Tackett[1] and David J. Bottjer[1]

1. University of Southern California, Department of Earth Sciences, 3651 Trousdale Parkway, Los Angeles, CA 90089-0740, United States.
Tackett@usc.edu

Shallow marine level-bottom faunal communities underwent major transitions in the Late Triassic, most likely in response to a proliferation of demersal predators specialized for durophagy - such as fish and sharks. Non-cementing stationary epifauna declined and were replaced by burrowers, cementers, and mobile animals over several million years. Here we detail the changes in morphological characters in shelly prey from Panthalassa (Luning and Gabbs Formations, west-Central Nevada) tracked during the major paleoecological transitions hypothesized to be responses to increased predations pressure during the Norian and Rhaetian stages of the Late Triassic. These features include size, ribosity, and shell thickness, *i.e.*, characters expected to impart adaptive advantages during increasing epifaunal predatory pressure, especially durophagous predation. Non-cementing stationary epifauna declined in average size and observed size ranges during the Norian Stage, both overall and within genera. The abundance of animals with ribbed shells increased throughout the Norian relative to non-ribbed animals, although the diversity of both groups increased during this interval. These findings suggest that the response of shelly prey to intensifying predation may be decoupled for diversity and abundance, and highlight the importance of morphological metrics in predation studies.

THREE METHODS OF COMPOSING IMAGES FOR BETTER SCIENCE PHOTOGRAPHY

Martin Valent[1]

1. National Museum, Palaeontological Department, Cirkusová 1740, 193 00 Praha, Czech Republic.
martin_valent@nm.cz

1. Greater depth of field (stacking images in axis Z). The depth of field shrinks with decreasing subject distance, decreasing aperture value (f-stop) and increasing focal length. This also happens when using a microscope – with higher magnification, the depth of field narrows. The easiest way to overcome this problem is to take a series of pictures with the same exposure, and varying depth of field. It is essential to use a tripod or stand, to have the pictures varying only in depth of field. The images are then stacked with software, like CombineZ (freeware).

2. Panoramic picture (composing images in X and Y axes). This method is very useful for taking pictures with wider focal lengths than is possible with available lenses. Another reason is creating pictures with higher pixel resolution than the resolution of the camera. It is possible to use this method with an optical microscope, SEM, camera on tripod or hand-held camera.

Fundamental steps: 1. Choose a focal length with minimal optical distortion; 2. Focus on desired subject. After that, it is useful to turn off automatic focusing (AF), by switching to manual focusing (MF); 3. Determine exposure: exposure is determined by the brightest part of the scene. Exposure values (exposure time, f-stop and ISO speed rating) are taken in any suitable automatic/semiautomatic exposure program (usually, the best program is A – aperture priority) and then set in manual exposure program M; 4. Turn off the camera's automatic white balance and set it to any acceptable preset value; 5. Remove any filters (except UV) from the lens; 6. It is essential that the imaged areas overlap by about 20% on both sides; 7. It is possible to take pictures in several rows; the camera can be oriented horizontally or vertically (preferable). For composing panoramic pictures, Microsoft Image Composite Editor (freeware) is available.

3. High dynamic range photography (HDR). This method is very suitable when you need to create a photo of a specimen with less distinct surface relief. It is essential to have the camera on a tripod or stand, and take a series of identical pictures with different exposure compensation value (e.g. -1 EV, 0 EV and +1 EV). Various software are available for creating HDR photography, like Picturenaut (freeware) and Luminance HDR (freeware).

ERUPTION PATTERNS AND DENTAL HISTOLOGY IN ARTIODACTYLS AS MARKERS OF POSTNATAL GROWTH AND LIFE HISTORY EVOLUTION

Kristof Veitschegger[1], Christian Kolb[1], Concepción Azorit[2] and Marcelo R. Sánchez-Villagra[1]

1. University of Zurich, Paleontological Institute and Museum, Karl-Schmid-Strasse 4, Zurich, CH-8006, Switzerland. kristof.veitschegger@pim.uzh.ch

2. University of Jaén, Department of Animal and Vegetal Biology and Ecology, Faculty of Experimental Sciences, 23071 Jaén, Spain.

The emergence of the permanent dentition in mammals varies among species in a non-random way. Phylogenies as well as life history are hypothesized to influence the pattern and speed of this process. One example is the Schultz's 'rule', which postulates the tendency to replace teeth early in species with fast growth and long life span and is mainly described for primates. To further evaluate this hypothesis, new data on the dental eruption of extant and extinct cervids are provided and integrated in a study of Artiodactyla. It is fundamental to place these data in a phylogenetic framework to investigate the influence of life history correlates. First results show that the smaller sized *Capreolus capreolus* replaces the first deciduous tooth, the first incisor, after the second molar has started to erupt. This seems to be also the case for the big sized *Alces alces*. In *Dama dama* this event happens already before the eruption of the second molar. Dental histology of cervids was also studied aiming at gathering life history data. Rest lines in the cementum of the first lower molar provide reliable estimates of individual ages of cervids in both extant and extinct species. This is demonstrated here for the extinct taxa *Megaloceros giganteus*, the giant deer, and the dwarf island cervids *Candiacervus ropalophorus* and *Candiacervus* spp. Maximum longevity estimates indicate 18 years for *Candiacervus* and 19 years for *Megaloceros giganteus*. Considering the allometric context, the big sized *Megaloceros* was rather short-lived. In general, for possible decoupling of the number of lines of arrested growth (LAGs) in long bones and the actual age of old individuals, rest lines in tooth cementum tend to be more reliable for age estimates than those in the bone cortex.

A NEW PYGMY SPERM WHALE (ODONTOCETI, PHYSETEROIDEA, KOGIIDAE) FROM THE LATE MIOCENE OF PANAMA

Jorge Vélez-Juarbe[1], Carlos De Gracia[2], Aaron R. Wood[3] and Austin J. W. Hendy[3]

1. Department of Mammalogy, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007, USA. velezjuarbe@gmail.com

2. Smithsonian Tropical Research Institute, Box 0843-03092 No. 8232, Balboa-Ancon, Panama.

3. Florida Museum of Natural History, University of Florida, Gainesville, Florida 32611, USA.

Pygmy sperm whales are nowadays represented by two species, *Kogia sima* and *K. breviceps*, which have worldwide distribution from the tropics to the temperate zones. Their fossil record begins around the early to middle Miocene, however, only five species have been described so far, with a number of additional records based on family-level diagnostic elements, such as the periotics. Here we report the first fossil kogiid from the Northern Neotropics. The fossil consists of well-preserved cranial and mandibular material collected from the late Miocene (~Tortonian) Piña Facies of the Chagres Formation, exposed along the Caribbean side of Panama. Comparison of the Chagres kogiid with other fossil and extant kogiids and physeteroids, show that it is most similar to *Praekogia cedrosensis* from the late Miocene to early Pliocene (Messinian-Zanclean) of Baja California. We added the Chagres kogiid to a matrix of 41 characters and 18 taxa (2 outgroup + 16 ingroup taxa) in order to perform a phylogenetic analysis of physeteroids. The analysis resulted in four most parsimonious trees 100 steps long; the strict consensus tree (107 steps long) places the Chagres kogiid within a group of crown kogiids that include other late Neogene species, *Praekogia cedrosensis* and *Scaphokogia cochlearis*, from the late Miocene of Peru, as well as *Kogia* spp. Other fossil cetaceans from the Piña Facies include physeteroids and inioids, and constitute a marine mammal assemblage that may eventually be comparable to those found in other higher latitude Neogene localities (*e.g.* Pisco, Peru; Isla Cedros, Baja California). This highlights the importance of fieldwork in poorly explored regions, such as Panama, in order to further understand the evolutionary history of cetaceans.

A SOUTHERN HEMISPHERE MID-LATITUDE CLIMATE RECORD ACROSS THE K-PG BOUNDARY FROM THE BAJADA DEL JAGÜEL SECTION, ARGENTINA

Johan Vellekoop[1], Lineke Woelders[2], Jan Smit[3], Silvio Casadio[4], Robert Speijer[2], Bas van de Schootbrugge[1], Jaap Sinninghe Damsté[5] and Henk Brinkhuis[1]

1. Marine Palynology, Utrecht University, Budapestlaan 4, Utrecht, 3584CD, The Netherlands. J.vellekoop@gmail.com
2. Division of Geology, KU Leuven University, Celestijnenlaan 200e, Leuven, 3001, Belgium.
3. Eventstratigraphy, VU University Amsterdam, De Boelelaan 1085, Amsterdam, 1081 HV, The Netherlands.
4. Universidad Nacional de Río Negro, Avda. Roca 1242, Roca, 8332, Río Negro, Argentina.
5. Royal Netherlands Institute for Sea Research (NIOZ), Landsdiep 4,'t Horntje, 1797 SZ, The Netherlands.

The Cretaceous-Paleogene (K-Pg) boundary represents one of the most significant geological transitions in Earth history, being characterized by one of the largest mass extinction events related to the impact of a large extraterrestrial body. Although the K-Pg boundary is characterized by rapid major global change, an accurate reconstruction of these climate changes proves to be challenging. Major extinctions amongst traditionally applied biotic proxy-carriers, e.g. planktic foraminifera, hamper accurate temperature reconstructions and consequently, the resulting records are often contradictory. Marine dinoflagellates that produce organic dinocysts survived the K-Pg mass-extinction relatively unscathed. Therefore, they are ideally suited for reconstructing pre- and post-extinction marine conditions and combined with biomarker-based quantitative temperature proxies such as TEX_{86} they can potentially resolve the enigmatic climate evolution across the K-Pg boundary. While these techniques have been applied on multiple Northern Hemisphere sites, very few records are so far available from the Southern Hemisphere, so environmental consequences of this impact on Southern Hemisphere environments is still poorly understood. Among the few Southern Hemisphere localities with potentially sufficient temporal resolution across the K-Pg boundary are several outcrops in Argentina, which so far have attracted relatively little attention. One of these is the Bajada del Jagüel section in the Neuquén Basin. To provide insight in Southern Hemisphere biological and environmental changes across the K-Pg boundary, we have applied a multiproxy study on the Bajada del Jagüel section, integrating: (1) quantitative dinocyst analysis, (2) quantitative planktic and benthic foraminifera analysis (3) stable carbon and oxygen isotope analyses, and (4) the quantitative temperature proxy TEX_{86}. Our results show that at Bajada del Jagüel, the K-Pg transition is stratigraphically condensed but complete. The $\delta^{18}O$ and TEX_{86} records show that the last 2 million years of the Cretaceous are characterized by multiple warming and cooling phases, with average sea surface temperatures (SSTs) varying between 23°C and 29°C. Within the boundary layer SST briefly drop to <19°C, most likely recording a brief 'impact winter' phase, followed by a rapid warming to 31.6°C. Both dinocysts and benthic foraminifera show clear, strong responses to the environmental changes in the Maastrichtian and across the K-Pg boundary.

AMMONOIDS OF THE BASAL SECTION OF THE VACA MUERTA FORMATION, NEUQUÉN BASIN, ARGENTINA

Verónica V. Vennari[1] and Beatriz Aguirre-Urreta[1]

1. Instituto de Estudios Andinos "Don Pablo Groeber", Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Intendente Güiraldes 2160 - Ciudad Universitaria, Pabellón 2, Ciudad Autónoma de Buenos Aires, C1428EGA, Argentina.
vvennari@gl.fcen.uba.ar

Marine successions of the Vaca Muerta Formation (early Tithonian-late Berriasian) in the Neuquén Basin, west-central Argentina, are worldwide known by their abundant and well preserved ammonoid content. A systematic revision of the ammonoid groups contained in the first portion (late early Tithonian - early middle Tithonian) of the Vaca Muerta Formation was performed. This study aims to clarify the stratigraphic distribution of the involved species, their relative abundance and diversity and their palaeobiogeographical affinities. Sampling was performed over eighteen stratigraphic sections, placed along a north-south transect in the basin, from the Aconcagua in northern Mendoza to Picún Leufú in southern Neuquén. Over 600 specimens were selected for the taxonomic analysis which resulted in the identification of thirteen species and one subspecies of ammonoids that, in turn, were grouped into six genera, four subfamilies and three families. Among them, a new genus and two new species are proposed. Members of the Family Ataxioceratidae, which encompass 86% of the species, dominated the faunal association, whereas the Families Aspidoceratidae and Simoceratidae grouped the 14% of the remaining species. Concerning Subfamilies, Virgatosphinctinae (65%) was the best represented, followed by Lithacoceratinae (21%), Physodoceratinae (7%) and Simoceratinae (7%). Subfamily Virgatosphinctinae comprises three genera: *Virgatosphinctes* Uhlig, with two species, *Virgatosphinctes andesensis* (Douvillé) and *Virgatosphinctes* (?) *densistriatus* (Steuer); *Pseudinvoluticeras* Spath with three species, *Pseudinvoluticeras douvillei* Spath, *Pseudinvoluticeras windhauseni* (Weaver) and *Pseudinvoluticeras* (?) n. sp.?; and *Choicensisphinctes* Leanza with four species, *Choicensisphinctes choicensis* (Burckhardt), *Choicensisphinctes erinoides* (Burckhardt), *Choicensisphinctes* n. sp. aff. *erinoides* and *Choicensisphinctes* n. sp. Subfamily Lithacoceratinae was found to be well represented by abundant specimens of "*Subplanites*" Spath, which hitherto has been found to encompass only one species, "*Subplanites*" *malarguensis* Spath. Subfamilies Physodoceratinae and Simoceratinae include one genus each: *Schaireria* Checa, with *Schaireria neoburgensis* (Oppel) and *Pseudovolanoceras* Cecca, with *Pseudovolanoceras* sp. cf. *Pseudovolanoceras aesinense krantzense* (Cantú-Chapa), respectively. The identification of a taxonomically homogeneous ammonoid assemblage in the lower portion of each of the studied Vaca Muerta Formation sections enables to support the hypothesis of a synchronous Tithonian transgression in the Neuquén Basin. Typical Indo-Pacific elements such as *Virgatosphinctes*, as well as Mediterranean forms like *Pseudovolanoceras*, confirm the well established marine connections of the Neuquén Basin with the Mediterranean and Indo-Pacific Subrealms, at least since the Tithonian. Endemic (e.g. *Choicensisphinctes*) and pandemic genera (e.g. *Schaireria*) have also been recorded in the analyzed stratigraphic interval. [Contribution C-78 of the Instituto de Estudios Andinos "Don Pablo Groeber"].

Open sessions / Oral

CALCAREOUS TUBEWORMS OF THE PHANEROZOIC: EVOLUTION AND PALEOECOLOGY

Olev Vinn[1]

1. Department of Geology, University of Tartu, Ravila 14A, Tartu, 50411, Estonia.
olev.vinn@ut.ee

The earliest tubeworm-like fossils appeared in the Ediacaran. Morphological similarities indicate that most of Palaeozoic problematic tubeworms form a monophyletic group- tentaculitoids. Members of this group share affinities with lophophorates. Evolution of tentaculitoids could have partly been driven by predation. Only a few studies have been published on reefs formed by tentaculitoid tubeworms in the Palaeozoic. The extinction of tentaculitoids in the Middle Jurassic was possibly at least partly caused by the ecological pressure by serpulid and sabellid polychaetes. Middle Mesozoic to Recent calcareous tubeworm fauna is dominated by serpulid polychaetes. Earliest serpulids appeared in the middle Triassic and they build elaborate calcareous tubes. Earliest calcareous sabellids are known from the Early Jurassic. Calcareous sabellids have less complex tubes than serpulids. There seems to have been some correlation between the aragonite and calcite seas and the skeletal mineralogy of Triassic–Recent polychaete tubeworms. Among Recent calcareous polychaete tubeworms, serpulids and cirratulids may form reefs. Serpulids colonized a wide variety of Mesozoic environments, including, from the late Mesozoic, hydrocarbon seep environments, where serpulids are frequent but a relatively understudied faunal element. Mass extinctions do not seem to have seriously affected calcareous tubeworm faunas of the Phanerozoic.

THE ROOTING SYSTEM OF THE RHYNIE CHERT LYCOPOD *ASTEROXYLON MACKIEI* (CA 407MA) AND ITS FUNGAL ASSOCIATES

Zuzanna Wawrzyniak[1], Christine Strullu-Derrien[2], Tomasz Góral[3] and Paul Kenrick[2]

1. Department of Palaeontology and Stratigraphy, Faculty of Earth Science, University of Silesia, Będzińska 60 St., 41-200 Sosnowiec, Poland. zuza.wawrzyniak@gmail.com

2. Department of Earth Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

3. Imaging and Analysis Centre, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

The early lycopod *Asteroxylon mackiei* had the most developed underground rooting system of the Rhynie Chert plants. *Asteroxylon* was reconstructed by Kidston and Lang as an erect plant with upright shoots, anisotomous branching and a subterranean rhizome. Stems grew to at least 45cm in length and 1.2cm in width, and they bore simple leaf-like appendages. Rhizomes were cylindrical (ca 1mm - 5mm wide) and branched dichotomously. They are often observed apparently *in situ* where they show positive geotropism in relation to the surrounding substrate. In marked contrast to other Rhynie Chert plants, including *Aglaophyton*, *Rhynia*, *Nothia* and *Horneophyton*, root-hairs or rhizoids were absent from *Asteroxylon*. We studied petrographic sections of exceptionally preserved specimens from the collections of The Natural History Museum (London, UK), The Hunterian Museum (Glasgow, UK) and The Swedish Museum of Natural History (Stockholm, Sweden). Specimens were examined and photographed in transmitted light and with a laser-scanning confocal microscope. In the inner cortex of *Asteroxylon mackiei* roots we found a new fungus that we attribute to Blastocladiomycota, which are a major basal clade of true fungi. The fungus developed a branched mycelial thallus with globose to elongated zoosporangia borne terminally on dichotomous mycelium branches. Resting sporangia developed sympodially in a more proximal position on the thallus. Modern Blastocladiomycota are saprobes and parasites of plants and arthropods. Many live in aquatic or semi-aquatic conditions and in soils producing thick-walled resting sporangia which can survive more dry periods. The mode of nutrition of the new fungus is uncertain, but parasitism is a possibility. The narrow and delicate inner cortex cells of *Asteroxylon* could have been a source of food. Good cellular preservation of the rhizomes and the fact that they are often found in growing position would be consistent with infection of living tissues by the fungus. However, no evidence of a host plant response was found. Our finding represents a new example of fungal-plant interaction already present at the early stage of plant terrestrialisation.

AN ORGANIC-WALLED MICROPHYTOPLANKTON ASSEMBLAGE FROM THE MIDDLE DEVONIAN ARKONA, HUNGRY HOLLOW, AND WIDDER FORMATIONS, ONTARIO, CANADA: BIOSTRATIGRAPHIC AND PALEOGEOGRAPHIC SIGNIFICANCE

Reed Wicander[1]

1. Central Michigan University, Department of Earth and Atmospheric Sciences, Mount Pleasant, Michigan 48859, U.S.A.
wican1r@cmich.edu

A diverse and abundant organic-walled microphytoplankton assemblage consisting of 33 species of acritarchs and prasinophyte phycomata was recovered from a 13.3 m section of the Middle Devonian (Givetian) Arkona, Hungry Hollow, and Widder formations at Hungry Hollow, Ontario, Canada. The three formations consist of interbedded shales, calcareous shales, argillaceous limestones, and massive crystalline limestones. Palynomorph abundance and diversity is greatest in the finer-grained lithotopes. As might be expected, there is a close similarity of this organic-walled microphytoplankton assemblage with other described Givetian assemblages from North America, e.g., the subsurface Hamilton Group, Ontario, Canada (84%,), Silica Shale, Ohio (62%), Columbus Limestone and Delaware Limestone, Ohio (56%), Boyle Dolomite, Kentucky (78%), and Rapid Member of the Cedar Valley Formation, Iowa (70%). Diverse and well-preserved Middle Devonian assemblages from elsewhere in the world include, among others, the Los Monos Formation, Argentina (48%), Middle Devonian exploratory wells, Ghana, Middle Devonian from the Algerian Sahara, Aouinet Quenine II Formation, Libya (44%), and Pillara Limestone, Australia (23%). Commonly occurring and characteristic Givetian taxa that are geographically widespread in North America and that occur in the Arkona, Hungry Hollow, and Widder formations include: *Arkonites bilixus, Baltisphaeridium distentum, Cymatiosphaera winderi, Dictyotidium variatum, Diexallophasis simplex, Duvernaysphaera angelae, Estiastra rhyidoa, Hapsidopalla chela, Leiofusa pyrena, Muraticavea munificus, Oppilatala sparsa,* and *Polyedryxium ambitum*. Other species common in the Arkona, Hungry Hollow, and Widder formations, and that have a longer stratigraphic range and are typically more cosmopolitan include: *Exochoderma arca, Navifusa bacilla, Polyedryxium pharaonis, Stellinium comptum,* and *Triangulina alargadum*. From a paleogeographic perspective, Middle Devonian organic-walled microphytoplankton taxa display a reasonably high degree of cosmopolitanism, with many species in common between Laurussia (Laurentia, Avalonia, Baltica), Gondwana (principally Argentina, Ghana, Libya, Algeria, western Australia), and western China, as evidenced from the similarity of species from the Arkona, Hungry Hollow, and Widder formations compared to the aforementioned areas. Furthermore, there are a number of endemic species that are restricted to the higher southern Gondwana paleolatitudes.

EARLY CRETACEOUS HIGH LATITUDE MARINE FAUNAL SUCCESSION IN THE EROMANGA BASIN OF AUSTRALIA

Lovisa Wretman[1] and Benjamin P. Kear[2]

1. Uppsala University, Norbyvägen 18A, Uppsala, 752 36, Sweden.
lovisa.wretman@ebc.uu.se

2. Uppsala University, Villavägen 16, Uppsala, 752 36, Sweden.

The Eromanga Basin is an enormous depositional depression covering most of northeastern Australia. It accommodates an almost continuous sequence of shales, mudstones and sandstones that were laid down in an Early Cretaceous (Valanginian–Albian) epicontinental seaway. At its acme, this transgression inundated most of the present Australian continental land surface and supported a distinct succession of biotically rich shallow marine ecosystems. Significantly, the Australian continent was also still attached to Antarctica during the Early Cretaceous, with the Eromanga Basin palaeolatitudinally situated between 60° and 70° S. Today, a marked faunal gradient can be observed through this rock unit transition, and has been popularly linked to coincident climatic warming across the Aptian–Albian boundary. Conversely, marine regression was also widespread at this time, implicating progressive basinal isolation and anoxia as other factors potentially influencing faunal replacement. This hypothesis is mooted from the fossil assemblages, which were taxonomically abundant during the Aptian–early Albian and included a diverse range of epifaunal–infaunal bivalves and pelagic ammonites/belemnites indicative of cosmopolitan affinities. Coeval vertebrate elements incorporated ubiquitous ichthyosaurians and up to five globally distributed plesiosaurian lineages, as well as chimaeroids. In stark contrast, middle–late Albian benthic communities were depauperate and dominated almost entirely by the hypoxic bivalve genera *Aucellina* and *Inoceramus*. Oddly though, this was concomitant with the emergence of endemic heteromorph ammonoids and a sudden appearance of teleost fishes and lamniform sharks. Marine amniotes alternatively display a degree of continuity with ichthyosaurians and at least three plesiosaurian taxa persisted, albeit with species-level alterations, through to the Cenomanian. Notably, however, these too are accompanied by the novel occurrence of early chelonioid sea turtles, which along with the advent of lamniforms, coincides with the seminal diversification of these clades elsewhere. The sudden manifestation of teleosts, on the other hand, is puzzling and might be an artefact of sampling. Indeed, the vast geographic area covered by the Eromanga Basin has yet to be exhaustively surveyed for fossils. Future exploration will therefore undoubtedly yield new discoveries, and perhaps change this existing picture of Early Cretaceous marine faunal diversity at the southern high-latitude reaches of Gondwana.

NEW INSIGHTS INTO THE CAMBRIAN-ORDOVICIAN BOUNDARY INTERVAL SEA-LEVEL HISTORY ON THE WISCONSIN ARCH, USA

Jay Zambito[1], Esther Stewart[1], Pat McLaughlin[1], Nick Sullivan[1] and Mike Hurth[1]

1. Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, 3817 Mineral Point Road, Madison, Wisconsin 53705, USA. jay.zambito@wgnhs.uwex.edu

The Cambrian-Ordovician strata of the North American Upper Mississippi River Valley (UMV) have long been considered a reference succession for shallow-water, inner detrital belt depositional environments. However, given the paucity and poor preservation of biostratigraphically useful fossils, relatively few high-resolution chronostratigraphic studies have been undertaken through the Cambrian-Ordovician boundary interval in this region. Previous studies focused primarily on sedimentology and lithostratigraphy, resulting in the boundary interval being described as either conformable or (to varying degrees) unconformable. This is in part due to the interbedded siliciclastic and carbonate succession (Stockton Hill Member of the lowest Oneota Formation) that was deposited during the earliest Ordovician in this area, and, therefore, the artificial appearance of a conformable and gradual transition from siliciclastic-dominated upper Cambrian Jordan Formation to carbonate-dominated Lower Ordovician Oneota Formation deposits. In this study, we integrate litho-, bio-, sequence-, and chemostratigraphic data from outcrops and recently acquired cores to reconstruct the sea level history at the Cambrian-Ordovician boundary on a transect in central Wisconsin arrayed slightly oblique to depositional strike, alongside and onto the positive-paleorelief Wisconsin Arch. In contrast to previous studies, the current study area is focused on the shallowest depositional environments of the UMV. Trilobites have not been recovered from these strata in the study area, but preliminary conodont biostratigraphy suggests that the ~10m thick study interval spans the *Eoconodontus* through *Cordylodus angulatus* zones, although it is not clear if intervening zones are present. Silcrete-formation, chert pebble conglomerates, and karst features associated with subaerial exposure are in some cases sharply overlain by stromatolitic (digitate and domal) hardgrounds indicating marine floodings. Abrupt elemental profile changes through the succession collected using a handheld XRF analyzer has allowed the identification of cryptic unconformities. We recognize numerous decimeter to meter-scale sedimentary packages bound by unconformities, some of which can be traced regionally up to 160 km. We tentatively place the Cambrian-Ordovician boundary at the lowest of these regional unconformities pending additional biostratigraphic sampling. Ongoing work will focus on determining whether the recognized regional unconformities represent a local sea-level signal, or are related to the Red Tops, Lange Range, Acerocare, and Black Mountain eustatic events.

TAXONOMY AND TAPHONOMY OF NAUTILOIDS FROM THE PALEOGENE OF CENTRAL CHILE

Patricio A. Zambrano[1], Sven N. Nielsen[2] and Wolfgang Stinnesbeck[1]

1. Institut für Geowissenschaften, Universität Heidelberg, Im Neuenheimer Feld 234, 69120 Heidelberg, Deutschland. patricio.zambrano@geow.uni-heidelberg.de

2. Instituto de Ciencias Ambientales y Evolutivas, Facultad de Ciencias, Universidad Austral de Chile, Valdivia, Chile.

Paleogene marine deposits crop out along the coast of south Central Chile at Algarrobo (33°21′41′′S), on the Arauco Peninsula (36°30′50′′S), Loanco (35°35′24′′S) and in South Chile on Tierra del Fuego (53°18′18′′S). The deposits from Arauco Peninsula are commonly assigned to the Bocalebu (Paleocene-Eocene) and Millongue formations (Middle Eocene) and contain nautiloids assigned to *Aturia*, *Hercoglossa*, *Cimomia* and *Eutrephoceras*. *Cimomia* is rare and was only detected in the Millongue Formation of Arauco, while *Eutrephoceras* is known from Algarrobo and Tierra del Fuego and resembles *Eutrephoceras* (*Euciphoceras*) *argentinae* from Seymour Island (Antarctic peninsula). *Aturia* was found in shallow marine tempestite layers and distal shelf deposits of Algarrobo, Loanco, Arauco peninsula and Tierra del Fuego. Suture line, shell features and siphuncular morphology of these specimens resemble Paleogene *Aturia* from the Caribbean and Antarctic Peninsula. Onthogenetic changes are evidenced by positive allometry and possible sexual dimorphism. *Hercoglossa peruviana* from the Arauco peninsula also displays onthogenetic changes and a possible sexual dimorphism. These specimens differ from Patagonian *Hercoglossa* in shell morphology and a larger size. *Hercoglossa* is rare in the Paleogene succession of Arauco, but a mass occurrence was detected in a single m-thick unit of the Millongue Formation and there appears to be related to a shallow water storm deposit. These specimens are represented by complete phragmocones presenting a differential preservation of the living chamber, filled with sandstone similar to the host rock. Innermost whorls present a calcite spar cement. This host layer directly overlies a tuffaceous siltstones unit, indicating a volcanic event at the time of sedimentation; it is likely that this event triggered important changes in the geochemical properties of the water, likely leading to a local mass-mortality. Micropaleontological analyses on turbiditic sediments underlying the mass-occurrence of *Hercoglossa* suggest that the MECO event (Maximum Eocene Climate Optimum) was stratigraphically close. During this main short-term global warming event, important changes took place in the marine paleoenvironments worldwide and may have caused the mass-mortality of shallow water inhabitants such as nautiloids. Similar approximately coeval shell accumulations have been registered in Peru (Hercoglossa), Patagonia (Hercoglossa) and the Antarctic Peninsula (*Eutrephoceras*). Up section from the *Hercoglossa* mass occurrence, no further nautiloids were detected. However, an important sedimentary gap is present in Central Chile and no marine sediments of Oligocene age are known. Nautiloids reappear during the lower Miocene, but only *Aturia* is present, with few morphological differences with regard to the Paleogene taxon.

LIFE AND DEATH IN THE SOUTHERN LAURUSSIAN EARLY FAMENNIAN SEA

Michał Zatoń[1], Paweł Filipiak[1], Michał Rakociński[1] and Krzysztof Broda[1]

1. University of Silesia, Faculty of Earth Sciences, Będzińska 60, PL-41-200 Sosnowiec, Poland.
mzaton@wnoz.us.edu.pl

The famous Kowala Quarry, Holy Cross Mountains, central Poland, contains an interesting fossil assemblage that allows the reconstruction of a southern Laurussian early Famennian shelf ecosystem. The conventional benthic shelly fossils are poorly diversified and dominated by inarticulate brachiopods (*Orbiculoidea*), while rhynchonellids and bivalves (*Guerichia*) occur rarely. The shelly nekton is dominated by orthoconic nautiloids, preserved as decalcified shells, while ammonoids occur sporadically in the form of carbonaceous compressions of their anaptychi. The fish fauna is represented by single occurrences of actinopterygian scales and shark teeth. Conodont elements are present, as well. The more interesting fossils, however, consist of arthropods, non-biomineralized algae and coprolites. Arthropods are numerically dominated by the enigmatic, crustacean-like thylacocephalan *Concavicaris*, followed by phyllocarids (*Montecaris* and other echinocaridids), and predatory eumalacostracan (*Angustidontus*). Due to phosphatization, these fossils provide an additional insight into the pelagic community of the early Famennian Laurussian shelf environment. The non-biomineralized algae, preserved as carbonaceous compressions, are represented by at least four different taxa which may be allied to the Dasycladales. The detailed preservation of some fossils may suggest they were benthic organisms buried close to their natural habitat. The coprolites recovered are phosphatic, small-sized (up to 18 mm), and contain various fossil inclusions, such as fish scales and teeth, conodonts, scolecodonts, and arthropod cuticles (mostly of the thylacocephalan *Concavicaris*, but also fragments of phyllocarid affinity). The fossil assemblages of the Kowala Quarry provide a window into the early Famennian sea-life, while the coprolites are evidence of death through predator-prey interactions. The presence of fish and pelagic arthropod remains in the coprolites, suggests that the potential predator was a pelagic fish, most probably a shark. [Contribution to the NCN 2011/01/B/ST10/ 00576 grant (MZ)].

NEOGENE BIRDS OF EURASIA: STATE OF THE ART

Nikita V. Zelenkov[1]

1. Borissiak Paleontological institute of Russian Academy of Sciences, Profsoyuznaya 123, Moscow, 117997, Russia.
nzelen@paleo.ru

The last decades have witnessed a considerable improvement of the avian fossil record, especially its Mesozoic and Paleogene parts, but the dynamics and composition of the Neogene avian faunas remain poorly understood. In particular, our knowledge of the Neogene Eurasian avian faunas is still very uneven: early Miocene birds are known almost exclusively from Western and Central Europe; many middle Miocene bird faunas are reported from Western and Central Europe, and only two middle Miocene avian faunas are known from Mongolia and Thailand. Late Miocene and early Pliocene birds have been described mostly from Eastern part of Europe, but there are few others from Mongolia and Indian region. Late Pliocene birds are reported from a minor number of Central Asian and Eastern European localities. The lack of enough number of coeval localities in many regions and huge geographical distances between many localities make it difficult to reconstruct the evolutionary history of particular taxa and the evolution of the Eurasian Neogene avian faunas in general. However, new materials on Central Asian and Eastern European Miocene and Pliocene birds, together with the reassessment of many previously described European and some Asian taxa, bring new possibilities to trace the avian evolution in Eurasia during the Neogene. The early Miocene stage is well studied based on Western European localities, but it is still unknown to what extent this early Miocene avian fauna (composed mainly from extinct genera) was spread to the east. The middle Miocene faunas from Asia (Western Mongolia) and Europe (Germany and France) share a number of taxa (mostly water birds), but Asian faunas still contain many endemic taxa, which were not reported from Europe. The only known early-middle Miocene bird fauna from Siberia (Baikal lake) is taxonomically similar to the middle Miocene fauna from Mongolia. More recent late Miocene and early Pliocene bird faunas from Mongolia share similarities with the North American contemporarily faunas, but there are apparently no taxa in common with the East European localities. A faunal turnover which has led to the origin of the present day avian faunas, apparently took place in the first half of the late Miocene, but the details of this process are largely unknown since this interval is dramatically poorly represented in the fossil record. The majority of the modern species-level lineages first appear in the latest Pliocene or even later.

WHY IS *TEGULA ATRA* (LESSON) (GASTROPODA) EXTINCT FROM PATAGONIA? BIOTIC RESPONSE TO LATE QUATERNARY CLIMATE CHANGES IN THE SOUTHWESTERN ATLANTIC

Marina L. Aguirre[1,2], Sebastián Richiano[1,3], Mariano Donato[1,4] and Ester A. Farinati[5]

1. CONICET, Argentina.

2. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Edificio Institutos, Cátedras y Laboratorios, Laboratorio 6, calle 64 No 3, 1900 La Plata, Argentina.
maguirre@fcnym.unlp.edu.ar

3. Centro de Investigaciones Geológicas, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, calle 1 N° 644, 1900 La Plata, Argentina.

4. Laboratorio de Sistemática y Biología Evolutiva (LASBE), Museo de La Plata, Paseo del Bosque S/N, 1900 La Plata, Argentina.

5. Departamento de Geología, Universidad Nacional del Sur, Bahía Blanca, Argentina.

The regional palaeobiogeographical context of *Tegula atra* (Lesson) revealed that it is a keystone endemic species within the marine Quaternary of Patagonia (Argentina, Southwestern Atlantic, SWA). A detailed systematic review together with field observations showed that it was absent from warmer than present Neogene sea-level episodes (*e.g.*, late Miocene, "Entrerriense", ca. 10 Ma) and up to the mid-Pleistocene (Marine Isotope Stage 11 (MIS), ca. 400ka B.P.). By contrast, it exhibits an excellent and abundant, Late Pleistocene fossil record (MIS9, MIS7 and especially MIS5), along more than 1000 km between Río Negro and southern Santa Cruz provinces (Patagonia). A total of 130 collected bulk samples (complete sedimentary matrix and molluscan content) containing *T. atra* from more than 30 Pleistocene fossiliferous sites in 9 wider geographical areas (San Antonio Oeste, Puerto Lobos, Bahía Vera, Cabo Raso, Camarones, Bahía Bustamante, Caleta Olivia, Puerto Mazarredo, Puerto Deseado, San Julián) analyzed through multivariate and cladistic techniques confirmed its importance as a biostratigraphical/paleoclimate/palaeoceanographical signal within dominantly cool coastal settings. Additionally, morphometric analyses of Pleistocene (Patagonian) and modern (Pacific, Southeastern Pacific, SEP) specimens and Ancestral Areas analysis showed that after its first appearance in the SEP during the late Pliocene (cooling trend) it dispersed during the late Pleistocene into the SWA by rafting on macroalgae (*Durvillaea antarctica*) along the Cabo de Hornos and Malvinas (Falkland) currents, becoming extinct in the Mar Argentino (Magellan Malacological province) after the Last Interglacial (MIS5). Its absence today represents a climate change-driven range shift following the amelioration trend after the Last Glacial Maximum (LGM) and an independent evidence for palaeoceanographical changes at the Pleistocene/Holocene transition: changes in sea surface temperature (SST)(ca. 2°C higher), wind velocities (less), light (less), nutrient availability (less), extension and intensity of cold (less) and warm (increased) shallow water currents altering water masses, productivity and biogeographical boundaries. Disadvantageous Holocene scenarios must have caused direct effects on its physiology and survival and prevented the occurrence of *D.antarctica* and a successful dispersal along the SWA, while its retraction to the cold Humboldt System was impossible (northwards direction of SWA cold currents). Dispersalist models explain the origin of key taxa such as *T. atra* and taxonomic differences along the SWA and SEP margins of South America with implications for future coastal scenarios. The distribution of *T. atra* across time reinforces strong linkages between earth history-climatic cycles-atmospheric-oceanic circulation patterns and biotic responses, showing future climate change consequences expected on nearshore communities.

SPECIES' ENVIRONMENTAL NICHE AND THE CONTROL OF PALEOBIOGEOGRAPHIC DYNAMICS OF MARINE MOLLUSKS DURING THE QUATERNARY

Alex H. Alballay[1] and Marcelo M. Rivadeneira[1]

1. Laboratorio de Paleobiología, Centro de Estudios Avanzados en Zonas Áridas (CEAZA) & Universidad Católica del Norte, Avenida Ossandón 877 Coquimbo, 1781421, Chile.
alex.alballay@gmail.com

Species modify their ranges of distribution across evolutionary timescales, either coordinately or individualistically, as revealed by numerous studies of terrestrial and marine taxa during the Quaternary. However, the ultimate causes explaining the species' variability in biogeographic dynamics remains little understood. Here we describe the paleobiogeographic dynamics of marine mollusk species along the temperate coast of South America from the Pleistocene to the present-day, and tested the role of species' environmental niches explaining these dynamics. We modeled the environmental niche of 113 mollusk species (bivalves and gastropods) present in both Quaternary fossil and modern assemblages (i.e. extralimital species were excluded). Analyses were based in more than 134.354 georeferenced occurrences crossed against 23 geophysical, biotic and climate variables, using a maximum entropy algorithm. Niche models show a very high accuracy (mean AUC = 0.998), indicating that sea surface temperature and nutrient concentration are the most important environmental factors explaining species distribution. A comparison of present-day versus fossil distributions reveals that the geographic range of most of species (74%) has remained remarkably stable from the Pleistocene to the recent, and 26% of species have either contracted/ expanded any or both of their northern/southern ranges. A random forest model analysis shows that the relative importance of environmental variables in niche models can successfully predict species with a stable biogeographic dynamic (pseudo-r^2=0.96), but not of those species showing range shifts (pseudo-r^2=0.04). This suggests that the stability of geographic ranges can be achieved by different niche configurations, and that long-term changes in the species' distribution are not related to niche-based processes and may be likely induced by extrinsic factors including coastal re-configuration due to eustatic and tectonic processes. [Project funded by FONDECYT 1140841].

IS THE GENUS *RETROTAPES* DEL RIO 1997 (BIVALVIA: VENERIDAE) A MONOPHYLETIC GROUP?

Maximiliano J. Alvarez[1] and Damián E. Pérez[1]

1. Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Av. Ángel Gallardo 470, Buenos Aires, C145DJR, Argentina. maxialvarez82@gmail.com

Retrotapes is a genus of the Subfamily Tapetinae created to group some extant and Cenozoic species from Patagonia and Chile that have three cardinal teeth inclining backwards or with the anterior tooth nearly vertical. Several authors have questioned the validity of this genus, proposing the synonymy of *Retrotapes* with *Frigichione* Fletcher, and that the extant species of *Retrotapes*, *R. exalbidus* and *R. lenticularis*, are members of the genus *Eurhomalea* Cossmann. Recently, others authors recognized the validity of *Retrotapes* suggesting the inclusion of the extant species mentioned above and others from the Eocene of Antarctica previously identified as members of genus *Eurhomalea* and *Atamarcia* Marwick, within *Retrotapes*. In the present contribution we analyzed the monophyly of genus *Retrotapes* considering as ingroup the extant species from Argentina and Chile, fossil species from the Miocene of Patagonia and Chile and Eocene of Antarctica, *Frigichione permagna* (type species of *Frigichione,* Miocene of Kerguelen Island), the extant species *Eurhomalea rufa* (type species of *Eurhomalea*) and *Atamarcia sulcifera* (type species of *Atamarcia,* Miocene of New Zeland). Additionally, we considered 16 species of the Subfamily Tapetinae as outgroup for this analysis. To test the affinities of *Retrotapes* we performed a cladistic analysis based on 67 shell characters of 31 species with TNT 1.1 through a heuristic search of 50 replicates of Wagner trees followed by TBR branch swapping algorithm holding 10 trees per replicate, under implied weighting with K values between 8 and 19. We obtained a tree with *Retrotapes* as a monophyletic clade, that includes *R. newtoni*, *R. fuegoensis* and *R. robustus* as successive sister groups; and two other clades, one grouping *R. striatolamellatus* and *R. ninfasiensis* both from the Miocene of Patagonia and the other grouping the extant species with *R. andrillorum* (Miocene, McMurdo Sound, Antarctica), *R. antarcticus* (Eocene, Marambio Island, Antarctica) and *R. navidadis* (Miocene, Chile). *Retrotapes* is supported by five unambiguous synapomorphies: wide hinge plate, right anterior tooth subvertical, lunule delimited by a deep groove, valves ornamented with comarginal lines more separate in juveniles but closer in adults and have some growth lines more pronounced than others. Moreover, *Retrotapes* is more closely related to the clade formed by *Paleomarcia tatei* (Miocene of Kerguelen Island) and *Atamarcia sulcifera* (Miocene of New Zeland). *Frigichione* was recovered as the most basal of the Tapetinae and *Eurhomalea rufa* was resolved in a different clade more closely related to species from the Northern Hemisphere. [Supported by Research Projects ANPCyT-PICT 57 and CONICET-PIP 320].

ONTOGENETIC ALLOMETRY AS A KEY DIMENSION TO UNDERSTAND CRANIAL SHAPE OF †*DOLICAVIA MINUSCULA* (RODENTIA, CAVIIDAE)

Alicia Álvarez[1,3] and Diego H. Verzi[2,3]

1. División Mastozoología, Museo Argentino de Ciencias Naturales, Av. Ángel Gallardo 470, 1405, Buenos Aires, Argentina. alicia.alvarez@macn.gov.ar

2. Sección Mastozoología, Facultad de Ciencias Naturales y Museo, Universidad de La Plata, Av. Paseo del Bosque s/n, 1900, La Plata, Argentina.

3. CONICET, Argentina.

†*Dolicavia minuscula* is an extinct member of the family Caviidae. It has an unusually rich record, represented by very complete cranial remains from the Chapadmalal Formation (Chapadmalalan stage, early-late Pliocene), cropping out in the Atlantic cliffs of Buenos Aires province (central Argentina). †*Dolicavia* bears a peculiar morphology, partially similar to that of the sister genus *Microcavia*. Outstanding features involve markedly enlarged orbits and inflated, bowed cranial vault. Here, we propose that these traits would represent a "juvenilized" morphology. To test this hypothesis, subadult to adult specimens of †*Dolicavia* were analyzed within an ontogenetic allometric space including the extant caviine *Cavia aperea*, *Galea musteloides*, and *Microcavia australis*. Patterns of cranial shape variation were examined through geometric morphometric techniques; 22 landmarks + 23 semilandmarks were digitalized onto pictures of crania in lateral view. A Principal Component (PC) analysis was carried out onto shape coordinates in order to accomplish a visual examination of allometric trajectories. Centroid size (CS) was estimated to be used as a proxy of age. Ordinary Least Squares regressions were performed to obtain the slope (shape change rate) and intercept (starting shape) of each trajectory along the first axis of variation. Differences among trajectories were assessed through covariance analyses. In the morphospace defined by PC1 and PC2, the first axis showed the major differentiation among genera. In a regression of PC1 on CS, *Cavia* and *Galea* had similar trajectories while *Microcavia* had the most separate, parallel trajectory. †*Dolicavia* located near adults of *Microcavia*. Covariance analyses supported significant differences among intercepts but not among slopes, suggesting lateral transposition as the pattern of change among trajectories. Ontogenetic pathway of *Microcavia* is interpreted as post-displacement by assuming that it is a result of changes occurring in early stages of development, prior to those represented in this study. Although ontogeny of †*Dolicavia* is unknown, its position in the allometric space suggests that less shape change from juveniles to adults is expected respect to that of extant species. According to the results, at least part of cranial variation in caviines can be interpreted through an ontogenetic approach as alternative to selective explanations for isolated characters. It remains to be examined whether "juvenilized" cranial morphology of †*Dolicavia* and *Microcavia* could be related to the occupation of arid environments as proposed for other clades of rodents.

TEACHING PALEONTOLOGY AT THE UNIVERSIDAD NACIONAL DE RÍO NEGRO: MORE THAN JUST BOOKS AND MEMORIZING NAMES

Fernando M. Archuby[1], Marien Béguelin[1,2], Silvio Casadío[1,2] and Juan I. Canale[1,2]

1. Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, Avenida Roca n° 1292 (8332), General Roca, Argentina. farchuby@unrn.edu.ar

2. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina.

At the Universidad Nacional de Río Negro (Patagonia, Argentina) we teach basic paleontology to second year undergraduate students of geology and paleontology by means of two courses following the student-centered pedagogy known as Problem-based learning (PBL). With this pedagogic approach students learn about a subject through the experience of problem solving. The goals of PBL are to help students developing motivation and skills for active self learning. The role of the professors is supporting, guiding, and monitoring students in order to facilitate the learning process. The backbone of our strategy with the students is encouraging them to develop a research project followed by writing a research article. The projects address the study of different invertebrate groups recorded in sections of the marine Maastrichtian-Danian Jagüel and Roca Formations. They must pass through the complete process of a regular scientific work, including the project, planning the sampling, applying for funding, etc. The students learn from how to think a title, to how to cite literature, and propose and test hypothesis. In the meanwhile, they have to read and write drafts. By the end of the course we organize a meeting with faculties and students of other courses, and every student has to expose their work. Then, every work has to be peer reviewed to finally pass the last examination. Reviewers are a student and a teacher. During 2012 and 2013 we implemented several strategies in order to reach our goals: we watched two movies, we proposed several online forums on different subjects, read books, played games, with concepts such as biostratigraphy or epistemology, developed conceptual maps with C-Map Tools, etc. We created a Didactic Collection hosting materials used to teach, as well as all the fossils the students collect in the field trips, that has at the moment more than 350 fossils or sets of fossils. We reinforce the teaching activities with a virtual classroom developed in the learning platform Moodle and hosted at the University server. There we upload literature, propose debates, open collaborative wiki-based texts, upload tasks and communicate with the students by an internal mailing system. We also innovate every year: in 2014, to help understanding invertebrate animals we are organizing a dinner in which six groups of students have to cook a meal having seafood. Previously, they have to identify the species and dissect them to recognize anatomical features. And there is more…

ANALYSIS OF DEEP MARINE BASIN PALEOENVIRONMENTS USING FORAMINIFERA

Kristina L. Arthur[1], Benjamin C. Kneller[2], Valesca B. Lemos[1] and Matthew I. Wakefield[3]

1. Universidade Federal do Rio Grande do Sul, Instituto de Geociências, Av. Bento Gonçalves, 9500, CEP 91501-970 Porto Alegre, Brazil. k.l.arthur@vu.nl
2. Department of Geology and Petroleum Geology, University of Aberdeen, Aberdeen, AB24 3UE, UK.
3. BG Energy Holdings Limited, Thames Valley Park Drive, Reading, RG6 1PT, UK.

Deep marine sedimentary systems are important locations for the formation of hydrocarbon reservoirs and accumulation of hydrocarbon deposits. Large-scale basin analysis can be seismically resolved; however identification of the small-scale, complex depositional environments within these systems requires detailed sedimentary analysis. Outcrop analogues can be studied to help constrain the sub-environments of deep-marine basins, providing a basis for interpretation of paleoenvironment and depositional setting. In this study we aim to provide a foraminiferal classification scheme based on marine microfossils from outcrop analogues in France (Grès d'Annot), Italy (Marnoso-Arenacea) and Mexico (Rosario Formation), incorporating the diversity of depositional settings recognized in outcrop analogues, and which can be applied to subsurface deposits. The classification scheme will be developed with the purpose of improving knowledge of deep-marine systems and related subenvironments. The outcrop analogues studied represent confined to ponded submarine fans (Grès d'Annot); a variably confined submarine fan to basin plain deposit (Marnoso-Arenacea); and a slope system including channels and levees (Rosario Formation). These systems have been chosen because of their comparability in age and depositional setting with some deep-marine sedimentary basin deposits offshore Brazil. Foraminifera are ubiquitous in global oceans throughout geological history, providing useful biostratigraphic and environmental information about the area in which they are deposited. A classification scheme for use in identifying deep marine system subenvironments will be established using planktic and benthic foraminifer species abundance and benthic morphogroups characteristic of different depositional environments. The relationship between key species or morphogroups with different water depths, environments and sedimentary substrate will enable the identification and interpretation of fine-scale depositional features within the deep-sea basin system. Preliminary results presented here will examine the paleoenvironmental characteristics of subenvironmental facies within the outcrop systems. Benthic morphogroup analysis will characterize the different benthic depositional environments, while key species of planktic and benthic foraminifera will give indications of water depth, oceanic environment and occurrences of downslope transport within the deposits. This paleoenvironmental assessment will be placed in the context regional depositional, climatic and tectonic systems.

A TEIID LIZARD FROM THE EUROPEAN EOCENE SUGGESTS TRANS-ATLANTIC DISPERSAL

Marc Louis Augé[1] and Santiago Brizuela[2]

1. Muséum National d'Histoire Naturelle UMR 7207 CNRS, CP 38, Rue Buffon, 75231, Paris Cedex 05, France.
2. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)-Departamento de Biología, Universidad Nacional de Mar del Plata, Funes 3350, B7602AYL, Mar del Plata, Argentina.
brizuela@mdp.edu.ar

The earliest records of teiids are from the early Paleogene of Brazil and Argentina. As far as we know, outside South America, teiid lizards have only been reported from the Neogene of North America. Here, we report the presence of teiids in the European Eocene. A frontal and several vertebrae (BFI 1877) from the late Eocene of Phosphorites du Quercy, France, are nearly identical to those of extant teiids. Several lizard remains from the Late Cretaceous have already been referred to Teiidae *s.l.* in Europe. None of these taxa persisted into the European Paleogene. Recent phylogenetic investigations showed that the purported Cretaceous teiids were actually distantly related to that family. The systematic position of these lizards is in a state of flux and could continue to shift with new analyses. Hence, Teiidae (*sensu stricto*) have no known Paleogene record in Europe. Therefore, independent evolution of the European forms is unlikely, for lack of suitable local ancestors. The disjunct distribution of teiids during the Eocene (South America and Europe) deserves some explanations, given the context of splendid isolation that characterizes South America in the Cenozoic. The probable origin of teiids is in the South American Late Cretaceous-Paleocene. Therefore, vicariance events explaining the distribution of teiid lizards are untenable because the opening of the South Atlantic Ocean dates back to the Early Cretaceous. Transatlantic dispersal must be favored. Two main hypotheses may be proposed: 1 - Dispersal of Teiidae to Europe may have occurred via a northern route (North America). 2 – Dispersal via a southern route, where Africa may have played the role of a stopover. Either hypothesis has its shortcomings: absence of fossil teiids in the Paleogene of Africa and North America. We favored the southern route as dispersal between Africa and South America as it is well documented for rodents and primates (Eocene – Oligocene). Land vertebrates with purported South American affinities have also been found in the European Eocene. Admittedly, the direction of major trans-Atlantic dispersal events between Africa and South America is westwards. However, some authors have already suggested bidirectional and even eastwards interchange during the early Tertiary.

THE FIRST OCCURRENCE OF *ANHANGUERA* AT PERNAMBUCO (EARLY CRETACEOUS ROMUALDO FORMATION), NORTHEASTERN BRAZIL

Tito Aureliano[1], Aline M. Ghilardi[2], Rudah R.C. Duque[1] and Alcina M.F. Barreto[1]

1. Universidade Federal de Pernambuco, Centro de Tecnologia e Geociências, Departamento de Geologia, Av. Acadêmico Hélio Ramos s/n, Cidade Universitária, Recife, PE, 50740-530, Brazil.
aureliano.tito@gmail.com

2. Universidade Federal do Rio de Janeiro, CCMN, Departamento de Geologia, Av. Athos da Silveira Ramos, 274, Bloco G, Ilha do Fundão, Rio de Janeiro, RJ, 21949-900, Brazil.

A new remain of pterodactyloid pterosaur was collected during field research at the municipality of Exu, Pernambuco, northeastern Brazil, the unexplored southernmost portion of the Araripe Basin. The fossil was found three-dimensionally preserved in a calcareous nodule, typical of the Romualdo Formation (Aptian/Albian) of the Araripe Basin. The specimen UFPE7516 is represented by a distal end of an ulna that shows the overall morphology that belongs to the clade Anhangueridae. The size of the shaft is 250 mm and the reconstructed size of the ulna is 420 mm. The articulation is expanded reaching 56 mm. The preserved proximal part of the shaft has a sub-circular transverse section of 32 mm. The distal articular contour shows strong similarity to the ones presented in *Santanadactylus pricei* and *Anhanguera araripensis*. There are only two records of Anhangueridae genera in the Romualdo Formation: *Tropeognathus* (monoespecific) and *Anhanguera*. Histological analysis on a transversal thin section in the midshaft shows the external fundamental system (EFS) covering the surface of the bone. The layer of endosteal bone is deposited surrounding the medular cavity and is eroded at some portions. Those are indicators that the animal had reached the adult ontogenetic state. The compacta is composed of obliquely anastomosing canals and many round and longitudinally oriented primary osteons. Some secondary (Haversian) osteons have invaded the internal cortex. The estimated wingspan of this specimen is 4.80 m, approximately 15% smaller than an adult *Anhanguera psicator* and almost half of the size of a same aged *Tropeognathus*. By gathering historical, anatomical and histological information altogether we can securely conclude that this specimen by the time of its death was an adult individual of the genus *Anhanguera*. This is the first record of this genus for the State of Pernambuco, and thus broadening the horizons of occurrence of pterosaurs at new localities within the Araripe Basin. The Exu site presents potential for continuing excavations for new tetrapod samples and to give new insights on the paleobiogeography of archosaurs during the Early Cretaceous.

METATHERIAN PETROSALS FROM THE MIDDLE-LATE EOCENE OF NORTHWESTERN ARGENTINA

M. Judith Babot[1] and Daniel A. García-López[2,3]

1. Fundación Miguel Lillo, Miguel Lillo 251, San Miguel de Tucumán, 4000, Argentina. jubabot@gmail.com

2. INSUGEO (CONICET-UNT), Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina.

3. Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina.

We present two incomplete petrosals (MHAS 062 and MHAS 063) collected by screen washing procedures in the Geste Formation exposed in Catamarca Province, Northwestern Argentina. The bones, assigned to the same morphotype, preserve the pars cochlearis almost complete and the most anterior portion of the pars canalicularis. The promontorium is globular and occupies nearly the entire tympanic aspect of the pars cochlearis; the rostral tympanic process is blunt; the epitympanic wing and the medial flange are absent. The stapedial ratio is 2.1 in MHAS 062 and 1.1 MHAS 063. The floor of the cavum supracochleare is present and the secondary facial foramen is located anterolateral to the fenestra vestibuli. The hiatus Fallopii opens in an intermediate (tympanic) position. The epitympanic recess, partially preserved, bears a small fossa incudis clearly demarcated from the facial sulcus by the crista parotica. The presence/absence of the prootic canal cannot be determined. The stapedius fossa is separated from the roof of the post-promontorial tympanic sinus by a faint crest. On the cerebellar aspect, the internal acoustic meatus (IAM) exhibits a kidney-shaped foramen acusticum inferius separated from a smaller foramen acusticum superius by a wide transverse crest. In posterior view, the pars canalicularis shows the anterior wall of a deep subarcuate fossa and the anterior parts of the semicircular canals. The petrosal crest is sharp. The cochlear canaliculus is located posteromedial to the IAM. Anterodorsally, an unnamed aperture penetrates the substance of the petrosal. The sulcus for the inferior petrosal sinus is barely visible. The presence of a rostral tympanic process, a sulcus for the inferior petrosal sinus, and the absence of promontorial grooves for the stapedial system allow us to refer these elements to Metatheria. Among this group, we found morphological similarities with the Itaboraian petrosal Type V and with the Peligran petrosal from Patagonia. In size, the new petrosals resemble the smallest Itaboraian metatherian petrosal (Type VIII). The estimated molar area for the auditory bones here studied falls within the range of *Minusculodelphis* and clearly differs from the larger teeth of the metatherian *Regia punae*, *Bonapartherium serrensis*, and *Punadolops alonsoi* recovered at Geste Formation. These findings reveal the presence of a wider diversity of small mammals than already known for Eocene beds of Northwestern Argentina. Additionally, these new records highlight the value of screen washing techniques as well as the need of considering different lines of evidence, when studying fragmentary records of fossil micromammals.

THE EVOLUTION OF FLORISTIC DIVERSITY IN WESTERN GONDWANA DURING THE LATE PALEOZOIC: A PALYNOLOGICAL APPROACH

Lucía Balarino[1], Ángeles Beri[2] and Pedro R. Gutiérrez[1]

1. Museo Nacional de Historia Natural "B. Rivadavia", Av. Á. Gallardo 470, C1405DJR, Buenos Aires, Argentina. lubalarino@macn.gov.ar

2. Facultad de Ciencias, Universidad de la República, Iguá 4225, 11400, Montevideo, Uruguay.

This work analyzed the evolution of palynological assemblage diversity using the number of the genera present in each sample. Samples from two boreholes from the Paraná Basin, Uruguay (26 samples of DI.NA.MI.GE. Paso de las Toscas N° 254 and 14 samples of DI.NA.MI.GE. Cerrillada N° 221), one borehole from the Claromecó Basin, Argentina (10 samples of UTAL.La Estrella.x-1) and 18 outcrop samples from the La Deheza Formation, Paganzo Basin, Argentina, were analyzed. All analyses were performed with PAST 2.16. The evolution of diversity, extinction and appearance curves for each analyzed unit were obtained. In the boreholes 254 and 221, the biozones *Cristatisporites inconstans-Vittatina saccata* (early Cisuralian) and *Striatoabieites anaverrucosus-Sataurosaccites cordubensis* (late Cisuralian – early Guadalupian) were recognized. In the La Deheza Formation, the biozones *Raistrickia densa-Convolutispora muriornata* (late Mississippian-Pennsylvanian), *Pakhapites fusus-Vittatina subsaccata* (late Pennsylvanian- early Cisuralian) and *Lueckisporites-Weylandites* (late Cisuralian- early Guadalupian) were recognized. The last two biozones can be partially correlated with those proposed in the Uruguayan boreholes. In the borehole La Estrella, the biozones *Converrucosiporites confluens-Vittatina vittifera* (early Cisuralian) and *Tornopollenites toreutos-Reduviasporonites chalastus* (late Cisuralian - Guadalupian) were recognized. The microfloristic assemblages from 221 and 254 boreholes and the La Deheza Formation show a similar diversity trend. An increase in diversity is observed at the basal section of each biozone and a steady diversity decrease towards their younger horizons. The genera appearance tends to be more important in the lowermost stratigraphic levels of each biozone. The extinction rates are predominant in the younger biozones. It is possible to observe that richness trends throughout the interval analyzed herein correlate with sedimentary facies that, in fact, are related to climatic changes. The pattern of palynofloral diversity evolution in boreholes 254, 221 and the La Deheza Formation indicates an increase of richness in glacial, glaciofluvial and deltaic environments with coal deposits. In lagoonal facies a peak of diversity first occurs, followed by a steady increase in extinction rates and scarce genera appearance. This process of extinction becomes more important in shallow marine facies. [Contribution to PICT N° 2012-1637 and PIP N°00585].

PALEOPATHOLOGY IN LATE PLEISTOCENE MAMMALS: A FOSSIL ASSEMBLAGE CASE REPORT FROM BRAZIL

Fernando H. de Souza Barbosa[1], Kleberson de Oliveira Porpino[2], Ana B. Lima Fragoso[2] and Edison V. Oliveira[3]

1. Universidade Federal do Rio de Janeiro, Av. Athos da Silveira Ramos, 274, Ilha do Fundão, 21941-916, Rio de Janeiro, RJ, Brazil. fhsbarbosa@gmail.com

2. Universidade do Estado do Rio Grande do Norte, Av. Professor Antônio Campos, s/n, Pres. Costa e Silva, 59610-090, Mossoró, RN, Brazil.

3. Universidade Federal de Pernambuco, Rua Acadêmico Hélio Ramos, s/n, Cidade Universitária, 50740-530, Recife, PE, Brazil.

Undoubtedly, the identification of bone diseases can shed light on several paleobiologic, taphonomic and systematic problems. However, paleopathology is still an incipient topic in the paleontology of the Pleistocene mammals from South America. Bone infection, arthritis and traumatic lesions have been the most common disease diagnosed in these animals. In this work some bone lesions were identified and interpreted on different fossils of Pleistocene mammals of a single fossil assemblage represented by four limestone caves deposits at Lajedo da Escada site, at the Baraúna Municipality, State of Rio Grande do Norte, Brazil (5°12′20″S, 37°42′50″W). Four hundred twenty two specimens housed at the paleontological collection Onofre Lopes of the Museu Câmara Cascudo/Universidade Federal do Rio Grande do Norte belonging to nine species of large- to mid-sized mammals were visually inspected. Besides this macroscopic analysis, eighteen specimens were submitted to radiologic examinations using an X-ray apparatus (Siemens Heliophos 4 S, 500 Ma, 125 Kv). These specimens were selected for radiography because they show more elusive macroscopic alterations that needed further evaluation. Bony lesions were identified in 17 specimens: (i) eight elements of hind and forelimb of *Glyptotherium* sp. showing signs of spondyloarthropathy with associated secondary osteoarthritis and calcium pyrophosphate deposition disease; (ii) three hind limb elements assigned to *Eremotherium laurillardi*, one femur of *Pachyarmatherium brasiliense* and one indeterminate bone with sings of bone infection; (iii) a femoral head of *E. laurillardi* with osteochondritis dissecans; (iv) one diaphysis of a long bone of *Xenorhinotherium bahiense* and other of *E. laurillardi,* both showing unspecific bone necrosis; and (v) one phalanx of *Toxodon* sp. with signs of periostitis. These specimens represent only 4.03% of the fossils in the assemblage of the studied site, revealing a scarce number of alterations considering the total number of specimens. *E. laurillardi* (minimum number of individuals = 5) was the species more affected by lesions, which were identified in 23.5% of the total number of specimens assigned to it. Despite the greater number of skeletal elements belonging to *Glyptotherium*, they are all assignable to a single individual. Infection was the better represented illness in the assemblage, affecting five specimens of two different species, although necrosis had also affected two species, but only two specimens. The femoral head of *E. laurillardi* bearing osteochondritis dissecans represents the first occurrence of this pathology in the paleontological record of South America.

RINCÓN DEL BUQUE: A LARGELY UNEXPLORED RICH SANTACRUCIAN (EARLY MIOCENE) LOCALITY IN SOUTHERN PATAGONIA, ARGENTINA

M. Susana Bargo[1,7], Sergio F. Vizcaíno[1,8], Richard F. Kay[2], Juan C. Fernicola[3,4,8], M. Sol Raigemborn[5], Verónica Krapovickas[6], Néstor Toledo[1,8] and Nahuel Muñoz[1,8]

1. División Paleontología Vertebrados, Museo de La Plata, Universidad Nacional de La Plata, Paseo del bosque s/n, B1900FWA La Plata, Argentina. vizcaino@fcnym.unlp.edu.ar

2. Department of Evolutionary Anthropology, Duke University, Box 90383, Durham, NC 27708, USA.

3. Paleontología de Vertebrados, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Ángel Gallardo 470, Ciudad Autónoma de Buenos Aires, C1405DJR, Argentina.

4. Departamento de Ciencias Básicas, Universidad Nacional de Luján, Ruta 5 y Avenida Constitución, 6700 Luján, Buenos Aires, Argentina.

5. CONICET-UNLP. Centro de Investigaciones Geológicas, Calle 1 N° 644, 1900 La Plata, Argentina.

6. IDEAN-CONICET. Departamento de Ciencias Geológicas, FCEyN, UBA, Ciudad Universitaria, Pabellón II, C1428EHA, Buenos Aires, Argentina.

7. Comisión de Investigaciones Científicas Buenos Aires (CIC), Argentina.

8. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.

The early Miocene deposits of the Santa Cruz Formation (SCF; Santacrucian Age), widely distributed in Southern Patagonia (Argentina), contain a rich assemblage of fossil mammals. The best-known fossiliferous exposures of SCF crop out along the Atlantic coastline of Santa Cruz Province, between Río Santa Cruz southward to Río Coyle and then to Río Gallegos. Localities south to Río Coyle haven been extensively studied in the last 20 years, but those to the north have received less attention. Isolated geological and paleontological studies for Cerro Observatorio and Monte León were performed in the 1990s, but a third major area, Rincón del Buque (= Media Luna), first reported in the 1920s has been neglected. This locality is of interest because it records the basal contact between the SCF and the underlying shallow marine Monte Léon Formation, a contact that is not exposed south to the Río Coyle, and because it is particularly rich in fossil vertebrates which are briefly mentioned in a short report in 1941. Since 2009, several field seasons to Rincón del Buque by the authors allow us to reconstruct the depositional paleoenvironments based on detailed stratigraphic profiles with sedimentological and ichnological data, and to make a large collection of vertebrates (~300 specimens). At Rincón del Buque there is a progradational succession, beginning with a marginal-marine-estuarine setting that transitions gradually to fluvial deposits. About 80% of the vertebrates were recovered *in situ* in two different tuff beds: a lower marine-bioturbated tuff immediately above the last oyster bed (the latter marking the top of the Monte León Formation), and a second tuffaceous bed at ~30 meters from the base deposited in a freshwater fluvial setting. The rest of the specimens come from surface collection at different levels. Specimens recorded belong to Calyptocephalellidae (Anura), Testudines, Phorusrhacidae (Aves), Paucituberculata and Sparassodonta (Marsupialia), Cingulata and Pilosa (Xenarthra), Toxodontia and Typotheria (Notoungulata), Litopterna, and Astrapotheria, Chinchilloidea, Cavioidea and Octodontoidea (Rodentia), and Primates. Most genera and/or species preliminarily identified have been previously recorded in the SCF, particularly in coastal localities south of Río Coyle. Rincón del Buque may hold the key to establishing details of faunal transitions in different areas where SCF crops out. On one hand connections are established between the lowermost levels north of Río Coyle and higher levels to the south, along the Atlantic coast, and on the other hand between the costal localities collectively and those of the Río Santa Cruz to the northwest.

THE FORE FOOT OF *COLBERTIA LUMBRERENSE* BOND (MAMMALIA: NOTOUNGULATA: OLDFIELDTHOMASIIDAE)

Lílian P. Bergqvist[1], Luiza B. Melki[1] and Jaime E. Powell[2]

1. Universidade Federal do Rio de Janeiro, Av. Athos da Silveira Ramos, Ilha do Fundão CEP 21.941-611, Rio de Janeiro, RJ, Brazil. luizamelki@gmail.com

2. Universidad Nacional de Tucumán, Ayacucho 491, San Miguel de Tucumán, Tucumán, Argentina.

Colbertia lumbrerense Bond comes from the Lumbrera Formation (lower Eocene) of Salta Province, Argentina. This species was proposed based sole on its skull and teeth morphology, although an almost complete postcranial skeleton was found associated. Until now, there is still little information about the postcranial elements, which were found articulated, except for the ribs and right fore and hind limbs that are almost completely absent. The material was prepared at Laboratório de Macrofósseis, Universidade Federal do Rio de Janeiro, Brazil. The fragility of the specimen prevented a more thoroughly preparation, and some bones were only visible with the help of tridimensional techniques. The left fore and hind limbs were analyzed under 1173 Skyscan micro-CT and the images were reconstructed using the software Avizo 7.0. The resulted 3D virtual models were used to complement the macroscopic description. The left hand bears four fingers (MC I is wanting), but only MC III is complete. MC II-III-IV are articulated in place, but MC V is displaced plantarly, behind MC IV. The proximal third of MC II-III are approximately of the same size, being MC III a little larger. The preserved proximal portions of MC IV-V suggest that these bones are of approximately the same size. Strangely, the trapezoid and the proximal series of carpal bones are displaced medially from its original location, whereas the other carpal bones are in place and articulated. The cuneiform is the largest bone of the proximal series and the lunar the smaller. Trapezoid is a flat bone, but differently from most typotheres, it is larger than scaphoid. Trapezium is broken, but the preserved part is tightly articulated to the very proximal portion of MC II. Magnum is a small bone, and bears no articulation with trapezoid, differing in this feature from all notoungulates in which the fore foot is preserved and described or figured. The unciform, also in place, is the larger bone of the distal series. It resembles that of *Protypotherium* and articulates with the same bones as this species. A large pisiform is present and displaced from its original position. A sole sesamoid is preserved, at the level of the proximal articulation of MC III. Only the proximal phalange of digit three is preserved in place and it is almost half size of MC III. Parts of other three phalanges are also preserved. The fore foot of *C. lumbrerense* resembles other Typotheria, being closer to Intherateriidae.

A NEW EXCEPTIONALLY PRESERVED UPPER JURASSIC ECOSYSTEM (OWADÓW-BRZEZINKI, CENTRAL POLAND)

Błażej Błażejowski[1] and Piotr Gieszcz[2]

1. Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warsaw, Poland.
bblazej@twarda.pan.pl

2. Association of Polish Climatologists,Faculty of Geography and Regional Studies,
Warsaw University, Krakowskie Przedmieście 30, 00-927 Warsaw, Poland.

Unusually well preserved fossils of latest Jurassic (middle Volgian) terrestrial and marine organisms have been recently discovered at the paleontological site of Owadów-Brzezinki Quarry, located about 19 km southeast of Tomaszów Mazowiecki (central Poland). The exposed carbonate sequence of the Sławno limestones belongs to the Kcynia Formation, and can be divided into four successive units. In general, units I, II and III probably represent a transition from an offshore to nearshore, perhaps lagoonal, setting, whereas unit IV bears evidence of a return to more open marine conditions. Below the Kcynia Formation, yellowish marls and marly clays of the Pałuki Formation occur. The lowermost part of the unit III is highly fossiliferous. Numerous specimens of horseshoe crabs (*Limulus* sp. nov. and *Crenatolimulus* sp. nov.) were found in association with an enormously rich assemblage of the soft shelled bivalve *Corbulomima obscura*, the remains of various fishes and marine reptiles, rare ammonites, decapod crustaceans, land insects (dragonflies, beetles, grasshoppers) and pterosaurs. The discovery of new, three-dimensionally preserved Late Jurassic horseshoe crabs adds significantly to our understanding of the group, the stratigraphic range of which spans almost the entire Phanerozoic. X-ray microcomputed tomography (XMT), a non-destructive technique, is used in order to elucidate details of internal structure of the specimens and provides data for further investigations. Three-dimensional reconstructions allow taxonomical verification; a possibility of 3-D printing gives the opportunity for work with a model in any desired scale, without a need of preparation, cutting, and without risk of damaging the specimen. The uniqueness of this new locality lies in its very close stratigraphical relationship to one of the famous Fossil-Lagerstätte localities in the world – Solnhofen and Nussplingen, in southern Germany, with approximately 5-7 Ma separating them. Marine and terrestrial creatures lived and died during the Late Jurassic at Solnhofen (lower Tithonian, *Hybonotum* Zone), Nussplingen (uppermost Kimmeridgian, *Beckeri* Zone) and in Owadów-Brzezinki (*Zarajskensis* Subzone of the *Scythicus* Zone), under closely related environmental conditions. Both marine and terrestrial organisms are very similar and allow comparative paleontological studies at a previously unattainable level of taxonomic resolution. Clearly, the Owadów-Brzezinki Quarry may be regarded as a new 'taphonomic window' into the living world of the latest Jurassic and it represents the first near-contemporary palaeontological 'supplement' to the previously known Fossil-Lagerstätten.

A NEW CORYSTOSPERM TRUNK WITH PRESERVED BARK FROM THE MIDDLE TRIASSIC OF SAN JUAN PROVINCE, WEST-CENTRAL ARGENTINA

Josefina Bodnar[1]

1. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) – División Paleobotánica, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, B1900FWA, Argentina.
jbodnar@fcnym.unlp.edu.ar

Anatomically preserved gymnosperm stems of the Middle Triassic Barreal Formation (Sorocayenese Group) at San Juan province, Argentina, are described and assigned to the seed fern family Corystospermaceae. The studied fossil axes were found in life position (vertical to stratification) in grey massive siltstones, altered by bioturbation and soil development, represented by roots, redoximorphic features, slicken-sides and rare nodules. These stems were preserved by siliceous cellular permineralization, and are characterized by a small pith, a secondary vascular system divided in wedges and a thick bark. The pith is 0.3 cm of diameter, eccentric and circular, with very poor cellular preservation. The secondary vascular system is irregularly fragmented by 0.2-0.4 cm wide parenchymatous rays, as result of differential cambial activity. Secondary xylem is pycnoxylic, and exhibits ring-like growth with a "latewood" band of 5 cells thick. Tracheids show uniseriate and biseriate bordered pits, with contiguous or compressed arrangement in opposite to sub-opposite pit rows. Cross-fields have one oval pit, simple or with a reduced border. Rays are homocellular; uniseriate and short (1-15 cells high). Bark is 2 cm thick, and contains distinctive clusters of sclereids. The presence of differential cambial activity, together with the pycnoxylic secondary xylem, allows the assignment of these axes to the Corystospermaceae. Within the family, the studied stems are superficially similar to the genus *Tranquiloxylon* owing to the dissected secondary vascular system, the absence of centripetal xylem, and the cross-fields with one pit. However, the specimens from the Barreal Formation differ from *Tranquiloxylon* because the former shows a very irregular fragmentation of vascular system and lack polyxyly. As a consequence, it is preferred not to assign the new material to any previously described genus. It is important to point out that it is the first description of permineralized trunks from the Barreal Formation, and it is one of the few references to preserved bark in Triassic permineralized trunks. Therefore, this contribution will improve the knowledge about the Corystospermaceae in the Middle Triassic of Gondwana.

UNTOLD MUDDY STORIES: THE ECOLOGICAL DYNAMICS OF AN OXYGEN-DEFICIENT FACIES WITHIN A SHALLOW, ISOLATED PERMIAN EPEIRIC SEA (PARANÁ BASIN, BRAZIL)

João G. Bondioli[1], Suzana A. Matos[1], Lucas V. Warren[2], Mario L. Assine[2], Claudio Riccomini[1] and Marcello G. Simões[3]

1. Instituto de Geociências - Universidade de São Paulo (USP), Rua do Lago, 562, Cidade Universitária-SP, 05508-080, Brazil. joao_bondioli@hotmail.com

2. Instituto de Geociências e Ciências Exatas - Universidade Estadual Paulista (UNESP), Avenida 24A, 1515, Rio Claro-SP, 13506-900, Brazil.

3. Instituto de Biociências - Universidade Estadual Paulista (UNESP), Rubião Júnior, s/n, Botucatu-SP, 18618-970, Brazil.

Oxygen-deficient facies dominate the sedimentary record of several epeiric seas and are common in the transgressive systems tracts of several Paleozoic, Mesozoic and younger age intracratonic sedimentary sequences. They are mainly materialized by monotonous, fossil-poor (barren) successions of black shales and/or massive or well-laminated mudstones deposited under conditions of oxygen depletion. During the late Paleozoic, the intracratonic Paraná Basin, located in central Gondwanaland, was covered by a huge (>1.600.000 km^2), shallow and isolated epeiric sea. Oxygen-deficient facies are commonly recorded in the *Mesosaurus*-bearing Irati Formation (Artinskian) and the barren, dark-grey mudstones of the Serra Alta Formation (Kungurian). Despite the low fossiliferal potential, a detailed sedimentological (sub-cm scale), ichnological, and taphonomical analysis in those deposits indicate a more dynamic and complex paleonvironmental scenario than presented in previous studies. Based on textural features (presence/absence of primary sedimentary structures and bioturbation), autochthonous to parautochthonous occurrences of shelly benthic invertebrates (bivalves) and the presence/ absence of concretion-dominated horizons and phosphate-rich layers, we report significant variations in the oxygen content, bathymetry, sedimentation rates, and changes in benthic substrate colonization. Our study indicates that the deposition of this “barren” mudstone-dominated succession was governed by a complex interplay of paleoenvironmental factors (variations in sedimentation rate and oxygen pulses) tied to high frequency changes in the relative sea level. Three distinct populations or paleocommunities were recorded, including resident adapted to: (a) background normal low-oxygen (dysaerobic) conditions (minute infaunal suspension-feeding bivalves and *Planolites*), (b) co-existing chemosymbiontic taxa (*e.g.*, giant bivalves) inhabiting chemically toxic substrates (exaerobic) substrates, and (c) opportunist populations inhabiting (aerobic/dysaerobic) substrates after punctual seafloor oxygenation events (*e.g.*, *Planolites* and *Thalassionoides*). These findings have significant implications for the understanding of the paleoenvironmental conditions and paleoecologic dynamics of the shelly benthic faunas during the most important transgressive event in the upper Permian of the Paraná Basin. Moreover, reveals that extremely isolated and shallow epeiric seas successions where oxygen-deficient facies are abundant, are, in fact, more complex and interesting than previously thought.

FOSSIL-BEARING CARBONATIC CONCRETIONS OF THE PERMIAN SERRA ALTA FORMATION, PARANÁ BASIN, BRAZIL, AND THE "PARADOX" OF CONCRETIONARY OBRUTION BEDS

João G. Bondioli[1], Suzana A. Matos[1], Lucas V. Warren[2], Mario L. Assine[2], Claudio Riccomini[1] and Marcello G. Simões[3]

1. Instituto de Geociências – Universidade de São Paulo (USP), Rua do Lago, 562, Cidade Universitária-SP, 05508-080, Brazil. joao_bondioli@hotmail.com

2. Instituto de Geociências e Ciências Exatas – Universidade Estadual Paulista (UNESP), Avenida 24A, 1515, Rio Claro-SP, 13506-900, Brazil.

3. Instituto de Biociências – Universidade Estadual Paulista (UNESP), Rubião Júnior, s/n, Botucatu-SP, 18618-970, Brazil.

The Permian Serra Alta Formation was mainly generated under transgressive conditions within a huge intracratonic basin. A monotonous succession of massive greenish-gray colored mudstones, mainly deposited under oxygen-deficient conditions (below storm wave base) is the main lithofacies of this unit. Fossils are generally rare in those barren offshore deposits, but certain layers may record extraordinarily well preserved bivalve shells in the nuclei of carbonate concretions. The valves (mainly preserved as recrystallized calcite shells) are mostly closed articulated indicating abrupt burial and *in situ* preservation of the shelly fauna. Moderate bioturbation is also recorded in association with the base and top of the concretions, suggesting strong intrastratal biological activity prior the early diagenesis. Thus, the episodic deposition of the offshore muds, which smothered the bivalve shells, was followed by periods of low sedimentation rates, when infaunal colonization of seafloor took place. Hence, each concretion-bearing bed is actually an individual obrution deposit (*i.e.*, a record of episodic deposition of fine-grained sediments followed by a period of non-deposition or starvation prior to sediment cementation). In this way, our case study full fills the main prerequisites of the recently proposed "paradox of rhythmic event beds" by Brett *et al.*, which preconizes "the superimposition of deposits generated by abrupt, episodic sedimentation followed by prolonged periods of sediment starvation and subsequent early diagenetic carbonatic cementation, which enhances fossil preservation". Finally, the concretion-bearing beds are not randomly distributed in the studied sedimentary succession of the Serra Alta Formation. Rather, they are recorded only in the sparsely fossiliferous offshore deposits of the basal to intermediate portions of the unit, always associated with characteristic bivalve species of the *Barbosaia angulata*-*Anhembia froesi* association biozone, which thrived in dysaerobic, muddy bottoms. In other words, the concretionary beds are preserved in particular intervals along the unit tied to oxygen-deficient offshore conditions. Locally, the concretion-bearing beds can be laterally tracked by tens of kilometers and may be used as a tool in facies analysis and stratigraphic correlation.

SHELL BEDS FROM THE BARDAS BLANCAS FORMATION (LOWER TOARCIAN-LOWER BAJOCIAN), NEUQUÉN BASIN, ARGENTINA

Graciela S. Bressan[1]

1. Instituto de Estudios Andinos Don Pablo Groeber (IDEAN, UBA-CONICET), Intendente Güiraldes 2160 CABA, C1428EGA, Argentina. gbressan@gl.fcen.uba.ar

The Bardas Blancas Formation (lower Toarcian-lower Bajocian) crops out in northern Neuquén Basin (Argentina). This unit is composed mostly by thick packages of hummocky cross-stratified, analaminated and massive sandstones and laminated mudstones interpreted as shoreface/delta front to offshore deposits settled in a storm dominated siliciclastic platform. Shell beds and trace fossils are common in sandstone beds. This work makes reference to these shell beds, which have been studied in five localities considering stratigraphic, sedimentologic, taphonomic and paleoecologic data. In general, these shell beds are dominated by disarticulated bivalve shells, fragmentation is variable and valves are highly altered by neomorphism (recrystallization and inversion) and dissolution making difficult its determination and the recognition of the processes that affected the specimens during their pre-depositional history (biostratinomic processes). Nevertheless, good stratigraphic and sedimentologic data allowed recognizing shell beds produced mostly by storm processes, including proximal and distal tempestites and storm wave deposits, settled above storm wave base (foreshore, shoreface and transition zone). Alternatively, some sections of the Bardas Blancas Formation have been interpreted as flood-dominated deltas based on sedimentologic features. This interpretation seems acceptable for the lower half of the Arroyo Loncoche section (the northernmost section) where shell beds are extremely scarce, developed as well-preserved very thin concentrations overlaid by thick sandstone beds. Whereas in other sections, shell beds are highly reworked and exhibit evidence of long periods of permanence in the water-substrate interface, associated with lower sedimentation rates and intense reworking related with storm events. These reworked sections exhibit fully marine conditions, including the presence of crinoid ossicles and brachiopods, not recognized in the Arroyo Loncoche section. It seems useful to use a taphonomic analysis of shell beds and their distribution as a tool to identify the processes involved in the sedimentation in different sections of this unit. A second application, related to their utility in the recognition of sequence stratigraphic significant surfaces, is not relevant in the Bardas Blancas Formation. The abundance of event and multievent beds associated with the base of the transgressive tracts and to the top of the regressive tracts satisfies the expectations, but the poor preservation of the shells prevents the distinction of lag and hiatal beds from event and multievent beds and thus precludes a sequence stratigraphic analysis. [Contribution C-84 of the IDEAN].

TOOTH FUNCTION IN WOMBATS. INSIGHTS FROM NEW TAXA FROM THE RIVERSLEIGH WORLD HERITAGE FOSSIL SITE IN NORTHWESTERN QUEENSLAND

Philippa Brewer[1]

1. Department of Earth Sciences, Natural History Museum, Cromwell Road, London SW7 5BD, United Kingdom.
p.brewer@nhm.ac.uk

The Vombatidae are an endemic Australian family of marsupials containing the three extant species of wombat. All three species are adapted to a grazing lifestyle and are the largest burrowing grazers in the world. These adaptations are of particular interest when examining marsupial responses to climate change from the Oligocene to present day, not least because early wombat taxa are known from rainforest deposits. In order to understand how, and why, a family notable for their grazing adaptations were living in a rainforest environment, a functional investigation of the cheek teeth of these early representatives with reference to their phylogenetic position is required. To accomplish this, a number of issues first need to be resolved. Despite an estimated divergence of 40 Ma between wombats and their closest living relative, the koala, the fossil record of wombats is very poor. A single species, *Rhizophascolonus crowcrofti*, has been described from deposits older than 10 Ma and is represented by a handful of isolated teeth. Evolutionary relationships between wombat taxa are obscured by the fact that cusp detail on the cheek teeth of wombats is present only in pouch young. In addition, the evolutionary relationships between wombats and other closely related families in the suborder Vombatiformes (including, for example, marsupial lions) is complicated by the fact that each of these families is highly autapomorphic. This, combined with the lack of suitable outgroups, results in a poor understanding of homologies. In an attempt to tackle some of these issues, a comparative study of the cheek tooth cusps on pouch young wombats was undertaken along with the description of two new species of late Oligocene to middle Miocene wombats from the Riversleigh World Heritage Site in northwestern Queensland, Australia. A phylogenetic analysis of the Vombatiformes was performed using dental, cranial and postcranial characters. The preliminary results from an investigation of the ultrastructure of the teeth of the oldest known wombat, *Rhizophascolonus crowcrofti*, are also presented here. As a result of these investigations, it is possible to present a viable hypothesis regarding the functional evolution of wombat teeth from a Miocene rainforest environment, to the arid habitat of the extant hairy nosed wombat.

THE CEDARBERG FORMATION - A BRIEF REVIEW

Claire Browning[1]

1. Council for Geoscience, 3 Oos Street, Bellville/Cape Town, 7535, South Africa.
browning.claire@gmail.com

The Hirnantian-aged Cedarberg Formation forms part of the Table Mountain Group within the Cape Supergroup, South Africa. It overlies the glacial deposits of the Pakhuis Formation and consists of two members; Soom and Disa. The former is composed mostly of black shales and finely laminated siltstones and the latter is coarser grained comprising fine to medium-grained micaceous sand and siltstones. These members form an upward coarsening transgressive cycle of sedimentation in a glaciolacustrine to shallow marine setting and are overlain by the dominantly fluvial sandstones of the Goudini Formation. The Soom Shale is particularly significant as it represents the only Ordovician Gondwanan Konservat-Lagerstätte as well as rarely preserved high latitude faunas. Historically, studies were focussed largely on the taphonomy and palaeontology of the Soom Member with key localities, such as Keurbos Farm in the Clanwilliam area, yielding exceptionally well preserved (soft-bodied) fossils most notably including conodonts as well as orthoconic cephalopods, naraoiid trilobites, eurypterids, brachiopods, chitinozoa and a few enigmatic taxa. Detailed sedimentology of the Soom Member in recent years has revealed uncharacteristically coarse sand laminae (associated with plankton-derived organics) within the dark mudrocks. These laminae have been interpreted as glacially derived loess having been blown either across seasonal sea ice or directly into the sea. A 40 m stratigraphic borehole through the Cedarberg and Pakhuis Formations was recently drilled at the farm Holfontein ~25 km south of Clanwilliam to extract material for detailed systematic analysis. The main aim is to use grain-size analysis to determine if wind-blown dust fertilized the growth of algae. The Soom Shale can potentially provide significant insights into the precise course of climate change as major ice-sheets retreat – and a greatly improved understanding of the climate dynamics of early Palaeozoic icehouse climates. Recent drilling at a number of localities including Clanwilliam, Somerset West and Oudtshoorn means that additional fresh diamond drill core intersecting the Cedarberg and underlying Pakhuis Formations is now available for study. A proposal to utilise this new data in a detailed sedimentology and basin evolution study is also being investigated.

HIGH-THROUGHPUT ANALYSES OF VERTEBRATE FAUNAL REMAINS USING COLLAGEN PEPTIDE MASS FINGERPRINTING – SPECIES IDENTIFICATION AND DECAY MEASUREMENT AT LOW COST

Michael Buckley[1]

1. University of Manchester, Manchester Institute of Biotechnology, 131 Princess Street, Faculty of Life Sciences, Greater Manchester, M1 7DN, UK. m.buckley@manchester.ac.uk.

With improved recovery methods, thousands of microfaunal remains are frequently being acquired from many palaeontological sites across the globe. However, with limited access to specialist expertise in morphological identification, large numbers of faunal remains are stored for decades in some cases, awaiting analysis. We have recently developed an objective method of species identification using collagen fingerprinting that can often be carried out with minimal alteration to morphology (i.e., non-destructively). In this study we carry out the first large-scale (>10,000 specimens) analysis of a Pleistocene assemblage from Pin Hole Cave (UK). Pin Hole Cave is a narrow fissure in the Magnesian limestone bedrock at Creswell Crags and one of the most important sites for studies into the early modern human occupation of Britain. The faunal remains include small mammals, bird bones, eggshell, fish bones and scales. However, only a very small proportion of these (<1%) could be identified to genus or species using morphology alone. This study attempts to identify the species of a large number of these spatially-mapped fragments using collagen fingerprinting to further investigate the changing cave deposit accumulations over 50 Ka in the presence of humans and the palaeoenvironmental inferences that can be made. This project also highlights significant improvements that could be made to the storage and handling of large numbers of microfaunal remains for future study.

FIRST REPORT OF THE PENNSYLVANIAN CRUSTACEAN *PLEUROCARIS* COLMAN (MALACOSTRACA-SYNCARIDA) FROM REBEICO-SOYOPA DISTRICT, SONORA, MEXICO

Blanca E. Buitrón[1], Ariel G. Navarro[2], Luigi Radelli[2] and Catalina Gómez-Espinosa[3]

1. Instituto de Geología, Universidad Nacional Autónoma de Mexico, Mexico D.F., 04510, Mexico. blancab@unam.mx

2. Departamento de Geología, Universidad de Sonora, Hermosillo, Sonora, 83000, Mexico.

3. Facultad de Ciencias Universidad Nacional Autónoma de Mexico, Mexico D.F., 04510, Mexico.

The marine Paleozoic outcrops in Mexico are scarce, relative to their territorial extent because the region experienced deformation caused by complex plate interactions; additionally Paleozoic rocks are commonly covered by thick sequences of Mesozoic and Cenozoic sediments and Cenozoic volcanic rocks. Nevertheless, many outcrops of upper Paleozoic rocks contain abundant invertebrates. A new record of a crustacean is added to the Pennsylvanian Sonora fauna while it is the first record of *Pleurocaris* in Mexico; in North America is the second record from this genus that was reported for the first time from the Pennsylvanian of Illinois, USA. Previously, *Pleurocaris* has been considered to have an exclusive European (England and ?France) distribution. Samples from this study were collected in outcrops that occur in a small creek in the vicinity of the Tepehuaje Mine, located at 28°48′15″N and 109°37′22″E, near the mineralized Soyopa Nappe, approximately 4 km west of the Yaqui river of the Rebeico-Soyopa district from central Sonora in northwestern Mexico. The fossiliferous outcrop consists of calcareous beds with intercalated cherty clasts, that appear in a very small (some 15-20 m long and 3-4 m wide) tectonic Paleozoic window under the Soyopa Nappe, which contains shale, marl and limestone. Pleurocarid samples were analyzed with a scanner to obtain a 3D image using the Power Shape version 211R3 software; images were impressed in photopolymers (fullCURE7B, ABS30, vero white). This is the first tridimensional image of a pleurocarid to obtain a more complete description of the morphology. Comparing the Pennsylvanian distribution of *Pleurocaris*, we conclude that there were connections between seas of western North America and Europe. The benthic Carboniferous Sonoran fauna was widely dispersed in the Tethyan Realm from western North America (USA, Illinois) and Mexico (Sonora) to England, Belgium, France, and Germany. The crustacean *Pleurocaris* suggests that the deposits occurred in a carbonate platform of tropical shallow seas. [Financed by projects CONACyT-165826, PAPIIT-105012 and ECOS-ANUIES-CONACyT M13-U01].

MIOCENE BALAENIDS (CETACEA: MYSTICETI: BALAENIDAE) FROM PATAGONIA (ARGENTINA) AND THEIR IMPLICATION FOR EARLY EVOLUTION OF RIGHT WHALES

Mónica R. Buono[1], Marta S. Fernández[2] and Mario A. Cozzuol[3]

1. Centro Nacional Patagónico (CENPAT-CONICET), Boulevard Brown 2915, Puerto Madryn, 9120, Chubut, Argentina. buono@cenpat.edu.ar

2. Museo de La Plata (CONICET), Paseo del bosque s/n, La Plata, 1900, Buenos Aires, Argentina.

3. Universidade Federal de Minas Gerais, Avenida Antônio Carlos 6627, Pampulha 31270-910, Belo Horizonte, Minas Gerais, Brazil.

Balaenids or right whales are large and skim feeding baleen whales represented by four living species. They have been considered a key group in the understanding of Mysticeti evolution because some phylogenetic studies considered it as the most basal surviving family of Mysticeti. Balaenid fossil record is temporally long (early Miocene-Present) but it is characterized by large stratigraphic gaps. In particular, the Miocene record is extremely rare and it is restricted to Argentinean Patagonia, with *Morenocetus parvus*, the oldest known balaenid (Gaiman Formation, early Miocene, Chubut). *Morenocetus* was named on the basis of two incomplete skulls and was not re-examined after its original description. It is a critical taxon not only to assist in resolving the balaenid phylogenetic relationships but also for its potential to help resolve higher mysticete relationships. In addition new balaenid specimens, belonging to a new genus and species, were collected from Puerto Madryn Formation (early late Miocene, Chubut). The importance of *Morenocetus* and the other taxon from Puerto Madryn Formation makes necessary a detailed study of the Miocene balaenids from Patagonia. The results of anatomic studies showed that *Morenocetus* is a valid taxon and it is represented by two subadult specimens. Besides, the three balaenid specimens from Puerto Madryn Formation include an adult, a subadult and a young which corresponds to a new genus and species (=Taxon A). A heuristic parsimony analysis of 30 species and 168 morphological characters was conducted using traditional search under equal and implied weight. Both analyses resulted in five most parsimonious trees. The strict consensus tree, both under equal and implied weight, shows balaenids forming a well supported group and sister to the clade of Balaenopteroidea and Cetotheriidae. Miocene balaenids (*Morenocetus* and Taxon A) form a basal clade within Balaenidae, with a well branch support and without unstable taxa. Stratigraphic calibration of cladogram showed an extensive ghost lineage among Miocene balaenids and more derived taxa (*Balaenella*, *Balaenula*, *Balaena* and *Eubalaena*). The extension of this ghost lineage (~15 Ma) is from late early Miocene (Burdigaliense) to early Pliocene (Zancliense). In addition, there is a large temporal gap in the fossil record of balaenids which covers more than half of their evolutionary history. The recovery of taxon A from Puerto Madryn Formation interrupts the temporal gap between *Morenocetus* and more derived balaenids, but it does not reduce the ghost lineage mentioned above.

A CALIBRATION OF PALYNOLOGICAL EVENTS IN THE MIDDLE JURASSIC BRENT GROUP WITH THE RAVENSCAR GROUP, ENGLAND

Nicholas Butler[1]

1. PetroStrat Ltd. Parc Caer Seion, Conwy, LL32 8FA, UK.
nick.butler@petrostrat.com

A calibration of palynological events in the Middle Jurassic (Aalenian to Bajocian) aged Brent Group (Northern North Sea) with an onshore, macrofossil constrained analogue, the Ravenscar Group (Cleveland Basin, Yorkshire, England) is reasonably well documented. However these findings, which were largely based on a major study commissioned by Statoil, have not previously been substantiated by any raw data. This study presents the quantitative raw data as distribution charts in Stratabugs TM format which demonstrate the robustness and stratigraphic utility of the events. Additionally, illustrations of significant, age diagnostic taxa (including *Dissiliodinium* sp. cf. *D. willei*, *Phallocysta thomasii*, *Luehndea spinosa*, *Nannoceratopsis gracilis* and *Classopollis* spp.) will also be presented.

GIS DATABASE FOR THE QUEGUAY LIMESTONES (LATE CRETACEOUS/ EARLY PALEOGENE) OF URUGUAY: AN INTERDISCIPLINARY VIEW

Fernanda Cabrera[1], Nicolás Batalla[2] and Richard Detomasi[2]

1. Departamento de Evolución de Cuencas, Facultad de Ciencias, Universidad de la República. Iguá 4225. C.P. 11400. Uruguay. fcabrera@fcien.edu.uy

2. Departamento de Arqueología, Facultad de Humanidades y Ciencias de la Educación, Universidad de la República. Magallanes 1577. C.P. 11200. Uruguay.

The Queguay limestones or Queguay Formation are a group of calcretes and silcretes, referred to the Late Cretaceous/early Paleogene. These rocks have been considered as facies of three lithostratigraphic units: Mercedes Formation (Late Cretaceous), Asencio Formation (Late Cretaceous), and Queguay Formation (early Paleogene). This tripartite scheme is in discussion nowadays and most authors, by considering these facies genetically related, referred them to the Queguay limestones or Queguey Formation. The Queguay limestones have economic importance because they are exploited as raw material for the elaboration of cement. These horizons are also relevant for both paleontological and archeological research by the presence of environmentally significant continental gastropods, and silica lens employed by past aboriginal groups to produce stone tools. However, considering that the Queguay limestones are mapped as facies of other formations, they are difficult to identify in Uruguayan geological charts. An interdisciplinary project, involving paleontologists and archeologists, with the aim to generate a Geographic Information System (GIS) of these limestones is currently underway. The obtention of data followed two succesive steps: i) random selection of five areas of 16 km^2 in the zone with outcrops of the Asencio and Mercedes formations; and ii) recopilation of information from those areas already known to contain limestones. The result of our research was that the presence of the Queguay limestones was confirmed in the five prospected areas. In each location we mainly checked: a) presence or absence of fossils, their abundance and richness; b) presence or absence of silica lens, and their quality to produce stone tools; c) areal distribution and thickness of the limestone outcrop. This information was digitalized into a GIS program to generate the database. These data will allow further estimation of potential areas containing the Queguay limestones.

MORPHOMETRY OF LATE CRETACEOUS – EARLY PALEOGENE BULIMULIDAE (GASTROPODA, ORTHALICOIDEA) IN THE QUEGUAY FORMATION, URUGUAY

Fernanda Cabrera[1] and Sergio Martínez[1]

[1]Departamento de Evolución de Cuencas, Facultad de Ciencias, Universidad de la República, Iguá 4225, C.P. 11400. Uruguay. fcabrera@fcien.edu.uy

The Queguay Formation is a fossiliferous unit composed by calcretes and in lesser extent silcretes. It is distributed along the littoral of the Uruguay River (North Basin) and in the Santa Lucía Basin in southern Uruguay. The first area yields the *Biomphalaria walteri* association, composed by freshwater gastropods (*Biomphalaria walteri*, *Biomphalaria* spp., *Physa* sp.), terrestrial gastropods (*Bulimulus klappenbachi*, *Bulimulus* spp., *Bahiensis priscus*, *Eoborus charruanus*, *Succinea* sp., Pupillidae indet.), other freshwater fossils (characean oogons, ostracods) and other terrestrial fossils (Hymenoptera nests and Coleoptera pupal chambers, *Celtis* sp. endocarps, rizoliths). In the south the *Eoborus charruanus* association is composed mostly by terrestrial gastropods (*Eoborus charruanus*, Clausiliidae indet., Pupillidae indet.). There are Coleoptera pupal chambers and Hymenoptera nests, *Celtis* sp. endocarps and rizoliths too. The bulimulids (Orthalicoidea) are represented in the Queguay Formation by *Bulimulus klappenbachi* (Parodiz) and two morphotypes (*Bulimulus* sp. A and B. sp. B). The aim of this study was to know if the two morphotypes are variants of *B. klappenbachi* or new species. The three morphs were compared with representatives of a modern species (*Bulimulus sporadicus*). All the species were photographed and the images digitalized using tps DIG 2 V2.17 Landmarks type 1, type 2 and type 3 and semilandmarks of all the specimens were taken. One way – ANOVA and Principal Components Analysis (PCA) were done using the program PAST 2.15. The three morphotypes present different characteristics. *B. klappenbachi* has a thin and elongated shell, the spiral has all the time the same growth rate and in consequence the spire whorls are proportional to each other; whorls are slightly convex, with notorious sutures. *Bulimulus* sp. A has a thin and elongated shell, slightly larger than *B. klappenbachi*, the penultimate whorl is rather larger than the rest, with a non-proportional growth of the spire, all whorls are convex, and the sutures are notorious. *Bulimulus* sp. B has a slightly oblong shell, slightly smaller than *B. klappenbachi*, with short spire, whorls slightly convex and almost straight and sutures barely visible.

FUNCTIONAL MORPHOLOGY ON MICROFOSSILS: AN INCREASING SUBJECT OF STUDY IN ARGENTINA

Lydia Calvo-Marcilese[1,3], Juan P. Pérez Panera[2,3], Gabriela C. Cusminsky[1], Emiliana Bernasconi[1], Laura Ferrero[4], Melina Márquez[4], Lorena Ramos[1], Corina Coviaga[1] and Patricia Pérez[1]

1. Centro Regional Universitario Bariloche, Universidad Nacional del Comahue, INIBIOMA-CONICET, Quintral 1250, Bariloche, 8400, Río Negro, Argentina. lydiacalvom@gmail.com

2. CONICET-División Paleontología Invertebrados-Museo de La Plata, Paseo del Bosque s/n, La Plata, 1900, Buenos Aires, Argentina.

3. Laboratorio de Bioestratigrafía, Área de Geociencias, YPF Tecnología S.A. Baradero s/n, 1925, Ensenada, Buenos Aires, Argentina.

4. Instituto de geología de costas y del Cuaternario UNMDP, IIMyC-CONICET, Funes 3350, CP 7600, Mar del Plata, Argentina.

The major purpose of this contribution is to discuss the functional morphology of diverse forms of calcareous microfossils. For decades one of the principal difficulties of comparative biology has been determining the function of a particular anatomical form. Shapes and forms are strongly correlated with life habit and function. So, the clue is to identify what is the adaptive advantage, if any, for selected variable morphological characters, and to use that information for paleobiological interpretations. Traditionally, micropaleontology and paleobiology have been in opposite sides, since microfossils are abundant in almost all types of sediments and are produced by species that evolve rapidly, their principal use has been in bioestratigraphy or connected to marine geology, with limited interest in paleobiological aspects. Many marine microorganisms are hard to be cultured in the laboratory, so the study of its biology is not easy. Despite this tradition, micropaleontologists have become increasingly interested in the paleobiology of their fossils. Nowadays, it is possible to find many studies related to the use of the substrate, diet, trophic webs and shell morphology in microfossils; for example, leg morphology in ostracoda and its relation to the type of sediment and way of locomotion; and carapace shape in ostracods related to reproduction patterns and environmental energy. Concerning another conspicuous group of microorganisms as foraminifera, the complex architecture of the shells is very useful to identify habits, habitats, a wide range of diets, and the recognition of analogous features permitting the search for the possible meaning of the functional element. Other calcareous microfossil groups yield not so evident morphology-function relation, but it seems difficult to assume that there is no adaptive advantage in the shape/ morphology of their hard parts. Coccoliths are a very good example of this case. The study of their functional morphology gave rise to a series of explanations and purposes that are conceptually reasonable, but have relatively low applicability and are extremely difficult to prove. Yet, it seems pointless that the highly variable, complex and energy-demanding coccosphaera has no function for the individual. A new perspective looking for new insights and possible pathways for micropaleontology, out of its applied framework has started. In Argentina first efforts culturing fresh water ostracods along with the study of modern analogs as useful tools for understanding the past has begun during the last decade and requires increased attention.

ENVIRONMENTAL SIGNIFICANCE OF MICROFAUNAL ASSOCIATIONS IN THE PAMPEAN REGION, BUENOS AIRES, ARGENTINA

Lydia Calvo-Marcilese[1,3], Elisa Beilinson[2], María S. Raigemborn[2], Gabriela C. Cusminsky[1] and David Piazza[4]

1. Centro Regional Universitario Bariloche, Universidad Nacional del Comahue, INIBIOMA-CONICET, Quintral 1250, Bariloche, CP 8400, Río Negro, Argentina. lydiacalvom@gmail.com

2. Centro de Investigaciones Geológicas (CONICET – UNLP), 1 #644, La Plata, B1900TAC, Argentina.

3. Laboratorio de Bioestratigrafía, Área de Geociencias, YPF Tecnología S.A., Baradero s/n, CP 1925, Ensenada, Buenos Aires, Argentina.

4. Dirección de Paleontología, Secretaría de Desarrollo Humano, Municipalidad de Marcos Paz (Buenos Aires), Argentina.

The Cantera Vignogna is a quarry located in the NE of Buenos Aires province and since the last decade vertebrate fossils have been recovered from this location, establishing an exceptional record of megafauna with a remarkable degree of preservation. Within this area, four particular sections were studied for sedimentological and facies analysis, with the aim of establishing paleonvironmental conditions during the late Pleistocene. The succession starts with laminated mudstones and siltstones interpreted as paludal or as marsh deposits with tidal influence, and it culminates with sandstones and silty sandstones related to fluvial channels and floodplain deposits. It is believed that accumulation of the lower units took place during highstand or transgressive base-level (or sea-level) conditions of the Marine Isotope Stage 3 (MIS 3) and that the upper units correspond to regressive fluvio-alluvial deposits. For the first time in this zone, calcareous microfossils (ostracods) have been collected in order to be used as proxy for paleoenvironmental reconstructions. In three of the four analyzed sections, a conspicuous association of freshwater to brackish ostracods has been registered. Even though the diversity and abundance is low, and some specimens presented signs of transport and reworking, various valves and carapaces were recovered. The ostracods assemblage is dominated by *Candona* sp., *Cyprideis multidentata* Hartmann, *Cyprideis salebrosa hartmanni* Ramírez and *Limnocythere* sp. This assemblage is common in continental to brackish environments, from truly freshwater to saline, with the presence of pools and ponds where salinity could be higher than in the surrounding areas. These preliminary data along with additional information in process, will be significant to characterize the climate variability occurred during the MIS 3 in South America.

EXTRA-MALVINOKAFFRIC FOSSIL BRACHIOPODS FROM ALTO GARÇAS SUB-BASIN (DEVONIAN, PARANÁ BASIN)

Fábio A. Carbonaro[1] and Renato Pirani Ghilardi[2]

1. Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto (FFCLRP), Universidade de São Paulo (USP), Av. Bandeirantes, 3900, CEP 14040-901, Bairro Monte Alegre, Ribeirão Preto, SP, Brazil.
fabiocarbonaro@yahoo.com.br

2. Departamento de Ciências Biológicas, Faculdade de Ciências, Universidade Estadual Paulista (UNESP), Campus de Bauru, Av. Engenheiro Luiz Edmundo Carrijo Coube, 14-01, CEP 17033-360 - Bairro Vargem Limpa, Bauru, SP, Brazil.

The Devonian of Paraná Basin consists in two crono-correlated sub-basins, the Alto Garças in the north and Apucarana in the south, which were separated by the Três Lagoas and Campo Grande highs. The depositional environment of Alto Garças sub-basin is represented by the Chapada Group, which was shallower than its temporal marine southern correspondent; this explains the prevalence of sandy facies. However, the fossil invertebrates were deposited in finer grained beds, which are corresponding with the Unit 4 of the Chapada Group that was deposited during the marine transgression of the Givetian. Nevertheless, none of the preserved specimens of this unit belong to the endemic fauna of the Malvinokaffric Realm like the brachiopods of the genus *Tropidoleptus* and *Pustulatia* registered in the literature, found around the county of Chapada dos Guimarães, Mato Grosso State, Brazil. Here we present cf. *Strophodonta*? sp. that was found around the Caiapônia city, in Goiás State, Brazil. This specimen is exogenous of the Malvinokaffric Realm. All of these extra-malvinokaffric specimens probably migrated from Parnaíba and Amazonas basins to the northeastern border of the Paraná Basin through marine connections related to the transgression previously cited. Near the bed where cf. *Strophodonta*? sp. was found, it was also observed the presence of dark shales probably related to a global extinction event named KAČÁK, which caused big alterations on the fauna of the Malvinokaffric Realm. Finally, more studies are necessary to improve the comprehension of the dispersion routes of brachiopods between the three main brazilian paleozoic basins. Hereafter, more fieldworks will be done in Mato Grosso and Goiás States with the aim to elucidate the events related to the introduction of invasive species in areas of occurrence of the Malvinokaffric Realm in the Devonian of the Paraná Basin. This study is important because it has been 25 years since the last published paper dealing with macroinvertebrates of Alto Garças sub-basin and marks a resumption of the works in this area. [Contribution to the FAPESP 2013/09683-3].

OPERATIONAL FORAMINIFERAL BIOSTRATIGRAPHY OF THE CATATUMBO BASIN, COLOMBIA

Claudia P. Cardenas[1], Gustavo A. Torres[1], German D. Patarroyo[2] and Daniel A. Rincon[3]

1. Corporación NATFRAC, Bucaramanga, Colombia.
claudiap.cardenasg@gmail.com
2. CGA ltda., Bucaramanga, Colombia.
3. ECOPETROL S.A. Instituto Colombiano del Petróleo, Piedecuesta-Santander, Colombia.

In recent years, several biostratigraphic studies have been carried out in outcrops and exploratory wells of the Catatumbo basin, northeastern Colombia, to characterize the Cretaceous succession and its major reservoir, the late Albian Aguardiente Formation. These studies have made possible to recognize several biostratigraphic events, such as first/last appearances and acme events of planktonic and benthic foraminifera. However, these events have proven to be variable between sections hampering a proper biostratigraphic control in drilling activities. Therefore, an operative biostratigraphic scheme was developed for the Cretaceous succession in the Catatumbo basin. In this scheme, zones have wider biostratigraphic ranges and are easier to identify during the drilling activities. Four zones of foraminiferal assemblages, recognized from top to base, in the Mito-Juan, Colon, La Luna, and the upper part of the Aguardiente formations, were established. On the top of the stratigraphic succession was identified the zone *Guembelitria cretacea-Discamminoides*, defined by the last occurrence (first downhole occurrence) of *G. cretacea* at the top, and the first downhole occurrence of *Pyramidina* spp. and *Siphogenerinoides bramlettei* at the base. The second zone, called *Bulimina petroleana-Haplophragmoides* sp. 2, was defined at the base by the last common occurrence in the drilling direction of *B. petroleana* and *Haplophragmoides* sp. 2. The following zone, called *Whiteinella-Heterohelix*, is delimitated at the base by the abundance (acme event) of specimens of the superfamily Rotaliporacea and *Hedbergella* spp. The base of the last zone (*Hedbergella*-Rotaliporacea) could not be determined due to lithologic variations in the upper Aguardiente Formation. This operative biostratigraphic scheme for the Cretaceous succession has been recently used in exploratory wells in the basin with promissory results.

PLANT-INSECT INTERACTION ON A *GLOSSOPTERIS* LEAF FROM THE PERMIAN OF PATAGONIA: EARLIEST EVIDENCE OF LEAF MINING?

Bárbara Cariglino[1]

1. Museo Argentino de Ciencias Naturales – CONICET, Av. Ángel Gallardo 470, C1405DJR, Argentina.
barichi10@gmail.com

Plant-insect interactions are widely known from the fossil record, evidence which extends back in time to the late Silurian. Six out of a total of seven extant functional feeding strategies (external foliage feeding, piercing-and-sucking, boring, galling, seed predation, and oviposition) have been recorded since the Paleozoic, leaf mining being the only interaction still not convincingly recognized. Here, a plant-insect interaction potentially assignable to a leaf mine is documented on a *Glossopteris conspicua* var. *patagonica* Archangelsky leaf from the La Golondrina Formation (Permian), Argentina. At least 3 curvilinear and contiguous traces, of constant width but varying length, are displayed on the right margin of the *Glossopteris* leaf. These bear central circular marks (exit holes?). More basally along the leaf's margin, there are what appear to be aborted mines, based on their smaller size and absence of the circular marks. The interaction here described is considered a leaf mine based on the following features: (1) curved linear trace forming an almost continuous loop-pattern, (2) trace delimits a necrotic zone where leaf veins are still visible, although less defined than the robust veins on the rest of the leaf blade, implying that the cuticle is left intact, (3) presence of circular marks (exit holes?) in the loops. However, other diagnostic characteristics are missing: no frass is observed and the trace does not show an obvious increase in size as a result of the larva's growth.

OSTRACODA (CRUSTACEA) FROM THE POZO D-129 FORMATION (LOWER CRETACEOUS), SIERRA SILVA, CHUBUT

Ana P. Carignano[1,2], José M. Paredes[3], Bruno Álvarez[3], José O. Allard[3], Nicolás Foix[1,3] and Sabrina X. Olazabal[3]

1. CONICET – Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina.

2. División Paleozoología Invertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. Paseo del Bosque s/n, La Plata, 1900, Argentina. anapcarignano@gmail.com

3. Departamento de Geología (FCN) Universidad Nacional de La Patagonia San Juan Bosco. Ruta Provincial N°1 S/N, Km.4, 9005, Comodoro Rivadavia. Chubut, Argentina.

The Pozo D-129 Formation is exposed in three areas of the Golfo San Jorge basin and is represented by lacustrine deposits of great areal extension in the subsurface of the basin. The samples studied here come from outcrops of the Cerro Chenques in the Sierra Silva Anticline of the San Bernardo Fold Belt, Chubut (45°17´S, 69°01´W). The age of the Pozo D-129 Formation was determined previously as late Barremian?-early Aptian, based on pollen associations. From 12 samples analyzed during this research, only 6 were fertile, and a single one, interpreted as deposited in a deep lacustrine environment (sample M4 at the base of the stratigraphic profile), presented a well-preserved and diverse association. The ostracods are represented by carapaces of the species *Damonella ultima* (Krömmelbein and Weber), *Neuquenocypris antiqua* Musacchio and *Rhinocypris diademae* Musacchio (Family Ilyocyprididae), *Candona* sp. B Ballent (Family Candonidae), *Pattersoncypris angulata* (Krommelbein and Weber) (Family Cyprididae), *Metacypris herreriensis* (Musacchio) and *Wolburgiopsis sarugnata* Musacchio (Family Limnocytheridae) and *Alicenula*? sp. (Family Darwinulidae). Particularly in the sample M4, the ostracod *D. ultima* is the dominant component of the association, representing 85% of the total, followed by *N. antiqua* (3%). Only two gyrogonites of charophytes, belonging to cf. *Flabellochara harrisi* (Peck) Grambast were recovered (sample M20), in facies associated with a sublittoral lacustrine environment. The species in common with other Argentinean basins are *N. antiqua* (Piedra Clavada Formation, Albian, Austral Basin), *W. sarugnata* (Ranquiles Formation, Aptian-Albian, Neuquén Basin), *Candona* sp. B (Albian, Lagarcito Formation, San Luis Basin), cf. *F. harrisi* (Ranquiles Formation, Aptian-Albian, Neuquén Basin). The present association is similar to that recovered from the Crato Formation (Aptian-early Albian, Jatobá Basin, Brazil), deposited in a lacustrine environment; both associations share the species *D. ultima*, *P. angulata* and *R. diademae*, whilst the Brazilian species *N. berthoui* Colin and Dépêche appears to be closely related to *N. antiqua*. Taking into account the similarities with the association of Brazil and the data provided by the pollen associations, an Aptian age is proposed for the outcrops of the Pozo D-129 Formation at Cerro Chenques.

THE OLDEST (LOWERMOST ORDOVICIAN) TABULATE CORAL, A DISTINCTIVE SESSILE METAZOAN COMPONENT OF CARBONATE MOUNDS FROM THE ARGENTINE PRECORDILLERA

Marcelo G. Carrera[1] and Ricardo A. Astini[1]

1. CICTERRA-CONICET, Facultad Cs Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba X5016GCA, Argentina. mcarrera@efn.uncor.edu

The earliest putative corals occur in the early Cambrian, although many of these generally coralline forms (the "coralomorpha") are of uncertain affinities, among them the Order Tabuloconida are undoubted corals. The oldest definite tabulate corals occurred in the Lower Ordovician (e.g. *Lichenaria* and other selected early tabulate corals such us: *Eofletcheria, Nictopora, Saffordophylum, Foerstephyllum* and *Lyopora*). The earliest favositid *Paleofavosites* come from the Middle Ordovician of the Urals and spread through Eurasia, North America and Australia by the Upper Ordovician. The aim of this contribution is to report and describe a favositid tabulate coral found in the lowermost Ordovician rocks of the Precordillera, Western Argentina. The studied material comes from the Tremadocian La Silla Formation, a carbonate unit located in the Precordillera basin, Western Argentina. The fossiliferous levels are within the *Cordylodus angulatus* conodont zone (lower Tremadoc) slightly over the Cambrian-Ordovician boundary, given by the presence of the *Clavohamulus hintzei* and *C. lindstromi* zones. The new tabulate is included in patchy mud-rich microbial mounds that have grown above a major flooding surface that initiates the second shallowing upward grand cycle within the La Silla Formation at ~95 m from its base. This unit has been considered a typical Bahamian shallow-water carbonate environment and, within the Precordillera, it represents the transition from the late Cambrian largely barren cyclic dolomites into the fossil-rich Ordovician limestones. These levels yield abundant gastropods and few trilobites intimately related to domal thrombolites. These facies association may be compared with the thrombolites-*Lichenaria* mounds reported in Newfoundland. The new form shows cerioid massive colonies, corallites polygonal, septal structure developed as septal spines, double wall with epitheca, common lateral increase, and mural pores specially corner pores. These main characteristics can be found in the favositids and in particular the diagnosis of *Paleofavosites.* However, tabulae and septal spines are scarce in our material and overall structure looks irregular with undulated walls. Although similar in general shape and structure, *Lichenaria*, shows corallites separated by fibrous, continuously fused common walls, lacking back-to-back epithecae. The septal structures are absent and it has also abundant tabulae. The new taxon represents the oldest record of a tabulate coral, probably older than the Lichenarid reports, and certainly the oldest occurrence of a favositid coral, whose oldest records come from the Middle Ordovician. *Lichenaria* is considered the basal genus in tabulates early radiation. This must be revised in the light of the new findings.

CHONDRICHTHYAN FAUNA FROM THE LATE MIOCENE CHAGRES FORMATION (PANAMA CANAL BASIN): A NEW PALEOENVIRONMENT INFERENCE

Jorge D. Carrillo-Briceño[1], Carlos De Gracia[2], Catalina Pimiento[2,3], Orangel A. Aguilera[4] and Carlos Jaramillo[2]

1. Paleontological Institute and Museum, University of Zurich, Karl-Schmid-Strasse 4, Zürich, 8006, Switzerland. jorge.carrillo@pim.uzh.ch

2. Center for Tropical Paleoecology, Smithsonian Tropical Research Institute, Balboa, Ancón, Panamá, 0843- 03092, Panamá.

3. Florida Museum of Natural History, Gainesville, FL 32911, USA.

4. Universidade Federal Fluminense, Instituto de Biologia, Campus do Valonguinho, Outeiro São João Batista, s/n, CEP 24020-141, Niterói, Rio de Janeiro, Brazil.

The late Miocene Chagres Formation (Messinian) contains the youngest outcrops of the Panama Canal Basin which are exposed at the northern end of the basin, sitting disconformably on the Gatun Formation. We report two chondrichthyan assemblages with at least 30 taxa (represented by a total of 476 specimens) from two different facies of the Chagres Formation: Rio Indio and Piña. We performed a paleobathymetry analysis to infer the depth range for the fossil taxa. The assemblage from Rio Indio is characterized by taxa with neritic affinities, with bathymetric ranges no greater than 100 m. In contrast, the assemblage from Piña is dominated by taxa with oceanic affinities, with a palaeobathymetry range between 200-300 m. A few specimens found here, however, show a neritic depth preference, suggesting of transfer of dental elements into deeper waters, or the incursion of these taxa into oceanic environments. In addition, based on the preponderance of Squaliformes (*Isistius*, *Squalus*, *Centrophorus*, *Dalatias*, *Trigonognathus*) and Hexanchiformes (*Heptranchias*) in Piña, we propose that the environments of this facies correspond to those of the external platform-upper slope with a deep water influence or a short platform shelf bordered by a deep margin. The assemblages from the Chagres Formation constitute the most diverse associations known from the Neogene of Panama. Our study provides a complete view of the chondrichthyan diversity inhabiting the Panama Canal Basin and its paleoenviroments during the later Miocene.

MORPHOLOGY AND CUTICULAR ANALYSIS OF THE CRETACEOUS PALEOFLORA FROM THE SPRINGHILL FORMATION, SOUTHERN PATAGONIA, ARGENTINA

Martín A. Carrizo[1] and Georgina M. Del Fueyo[1]

1. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Angel Gallardo 470, 1405 Buenos Aires, Argentina. blackdisk@gmail.com

The Springhill Formation (Early Cretaceous) stands out within the Austral Basin (Argentina) due to its economical value as an oil producer unit and its geographical extension, but it is currently lacking detailed megafloristic studies, the few existing ones being based on fragmentary plant materials. A thorough survey of the outcrops of the Springhill Formation was carried out in both geological and paleobotanical aspects, including both banks of the Pueyrredón and Posadas Lakes, the eastern bank of the Salitroso Lake, the northern bank of the Ghío Lake, southern part of the Buenos Aires Lake and the proximities of Estancia El Salitral located in Santa Cruz Province, Argentina. Stratigraphic sections were measured at Estancia El Salitral and Río Correntoso localities, in which abundant fossil plant material was collected, consisting mainly in compressions of leafy shoots with several branching orders, complete to partially preserved fronds, simple to pinnate leaves and fertile scales. The analysis of these materials allowed the description of 21 new taxa which add to the already known flora of the Springhill Formation; 9 of these taxa were found in Estancia El Salitral, and 12 in Río Correntoso. The floristic diversity of the unit has increased through the discovery of the first megafossils of pteridosperms (*Ruflorinia* sp. nov. 1 and *Ruflorinia* sp. nov. 2) and ginkgophytes (*Baiera* sp. 1 and *Baiera?* sp. 2), while new taxa has been described within the divisions Pteridophyta, Cycadophyta and Pinophyta. Analyses of the epidermis of vegetative and reproductive structures of the various groups included within this megaflora have proved to be a valuable tool for the recognition and individualization of species, and have suggested a wet to temperate climate during the deposition of the Springhill Formation at the studied localities. Also, the compositional comparisons among coetaneous flora from the Western Gondwana have shown that the plant community of the Springhill Formation is more similar to the well known Baqueró Flora, than those of Patagonia (Kachaike Formation), Antarctica, and Brazil (Crato Formation). [Contribution to ANPCyT PICT 2012/528 and CONICET PIP 112-201201-00212].

LIMB ELEMENTS OF AN EXTINCT SIGMODONTINE FROM THE PLEISTOCENE OF ARGENTINA. POSSIBLE LOCOMOTOR TYPES IN *TAFIMYS POWELLI*

Luz V. Carrizo[1,2] and Pablo E. Ortiz[3,4]

1. Facultad de Ciencias Exactas, Químicas y Naturales, Universidad Nacional de Misiones, Félix de Azara 1552, C.P. N3300LQH, Posadas, Misiones, Argentina.
2. CONICET, Argentina.
3. INSUGEO (CONICET – UNT), Tucumán, Argentina.
4. Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Miguel Lillo 205, 4000 San Miguel de Tucumán, Argentina. peortizchamb@gmail.com

The fossil record for rodents of the predominantly South American Subfamily Sigmodontinae (Mammalia: Rodentia: Cricetidae) is based almost exclusively on cranial and dental elements. Very limited data are known for the rest of the skeleton in fossil forms. Here we present the first study of postcranial elements for an extinct sigmodontine, *Tafimys powelli*, known only for the Pleistocene of Northwestern Argentina. The studied material comes from the Tafí del Valle Formation, La Angostura, Tucumán province, Argentina, and was recovered from a very rich rodent assemblage constituted by more than 300 individuals belonging to 15 species. In this assemblage *T. powelli* was the dominant species, reaching more than 60% of all the recovered specimens according to the number of mandibles and maxillae. Here we present a morphofunctional analysis of previously unknown limb bones (ulna, humerus and femur) of this sigmodontine, with the purpose to infer the probable locomotor behaviour of this extinct mouse. Limb bones of species pertaining to all the extant rodent genera recorded in the Pleistocene site (*Abrothrix*, *Akodon*, *Necromys*, *Oxymycterus*, *Oligoryzomys*, *Calomys*, *Phyllotis*, *Reithrodon*, *Neotomys*, *Andinomys*, *Cavia*, *Galea*, and *Ctenomys*) were used for comparison. Postcranial bones of *Tafimys* were identified because they present a similar proportion to that found in the cranial remains and because this dominant morphology was quite different from any of the rodent species represented in the fossiliferous deposit. We measured the lengths and midshaft diameters of the limb bones of fossil and living rats to compute 20 functional indices indicative of locomotor adaptations. The humerus, ulna and femur of *Tafimys* show the main osteological features related to terrestrial locomotive type (e.g., short medial humeral epicondyle; elongated olecranon process of the ulna; higher greater trochanter; lesser trochanter posteriorly placed). This suggests that *Tafimys powelli* possibly presented abilities consistent with a model of a generalized sigmodontine that move mainly on the ground but could readily dig. Our results also find that limb bones of *Tafimys* present a general morphological pattern similar to genera belonging to Abrotrichini and Akodontini tribes (*Abrothrix*, *Akodon*, and *Necromys*).

ENAMEL IN *DASYPUS* (XENARTHRA, CINGULATA): PHYLOGENETIC RELEVANCE

Mariela C. Castro[1,4], Martín R. Ciancio[1,3], Emma C. Vieytes[2,3] and Alfredo A. Carlini[1,3]

1. División Paleontología de Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, 1900, Argentina.

2. División Zoología de Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, 1900, Argentina. cvieytes@fcnym.unlp.edu.ar

3. CONICET, Argentina.

4. CAPES, Argentina.

Reduction and simplification characterize dentition of Xenarthra, which is usually homodont, hipselodont, and lacks enamel. The presence of this latter was only mentioned for some Dasypodidae armadillos. In Euphractinae, it is exclusively known in *Utaetus buccatus* (late Eocene, Argentina). Among the Dasypodinae, the presence of enamel was mentioned for an Astegotheriini (*Astegotherium*; middle Eocene, Argentina) and was described as radial, bearing small prisms and abundant interprismatic matrix. In *Dasypus*, the occurrence of enamel is recognized in embryos of *D. novemcinctus* (late Pleistocene–present, America) and in subadults/adults of that species and *D. hybridus*. The present contribution comparatively describes the enamel microstructure in other *Dasypus* species. Deciduous and permanent molariforms of the extinct *D. punctatus* (late Pleistocene–early Holocene, Brazil) and the extant *D. sabanicola* were examined. The upper portion of their teeth was polished along the transversal and longitudinal axes, briefly treated with hydrochloric acid, and analyzed under Scanning Electron Microscope. As in the previously studied species, a vitreous layer is macroscopically observed in the apex of unworn deciduous molariforms. Under greater magnification, we observed that this tissue is amorphous and only growth lines are distinguished; it is interpreted herein as a thin cap of vestigial enamel deposited over the dentine. In fully formed permanent molariforms previous to its eruption, a continuous cap of enamel was detected around the entire tooth, ranging from 20 to 36 μm in thickness, with enamel tubules and growth lines parallel to the external surface of the tooth. No prisms were observed in *D. hybridus*, *D. sabanicola*, and *D. punctatus*. On the other hand, in *D. novemcinctus* the enamel has few scattered prisms, 3 to 4 μm in diameter, parallel to each other, either with open or closed sheath. Considering the enamel structure in the above-mentioned Astegotheriini, the ancestral condition of this tissue in Xenarthra could have been more complex, as in other placentals, and suffered a progressive reduction in the lineage of *Dasypus*. The retention of a thin enamel layer in the genus, in addition to the fact that it is the only living xenarthran with two functional dental generations, agrees with the basal phylogenetic position of *Dasypus* among the cingulates, as supported by cladistic analyses based both in morphologic and molecular data.

APPARENT CANNIBALISM IN *POLINICES MARAMBIOENSIS* (NATICIDAE) FROM LA MESETA FORMATION (EOCENE), ANTARCTIC PENINSULA

Norma Cech[1], Soledad S. Brezina[1,2], Diego M. Serralta[3] and Silvio Casadío[1,2]

1. Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, Belgrano 516, R8332FDJ, General Roca, Argentina. sbrezina@gmail.com

2. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). Av. Rivadavia 1917, C1033AAJ, Ciudad Autónoma de Buenos Aires, Argentina.

3. Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, Uruguay 151, L6300CLN, Santa Rosa, Argentina.

Polinices marambioensis Stilwell and Zinsmeister, is a naticid gastropod which is the most common constituent in fossils accumulation in the upper section of Cucullaea I Allomember (Eocene), at the La Meseta Formation, in the James Ross Basin of the Antarctic Peninsula. This is the unique naticid species registered in the formation. This species probably was an important predator of infaunal bivalves and gastropods including other naticids. The aim of this work is to contribute to the knowledge of predatory pattern of *P. marambioensis* and to assess possible cannibal behavior. A total of 2,648 specimens were collected from three different levels (M10, M12 and M13) of the accumulations. The boring traces were examined and identified as *Oichnus paraboloides* (Bromley) assigned to naticids. The attack frequency (AF) is almost 20% for M10 and M12, whereas for M13 is less than 5%. The drilling frequency (DF) is about 15% for M10 and M12, and the success rate is similar between M10 and M13 (around 60%), but in M12 is higher (nearly 80%). Statistical analysis also showed that there was a size and site selection by *P. marambioensis* and then a stereotypic behavior. The most prey size preferred by this naticid was between 8-22 mm of shell high (both successful and failed attack) for the three samples. The preferred segment with the highest incidence of complete and incomplete drill holes was nearer the umbilical region than the whorl suture. Comparisons between drilled specimens indicated that there is a significant correlation between prey size and predator size suggesting that attacks were size selective. The ratio of successful attacks declines with the increase in the snail size, indicating a strong size-refuge effect. The prey size with failed attacks is significantly larger than those drilled successfully. We conclude that *P. marambioensis*, as the major component of the fossil accumulation, has a stereotypic and cannibal behavior.

MICROBIAL MINERALIZATION FROM MODERN SULFUROUS SPRINGS IN NORTHEASTERN MEXICO

Elizabeth Chacon Baca[1] and Felipe Torres de la Cruz[1]

1. Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo León, (UANL), Carretera Cerro Prieto Km 8, Linares, 67700, Nuevo León, Mexico. baicalia2012@gmail.mx

Baño San Ignacio is a hydrothermal sulfurous spring and a natural protected area that harbors not only an endemic flora and fauna but also a rich microbial life. This hydrothermal spring represents an ecosystem with mild conditions in temperature and pH (36°C and pH of 7.4 in average) but with a high mineral content, and is linked to the geotectonic evolution of underground continental waters trapped into a closed standard circuit. Travertines are found as associated sediments at the external facies of these springs, linking microbial processes to geochemical conditions. This work provides a biosedimentological analysis of the Baño San Ignacio microbial mats under continuing mineralization. The cyanobacteria constitute a substantial part of the microbial mats developing at Baño San Ignacio, although the obvious presence of other significant bacteria remains to be investigated. These dense microbial mats show stratiform and circular shapes reaching up to 30 cm in diameter with a well-defined lamination alternating with calcified layers. The cyanobacteria and diatoms, and to a lesser extent, fungal hyphae and green algae are the main components in these mats. The characterization of mats and travertines was carried out by microscopy and geochemical analysis. Our results show that the extracellular matrix is organized as a three-dimensional net with abundant organic fibers associated with the dominant biota. The calcification is not limited to only one type of filament; in fact, mineral precipitates are diverse and show heterogeneity in form, size and distribution. The identification of several textures in the internal network suggests that trapping and union are the main controlling process in mineralization. This locality, as many other recent geoparks, provides microbial records of the interactions between minerals and microbes where to search morphological, chemical, and mineral biosignatures with great astrobiological potential.

THE FIRST CRETACEOUS BENNETTITALEAN TRUNK FROM INNER MONGOLIA, CHINA

Ye-Ming Cheng[1], Xi Wang[1] and Kai Tan[1]

1. The Geological Museum of China, Beijing 100034, China.
chengyeming@hotmail.com

A big, well preserved, *Cycadeoidea* (Bennettitales) fossil trunk has been recently found in Cretaceous strata of Baotou, Inner Mongolia Autonomous Region, northern China. It is the first complete fossil trunk of *Cycadeoidea* found in China. The trunk is columnar, 56 cm in height and 48 cm in maximum diameter, and consists of central pith surrounded by a peripheral xylem cylinder, cortex, petiole bases and cones. Petiole bases are rhombic, helically arranged, and decrease in size from the periphery to the apex of the stem. The cones are unevenly scattered between petiole bases. The gymnosperm fossil wood *Xenoxylon latiporosum* (Cramer) Gothan is in association with the stem. The trunk and associated fossil wood constitute important tools for studying the evolution of the Cycadeoidaceae and the Cretaceous flora community in northern China.

INTERNET-BASED DATASETS OF FAUNA AND FLORA—THREE EXAMPLES FROM THE CARBONIFEROUS OF EASTERN NORTH AMERICA

Donald R. Chesnut, Jr[1]

1. University of Kentucky (retired), 1402 Fincastle Rd., Lexington, KY 40502, USA.
chesdonald@hotmail.com

Very few modern publications have comprehensive descriptions of faunas and floras of stratigraphic units. This type of publication was fairly common in the late Nineteenth and Twentieth Centuries. These older publications are difficult to find and many are fragile. Thankfully, a number of dedicated people are digitizing and publishing these online. However, more modern taxonomies and photographs of these faunas and floras are lacking, making the situation difficult for the next generation of paleontologists. I have been compiling information about three Carboniferous macrofaunas from eastern North America—the Nada Member of the Borden Formation (late Tournaisian), the Somerset Shale Member of the Salem Formation (Visean), and the Sloans Valley Member of the Paragon Formation (the member is latest Visean). Prototype web pages for each of these have been published online at bit.ly/1iHZGkG, bit.ly/1evGrDV, and bit.ly/1byjTBy, respectively. These examples are works-in-progress and new descriptions, taxonomies, and photographs will be added. I encourage feedback and new information.

BERGMANN´S RULE: A CASE STUDY ON POLYDOLOPID MARSUPIALS

Laura Chornogubsky[1], Natalia Zimicz[2] and Roberto R. Pujana[3]

1. CONICET- Sección Paleontología de Vertebrados, Museo Argentino de Ciencias Naturales, Av. Ángel Gallardo 470, Buenos Aires, C1405DRJ, Argentina. Departamento de Ciencias Básicas, Universidad Nacional de Luján Ruta 5 y Avenida Constitución, Luján, 6700, Prov. de Buenos Aires. Argentina. lchorno@macn.gov.ar

2. CONICET- IBIGEO-Universidad Nacional de Salta, Av. Bolivia 5550 Ciudad de Salta, 4401, Salta, Argentina.

3. CONICET- División Paleobotánica, Museo Argentino de Ciencias Naturales, Av. Ángel Gallardo 470, Buenos Aires, C1405DRJ, Argentina.

Polydolopidae is a family of Paleogene marsupials, recorded in Southern South America (Patagonia in Argentina, Central Chile) and the Antarctic Peninsula (in Marambio/Seymour Island). Two localities with polydolopids have been dated and are almost synchrounous: Laguna Fría (Ignimbrita Barda Colorada Formation), in the vicinity of Paso del Sapo (Chubut Province, Argentina) and Marambio/ Seymour Island (Cucullaea I Allomember, La Meseta Formation; Antarctic Peninsula). The beds with fossil vertebrates at Laguna Fría are no older than 49.51 ± 0.32 my and not younger than 47.89 ± 1.21 my. Alternatively, the Cucullaea I Allomember beds at Marambio/Seymour Island have an age of *ca.* 49–51 my. The latter locality represents a fossil forest dominated by Podocarpaceae, with the occasional Nothofagaceae and other families present in temperate forests, such as Araucariaceae, Grossulariaceae, Proteaceae, Myrtaceae and Cupressaceae. The fossil floras near Laguna Fría represent a more diverse rainforest with Australasian components (i.e. *Eucalyptus*, *Casuarina*) and Podocarpaceae, but Nothofagaceae are absent. Comparatively, the Antarctic flora suggests cooler conditions than the floras from Patagonia. Bergmann´s Rule argues that homeothermous vertebrates from colder regions are larger than the ones present in warmer conditions. Here, we analyze the body mass of polydolopids within a phylogenetic framework from the localities mentioned above. A phylogenetic comparative method (Phylogenetic Eigenvector Regression) was applied to detect phylogenetic signal in the body mass data. A principal coordinate analysis was performed on the double-centered phylogenetic distance matrix in order to extract significant eigenvectors. These eigenvectors were used as independent variables versus body mass in a multivariate regression. The residual portion of this regression represents the amount of variation independent from the phylogenetic structure. Based on the analysis, 44% of the body mass variation of polydolopids can be explained by phylogenetic inertia. The plot of de-transformed residuals shows the same pattern as the single analysis of body mass. This means that the portion of body mass independent from phylogeny shows a pattern consistent with Bergmann`s rule: larger polydolopids were located at higher latitudes and cooler climates (Marambio/Seymour Island), while smaller polydolopids were located at lower latitudes and warmer environments (Laguna Fría).

THE RELATION BETWEEN CLIMATE AND FLORA IN THE PARANÁ BASIN, BRAZIL, DURING THE LATE PALEOZOIC

Isabel Cortez Christiano-de-Souza[1] and Fresia Ricardi-Branco[1]

1. Department of Geology and Natural Resources, Institute of Geociences, State University of Campinas, Rua João Pandiá Calógeras, 51, CEP 13083-870, Campinas, Brazil.
isabel.cortez@ige.unicamp.br

A severe climate change marks the late Paleozoic worldwide. At the end of the Pennsylvanian, the planet was under the influence of a glacial cycle, and experienced milder climates due to the end of glaciations in the Cisuralian. Floristic provinces, and specially the Gondwana Floristic Province, were affected by climate changes. Migration and evolution of plant communities can be observed in Gondwana, as well as variations in their geographical distribution. These phenomena were recorded in lithostratigraphic sequences of the Paraná Basin and its fossil floras. In order to verify, through the aid of SIG and geological information, how plants were affected by climate change, the floras were grouped into three main climatic phases. The initial/glacial phase, lithostratigraphically represented by the Itararé Group, is marked by the alternation of glacial and interglacial climate periods; it is characterized by the predominance of seed plants (pteridosperms and conifers), as well as the phyto fossiliferous record of transportation resistant organs, such as seeds and fragments of logs. The intermediate/temperate phase, lithostratigraphically represented by the Guatá Group, possesses a more significant plant diversity, if compared with the previous phase, and an increased occurrence of hygrophilous species (lycophytes and sphenophytes). Finally, in the last sub-tropical phase, present in the Passa Dois Group, mostly sphenophytes and ferns are observed, together with a decrease in the total number of genera. Climate changes were accompanied by an increase of the area occupied by forests (restricted in the first phase, but widely distributed towards the second and final phases). At the intermediate and final phase, the flora was widely distributed throughout the area, although the final one shows a lower diversity. In conclusion, the fundamental observation of this study is that the initial and intermediate phases display a relative similar plant biodiversity, characteristic of cold climates. The third phase is different in composition, characterized by a low diversity plant community that grew in relation of bodies of water under a warmer and drier climate.

LOWER DEVONIAN CEPHALOPODS FROM PRECORDILLERA, WESTERN ARGENTINA

Marcela Cichowolski[1] and Juan J. Rustán[2]

1. Instituto de Estudios Andinos "Don Pablo Groeber" (IDEAN), CONICET and Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, Pab. 2, C1428EGA, Buenos Aires, Argentina. mcicho@gl.fcen.uba.ar

2. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), CONICET and Centro de Investigaciones Paleobiológicas (CIPAL), Universidad Nacional de Córdoba, Córdoba, Argentina.

We report for the first time a cephalopod assemblage from the Lower Devonian of Argentina. Fossils come from the Talacasto Formation, which is extensively exposed in the Central Argentine Precordillera in San Juan Province. This unit represents a muddy shelf depositional system developed during a highstand, embracing the early Lochkovian-late Emsian. Sixty cephalopod specimens were recovered from several levels throughout the succession and preliminary analyzed. Many of them are very poorly preserved, and then were classified as indeterminate forms of Orthocerida and Oncocerida. In addition, the recognition of Bactritida represents the first mention in Argentina of this phylogenetically important group. Based on a few specimens studied by means of medial polished sections, Pseudorthocerida was also recognized in spite of having no preserved apices. The type of endosiphuncular deposits, furthermore, suggests they can be assigned to Pseudorthoceratidae. These new data are relevant in paleobiogeographic discussions related to the Malvinokaffric Realm, a marine Early-Middle Devonian southern circumpolar region (including basins from southern South America, South Africa and Antarctica) characterized by a high endemism level and absence of some typical Paleozoic groups. Cephalopods were interpreted to be absent from the Malvinokaffric Lower Devonian, despite the fact that "*Michelinoceras*" was reported from Bolivia, and scarce specimens assigned to the taxonomic wastebasket "*Orthoceras*" and "*Spyroceras*" were cited from the Brazilian Paraná Basin. Our new evidences constitute the best-known record of Early Devonian Malvinokaffric cephalopods, demonstrating that they were undoubtedly present in the southwestern marine margin of Gondwana during Early Devonian times, being relatively diverse and abundant.

A LOWER PERMIAN MIXED FAUNA FROM CARBONATE SUCCESSIONS OF CHILE AND ITS IMPLICATIONS IN THE PALEOBIOGEOGRAPHY OF THE SOUTHWESTERN GONDWANA MARGIN

Gabriela A. Cisterna[1], Andrea F. Sterren[2] and Hans R. Niemeyer[3]

1. CONICET-Universidad Nacional de La Rioja, Av. Luis M. de la Fuente s/n, La Rioja, 5300, Argentina. gabrielacisterna@conicet.gov.ar

2. CONICET-CICTERRA-CIPAL. Facultad de Ciencias Exactas, Físicas y Naturales. Universidad Nacional de Córdoba, Av. Vélez Sarsfield 299, Córdoba, 5000, Argentina.

3. Universidad Católica del Norte, Departamento de Ciencias Geológicas, Casilla 1280, Antofagasta, Chile.

Outcrops of the early Permian marine deposits from Chile are located in two regions: the Coquimbo area, around the central part of the country (Huentelauquén Formation), and in the north, the widely extended sequences of Juan de Morales, Cerros de Cuevitas and Cerro El Árbol formations. Brachiopods dominate the marine fauna of the Huentelauquén Formation although scarce trilobites, bivalves and bryozoans are mentioned. The group of brachiopod genera described is composed of Boreal type faunas (*Yakovlevia* (*Muirwoodia*) Fredericks and *Spiriferella* Tschernyschew), with other that exhibit Tethyan affinities (*Liosotella* Cooper, *Alpavlia* Lazarev and *Gypospirifer* Cooper and Grant). Cosmopolitan elements (*Hustedia* Hall and Clarke, *Cleiothyridina* Buckman), as well as, the genus *Anidanthus* Hill characteristic from Boreal-Tethyan transitional zones, have been also recognized. Faunal assemblages from carbonate deposits of northern Chile are relatively more diversified than those of the Huentelauquén Formation, and they are characterized by abundant brachiopods accompanied by bivalves, gastropods, crinoids and bryozoans. Two brachiopod genera are dominant in these assemblages: *Waagenoconcha* Chao, restricted to the Juan de Morales Formation (Iquique area) and *Kochiproductus* Dunbar that appears accompanied by *Kozlowskia* Fredericks, *Gypospirifer, Hustedia, Cleiothyridina* and *Dielasma* King, in the Cerros de Cuevitas and Cerro El Árbol formations (Antofagasta area). *Waagenoconcha* and *Kochiproductus* are common but not restricted to the Boreal Province and they have been also studied from mixed Boreal-Tethyan brachiopod faunas. In Argentina, *Kochiproductus* has been described from the early Permian carbonate deposits of the Arizaro Basin, as well as from the Precordillera, where it is related to a group of gondwanic genera that characterizes the latest Carboniferous *Tivertonia jachalensis*-*Streptorhynchus inaequiornatus* Zone. The bivalve fauna associated with the brachiopods from northern Chile is characterized by the genera *Myalina* De Koninck, *Heteropecten* Kegel and Costa and *Wilkingia* Wilson, which show an extensive latitudinal distribution. However, some of these elements (i.e. *Wilkingia, Heteropecten*) also described from central-west Argentina and Bolivia, appear usually associated with warm faunas. This mixed character has been previously identified in the late Carboniferous-early Permian bivalves from the central western Argentinean basins. From a paleobiogeographic viewpoint, early Permian faunal assemblages from Chile, particularly the brachiopods, have been generally defined by their Tethyan affinities, closely related to those from Copacabana Formation in Bolivia and Perú. The new studies indicate that these assemblages can be understood as a mixed fauna, which allows reconsider the paleobiogeography of the southwestern Gondwana margin.

CHANGES IN DEEP-SEA OSTRACODE (CRUSTACEA: OSTRACODA) ASSEMBLAGES FROM THE LATE QUATERNARY OF CAMPOS BASIN, BRAZIL

João C. Coimbra[1], Demétrio Dias Nicolaidis[2], Lisandra A. Alves Sartori[1] and Cristianini T. Bergue[2]

1. UFRGS, IGeo, DPE, Cx. P. 15001, Cep. 91501-970, Porto Alegre, RS, Brazil.
joao.coimbra@ufrgs.br

2. UNISINOS, ITT-Fossil, Av. Unisinos, 950, Cep. 93022-000, São Leopoldo, RS, Brazil.

Since the beginning of this century, a number of studies have demonstrated the influence of climatic events on the composition of deep-sea ostracode faunas. In order to evaluate the influence of these events on the bathyal ostracodes from the Campos Basin, 25 samples from a piston core taken at 1,287 m water depth were studied. The entirety of both autochthonous and allochthonous species were identified; however, only the former were analyzed in detail. The age of the samples was determined based on oxygen stable isotope data from tests of the planktonic foraminifer *Globigerinoides ruber* and compared to SPECMAP (Spectral Mapping Project) ones, calibrated with accelerator mass spectrometer (AMS) ^{14}C dating in six samples from different parts of the core. Around 46 autochthonous species were identified so far. *Krithe* (family Krithidae) and *Cytheropteron* (family Cytheruridae) were the more diverse genera, supporting other studies on ostracode bathyal faunas. The oldest analyzed sample was dated as 42.9 ka, and the youngest one as 210(?) years. The Jaccard similarity grouping analysis shared the samples into two groups being the sample 12 (20.7 ka) the limit between them, which corresponds to the Last Glacial Maximum. The diversity varied significantly between glacial and interglacial periods, being lower in the former and higher in the latter. The generic composition varied among the deglacial, interglacial, LGM, and glacial. *Xestoleberis* was registered with relatively steady diversity values along the core. An analysis of taxonomic distances between the species in the glacial and interglacial has been performed. The ostracode faunas from the Campos Basin responded to the Quaternary climatic events, reinforcing the use of deep-sea ostracodes changes as a paleoceanographic proxy.

KAČÁK EXTINCTION EVENT IN THE GIVETIAN OF PARANA BASIN (BRAZIL), CORROBORATED BY PALEOMETRICAL ANALYSIS

Jeanninny C. Comniskey[1], Renato P. Ghilardi[2] and Mirian Liza A. F. Pacheco[3]

1. Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Pós-Graduação em Biologia Comparada, Universidade de São Paulo, USP, Av. Bandeirantes, 3900, CEP 14040-901, Bairro Monte Alegre, Ribeirão Preto, SP, Brazil. jcomniskey@usp.br

2. Faculdade de Ciências, Departamento de Ciências Biológicas, Universidade Estadual Paulista, UNESP, Av. Eng Luiz Edmundo Carrijo Coube, 14-01, CEP 17033-360, Bauru, SP, Brazil.

3. Departamento de Biologia, Universidade Federal de São Carlos, UFSCar, Campus Sorocaba, Rodovia João Leme dos Santos (SP-264), Km 110, Bairro do Itinga, CEP 18052780, Sorocaba, SP, Brazil.

Kačák Event is related to a transgressive peak and described as widespread deposition of black shales linked to drastic changes to the environment, such as global hypoxia. Together with trilobites, brachiopods and others, tentaculitids from Ponta Grossa Formation (Paraná Basin, Brazil) are among the representative biota from Kačák Event, also recorded in Morocco, North America and Bolivia. Here we proceed to a paleometrical analysis of fossils from São Bento outcrop (Eogivetian), Paraná Basin, Brazil. We analyzed 10 specimens of tentaculitids under spectroscopic techniques such as X-ray Energy Dispersive Spectroscopy (EDS) and Energy Dispersive X- Ray Fluorescence Analysis (EDXRF), as well as Scanning Electron Microscopy (SEM). Among other elements, our chemical analyses showed the presence of iron and sulfur, and SEM investigations revealed that shells are closely associated with clay minerals. Taking together, the analyses are indicative of deep oxygen-poor environments, corroborating that tentaculitids might be related to a great global extinction. The tentaculitids are related to another extinction event, described for the Northern Hemisphere, known as Kellwasser Crisis (Frasnian – Famennian boundary), and also one of the causes was the lack of oxygen. We also found higher amounts of chromium in tentaculitids shells. It is well known that chromium oxidation is indirectly mediated by microbial synthesis of manganese oxides. Maybe the presence of chromium in shells is also indicative of fossilization under tectonic activity. [Financial support: Fapesp].

THE LEAF OF *GLOSSOPTERIS*: CHARACTER'S RESTATEMENT TO ALLOW A CLUSTER ANALYSIS BASED ON THE MORPHOGRAPHY

Eliana P. Coturel[1]

1. CONICET. División Paleobotánica, Museo de La Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, B1900FWA, Argentina.
elianacoturel@gmail.com

The Permian flora of Gondwana is portrayed by the presence of *Glossopteris*, a genus of tongue-shaped, entire leaves. This genus includes almost one hundred species, leading several authors to think about an artificially over-represented diversity at the species level. A major problem comes from the fact that leaves are mostly represented as impressions, showing few useful characters for taxonomic discrimination. Permineralizations and cuticle preservation increase the number of characters available for taxonomic analysis, but few studies are able to determine natural taxa combining different preservation types. Several authors have pointed-out different useful characters in taxa discrimination, but classifications still allow subjective interpretations, with no clear limits between species. However, the abundance and morphological variability of *Glossopteris* allow the searching of new approaches to solve the problem of its classification. I propose herein the use of software classification tools and the reassessment of leaf characters in order to group them based on their similarities. The ultimate objective of this method is to create a parataxonomy that could be used world-wide, and reduce the number of potential artificial species. The first appointed character I have considered is the course of secondary veins. This character has been defined by: (i) the angle of departure from the midvein, (ii) the general course of veins, and (iii) the angle of contact of the veins with the leaf margin. To compare (i)-(iii) together as a same unit, I have: 1) standardized the leaves to remove the differences caused by size, 2) reinterpreted the veins as a curve, and 3) obtained the formula that describes the curve in the standardized interval between the midvein and the margin. This allowed me to get a full characterization of the veins, and compare the positions of different veins in a coordinate axis point by point. Other standardized characters were the density of secondary veins and the types of intersection between veins. The comparison was made using distance coefficients, resulting in several morphogroups. These morphogroups are in part correlated with the already known species. The improvement of the analysis with a larger dataset, may result in a grouping that could be useful for paleoecological, systematic and biostratigraphic studies.

NEW FLORAL ELEMENTS FROM THE CISURALIAN ARROYO TOTORAL FORMATION (LA RIOJA PROVINCE, ARGENTINA)

Eliana P. Coturel[1] and Pedro R. Gutiérrez[2]

1. CONICET. División Paleobotánica, Museo de La Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, B1900FWA, Argentina.
elianacoturel@gmail.com

2. CONICET. Sección Paleopalinología, Área Paleontología, Museo Argentino de Ciencias Naturales "B. Rivadavia", Av. Ángel Gallardo 470, Buenos Aires, C1405DJR, Argentina.

The aim of this contribution is to present several new taxa from the Permian Arroyo Totoral Formation fossil flora. This formation crops out in Sierra de los Llanos, La Rioja Province (Argentina), a well-known Permian locality of the Paganzo Basin. Sedimentological profiles were logged at four localities (PF1, PF2, PF3, and PF5), and nine fossiliferous levels were recognized. A total of 21 taxa were identified: *Asterotheca feruglioi*, *Paracalamites australis*, *Phyllotheca leptophylla*, *Botrychiopsis plantiana*, *Eusphenopteris* sp., *Arberia* cf. *minasica, Gangamopteris obovata*, *Glossopteris occidentalis*, *Glossopteris wilsonii*, *Cordaites hislopi*, *Ferugliocladus riojanum*, *Genoites* sp., *Ginkgophyllum* sp., *Eucerospermum* sp., *Cornucarpus* sp., *Samaropsis* sp. A, *Samaropsis* sp. B, including the first mention for this formation of *Paracalamites* cf. *frigidus*, *Cruciaetheca patagonica, Arberia* cf. *madagascariensis*, and new species of *Genoites* and *Asterotheca. Paracalamites* cf. *frigidus* is different from any other sphenophyta stem known in the formation. *Cruciaetheca patagonica* is a sphenophyta with rows of sporangiophores and *Phyllotheca*-like foliage and, in spite of showing fewer rows of sporangiophores, it resembles the type species of the genus. Specimens referred to *Arberia* cf. *madagascariens* shows a basal bifurcation and a striated body, however, ovules are lacking. There is also a specimen of *Glossopteris wilsonii* with a long stalk attached to the petiole, and a polysperm similar to *Arberia* cf. *madagascariensis* in the extreme. In other specimen, dispersed polysperms are associated with a stalk. *Genoites* sp. nov. shows several ovules attached to the branch, axillar to leaves, and two kinds of foliage, different to the type species of this genus, *Genoites patagonica*. *Asterotheca* sp. exhibits partly fused pinnulae and a venation comparable to *Asterotheca golondrinensis*. A specimen referred to *Asterotheca feruglioi* bears synangia, still undescribed for this species; each sporangium is pyriform and displays a pointed apex; sporangia are fused at the base and free at the apex. The discovery of all these new taxa improves the knowledge of the Arroyo Totoral Formation flora, enhances its paleoecological knowledge, and refines the correlation between the *Gangamopteris* Biozone of Paganzo and the *Gingkoites eximia* Biozone of the Tepuel Genoa Basin.

NEW VERTEBRATE ASSEMBLAGE FROM THE BROCHERO FORMATION (LATE PLIOCENE), CORDOBA PROVINCE, ARGENTINA

Laura E. Cruz[1,2], Juan C. Fernicola[1,2,3], Claudio A. Carignano[1,4], M. Susana Bargo[5,6], Mariano Bond[1,6], Santiago Brizuela[1,7], Adriana M. Candela[1,6], Cecilia M. Deschamps[5,6], Jonatan Kaluza[2], Pablo Ortiz[1,8], Ulyses F.J. Pardiñas[1,9], Celeste Pérez Ben[10], Pablo Teta[1,8] and M. Guiomar Vucetich[1,6]

1. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina. cruzlaurae@gmail.com

2. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Ángel Gallardo 470, Ciudad Autónoma de Buenos Aires, C1405DJR, Argentina.

3. Departamento de Ciencias Básicas, Universidad Nacional de Luján Ruta 5 y Avenida Constitución - (6700) Luján, Buenos Aires, Argentina.

4. Universidad Nacional de Córdoba, Facultad de Ciencias Exactas, Físicas y Naturales, Centro de Investigaciones en Ciencias de la Tierra. Av. Vélez Sarsfield 1611, Córdoba, X5016GCA, Argentina.

5. Comisión de Investigaciones Científicas, Provincia de Buenos Aires, Argentina.

6. División Paleontología Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, 1900, La Plata, Argentina.

7. Departamento de Biología, Universidad Nacional de Mar del Plata, Funes 3250, B7602AY, Mar del Plata, Argentina.

8. Instituto Superior de Correlación Geológica, Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán. Miguel Lillo 205, T4000JFE, San Miguel de Tucumán, Argentina.

9. Centro Nacional Patagónico, Casilla de Correo 128, 9120, Puerto Madryn, Argentina.

10. Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Intendente Güiraldes 2160, C1428EGA, Ciudad Autónoma de Buenos Aires, Argentina.

The Brochero Formation ("Horizonte Brocherense" of Castellanos) was created on the basis of a mammal assemblage from its type locality Valle de Traslasierra (San Alberto Department), and from Valle de Los Reartes (Calamuchita Department), both in Córdoba Province, Central Argentina. The list of taxa included: *Nonotherium* and *Paedotherium* (Notungulata); *Plaina*, *Propanochthus*, *Nopachthus* and *Plohophorus* (Xenarthra, Cingulata); *Orthomyctera*, *Ctenomys* and *Paleocavia* (Rodentia); and Felidae indet. (Carnivora). In 1944, this mammal association was assigned by Castellanos to his "Uquian Stage" (early Pliocene for Castellanos). Later, different authors considered this association either Montehermosan Stage/Age (early Pliocene) or Huayquerian Stage/Age (late Miocene). Here we present new vertebrates from the Brochero Formation, recovered in recent field trips to the type locality, and discuss the age of the fauna and its bearing sediments. This stratigraphic unit crops out along the Valle de Traslasierra and is composed by two red beds facies normally graded, with discontinuous laminate and nodular calcretes. The basal facies is a very fine matrix-supported conglomerate; the grain size is sabulitic and the matrix is sandy silt. The upper facies is a fine sandy to clayed silt with paleosoils. The vertebrates recovered include the following taxa: the anurans *Rhinella* cf. *R. arenarum* and *R.* cf. *R. spinulosa* (Bufonidae); squamate reptiles represented by snakes ("Colubridae" indet.) and different lizards: *Teius* sp. (Teiidae), Iguanidae indet. and Tropidurinae indet. Within mammals, Rodentia are represented by "*Akodon* (*Abrothrix*)" *magnus* and a new, still unnamed, genus (Cricetidae), *Phugatherium* cf. *P. novum* (Hydrochoeridae), and an Echimyidae indet; xenarthrans include the cingulates *Doellotatus* cf. *D. chapadmalensis* (Dasypodidae) and Panochthidae indet. Snakes, lizards, *Rhinella* cf. *R. spinulosa*, the rodents, and the dasypodid are first records for the Brochero Formation. *Phugatherium novum* is recorded in the Chapadmalalan (late Zanclian-early Piacenzian), whereas "*Akodon* (*Abrothrix*)" *magnus* is recorded in the Vorohuean (Piacenzian) in the Atlantic coast of Buenos Aires Province. These new records suggest that the Brochero Formation would have been deposited in the late Zanclean-Piacenzian interval. However, in order to refine its age further analyses and field works are needed. [PICT 2012-1054 (LEC), UNLu CCD-CD: 054/12 (JCF), PICT 2010-0804 (EPT), PICT 2008-547 (to UFJP), and PIP 2011-164 (to UFJP)].

FORAMINIFERS AND CALCAREOUS NANNOFOSSILS ACROSS THE CRETACEOUS/PALEOGENE BOUNDARY IN THE SUBSURFACE EASTERN AUSTRAL BASIN, ARGENTINA

Carlos D. Cuciniello[1], María L. Hiriart[1] and Juan P. Pérez Panera[1,2]

1. Laboratorio de Bioestratigrafía. Área de Geociencias. YPF Tecnología S.A. Baradero s/n, Ensenada, 1925, Buenos Aires, Argentina. carlos.cuciniello@ypf.com

2. CONICET – División Paleontología Invertebrados-Museo de La Plata. Paseo del Bosque s/n, La Plata, 1900, Buenos Aires, Argentina.

Selected samples from Sur Río Chico borehole in the eastern Austral Basin were prepared for calcareous microfossil analysis. The purpose of this study is to record the changes in the assemblages across the Cretaceous/Paleogene boundary, to identify biostratigraphically important taxa and to evaluate paleoenvironmental changes. Sur Río Chico well is one of the few places whereas the late Maastrichtian has been recorded in this part of the basin, and that makes it a promising site to study the paleoenvironmental conditions of the basin during the beginning of the late Maastrichtian transgression. Most commonly, this transgression produced a discordance that involves both the late Maastrichtian and the earliest Danian. At the base of the studied section (1070-1075 to 1010-1015 mbbp) samples are barren of calcareous nannofossils and yield the low diversity assemblage of agglutinated foraminifera *Spiroplectammina–Textularia* sp., characteristic of hipohaline and/or high turbidity marginal-marine environments. These samples record the topmost regressive cycle of the early Maastrichtian. Overlying (1005-1010 to 990-995 mbbp), a late Maastrichtian calcareous nannofossil assemblage characterized by *Arkhangelskiella maastrichtiana, Kamptnerius magnificus, Micula concava, M. staurophora, Nephrolithus frequens,* and *Prediscosphaera stoveri*, together with the foraminifers *Coryphostoma incrassata, Praebulimina carceyae* and the planktonic *Rugoglobigerina rugosa* have been recovered. *Nephrolithus frequens* is an important high latitude marker species on which a Late Maastrichtian age was interpreted. An increasing high relative abundance of *Micula* spp. is characteristic of the latest Maastrichtian of the Colorado and Neuquén basins, and this pattern is also observed in the youngest samples of this section. A third calcareous nannofossil assemblage characterized by *Cruciplacolithus edwarsii, C. primus, Hornibrookina teuriensis, Markalius inversus, Placozygus sigmoides, Praeprinsius dimorphosus* and *Toweius africanus* has been recorded in the upper levels (985-990 to 955-960 mbbp). All these are marker or typical species of the early to middle Paleocene. However, the absence of some lowermost Danian markers as *Biantholithus sparsus,* lead us to interpret that the very base of the Danian (NP1 biozone) is absent. Regarding the foraminifera, a low diversity and poorly preserved assemblage of Paleocene benthic foraminifera characterized by *Bulimina quadrata, Lenticulina midwayensis, L. mexicana nudicostata* and *Nodosaria latejugata* has been recovered. According to these results, the beginning of the late Maastrichtian transgression is very well documented by the foraminifera and calcareous nannofossils and they suggest a rapidly rise of the sea level with the establishment of a marine platform that lasted up to the middle Paleocene.

TAPHONOMIC ASPECTS OF VERTEBRATE FOSSILS ON THE GUABIROTUBA FORMATION (CURITIBA BASIN, PALEOGENE), PARANÁ, BRAZIL

Renata Floriano da Cunha[1], Eliseu Dias[2], Fernando Sedor[3] and Luiz Alberto Fernandes[1]

1. Universidade Federal do Paraná, Departamento de Geologia, Curitiba, Campus do Centro Politécnico, Rua Cel. Francisco H. dos Santos 100, Curitiba, 81531-990, Brazil. floriano.cunha@gmail.com

2. Laboratório de Geologia e Paleontologia, Centro de Ciências Biológicas e da Saúde, Universidade Estadual do Oeste do Paraná, UNIOESTE, Rua Universitária 2069, Cascavel, 85819-110, Brazil.

3. Universidade Federal do Paraná, Setor de Ciências Biológicas, Museu de Ciências Naturais, Campus do Centro Politécnico, Rua Cel. Francisco H. dos Santos 100, Curitiba, 81531-990, Brazil.

The Curitiba Basin is located on the geomorphological compartment named First Paranaense Plateau, and is set on the southernmost portion of the Southeastern Brazil Cenozoic Rift System. The basin was filled with Paleogene sediments referred as Guabirotuba Formation, composed by nine main lithofacies that constitute six facies associations corresponding to architectural elements of transitional deposits between the proximal, middle and distal zones of fluvial distributaries systems under reasonably wet climate conditions. This is confirmed by the abundant amount of mud deposits, and absence of eolian facies and exposure features. The fossils recognized so far at only one outcrop, occur in poorly sorted, massive sand facies, containing occasionally granules and pebbles; and also in massive mud facies with different amounts of sand. The fossil association is constituted by spores, invertebrate ichnofossils, Gastropoda, fragmentary remains of Crocodylomorpha, Testudines, Aves, Mammalia; and unidentified fragments, whereas in this work only the vertebrate remains will be approached. The remains found in the sand facies have different coloration, degrees of abrasion, weathering and size sorting, suggesting remobilization and mixing with pre-deposited material. Fossils incorporated to the muddy matrix are moderately fractured, but with reasonable integrity. Calcrete levels may contain bone fragments showing pre-depositional fractures. The features of the facies in which the fossils occur suggest transport by fluvial processes of channel overflow in the floodplain environment. The presence of elements with a wide range of hydraulic equivalence suggests that the assembly has not been subjected to extensive action of currents. The massive mud indicates deposition on unconfined gravity flows in muddy lowest energy overflow events, characterizing the most distal portion of the alluvial fans.

PLANT-SEDIMENT INTERACTIONS IN QUATERNARY TERRESTRIAL AND SHALLOW-MARINE SEDIMENTS AND ROCKS OF THE BAHAMAS: EXAMPLES AND IMPLICATIONS

H. Allen Curran[1] and Bosiljka Glumac[1]

1. Department of Geosciences, Smith College, Northampton, Massachusetts 01063, USA.
acurran@smith.edu

Rhizoliths, fossilized organosedimentary structures, represent various modes of preservation of plant roots and are the most common evidence of ancient plant-sediment interactions in the Bahamas. However, there are many other examples of significant carbonate substrate modification by terrestrial and marine plants. Some of these examples are well known, such as the important role of modern red mangrove (*Rhizophora mangle*) root systems in trapping sediment and reducing coastal erosion. Although not as well documented, other examples of plant-sediment interactions provide evidence of past vegetation and can be used as paleoclimate indicators of temperature and precipitation regimes. Modification of carbonates by plants also can produce significant amounts of porosity and permeability, which can increase reservoir quality (i.e. storage potential for water and petroleum) of host rocks. Sediment in the Bahamas is composed of the carbonate minerals calcite and aragonite ($CaCO_3$), and both are highly susceptible to chemical weathering by dissolution under acidic conditions and to physical and biological modifications, such as erosion by storms and bioturbation, respectively. Due to rapid lithification, carbonate deposits have high potential for preserving a record of these modifications. The following examples of plant interactions with carbonate deposits from coastal and shallow subtidal settings in the Bahamas demonstrate their highly variable nature and products: 1. impressions of silver thatch palm fronds (*Coccothrinax argentata*) in eolianites (wind-blown dune deposits); 2. impressions of terrestrial plant roots (sea grape = *Coccoloba uvifera*), prostrate stems (bay geranium = *Ambrosia hispida*), and runners (railroad vine = *Ipomoea pes-caprae*) in eolianites and back-beach grainstones; 3. vertical pipes in eolianites that may represent buried palm tree trunks and/or clusters of large roots, although roots can also exploit pre-existing pathways created by dissolution; 4. highly porous "spongiform" texture of eolianites, which likely formed by sand trapping and lithification around dense roots, stems, and organic litter of grass and shrub vegetation, including their microbial, fungal and insect communities, as well as accumulation and burial of marine algae (e.g., *Sargassum*) and seagrasses in beach sediment; and 5. extensive seagrass (*Thalassia testudinum*) root systems that trap sediment in shallow marine subtidal settings and may have potential to leave traces in the geological record but have not commonly been documented from ancient strata. Similarly, extensive palm-tree roots do not seem to be easily preserved and recognized, but they may be partially responsible for producing the commonly observed spongiform texture found in Holocene non-marine carbonate deposits throughout the Bahamas.

THE OSTRACOD GENUS *HEMINGWAYELLA*: A JOURNEY FROM MESOZOIC TO RECENT, NORTH TO SOUTH AND WARM TO COLD

Gabriela Cusminsky[1], Ana P. Carignano[2], Laura Ferrero[3], Daiane Ceolin[4] and Robin C. Whatley[5]

1. INIBIOMA-CONICET CRUB. Quintral 1250, San Carlos de Bariloche, 8400, Río Negro, Argentina. gcusminsky@gmail.com
2. División Paleozoología Invertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. CONICET, Argentina.
3. Instituto de Geología de Costas y del Cuaternario, UNMDP, Funes 3350, Mar del Plata, 7600, Argentina.
4. Universidade do Vale do Rio do Sinos (UNISINOS), Cristo Rei-Sao Leopoldo, RS, PO Box 275, Brazil.
5. Department of Geology, Institute of Earth Sciences, Aberystwyth University, Aberystwyth, Cardiganshire SY23 3DB, UK.

The cytheroid ostracod *Hemingwayella* Neale, a marine genus with a gondwanine distribution, was first described from the Upper Cretaceous (Santonian) of Western Australia, in sediments representative of a relatively warm and shallow shelf sea environments. In Argentina, Bertels described two species, *P. intensosulcata* [ex *Orthonotacythere*?] and *Paracytheridea rionegrina*, both of which can now be clearly seen to belong to a single species of *Hemingwayella*. This species was encountered in the Allen and Jaguel formations (upper Campanian to lower Danian) of the Neuquén Basin, which occurs in both the provinces of Neuquén and Río Negro and in similar inferred, essentially warm palaeoenvironments as the Western Australian species. Conversely, species such as *Hemingwayella pumilio* (Brady) and *H. antarctica* (Hartmann) were described from the Pliocene to Recent in Antarctic deep waters, shelf and littoral sediments of Argentina, Malvinas (Falklands) Islands and Brazil, and the southernmost parts of the Indian Ocean. There is also a possible record from the shelf of southwestern Africa. Despite the Argentinian Maastrichtian record, there are no subsequent Palaeogene occurrences. It is suggested, therefore, that this taxon after the K/P boundary, retreated to refugia which have not been sampled or have been destroyed by normal geological processes. Some of these refugia, however, supplied those populations which, as Lazarus taxa in South America and the Southern Ocean, have survived to the present day.

PALEOECOLOGY OF ORDOVICIAN GASTROPODS FROM THE GREAT BASIN, USA

Robyn Dahl[1] and Mary Droser[1]

1. Dept. of Earth Sciences, University of California, Riverside, 900 University Avenue, Riverside, CA 92521, USA.
robynmdahl@gmail.com

Gastropods are highly diverse and ecologically dominant in modern ocean ecosystems. While the clade is considered a key component of the Modern Evolutionary Fauna, its history stretches back into the earliest Paleozoic. Like most marine clades, gastropods diversified rapidly during the Ordovician Radiation event. Ordovician gastropods have been examined almost exclusively in a phylogenetic context, and while the diversity dynamics of this clade during the Ordovician Radiation is well-understood, the paleoecology of gastropods is not. To quantify the ecological roles that Ordovician gastropods occupied, we turned to the rich fossil assemblages of the Great Basin Region of the Western United States. This region serves as an ideal natural laboratory in which to study Ordovician gastropod paleoecology because of the broad range of depositional environments exposed and the long history of paleoecological research on this succession. For this study, we measured stratigraphic sections at eleven localities, collected bulk samples of each unique depositional environment represented at each locality, extracted and identified all gastropod specimens, and calculated relative abundance of gastropods in each depositional environment. Through this process, we were able to establish not only the depositional environments in which gastropods were present, but also which they flourished in. Results show that, contrary to general assumptions about the rarity of Ordovician gastropods, they are present in nearly all depositional environments examined, from outer carbonate shelf to shallow nearshore environments. Furthermore, while relative abundance of gastropods compared to other typical early Paleozoic fauna (brachiopods, trilobites) is low in most assemblages, gastropods dominate certain extreme environments (hypersaline shallow lagoon, deep restricted basin), suggesting that some gastropods may have been adapted to and flourishing in harsh environmental conditions. An understanding of the paleoecology of these earliest gastropods is necessary to understanding the evolutionary trajectory of this important marine clade.

FIRST RECORD OF A HIGHLY CHEMICALLY RESISTANT MACROPOLYMER IN CUTICLES OF *DICROIDIUM* AND *JOHNSTONIA*: A SECRET *ARMA PLANTARUM* AGAINST MASSIVE EXTINCTIONS?

José A. D'Angelo[1,2] and Erwin L. Zodrow[2]

1. IANIGLA-CCT-CONICET-MENDOZA and Área de Química, ICB, Universidad Nacional de Cuyo, M5502JMA, Mendoza, Argentina. joseadangelo@yahoo.com
2. Carboniferous Palaeobiology Laboratory, Cape Breton University, B1P 6L2, Sydney, Nova Scotia, Canada.

The high resistance to harsh chemical conditions and the refractory nature of cuticles of *Johnstonia coriacea* and *Dicroidium odontopteroides* (Corystospermaceae) are recorded for the first time. Additionally, a highly aliphatic, oxidation-resistant, cutin-like macropolymer obtained from the cuticle of *J. coriacea* is reported. Specimens of Upper Triassic strata (Cacheuta, Argentina) are preserved as (i) fossilized cuticles and (ii) coalified compressions. Changes in functional groups and microscopic structure of cuticle and cutin-like macropolymer as a function of Schulze's oxidation conditions were monitored via semi-quantitative Fourier transform infrared (FTIR) spectrometry, scanning electron microscopy, and optical microscopy. Specimens of *J. coriacea* preserved as fossilized cuticles (i.e., having a certain degree of natural oxidation) were subjected to an unprecedented oxidation time of 60 days. FTIR monitoring showed the following changes in functional groups with increasing oxidation time: a) considerable decrease of aliphatic groups, with increasing values of CH_2/CH_3 (i.e., longer and more branched aliphatic side chains), b) increase of C=O compounds and c) disappearance of aromatic groups. Morphological changes were minimal after the 60-day oxidation period. Schulze's oxidation of coalified compressions, using standard procedure (» 25^{o} C) and hot maceration (» 500^{o} C) yielded similar chemical and morphological results to those described above for fossilized cuticles. Results indicate that highly aliphatic geomacropolymers composing the cuticle of both *D. odontopteroides* and *J. coriacea* are extraordinarily resistant to high temperatures and harsh oxidative conditions. It is suggested that this geomacropolymer is likely related to the resistant biomacropolymer making up the cuticle of the once living plants. If confirmed, the high resistance of the ancient biopolymer could be associated with a physiological adaptation to surviving extreme conditions (e.g., hot and dry environments) as those proposed for Late Triassic times in southern Gondwana.

PROBLEMS USING CATEGORICAL VARIABLES WITH POPULAR INDICES OF FUNCTIONAL DIVERSITY MINIMIZED BY NEW METHODS ALLOWING DISCRETE CHARACTERS AND TRAIT UNCERTAINTY

Matt Davis[1]

1. Yale University, Department of Geology and Geophysics, PO Box 208109, New Haven, 06520, USA.
matthew.davis@yale.edu

Continuous indices of functional diversity like FD, FEve, and FRic provide better predictions of ecosystem processes than traditional discrete functional groups or guilds which is why these indices are being widely adopted by both paleontologists and neontologists for investigating community assembly, habitat fragmentation, extinction, and macroecological theory. For a functional diversity index to be useful to paleontologists though, it needs to operate on both continuous and discrete trait data and account for uncertainty in trait values as we rarely have accurate continuous measures of function for extinct taxa. Both paleontologists and neontologists frequently use Gower's distance to place discrete functional traits into a multidimensional space where continuous indices like FRic can be calculated. However, the effect of Gower's distance and discrete traits on functional diversity indices remains untested. Here, I present the results of simulations showing that, under common parameters, functional diversity indices created using discrete traits and Gower's distance rarely match expected values. I present new methods that minimize the inherent drawbacks of discrete data by coding the traits so they more closely reflect the underlying continuous distribution. To test the effect of including discrete characters, I created a simulation that took example datasets of community occurrence data and continuous functional variables and artificially discretized the traits. The functional diversity index values for each community obtained from the original continuous data with Euclidean distance and the artificially discretized data with Gower's distance were then compared. Agreement between categorical data and original continuous data did improve as traits were discretized into more ordered levels or a smaller proportion of traits were discretized. But overall, methods using Gower's distance and discrete traits performed poorly. Better results were obtained by using Euclidean distance on pseudo continuous variables made from discrete traits that were carefully coded into four or more values equally spaced across the hypothesized underlying continuous distribution of trait values. With pseudo continuous traits, results can be further improved by incorporating a trait uncertainty matrix with a parameter for each species-trait combination showing the level of trait variability due to uncertainty or natural intraspecific variation. Trait values are then drawn from a distribution of possibilities instead of one categorical value. With the high probability of erroneous results in current methods, I suggest the adoption of these new methods that minimize potential error and quantify our uncertainty about final index values.

INSIGHTS INTO THE LEAF CUTICLE FINE STRUCTURE OF GINKGOITES SKOTTSBERGII LUNDBLAD FROM THE ALBIAN OF PATAGONIA AND ITS RELATIONSHIP WITHIN GINKGOALES

Georgina M. Del Fueyo[1], Gaëtan Guignard[2], Liliana Villar de Seoane[1], Martín A. Carrizo[1] and Maiten A. Lafuente Díaz[1]

1. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia". - MACN. Av. Angel Gallardo 470, 1405 Buenos Aires, Argentina. georgidf@yahoo.com.ar

2. Université Lyon 1, F-69622, Lyon, France; CNRS, UMR5276, Laboratoire de Géologie de Lyon. Herbiers de l'Université Claude-Bernard Lyon 1, France.

During the Mesozoic, the Ginkgophytes were one of the most diversified and worldwide spread groups of gymnosperms that began radically to decline in the Cenozoic and nowadays are restricted to East Asia. In Argentina, the fossil record of the group can be traced back to the Carboniferous, represented by a few taxa although during the Mesozoic its diversity becomes higher. This richness is observed particularly in the Cretaceous of Patagonia where several vegetative and reproductive remains have been found. Among the first records, leaves of *Ginkgoites* Seward are remarkably abundant in number of species, having most of them well preserved cuticular features. In this contribution the leaf cuticle fine structure of *Ginkgoites skottsbergii* Lundblad recovered from the Kachaike Formation (Albian) at Bajo Comisión locality in Santa Cruz Province, Argentina, is described in order to compare it with those of other *Ginkgoites* and *Ginkgo*-like species and also, to find out its correct family affinity within Ginkgoales. The cuticle of *G. skottsbergii* was observed using both electron (SEM and TEM) microscopic techniques. *G. skottsbergii* has a simple, petiolate and amphistomatic leaf with deeply incised lamina up to 12 lanceolate-lineal lobes. Epidermal cells in both adaxial and abaxial surfaces vary from rectangular to isodiametric in shape; their anticlinal walls are pitted. Stomatal apparatuses are irregularly disposed; monocyclics to dicyclics with 6-8 papillate subsidiary cells overarching the pit while the guard cells are sunken. As several *Ginkgo* and *Gingkoites* taxa already studied at ultrastructural level, the cuticle of *G. skottsbergii* consists of a cuticle proper (divided in polylamellate A1 upper and lower zones, then granular A2 layer) and a cuticular layer (fibrilous B1 layer), however proportions of the layers are significantly distinct and therefore specific for this taxon. These results show that the leaf gross morphology and the cuticle fine structure of *G. skottsbergii*, are clearly different from those seen in other studied fossil species of *Ginkgoites*, *Ginkgo* and the living *G. biloba*. In addition, very well preserved cuticle in *G. skottsbergii* confirms the importance that this type of study has for the correct specific identification of this taxon. In Patagonia, during the Early Cretaceous two ginkgoalean lineages were already well established; the Karkeniaceae and the Ginkgoaceae represented by *Ginkgoites tigrensis* Archangelsky and *G. ticoensis* Archangelsky, respectively. In this contribution a new Patagonian member, *G. skottsbergii*, is added to the Ginkgoaceae, highlighting Patagonia as a key area for the development of the Ginkgoales. [Contribution to ANPCyT PICT 2012/528 and CONICET PIP 112-201201-00212].

NEW SEBECOSUCHIAN ZIPHODONT TEETH FROM THE GUABIROTUBA FORMATION, CURITIBA BASIN (PALEOGENE), SOUTHERN BRAZIL

Eliseu V. Dias[1] and Fernando A. Sedor[2]

1. Universidade Estadual do Oeste do Paraná, UNIOESTE - Campus de Cascavel, CCBS, Rua Universitária 2069, Cascavel - Paraná, CEP 85819-110, Brazil. eliseu.dias@unioeste.br

2. Museu de Ciências Naturais, Setor de Ciências Biológicas - Universidade Federal do Paraná, Campus do Centro Politécnico, Rua Cel. Francisco H. dos Santos n.100. Jardim das Américas - Curitiba - Paraná, CEP 81531-990, Brazil.

The Curitiba Basin belongs to the Cenozoic rift of southeastern Brazil that uplifted within basement tectonic depressions during the Paleogene. In this basin, the sediments of an alluvial fan system are called Guabirotuba Formation. The unpublished mammals found on this unit indicate middle Eocene to early Oligocene. The occurrence of a crocodilian tooth in the Guabirotuba Formation was recently noticed based on a single incomplete specimen. Field works in the same locality provided thirteen new specimens of ziphodont teeth and incomplete osteoderms, which are housed in the Museu de Ciências Naturais, Universidade Federal do Paraná. The teeth vary from almost rounded to very elliptical in cross-section in which the base also varies in size from 10 mm to 20 mm in the major axis; the length of the most complete specimen is around 30 mm and some specimens can reach estimated 45 mm long. Five of these teeth are almost straight with the anterior margin strait or slightly curved, and four presents both margins curved. Teeth margins show the sebesucochians ziphodont pattern represented by the presence of carenae with rounded tubercles (or denticles) covered by enamel. Observations under stereo microscope, SEM and CT-Scan reveal a very sharp and strait enamel ridge at the edge of the carenae. Between tubercles this enamel crest presents indentations which never separate them totally. These tubercles are shorter near the tip (apex) and increase in size to become twice longer near the tooth base. The studied teeth presents shallow basal pulpar cavities of around 1/10 of tooth shaft and this cavity closes (tighten up) suddenly; the other medial 5/10 there is not an open pulp cavity; distally, in the other 4/10 the pulp cavity appear in the CT-Scan as a very thin pulp canal. Near the base of the tooth, the dentine mineralization presents conspicuous growth lines. These configurations are also visible in a sample in which only a longitudinal half is preserved. The two known osteoderms are almost complete and presents the typical pit and ridges superficial pattern. The most complete, 20mm in length, also presents a central crest (keel) with 10mm height. Paleogene ziphodont crocodilians include pristichampsids and sebecosuchids, the only non-eusuchians that lived in the Paleogene. In the Cenozoic of Brazil, these crocodilians are also known from the Itaboraí Basin which is in the same rift system. These new specimens strengthen the presence of sebecosuchians in the Guabirotuba Formation and amplify their distribution in South America.

REDESCRIPTION OF *CLOUDINA LUCIANOI* (BEURLEN AND SOMMER), TAMENGO FORMATION, EDIACARAN, MATO GROSSO DO SUL STATE, BRAZIL

Dermeval A. Do Carmo[1], Matheus Denezine[1], Detlef Walde[1], Juliana R. Vasconcelos[1], Thaís C. Tobias[1], Edi M. Guimarães[1], Lucieth C. Vieira[1], Silane A. S. Caminha[2] and Paulo Z. Suarez[3].

1. University of Brasilia, Institute of Geosciences, Campus Universitário Darcy Ribeiro, Brasilia, DF, 70.910-900, Brazil. matheusdenezine@yahoo.com.br

2. Federal University of Mato Grosso, Department of General Geology, Avenida Fernando Correa da Costa, 2.367 Cuiabá, MT, 78.060-900, Brazil.

3. University of Brasilia, Institute of Chemistry, Campus Universitário Darcy Ribeiro, Brasilia, DF, 70.910-900, Brazil.

The genus *Cloudina* Germs has seven species restricted to Ediacaran strata: 1. *Cloudina lucianoi* (Beurlen and Sommer) (Tamengo Formation, Brazil), 2. *Cloudina hartmannae* Germs (Nama Group, Namibia), 3. *Cloudina riemkae* Germs (Nama Group, Namibia), 4. *Cloudina waldei* Hann and Pflug (Tamengo Formation, Brazil), 5. *Cloudina lijiagouensis* Zhang, Li and Dong (Yangtsé platform, China), 6. *Cloudina sinensis* Zhang, Li and Dong (Yangtsé platform, China), 7. *Cloudina carinata* Cortijo *et al.* (Spain). *Cloudina lucianoi* was originally attributed to the genus *Aulophycus* Fenton and Fenton and, later on, suggested as a member of *Cloudina*. Basically, *Cloudina* differs from *Aulophycus* in having cone within cone and lamellar exoskeleton instead of a tubular shaped skeleton. *Cloudina* species have records restricted to the Ediacaran, with extinction of all of them at the end of this period. Besides the rare number of publications, *Aulophycus* has been considered restricted to the Cambrian. New description, diagnosis and illustrations of *Cloudina lucianoi* are presented. Additionally, an updated stratigraphic approach and illustrations of the type-horizon of this species are included. A detailed comparison between the seven species is conducted in order to present a clearer diagnosis at the species level based on material recovered from Brazil.

VERTEBRATE FAUNAL TURNOVER AT THE CRETACEOUS/ PALEOGENE PARAÍBA BASIN MARINE DEPOSITS, NE BRAZIL

Rudah R. C. Duque[1], Aline M. Ghilardi[2], Marcia C. da Silva[3] and Alcina M. F. Barreto[1]

1. Universidade Federal de Pernambuco (UFPE), Centro de Tecnologia e Geociências, Departamento de Geologia, Av. Acadêmico Hélio Ramos s/n, Cidade Universitária, Recife, PE, 50750, Brazil. rudah_cd@hotmail.com

2. Universidade Federal do Rio de Janeiro (UFRJ), CCMN, Departamento de Geologia, Av. Athos da Silveira Ramos, 274, Bloco G, Ilha do Fundão, Rio de Janeiro, RJ, 21949-900, Brazil.

3. Núcleo da Biologia, Universidade Federal de Alagoas (UFAL) - Campus Arapiraca, Av. Manuel Severino Barbosa, s/n, Bom Sucesso, Arapiraca, AL, 57309-005, Brazil.

The Paraíba Basin is located in the coastal region of the states of Paraíba and Pernambuco, Northeastern Brazil. Its origin is related to the opening of the South Atlantic Ocean and its sedimentary sequence stands out as it includes records of the Cretaceous/Paleogene transition. The basin is divided into the Beberibe (Turonian-Campanian/Late Cretaceous), Gramame (Campanian-Maastrichtian/Late Cretaceous) and Maria Farinha (Danian/Paleogene) formations. The present work aimed to investigate the paleovertebrate faunal change at the Cretaceous/Paleogene transition in the context of the highly fossiliferous marine Gramame and Maria Farinha formations. The lower part of the Gramame Formation consists on marine calcareous sandstones and phosphorites, and the upper part of marine limestones and calcareous claystones. The Maria Farinha Formation sits just above the Gramame Formation and is formed by marine limestones, marls and clays. The fossils studied belong to the Universidade Federal de Pernambuco paleontological collection and were prospected over more than 50 years, forming a vast assembly. From more than 230 fossils analyzed, it was possible to recognize 33 different taxa from both geological units, represented by isolated teeth and various bony elements. The Gramame Formation contains at least nine species of Condrichtyes, eight of Osteichtyes, one Crocodylomorpha, five Mosasauridae, two Plesiosauria and one pterosaur. The Maria Farinha Formation holds eight species of Condrichtyes, five of Osteichtyes, one Testudines and one Crocodylomorpha. It can be observed that some species surpassed the K/Pg barrier, all of them fishes (*Cretolamna biauriculata*, *Cretolamma appendiculata, Squalicorax pristodontus*, *Enchodus elegans*, *Enchodus lybicus* and *Enchodus oliveirai*), while others disappear from the register. The number of species was reduced from 26 in the Cretaceous to 15 in the Paleogene, which means a 42.3% species richness loss. The Sørensen Similarity Index between the two taphocoenosis shows a low similarity at species (0.36) and family level (0.38), the reason being mostly because of the absence of large marine reptiles and pterosaurs in the later stratigraphic unit (these groups are known to have disappeared from the fossil record all over the world at the K/Pg boundary), and also some fish groups. In general, the taxa occurring in the Gramame Formation indicate a deeper marine environment such as the external shelf, while the vertebrate paleofauna of the Maria Farinha Formation is more associated with a shallower scenario. The observed difference between them, therefore, may be explained not only by extinctions, but also because they represent different deposition environments.

REDISCOVERING THE BRAZILIAN *DICROIDIUM* FLORA: A "FOSSIL-LAGERSTÄTTE" IN RED BEDS?

Tânia Lindner Dutra[1] and Ronaldo Barboni[1]

1. Graduation Program in Geology - PPGEO, Vale do Rio dos Sinos University-UNISINOS, Av. Unisinos, 950, 93022-000, São Leopoldo, Rio Grande do Sul, Brasil. tdutra@unisinos.br

New geological prospects in the Triassic, *Dicroidium*-bearing red bed successions of southernmost Brazil, allow the restatement of the type section of the Passo das Tropas Member (Santa Maria Formation). Our survey attests the unexpected diversity and conservation status of fossils, with cuticle impressions preserved in the interior of iron hydroxide wrappers covering the fossil leaves. The iron wrappers could be originated by bacterial action. We found nearly complete fronds of *Dicroidium* and its allies, and many reproductive structures. We also verified conspicuous insect-plant interactions. Insect wings, isolate fish scales, and conchostracans are minors constituents of the fossil assemblage. The fossils were recovered from two meters thick lacustrine, silt and mud laminated section, interbedded with fluvial (braided) deposits. *Dicroidium* remains are dominant. Gynkgoaceae are the second group in importance, followed, as minor components, by *Taeniopteris, Pseudoctenis,* and conifers (*Rissikia*, *Heidiphyllum*). Our findings expand the records of *Xylopteris*, *Zuberia*, and *Jhonstonia*. Well-preserved male and female reproductive structures include forms referred to the corystosperms (*Pteruchus*, *Umkomasia, Fanerotheca*), and the Gynkgoaceae (*Hamshawvia*, *Stachyopitys*). There are also isolated seeds. The presence of *Dicroidium switzifolium* and *D. helvetifolium,* allows us to refer the fossil assemblage to the Middle/ basal Late Triassic. The taphoflora reflects the existence of different habitats (*i.e.*, uplands, riverbanks) and a seasonal warm climate. [Contribution to grants of CNPq and PROSUP/CAPES].

ONTOGENY OF THE SPECIES OF *SCABROTRIGONIA* FROM THE MAASTRICHTIAN RIPLEY FORMATION, USA

Javier Echevarría[1]

1. CONICET – División Paleozoología de Invertebrados, Museo de la Plata, FCNyM, UNLP, Paseo del Bosque s/n, 1900 La Plata, Argentina. javierechevarria@fcnym.unlp.edu.ar

The ontogeny of the species *Scabrotrigonia thoracica* (Morton), and *Scabrotrigonia eufaulensis* (Gabb) from the Ripley Formation (Maastrichtian from McNairy county, Tennessee) is explored here. A geometric morphometric analysis of the shell in lateral view was performed, using as landmarks the umbo and the intersections of the posterior margin with the boundaries between the area and the escutcheon and flank. The ventral margin and both boundaries of the area were digitized by semi-landmarks. Flank costae disposition on the flank-area boundary was also analyzed by means of the ordinary least squares regression coefficients obtained from the log-transformed values of distance from each costae to the umbo (x) and the log-transformed values of distance from each costae to the next costae (y). Two stages of shell shape development in lateral view can be recognized in *S. eufaulensis*: the first one shows a strong reduction of area surface together with some elongation of the shell, while the second one is marked by dorsal incurvature of the shell, responding to an increase on the tangential growth component of the shell. This development is remarkably similar to that found in *Myophorella garatei* Leanza, probably indicating a common developmental pattern among rostrate myophorelloids. The smaller individuals of *S. thoracica* that could be identified are very similar in shell shape to some of the larger individuals on the first stage of development of *S. eufaulensis*, suggesting a shared first stage of development; nevertheless, shell shape tends to differ in larger specimens, resulting in a less incurved area in *S. thoracica* but with a change in posterior margin attitude (resulting in a smaller angle with the dorsal margin). This suggests a later increment of the tangential growth component. Regarding costae disposition on the flank, *S. thoracica* shows higher values of slope (implying anterior costae more densely disposed and posterior costae more loosely disposed) and intercept (indicating less densely disposed costae) than *S. eufaulensis*. Both indices seem to be correlated, although not all samples behave the same way: some of them seem to follow such correlation, whereas others do not. A detailed analysis considering the accurate stratigraphic provenance of the samples should help to better understand the evolution of the characters studied here in these two closely related species.

PALEOBIOLOGICAL ASPECTS OF AN EARLY JURASSIC *EQUISETUM* SPECIES FROM PATAGONIA, ARGENTINA

Andres Elgorriaga[1], Ignacio H. Escapa[2], Benjamin Bomfleur[3], Rubén N. Cúneo[2] and Eduardo G. Ottone[4]

1. Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón 2, Ciudad Universitaria, C1428EHA, Buenos Aires, Argentina. aelgorriaga@gmail.com

2. Consejo Nacional de Investigaciones Científicas y Técnicas, Museo Paleontológico Egidio Feruglio, Avenida Fontana 140, Trelew 9100, Chubut, Argentina.

3. Department of Palaeobiology, Swedish Museum of Natural History, P.O. Box 50007, SE-104 05 Stockholm, Sweden.

4. Instituto de Estudios Andinos Don Pablo Groeber-Consejo Nacional de Investigaciones Científicas y Técnicas, Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón 2, Ciudad Universitaria, C1428EHA, Buenos Aires, Argentina.

Equisetaleans are a nearly worldwide-distributed group of plants that can be traced up to the Devonian. Their abundance reached a peak in the Carboniferous, when they were main constituents of swamp ecosystems. In present days, the equisetaleans are represented by a single herbaceous genus, *Equisetum*, with 2 subgenera and 15 species. Fossil species assigned to *Equisetum* can be traced back into the Late Triassic or Early Jurassic. In the present work we describe a new species from the Early Jurassic of Cerro Bayo, Chubut Province, Argentina. Assignment to *Equisetum* is suggested on the base of numerous reproductive and vegetative features, which allowed an almost complete reconstruction of the plant. The detailed description and interpretation of this species revealed different paleobiological aspects of basal *Equisetum* representatives. For instance, the Patagonian specimens bears two types of foliage, one bearing leaf whorls composed by a basal sheath and short free tips, and a second type bearing long free tips. Interestingly, the second type of leaf whorls is exclusively disposed on reproductive stems, suggesting a morphological trend in evolution of the Equisetales leaves. Another distinguishing feature of this species is the presence of pagoda-like structures placed at the apex of the stems. The pagodas are formed by tightly packed leaf whorls, following a peculiar sequence of development. It is interesting to note that this diagnostic feature has been considered as an autopomorphy for the extant *Equisetum hyemale*, while with its presence on the new Jurassic species suggests this character may actually represent a plesiomorphy for the group. Finally, the presence of two morphologically distinct transverse views of the nodes is also a remarkable feature of the new species. A central pitted diaphragm characterizes the first type, while the second type shows a cart-wheel structure with scalloped margins. The structural relationship between these two different transversal views and its relationships with the vascular tissues is shown, at the time that a reconstruction is proposed. Altogether, the better understanding of these and additional features (e.g., stomata morphology and distribution, branch pattern) suggest the presence of a new subgenus of *Equisetum.* Future phylogenetic analyses are required to confirm the presence of this worldwide distributed Jurassic subgenus, which would include additional species such as *Equisetum laterale* and *Equisetites ferganensis.* In addition, a better knowledge on the basal representatives of the genus may allow for a better interpretation of its relationships in the context of the Equisetales evolution.

SOME TAPHONOMIC FEATURES OF THE CARBONATIC-SILICICLASTIC SUCCESSION OF THE PIRABAS FORMATION (MIOCENE), SALINÓPOLIS, PARÁ, BRAZIL

Fernando Erthal[1], Afonso C. R. Nogueira[1], Franco F. O. Costa[1], Francisco R. Abrantes Jr.[1], José B. C. Silva Jr.[1] and Joelson L. Soares[1]

1. Universidade Federal do Pará, Instituto de Geociências, Grupo de Análise de Bacias Sedimentares da Amazônia – GSED, Av. Augusto Corrêa, n° 1, Guamá, Belém, Pará, CEP: 66075-900, Brazil. fer.erthal@gmail.com

Biclastic rudstones and packstones predominate in the carbonatic-siliciclastic succession of the Miocene Pirabas Formation, exposed at the Atalaia beach, Salinópolis Municipality (Northeastern Pará State, Brazil). Greenish and greyish shales are also present; the paleoenvironments are interpreted as lagoon, mangrove and shallow marine shelf deposits, partly influenced by storms. This study aims to determine its preservation potential, and to test the utility of the invertebrate fauna as a tool for facies and paleoecological analysis. The main biostratinomic features seen in the bioclastic rudstones and packestones were: necrolysis, orientation, articulation, fragmentation, corrosion, encrustation, volume of bioclasts, packing, size sorting, and geometry of the fossil-bearing sedimentary bed. Facies description along with biostratinomic characterization allowed recognizing two main taphofacies. Taphofacies 1 consists of fossil concentrations represented by bioclastic rudstones and packstones of tabular geometry, bioclast-supported (95%) dominated by bivalve and gastropod carapaces, with grain size varying from gravel to coarse sand in a carbonate matrix. A dense concentration of fragmented, disarticulated shells, poorly-selected and randomly distributed in the frame (residual deposit) marks this taphofacies. The microfacies packstone is grain-supported (76%), with 54% of bioclasts and 22% of siliciclastics, 10% of microcrystalline calcite matrix and 10% of calcite spar cement. The grains are mostly bioclasts: bivalve and gastropod shells, foraminiferan tests, fragmented echinoid plates and red algae. Taphofacies 2 is marked by inferred life-positioned individuals, included in the rudstone strata. The gastropod *Turbinella tuberculata* and the bivalve *Mercenaria prototypa* dominate this biofacies. The gastropods, with a predominantly benthonic life mode, are found with their single-valved shell with aperture facing downwards (in contact to the substrate). Similarly, individuals of *M. prototypa*, of putative epibenthonic life mode, were observed with their shells closed and perpendicular to the bedding plane. It is here interpreted that both mollusks are preserved in life position. Finally, we suggest that the genesis of the identified taphofacies be associated with a neritic environment with episodic storm events, which generated oscillatory or combined flows of NW-SE direction. The high energy events might have eroded the shelf bottom generating disarticulation and fragmentation of exhumed valves (event 1), forming firmgrounds or hardgrounds as a consequence (Taphofacies 1). Stable environmental energy might have allowed the colonization of those firm/hardgrounds by *T. tuberculata* and *M. prototypa*, which were catastrophically buried in a second event of rising energy (event 2) with substrate reworking and preservation of individuals in life position (Taphofacies 2).

MICROBIALLY INDUCED SEDIMENTARY STRUCTURES AND A TRACE FOSSIL FROM THE TRÊS MARIAS FORMATION: AN EARLY CAMBRIAN AGE FOR THE UPPERMOST BAMBUÍ GROUP OF BRAZIL?

Thomas R. Fairchild[1], Evelyn A. M. Sanchez[2] and Alexandre Uhlein[3]

1. Instituto de Geociências, Universidade de São Paulo, Rua do Lago, 562, São Paulo, SP, 05508-080 Brazil. trfairch@hotmail.com

2. Instituto de Geociências, Universidade Federal de Minas Gerais, Avenida Antonio Carlos, 6627, Pampulha, Belo Horizonte, MG, 31270-901 Brazil.

Here we report microbially induced sedimentary structures (MISS) and an apparent trace fossil from reddish siltstones near the base of the Três Marias Formation, uppermost unit of the Bambuí Group, traditionally considered as Neoproterozoic from Três Marias, Minas Gerais, Brazil. MISS comprise evidence of superficial microbial mats in siliciclastic rocks and are here represented by aligned and interconnected pustules, wrinkle marks and elephant skin. The apparent ichnofossil is preserved in positive hyporelief over an area of about 15 cm by 4.5 cm and has the same lithology as the overlying sediment. It consists of straight to curved segments 2 to 5 mm wide and 1.7 to 4 cm long joined in-line or slightly offset to form a slightly curved main axis with a few acutely branching projections 0.9 to 2 cm long. Although only one specimen was recovered, its similarity to members of the ichnogenus *Treptichnus,* known from the early Cambrian, lends credence to recent claims for a very young Ediacaran age for rocks near the base of the Bambuí Group. Despite an age determination of 740 ± 22 Ma (Pb-Pb method) for the cap carbonate at the base of the Sete Lagoas Formation, the basal unit of the Bambuí Group, detrital zircons from the top of this formation have yielded ages of ≥557 Ma and 650 Ma in the southern and northern parts of the basin, respectively. Our finding is consistent with the recent discovery of the latest Ediacaran index fossil *Cloudina* from this same Sete Lagoas Formation in the northern part of the basin that strongly suggests a much younger age for the Bambuí Group than traditionally thought. To prove that the Precambrian-Cambrian boundary may be present somewhere in the Bambuí Group between the Sete Lagoas and Três Marias formations, however, will require corroboration of the presence of *Treptichnus* in the Três Marias Formation or the discovery of other fossils typical of the latest Ediacaran or earliest Cambrian.

PALEOENVIRONMENTAL RECONSTRUCTION OF THE MAR CHIQUITA COASTAL PLAIN (BUENOS AIRES PROVINCE, ARGENTINA) DURING THE HOLOCENE

Rocío Fayó[1,2], José Bedmar[1,2], Federico I. Isla[1,2] and Marcela A. Espinosa[1,2]

1. Instituto de Geología de Costas y del Cuaternario. Universidad Nacional de Mar del Plata, Funes 3350, Mar del Plata, 7600, Argentina. gully_rochi@hotmail.com

2. Instituto de Investigaciones Marinas y Costeras. CONICET/UNMdP. Funes 3350, 7600 Mar del Plata, Argentina.

Diatom assemblages of a core from Mar Chiquita coastal lagoon area, Buenos Aires Province, Argentina, were analyzed in order to recognize environmental changes in term of salinity and depth. The core contains sediments that range in age from 5,802±70 ^{14}C years BP (6,751-6,440 cal years BP) to present times, and it was obtained using vibracoring techniques, in a site north of the lagoon (37°23′39″S, 57°9′33″W). Four sedimentary facies were defined according to different characteristics such as grain size distribution, macrofossil content, sedimentary structures (when present) and general aspect. From bottom to top they were: greenish-grey silt, brownish-grey sandy silt, heterolithic facies (showing flasser bedding) and brown sandy silt. Two diatom zones were characterized by cluster analysis (single linkage, Euclidean distance) in the fossil sequence. Fossil and modern diatom assemblages were compared with multidimensional scaling (MDS). Two hundred diatom species were identified and grouped based on their salinity tolerances and life form characteristics. The lower section of the sequence (Zone 1) was dominated by *Paralia sulcata* (Ehrenberg) Cleve and *Psammococconeis* cf. *disculoides* (Hustedt) García, both tychoplanktonic and marine/brackish species. They were accompanied by marine and marine/ brackish plankton, epipsammon and epiphyte diatoms. This assemblage indicates a coastal environment with significant marine influence. To the top, the marine influence and the depth decrease. Salinity decrease was showed by the abrupt reduction of *P. sulcata* and the presence of brackish species like *Planothidium delicatulum* (Kützing) Round and Bukht (epiphytic) and brackish/freshwater species like *Hippodonta hungarica* Grunow, *Staurosirella pinnata* (Ehrenberg) Williams and Round, and *Staurosira venter* (Ehrenberg) Kobayasi. This assemblage is typical of tidal marshes. The shallower environment was inferred by the increase of benthic and epiphytic species. Furthermore, the results of MDS showed that fossil diatom assemblages were similar to the modern diatom assemblages located at the inlet of the Mar Chiquita coastal lagoon. The new diatom and sedimentological data presented here support the regional model for the Holocene sea-level fluctuation in this area. These analyses allowed us to infer the existence of a marginal coastal system in the area during the regressive phase close to the maximum sea-level after 6,500-6,000 years BP. This coastal environment evolved gradually into a brackish/freshwater marsh from the final regressive state until today.

FOSSIL POLLEN AND SPORES FROM THE EOCENE RÍO TURBIO FORMATION, SANTA CRUZ PROVINCE, ARGENTINA

Damián A. Fernández[1], Viviana D. Barreda[1], Luis Palazzesi[1] and María C. Tellería[2]

1. CONICET-Sección Paleopalinología, MACN "B. Rivadavia", Ángel Gallardo 470 (C1405DJR) CABA, Argentina. dafernandez@macn.gov.ar

2. CONICET-Laboratorio de Sistemática y Biología Evolutiva (LASBE), Museo de La Plata, UNLP, Paseo del Bosque s/n° (B1900FWA) La Plata, Argentina.

We present a diverse and well preserved palynological assemblage from the Río Turbio Formation, mid-late Eocene, SW Santa Cruz Province, Argentina. The region supports at the present time a low diverse southern beech forest dominated by *Nothofagus antarctica* (Forster) Oersted. The palynological assemblage preserved in the Río Turbio Formation includes marine and continental palynomorphs. Spores of fungi and ferns, together with pollen of angiosperms and gymnosperms, were abundant and diverse. Within fern families, Cyatheaceae/Dicksoniaceae/Schizaceae, Osmundaceae, and Gleicheniaceae were represented. Within angiosperms, pollen of Nothofagaceae (*Nothofagidites* spp.), Myrtaceae (*Myrtacidites* spp.), and Proteaceae (*Cranwellipollis* sp., *Propylipollis* sp., *Proteacidites* sp.) were dominant in the assemblage. Pollen assigned to two pairs of phylogenetically unrelated genera (*Nothofagus*/*Misodendrum* and *Prosopis*/*Tripodanthus*) may trace back the host-parasite interaction between them to the Eocene. The gymnosperm record is dominated by Podocarpaceae, and specially, by pollen similar to extant *Podocarpus* (*Podocarpidites rugulosus* Romero, *P. elegans* Romero), *Lagarostrobus* (*Lepidothamnus* sp.) and *Phyllocladus* (*Phyllocladidites mawsonii* Couper). Overall, the spore/pollen assemblage includes more than 54 morphotypes (rarefied at a count of 300 specimens), suggesting a highly diverse paleoflora developed during mid-late Eocene times. This interval coincides with a period of pronounced global warming recorded at middle to high latitudes in both hemispheres. Fossil plants preserved in the Río Turbio Formation are represented today by groups confined to temperate and subtropical/tropical rainforest in lower latitudes of South America as *Ilex* (*Ilexpollenites* sp.), *Cupania* (*Cupanieidites* sp.), and members of the Malpighiaceae (*Perisyncolporites pokornyi* Germeraad, Hooping and Muller), Bombacaceae (*Bombacacidites* sp.), and Arecaceae (*Arecipites* sp., *Mauritiidites* sp.), together with typical taxa of dry, sclerophyll forests of northern Argentina as *Prosopis* sp.

EVOLUTION OF TARSAL MORPHOLOGY AND WEIGHT SUPPORT IN GLYPTODONTS (MAMMALIA XENARTHRA, CINGULATA)

Juan Carlos Fernicola[1,2,3], Néstor Toledo[1,4], M. Susana Bargo[4,5] and Sergio F. Vizcaíno[1,4]

1. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina. jctano@yahoo.com
2. Paleontología de Vertebrados, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Ángel Gallardo 470, Ciudad Autónoma de Buenos Aires, C1405DJR, Argentina.
3. Departamento de Ciencias Básicas, Universidad Nacional de Luján Ruta 5 y Avenida Constitución - Luján, 6700, Buenos Aires, Argentina.
4. División Paleontología Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina.
5. Comisión de Investigaciones Científicas, Buenos Aires, Argentina.

Glyptodonts (middle Eocene-late Pleistocene/early Holocene) are a unique group of placental mammals that evolved in America, characterized by a dorsal carapace and elephantine hind-feet, among other features. During the late Pleistocene, these herbivorous animals reached gigantic sizes, varying between 500 kg and two tons. In the early twentieth century, Scott described the foot of the Miocene *Propalaehoplophorus* (~ 80 kg), emphasizing that the relationships among the tarsal elements were different from those observed in the larger Plio-Pleistocene glyptodonts. A reexamination of the relationships among the tarsal elements of glyptodonts, their sister-group pampatheres, and armadillos is presented here. Within glyptodonts, the tarsal elements of *Propalaehoplophorus*, and the Pleistocene *Glyptodon* (800-2000 kg), *Neosclerocalyptus* (600 kg), *Doedicurus* (1500 kg) and *Panochthus* (1000 kg) show a unique articular pattern, where the distal facet of the lateral cuneiform articulates with both metatarsals III and IV. In the Pleistocene pampathere *Holmesina* (180 kg), the extinct armadillos *Proeutatus* (Miocene; 15 kg) and *Eutatus* (Pleistocene; 50 kg), and the extant *Chaetophractus* (4 kg), *Priodontes* (45 kg) and *Dasypus* (2.5 kg), this facet articulates only with metatarsal III. The arrangement in glyptodonts allowed a greater interlocking of the midtarsal segment of the foot, and would enable a more widespread distribution of the weight loads from astragalus to I, II, III and IV digits. The digits IV and V, also receive loads indirectly from calcaneum via the cuboid. In pampatheres and armadillos, the weight loads from talus distribute via the navicular and cuneiforms only to digits I, II and III, while digits IV and V receive loads indirectly from calcaneum via the cuboid. At a first glance, this pattern appears as independent from body size because *Holmesina* is larger than the basal glyptodont *Propalaehoplophorus*. However, this articular pattern shows variation throughout the glyptodont clade, concurrent with the increase in body size evidenced by this group from the Miocene to the Pleistocene. The articular contact between the ectocuneiform and the metatarsal IV increases from 1/5 of the distal facet of the cuneiform in the smaller Miocene taxa, to 1/2 of the facet in more derived and larger Pleistocene genera (*Glyptodon, Neosclerocalyptus*, *Doedicurus* and *Panochthus*). Although it seems clear that this arrangement was not to support a large body size in Miocene glyptodonts, it enabled the developing of giant body sizes along the evolution of the group.

EARLY JURASSIC MARINE GASTROPODS FROM ARGENTINA: VETIGASTROPODA FROM THE NEUQUÉN BASIN AND THEIR PALAEOBIOGEOGRAPHICAL SIGNIFICANCE

Mariel Ferrari[1] and Susana Damborenea[2]

1. CONICET, Museo Paleontológico EgidioFeruglio, Av. Fontana, 140. U9100GYO, Trelew, Chubut, Argentina.

2. CONICET, Departamento Paleontología Invertebrados, Museo de Ciencias Naturales, UNLP, Paseo del Bosque s/n, A1900FWA La Plata, Argentina. sdambore@fcnym.unlp.edu.ar

Gastropod species are represented in the Early Jurassic of Argentina by four major taxa: Vetigastropoda, Caenogastropoda, Ptenoglossa and Opisthobranchia. The present approach aims at the characterization of eight vetigastropod species from the Early Jurassic marine deposits of the Neuquén basin: *Proconulus* sp., *Chartronella* sp., *Guidonia* sp., *Ambercyclus* sp. 1, *Ambercyclus* sp. 2, *Discohelix* sp., *Ptychomphalus* sp. 1 and *Ptychomphalus* sp. 2. Other three previously described vetigastropods are reported for the first time in the area: *Chartronella gradata* Ferrari, *Ataphrus mulanguiniensis* Ferrari and *Colpomphalus*? aff. *musacchioi* Ferrari, extending also their palaeobiogeographical distribution in the Andean region of Argentina. *Lithotrochus humboldtii* (von Buch), *Lithotrochus rothii* Damborenea and Ferrari, *Ptychomphalus* sp., and an undetermined ataphrid species are also known from marine beds in the Neuquén basin. A quantitative palaeobiogeographical analysis was performed, integrating the available systematic data of all Early Jurassic marine vetigastropod species recorded thus far from Argentina. The data include members of 11 vetigastropod families recorded from 28 marine localities in the Neuquén and Chubut basins. The primary results of the analysis indicate that for the late Pliensbachian-early Toarcian interval two palaeobiogeographical units can be recognized in the Andean region of Argentina, in the Neuquén and Chubut basins respectively. The vetigastropod distribution patterns and local high endemism in both areas of the Andean region of Argentina are most probably related to an independent and separate evolution of the Neuquén basin (*s.s.*) since the early Hettangian to the early Pliensbachian, and the absence of marine deposits in Chubut at that time. However, a shallow marine connection between the Neuquén and Chubut basins during the late Pliensbachian-early Toarcian through the Palaeo-Pacific seaway may explain the coincident occurrence of some vetigastropod species in both palaeogeographical areas. These new and updated taxonomic data greatly improve our palaeobiogeographical knowledge along the Andean region of South America and the southern hemisphere.

NEW DATA ON THE INTERNAL CONSTRUCTION OF *TERGOBULASPORITES* AND *CRUMENASPORITES* MIOSPORES FROM THE FAMENNIAN OF RUSSIA

Paweł Filipiak[1]

1. The University of Silesia, Department of Earth Sciences, Będzińska 60 Str. 41-200 Sosnowiec, Poland.
filipiak@us.edu.pl

Samples from the Famennian section of the Russkiy Brod Quarry (Central Devonian Field, Russia) yielded very well-preserved palynomorph assemblages strongly dominated by miospores, accompanied by some prasinophyte and single acritarch taxa. Based on the presence of key species, the early Fammenian CZ (*Cyrtospora cristifer-Diaphanospora zadonica*) miospore zone was recognized. The assemblage is characterized by the presence of: *Bulbosisporites volgogradicus*, *Chelinospora lepida*, *Corbulispora vimineus*, *Cyrtospora crystifer*, *Converrucosisporites curvatus*, *Cristatisporites trivialis*, *Crumenasporites monosaccus*, *Diaphanospora macrovarius*, *D. zadonica*, *Diducites radiatus*, *Geminospora notata* var. *macrospinosus*, *G. vasjamica*, *Grandispora subsuta*, *Hystricosporites pleiomorphus*, and *Kedosporis evlanensis*. High frequency of *Tergobulasporites immensus* allows recognition of the *Convolutispora zadonica* (Za) subzone (upper part of the CZ Zone). This can be correlated with the standard *crepida* conodont zone. *Tergobulasporites immensus* and *Crumenasporites monosaccus* have been described as gulate, two-layered pseudosaccate miospores. The exceptional preservation of the Russkiy Brod Quarry microflora allows the recognition of new and important details in the miospore internal construction. These species possess strongly developed labra, a more or less developed pseudosaccus, and their polar axis is longer than the equatorial. The specimens studied herein display an additional, third layer, encompassing the central body. This internal layer is often folded and hidden, especially by the (darker) external exospore layers. The complete wall is constructed of three separated layers: the thin internal intexine separated from the thicker exoexine and the outermost layer (perispore?) creating the distal sac. The presence of a complex, three-layered wall, a characteristic shape, and prominent labra supports some earlier hypothesis that, in spite of their relative small size (<200 μm), considered these miospore genera, as megaspores. [Contribution to the NCN grant 2011/01/B/ST10/00576 (MZ)].

A NEW THEROPOD ASSEMBLAGE FROM THE LATE CRETACEOUS OF WESTERN GONDWANA, LA RIOJA PROVINCE, ARGENTINA

Lucas E. Fiorelli[1], Martín D. Ezcurra[2], E. Martín Hechenleitner[1], Diego Pol[3] and Gerald Grellet-Tinner[1]

1. Centro Regional de Investigaciones Científicas y Transferencia Tecnológica La Rioja (CRILAR - CONICET). Entre Ríos y Mendoza s/n., Anillaco, 5301 La Rioja, Argentina. lucasfiorelli@gmail.com

2. School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham, UK.

3. Museo Paleontológico Egidio Feruglio, Avenida Fontana 140, Trelew, 9100 Chubut, Argentina.

Late Cretaceous vertebrate assemblages are well known in southern Argentina, but they are considerably less sampled in the north of the country. Indeed, Cretaceous dinosaur-bearing beds in La Rioja Province (NW Argentina) were virtually unknown until the discovery in 2007 of dinosaur eggshells and subsequently the Sanagasta sauropod-nesting site in beds of the Los Llanos Formation. Recent field work in the Tama locality of this unit resulted in the discovery of a new and diverse terrestrial vertebrate assemblage in a semi-arid palaeoenvironment with an active eolian sedimentation. These vertebrate remains are associated with Late Cretaceous microfossils (ostracods and charophytes) and include turtles, notosuchian crocodyliforms, and titanosaur, ornithischian and theropod dinosaurs. Four theropod specimens (CRILAR-Pv 501, 503, 505, 524) have been collected and their phylogenetic affinities are reported here. CRILAR-Pv 501 is represented by a partial left frontal and fragments of both prootics. This specimen is assigned to Abelisauridae because it possesses a dorso-ventrally thick frontal with a coarse dorsal ornamentation, formed by low tubercles, and a median fossa between both supratemporal fossae. The prootics preserve partial natural casts of the innear ear and the osteological correlate of a small flocculus, which may represent an additional abelisaurid apomorphy. CRILAR-Pv 524 consists of a partial pelvic girdle that was found in association with CRILAR-Pv 501 and may belong to the same individual. In agreement, this pelvic girdle resembles that of abelisaurids in the presence of co-ossified bones and a straight dorsal margin of the ilium. CRILAR-Pv 503 includes the proximal end of a right pubis and fragments of femoral, tibial, and fibular shafts. This specimen is assigned to Maniraptora because it possesses a preacetabular tubercle and lacks a pubic apron on the proximal half of the bone. Lastly, CRILAR-Pv 505, a distal end of tibia with a weathered, articulated astragalus, is interpreted as an indeterminate averostran because of the presence of anteriorly projected condyles on the astragalar body. Within Averostra, this specimen resembles some abelisauroids, megaraptorans and coelurosaurs in the absence of a distinct step for the reception of the ascending process of the astragalus on the anterior surface of the tibia. The taxonomic composition of the theropod assemblage of the Los Llanos Formation contains theropod groups recorded in other Jurassic-Cretaceous beds of Gondwana and, as a result, is consistent with the Late Cretaceous dating of the unit recently suggested by micropalaeontological evidence and not with previous claims of a Cenozoic age.

LOST AND FOUND: REDISCOVERY OF DE RYCKHOLT'S COLLECTION OF CRETACEOUS MOLLUSCA (BELGIUM AND N. FRANCE)

Valentin Fischer[1,2], Julien Denayer[1,3] and Bernard Mottequin[1,2]

1. Geology Department, University of Liege, Allée du Six-Août, B18, Sart Tilman, 4000 Liège, Belgium. v.fischer@ulg.ac.be
2. Earth and History of Life O.D., Royal Belgian Institute of Natural Sciences, 29 Rue Vautier, Brussels 1000, Belgium.
3. School of Earth Sciences, University of Queensland, Australia.

De Ryckholt's publications rank among the first monographs dedicated to Cretaceous invertebrate faunas from Western Europe and need to be thoroughly re-evaluated. But, until now, the revision of his systematic studies was impossible because large parts of the described and/or illustrated material were considered lost. De Ryckholt's studies remain largely unknown to the paleontological community because his publications are very rare. As a consequence, much of these rich assemblages have not been thoroughly studied since de Ryckholt's original publications, and constitute an unprecedented opportunity to investigate the taxonomy and diversity of Late Cretaceous mollusks. A significant part of the Cretaceous (Cenomanian, Campanian and Maastrichtian) collection of gastropods and bivalves, which were described and/or illustrated in de Ryckholt's *Mélanges paléontologiques* between 1854 and 1862, has been recently recovered from the historical collections of Liège University. This is an important step for future research on Cretaceous invertebrates from Western Europe as de Ryckholt's collection, currently contains more than 206 specimens, including 194 name-bearing types (lectotypes and genotypes). Through the first two volumes of the *Mélanges Paléontologiques*, de Ryckholt described and figured *c.* 75 gastropod species (from the Devonian, Carboniferous, Jurassic and Cretaceous), six Palaeozoic bellerophontids, *c.* 160 Devonian to Paleogene bivalve species, six Devonian to Paleogene vermes species, 10 Devonian and Carboniferous brachiopod species, 10 Devonian, Carboniferous and Cretaceous scaphopod species, two Carboniferous polyplacophorans and one Devonian conularid. In the third volume there are 297 Cretaceous gastropods figures. In total, de Ryckholt described and illustrated 642 species including 19 new genera and 564 new species. The genotypes of the gastropod genera *Tudicula* de Ryckholt (= junior objective synonym of *Tudicla* Röding) and *Prosopostoma* de Ryckholt were recovered and recently illustrated photographically for the first time. *Prosopostoma bucculans*, from the Cenomanian Bernissart Formation (formerly 'Tourtia de Tournai'), was chosen as the type species of the genus *Prosopostoma*. The stratigraphic age of the type localities is also reviewed under the revised stratigraphic framework of Belgium.

THE BADLANDS FROM MENDOZA AND THE HUAYQUERIAN AGE: INSIGHTS INTO THE LATE MIOCENE

Analía M. Forasiepi[1], Francisco J. Prevosti[2,3], Bárbara Vera[1], Guillermo F. Turazzini[4], Sebastián Echarri[2], Alberto C. Garrido[5], Diego Verzi[6], Luciano L. Rasia[6], Gabriela I. Schmidt[7], Graciela Esteban[8] and Verónica Krapovikas[4]

1. IANIGLA, CCT-CONICET-Mendoza, Av. Ruiz Leal s/n, 5500 Mendoza, Argentina. borhyaena@hotmail.com

2. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" -CONICET, Av. Ángel Gallardo 470, C1405DJR Ciudad Autónoma de Buenos Aires, Argentina.

3. Universidad Nacional de Luján, Intersection Nac. Routes 5 and 7, 6700 Luján, Argentina.

4. FCEyN, UBA, Pab. 2, Ciudad Universitaria, C1428EHA Ciudad Autónoma de Buenos Aires, Argentina.

5. Museo Provincial de Ciencias Naturales "Profesor Dr. Juan A. Olsacher", Etcheluz y Ejercito Argentino, 8340 Zapala, Argentina.

6. Museo de La Plata, Facultad de Ciencias Naturales y Museo -CONICET, B1900FWA La Plata, Argentina.

7. CICyTTP-CONICET, Materi y España, 3105, 3105 Diamante, Argentina.

8. INSUGEO, Facultad de Ciencias Naturales e Instituto Miguel Lillo, Miguel Lillo 205, 4000 San Miguel de Tucumán, Argentina.

The badlands exposed in central-northern Mendoza, Argentina, have been the subject of paleontological studies in the first half of the 20th century. The area is a large faulted anticline with the Huayquerías Formation cropping out in the east. This formation is estimated to date from less than 10.5/9.5 Ma (dating from the lower Tobas Angostura Formation) to 5.8 Ma (dating from the upper levels of the Huayquerías Formation). The Huayquerian Age (late Miocene) was defined on the basis of a small mammalian association from the Huayquerías Formation and currently includes: *Megatheriops rectidens* (Megatheriidae), *Proscelidodon gracillimus* (Mylodontidae), *Hemihegetotherium achataleptum* (Hegetotheriinae), "*Proterotherium*" sp. (Proterotheriidae), *Huayqueriana cristata* (Macraucheniidae), *Cyonasua pascuali* (Procyonidae), and *Lagostomus pretrichodactyla* (Chinchillidae). Consequently, the Huayquerian Age is currently characterized by other associations from South America that are considered to be equivalent in time. This grouping, along with inclusion of taxa with controversial geographical and stratigraphical location renders the definition of the Huayquerian Age imprecise. New field work has been conducted in the Huayquerías Formation with the aim of characterizing this age with the faunal content from the type locality. The new findings (housed in IANIGLA-PV) include *Macrochorobates*? sp., *Chasicotatus* cf. *Ch. ameghinoi*, and *Chorobates* sp. (Dasypodidae), *Paedotherium* sp. and *Tremacyllus* sp. (Pachyrukhinae), a probable new Macraucheniidae (Litopterna), cf. *Cyonasua* larger than *C. pascuali* (Procyonidae), *Pseudoplataeomys* aff. *P. formosus*, *Pithanotomys*? and *Palaeoctodon* sp. (Octodontidae), aff. *Palaeocavia* (Caviidae) and *Lagostomus pretrichodactyla* (Chinchillidae). Also recovered were vertebrae of Boidae indet. (Serpentes), a maxilla referred to cf. *Ceratophrys* sp. (Anura), large tridactyl footprints referred to *Macrauchenichnus rector*, an ichnogenus that could be used to represent litopterns, and small tridactyl footprints produced by rodent-like mammals, possibly small notoungulates. These include the first footprints found in the Huayquerías Formation and 13 new taxa, elevating the taxonomic list from seven to 20 taxa. This association is currently accepted to be largely congruent with other late Miocene faunas referred to the Huayquerian Age. Uncertainties exist with the rodent *Pseudoplataeomys* aff. *P. formosus*. Previously, only the holotype of *P. formosus* was known, collected from Monte Hermoso (Buenos Aires, type locality of the Montehermosan Age, lower Pliocene), lacking precise stratigraphic data. Although this recent work has expanded the taxonomic list, the association remains small compared to other assemblages. Further work may append many more taxa to the list with the potential to improve the definition of the Huayquerian Age and its calibration in the biostratigraphic chart of the late Neogene.

PHYLOGENY OF PALEOZOIC GASTROPODS INFERRED FROM THEIR ONTOGENY: HOW MANY HIGHER-LEVEL CLADES LIVED DURING THE PALAEOZOIC ERA?

Jiří Frýda[1,2] and Barbora Frýdová[1]

1. Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, 165 21 Prague 6 – Suchdol, Czech Republic. bellerophon@seznam.cz

2. Czech Geological Survey, P.O.B. 85, 118 21 Prague 1, Czech Republic.

Gastropods are not only one of the most diverse groups of living animals occurring in marine, freshwater as well as terrestrial environments, but also have a rich fossil record extending back to the Cambrian. Because a third of all gastropod families are extinct, understanding of gastropod evolution and phylogeny necessarily involves study of both fossil and living species. Knowledge of the latter can be obtained from anatomical, morphologic, and molecular data, but for extinct forms virtually the only data source is the shell; typically it presents us with few characteristics. For both living and fossil gastropods, elucidation of ontogenic strategies is of prime importance in understanding the high-level phylogeny of this enormously diverse group. The analysis of Palaeozoic gastropods presented here relies heavily on ontogenies based on shell characteristics. It is argued that these results coordinate well with phylogenies of living gastropods inferred from the wider aggregate of anatomical, morphological, and molecular data. On the other hand, the analysis has highlighted problems with published phylogenies of living gastropods and, moreover, has produced evidence for the existence of several order-rank and long-lasting gastropod lineages forming an important part of Palaeozoic gastropod faunas but which failed to cross the Permian–Triassic boundary. Clearly, for understanding the phylogeny of the Gastropoda, it is imperative that the history of fossil gastropod clades be included.

HISTOLOGY OF OSSIFIED EPAXIAL TENDONS IN *GASPARINISAURA CINCOSALTENSIS* (ORNITHISCHIA: ORNITHOPODA)

Luis M. Garat[1], Yamile S. Yunes[1], Ignacio A. Cerda[2] and Marianela Talevi[3]

1. Universidad Nacional de Río Negro, Belgrano 526, General Roca, 8332, Argentina.

2. Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, Museo Carlos Ameghino- CONICET, Belgrano 1700, Paraje Pichi Ruca (predio Marabunta), Cipolletti, 8300, Argentina.

3. Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro-CONICET, Belgrano 526, General Roca, 8332, Argentina. talevimarianela@hotmail.com.ar

The presence of ossified tendons along the vertebral column is a synapomorphy of Ornithischia. In ornithopod dinosaurs, basal iguanodontians (e.g., *Tenontosaurus*) have ossified tendons arranged in long bundles down the back and out along the tail vertebrae. These tendons parallel the vertebral column. On the other hand, more derived iguanodontians (such as hadrosaurs) have ossified tendons arranged in a crisscrossing trellis-like configuration down the back and tail. Although the microstructure of ossified tendons in derived iguanodontians has been well studied, studies in more basal forms are rather scarce. In the present work the microstructure of the ossified tendons of the basal ornithopod *Gasparinisaura cincosaltensis* is studied. The sample consists of several tendons from the caudal region of a specimen (MCSPv 111) collected from the Cinco Saltos locality (Northern Patagonia), in outcrops of the Anacleto Formation (Late Cretaceous). Ossified tendons consist of a homogeneous matrix composed of coarse mineralized collagenous fibers oriented along the tendon main axis. Bone cell lacunae are abundant and they are oriented following the fiber arrangement. The vascularization is low and consists of simple vascular canals and primary osteons. No lines of arrested growth and periosteal bone remodeling are observed. The low degree of secondary remodeling in the sampled bones of *Gasparinisaura* suggests an early growth stage in this specimen, similar to the reported in ossified tendons of juvenile hadrosaurs. The nature of the primary bone matrix in the ossified tendons of *Gasparnisaura* indicates that these structures mainly originated through direct mineralization (metaplasia) of tendinous structures. This mechanism has been previously proposed for the origin of ossified tendons in other ornithischians and in cervical ribs in sauropod dinosaurs.

PALAEOENVIRONMENTAL CHANGES FROM SEMI-ARID AUSTRALIA: THE MACQUARIE MARSHES, NEW SOUTH WALES

Adriana García[1], Allan R. Chivas[1], Lily Yu[1] and John Tibby[2]

1. GeoQuEST Research Centre, School of Earth and Environmental Sciences, University of Wollongong, NSW 2522, Australia. adriana@uow.edu.au

2. Geographical and Environmental Studies, University of Adelaide, South Australia 5005, Australia.

The Macquarie Marshes (MM, area ~ 220,000 ha) are one of the largest floodplain areas in the Murray-Darling Basin, eastern Australia and developed over the last ~ 6 ka in the floodplain of the permanent Macquarie River. Seventeen percent of the MM was declared a Ramsar site in 1986, based on their ecological role (*i.e.* large freshwater wetlands amongst semi-arid to arid area, site of colonial-nesting birds, refuge for flora and fauna). The marshes' survival depends on flooding events which naturally occurred by over-flow of the Macquarie River and numerous smaller channels developed within the marshes, fed by rains in the highlands towards the east where the river originates. Natural increasing aridity in Australia, but more importantly, human activities such as cattle grazing, land clearance and building of dams have been held responsible for the decline of ~ 40-50% of the MM. We reconstructed past ecologies using sedimentology, charophytes, and macrophyte (ferns, aquatic and terrestrial plants) distribution/diversity using two cores (a 2 m long core – LOLA - spanning the past 50 ka years, although with non-continuous sedimentation, and a 1 m core - B3-2 - spanning the past 2 ka); the latter dated at decadal scale established using high-resolution optically stimulated luminescence. Core LOLA was dated at the base at 50 ka ago and is barren of biological remains from the 15th century until present starting with abundant charophytes (*Nitella sonderi*, *N. stuartii, Chara braunnii*, with the addition of *N. cristata*, *Sphaerochara* sp., *C. muelleri*, and *C. globularis* in the uppermost layer). This site has held more water in recent times, behaving like a channel during the Pleistocene. Core B3-2 displays abundant charophytes with *N. sonderi*, *N. stuartii, Sphaerochara* sp., *Chara australis* and *C. braunii* present since 1700 AD - ~ 1940 AD (indicating a wetland with deep water); followed by an association of *N. sonderi*, *N. stuartii, C. braunii* and *C.* cf. *fibrosa*, with abundant *Myriophyllum* and *Azolla*, between 1940 and 1962 AD (indicating frequent inundation and a shallow intermittent waterbody) being replaced by taxa requiring less water (Cyperaceae, *Azolla* sp.), dry-tolerant terrestrial taxa (Chenopodiaceae, *Glinus* sp.), and Myrtaceae (*Eucalyptus* sp.) during the past 50 years. We conclude that the MM had more water and was inundated for longer before 50 years ago.

ARARIPE'S FOSSILS (CEARÁ, BRAZIL) IN PORTUGUESE MUSEUMS: PRELIMINARY NOTE

Karina L. Garcia[1], José M. Brandão[2] and Carlos A. Marques[3]

1. Departamento de Geociências, Pólo de Estremoz, Universidade de Évora. Estremoz, Convento das Maltezas 7100-513, Portugal. karinalg1000@yahoo.com.br

2. Centro de Estudos de História e Filosofia da Ciência, Universidade de Évora, Lg. Marquês de Marialva, 8 Évora, 7000-554, Portugal.

3. Departamento de Geologia, Universidade de Lisboa, Campo Grande, Lisboa, 1749-016, Portugal.

The aim of this work is to characterize the Araripe fossil collections housed in the three major Portuguese Natural History Museums, and demonstrate the importance of research work and dissemination of paleontological knowledge in Portugal. This research is part of a larger work, still in progress, based on two main goals: i) list the Brazilian fossil collections in Iberian museums, ii) verify and characterize how these materials have been used to increase the knowledge of paleontology and the study and dissemination of the Brazilian geological heritage. The Araripe Basin, located on the common border of the Brazilian states of Ceará, Piauí and Pernambuco, contains one of the richest Early Cretaceous (Aptian/ Albian) fossiliferous deposits of northeastern Brazil. These deposits are known since the early nineteenth century and caught the attention of paleontologists, private collectors and public in general since then. This *lagerstätte* holds fossils in an excellent state of preservation, resulting from an extraordinary geological event that generated exceptional fossilization conditions, preserving a diversified biota representative of an extraordinary Cretaceous ecosystem. Although similar Brazilian fossils are known in other Portuguese museums, the National Natural History and Science Museum of Lisbon, the Natural History Museum of Sintra, and The Sea Museum King Dom Carlos of Cascais hold together a large number of specimens of Araripe (*ca.* 200), in an excellent state of preservation. The National Natural History Museum has six fossil fishes, representatives of the four major groups described nowadays in the Araripe Basin (*Rhacolepis* sp, *Brannerion vestitum, Tharrhias* sp, *Vinctifer comptoni, Axcelrodichthys araripiensis* and *Aspidorhynchus* sp). The Sea Museum has *ca.* 90 specimens of fossil fishes (only six of them were identified and assigned to the genera *Vinctifer, Rhacolepis, Tharrhias, Leptolepis*). The largest collection belongs to the Sintra Natural History Museum, with *ca.* 100 specimens (80 fishes referred to the genera *Araripescorpius, Tharrhias, Vinctifer, Rhacolepis, Cladocyclus, Araripichthys, Enneles, Leptolepis, Proscinetes*), 25 insects, 1 pterosaur, and 1 Chelicerata. Among the exhibits stands out the pterosaur (newly described as *Gracilirostris barbosania*). The collections were formed with specimens received from research institutions, universities and private collectors, and reflect the paleontological potential of Araripe. We conclude that the Portuguese museums holding the Araripe fossils collections have an unexplored scientific and cultural value, and a great potential for scientific dissemination of Brazilian natural heritage.

THE PUBLIC PERCEPTION OF PALEONTOLOGY IN BRAZIL

Aline M. Ghilardi[1], Tito Aureliano[2], Rudah R. C. Duque[2] and Jakeline F. de Azevedo[2].

1. Universidade Federal do Rio de Janeiro (UFRJ), CCMN, Departamento de Geologia, Av. Athos da Silveira Ramos, 274, Bloco G, Ilha do Fundão, Rio de Janeiro, RJ, 21949-900, Brazil.

2. Universidade Federal de Pernambuco (UFPE), Centro de Tecnologia e Geociências, Departamento de Geologia, Av. Acadêmico Hélio Ramos s/n, Cidade Universitária, Recife, PE, 50740-530, Brazil. rudah_cd@hotmail.com

Few formal studies have been done about how paleontology is perceived by the public. Perhaps the reason is that very few professional paleontologists have concerned themselves with public opinion. Generally they are absorbed by their research topic or more concerned with grant proposals. However, public support is necessary for reinforcing and developing paleontology as a science. Here we describe the result of 500 interviews about public's perception of paleontology in Brazil. Our survey focused on five topics: knowledge of paleontology, the role of paleontology for society, interest in paleontology, knowledge of Brazilian paleontology, and the role of museums in paleontological education. The data was collected through an on-line survey, and distributed using social networks. Answer to the first questions involving people's knowledge about paleontology, showed misconceptions between paleontological and archeological concepts. Words such as mummies, pyramids, ancient civilizations and "Indiana Jones" were frequently associated with paleontology (a mean of 24% mentioned some of these terms). After answering these questions, a short definition of paleontology was given and people were questioned about the relevance and their interest in paleontology: 93% declared to believe that paleontology has some relevance for society, 5% that it has no relevance, but still a curious subject, and 2% consider that paleontology has no relevance at all. More than 85% declared to have some degree of interest in topics concerning paleontology. Regarding Brazilian paleontology, 41% were able to remember a name of at least one fossil organism from Brazil and 73% mentioned at least one locality where fossils are found in their country. Finally, concerning the role of museums, 80% already visited a museum, but only 40% visited a museum with a paleontology exhibition. Less than 2% consider museums not important for education. This survey reflects the opinion of only a portion of the society, since it was observed that almost 80% of the questioned have some degree of high-level education, which does not reflect the observed in the Brazilian population as a whole. The deviation can be explained for this fraction of society has easier access to internet. The survey is still on course and will be expanded, in order to include more segments of society. Paleontology is very popular and has valuable knowledge to offer humanity. A positive public opinion may lead to more investment in the area. Paleontologists may understand that might be someone else interested in their findings and must be ready to communicate science in more accessible ways.

THE '*SPIRORBIS*' PROBLEM REVISITED: SEDIMENTOLOGY AND BIOLOGY OF MICROCONCHIDS IN MARINE-NONMARINE TRANSITIONS

Elizabeth H. Gierlowski-Kordesch[1] and Christopher F. Cassle[2]

1. Department of Geological Sciences, Ohio University, Athens, OH 45701, USA. gierlows@ohio.edu

2. Encana Oil and Gas, Inc., 370 17th St., 1700 Denver, CO 80802, USA.

'*Spirorbis*' worm tubes, described from the geologic record spanning the Silurian through the Middle Jurassic, have been assigned freshwater to brackish to marine affinities. Now interpreted as phoronid worm tubes of microconchid origin (including *Palaeoconchus*, *Microconchus*, *Punctaconchus*, *Annuliconchus*, and *Polonoconchus*), the true paleoenvironment (*i.e.* paleosalinity) for these tubeworms can be determined with a detailed study of their distribution with respect to local sedimentology as well as with recognition of their biologic characteristics to determine their ability to osmoregulate. Osmoregulation is a key characteristic in determining the ability of a marine body type to tolerate freshwater. Over three hundred localities worldwide covering Phanerozoic lacustrine sites and Paleozoic to Lower Triassic marine-influenced sites were searched and those containing microconchid fossils ranging from freshwater to marine have been documented; data collection included presence or absence of these worm tubes, their preservation mode (*in situ* vs. clastic), and their associated fauna and flora along with paleoenvironmental interpretation from sedimentologic information. These worm tubes are not documented from any purely freshwater continental paleoenvironment unconnected to the ocean. All fossil occurrences of these microconchid tubes are in association with coastlines, whether within a nonmarine-marine transition (tidal coast, estuary, delta) or a distal transition floodplain within a low-gradient coastal area potentially affected by rare storm surges or tsunamis. Opportunistic settling on hard substrates or plants and the growth of a shell occurring within an hour during larval settlement are similar to modern spirorbid polychaete worms. The biology of this lophophorate organism supports a marine affinity because of its and its sister phylum Brachiopoda need for osmoregulation within marine salinities only. Bryozoans, also a lophophorate, successfully crossed the salinity barrier into freshwater because they do not have an excretory system so osmoregulation is not needed The '*Spirorbis*' problem of multiple life habitats is solved: microconchid worm larvae can settle anywhere where currents exist along a coastline and as far inland as storm surges can go, but they only thrive within true marine conditions and are not freshwater fauna. Microconchid worm tubes preserved within continental settings indicate marine influence only, not living habitats.

SEDIMENTOLOGY AND ICHNOLOGY AT THE COLOMBIAN PACIFIC UPPER MIOCENE, TUMACO BASIN

Carlos A. Giraldo[1,2], Sergio A. Celis[1,2], Francisco J. Rodríguez-Tovar[3], Andrés Pardo[1,2] and Raúl A. Trejos-Tamayo[1,2]

1. Department of Geology, University of Caldas, Calle 65 Nº 26 – 10, Manizales, 275, Colombia. carlosgiraldo92@hotmail.com

2. Instituto de Investigaciones en Estratigrafía-IIES, Calle 65 Nº 26 – 10, Manizales, 275, Colombia.

3. Department of Stratigraphy and Paleontology, University of Granada, Avda. Severo Ochoa s/n, Granada, Spain.

Miocene rocks of western Colombia show a wide record and diversity of trace fossils. These reflect the relationship between the environmental conditions and sedimentologic patterns. In this study, we show the results of an interval between 5381-5563 feet in the well Tumaco 1 -ST –P. Previous microfossils studies (calcareous nannofossils, foraminifera, and pollen) indicate that these rocks were deposited during Tortonian and Messinian times. The sequence is dominated by green mudstones and gray claystones, interbedded with layers of lithic sandstones. In addition, fine-grained volcanic intervals are common in the section. The main sedimentary structures identified are flat parallel stratification, heterolithic and graded bedding. Thanks to the good trace fossil preservation, 21 ichnogenera were identified: *Asterosoma, Alcyonidiopsis, Bichordites, Chondrites, Conichnus, Cylindrichnus, Diplocraterion, Macaronichnus, Ophiomorpha, Palaeophycos, Phycosiphon, Planolites, Rhizocorallium, Schaubcylindrichnus, Scolicia, Siphonichnus, Sphyrophyton, Taenidium, Teichichnus, Thalassinoides*, and *Zoophycos.* This ichnofossil association belongs to the *Cruziana* ichnofacies. In agreement with this recovery, the sedimentary conditions were stable with low-moderate energy and low sedimentation rates. Furthermore, the facial and ichnofossil analyses reveal that the unit was deposited between lower shoreface and lower offshore with prodelta influence. We observed four ichnofabrics. The ichnofabrics with major bioturbation indexes are interpreted as events with high oxygenation and nutrients. These characteristics were observed mainly at the middle part of the section. Ichnogenera such as *Rhizocorallium* and *Diplocraterion* were viewed four times between the base and middle of the core. These records would indicate no-deposition and/or erosion episodes.

TAPHOFACIES MODEL OF A CARBONIFEROUS TRANSGRESSIVE SYSTEMS TRACT, SONORA, MEXICO

Catalina Gómez-Espinosa[1] and Blanca Buitrón[2]

1. Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de Mexico, Ciudad Universitaria, Mexico D.F. 04510, Mexico. c_gomez@ciencias.unam.mx

2. Instituto de Geología, Universidad Nacional Autónoma de Mexico, Ciudad Universitaria, Mexico D.F. 04510, Mexico.

La Joya Formation in the Sierra Agua Verde is located in Sonora State; appears as a transgressive systems tract (TST) whose main lithologies are marine fossiliferous limestones intercalated with nodular cherts and calcareous siltstones. A Carboniferous fossil assemblage is composed by fusulinids, chaetetids, brachiopods, gastropods and crinoids. Five taphofacies are proposed. Taphofacies I: abundant crinoids, rare bryozoans, brachiopods, fusulinids and algae; characterized by disarticulated remains with random orientation. Sedimentologic concentration of allochthonous elements result from hydraulic processes under a low net sedimentation. Taphofacies IA: abundant fusulinids, rare bryozoans, microforaminifers and remains of crinoids and brachiopods; high degree of corrasion and chaotic orientation. Sedimentologic concentration of allochthonous elements result of a turbidity current in a shallow environment. Taphofacies II: abundant fusulinids, rare microforaminifers, remains of gastropods and brachiopods; fusulinid testae pristine and poorly sorted. Sedimentologic concentration of autochthonous-parautochthonous organisms in a low energy environment with a high sedimentation rate. Taphofacies III: abundant brachiopods, inconspicuous macrofauna; corrasion medium to high, remains randomly oriented. Sedimentologic concentration of allochthonous organisms result of transport in an abrasive turbulent flow, in a shallow environment with episodic sedimentation. Taphofacies IV: dispersed gastropods with a random orientation and low corrasion. Sedimentologic concentration of autochthonous/ parautochthonous organisms. Represents a low energy environment; with remains buried shortly after death and short exhumation periods. Taphofacies V: dominated by chaetetids, rare fusulinids; low grade of corrosion, remains are *in situ*. Biogenic concentration of autochthonous organisms. This taphofacies represents a low energy environment under the normal wave base. During the deposit of the La Joya Formation environmental conditions had continuous fluctuations. The section represents a mosaic of marine environments developed successively in a short time interval, with very complex lithological and biotic changes in a vertical/lateral gradient, typical of Carboniferous platforms. The temporal mixture of biota from different habitats is variable and along the analyzed outcrop there is a diversity of environments. [Projects CONACyT-165826, PAPIIT-105012 and ECOS-ANUIES-CONACyT M13-U01].

NEW RECORDS OF *VETELIA* AMEGHINO (MAMMALIA, XENARTHRA, DASYPODIDAE) IN THE MIOCENE OF ARGENTINA: ANATOMICAL AND PALEOBIOGEOGRAPHIC IMPLICATIONS

Laureano R. González Ruiz[1,7], Flávio Góis [2], Gustavo J. Scillato-Yané[3,7], Cristian Oliva[4], Víctor H. Contreras[5] and Graciela Esteban[6]

1. Laboratorio de Investigaciones en Evolución y Biodiversidad, Facultad de Ciencias Naturales sede Esquel, Universidad Nacional de La Patagonia San Juan Bosco (LIEB, UNPSJB), Edificio de Aulas, Ruta Nacional Nº 259, Km. 16.5, Esquel, 9200, Argentina. gonzalezlaureano@yahoo.com.ar

2. Laboratorio de Paleontología de Vertebrados, Centro de Investigaciones Científicas y Transferencia de Tecnología a la Producción (CICYTTP-CONICET), Materi y España, 3105 Diamante, Entre Ríos, Argentina.

3. División Paleontología Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, 1900, Argentina.

4. Centro de Registro del Patrimonio Arqueológico y Paleontológico (CRPAP), Dirección Provincial de Patrimonio Cultural (DPPC), Instituto Cultural de la provincia de Buenos Aires (ICPBA), Calle 50 N° 539, La Plata, 1900, Argentina.

5. Instituto de Geología Emiliano P. Aparicio (INGEO) y Departamento Geología, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de San Juan, Av. Ignacio de la Roza y Meglioli, Rivadavia, San Juan, 5400, Argentina.

6. INSUGEO, Facultad de Ciencias Naturales e Instituto Miguel Lillo, Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina.

7. CONICET.

Vetelia Ameghino (Dasypodidae, Euphractini) includes three described species: 1) *V. puncta* Ameghino (early and middle Miocene; Santacrucian *sensu lato*, Friasian *sensu stricto*, Colloncuran); 2) *V. perforata* Scillato-Yané (middle and late Miocene; Mayoan, Chasicoan, Huayquerian, "Araucanian"); and 3) *V. gandhii* Esteban and Nasif (late Miocene; Chasicoan, Huayquerian). The type specimens of all species, and most attributed specimens, are disarticulated osteoderms of the carapace. Since its original description in 1891, only one fragment of right dentary (associated with incomplete osteoderms) has been described in the genus (*V. perforata*, MLP 76-VI-12-95, ex-MLP CH 96, Arroyo Chasicó Formation, late Miocene, Chasicoan). Therefore, discoveries of skulls and mandibles associated with osteoderms became important. Here we present new specimens of *Vetelia* from Neogene outcrops of San Juan and Buenos Aires provinces: 1) *Vetelia gandhii*: PSJV 289 (Loma de Las Tapias Formation, late Miocene, Chasicoan, San Juan Province), which represents the most complete specimen of the genus and includes most part of the skull, a fragment of left dentary, and articulated fragments of the dorsal carapace; PSJV 290 (Loma de Las Tapias Formation, late Miocene, Chasicoan, San Juan Province), a fragment of skull and two associated osteoderms; 2) *Vetelia* sp.: MLP 64-VI-21-3 (Los Berros, late Miocene, San Juan Province), a fragment of right dentary; 3) *Vetelia perforata*: MMH-CH-87-7-109 (Arroyo Chasicó Formation, late Miocene, Chasicoan, Buenos Aires Province), almost complete right dentary and three associated osteoderms. After preliminary analyses of all specimens and other several isolated osteoderms as well, we identified new characters of *Vetelia*: 1) presence of at least five movable bands in the dorsal carapace; 2) presence of a rudimentary scapular buckler; and 3) presence of at least nine upper and lower molariforms. *Vetelia perforata* has a wider paleobiogeographic distribution than *V. gandhii*, with records in Neogene sediments of south, central and west Argentina (Santa Cruz, Chubut, Buenos Aires, La Pampa, San Juan, La Rioja and Catamarca provinces) whereas *V. gandhii* is restricted to the west (San Juan and Catamarca provinces). Finally, although both species are present during the late Miocene they have never been recorded together in the same fossil locality.

THE FAMILY MYTILDAE (MOLLUSCA: BIVALVIA) IN THE PALEOGENE/NEOGENE OF PATAGONIA

Miguel Griffin[1] and Santiago Genta Iturrería[1]

1. División Paleozoología Invertebrados, Museo de La Plata Paseo del Bosque s.n., B1900FWA La Plata, Argentina.
miguelgriffin@aol.com

Paleogene and Neogene Mytlidae of Patagonia are represented by twenty-six species accross ten genera. A systematic revision of the family allowed establishing the precise stratigraphic range of the taxa involved. Paleocene rocks yielded *Mytilus*? *brandmayri*, *Gregariella amara*, *Lithophaga exilis*, *Modiolus rionegrensis* and *Modiolus aprilis*. *Gregariella amara* occurs in the Roca Formation and is one of the few species that survived K/Pg boundary there. *Lithophaga exilis* occurs in the Salamanca Formation (Paleocene) and probably survived until the Eocene. *Modiolus rionegrensis* was described based on material from an uncertain locality at which the Roca Formation is exposed, probably near General Roca in Río Negro, although this requires confirmation. The Salamanca Formation exposures along the coast of Chubut Province yielded *Modiolus aprilis* but missing data on the geographic and stratigraphic occurrence, together with the poor preservation of the material allow no precisions on the affinities and distribution of this species. Three species of mytilids are recorded in Eocene rocks, i.e. *Modiomytilus merecerati, Modiolus* cf. *M. thomsoni* and *Lithophaga* cf. *L. exilis*. This is the earliest record of *Modiomytilus*, a genus that survived until the early Miocene. *Modiolus* cf. *M. thomsoni* is very similar to the Antarctic *Modiolus thomsoni*. *Lithophaga* cf. *L. exilis* appears boring large valve of *Crassostrea* sp. in the Río Turbio Formation. The late Oligocene San Julián Formation carries the oldest species referable to *Aulacomya*, i.e., *Aulacomya minuta* n. sp. Fragments probably belonging in *Perna* comes from the Meseta Chica Member of the San Julián Formation. Ten species were recorded from the early Miocene. *Mytilus*? *wehrlii* from rocks in the area surrounding Bariloche (Río Negro Province) and probably belonging to the Nahuel Huapi Group, *Aulacomya* cf. *A. atra* from rocks of the 25 de Mayo Formation exposed south of Lago Argentino, *Crenella camaronesia*, *Gregariella andina*, *Lithophaga* (*Diberus*) *dalli*, *Modiolus ameghinoi*, *Modiolus arctus*, *Modiomytilus argentinensis*, *Modiomytilus*? *pseudochorus* and *Modiomytilus*? *hauthali*. The late Miocene Puerto Madryn Formation yielded six species, i.e., *Perna patagonica* n. sp., similar to the recent species living in the Magellanic Province, *Brachidontes* cf. *B. rodriguezi*, *Lithophaga* cf. *L. platensis*, *Modiolus camachoi* n. sp., *Modiolus bruneti* n. sp. and *Modiolus* cf. *M. platensis*. The taxonomic composition of the faunas varied throughout the Cenozoic and was definitely different from the fauna now inhabiting the adjoining shelf.

DIFFERENTIAL PRESERVATION OF FRESHWATER DIATOMS AND MOLLUSKS IN LATE HOLOCENE SEDIMENTS: PALEOENVIRONMENTAL IMPLICATIONS

Gabriela S. Hassan[1], Eleonor Tietze[1], Paula A. Cristini[1] and Claudio G. De Francesco[1]

1. Instituto de Investigaciones Marinas y Costeras (IIMyC), Consejo Nacional de Investigaciones Científicas y Técnicas - Universidad Nacional de Mar del Plata, Juan B. Justo 2550, B7608FBY Mar del Plata, Argentina.
ghassan@mdp.edu.ar

One of the limitations of paleoenvironmental reconstructions based on multiple bioindicators is the lack of knowledge on the differential preservation of hard parts, which may lead to biases in the interpretations. This is particularly important when biological proxies differ in their intrinsic properties, as skeletal mineralogy or size. We explored and compared the preservational patterns of siliceous (diatoms) and carbonatic (mollusks) indicators during the late Holocene (last ca. 4000 cal. years BP) in two lacustrine sedimentary successions from Argentina (Nahuel Rucá and Hinojales San Leoncio). Fragmentation and fine-scale surface alteration indices were calculated on two target species: the diatom *Cyclotella meneghiniana* and the snail *Heleobia parchappii*. The taphonomic curves obtained were smoothed along depth with a locally weighted regression (LOESS), and statistically compared using Spearman correlations. Additionally, past environmental conditions were inferred from the autoecology of the dominant taxa. Diatoms and mollusks displayed similar tendencies in fragmentation ($r=0.31$, $p<0.001$ for Nahuel Rucá; $r=0.87$, $p<0.001$ for Hinojales San Leoncio), which decreased towards the top of both successions. On the other hand, trends in surface preservation were opposite ($r=-0.34$, $p<0.001$ for Nahuel Rucá; $r=-0.42$, $p<0.01$ for Hinojales San Leoncio): while diatoms exhibited higher alteration in the oldest sedimentary levels, mollusk surface was more altered at the topmost levels. These differential preservational patterns were related to changes in salinity and productivity. Overall, diatom preservation was worse under saline conditions as consequence of higher silica solubility. However, salinity would have promoted higher carbonate concentrations and lower bioerosional activity, thus, favoring mollusk preservation. Under freshwater and more productive conditions increased bioerosional activity prevented mollusk preservation. Hence, the accuracy of the paleoenvironmental information provided by both indicators under these contrasting conditions is strongly affected by the taphonomic biases suffered, which highlight the relevance of including taphonomic traits in Quaternary paleoenvironmental or paleoclimatic studies.

A NEW LOWER CAMBRIAN RELICT OF WESTERN PERIGONDWANA IN GERMANY (SAXOTHURINGIAN ZONE, NORTHEASTERN BAVARIA)

Hans-Georg Herbig[1] and Thomas Wotte[1]

1. Universität zu Köln, Institut für Geologie und Paläontologie, Zülpicher Str. 49a, Köln, D-50674, Germany.
herbig.paleont@uni-koeln.de

Calcimicrobe-archaeocyathid-bearing carbonate rocks are typical for the shallow platform realms of the low- to mid-latitude western Perigondwana realm. The facies is well-known from the Moroccan Antiatlas, the Iberian Peninsula (Sierra Morena, Cantabrian Mountains), southern France (Montagne Noire) and Sardinia. Few isolated occurrences in Central Europe prove the dispersion of peri-Gondwana terranes belonging to the Armorican terrane assemblage. Archaeocyathid-bearing carbonates have been reported from recrystallized and metamorphic rocks of the Bohemian Massif (Poland, Czechia). In Germany, they are well-known from subsurface of the Saxothuringian Zone in the vicinity of Leipzig (Saxonia, Doberlug-Torgau-Delitzsch syncline). Herein, we report a new discovery from the Saxothuringian Zone in northeast Bavaria (Franconian Forest, southern Germany). Middle Cambrian siliciclastic strata have been known since decades from the region, but this is the first proof of Cambrian carbonate rocks and the first definite proof of the lower Cambrian. The occurrence was originally described as a several meter big lens of "algal limestone" within the late middle Viséan/early late Viséan "Heinersreuth Blockkonglomerat". The conglomerate belongs to a Viséan wildflysch succession in front of the Variscan orogen and consists of different lithotypes, reworking a variable suite of Cambrian to Carboniferous sedimentary rocks. New observations prove that instead of a single slide block, a couple of isolated and disoriented, debris flow-related limestone blocks are preserved. Several carbonate microfacies occur. Most spectacular is a calcimicrobe-archaeocyathid boundstone with two types of abundant *Epiphyton* tufts. Irregular and regular archaeocyathids, *Girvanella* and *Kordephyton* tufts are associated. Encrusting bubble-like structures appear to be juvenile archaeocyathids. A microbial bindstone, in cases with abundant *Girvanella*, consists of stacked mats, often strongly micritized into spongiostromatic masses. Occasionally the mats are separated by quartz-rich layers, which might give rise to irregular stylo-bedding. The mats might be also reworked as algal biscuits forming flat-pebble conglomerates. Biostratigraphic data still have to be acquired. However, the striking facies similarity of the calcimicrobe-archaeocyathid boundstones from the subsurface of Saxonia, which are all of Atdabanian age, favour the same age for the occurrence from the Franconian Forest.

NEW DATA ON THE NEUROANATOMY OF *ADINOTHERIUM OVINUM* (NOTOUNGULATA, TOXODONTIDAE, NESODONTINAE) FROM VIRTUAL CRANIAL ENDOCAST

Santiago Hernández Del Pino[1], Guillermo H. Cassini[2,3], Esperanza Cerdeño[1] and Sergio F. Vizcaino[4]

1. Paleontología, IANIGLA, Centro Científico Tecnológico, CONICET, Mendoza, Av. Ruiz Leal s/n, 5500 Mendoza, Argentina. shdelpino@mendoza-conicet.gob.ar

2. División Mastozoología, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", CONICET, Av. Ángel Gallardo 470, Ciudad Autónoma de Buenos Aires, C1405DJR, Argentina.

3. Departamento de Ciencias Básicas, Universidad Nacional de Luján, Ruta 5 y Av. Constitución, Luján, 6700, Buenos Aires, Argentina.

4. División Paleontología Vertebrados, Museo de La Plata, CONICET, Paseo del Bosque s/n, B1900FWA La Plata, Argentina.

Toxodontids were endemic South American ungulates, characteristic of the Cenozoic faunas. Although variable in size, their skulls present a conservative morphology. Among them, *Adinotherium ovinum* is a rather small basal taxon characteristic of the early Miocene Santacrucian Age (Santa Cruz Province, Argentina). The primary objective of this contribution is to provide a detailed anatomical description of the endocranial morphology of *A. ovinum*, an approximation of the brain and associated soft-tissue structures, and considerations about the relative brain size in this species. For the present study we reconstructed a virtual cranial endocast of an adult specimen (MPM PV-3532) based on CT scans and estimated the encephalization quotient (EQ= brain mass/0.055 × body mass$^{0.74}$) for a sample of eight genera of Santacrucian South American native ungulates. The obtained virtual endocast is almost complete, showing only a slight lateral deformation due to lithostatic pressure, allowing the description from all views and obtaining linear and volumetric measurements. The general morphology is in agreement with previous anatomical data on the endocranial cavity of *Adinotherium* documented by Patterson in the 1930s (i.e., the high, arched and upwardly inclined cerebrum, the dorsal exposure of the cerebellum sloping downward, and the enormous hypophysis) and also shows a more complex pattern of sulci for the neopallium than that registered in previous works. The EQ (from an endocast volume of 105.077 cm^3 and estimated body mass of 56.35 kg) is 0.61 and represents a lower value than that previously reported by Radinsky (EQ= 0.78) for *Adinotherium* in his work about brain evolution in South American native ungulates, who also estimated a lower body mass (40.31 kg). The EQ obtained in our estimation is around the mid values when compared with EQs obtained for other Santacrucian ungulates: the interatheriid *Protypotherium* (0.86; the highest value) and the toxodontid *Nesodon* (0.34; the lowest one) among Notoungulates, and the astrapothere *Astrapotherium* (0.43). Our results indicate that *A. ovinum* has a higher relative brain size than the larger well-known and coeval nesodontine toxodontid *Nesodon* (body mass of 308.93 kg). This agrees with previous ontogenetic studies on nesodontine skulls, which revealed that cranial measurements related to the neurocranium show higher allometric coefficients in *A. ovinum* than in the larger *Nesodon*, resulting in a proportionally greater brain in the former. This kind of description constitutes a base for broader studies, with a larger sample, on the ontogenetic development of the cranial cavity and the brain in both nesodontine genera.

CORALS AND REEFS ACROSS THE TRIASSIC-JURASSIC BOUNDARY IN NORTH AMERICA

Montana S. Hodges[1] and George D. Stanley Jr.[1]

1. The University of Montana Paleontology Center, 32 Campus Drive, Missoula, MT, 59812, USA.
montana.hodges@umontana.edu

The end-Triassic mass extinction represents a time of intense environmental changes and biotic turnover, particularly for corals. During this time of changing climate approximately 200 million years ago the supercontinent Pangea was undergoing rift volcanism (CAMP), releasing prodigious amounts of greenhouse gases and volatiles, ocean pH was increasing, and sea level was dropping. Corals reefs collapsed abruptly at the end of the Triassic. While the recovery started in the Tethys Ocean soon after the extinction, reefs and coral diversity did not fully recover until the end of the Early Jurassic, some 25 million years later. Compared to the Tethys, precious little is known about western North America where reefs and diverse corals of the Late Triassic lived around volcanic islands of western Panthalassa. Some reef-like associations on the Wrangellian terrane survived until Rhaetian time. Here we report coral reefs in the Early Jurassic of Sonora, Mexico, and Early Jurassic corals from the most complete Triassic-Jurassic section at New York Canyon, Nevada, USA. The section at the New York Canyon site is well documented across the T/J boundary and yields small solitary taxa, which appear to be the earliest Jurassic corals in the USA. They are compared with counterparts in the Tethys and elsewhere in North America to provide insight into the paleobiogeography and the nature of the recovery after the mass extinction. In northern Sonora, ongoing research focuses on an Early Jurassic reef, which may be the earliest example in North America. The shallow-water patch reefs are well developed, reaching 20-30 meters in thickness and extend laterally for more than a kilometer. Patches are constructed by large coral colonies and inhabited by serpulid worms, brachiopods, bivalves, and crinoids. Solitary and colonial sheet-like and branching corals construct the largest patch and co-occur with bivalves *Pinna* sp. and abundant rhynchonellid brachiopods. A smaller patch reef is characterized by thickly-bedded, bioclastic limestone with abundant fragmental and complete colonies of corals, brachiopods and bivalves. The coral faunas of both Sonora and Nevada are useful in unravelling details of the recovery of corals and reef-faunas following the end-Triassic mass extinction.

THE EARLY CAMBRIAN OF ANTARCTICA: FAUNAS AND CHEMOSTRATIGRAPHY OF THE SHACKLETON LIMESTONE

Lars E. Holmer[1], Glenn A. Brock[2], Christian B. Skovsted[3], Timothy P. Topper[1], Lewis Bassett-Butt[1], Lars Stemmerick[4] and Paul Myrow[5]

1. Department of Earth Sciences, Palaeobiology, Villavägen 16, SE-75236, Uppsala, Sweden. timothy.topper@pal.uu.se
2. Department of Biological Sciences, Macquarie University, Sydney, New South Wales, 2109, Australia.
3. Department of Palaeobiology, Swedish Museum of Natural History, Box 50007, SE-104 05, Stockholm, Sweden.
4. Natural History Museum, University of Copenhagen, Øster Voldgade 5-7, Copenhagen K, Denmark.
5. Department of Geology, The Colorado College, 14E. Cache La Poudre, Colorado Springs, CO 80903, USA.

During the critical period of expansive biotic radiation in the early Cambrian, Antarctica and southern Australia where sutured together near the equator forming East Gondwana. The rocks deposited during this interval provide ample evidence of a shared geological, palaeontological and palaeogeographic heritage. However, there has been almost no previous systematic sampling of lower Cambrian fossiliferous successions for phosphatic shelly fossils, which have proven so important in providing a chronological framework for understanding the early evolution, ecology and biogeography of bilaterian animals. The retrieval of such faunas provides raw material for investigating the morphological diversity and phylogeny of early (stem group) bilaterians as well as a mean to undertake detailed biostratigraphic correlations between lower Cambrian sequence packages in Antarctica and South Australia. Detailed sampling along stratigraphic sections measured through autochthonous, fault repeated, lower Cambrian succession of shallow water carbonate platform complete with peri-reefal bioherms in the Shackleton Limestone and overlying carbonate ramp and slope transition in the Holyoake Formation has produced a moderately diverse fauna of shelly fossils including tommotiids (*Dailyatia*) chancelloriids, helcionellid molluscs, cupitheciids, hyolithelminth tubes, echinoderm ossicles, brachiopods (*Eohadrotreta*, *Eodicellomus* and *Eoobolus*) and trilobites (*Pensacola*). The $\delta^{13}C$ chemostratigraphic record of the Shackleton Limestone is presented, supplementing lithostratigraphical and biostratigraphical information. This newly discovered fauna provides direct correlation to the Mernmerna Formation in the Flinders Ranges (Arrowie Basin), South Australia and to other Cambrian palaeocontinents (Laurentia) and indicates a Botomian (Cambrian Series 2, Stages 3-4) age for the upper Shackleton Limestone in the Holyoake Range. The chemostratigraphic record reveals a marked $\delta^{13}C$ negative excursion in the middle Shackleton Limestone. This negative $\delta^{13}C$ shift may correspond to a globally recognized upper Terreneuvian, Cambrian Stage 2 negative anomaly (approximately 524 My), suggesting that the immediately overlying trilobites (basal Cambrian Stage 3) are potentially the oldest trilobites from East Gondwana.

A BIOSTRATIGRAPHIC INVESTIGATION OF THE PROTEROZOIC AND LOWER PALAEOZOIC OF COLOMBIA: PALYNOLOGICAL ANALYSES OF SIX WELLS FROM THE NORTHERN LLANOS BASIN

Gareth M. G. Hughes[1], Felipe de la Parra[2], M. Carolina Vargas[2] and Henry G. Suarez[3]

1. PetroStrat Ltd., Tan-Y-Graig, Parc Caer Seion, Conwy, LL32 8FA, UK. gareth.hughes@petrostrat.com
2. Biostratigraphy team, Instituto Colombiano del Petróleo-Ecopetrol, AA 4185, Bucaramanga, Colombia.
3. Empresa Colombiana de Petróleo ECOPETROL, Bogotá, Colombia.

The Proterozoic and Palaeozoic rocks of Colombia are poorly understood in comparison to those of the younger oil–producing Cenozoic and Mesozoic chronostratigraphic intervals. Here, we take advantage of six well bores (A, B, C, D, E, and F) drilled into the Proterozoic–Palaeozoic basement beneath younger hydrocarbon reservoirs in the Northern Llanos Basin to investigate the palynology of the strata encountered, with the aim of establishing a chronostratigraphic and biostratigraphic framework for these intervals. Washed and dried wellbore ditch–cuttings samples from each well were subjected to traditional palynological HF acid maceration techniques and analysed quantitatively, using 200 palynomorph counts where possible. All six wells investigated yielded acritarch assemblages, indicating deposition in marine environments, and allowing for a chronostratigraphic breakdown of each well. Other palynomorphs recovered included chitinozoa, graptolites, stromatolite filaments and *Wiwaxia* sclerites, and these were also used to help establish the ages of the palynological assemblages. In general, the results show that the Palaeozoic sequence drilled by the wells is older toward the northeast and younger toward the southeast in the study area. The oldest sequence was found in the well A (10 samples) and yielded an assemblage of acritarchs and algal filaments indicative of a probable middle–late Riphean age (Mesoproterozoic–Neoproterozoic). Well B (55 samples) yielded a rich acritarch assemblage (together with a number of *Wiwaxia* sclerites) indicative of an early Drumian age (middle Cambrian). Well C (17 samples) yielded an acritarch assemblage indicative of a Furongian - early Floian age (late Cambrian–Early Ordovician). Well D (7 samples) yielded a lean assemblage indicative of a late Tremadoc–early Floian age (Early Ordovician). Well E (10 samples) yielded a rich acritarch and chitinozoan assemblage indicative of a late Floian–Dapingian age (Early–Middle Ordovician). Well F (16 samples) yielded a rich acritarch assemblage indicative of a Darriwilian age (Middle Ordovician). These results have not only established the chronostratigraphic breakdown of the well intervals analysed, but also demonstrate the potential for palynology to play a key role in the future understanding of the Proterozoic and Palaeozoic rocks of Colombia.

INDO-BRAZILIAN PERMIAN FLORAL SUCCESSIONS: A TENTATIVE CORRELATION

Roberto Iannuzzi[1], Mary E.C. Bernardes-de-Oliveira[2], Rajni Tewari[3] and Pauline Sabina[3]

1. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves 9500, Porto Alegre, RS, 91.540-000, Brazil. roberto.iannuzzi@ufrgs.br

2. Centro de Pós-Graduação e Pesquisa da Universidade Guarulhos e Instituto de Geociências, Universidade de São Paulo, Rua do Lago 562, São Paulo, SP, 05508-080, Brazil.

3. Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow, 226 007, India.

This contribution proposes a tentative correlation between the Permian floral succession of the Brazilian Paraná Basin and the Indian floral stages. This scheme of correlation could be considered as a start point for future investigations concerning paleobotany, paleogeography, and paleoclimatology. The Asselian-Sakmarian uppermost Itararé Group (IG) corresponds, on a palynological viewpoint, to the lower *Vittatina costabilis* Interval Zone (*Vc*IZ), and in terms of plant zonation, to three equivalent informal stages: the Transitional Taphoflora, the *Phyllotheca*–*Gangamopteris* Flora, and the *Gangamopteris*-*Rubdigea*-*Stephanophyllites* Association. This interval is characterized by the first appearance of glossopterid elements and the predominance of species of *Gangamopteris* in relation to species of *Glossopteris*. The IG micro- and megaflora can be compared to equivalent assemblages of the Indian Talchir Stage. The overlying Sakmarian-Artinskian Rio Bonito Formation (RBF) corresponds, on a palynological viewpoint, to the middle-to-upper *Vc*IZ, and to three comparable floral stages, *e.g.* Taphofloras B and C / *Glossopteris*–*Brasilodendron* Flora. The genus *Glossopteris* becomes dominant, and replaces *Gangamopteris*, towards the top of the RBF. Besides, characteristic Indian taxa as *Cheirophyllum*, *Kawizophyllum*, and *Giridia*, are present in the uppermost IG and the RBF. The RBF assemblage is comparable to the flora of the Indian Karharbari and lower Barakar stages. The next unit, the Kungurian Irati Formation (IF), is characterized by a new palynozone, the *Lueckisporites virkkiae* Interval Zone (*Lv*IZ), and two equivalent floral stages, the Taphoflora D, and the *Polysolenoxylon*–*Glossopteris* Flora. The presence of *Polysolenoxylon*-like woods and the disappearance of *Gangamopteris* allow the correlation of the IF with the Indian upper Barakar Stage. In the overlying Guadalupian Teresina Formation (TF) occurs the last record of palynomorphs referred to the *Lv*IZ, and the presence of the impoverished, *Lycopodiopsis*-dominated floral assemblage of the *Lycopodiopsis derby* Zone. The TF floral assemblages suggest a possible correspondence with the Indian Kulti/Barren Measures Stage. The uppermost Guadalupian-Lopingian Rio do Rasto Formation (RdRF) includes two phytozones: *Sphenophyllum paranaense* (= Taphoflora E) and *Schizoneura gondwanensis*. The correlation of the RdRF assemblages with the lower-middle Raniganj Stage is suggested by a remarkable increase of *Glossopteris* species and the abundance of sphenophytes and ferns. [Contribution to CNPq Indo-Brazilian Cooperation Project 490829/2007-4].

A COPROLITE WITH CROCODYLIFORM REMAINS FROM THE BAURU BASIN (LATE CRETACEOUS), BRAZIL

Fabiano Vidoi Iori[1] and Thiago da Silva Marinho[2]

1. Museu de Paleontologia "Prof. Antonio Celso de Arruda Campos", Praça do Centenário, Monte Alto, São Paulo, 15910-000, Brazil.

2. Instituto de Ciências Exatas, Naturais e Educação (ICENE), Universidade Federal do Triângulo Mineiro (UFTM), Av. Dr. Randolfo Borges Jr. 1700, Univerdecidade, 38064-200, Uberaba, Minas Gerais, Brazil. tsmarinho@icene.uftm.edu.br

During fieldwork in March 2002 many fossils were discovered in Taquaral County, São Paulo state, Brazil (Bauru Basin, Adamantina Formation). The Cretaceous materials consist of dinosaurs and crocodyliforms remains, fish scales and coprolites. One of these coprolites (MPMA 18-0004/02) presents three osteoderms of a crocodyliform included in the fecal mass. This material possesses about 100 mm length in the main axis, shapeless aspect, whitish color with small greyish marks and portions of brownish sandstone. One osteoderm presents 10 mm in length and its external face is exposed in the coprolite surface; it is oval, with a low medial keel and ornamentation composed by small pits. The other osteoderms were inside and became visible due the breaking of the coprolite. Although both are fragmentary, it is possible to observe typical structures of the ventral osteoderm. One presents its internal side exposed, while the second exhibits the external surface. They are flat; the ornamented face is marked by small pits while the internal face shows the typical interwoven osseous fibers. Due to the fragmentary condition of the material, it is not possible to assign the osteoderms to a taxon, but possibly this dermic elements are more related to Peirosauridae or Trematochampsidae than to Notosuchia, and are most likely to have belonged to a single specimen due to their sizes and overall characteristics. This is a rare evidence of crocodyliform predation in the Brazilian Cretaceous and among the possible predators are theropods and crocodyliforms. Assigning the production of the analyzed coprolite to theropod seems more plausible, considering that bone structures of their prey are fully digested in the digestive tract of extant crocodiles and alligators. Another possibility is that extinct crocodyliforms such as notosuchians and peirosaurids would have had a different digestive physiology in which bones could not be fully digested.

TREPOSTOMATE BRYOZOANS FROM THE ORDOVICIAN ANTARCTIC POLAR CIRCLE

Andrea Jiménez-Sánchez[1], Enmanuelle Vennin[2] and Enrique Villas[3]

1. Center of Biology, Geosciences and Environmental Education, University of West Bohemia, Klatovská 51, 306 19 Plzen, Czech Republic. jimenez@cbg.zcu.cz

2. Biogéosciences, Université de Bourgogne, 6 bd. Gabriel, 21000 Dijon, France.

3. Departamento de Ciencias de la Tierra, Facultad de Ciencias, Universidad de Zaragoza, c/ Pedro Cerbuna 10, 50009 Zaragoza, Spain.

Although the Late Ordovician bryozoans from the Mediterranean Province are well known, with more than 50 identified genera, little has been said about them on the highest latitude regions within the province. The Moroccan Anti-Atlas was located by this time above 65º or even 70º south latitude, on the North Gondwana margin. In the Eastern Anti-Atlas, west of Erfoud, 12 genera and 21 species of bryozoans of the order Trepostomata have been recorded from the Khabt-el-Hajar Formation, late Katian in age. They are only a small part of a larger collection, among which only this order and the order Cryptostomata are clearly represented. The studied bryozoans have been collected from the second unit of the formation, made up of marls to fine-grained limestones. The bryozoan biofacies that characterizes this unit is composed of *in situ* robust and delicate-branching bryozoans that formed metre-scale patches and bioaccumulations embedded in a marly substrate developed on outer-ramp environments. The superbly preserved Anti-Atlas bryozoans offer a unique opportunity of analyzing the mineralogical, geochemical and morphological features of high latitude bryozoans, and their comparison with those from middle and low latitudes. A total of 21 species included in the genera *Anaphragma*, *Aostipora*, *Atactoporella*, *Calloporella*, *Cyphotrypa*, *Dekayia*, *Diplotrypa*, *Homotrypa*, *Monotrypa*, *Monticulipora*, *parvohallopora* and *Prasopora* are described. The species *Anaphragma mirabile*, *Monotrypa jewensis* and *Prasopora falesi* were already known from the equatorial-tropical paleocontinents of Baltica, Laurentia and Siberia, while *Cyphotrypa magna* and *Diplotrypa languedociana* are exclusive from the Mediterranean Province. The species *Anaphragma* n. sp., *Aostipora* n. sp., *Atactoporella* n. sp., *Cyphotrypa* n. sp., *Monticulipora* n. sp. 1, *Monticulipora* n. sp. 2 and *Parvohallopora* n. sp. are new. One of the most outstanding features of the studied collection is the predominance of the order Trepostomata in the fossil assemblages, representing more than 75% of the total identified genera. This strongly contrasts with the rest of the Mediterranean Province where, besides the two orders represented in Morocco, a diverse representation of the orders Cystopora, Cyclostomata and Fenestrata is found.

DIETARY ADAPTATIONS AND MASTICATION IN TRITYLODONTIDS (SYNAPSIDA, CYNODONTIA) BASED ON TOOTH WEAR PATTERNS

Daniela C. Kalthoff[1], Julia A. Schultz[2], Ellen Schulz[3], Thomas Martin[2], Steve McLoughlin[4] and Ian Corfe[5]

1. Swedish Museum of Natural History, PO Box 50007, Stockholm, SE–10405, Sweden. daniela.kalthoff@nrm.se
2. Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Nussallee 8, 53115 Bonn, Germany.
3. Biocenter Grindel and Zoological Museum, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany.
4. Swedish Museum of Natural History, PO Box 50007, Stockholm, SE–10405, Sweden.
5. EvoDevo lab, Institute of Biotechnology, University of Helsinki, Viikinkaari 9, FIN-00014, Finland.

Tritylodontids are small to medium-sized, mainly terrestrial synapsids, which ranged from the Late Triassic until late Early Cretaceous and are highly abundant in many localities. They possess several mammal-like characters of which their multi-rooted, multi-cusped molariform teeth with precise occlusion are the most remarkable. The combination of enlarged incisors, diastema and three cusp rows on upper molariform teeth and two on the lower results in the tritylodontids dental pattern resembling that of multituberculates and modern murids (Rodentia), but this pattern evolved independently within the three groups. Tritylodontids developed a palinal power stroke, also in parallel to but independently from multituberculates, but in contrast to the proal jaw movement of murids. Based on the details of their tooth morphology, tritylodontids are considered to have been herbivorous. Here, we present preliminary results for light-optic microwear and surface texture analysis (according to ISO 25178) in a small sample of the molariform teeth of seven tritylodontid taxa from the Early to Middle Jurassic of the United Kingdom, southern Africa and the United States. In general, tooth wear features such as frequent small pits and sparse scratches indicate low abrasiveness of food items for all analyzed species. However, the larger, fox- to dog-sized species *Dinnebitodon amarali* and *Kayentatherium wellesi* suggest somewhat more abrasive food resources than the smaller rodent-sized species (*Oligokyphus major*, *O.* sp., *Tritylodon longaevus*, *Stereognathus ooliticus*, Tridylodontidae indet.). Coarser features such as deep puncture pits in all analyzed species suggest consumption of hard items from plant reproductive structures (probably small and durable seeds). The overall smooth surface texture indicated by low values of root-mean-square roughness (*Sa*), peak density (*Spd*), and material volume (*Vm*) does not point to foraging for underground food items but to softer but heterogeneous plant components with moderate cuticle thickness. Examples include leaves, shoot tips, herbaceous pteridophytes, lichens, or perhaps the softer components of gymnosperm reproductive structures. Possible candidates for fodder plants with corresponding foliar and disseminule characteristics can be found amongst several gymnosperm groups e.g. Caytoniaceae, Pachypteridae, Ginkgoales, Leptostrobales and Williamsoniaceae. Tooth wear patterns are in accordance with a predominantly herbivorous diet. However, it has been shown that consumption of invertebrates with soft or no exoskeleton can produce similar tooth wear features. We hypothesize that the smaller tritylodontid taxa were feeders with an opportunistic diet and/or at least a seasonally dependent diet of plants and soft-bodied animals; whereas the larger taxa were almost exclusively herbivorous.

PALEOECOLOGY OF ECHINODERMS FROM COLD SEEP DEPOSITS: ADAPTATION OF ECHINODERMS TO THE COLD SEEP ENVIRONMENTS

Moe Kato[1], Tatsuo Oji[2], Neal L. Larson[3] and Jamie Brezina[4]

1. Graduate School of Environmental Sciences, Nagoya University, Nagoya, 464-8601, Japan. katou.moe@d.mbox.nagoya-u.ac.jp
2. The Nagoya University Museum, Nagoya University, Nagoya 464-8601, Japan.
3. Larson Paleontology Unlimited, 216 Main St., Hill City, South Dakota 57745, USA.
4. P.O. Box 726, Rapid City, South Dakota 57709, USA.

Cold seep is one of the unique environments where special fauna called "the chemosynthesis community" inhabits. Echinoderms were thought to be rare in a cold seep environment and had not been treated as a member of the chemosynthesis community until recently. However, in the last 10 years, some modern and fossil species of echinoderms have been reported from hydrothermal vents or cold seeps, or from their fossil analogues. Fossil echinoderms including crinoids, echinoids (*Hemiaster* sp. and *Salenia* sp.), ophiuroids and asteroids are found in carbonate mounds associated with methane seeps in the Upper Cretaceous (upper Campanian) Pierre Shale, South Dakota. However, the taxonomic and paleoecologic studies about these echinoderms have not been sufficiently done, and the relationship between these echinoderms and cold seeps has been unsolved either. To evaluate the degree of relation of these echinoderms had gained energy from seep hydrocarbon, and to identify if these echinoderms were truly included in the chemosynthetic community, stable carbon isotopes ($\delta^{13}C$) analyses of fossil echinoderm skeletons were also conducted. As a result, fossil crinoids from seep carbonates have unique morphologies and very low $\delta^{13}C$ values (-20‰ or less). These results suggest that crinoids from seep carbonates were a member of the chemosynthesis community. On the other hand, echinoids from seep carbonates have higher $\delta^{13}C$ values than seep crinoids, and morphologically they are not significantly different from those found in non-seep environments. Therefore, the echinoids from seep carbonates were not considered as a true member of chemosynthetic community. It is concluded that the degrees of adaptation to cold seeps are different among echinoderm species.

THE LATE MIOCENE BOVIDS (BOVIDAE, MAMMALIA) FROM DHOK PATHAN FORMATION OF SIWALIKS, NORTHERN PAKISTAN

Muhammad Akbar Khan[1], Sayyed Ghyour Abbas[1], Muhammad Akhtar[1] and Abdul Majid Khan[1]

1. Palaeontology laboratory, Department of Zoology, Quaid-e-Azam Campus, Punjab University, Lahore, Pakistan. majid.zool@pu.edu.pk

The present paper deals with an investigation in the late Miocene bovid fauna of the Dhok Pathan Formation of Chakwal district, northern Pakistan. The aim of this work is to expose as briefly as possible the richness and diversity of the bovids from the Dhok Pathan type locality by updating the taxonomy of the fossil sites. New remains comprising upper and lower molars are described and discussed here. The material belongs to eight bovid species: *Pachyportax latidens*, *Pachyportax* cf. *nagrii*, *Selenoportax* cf. *vexillarius*, *Tragoportax punjabicus*, *Tragoportax* cf. *browni*, *Tragoportax* cf. *salmontanus*, *Elachistoceras khauristanensis* and *Gazella lydekkeri*. The abundance of the boselaphines in the Dhok Pathan type locality indicates that the Siwaliks were inhabited by various boselaphines during the late Miocene-early Pliocene, and the new findings enlarge our knowledge on the anatomic features of the reported species. The bovid fossil record from the Siwaliks is generally very good in comparison with that of other parts of the world. The late Miocene Siwalik localities of Chakwal in northern Pakistan have yielded one of the richest fossil bovid faunas from south Asia, making these sections excellent candidates for palaeoenvironmental analysis. The Siwalik geological range spans from the early Miocene to the Pleistocene. The bovid fossils from the Kamlial Formation of the Siwaliks are almost 18.3 Ma old and those from the Vihowa Formation of the pre-Siwaliks range between 17.0 Ma and 17.6 Ma, and they are considered the oldest ones. The Dhok Pathan Formation belonging to late Miocene-early Pliocene is one of the richest formations of the Siwaliks and, in particular the abundant faunas of the Middle Siwaliks characterize the evolution, biostratigraphy, and palaeogeography of Neogene bovids.

INSECT FAUNA IN THE SOUTH-EASTERN EXTREME OF GONDWANA (ARGENTINA): CO-ASSOCIATION INSECT/PLANT AND CLIMATE PROVINCIALISM DURING TRIASSIC TIMES

Maria B. Lara[1] and Ana M. Zavattieri[2]

1. Área Paleontología (Centro de Ecología Aplicada del Litoral-CONICET) y Entomología, Facultad de Ciencias Exactas y Naturales y Agrimensura, Universidad Nacional del Nordeste, Casilla de Correo 128, 3400 Corrientes, Argentina.

2. Laboratorio de Paleopalinología, Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, Centro Científico y Tecnológico, Consejo Nacional de Investigaciones Científicas y Técnicas - Mendoza, Casilla de Correo 131, 5500 Mendoza, Argentina. amz@mendoza-conicet.gov.ar

The richness of insects found in the Triassic continental sediments positions Argentina as the main paleoentomological region of South America and one of the most important from southern Gondwana. At the moment, the insect faunas of the Molteno Formation, Karoo Basin, South Africa (335 species), and the Ipswich Series, Queensland, Australia (115 species) are more abundant and diverse. The bioestratigraphic distribution of the insect fauna occurs mostly in association with the typical and diverse *Dicroidium* Flora during the Middle and Late Triassic. The paleogeographic position of Argentina, South Africa and Australia Triassic basins explains the presence of a marked floristic provincialism through southern Gondwana, and a similar eco-environment and climate patterns. The *Dicroidium* Flora occupied middle to high paleolatitudes (>30º) in the extratropical belt of Gondwana. It progressed under temperate/warm and humid conditions in a megamonzonic climate. The insects would be thus adapted to strongly seasonal conditions. The significant paleoentomological potential of the Argentine Triassic is based on more than 510 specimens of insects classified into 12 orders, 25 families and 83 species. The insect bearing levels come from fluvial environments of the: Ischichuca (~Anisian-Ladinian) and Los Rastros (~Carnian) formations, Bermejo Basin, San Juan and La Rioja Provinces; Cerro de Las Cabras (~Anisian-Ladinian) and Potrerillos (~Carnian) formations, Cuyo Basin, Mendoza Province; Llantenes Formation (~Norian), Malargüe Basin, Mendoza. The Los Rastros (44 species) and Potrerillos (23 species) formations contribute with 61% of collected specimens, being essentially similar in taxonomic composition. The insect records comprise fragmentary and occasionally articulated specimens with different preservation modes as impressions/molds of wings, part of bodies and complete bodies attributable to blattids, hemipterans, beetles, orthopterans, mecopterans, miomopterans, grylloblattids, plecopterans, miomopterans, dipterans, hymenopterans, odonatans and glosselytrodeans. Most of the groups exhibit terrestrial habit (adult stages); however, records of aquatic forms (immature stages) are also present. The dominant forms of the assemblages are insects with sclerotized wings: Coleoptera (32 species), Blattodea (17 species) and Hemiptera (16 species), a similar characteristic to the largest entomological deposits of South Africa and Australia. Among the most important findings of insects in Argentina are the first records of several orders/families for South America and Gondwana that provide new evidence about close faunal connections between Laurasia and Gondwana during the Mesozoic. The study of fossil insects provides valuable information about the taxonomical composition of the Triassic communities, the evolution of Mesozoic insects, the relationship plant-insects-habitat, and the reconstruction of ecosystems in response to paleoenvironment and climatic conditions.

TOWARD A COMPREHENSIVE BIOSTRATIGRAPHY OF THE CHESAPEAKE AND DELAWARE CANAL CRETACEOUS TRACTS, STATE OF DELAWARE, USA

Edward M. Lauginiger[1], Rodrigo A. Pellegrini[1] and David C. Parris[1]

1. New Jersey State Museum, Trenton, NJ, 08625-0530, USA.
Rodrigo.Pellegrini@sos.state.nj.us

After nearly two centuries of paleontological studies along the banks of the Chesapeake and Delaware Canal, it remains a productive area for research in the Merchantville, Englishtown, Marshalltown, and Mount Laurel Formations. It includes the type localities of some of the most useful North American ammonoid guide fossils of Cretaceous age, such as *Scaphites hippocrepis* (DeKay). It has also produced significant arthropod, echinoderm, and vertebrate specimens. Vagueness of early records, complications of spoil pile recoveries, and difficulties of consolidating data have all been barriers to a comprehensive biostratigraphy, but major advances have taken place during recent years. Our approach to this problem includes the detailed study of the pivotal (*in situ*) Deep Cut Local Fauna of the Merchantville Formation, placing significant fossil vertebrates within a biostratigraphic spectrum that was established with pelecypod and cephalopod taxa. The results enable us to propose a revised biostratigraphy relative to the Late Cretaceous (Campanian and Maastrichtian) which now includes the chondrichthyan taxa *Ischyodus*, and *Scapanorhynchus texanus* Roemer, the osteichthyan *Enchodus petrosus* Cope, the mosasaur *Halisaurus platyspondylus* Marsh, several genera of turtles, and several genera of pterosaurs, all of which have well known phylogenies and biostratigraphic ranges.

TAPHONOMY OF CARBONATE CONCRETIONS WITH IRREGULAR ECHINOIDS FROM THE LOWER CRETACEOUS AGRIO FORMATION, NEUQUÉN BASIN, WEST-CENTRAL ARGENTINA

Oscar E. R. Lehmann[1], Darío G. Lazo[1] and Beatriz Aguirre-Urreta[1]

1. Instituto de Estudios Andinos "Don Pablo Groeber" (CONICET), Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón II, Ciudad Universitaria, C1428EGA, Buenos Aires, Argentina. lehmanncxii@gmail.com

Echinoid-dominated assemblages are valuable taphonomic and palaeoecological tools and very useful to determine environmental parameters such as rate of sedimentation, water energy and substrate consistency. Despite this fact, they are rather poorly known from the Lower Cretaceous worldwide, particularly from South America. In this work, a total of four complete ellipsoidal carbonate concretions and 11 loose fragments, hosting mass accumulations of small irregular echinoids, were studied. They proceed from the upper third of the Agua de la Mula Member of the Agrio Formation, at Mina San Eduardo locality in the Neuquén Basin of west-central Argentina. The unit has been interpreted as shallow mixed clastic-carbonate marine deposits, being most of its macrofossil assemblages dominated by mollusks. All of the studied concretions and fragments were sampled from a single stratigraphic level in which they were found scattered and immersed in one thick bed of grey shales. This bed was precisely dated as late Hauterivian by means of the associated ammonoid fauna. The echinoids are provisionally identified as *Coenholectypus* Pomel, having a diameter between 2.5 and 8 mm. The concretions correspond to floatstones, ranging from 10 to 15 cm of maximum length and 5 to 5.5 cm of maximum thickness and present an externally grey and internally dark-grey coloration. They are composed of loosely to densely packed echinoid tests supported by a carbonate mud matrix. Tests are well sorted and randomly orientated both in plan view and cross section. The echinoid assemblage is monotypic, although in one of the concretions a few small-sized burrowing bivalves were also observed. Echinoids are preserved as hardparts, which can be found empty, or partially to totally filled with sediment concordant with the surrounding mud matrix. Most of them correspond to denuded tests, lacking apical, periproctal and oral plates. However, some specimens still have articulated spines and lantern. There are no signs of bioerosion or encrustation in any of the tests. We suggest that these concentrations of echinoids may be regarded as mixed biogenic-sedimentologic in origin, possibly related to mass-reproduction events of echinoids coupled with little physical reworking and minor lateral transport within small patches or pots. Time-averaging is thought to be very small, in the order of a census assemblage.

NANNOCONID ASSEMBLAGES FROM THE UPPER JURASSIC AND LOWER CRETACEOUS SEDIMENTS OF THE VACA MUERTA AND AGRIO FORMATIONS (NEUQUEN BASIN, ARGENTINA)

Marina Lescano[1] and Andrea Concheyro[1-3]

1. IDEAN-Instituto de Estudios Andinos 'Don Pablo Groeber'. Consejo Nacional de Investigaciones Científicas y Técnicas. Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires. Pabellón II. Ciudad Universitaria. CP 1428. Ciudad Autónoma de Buenos Aires, Argentina. lescano@gl.fcen.uba.ar

2. Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina.

3. Instituto Antártico Argentino, Balcarce 290, C1064AAF, Ciudad Autónoma de Buenos Aires, Argentina.

Several studies on calcareous nannofossils have been performed through the last years in Argentina, with the aim of establishing geologic correlations between different stratigraphic sections of the Neuquén Basin and with other Mesozoic Tethyan basins. The nannoconids, considered of uncertain affinity, have been included within the calcareous nannofossils, because of their calcareous algal origin, size and morphological features. The gender *Nannoconus* has appeared on the Early Tithonian and has extinguished in the Campanian. In the Neuquén Basin the late Tithonian-Hauterivian interval is represented in sediments of the Vaca Muerta and Agrio Formations. In this contribution Late Jurassic- Early Cretaceous nannoconid assemblages recognized in thirteen sections of the Neuquén Basin are disclosed. Sections are: Arroyo Durazno (35°05'S-69°45'W), Las Loicas (35°47'S-70°09'W), Don Alfaro (36°18'S-70°21'W), Lonco Vaca (36°22'S-70°12'W), Quebrada Maravilla (36°28'S-70°12'W), Cerro La Parva (37°16'S-70°26'W), Mina San Eduardo (37°31'S-70°01'W), Loma Rayoso (37°36'S-70°01'W), Agua de la Mula (38°04'S-70°01'W), Bajada del Agrio (38°27'S-70°04'W), Cerro Birrete (39°17'S-70°0.5'W), Barda Cerro Marucho (39°26'S-70°13'W) and Cerro Marucho (39°26'S-70°13'W). The nannoconids have been found in all studied sections, and therefore have a wide geographic distribution in the analyzed formations, and are represented by 7 species and 11 subspecies of *Nannoconus*. The finding of *Nannoconus elongatus minutus, Nannoconus quadriangulus apertus, Nannoconus steinmannii minor, Nannoconus truitti frequens, Nannoconus truitti rectangularis* and *N. wintereri* in the basin, constitute their first references for Argentina, and for two of them they are the first records for the Southern Hemisphere. In sediments of the Vaca Muerta Formation the first occurrence (FO) of *N. wintereri* (Tithonian) has been identified as well as the FOs of *N. kamptneri minor*, *N. kamptneri kamptneri*, *N. steinmannii minor* and *N steinmannii steinmannii* (Berriasian). These bioevents indicate the calcareous nannofossil Biozones NJK-NK1. In addition, three calcareous nannofossil bioevents have been recognized in sediments of the Agrio Formation, and include the FO of *N. bucheri* and *N. circularis* assigned to the late Valanginian, and the FO of *N. ligius* correlated with the late Hauterivian. All these bioevents in the Neuquén Basin belong to the CC4A-CC4B Zone. Taking this study into account, *Nannoconus minutus elongatus, Nannoconus quadriangulus quadriangulus, Nannoconus quadricanalis, Nannoconus truitti frequens* and *Nannoconus truitti rectangularis* would extend their known stratigraphic ranges. During the Late Jurassic and Early Cretaceous, the nannoconid assemblages suggest Tethyan affinities and they would allow us to establish reliable intercontinental correlations between the Neuquén Basin and the Mediterranean Region.

NEW PRECISIONS CONCERNING THE ANGIOSPERM RECORD IN THE BAQUERÓ GROUP, PATAGONIA, ARGENTINA

Magdalena Llorens[1,6], Mauro G. Passalia[2,3,6], Valeria S. Pérez Loinaze[4,6], Ezequiel I. Vera[4,5,6], Silvia N. Césari[4,6] and Carlos O. Limarino[5,6]

1. Comisión Nacional de Energía Atómica, Regional Patagonia, 26 de Noviembre s/n, 9100 Trelew, Argentina.
2. Instituto de Investigaciones en Biodiversidad y Medioambiente, CONICET-UNCo, Quintral 1250, R8400FRF San Carlos de Bariloche, Argentina. passaliam@gmail.com
3. Universidad Nacional de Río Negro, 25 de Mayo 880, General Roca, Argentina.
4. Museo Argentino de Ciencias Naturales "B. Rivadavia", Av. Ángel Gallardo 470, C1405DJR Buenos Aires, Argentina.
5. Departamento de Ciencias Geológicas, Universidad de Buenos Aires, Pabellón 2, Ciudad Universitaria, 1428 Buenos Aires, Argentina.
6. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.

The Baqueró Group, located in the Argentinian Patagonia, with its diverse, exquisitely preserved, and accurately dated megafloristic and palynologic remains, is one of the most relevant units for the study of the early diversification of angiosperms in southern Gondwana. The floristic and environmental framework in which the diversification of early flowering plants took place is accurately contextualized by the extensive knowledge of non-angiosperm floral components and sedimentological data. The Baqueró Group comprises three units, i.e. Anfiteatro de Ticó, Bajo Tigre and Punta del Barco formations, deposited during an interval constrained between 118.23 ± 0.09 and 114.67 ± 0.18 Ma (late Aptian). The lower and upper units contain remains of flowering plants, whereas deposits of the Bajo Tigre Formation are devoid of them. Angiosperm leaves from the basal Anfiteatro de Ticó Formation include a festooned brochidodromous morphotype (Nymphaeaphyll morphotype) and a variety of micromesophyll, lobate serrate morphotypes with craspedodromous venation. In all cases, the leaves are characterized by multistranded veins, a feature considered a symplesiomorphy within the group. The only possible angiosperm megafloristic record from the Punta del Barco Formation consists of nanophyll leaves with incised laminae and actino to palinactinodromous venation. The palynological assemblages studied from the Anfiteatro de Ticó Formation are characterized by eight types of angiosperm pollen grains, referred to the genera *Clavatipollenites*, *Retimonocolpites* and *Jusinghipollis*, with some species exclusive from this unit. The Punta del Barco Formation yielded five types of angiosperm pollen, referred to *Clavatipollenites* and *Retimonocolpites*. Among them, *Clavatipollenites* sp. B, *Retimonocolpites* sp. B and *Retimonocolpites* sp. C are exclusive from this unit. Differences in pollen richness along the Baqueró Group may reflect adverse environmental conditions towards the top of the unit, which are in accordance with observed lithological features. Nevertheless, according to the new data presented herein, and especially from the palynological record, it results evident that the diversity of early angiosperms in Patagonia during the late Aptian, was higher than previously thought.

CALIBRATING MORPHOMETRIC PROXIES OF CHEMOSYMBIOSIS: A TEST CASE USING LUCINIDAE (BIVALVIA)

Brooke Long[1], Laurie C. Anderson[1] and Annette S. Engel[2]

1. South Dakota School of Mines and Technology, 501 E St. Joseph St., Rapid City, SD 57701, USA.
Brooke.Long@mines.sdsmt.edu

2. University of Tennessee, 1412 Circle Dr, Knoxville, TN 37996, USA.

Detecting chemosymbiosis in the fossil record is difficult, as many proxies that could test taxonomic-uniformitarian assumptions have limited application (geochemical proxies applied to shell carbonate) or run the risk of circularity of reasoning (morphologic proxies). For instance, lucinid bivalves are an ancient bivalve clade in which all living members examined to date possess sulfur-oxidizing bacterial endosymbionts. Although a basal synapomorphy is the most parsimonious explanation for universal chemosymbiosis in extant taxa, other mechanisms, including differential extinction of nonsymbiotic lineages, could produce the same character distribution. A proxy for chemosymbiosis applicable to fossil taxa could be used to test hypotheses of endosymbiotic evolution as well as elucidate paleocommunity dynamics and biogeochemical cycling for the wide range of marine ecosystems that these bivalves inhabit. However, because shell carbonate is precipitating in equilibrium with seawater, because lucinids occur in a wide range of marine environments (coastal to abyssal), and because shell conchiolin (which does carry a chemosymbiotic signal) has low preservation potential, a widely applicable geochemical proxy has been elusive. Alternatively, a geometric morphometrics examination of eight shallow-marine lucinid species along with two other 'lucinoid' taxa (one chemosymbiotic) indicated both significant shape differences among taxa and a possible association of thin-plate spline configurations with the position of mantle modifications associated with chemosymbiosis. That said, however, there is a stronger association between shape and life position than with possession of chemosymbionts. A closer examination of morphology within one taxon (*Phacoides pectinatus*) for which we have data on gill microbes and on sediment geochemistry are being used to test for associations between shell shape and a host of ecologic, environmental, and life history factors. Although such a morphologic proxy does run the risk of circular reasoning, the distinctive morphologic features being examined are readily preservable on fossil shells and/or their internal molds.

A NEW ICHNOGENUS OF LARGE BURROWS ATTRIBUTED TO CENOZOIC MAMMALS OF SOUTH AMERICA

Renato P. Lopes[1], Heinrich T. Frank[2], Francisco S. C. Buchmann[3] and Felipe Caron[4]

1. Universidade Federal do Rio Grande do Sul. Programa de Pós-Graduação em Geociências. Av. Bento Gonçalves, 9500, CEP 91501-970, Porto Alegre, RS, Brazil. paleonto_furg@yahoo.com.br

2. Universidade Federal do Rio Grande do Sul, Instituto de Geociências. Av. Bento Gonçalves, 9500, CEP 91501-970, Porto Alegre, RS, Brazil.

3. Universidade Estadual Paulista, Laboratório de Estratigrafia e Paleontologia. Campus do Litoral Paulista. Praça Infante Don Henrique, s/n., CEP 11330-900, São Vicente, SP, Brasil

4. Universidade Federal do Pampa, Campus de Caçapava do Sul. Av. Pedro Anunciação, s/nº - CEP 96570-000, Caçapava do Sul, RS, Brazil.

In recent years, more than 1,500 large burrows have been found in continental settings in Argentina and Brazil, in various types of substrates ranging from Plio-Pleistocene consolidated sediments to Precambrian weathered rocks, Permian sedimentites and Jurassic-Cretaceous sandstones and weathered basalts. So far, two types of burrows have been found: the smaller ones measure between ~1.3 and 1.4 meter in diameter, exhibit sub-elliptical to sub-circular outline, most (up to ~90%) are found filled by sediments (crotovinas) and seem to be restricted to consolidated sediments and sandstones; the larger type can reach up to 4 meters in width and 2 meters in height and so far has only been found in sandstones and weathered volcanic rocks. In some cases this type of burrow exhibit heights of up to 4 meters, due to the collapse of the ceiling. The smaller ones display varying degrees of dip, are straight or slightly sinuous, cylinder-shaped and often branched, and the total length of each individual tunnel is highly variable, in some cases surpassing 30 meters. The larger type is sub-horizontal and branched and can reach tens of meters in length. Inside most of the burrows the walls and ceiling exhibit hundreds of densely-grouped scratch marks in the form of ~2-3 centimeter-deep, 4 centimeter-wide and up to 50 centimeter-long grooves, considered to be evidence of digging activity; one of the smaller burrows found in alluvial sediments in southern Brazil exhibit imprints consistent with the shell of a large armadillo, while others exhibit rugose imprints seemingly produced by body fur. Sixteen large burrows in southeastern Brazil exhibit some large (~2 meter-long) sub-elliptical smooth depressions on the walls and floor; these structures are interpreted as resting places for large animals, probably ground sloths. Body fossils so far have only been found in burrows of the smaller type dug in Pliocene sediments of the Chapadmalal Formation in Argentina; these fossils include carnivores, rodents, ground sloths, dasypodids, glyptodonts and marsupials, which suggest multiple re-occupations through time. These burrows are regarded as permanent dwelling places (Domichnia ethological class). Here we propose to classify these burrows under a new ichnogenus and we also intend to group the smaller and the larger burrows under two new specific names.

FOSSIL-RICH HORIZONS FROM THE UPPER JURASSIC IN NE MEXICO

Iriliana López-Caballero[1], Ana B. Villaseñor[2] and Federico Olóriz[3]

1. Posgrado en Ciencias de la Tierra, Sede Instituto de Geología, UNAM, Ciudad Universitaria, 04510 Mexico D.F. Mexico. irilianalc@yahoo.com.mx

2. Departamento de Paleontología, Instituto de Geología, UNAM, Ciudad Universitaria, 04510 Mexico D.F., Mexico.

3. Departamento de Estratigrafía y Paleontología, Facultad de Ciencias, Universidad de Granada, Av. Fuentenueva s/n, 18002 Granada, Spain.

Ammonite-rich stratigraphic horizons of Kimmeridgian age have been reported from NE Mexico in deposits belonging to the La Caja and La Casita formations, which are interpreted as deposited in relatively distal and proximal depocenters respectively. The present contribution reports preliminary results of a biostratigraphic and taphonomic research of an ongoing PhD thesis. Four sections have been investigated in Zacatecas (Cañón de San Matías-MZ-3, Cañada Las Bocas-MZ-5, Cañón del Toboso-TO-1) and Coahuila (Puerto Piñones-PP-1). Ammonite identification and quantified taphonomic observations have been supported on a bed-by-bed, centimeter-thick sampling under precise biostratigraphic control. Fossil distribution and orientation were approached through block sample (3D) and bed surface (2D) analyses, complemented with observation of rock surfaces obtained from cut slices parallel and perpendicular to bedding. Taxonomic interpretations focused on macrofauna, especially ammonites. Ammonite biostratigraphy confirms a late Kimmeridgian age (*Eudoxus* Chron in the European secondary biochronostratigraphic standard scale) for the investigated fossil-rich horizons, which are micro-stratigraphically discontinuous at the outcrop level. At present, no intra-biozone biostratigrahic subdivision has been possible in these fossil-rich horizons, which places time-averaging order and potential reworking degree below biostratigraphic resolution. Preliminary sedimentological observations indicate packing of fossil remains fluctuating between 55% and 15%, higher in TO-1 and PP-1 sections and lower in MZ-sections, within-bed recurrence of fossil-rich horizons with variable abundance of fossils, and poor size bioclast selection. Taphonomic features were quantified in 3022 macroinvertebrate fragmentary specimens and fragments. Crushed macrofossils largely dominate (89%). Ammonites dominate (53.3%) and then aptychi (32.3%), bivalves (13.3%), and very scarce gastropods (1.2%). Bodychamber preservation is rare (2.3%), articulated bivalves and aptychi very rare (0.4%), concave-up shells (8%) and convex-up shells (92%). Other taphonomic traits quantified were the orientation of macrofossil settling (97% horizontal), the fragmentation index (50.28%), the corrasion index (58.2%), and the occurrence of bored shells (1%). The current interpretation of the obtained data reveals the incidence of shell transport with a relatively high incidence in fragmentation and disarticulation. The settling of skeletal parts was mainly horizontal experiencing a relatively high corrosion degree, without evidence for long-lasting exposure on the seabed (i.e., rapid burial). All this information points to recurrent, rather moderate to low-density flows most probably related to high-energy but distant storms, with effects of mass mortality, hydraulically forced reworking, and final stages with deposition under laminar flow dynamics. The obtained information allows envisaging differential ecological and sedimentary conditions in relatively close depocenters within a carbonate-fine siliciclastic shelf system, and post-depositional, moderate to high compaction affecting the sedimentary horizons investigated. [PAPIIT IN-105311-3 UNAM, Mexico; MINECO project CGL2012-39835, Spain; Posgrado en Ciencias de Tierra, UNAM, Mexico].

NEW POSTCRANIAL MATERIALS OF *ACERORHINUS YUANMOUENSIS*, AND THE PHYLOGENY OF ACERATHERIINAE

Xiaokang Lu[1,2] and Deng Tao[1]

1. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, 100044, China. luxiaokang@ivpp.ac.cn

2. University of the Chinese Academy of Sciences, Beijing, 100049, China.

Compared to other groups of Rhinocerotidae, Aceratheriinae are less specialized in having a hornless or small horned skull. However, the taxonomy of Aceratheriinae is confused, and the group is not monophyletic. A recently discovered partial skeleton of *Acerorhinus yuanmouensis* provided an opportunity to re-evaluate the phylogenetic relationships of Aceratheriinae. Our phylogenetic analysis includes all genera currently regarded as aceratheres *sensu lato* (i.e., *Mesaceratherium*, *Protaceratherium* and *Diaceratherium*). The characters used in the present analysis include many that have been previously evaluated together with 105 new ones, resulting in a data matrix of 387 characters scored for 50 rhinocerotid species and one extant tapir as out-group. Coding has been revised for several characters, both in the light of recent observations and also in order to eliminate unwarranted assumptions. The analysis recovers Teleoceratini as sister group of Aceratheriini forming a monophyletic group within Rhinocerotidae. In contrast to previous analyses and traditional taxonomy, North American aceratheriines do not form a clade, and *Mesaceratherium gaimersheimense* is placed within Teleoceratini. Another salient result is the placement of *Turkanatherium acutirostratus*as a stem rhinocerotid, falling outside Aceratheriinae. The relationships of the genera within Aceratheriinae are complex, and some remain debatable: *Alicornops simorrense* appears as sister group of *Aceratherium incisivum*, instead of *Alicornops laogouensis*, and *Aphelops mutilus* has a variable position with respect to other late Neogene aceratheriines.

THE OLDEST RECORD OF *PALAEOCAVIA* AMEGHINO (MAMMALIA, RODENTIA, CAVIIDAE) FROM THE LATE MIOCENE OF CATAMARCA, ARGENTINA

M. Carolina Madozzo Jaén[1,2], Pablo E. Ortiz[1,2] and Norma L. Nasif[1,2]

1. INSUGEO, Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina. cmadozzo@gmail.com

2. Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán. Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina.

Caviid rodents are conspicuous elements of the living South American small mammal communities. However, although their Neogene fossil record is relatively rich, many aspects of the early evolution of the group are unknown. The extinct genus *Palaeocavia* is represented in Argentina by six species recorded in Entre Ríos (Ituzaingó Formation, late Miocene), La Pampa (Cerro Azul Formation, late Miocene), Buenos Aires (Pliocene), Córdoba ("Formación Pampeana", Pleistocene), Jujuy (Maimará Formation, late Miocene-early Pliocene), and Catamarca provinces (Andalhuala Formation, late Miocene). Here we describe the oldest record for the genus, coming from levels of El Jarillal Member (Chiquimil Formation), croping out near Villavil, Catamarca, northwestern Argentina. This unit underlies the Andahuala Formation, therefore the bearing levels are older than the 7.14 Ma limit between the two formations. The material corresponds to a fragment of left mandible with p4-m3. Molariforms are euhypsodont and bilobated, with each lobe showing a slight constriction on its labial apex in occlusal view. The p4 and m3 are respectively the smallest and the largest teeth of the series; m1 and m2 are subequal in size. The anterior lobe is smaller than the posterior one in all teeth; additionally, the lingual furrow of the posterior lobe is wide, shallow, and situated on its anterior edge. The hypoflexid is wide and deep, showing parallel edges on its internal portion; nevertheless, the lingual end of this flexid is deeper on its anterior side, forming a bezel-like outline. Interprismatic cement covers the internal third of the hypoflexid. The enamel layer is continuous on the labial side of p4-m3; besides, it is absent only on the postero-lingual corner of the posterior lobe of p4 and m1 (the poor preservation prevents the observation of this feature on m2-m3). The anterior lobe of the p4 is obliquely arranged regarding the antero-posterior axis of the mandible and there is no evidence of the additional anterior elongation, being both features diagnostic characters of *Palaeocavia*. The genus was listed for other late Miocene sites but these remains were never described or figured. The presence of *Palaeocavia* in Villavil in dated levels confirms its existence since at least this age. Several facts such as the absence of taxonomic revisions of the genus (none of its species have been re-studied since their original descriptions), the loss of holotypes of several nominal forms, and the uncertain stratigraphic provenance of some remains, make the redefinition of the genus mandatory.

TOWARDS REFINED SILURIAN CHRONOSTRATIGRAPHY: HOMERIAN EVENTS AND NEW GSSP PROPOSED IN THE PRAGUE SYNFORM (CZECH REPUBLIC)

Štěpán Manda[1], Petr Štorch[2], Vojtěch Turek[3] and Ladislav Slavík[2]

1. Czech Geological Survey, Klárov 3, 118 21 Praha 1, Czech Republic. stepan.manda@geology.cz,
2. Institute of Geology, Academy of Science of the Czech Republic, v.v.i., Rozvojová 269, 165 00 Praha 6, Czech Republic.
3. National Museum, Department of Palaeontology, Václavské náměstí 68, 115 79 Praha 1, Czech Republic.

The Homerian Stage of the Silurian Wenlock Series (426–423 Ma) exhibits structural changes in marine ecosystems. Homerian times witnessed stabilisation of current systems outside tropical zones and substantial decline of early Silurian anoxic conditions, which resulted in large-scale poleward faunal immigrations, and formation of several new types of faunal communities. New fauna inhabited carbonate platforms established within the Rheic Ocean. A prominent change is recorded in pelagic faunas. Although pelagic cephalopods appeared in the Early Ordovician and formed locally predominant faunas since the Late Ordovician, widespread pelagic cephalopod-dominated faunas appeared in the Homerian and recurrently alternated with graptolite-dominated faunas until the earliest Devonian. In deeper, poorly oxygenated sedimentary settings empty cephalopod shells provide substrate for epibyssate bivalves, brachiopods and crinoids, which gave origin to a new type of benthic communities. Marine ecosystems strongly affected by late Homerian environmental crisis experienced selective massive extinction (Mulde/Lundgreni Event), particularly among conodonts and graptolites. The event involved also local extinctions of several groups in higher latitudes, and temporary restriction of carbonate sedimentation along with widespread anoxia. Many discrepancies in high resolution correlations of the Silurian strata became evident in recent decades, in part due to unsatisfactory international boundary stratotypes of several Silurian stages/series. In response to ISSS efforts to replace some current stratotypes close attention has been paid to a prospective candidate section of the base Homerian in the Prague Synform. Sheinwoodian/Homerian boundary strata, un-metamorphosed and undisturbed by tectonics, are well exposed in an abandoned Kosov quarry, SW from Prague. An Upper Sheinwoodian–Homerian succession is formed by a continuous sequence of black, calcareous shales with mudstone nodules and several tuffitic-carbonate intercalations slumped from a carbonate platform that fringed adjacent volcanoes. Shale succession is rich in both graptolites (18 species) and chitinozoans (16 species). Upper *rigidus*, *ramosus-ellesae* and *lundgreni* graptolite zones are involved in the section proposed herein as a boundary stratotype of the Homerian Stage. Base of the Homerian is marked by FAD of *Cyrtograptus lundgreni*, which is coincident with LAD of *Gotlandochitina martinssoni*. Carbonate intercalations yielded coniform conodonts. Pelagic cephalopods, bivalves, brachiopods and other fossils are common. Palaeogeographic position of the Prague Basin between tropical and cool water realms caused mixing of faunas from both realms and thus facilitated long-range correlations. Chitinozoans and benthic fauna allowed correlation with coeval shallow-water carbonate strata and further contributed to long time desired integration of conodont and graptolite zonal schemes, which is a general problem of Silurian biostratigraphic correlation.

MODERN PHOTOGRAPHIC TECHNIQUES APPLIED IN PERMO-CARBONIFEROUS MACRO AND MICROFOSSILS FROM PARANÁ BASIN, BRAZIL

Paulo C. Manzig[1,2] and João H.Z. Ricetti[1,3]

1. Universidade do Contestado (UnC), Centro Paleontológico da UnC (CENPÁLEO), Av. Pres Nereu Ramos 1071, Mafra, 89300-000, Brazil. paulomanzig@geotematica.com.br

2. Universidade Estadual de Campinas (UNICAMP), Programa de Pós-Graduação IEL-Labjor, Cid. Univ. "Zeferino Vaz", Campinas, 13083-970, Brazil.

3. Universidade Federal do Rio Grande do Sul (UFRGS), Programa de Pós-Graduação em Geociências (PPGGeo), Av. Bento Gonçalves, 9500, Porto Alegre, P. Box 15001, 91501-970, Brazil.

The development reached from the beginning of the century in the digital technology brings a considerable impact in photography, especially in the high performance attained by modern professional cameras in image capturing under low luminosity conditions and, in the availability of image acquisition and post-production software. This resume refers a case study of photographical technique application in paleontological research, i.e., invertebrates and microfossils from the "Lontras Shale", Rio do Sul Formation, Permo-Carboniferous boundary of the Paraná Basin (Mafra city, Santa Catarina State, Brazil). Fossil insects and scolecodonts (jaw apparatuses of organic composition) are preserved inside concretions and conodont feeding apparatuses in shales, but there are also wings and body segments of insects preserved as pyritizations. The fossil material has been photographed using a digital camera NIKON D800 coupled in a stereoscopic microscope, or, using specific macro objectives. We photographed the fossils *in natura*, submersed in mineral oil and metalized by carbon, with the aid of a halogenous light LEDs device. The image capture has been monitored, in different focalization plains, by the Helicon Remote 3.1.2 software. The photos have been transferred to the Helicon Focus 4.2.9 software that can merge all photographs in one focused image, technique known as "stack photography". The adequacy of original exposure levels, contrast and color enhancement, to highlight fossil structures, was made in Adobe Photoshop. This process have reveal promising for the visualization of unperceived characters, difficult to observe by optical devices. Each fossil group responded in a particular way to different lightning techniques. "Stack photography" enhances the observation of conodonts, and fossils from concretions but is not suitable for pyritized insect remains. The adoption of this technique opens a new field in fossil image capturing.

PALEOECOLOGY OF FORAMINIFERA FROM A HOLOCENE SEQUENCE CROPPING OUT AT LAS BRUSQUITAS CREEK, BUENOS AIRES, ARGENTINA

Melina Márquez[1], Laura Ferrero[1] and Gabriela C. Cusminsky[2]

1. Instituto de Geología de Costas y del Cuaternario UNMDP, IIMyC-CONICET, Funes 3350, Mar del Plata, 7600, Argentina. mmarquez@mdp.edu.ar

2. Centro Regional Universitario Bariloche. Universidad Nacional del Comahue. INIBIOMA-CONICET. Quintral 1250, Bariloche, 8400, Río Negro, Argentina.

Foraminifera associations from sediments cropping out at Las Brusquitas Creek, in the southeastern coast of the Pampas of Argentina, were studied in order to provide evidence of Holocene paleoenvironmental evolution and its probable relationship with the last transgressive-regressive cycle. The most frequent and abundant species were *Ammonia parkinsoniana* (d'Orbigny), *Ammonia tepida* (Cushman) and *Buccella peruviana* (d'Orbigny). Qualitative and quantitative analyses allowed the recognition of three main stages in the palaeonvironmental evolution of the studied sequence. In the first stage previous to *ca*. 6400 years BP, foraminifera were very scarce, but based upon previous studies estuarine and low salinity conditions would have prevailed. In a second stage deposited between *ca*. 6400 and 5100 years BP, more diversified associations indicate an increase of the marine influence, probably representing the transgressive event; towards the top of this part a gradual decrease of marine influence is recorded. The third stage –after 5000 years BP– shows scarce and less diverse foraminifera associations, revealing the evolution towards brackish-fresh water, low energy and more restricted environments. This last phase may be explained by the onset of the sand-dune barrier during the regressive phase of the Holocene transgression. Finally, the record was buried by dune sands partially modified by soil development.

CHIRONOMID RECORD FROM THE LITTLE ICE AGE IN LAGUNA AZUL, SOUTHERN PATAGONIA (ARGENTINA)

Rodrigo Martín[1], Julieta Massaferro[2], Josefina Ramón Mercau[1], Andreas Lücke[3], Christoph Mayr[4] and Cecilia Laprida[2]

1. Instituto de Estudios Andinos "Don Pablo Groeber", Int. Guiraldes 2160, Ciudad Autónoma de Buenos Aires, 1428, Argentina. rodrigosmartin88@gmail.com

2. Centro de Estudios Nacionales Aplicados a la Conservación, Fagnano 244, Bariloche, 8400, Argentina.

3. Institute of Bio-and Geosciences, Research Center Jülich, D-52425, Jülich, Germany.

4. Friedrich-Alexander-Universität Erlangen-Nürnberg, 91054, Erlangen, Germany.

Due to its unique geography and climate, paleoenvironmental records from the Patagonian region are key in the understanding of the climatic variability of the last millennia. Lacustrine sediments are among the few records of past environmental conditions in the Patagonian Steppe and allow the study of a wide variety of inorganic and organic proxies. Chief among them are chironomids (Insecta: Diptera), which show great potential for reconstructing mean air temperature. Here we present the chironomid record of a radiocarbon-dated sediment core AZU03/4-1 obtained from the steppe crater lake Azul (52°05'S, 63°35'W) for the period between ~ 1550 – 1840 AD, which comprises the approximate time window of the so-called Little Ice Age. A zonation was performed on the profile by means of the Optimal Sum-of-Squares method and its significance was statistically validated by comparing against a Broken-Stick null model, which yielded four statistically significant divisions. Zone A (~1550 – 1645 AD) is characterized by the dominance of *Tanytarsini* species with *Parachironomus* among the accompanying taxa, which indicates relatively cold conditions. Upcore, the later species dwindles and the former increase their abundance, which defines Zone B (~1645 - 1740 AD), corresponding to a colder period. Between 1740 – 1800 AD, *Tanytarsini* sp. 1A disappears, and the accompanying *Parachironomus* increases its relative abundance again, pointing to a slight amelioration of temperature and a lowering in the lake level related to warmer conditions; fluctuations in the remaining *Tanytarsini* species define the remaining divisions in the profile indicating a new very cold pulse starting around 1830 AD. These results are in accordance with the conclusions of a multi-proxy study performed on the same sediments, which postulates climatic-driven lake level fluctuations for the analyzed time window with a relative temperature minimum between ~ 1670 – 1890 AD, attesting to the suitability of chironomids for paleoenvironmental reconstructions in Patagonia.

A NEW PROBAINOGNATHIAN CYNODONT (THERAPSIDA) FROM THE EARLY LATE TRIASSIC OF SOUTHERN BRAZIL

Agustín G. Martinelli[1], Marina Bento Soares[1] and Cibele Schwanke[2]

1. Departamento de Paleontologia e Estratigrafia, Universidade Federal do Rio Grande do Sul. Ave. Bento Gonçalves 9500, Agronomia, 91501-970, Porto Alegre, RS, Brazil. agustin_martinelli@yahoo.com.ar

2. Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, Campus Porto Alegre, Rua Coronel Vicente 281, Centro Histórico, 90030040, Porto Alegre, RS, Brazil.

The South American record of late Ladinian-early Carnian probainognathian cynodonts is represented by *Chiniquodon theotonicus*, *Protheriodon estudanti* and *Candelariodon barberenai* from the *Dinodontosaurus* Assemblage Zone (AZ) (Santa Maria 1 Sequence), Southern Brazil and by *Ch. theotonicus* and *Probainognathus jenseni* from the Chañares Formation (Agua de la Peña Group, Villa Unión-Ischigualasto Basin), Northwestern Argentina. Other early Carnian probainognathians come from the *Santucruzodon* AZ (Santa Maria 1 Sequence), including cf. *Probainognathus* and *Chiniquodon* sp. We present here a new probainognathian cynodont from the *Dinodontosaurus* AZ. The two known specimens (MCT-1716-R and MCT-1717-R) were found in 1946, by L.I. Price, in the Candelária Municipality, Rio Grande do Sul State. MCT-1716-R includes a skull lacking most of the skull roof with partial dentition, articulated lower jaws, and most of its postcranial skeleton (although poorly preserved), whereas MCT-1717-R consists of an anterior half of skull with articulated lower jaws, with partial dentition. Both were found together with a *Dinodontosaurus* skeleton. The new taxon is diagnosed by the following association of characters: four upper incisors, circular in cross-section; I1 to I3 of similar size, I4 slightly smaller; incisors widely separated among them, with largest diastema between I3-I4; large upper canine, transversely narrow and mesiodistally elongate, with serrated distal margin; upper postcanines (PCs) extremely narrow labiolingually, bearing three to five aligned cusps; anterior three PCs with three cusp, symmetrical, with main cusp A and accessory cusps B and C; PC4-PC5, the largest of the series, asymmetrical with large main cusp A, small cusp B, and two (PC4) or three (PC5) distal accessory cusps (C, D, and accessory) (A>B=C>D); last PC6 reduced, similar in morphology to anterior PCs; lower postcanines (pcs) narrow labiolingually, with up to four aligned cups; prominent main cusp a, large cusp b, smaller cusp c and d in posterior pcs (a>b>c>d); well-developed articular process of the dentary (although not reaching the squamosal) with relatively large post-dentary bones; well-developed masseteric fossa extending forward below last preserved postcanines; dentary relatively high in comparison to prozostrodontians. A performed phylogenetic analysis of non-mammaliaform cynodonts has placed the gen. et sp. nov. as a basal probainognathian, being the sister-taxon of *Probainognathus* plus prozostrodontians. This finding provides a new carnivoran/insectivoran taxon for the late Ladinian-early Carnian faunal association of South America, positioned at the base of the lineage leading to Mammaliaformes.

EVIDENCES OF INTERACTIONS (FEED AND DISPERSION) BETWEEN CYCADALES AND DINOSAURS IN JURASSIC ECOSYSTEMS

Leandro C. A. Martínez[1,2]; Analía E. E. Artabe[2], Ignacio J. Canudo[3], Alberto C. Garrido[4,5] and Leonardo Salgado[3]

1. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Avda. Ángel Gallardo 470, Buenos Aires (1405), Argentina. gesaghi@gmail.com

2. Facultad de Ciencias Naturales y Museo, División Paleobotánica, Universidad Nacional de La Plata, Paseo del Bosque S/N, La Plata (1900), Argentina.

3. Facultad de Ciencias, Universidad de Zaragoza, C/ Pedro Cerbuna 12, 50009 Zaragoza, España.

4. Museo Provincial de Ciencias Naturales "Profesor Dr. Juan A. Olsacher", Dirección Provincial de Minería, Etcheluz y Ejército Argentino, Zapala (8340), provincia del Neuquén, Argentina.

5. Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, Isidro Lobo y Belgrano, General Roca, Argentina.

Gut contents preserved within a dinosaur articulated skeleton from the Los Molles Formation are described herein. The dinosaur preserves the skull articulated with a series of vertebrae and the appendicular skeleton. It is considered to be close to the Thyreophora (Ornithischia). A mass of permineralized seeds (the gut content) was recovered close to the ribs. The seeds are ovoid, and almost radial in symmetry. There are at least two types of seeds, distinguished by their size: the largest (30.8 mm long, ca. 16.3 mm wide), and the smaller (13.6 mm long, 7 mm wide). The largest seeds preserved three layers: an outer coat (similar to the sarcotesta), the sclerotesta (with a well-defined coronula at the micropylar zone), and the inner layer (possibly corresponding to the nucellus). The largest seeds can accurately be assigned to the Cycadales. Seeds of Mesozoic gymnosperms (i.e. Bennettitales, Caytoniales, Ginkgoales and Pentoxylales) have a similar morphology, but they are small to minute. Therefore, the largest seeds display a coronula, a character that is diagnostic for the Stangeriaceae and Zamiaceae. The presence of seeds preserved as gut content within an articulated dinosaur skeleton, reinforces the hypothesis about interactions (endozoochory) between cycads and dinosaurs, especially in the dispersion of seeds. The seeds of cycads have a brightly, coloured, and juicy seed sarcotesta. In addition, the sarcotesta has chemicals that facilitate dormancy and its persistence inhibited seed germination. The ingestion of cycad seeds would be limited to dinosaurs that lacked grinding teeth (as is the case of these Ornithischia), because a strong mastication would release the toxins characteristics of this group of plants. It is also inferred that the sclerotesta would have prevented the digestion of the seed content by gastric fluids, allowing its passage through the digestive system up to be excreted as seed kernels. The extinction of herbivores (frugivores) dinosaur taxa would have a negative effect in cycads dispersion, leading to a lesser in the genetic variability of the group. Finally, the extinction of many genera of cycads in the Late Cretaceous/ Cenozoic would be related mainly to the climatic change and absence of dispersion. These factors would have prevented migration of cycads to refuges or tropical areas during the earth cooling periods.

PALEOECOLOGY OF THE LOW-OXYGEN ADAPTED BIVALVES, PERMIAN SERRA ALTA FORMATION, PARANÁ BASIN, BRAZIL

Suzana A. Matos[1], João G. Bondioli[1], Lucas V. Warren[2], Mario L. Assine[2], Claudio Riccomini[1] and Marcello G. Simões[3]

1. Instituto de Geociências, Universidade de São Paulo (USP), Rua do Lago, 562, Cidade Universitária, SP, 05508-080, Brazil. sumatos.s@gmail.com

2. Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista (UNESP), Avenida 24A, 1515, Rio Claro, SP, 13506-900, Brazil.

3. Instituto de Biociências, Universidade Estadual Paulista (UNESP), Rubião Júnior, s/n, Botucatu-SP, 18618-970, Brazil.

The endemic Permian, Paranean molluscan fauna evolved within a huge epeiric sea (Paraná and Chaco-Paraná basins, South America; Huab Basin, Namibia, and Main Karoo Basin, South Africa) under conditions of extreme geographic isolation and high environmental stress. In the Brazilian portion of the Paraná Basin, the oldest known members of this remarkable fauna are recorded in the Kungurian Serra Alta Formation, representing the first recolonization of the sea floors after the Irati-Whitehill anoxic event. The Serra Alta Formation is mainly represented by dark grey mudstones interbedded with thin layers of fine-grained sandstones and rare limestones, deposited in oxygen-deficient (dysoxic-anoxic) conditions. Here, we investigated two geological sections in the eastern border of the Paraná Basin, as well as the literature data, in order to elucidate the paleoecology of those bivalves. Our results demonstrate that, besides the barren dark grey mudstones, mainly deposited under anoxic conditions, two distinct assemblages can be recorded: 1. Small bivalves preserved in the massive mudstones, disarticulated/articulated (splayed/closed), with no signs of transportation. These were autochthonous to parautochthonous elements (*Maackia contorta*, ?*Anthraconaia* sp., *Barbosaia angulata*, *Rioclaroa lefrevei*), probably representing low-oxygen (dysaerobic) adapted taxa. 2. Bivalves associated with calcareous concretions in massive mudstones, recording large, articulated shells (splayed/closed), some preserved *in situ*. These may have large shells, as in *Tambaquyra camargoi*, which is ten times larger than all co-occuring bivalves, or have unusual morphologies (*e.g.*, *Anhembia froesi* that has a rostrum similar to that of *Arconaia lanceolata*, a living chemosymbiotic bivalve). Based on this evidence, these bivalves seem to be chemosymbiotic mollusks, and may have lived under exaerobic conditions. Their shells may occur in great abundance (~600 specimens/1m^2) in some bedding planes. In these cases, there is always a predominance of a given taxon (*i.e.*, *M. contorta*, *T. camargoi*, ?*Anthraconaia* sp.). These features are generally associated with opportunistic colonization of the seafloor by benthic invertebrates affected by stressing factors (*e.g.*, drastically bottom oxygen fluctuations). Therefore, the bivalves of the Serra Alta Formation thrived in conditions of variable oxygen content, offering us a brief picture of the marine communities flourishing in muddy, low oxygen offshore settings within a geographically isolated epeiric sea.

VERTEBRATE FAUNA AND ENVIRONMENTAL INTERPRETATION OF THE ITAPECURU AND ALCÂNTARA FORMATIONS (EARLY-LATE CRETACEOUS OF THE PARNAÍBA AND SÃO LUÍS BASINS)

Manuel A. Medeiros[1], Patrick Führ Dal`Bó[2], Rafael Matos Lindoso[3] and Ismar de Souza Carvalho[2]

1. Lab Paleontologia, Dep Biologia, UFMA, Campus do Bacanga, CEP 65.085-580, São Luís, MA, Brazil. manuel.alfredo@ufma.br

2. Instituto de Geociências, Universidade Federal do Rio de Janeiro, Cidade Universitária, Ilha do Fundão, CEP 21.941-916, Rio de Janeiro, RJ, Brazil.

3. Programa de Pós-Graduação em Geologia, Universidade Federal do Rio de Janeiro, Cidade Universitária, Ilha do Fundão, CEP 21.941-916, Rio de Janeiro, RJ, Brazil.

The Itapecuru and Alcântara formations have yielded important records of the Aptian, Albian and Cenomanian continental faunas of northeastern South America. Formerly considered to be a unique sedimentary unit, these two successions were recently individualized based on facies analysis and environmental settings, although there is general agreement that they are closely related. The coastal deposits of the Alcântara Formation (Cenomanian) represent a marginal marine succession deposited above the continental fluvial deposits of the Itapecuru Formation (Aptian/Albian). The Itapecuru Formation is composed of fine to very fine sandstone and mudstone facies deposited in a floodplain environment with well-developed paleosol profiles. The profiles show evidence of seasonal changes in moisture content attested by frequent intercalations of alluvial clay skins and carbonate nodules. In this study, we perform a comparison of the vertebrate fauna of these formations and their paleoenvironmental context. Most of the vertebrates from the Itapecuru Formation are very similar to those collected in the Alcântara deposits (e.g., *Mawsonia*, *Lepidotes*, *Ceratodus brasiliensis*, *Arganodus* sp., *Candidodon itapecuruense*, *Carcharodontosaurus* sp., *Spinosaurus* sp. and undetermined diplodocoids and titanosauria). Nonetheless, *Amazonsaurus maranhensis*, from the Itapecuru deposits, has not yet been identified amongst the dozens of diplodocoid caudal vertebrae collected in the Alcântara region. The diplodocoid vertebral centra collected from the deposits of Alcântara Formation belong to another rebbachisaurid related to *Limaysaurus* (= *Rayososaurus*) *tessonei*. This scenario strongly indicates that some particular environmental parameters were present in both regions and that only discrete evolutionary changes occurred in the vertebrate fauna from the end of the Aptian to the beginning of the Cenomanian. These changes were possibly at the species level and, in some cases, genera, leading to modifications imperceptible in the disarticulated and fragmented material available. *Spinosaurus*, *Mawsonia*, dipnoans and undetermined aquatic crocodiles were certainly ecologically integrated and indicate environments with fluvial influence. The lungfish indicates a well-marked seasonal regime with episodes of drought, a circumstance that is also evidenced by the dryness of the xylematic tissue in conifers of the Alcântara Formation. The continuance of the same faunistic (aquatic and terrestrial) components along the end of the Aptian, the entire Albian and the beginning of the Cenomanian in northeastern South America indicates stability of the environmental conditions and climate during this interval.

ALLOMETRIC GROWTH PATTERN IN THE GENUS *PTYCHOMYA* FROM THE LOWER CRETACEOUS OF THE NEUQUÉN BASIN, WEST-CENTRAL ARGENTINA

Pablo S. Milla Carmona[1,2], Darío G. Lazo[2] and Ignacio M. Soto[1]

1. Instituto de Ecología, Genética y Evolución de Buenos Aires (CONICET); Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina.
pablomillac@gmail.com

2. Departamento de Ciencias Geológicas, Instituto de Estudios Andinos "Don Pablo Groeber", Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina.

Ptychomya koeneni Behrendsen is a frequently recorded heterodont bivalve in Lower Cretaceous marine rocks of the Neuquén Basin, especially in the Agrio Formation. It shows a characteristic divaricate ornamentation, which makes it easy to be identified. The sole published study to date on its taxonomy has established the existence of six varieties of subspecific rank. However, a recent unpublished study by the authors based on newly collected specimens from the Agrio Formation and type specimens of the mentioned varieties from the Burke Museum of Natural History & Culture (Seattle, USA) found out that there is a wide morphological gap between one of the varieties, namely *P. koeneni coihuicoensis,* and the rest of them, suggesting that they could be two distinct groups. The aim of this work was to compare the allometric growth patterns of *P. k. coihuicoensis* and the *P. koeneni* cluster in order to determine if they share a common ontogeny. Two aspects of external morphology of the shell were quantified (general outline and ornamentation) for specimens of each group at different shell sizes (i.e. growth stages) using geometric morphometrics. Allometric curves were statistically compared through regressions with categorical predictors for each morphological variable. Results showed that while some morphological variables seemed to share a common allometric curve, there are other variables that differ in their growth attributes (i.e. regression curves have a statistically different origin and/or slope). Shape trajectories of *P. k. coihuicoensis* and the *P. koeneni* cluster differed along the ontogeny in the multivariate morphospace, meaning that the overall growth pattern was different between these two groups. This evidence supports the hypothesis that *P. k. coihuicoensis* is a distinct group separated from the rest of the *P. koeneni* varieties, and points out the need for a taxonomical reevaluation of the genus *Ptychomya* in the Lower Cretaceous of the Neuquén Basin.

CALCAREOUS PLANKTON AND ISOTOPE DATA FROM AN EXPANDED EARLY LATE PALEOCENE HYPERTHERMAL EVENT (RÍO GOR HEMIPELAGIC SECTION, BETIC CORDILLERA, SOUTHERN SPAIN)

Simonetta Monechi[1], Victoriano Pujalte[2], Xabier Orue-Etxebarria[2], Estibaliz Apellaniz[2], Fernando Caballero[2], Silvia Ortiz[3] and Birger Schmitz[4]

1. Dipartimento di Scienze della Terra, Università di Firenze, Via La Pira 4, I-50121 Firenze, Italy. simonetta.monechi@unifi.it

2. Department of Stratigraphy and Paleontology, Faculty of Science and Technology, University of the Basque Country UPV/EHU, Ap. 644, 48080 Bilbao, Spain.

3. PetroStrat Ltd, Tan-y-Graig, Parc Caer Seion, Conwy, Wales, LL32 8FA, UK.

4. Division of Nuclear Physics, Department of Physics, University of Lund, P.O. Box 118 SE-221 00 Lund, Sweden.

The Río Gor section is far more expanded and complete than Alamedilla, so far the most studied lower Paleogene hemipelagic section of the Betic Cordillera. This fact is specially striking in the Paleocene succession, which in Río Gor is about 250 metres thick and probably continuous while in Alamedilla is less than 20 metres thick, with an important hiatus comprising most of the Danian, the entire Selandian and the lower part of the Thanetian. The probability of locating Paleocene hyperthermals is, therefore, far greater in Río Gor than in Alamedilla. The Paleocene is mainly represented at Río Gor by grey-coloured lithologies, the lower part of the section being formed by alternating calcarenites and marls, the remainder by marls and marly limestones. However, intercalated within these grey marly lithologies, there occurs an interval *ca.* 10 m thick of a prominent red colour that, on a preliminary survey, was tentatively assigned to the Paleocene–Eocene Thermal Maximum (PETM). The more detailed study herein presented, based on analyses of foraminifera, calcareous nannofossils and carbon isotope composition of dispersed organic matter of 26 samples, leads to a different interpretation. In effect, the planktonic foraminiferal assemblage suggests a mid-Paleocene age. The calcareous nannofossil assemblage reinforces such conclusion. The lowest occurrence (LO) of *H. kleinpellii*, marker of the base of NP6, indicates for this interval the upper part of Zone NP5 and Zone NP6. The studied interval has been subdivided into five parts based on its foraminiferal associations. Planktonic foraminifera are abundant and vary notably in size. Benthic foraminifera are moderately diverse but low in evenness, as they are characterized by the dominance of small abyssamminids known to peak after the PETM and other Eocene hyperthermals. Although the isotopic values show significant scatter, with $d^{13}C_{toc}$ values ranging between –22.2 and –27.5‰, the typical early to middle Paleocene gradual rise in $d^{13}C_{toc}$ can be seen. It is concluded that the studied interval contains what is probably the most expanded record of the early late Paleocene event (ELPE) so far reported. In the stratotypic Zumaia section (western Pyrenees) the core of the ELPE was found to occur eight precession cycles below the GSSP of the Thanetian Stage, situated at the base of magnetochron C26n. It is thus a good criterion to approximate the Selandian/Thanetian boundary, its utility being reinforced by its finding in the Betic Cordillera.

EVOLUTIONARY TRENDS OF TRIASSIC AMMONOIDS IN CANADA

Claude Monnet[1]

1. University of Lille, CNRS UMR 8217 Géosystèmes, Avenue Paul Langevin, Villeneuve d'Ascq, 59655, France.
claude.monnet@univ-lille1.fr

Evolutionary trends are a long standing and central theme in evolutionary biology and especially in paleontology thanks to the fossil record, which acts as a witness. Ammonoids have already been used successfully to provide insights into the understanding of evolutionary trends (*e.g.*, suture complexity) of which patterns and processes remain debated. This topic is here investigated thanks to the Triassic ammonoid record. Due to their near extinction at the Permian/Triassic boundary, Triassic ammonoids constitute a quasi-monophyletic clade adequate to study evolutionary trends during a recovery and then in a more stable period. Evolutionary trends of Triassic ammonoids are investigated by focusing on various traits such as adult shell size, taxonomic diversity and morphological disparity. This study also focuses on the Canadian record, which is a Boreal region characterized by a rich and regular record of ammonoids throughout the entire Triassic, for which an exhaustive morphological database with a revised taxonomic and stratigraphic framework is available. Triassic ammonoids cover a vast range of morphologies with regard to size, geometry (whorl shape and involution), ornamentation, and suture patterns. Their evolutionary trends are statistically evaluated and compared to known environmental changes in order to, *e.g.*, decipher which processes hold for generating evolutionary trends in ammonoids and in which conditions.

RHODOLITHS FROM THE BATEQUE FORMATION, BAJA CALIFORNIA SUR, MEXICO

Priscila Morales-Ortega[1], Rafael Riosmena-Rodríguez[2] and Gerardo González-Barba[1]

1. Museo de Historia Natural, Universidad Autónoma de Baja California Sur, A.P.19B, C.P.23080, La Paz, Baja California Sur, Mexico. prisortega@gmail.com

2. Programa de Investigación en Botánica Marina, Departamento de Biología Marina, Universidad Autónoma de Baja California Sur, A.P.19B, C.P.23080, La Paz, Baja California Sur, Mexico.

The Bateque Formation is an important lithostratigraphic unit because it includes the most complete Eocene marine fossil record from the North American Pacific region. This formation is found from east and west of Cuenca Laguna San Ignacio up to Arroyo Mezquital (between San Juanico and La Purísima), Baja California Sur, Mexico. Fossil record of rhodoliths are scattered around the world. Rhodoliths range from high latitudes (Norway to New Zealand) to the tropics, from Cretaceous to Recent. We present herein a new record of rodoliths from the Bateque Formation. In order to identify accurately and reliably rhodolith genus and/or species, and examine their vegetative and reproductive characters, we performed histological sections in the Bateque Formation limestones. This technique allowed us to identify three rhodolith genera: *Neogoniolithon*, *Sporolithon*, and *Lithothamnion*, reported for the first time in the North American Pacific region. Rhodolits represent an important fossil flora in the North American Pacific region and, even though there are still many problems about their taxonomy and phylogeny, this record could answer some questions about the biogeography of the group.

PRELIMINARY REPORT ON ISOTOPIC STUDIES ($\Delta^{13}C$) IN LIVING AND LATE PLEISTOCENE UNGULATES OF URUGUAY: PALEOECOLOGICAL INFERENCES

Elizabeth Morosi[1] and Martin Ubilla[1]

1. Faculty of Sciences, Iguá 4225, Montevideo, 11400, Uruguay.
elimor37@yahoo.com

The first $\delta^{13}C$ isotope data of immigrant ungulates belonging to an atypical fauna of Uruguay (Formación Sopas, Late Pleistocene, 60-30 ky BP) are provided. In addition, $\delta^{13}C$ isotope data were produced in the living *Ozotoceros bezoarticus* and *Mazama gouazoubira* with the purpose of establishing isotopic control patterns and assess their potential for trophic and environmental predictability. The $\delta^{13}C$ analyses were done in dental enamel. Fossil specimens belong to the Paleontological collections of the Faculty of Science and National Museum of Natural History (MNHN) of Montevideo; living specimens belong to zoological collections of the Clemente Estable Research Institute-SG and MNHN. GNS Laboratory (New Zealand) facilities were used, following the protocols set for samples collection, pre-treatment and shipment. In determining the types of diet, the Fenerac-MacFadden model was follow: C_3 diet, $\delta^{13}C$ values from -19 to -9 ‰; C_4 diet, $\delta^{13}C$ from -2 to 2 ‰, and C_3/C_4 diet (mixed diet), $\delta^{13}C$ from -9 and -2 ‰. The first $\delta^{13}C$ base line of extant ungulates from Uruguay was obtained, in which the mean values of $\delta^{13}C$ for *Mazama gouazoubira* (N=5) was -15.96 (-17.64 to 14.63) ‰, and for *Ozotoceros bezoarticus* (N=5) -12.98 (-14.34 to -6.79) ‰. *M. goauzoubira* is a good predictor of C_3 plants consumer in closed environments (canopy), while *Ozotoceros bezoarticus* reflects a more browser diet than expected, for an open contexts inhabitant at this latitude. The average $\delta^{13}C$ for fossils deer (N=3) was -8.80 (-10.01 to -7.44) ‰, which indicates mixed diet. The $\delta^{13}C$ average for the horse *Hippidion* cf. *H. principale* (N=2) was -11.49 (-12.18 to -10.08) ‰, consistent with animals living and browsing in wooded areas. For *Equus* cf. *E. neogeus* (N=2), the $\delta^{13}C$ average was -8.33 (-8.97 to -7.68) ‰, that indicates mixed diet. Finally, one camelid showed a $\delta^{13}C$ of -6.81 ‰. It is noteworthy that not C_4 grassers were detected. From Late Pleistocene beds of Southern Uruguay (Colonia Department), similar information to those obtained for Sopas Formation was produced (the extinct camelid *Hemiauchenia* presented $\delta^{13}C$ -9.49 and *Hippidion* cf. *H. principale* $\delta^{13}C$ -11.14). Although these are preliminary data, the results reflect browser and mixed diet predominance (with greater or lesser component of C_4 pasture), but not assignable values to C_4 grassers, which could be interpreted as preponderance of semi-open environments likely modeled by the Marine Isotope Stage 3 (MIS3) climatic conditions. [Contribution to PhD Project-Pedeciba-Biologia (E. M.) and CSIC-Project-C211-348 (M. U.)].

THE HANGENBERG EVENT (UPPERMOST FAMENNIAN) IN SOUTHERN BELGIUM (NAMUR–DINANT BASIN)

Bernard Mottequin[1] and Edouard Poty[2]

1. Royal Belgian Institute of Natural Sciences, Earth and History of Life, rue Vautier 29, B 1000 Brussels, Belgium. bernard.mottequin@naturalsciences.be

2. University of Liège, Unit of Animal and Human Palaeontology, Allée du 6Août, B18, B 4000 Liège 1, Belgium.

The uppermost Famennian succession of southern Belgium consists of a relatively thick series of shallow water siliciclastic–carbonate deposits, which locally include stromatoporoid biostromes. This thick series permits a better understanding of the Famennian and Tournaisian transition than the condensed basinal sections, which are investigated usually. However, due to the absence of *Siphonodella sulcata*, the Devonian–Carboniferous boundary is drawn on the basis of conodonts of the *praesulcata* Zone and the extinction of the so–called Devonian fauna (e.g. quasiendothyrid foraminifers and 'Strunian' rugose corals). In the Namur–Dinant Basin, the Hangenberg Black Shale Event is generally not marked lithologically. This absence was interpreted by some authors as a stratigraphic gap on the basis of the non–recognition of the LN spore Zone but these anoxic facies, corresponding to a high sea–level event, probably never spread or only exceptionally into the shallow–water environments of the Namur–Dinant Basin, where carbonate facies rich in benthic fossils continued to develop. Indeed, few sections show dm to m–thick black shale horizons with impoverished marine faunas in the uppermost part of the Strunian Comblain–au–Pont Formation that can be considered as inputs of dysoxic–anoxic waters from deeper areas where Hangenberg Shale developed. Contrarily, the following Hangenberg Sandstone Event, which most probably reflects a strong sea–level drop, is easily recognizable and traceable from the Aachen (Germany) to the Dinant areas, except for the most distal part of the Dinant sedimentation area. It corresponds to dm to m–thick sandstone and siltstone levels that frequently include reworked Strunian brachiopods, foraminifers and rugose corals. Therefore, in the Namur–Dinant Basin, the extinction event perfectly fits the sudden sea–level drop reflected by the deposition of sandstone and more or less sandy limestone, but not the development of black shale facies as usually observed in deeper water settings and absent here. This sea–level drop and the extinction event may be related to a single short ice–age as suggested by some authors. The diachronic Hangenberg Black Shale (corresponding to the whole of the Middle *praesulcata* Zone or only to a thin bed of short duration) caused only local, but not definitive, extinctions, as was also the case with the diachronic development of the upper Frasnian dysoxic–anoxic Matagne Black Shale, whose range spans the interval of the early *rhenana* Zone to the *linguiformis* Zone, and caused local extinctions before the end Frasnian Upper Kellwasser Event.

MARINE CADDISFLIES LARVAL CASES FROM THE PERMIAN OF BRAZIL

Lucas D. Mouro[1], Antonio C. S. Fernandes[2], Michal Zatoń[3], Matheus K. Flach[1] and Joao C. D. Mouro Junior[4]

1. Universidade Federal de Santa Catarina/PFRH-PB 240, Campus Universitário Reitor João David Ferreira Lima, Florianópolis, 88040090, Brazil. delmouro@ufrj.br
2. Universidade Federal do Rio de Janeiro/Museu Nacional,Quinta da Boa Vista, Rio de Janeiro, 2094040, Brazil.
3. University of Silesia, Faculty of Earth Sciences, Będzińska 60, Sosnowiec, 41-200, Poland.
4. Uninter, Cascavel, 85807300, Brazil.

Caddisflies (Order Trichoptera) are a large group of aquatic insects broadly dispersed during the Gondwana break-up. Although their fossils are known from the lower Permian (Artinskian), the first records of caddisflies' larval constructions are known from not before the Middle Jurassic of Mongolia and East Siberia. In Brazil, Trichoptera fossils and larval constructions were only reported from Mesozoic and Cenozoic deposits. However, in southern Brazil, 134 specimens assigned to Endopterygota (Holometabola) fossil cases have been recovered from the Lontras Shale (Permian, Asselian–Sakmarian) in the Campáleo outcrop, lower portion of the Rio do Sul Formation. This lower interval is almost 40 m thick and was deposited during a post-glacial marine transgressive event. It consists of thin, varved shales with dropstones overlain by bioturbated siltstones, fossiliferous black shales with abundant concretions and shaly rhythmites at the top. Until 2012, these specimens were assigned to sponges, but the lack of evidence linking them with the Phylum Porifera allowed interpreting them as fossils of unknown taxonomic affinity. The specimens have cylindrical shape tapering to the insect adherence base, are composed of thin filaments, which sometimes are mixed with other fossils as plant fragments, conodont elements, fish scales and teeth. Their height varies from 6.74 mm to 54 mm, and the width varies from 5.13 to 24 mm. SEM observations coupled with EDS analyses showed the presence of organic matter spots and framboid pyrite in some parts of the construction. In most parts, however, they are composed of silicate material (62.64%). Comparisons with Trichoptera larval case constructions and considering the paleoenvironmental setting interpreted with the aid of palynofacies analyses; we interpret these larval constructions as belonging to the trichopteran family Hidroptilidae. These findings not only change the chronological distribution of the fossils, but also confirm the presence of fossil caddisfly larval cases in marine paleoenvironments for the first time. The marine caddisfly construction cases are only known from living forms inhabiting Australia and New Zealand. Thus, we suggest that Trichoptera behavior in building the larval cases originated as early as early Permian, being spread across Gondwana before the break-up of Pangea but leaving no fossil record in marine deposits onward. Alternatively, the behavior might have been lost in that group due to some competition and/or environmental conditions to reappear again only recently.

FOSSIL COLLECTION PRACTICES AND THEIR EFFECT ON MUSEUM COLLECTIONS COMPOSITION AND PALEOBIODIVERSITY ESTIMATES: EXAMPLES FROM THE MIDDLE EOCENE OF NORTH AMERICA

Paul C. Murphey[1] and K. E. Beth Townsend[2]

1. San Diego Natural History Museum, San Diego, CA, United States of America. pmurphey@sdnhm.org

2. Midwestern University, Glendale, AZ, United States of America.

Numerous studies have utilized collections-based data to evaluate potential mammalian paleoecological trends, and they typically focus on evaluating some aspect of diversity, whether taxonomic or ecological. This type of approach relies on raw counts of specimens and taxa, data that are generally taken from the scientific literature. Recent studies have demonstrated that museum collections data should be incorporated into diversity studies whenever possible because the sole use of literature-derived data produces an "additional taphonomic filter." Yet, the effects that field collection practices have on the diversity of museum collections and the paleoecological studies executed using these collections are poorly understood. We selected nine middle Eocene mammalian assemblages of Uintan and Duchesnean North American Land Mammal Age (NALMA) to examine the effect of fossil collecting practices on overall diversity. Over 27,000 individual cases were evaluated for both taxonomic and body mass diversity, representing 14 orders, 123 genera, and over 130 species of mammals. These data were compared among the nine assemblages, and then combined into two larger groups for the purpose of comparing the older to the more recent collections that were made using different fossil collection techniques including wet-sieving of bulk matrix samples. Rodents, insectivorans, and primates exhibit more than twice the generic diversity in collections made during the last 30 years than collections made prior. Also, the taxonomic diversity of the Duchesne River Formation assemblage (Utah) was doubled due to recent wet-sieving efforts. Additionally, the new collections contain as many as two to over 100 times more specimens for some taxa, particularly for the following groups: rodents (13,850 specimens), primates (1,411), perissodactyls (532), insectivorans (6,655), and artiodactyls (2,084). Furthermore, there is a greater diversity of body mass sizes in the newer collections, with 31% of genera classified as weighing < 500 grams, and some genera with species spanning more than one body mass class (e.g., *Protoreodon*). These data demonstrate that wet-sieving greatly increases the number of small-bodied taxa available for study, and it is therefore essential that fossil collecting practices be routinely evaluated as an aspect of taphonomic investigations because of their significant effect on paleoecological interpretations.

DECIPHERING PLESIOMORPHIES AND EVOLUTIONARY INNOVATIONS IN CAMBRIAN ECHINODERMS BASED ON THE UNCLASSIFIED GENUS *CIGARA*

Elise Nardin[1], Christina Franzén[2] and Stephan Bengston[2]

1. Géosciences Environnement Toulouse (OMP), UPS, CNRS, IRD, 31400 Toulouse, France.
elise.nardin@get.obs-mip.fr

2. Department of Paleobiology, Swedish Museum of Natural History, 10405 Stockholm, Sweden.

Cambrian is a crucial period in the evolution of marine life. Echinoderms disarticulated remains occur in the Cambrian stage 2 and the oldest fully articulated specimens are from the Cambrian stage 3, with a peak in diversity during the Cambrian stage 5 and the Drumian. Echinoderms are highly diverse, representing at least 8 classes and few taxa unclassified. Swedish early Cambrian stage 5 strata (Oelandicus shale, Närke, Norrtop) have yielded more than ten specimens of two species of *Cigara*. One species is also known from the Jince Formation (mid Drumian) of Czech Republic. This genus is considered as unclassified echinoderm because of its odd morphology. The body wall is decomposed in three distinct parts. The adoral part is tapering, composed of several dozens of relatively small granulated plates, bearing simple respiratory pores (epispires). The median part is constituted by elongate rod-like plates crossing in X-shaped pattern, defining spaces probably filled by thin (poorly calcified?) small hexagonal plates. The aboral part is conical, characterized by thin polygonal tessellate plates. The aboral part joins the slender appendage, itself organized in two distinct regions. The proximal region is cylindrical, composed of thin elongated incurved hexagonal plates alternating with large ornamented plates, whereas the distal region shows unorganized but slightly imbricated irregular polygonal plates. Neither the oral area nor the feeding structures are preserved in the Swedish or the Czech material. This morphology is very peculiar and bears characters of several classes. The unusual X-braced plating of the median portion of the body wall is unknown in all early Palaeozoic echinoderms but could be relatively similar to some early stylophoran echinoderms. The adoral portion of the body wall bears characteristics (epispires, granulated tessellated polygonal plates) expressed in early eocrinoids, edrioasteroids, and in a less importance in cinctans and stylophorans. The distal appendage can be also compared to the stele of the solutans in its general morphology. The imbricate plating is also observed in several classes, as the helicoplacoids, the lepidocystitids, the edrioasteroid-like taxa and the solutans. The absence of feeding structures prevents a clear attribution to the blastozoans (either eocrinoids, solutans or lepidocystids) or to the edrioastroids. Further morphological and phylogenetical analyses of the *Cigara* morphology will help to decipher morphological innovations among early echinoderms and to propose a taxonomic classification.

IMPROVING THE KNOWLEDGE OF THE DENTAL ONTOGENY OF DINOMYDS (RODENTIA, HYSTRICOGNATHI)

Norma Nasif[1] and Fernando Abdala[2]

1. Facultad de Ciencias naturales, Universidad Nacional de Tucumán, Miguel Lillo 205, 4000, San Miguel de Tucumán.

2. Evolutionary Studies Institute, University of the Witwatersrand, South Africa. Nestor.abdala@wits.ac.za

The Family Dinomyidae (Hystricognathi, Caviomorpha), with only one extant species, *Dinomys branickii* (the pacarana), has an important late Oligocene to Pliocene fossil record in South America, with its highest diversity during the late Miocene. They include a wide range of body-sizes, from small to gigantic, and different degrees of molar hypsodonty. Despite its important diversity in the past, information about anatomy and ontogeny of dinomyds is scarce. We are presenting here new data on dental ontogeny produced by new fossils and by small (young) specimens of the living pacarana. A deciduous upper third premolar (dP3) is present in the dental development of dinomyds, a condition represented in *Branisamys* from the Bolivian late Oligocene, the earliest representative of the family, and also in one of the youngest specimens of the living pacarana. In both cases the dP3 is a tiny, rooted, non-molariform tooth located in front and very close to the dP4. The dP3 is shed and not replaced and its alveolus becomes ossified. Shed of the dP3 in *Branisamys* would occur in an advanced stage of development, before or during the replacement of the dP4, whereas *Dinomys* will shed this tooth in a very early postnatal stage where dP4 and M1 are erupting showing an incipient occlusal worn. Replacement of the dP4 and dp4 in euphypsodont dinomyd fossils is corroborated. In brachydont dinomyds with unilateral hypsodonty and, eventually, the first protohypsodonts (*Branisamys* and *Drytomomys*) replacement of dP4/dp4 occurs after M3/m3 is functioning. In the late Miocene protohypsodont Potamarchinae (*Paranamys*), replacement of the dP4/dp4 occurs before eruption of M3/m3, whereas in euhypsodontid forms (late Miocene of northwestern Argentina) replacement only occurs when the last molar is erupting and did not reach the occlusal surface, or when M3/m3 is totally functional as in the pacarana. The presence of the dP3 in the oldest representatives and in the only living form, suggests their putative presence during stages of the ontogeny of each lineage of the family, even though they are not documented in the fossil record of several taxa. The presence of this tooth would support the hypothesis of a basal position of dinomyds in the context of South American hystricognathes. In the dental evolution of dinomyds, heterochrony in the dental replacement sequence of the dP4/dp4 in relation to the M3/m3 is related with development of hypsodonty and with the retention of deciduous premolar in a more prolonged time during the ontogeny.

LATE PALEOZOIC BIVALVE FAUNAS FROM AMOTAPE MOUNTAINS, NORTHWESTERN PERU, AND THEIR BIOSTRATIGRAPHIC SIGNIFICANCE

Jacqueline P. Neves[1] and Marcello G. Simões[1]

1. Instituto de Biociências, Universidade Estadual Paulista, Distrito de Rubião Junior, CP.510, 18.610-000, Botucatu, SP, Brazil.
profmgsimoes@gmail.com

Marine, Permo-Carboniferous invertebrate faunas of the upper Paleozoic strata of northwestern Peru, Amotape Mountains, were intensely studied during the 50-70's. Despite that, their biocorrelation with other coeval South American Late Paleozoic faunas is still poorly constrained. Recent stratigraphic advances suggest that the Amotape units are equivalent to those of the Ambo Group, Peru. In the type areas, Cerro Prieto and Cerro Palaus, the upper Paleozoic succession encompasses the Chaleco de Paño Formation, which is coeval to Mississipian strata of the Ambo Group. Above this, the Cerro Prieto Formation (Pennsylvanian) is equivalent to the Tarma Formation, and the Palaus Formation (early Permian) to the Copacabana Group. Since 1953, after the benchmark study of N. Newell and collaborators, some authors suggested biocorrelations of the Peruvian bivalve faunas with others of the late Paleozoic strata of the South America continent (*e.g.*, Itararé Group, Brazil). However, this biocorrelation was not fully confirmed by very recent taxonomic studies of the Brazilian fauna. Hence, here we revised the type material studied by N. Newell and collaborators, which is stored in the American Museum of Natural History, NY, USA. According to our interpretations at least 11 distinct species were recorded, belonging to two distinct faunas. The fauna from the Cerro Prieto Formation is relatively diverse, and dominated by infaunal, suspension feeding bivalves, including *Phestia browni* (=*Nuculana browni*), *Heteropecten multiscalptus* (=*Aviculopecten multiscalptus*), *Limipecten araneosus*, *Schizodus* cf. *S. meekanus*, *Sanguinolites peruvianus*, *Exochorhynchus barringtoni* (= *Allorisma barringtoni*) and *Wilkingia insolitum* (=*Allorisma insolitum*). This is probably Pennsylvanian in age. The fauna of the Palaus Formation is dominated by epifaunal byssate forms, including *Septimyalina* cf. *S. burmai*, *Streblochondria* sp., *Streblopteria* sp. and *Aviculopecten crassipinosus*, and probably is early Permian in age. Despite the presence of *Phestia*, *Streblopteria*, *Heteropecten* and *Exochorhynchus*, the Cerro Prieto fauna is clearly distinct from that of the Itararé Group, Taciba Formation, Brazil. Actually, the bivalve faunas of the Amotape Mountains, Peru, are dominated by bivalve genera and species that are common in strata of the Extragondwanic realm of the South American continent, and probably much closer to the late Paleozoic faunas of the Parnaíba and Amazon basins, in Brazil, and coeval North American strata.

BIODIVERSITY OF CAMBRIAN ACRITARCHS: A LINK TO THE CAMBRIAN EXPLOSION?

Hendrik Nowak[1], Thomas Servais[1], Claude Monnet[1] and Thijs R. A. Vandenbroucke[1]

1. University of Lille, CNRS UMR 8217 Géosystèmes, Avenue Paul Langevin, Villeneuve d'Ascq, 59655, France.
claude.monnet@univ-lille1.fr

The early Paleozoic witnessed two major key events among marine life: the Cambrian Explosion with the settlement of essentially benthic marine ecosystems and the Great Ordovician Biodiversification Event with the colonization of the pelagic realm. A key component of these ecological evolutionary steps might be the development of the marine phytoplankton. Acritarchs, organic-walled microfossils of uncertain phylogenetic affinity, are often thought to be, at least for their majority, cysts of single-celled microphytoplankton and consequently the main source of information about marine phytoplankton in the Cambrian. In order to gain insights into their biological evolution and its environmental triggers at those times, this study investigated the evolution of the biodiversity of acritarchs through the Cambrian. The biodiversity of Cambrian acritarchs is here based on a new biostratigraphic compilation leading to a database including more than 100 references, about 170 genera and 600 species. Their biodiversity is investigated by means of several taxonomic richness indices (i.e. normalized and total diversity) and evaluated by means of statistical methods. The analysis is also conducted at various temporal (*i.e.* stage and biozone) and geographic scales (*i.e.* global and regional). These analyses highlight that the diversity of acritarchs shows a protracted increase during the Terreneuvian and Series 2 (early Cambrian), in parallel to the Cambrian Explosion of metazoans. This trend is then followed by a plateau of decreased diversity during most of Series 3 and the Furongian (middle to late Cambrian). Finally, the latest Cambrian recorded an abrupt increase of diversity, which may indicate that the Great Ordovician Biodiversification Event was preceded by a diversification of the phytoplankton. These patterns hold to varying degrees at the genus and species taxonomic ranks, as well as at the global and regional paleogeographic scales. Finally, the correlation between diversity values and the number of included monographies (sampling bias) is rather small, thus indicating that the described diversity patterns are quite robust.

EVOLUTIONARY PATTERN OF *EUMYSOPS* (RODENTIA, ECHIMYIDAE) FROM THE PLIOCENE OF SOUTHERN SOUTH AMERICA

A. Itatí Olivares[1] and Diego H. Verzi[1]

1. CONICET, Sección Mastozoología, Museo de la Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque S/N 1900, La Plata, Buenos Aires, Argentina. iolivares@fcnym.unlp.edu.ar

Echimyidae is the most diverse family of hystricomorph rodents, which is currently distributed mainly in tropical forests and occasionally more open, xeric habitats in northern South America. However, part of its modern history (late Miocene to Pleistocene) took place in open habitats of southern South America. *Eumysops* is part of these modern lineages and the only echimyid with a long evolutionary history in southern South America (central Argentina). In a phylogenetic analysis, obtained from both morphological data and combined molecular and morphological evidences, *Eumysops* was recovered as a monophyletic clade, sister to the extinct †*Pampamys* and the living *Thrichomys*. The position of this grouping in a major clade including non-"eumysopine" echimyids constrains the traditional taxon Eumysopinae only to these three genera. The stratigraphic distribution (assessed by locality and level) reveals a probable coexistence among species of *Eumysops*, a unique pattern among the octodontoid genera from the Pliocene of the Pampasia: *E. laeviplicatus* and *E. formosus* in the Montehermosan; *E. chapalmalensis* and *E. gracilis* in the Chapadmalalan; *E. chapalmalensis*, *E. gracilis* and *Eumysops* sp. nov. in the Vorohuean and Sanandresian. Such distribution and phylogenetic relationships suggest a predominant cladogenetic pattern for the genus. Beyond this, a gradual directional change is shown by *E. chapalmalensis* from the Chapadmalal Formation to the overlying San Andrés Formation. This trend includes an increase in the size and robustness of the skull and jaw, and in the height of molars. Similar features are present in *Eumysops* sp. nov. from the Vorohuean–Sanandresian, or even are acquired by other octodontoid lineages during this lapse. According to numerical ages, and magnetostratigraphic and biochronological data, the interval Vorohuean–Sanandresian is a local representation of the global cooling and drying trend recorded between ~3.0 and 2.5 Ma. Changes detected in *Eumysops* during this interval integrate an important faunal turnover which involves the sudden first appearance of the caviomorph extinct fauna most clearly indicative of arid environments so far recorded. Distinctive skeletal and dental anatomy of *Eumysops*, including cranial and postcranial specializations, and marked hypsodonty, would be a result of its southern history related to a particular palaeoclimatic context.

MORPHOLOGY AND FUNCTION OF THE AXIAL SKELETON OF *AUSTRALERPETON COSGRIFFI* (TEMNOSPONDYLI, RHINESUCHIDAE)

Maria A. Ordoñez[1], Adriana S. Souza[2], Marina. B. Soares[2] and Claudia A. Marsicano[1]

1. IDEAN-CONICET, Universidad de Buenos Aires, Ciudad Universitaria, Pb. II - C1428EHA, Ciudad Autónoma de Buenos Aires, Argentina. maordoez@gl.fcen.uba.ar

2. Universidade Federal do Rio Grande do Sul. Av. Bento Gonçalves 9500, CEP 91501-970, Caixa Postal 15001, Porto Alegre, Rio Grande do Sul, Brazil.

Australerpeton cosgriffi is a temnospondyl taxon found in the upper Permian Rio do Rasto Formation (Parana Basin, Brazil). The studied specimens, an adult (UFRGS-PV-0319-P) and a juvenile (UFRGS-PV-0320-P) are fully articulated axial skeletons which allowed to analyze their locomotor capabilities. The vertebral column is composed by rhachitomous vertebrae, consisting of large crescent-shaped intercentra, two small dorso-posterior pleurocentra and the neural arch. The ribs are well preserved in the anterior presacral region and some of them have very well developed distal uncinate processes. They are mainly developed anteriorly in the adult specimen. The neural spines are straight and posteriorly displaced relative to the neural arches. The spines have longitudinal ridges that run on each side. In the juvenile, the longitudinal ridges are more evident in the anterior part of the column. The zygapophyses are well-developed and inclined approximately 45°. The structure of the axial skeleton of *A. cosgriffi* suggests a strong swimmer. The presence of ridges on the lateral sides of the spines indicates a well-developed epaxial musculature, combined with the presence of tall and straight neural spines, implies a reduce capability of column torsion. This condition combined with the presence of the overlapping uncinate processes would indicate that lateral movements of the trunk during swimming were limited. Therefore the trunk was mainly rigid during progression and was probably the tail the propulsive element. Another possibility, according to the structure of the neural spines and zygapophyses, is the presence of dorsoventral movements of the axial skeleton. This combined with the strong epaxial musculature, seems to have allowed dorsoventral movements, particularly of the head. In the juvenile, the spine longitudinal ridges and the uncinate process are less developed and diminished in size backward. This structure of the axial skeleton would suggest lateral movements of the body and thus the possibility of undulated swimming in the juveniles. In contrast, the adults had a more restricted presacral axial skeleton with a relatively stiff trunk which allowed mainly dorsoventral movements that could be related to a more active diving in larger individuals.

A NEW AKODONTINI (MAMMALIA: RODENTIA: CRICETIDAE) FROM THE PLIOCENE OF ARGENTINA: ENLARGING THE PAST DIVERSITY OF THE SIGMODONTINE

Pablo E. Ortiz[1,2], J. Pablo Jayat[3,4], Pablo Teta[4,5], Ulyses F. J. Pardiñas[4,5] and F. Rodrigo González[2]

1. INSUGEO (CONICET-UNT), Miguel Lillo 205, San Miguel de Tucumán, CP 4000, Argentina. peortizchamb@gmail.com

2. Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Miguel Lillo 205, San Miguel de Tucumán, CP 4000, Argentina.

3. IAMRA, Universidad Nacional de Chilecito, Ruta Los Peregrinos s/n, Chilecito, F5360CKB, La Rioja, Argentina.

4. CONICET, Argentina.

5. Unidad de Investigación Diversidad, Sistemática y Evolución, Centro Nacional Patagónico, Puerto Madryn, CP 9120, Chubut, Argentina.

Despite some significant recent findings, the fossil record of South American cricetids is still scarce and unevenly distributed across the continent. This is particularly noticeable in the case of the Pliocene fossils, most of them recovered from central Argentina deposits. Here we report a new Akodontini coming from late Pliocene deposits of the Middle Unit of the Uquía Formation (Marplatan stage) in San Roque, Jujuy province, northernmost Argentina. These levels can be dated at about 2.5–3 Ma. The new akodontine was found in close association with other several small vertebrates including frogs, lizards, birds, marsupials, and caviomorph and other extinct cricetid rodents. The studied material consists of six mandibles, two fragments of maxillae with molar series, and a few isolated molars, representing at least three individuals. These specimens show morphological affinities with the genera members of the *Akodon* division. However, the particular combination of characters in skull (*e.g.* short incisive foramina), mandible (*e.g.* masseteric crest above the middle height of the mandible, its anterior margin developed as a weak knob and above the level of the mental foramen; capsular projection situated somewhat backward; condyle something broad dorsoventrally; anterior point of the symphysis at the same level or slightly above the alveolar toothrow plane) and molars (*e.g.* M1 with vestigial anteroloph and mesoloph and no trace of enteroloph in young individuals; m1 with shallow anteromedian flexid and no trace of mesolophid, ectolophid and ectostylid, even the youngest individuals; anterolabial cingulum well developed, arising from the anterolabial conulid) suggest that the material belongs to an undescribed genus of small akodontine. According to the paleoenvironmental signal from the small vertebrate assemblage, the new akodontine would have lived in open arid environments in Puna-like or Monte-like habitats. The discovery of an extinct akodontine related to *Akodon* division in the Central Andes during the late Pliocene supports the hypothesis that this region represented an area of diversification for the tribe or, at least, a particular episode in the early evolution of the Akodontini. The absence in the Uquía Formation of *Akodon*, a genus whose species constitute dominant elements of the recent communities in the southern half of South America, suggests that most of the living akodontines, at least the forms with mainly Andean distribution, radiated after the late Pliocene. The presence of the extinct akodontine in the late Pliocene of the Central Andes indicates a greater diversity than previously thought.

APPLICATION OF RAMAN SPECTROSCOPY TO STUDY EXCEPTIONAL FOSSIL PRESERVATION IN THE CRATO FORMATION (CRETACEOUS), BRAZIL

Gabriel L. Osés[1], Gustavo M. E. M. Prado[1], Fábio Rodrigues[2,3], Douglas Galante[2,3]. Guilherme R. Romero[1], Setembrino Petri[1], Luis E. Anelli[1] and Mirian L. A. F. Pacheco[4]

1. Instituto de Geociências da Universidade de São Paulo, São Paulo, Rua do Lago, 562, Butantã, 05508-080, Brazil. abriel.ladeiraoses@gmail.com

2. Laboratório de Astrobiologia do Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo, Rua do Matão, 1126, Butantã, 05508-090, Brazil.

3. Centro Nacional de Pesquisa em Energia e Materiais, Campinas, Rua Giuseppe Máximo Scolfaro, 10.000, Polo II de Alta Tecnologia, 13083-970, Brazil.

4. Universidade Federal de São Carlos - Campus Sorocaba, São Carlos, Rodovia João Leme do Santos (SP 264 Km 110), Bairro do Itinga, 18052-780, Brazil.

The Crato Formation, Araripe Basin, is an important fossil *Konservat Laggerstätte* from the Early Cretaceous of northeasten Brazil. This geological unit is well known for its rich and exquisitely preserved fossil fauna and flora. The Crato Formation is composed by laminated limestones, shales, sandstones and marls deposited in a rift basin, during the opening of the South Atlantic Ocean, in the Aptian-Albian transition. The palaeoenvironment is interpreted as a lacustrine stratified deposit with anoxic and hypersaline bottom waters, located in a semi-arid to arid region. The Crato Formation holds most occurrences of isolated fossil feathers in Brazil. Despite the lack of direct association between bones and feathers, the presence of the latter is an indicative that the region around the palaeolake was also populated by feathery dinosaurs. Melanosomes preservation suggests that sexual selection played a significant role besides protection against radiation, and it also gives details of interspecific relations. The fossil insects from this geologic unit are exceptionally well-preserved as the specimens are usually found preserved in three dimensions and, occasionally, with soft tissues. The Crato Formation insects have significant palaeobiological implications, revealing, for instance, early stages of their coevolution with flowering plants. Therefore, the study of the preservation of fossil feathers and insects with such palaeobiological implications is a central issue in palaeontological research concerning the Crato Formation fossil beds. Although previously analyzed, the mechanisms and processes of fossil preservation in this unit are still under debate. For the first time, we have applied Raman spectroscopy, a high resolution nondestructive technique, to investigate the composition of fossil feathers and insects from Crato Formation. Raman laser is a technique used to analyze molecular interactions and is commonly applied to geochemical research. We have analyzed the fossil specimens in a Renishaw micro-Raman equipment, using 633 cm^{-1} and 785 cm^{-1} laser wavelengths. The data was later processed in the software Origin. The spectra obtained reveal peaks characteristic of iron oxy-/hydroxides, possibly amorphous hematite or limonite, in the fossils, while spectra of the rock matrix (laminated limestone) show peaks of calcite, as expected. We interpret the presence of iron oxy/hydroxides replacing the original composition of both fossil insects and feathers, as the result of pyrite alteration. Therefore, the already proposed initial pyritization of the organisms by bacterial activity, during early diagenesis, is further supported, enlightening the processes responsible for the exceptional preservation of the Crato Formation fossils. [Funding agencies: CNPq and FAPESP].

SHRIMP U–PB ZIRCON DATING OF THE TRIASSIC PUESTO VIEJO GROUP, ARGENTINA, AND CORRELATIONS ACROSS SOUTHERN GONDWANA

Eduardo G. Ottone[1], Mariana Monti[2], Claudia Marsicano[1], Marcelo de la Fuente[2], Maximiliano Naipauer[1], Richard Armstrong[3] and Adriana Mancuso[2]

1. Instituto de Estudios Andinos, Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Buenos Aires, Argentina.
ottone@gl.fcen.uba.ar

2. Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, Mendoza, Argentina.

3. Research School of Earth Sciences, The Australian National University, Canberra, Australia.

The Puesto Viejo Group crops out in the San Rafael Block, southwest of San Rafael city, Mendoza, Argentina at approximately 35°S and 68°20'W. It consists of the basal mainly grayish Quebrada de los Fósiles Formation overlying by the reddish Río Seco de la Quebrada Formation. The basal unit includes both plant remains (pleuromeians and sphenopsids) and vertebrates (scattered fish scales, dicynodont synapsids and an archosaur). In contrast, the Río Seco de la Quebrada beds have yielded only vertebrates, although a more diverse fauna. It includes cynodonts as *Cynognathus*, *Pascualognathus* and *Diademodon*, and also dicynodonts (*Vinceria* and *Kannemeyeria*). Due to the tetrapod content the bearing levels were correlated to the *Cynognathus* assemblage zone of South Africa and thus referred to the Anisian. During recent work in the Puesto Viejo Group succession, a SHRIMP $^{238}U/^{206}Pb$ age in zircons of 235.8 ± 2.0 Ma was obtained from a rhyolitic ignimbrite interdigitated between the Quebrada de los Fósiles and the Río Seco de la Quebrada formations at the Quebrada de los Fósiles section. This new radio-isotopic age for the Puesto Viejo Group suggests that the tetrapod fauna in the Río Seco de la Quebrada beds developed during the Late Triassic (early Carnian), thus *ca.* 10 Ma later than the age attributed to the *Cynognathus* zone of South Africa. Two scenarios might explain our results. First, the *Cynognathus* zone of South Africa is wrongly assigned to the lower Middle Triassic (Anisan) and should be considered instead younger in age, Late Triassic (Carnian). Second, the relative age of the *Cynognathus* zone of South Africa is correct but the inferred range of *Cynognathus* and *Diademodon* is incorrect as they were present during the Late Triassic (Carnian) at least in South America. In any case, this new date poses serious doubts about the validity of biostratigraphic correlations based solely on tetrapod taxa, a common practice for Triassic continental successions across Gondwana.

OXFORDIAN MICROBIAL LAMINITES FROM LA MANGA FORMATION: REMARKABLE NANOBACTERIA PRESERVATION, NEUQUEN BASIN, ARGENTINA

Ricardo M. Palma[1], Diego A. Kietzmann[1], Graciela S. Bressan[1] and Marcos Comerio[1]

1. Instituto de Estudios Andinos Don Pablo Groeber (IDEAN, UBA-CONICET), Intendente Güiraldes 2160 CABA, C1428EGA, Argentina. gbressan@gl.fcen.uba.ar

The Callovian-Oxfordian of the Neuquén Basin (Argentina) is characterized by an extensive marine carbonate system (La Manga Formation) with a predominance of shallow and middle ramp deposits. The intertidal-supratidal deposits are interesting because of the abundance of stromatolite beds developed during the middle Oxfordian (*Perisphinctes-Araucanites* zone). A detailed study of these beds through analysis of growth fabric, laminae variations and exceptional preservation of a rod-like bacteria community has been done in the localities of Arroyo Los Blancos, Arroyo La Manga and Yeseras Grandes (southern Mendoza province). These facies exhibit planar and crinckle lamination often disrupted by subaerial exposure surfaces such as sheet-cracks, mud-cracks, and fenestral pores. Different lines of evidence suggest that these stromatolites are typical of low energy upper intertidal to lower supratidal environments. Extensive SEM examinations of polished stromatolite samples were carried out showing bacteria filaments with subspherical microstructure and framboidal pyrite aggregates. The microbial filaments (rod-like bacteria) consist of a network of irregular distributed filaments, which range from 150 nm to an uncommon 640 nm in length, meanwhile diameters range from 54 nm to 90 nm. Besides the excellent preservation of these rod-like bacteria there are small holes that are reminiscent of filament molds. The result of the EDX analysis reveals that the filaments and spheroidal bodies are both composed of calcium carbonate. The presence of a K peak may be related to potassium ions occupying interstitial sites in the calcite lattice. Nanometer-scale spheroids are considered as nanobacteria and have been observed in microbial mats as old as Proterozoic, while the occurrence of framboidal pyrite is related to the metabolic activity of sulfate–reducing bateria and decay of organic matter. The presence of abundant filaments of rod-like bacteria, whose sizes are very similar to those observed in modern microbialites, is a strong evidence of the role of microorganisms in stromatolite formation. [Contribution C-85 of the IDEAN].

PALEOTEMPERATURE ESTIMATIONS FOR THE RÍO TURBIO FORMATION (SANTA CRUZ, ARGENTINA): A KEY FOR UNDERSTANDING THE EOCENE CLIMATE DETERIORATION

Carolina Panti[1]

1. Consejo Nacional de Investigaciones Científicas y Técnicas – Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Ángel Gallardo 470, Ciudad Autónoma de Buenos Aires, C1405DJR, Argentina.
caropanti@gmail.com

The Eocene was a time of a great climatic turnover, ranging from the warmest global climates during the early Eocene to cold temperate climates close to the Eocene/Oligocene boundary. Although the analyses of Eocene climates have received great interest during the last years, middle/late Eocene climatic conditions in southern South America are not so well constrained. The study of fossil angiosperm leaves from the Río Turbio Formation shows a strong reduction in diversity from the lower towards the upper levels of the unit (up to 30%), mainly caused by a decline of neotropical elements. This reduction may have been caused by several factors, being climate change one of the most important. In order to support this assumption, we estimated temperature for the Río Turbio Formation on the bases of the analysis of leaf assemblages preserved in this unit. The mean annual temperature (MAT) estimation was performed using univariate (LMA) and multivariate (CLAMP) approaches based in the updated version of the newest climatic-leaf data set knows as CLAMP3 SA. The study was carried out at three levels: (1) MAT estimation for the Río Turbio Formation; (2) MAT estimation for the Lower Member and (3) MAT estimation for the Upper Member. Univariate models for the Río Turbio Formation indicate a MAT of 17 (±2.1) ºC value slightly below that the one obtained for the Lower Member (18.5 ±2.1ºC). On the other side, the MAT calculated for the Upper Member show a decrease of about 5ºC (13 ±2.1ºC). Canonical correspondence analysis shows similar tendencies to those obtained from univariate models with barely high values being more pronounced for the Upper member (16ºC). This analysis show a decrease in the MAT values during the deposition of the Río Turbio Formation indicating that the climatic conditions became cooler towards the upper levels allowing the development of the subantarctic paleoflora type in this region. These results are also consistent with the observed upwards reduction in diversity, decline of neotropical elements and increase of austral components, mainly represented by *Nothofagus*.

FORAMINIFERAL ASSEMBLAGES AND PALEOENVIRONMENTS OF THE EARLY-MIDDLE EOCENE SUCCESSION IN THE SINU-SAN JACINTO BASIN, NORTHERN SOUTH AMERICA

Diana C. Parra[1] and Daniel A. Rincón[2]

1. Corporación Natfrac, Bucaramanga, Colombia.
diana.parra@ecopetrol.com.co
2. Instituto Colombiano del Petróleo – ECOPETROL S.A., Bucaramanga, Colombia.

The Eocene succession of northern South America was characterized by a complex tectonic configuration developing provinces with characteristic structural and tectonic features which have petroleum potential. One of these provinces is the Sinu-San Jacinto Basin. It is located in the north of Colombia and is composed of Late Cretaceous to Holocene sediments in the San Jacinto Folded Belt and sediments not older than late Oligocene in the Sinu Folded Belt. For the purpose of contributing to the knowledge about paleo-environmental conditions for early-middle Eocene succession in the Sinu-San Jacinto Basin, we analyzed the planktonic and benthic foraminifera from samples of the Chengue Formation in two stratigraphic sections. Microfaunas analyzed were composed of abundant planktonic and benthic foraminifera, where the benthic foraminifera with hyaline wall were the most common. Foraminiferal assemblages were characterized mainly by planktonic specimens of *Clavigerinella akersi*, *C. colombiana*, *Pseudoglobigerinella bolivariana*, *Acarinina pentacamerata*, *Morozovella aragonensis*, *Igorina broedermanni*, *Paragloborotalia nana* and *P. griffinoides*. Benthic foraminifera were represented by *Bolivina* spp., *Bulimina* spp., *Uvigerina* spp., *Hanzawaia* spp., *Cibicides* spp. and specimens of Nodosariacea. Environmental conditions were estimated from paleo-bathymetric analyses, diversity analyses, planktonic and benthic foraminifera ratio, triangular plots for the foraminiferal assemblage structure based on types of wall textures in benthic foraminifera, epifauna/infauna ratio and other ecologic characteristics of foraminifera. The interpretation of the depositional environment suggests that the sediments analyzed from the Chengue Formation (early-middle Eocene) were deposited in neritic environments of shelf with possible variations to bathyal environments (upper-middle slope). The results match with previous analyses in this basin which propose neritic environments with possible variations from transitional to shelf. However, they do not suggest possible changes to bathyal environments from upper to middle slope, as proposed by this study. Moreover, the presence of planktonic foraminifera as *Clavigerinella* spp., *Pseudoglobigerinella bolivariana* and *Paragloborotalia griffinoides* could indicate that the depositional environment was characterized by high biological productivity probably associated with upwelling events. Finally, high abundances of *Bolivina* spp., *Bulimina* spp., *Uvigerina* spp. and specimens of Nodosariacea suggest environments with low oxygen levels.

NEW FOSSIL INVERTEBRATES FROM THE MIOCENE OF CENTRAL EASTERN COLOMBIA (MACARENA-LLANOS-AMAZONAS SOUTH) AND ITS IMPLICATIONS IN THE PALEOGEOGRAPHY OF NORTHWESTERN SOUTH AMERICA

Francisco Javier Parra[1,2] and Rosa E. Navarrete-Parra[2]

1. Géosciences-Environnement Toulouse, Université de Toulouse, 14 Avenue Édouard Belin, F-31400 Toulouse, France. paleosedes@gmail.com, fjparran@unal.edu.co

2. Universidad Nacional de Colombia, Bogotá, Colombia.

In new fossiliferous localities in Central Colombia (southwest of the Western Llanos Basin and southwest of La Macarena) and in new collections of the Amazonian Trapezium, molluscs, ostracods and foraminifers of Burdigalian to early Tortonian age, were found. The molluscs are dominated by *Dyris* Conrad and *Pachydon* (Gabb), with the species *Pachydon hettneri* (Anderson) common in northern South America. Among the ostracods predominate *Schizocythere* Triebel and *Cyprideis* with the species *purperi* Sheppard and Bate. The foraminifera are best represented by agglutinated forms and some rotalids with *Protelphidium* Haynes and *Elphidium* Montfort. The new findings provide a substantial point of view to the paleogeography during the early Miocene to early late Miocene of the interior of northwestern South America. The new collections of central Colombia are attributed to the Pebas Fauna of the Western Amazon (Pebasian Faunas), which document that there was a continuous biogeographic link between the Eastern Basin of Venezuela to the north, through the Marañon-Ucayali basins of Peru to the south, during the early Miocene and the early middle Miocene, but not during the late middle Miocene and the early late Miocene. However, for that interval, the new records show that the Macarena region formed a seaway toward the low Amazonian Basin (Acre/Marañón basins in Peru), Solimões in Brazil, and Colombian Amazon. The new findings suggest that at least during the late middle Miocene and early late Miocene, the Pebas system, spread much more northward, reaching the Llanos Basin. The invertebrate fossils of the Macarena – Llanos – Amazon lived at the time of the onset Llanos/Amazon, where a transitional fluvial-marine and estuarine environment was established between the Caribbean to the north and the Amazon to the south, occupying the Llanos/Amazon limit.

MICROSTRUCTURAL DESCRIPTION OF CROCODYLIFORMES OSTEODERMS FROM BAURU BASIN (UPPER CRETACEOUS), BRAZIL: PALEOAUTOECOLOGY AND PALEOBIOLOGY IMPLICATIONS

Paulo V. L. Gomes da Costa Pereira[1], Thiago da Silva Marinho[2] and Lílian Paglarelli Bergqvist[1]

1. Universidade Federal do Rio de Janeiro, Laboratório de Macrofósseis, Departamento de Geologia, Av. Athos da Silveira Ramos, 274, Ilha do Fundão, Rio de Janeiro, RJ, 21941-611, Brazil. paulovictor29@yahoo.com.br

2. Universidade Federal do Triângulo Mineiro, Instituto de Ciências Exatas, Naturais e Educação, Departamento de Ciências Biológicas, Av. Randolfo Borges Jr., 1700, Universidade, Uberaba, Minas Gerais, 38064-200, Brazil.

Crocodyliformes represent the most diverse group of vertebrates in the Upper Cretaceous Bauru Basin, Brazil. The goal of present work is to provide a microstructural description of osteoderms of crocodyliforms from the Bauru Basin, the interspecific and intraspecific comparisons of their microstructures and do, when possible, paleoautoecology and paleobiology inferences. Sections were made in osteoderms of *Armadillosuchus arrudai* (cervical shield and mobile band), *Itasuchus jesuinoi* (dorsal and caudal), *Baurusuchus* (dorsal and caudal) and *Uberabasuchus terrificus* (dorsal), following the traditional methodology for paleohistological analysis. The four taxa bear osteoderms composed mainly of fibrolamellar or lamellar bone. In *Itasuchus* the osteoderm is only composed by compact bone with about 20 lines of arrested growth arranged in three cycles and some osteons at the core zone. These lines are suggestive of a minimum age of 21 years at the time of its death and the cycles may be related to paleoenvironmental and climatic changes affecting its habitat. The microstructure of *Uberabasuchus* differs from that of *Itasuchus* by a larger number of osteocytes and zonation, showing a faster bone growth and a better terrestrial mobility when compared to *Itasuchus*. *Armadillosuchus* presents few growth marks, primary and secondary osteons and bundles of collagen fibers parallel to the cut, and a different microstructure from armadillos in which its name was inspired. Osteoderms of *Baurusuchus* are composed of compact bone alone housing numerous osteons and some Volkmann's channels. Except *Baurusuchus*, the others taxa have presented variation as well: presence and size of trabecular bone, the collagenous fibers and so on. This study highlights the high interspecific and intraspecific variation in microstructure of studied osteoderms and shows the importance of paleohistology as a starting point for a better understanding of extinct taxa. [Financial support: FAPERJ and CNPq].

PRELIMINARY PHYLOGENY OF THE VENERICARDIINAE CHAVAN (BIVALVIA: CARDITIDAE)

Damián E. Pérez[1] and Maximiliano J. Alvarez[1]

1. Museo Argentino de Ciencias Naturales. Av. Angel Gallardo 470, C1405DJR, Buenos Aires, Argentina.
maxialvarez82@gmail.com

Carditidae Férussac is a big family of bivalves with an explosive diversification during the early Cenozoic. At the present time, this family has more than 140 species and six subfamilies. The boundaries among some subfamilies are not clear, and the limits among different genera and subgenera are argued and used with dissimilar criteria by previous authors. For example, in some revisions, the genus *Venericardia* Lamarck includes the subgenera *Claibornicardia* Stenzel and Krause, *Venericor* Stewart or *Megacardita* Sacco, while in other ones, these subgenera have genus status. *Venericardia* is the genus-type of the subfamily Venericardiinae. This subfamily includes from three to more than ten genera according to different authors, and many others subgenera were considered subgenera of *Venericardia*. Two lineages were recognized in the subfamily Venericardiinae: the large 'planicostae' (*Venericor*-like), with elevated hinge plates with highly developed, subtrigonal-shaped shells and smooth flattened radial ribs; and the "alticostae" (*Venericardia*-like), with lower hinge plates, subelliptical-shaped shells and noded and tripartite radial ribs. The monophyly of each of these lineages is debated. In this contribution, to test the relationships among these carditids, a phylogenetic analysis of the Venericardiinae was carried out. The cladistic analysis based on 103 shell-characters scored for 40 fossil and recent species (including the type species for 25 genera) was performed with TNT 1.1. The ingroup comprises the planicostate *Venericor* (3 spp.), *Leuroactis* Stewart and *Pacificor* Verastegui, the alticostate *Venericardia* (4 species), *Arcturellina* Chavan, *Purpurocardia* Maxwell, *Fasciculicardia* Maxwell (2 spp.), *Baluchicardia* Rutsch and Schenck, *Rotundicardia* Heaslip (2 spp.), *Claibornicardia* (2 spp.), and *Glyptoactis* Stewart. Additionally, we considered 16 other species of 11 genera. Our results show that the "planicostae" and the "alticostae" are clearly separated. *Megacardita* and *Bathycardita* Iredale are sister-groups of the planicostate clade. *Cardiocardita* Anton and *Paraglans* Chavan are included into the alticostate clade. *Cyclocardia* Conrad, *Pleuromeris* Conrad, *Pteromeris* Conrad, *Vimentum* Iredale and *Scalaricardita* Sacco resulted into a completely-resolved clade, closely related to alticostates venericardids. *Cardites* Link is closer to the *Cyclocardia*-group and alticostates than to other taxa. *Glans* Megerle and *Centrocardita* Sacco form a group outside de venericardids. This preliminary exploration of the phylogenetic relationships of this group is a key step to a better understanding of the relationships of the subfamily, which we intend to improve by including more species, fossil and recent.

CALCAREOUS NANNOFOSSIL EVENTS IN THE PABDEH FORMATION (LATE PALEOCENE - LATE OLIGOCENE) AT THE DEHLORAN SECTION, LORESTAN PROVINCE, IRAN

Juan P. Pérez Panera[1,2] and Manooseh P. Khavari Khorassani[3]

1. CONICET-División Paleontología Invertebrados-Museo de La Plata.
Paseo del Bosque s/n, La Plata. CP 1900. Buenos Aires, Argentina.
juan.p.panera@ypftecnologia.com

2. Laboratorio de Bioestratigrafía. Área de Geociencias. YPF Tecnología S.A.
Baradero s/n, Ensenada. CP 1925. Buenos Aires, Argentina.

3. Department of Geology, School of Science, Ferdowsi University at Mashhad, Mashhad, Iran.

The Pabdeh Formation is recognized both in outcrops and subsurface in the Zagros Basin (southeast Turkey, northeast Iraq, west and southeast Iran). It is a Paleogene marine deposit represented by purple shales, with inter-bedded green shales at the base, followed by gray shales, limestones, and marls. The 333 meters outcrop at the Dehloran section was sampled for calcareous nannofossil analysis. Our preliminary results on the biostratigraphy and paleoceanography of nannofossils recovered from the section are presented herein. The assemblages are, in general, quite affected by overgrowth but highly diverse and abundant. It was possible to recognize a series of nanno-events that lead to a biostratigraphic interpretation. At the base of the section, the last occurrences (LO) of *Discoaster araneus, Fasciculithus tympaniformis, Sphenolithus editus, S. anarrhopus* and *Toweius eminens* disclose the Paleocene/Eocene boundary. Above it, the early Eocene was interpreted based on the first occurrence (FO) of *Discoaster kuepperi, D. lodoensis* and *Girgisia gammation*, and the LO of *Chiasmolithus bidens* and *Tribrachiatus orthostylus*. The early Eocene/ middle Eocene boundary was interpreted by the LO of *Discoaster kuepperi* and *D. lodoensis.* Throughout the middle Eocene, the FO of *Reticulofenestra umbilica* and *R. reticulata*, and *R. bisecta* and *Helicosphaera bramlettei*, allow us to identify the late Lutetian and the Bartonian respectively. The late Eocene and early Oligocene were interpreted by the recognition of the subsequent nano-events: the LO of *Chiasmolithus grandis* and *Discoaster barbadiensis*, the LO of *Discoaster saipanensis,* the FO of *Coccolithus formosus* and the LO of *Reticulofenestra umbilica.* The latter allows the identification of the early Oligocene/middle Oligocene boundary, and above it, the middle Oligocene/late Oligocene was interpreted on the basis of the LO of *Helicosphaera compacta.* Paleooceanographic interpretations were attempted by the analysis of the nannofossil assemblages. At the lower part of the section, the association suggests oligotrophic and warm conditions that could be related to the Paleocene-Eocene Thermal Maximum event. Afterwards, a long cooling trend is interpreted by the abrupt diminution in the relative abundance of discoasters and sphenolithus. In the middle to late Eocene, warmer conditions were reestablished and are related to the Middle Eocene Climatic Optimum. In the latest Eocene and throughout the Oligocene, another cooling trend is interpreted mainly due to an increasing abundance of *Coccolithus pelagicus* and *Cyclicargolithus floridanus,* both species with affinity to temperate to cold surface waters. This section appears to be a promising site for Paleogene eastern-Tethys further studies.

BIOTIC CRISES AND MORPHOLOGICAL CHANGE, THE WAPUM METHOD APPLIED TO MARINE AND TERRESTRIAL TAXA: BIVALVES AND INSECTS

Julian F. Petrulevičius[1], André Nel[2] and Sonia Ros-Franch[1]

1. CONICET and División Paleozoología Invertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, La Plata, 1900, Argentina. levicius@fcnym.unlp.edu.ar

2. UMR CNRS 7205, Entomologie, Muséum National d'Histoire Naturelle, 45 rue de Buffon, Paris, F-75005, France.

The analysis of global, planetary, faunistic and floristic changes during the Phanerozoic eon is very important to define the stratigraphic divisions and the major crises of biodiversity. The Wagner Parsimony Applied to Palaeosynecology Using Morphology (WAPUM) consists in the application of the Wagner Parsimony algorithm to classify the geological periods using morphological characters instead of taxa. In the WAPUM a character is 'presence *versus* absence of species bearing a morphological structure'. With this method we avoid the difficulties related to the monophyly/paraphily of the taxonomic groups used in more traditional approaches. The method is applied here on morphological characters of bivalves and insects. Study of marine biotic crises was a classical and historical scope *via* the typological methods for centuries. For the first time, we applied the WAPUM method to a marine group, the Pectinoidea *sensu* Waller. Preliminary results indicate strong morphological changes through the Permo/Triassic (P/T) boundary but also an interesting grouping of the three Paleozoic periods considered: Devonian, Carboniferous and Permian, which implies a characteristic Paleozoic morphology for the Pectinoidea. Other morphological changes occur between the Lower and Middle Triassic but not in the Cretaceous/Tertiary (K/T) boundary. From the terrestrial taxa analyzed, especially the Odonatoptera, we noticed no significant morphological changes during the P/T and K/T boundaries. However, there were important changes at the Lower-Upper Cretaceous boundary, probably linked to the angiosperm diversification and the eutrophication of freshwater environments. Although our results are preliminary, and the method has to be applied to more taxa, the groups analysed have dissimilar histories and seems that they have been affected by different events. We consider that the application of the WAPUM to other groups could help to confirm or object the currently available scenarios for the global changes in the evolution of past diversity and disparity of organisms (major changes or global crises of diversity).

THE UPPER PLEISTOCENE FAUNA FROM HIJENSKA PEĆINA (CROATIA): IDENTIFYING THE CAUSES OF ACCUMULATION

Leda Piculjan[1], Dejana Brajkovic[2], Sinisa Radovic[2], Benedetto Sala[3] and Preston Thor Miracle[4]

1. Museum für Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin, Invalidenstrasse 42, Berlin, 10115, Germany. leda.piculjan@mfn-berlin.de
2. Institute for Quaternary Paleontology and Geology, Croatian Academy of Sciences and Arts, Ante Kovačića 5, Zagreb, 10000, Croatia.
3. Dipartimento di Biologia ed Evoluzione, Universita degli studi di Ferrara, Via Savonarola, 9, Ferrara, 44121, Italy.
4. Department of Archaeology and Anthropology, University of Cambridge, Downing Street, Cambridge, CB2 3DZ, UK.

Hijenska pećina (“Hyena cave”), an Upper Pleistocene cave site, is located in the Plovanija quarry, north of Buje in Istria, Croatia. After being discovered in 1972, the fossil cave was excavated and described by Mirko Malez, who focused more on the geological features of the cave, only briefly mentioning the paleofaunal composition. Our study deals specifically with the fossil material, which consists of 453 bones, bone fragments and teeth, plus eight hyena coprolites. Twenty different taxa were identified, including large and small mammals and one reptile. Fossil bones and teeth belonging to *Crocuta crocuta spelaea* are the most common (41% of the total number of identified specimens, NISP), followed by *Equus ferus* (13.7%), which is mostly represented by teeth, *Bos*/*Bison* (7.6%), *Ursus spelaeus* (6.8%) and *Canis lupus* (6.5%). Three possible main factors responsible for the accumulation were suggested: humans as accumulators, hyenas as accumulators and an opening in the ground acting as a natural trap. Humans, as being entirely responsible for the accumulation, were eliminated, because from 453 bones present in the assemblage, only one bone (HP365 – *Bos primigenius* tibia) contains possible cut marks. However, their potential contribution to the accumulation cannot be ruled out. Several criteria were used in order to determine if hyenas were responsible for the accumulation: presence of cub remains, presence of hyena coprolites, gnawing damage on at least 50% of the bones in the assemblage, presence of digested bones, carnivore to ungulate minimum number of individuals (MNI) ratio of 20% or more, 15-45% of hyena remains in the assemblage, limb bones being the most represented skeletal parts, larger minimum number of elements (MNE) of distal epiphyses than the MNE of proximal epiphyses. All of these criteria were fulfilled except one: hyena gnawing damage was found on only three bones. If the possible gnawing marks and gnawing marks from unidentified animals are also assigned to the activity of hyenas, still the percentage of carnivore gnawed bones would be only 7.67%, which is way below the required 50%. However, as there are no indications that the cave used to act as a natural trap, it seems most likely that Hijenska pećina was a hyena den and hyenas were responsible for at least part of the accumulation. Other factors contributing to the accumulation are not excluded.

GLABROCINGULUM THOMAS (GASTROPODA, EOTOMARIIDAE) IN THE UPPER PALEOZOIC TEPUEL-GENOA BASIN, CHUBUT PROVINCE, ARGENTINA

María Karina Pinilla[1]

1. División Paleontología Invertebrados. Museo de Ciencias Naturales de La Plata. Universidad Nacional de La Plata. Paseo del Bosque S/N, La Plata 1900, Buenos Aires, Argentina.
mkapinilla@fcnym.unlp.edu.ar

The genus *Glabrocingulum* Thomas (Gastropoda, Eotomariidae) ranges throughout the Carboniferous and Permian. Species of the subgenus *G.* (*Glabrocingulum)* were recorded from Europe, North America, South America, Australia and Asia, whilst *G.* (*Stenozone)* has only been reported in the last four regions. The first records of *Glabrocingulum* in Argentina correspond to *G. (S.) argentinus* (Reed) and *G. (G.) advenus* (Reed) from the upper Carboniferous of the Calingasta-Uspallata Basin, San Juan Province. *G. (S.) argentinus* was also described from the Pampa de Tepuel, Mojón de Hierro and Río Genoa Formations in the Tepuel-Genoa Basin, Chubut Province, in association with *G. (Glabrocingulum) poperimensis* (Maxwell). This assemblage includes also *Cinclidonema sueroi* Sabattini, *Nordospira yochelsoni* Sabattini, *Tropidostropha* sp., *Callitomaria tepuelensis* Sabattini and Noirat, *Platyteichum tenuicostatum* Sabattini, *Neoplatyteichum barrealensis* (Reed), *Glyptotomaria (Dictyotomaria)* cf. *quasicapillaria* (Rollins), *Ananias riccardii* Pinilla, *Euphemites chubutensis* Sabattini, *Sinuitina (Spirilira) tenuis* Pinilla *et al.*, *S. (Spirilira) gonzalezi* Sabattini, *Peruvispira australis* Sabattini and Noirat and *Peruvispira sueroi* Sabattini and Noirat. Its age ranges from Bashkirian to Artinskian. Two new species of *G. (Stenozone)* are here described from the Mojón de Hierro and Río Genoa Formations. One of them resembles *G. (S.) costatiformis* Swart and the other *G. (S.) elegans* Swart, both from the early Permian (Kungurian) of the Carnavon Basin, Australia. The new species are associated with other gastropods, including *Retispira patagoniensis* Pinilla and Sabattini, *Borestus lunatus* Pinilla *et al.*, *Glabrocingulum (Stenozone) argentinus* Reed, *G. (G.) poperimensis*, *Mourlonia cuneoi* Ferrari and Sabattini, *Eirlysia* sp., *Amaurotoma* sp., *Euomphalus* sp., and *Austroneilsonia* sp., which indicate a Kasimovian-Artinskian age. Therefore, in the Tepuel-Genoa Basin the subgenera *G. (Glabrocingulum)*, as well as *G. (Stenozone) argentinus* are represented from the Bashkirian to the Artinskian, whilst two new species of *G. (Stenozone)* have a Kasimovian to Artinskian age.

A NEW RECORD OF *AMOSICERAS RETICULATUM* SABATTINI *ET AL.* (CEPHALOPODA, NAUTILIDA) FROM THE UPPER PALEOZOIC TEPUEL-GENOA BASIN, CHUBUT PROVINCE, ARGENTINA

María Karina Pinilla[1] and María Alejandra Pagani[2]

1. División Paleontología Invertebrados. Museo de Ciencias Naturales de La Plata. Universidad Nacional de La Plata. Paseo del Bosque, S/N, La Plata 1900, Buenos Aires. Argentina.
mkapinilla@fcnym.unlp.edu.ar

2. CONICET - Museo Paleontológico Egidio Feruglio. Trelew, Chubut. Argentina.

Cephalopods from the Neopaleozoic Tepuel-Genoa Basin in Chubut Province, Argentina, are relatively rare and endemic; however, some species have proved to be useful for biostratigraphy. Two successive cephalopod biostratigraphic units were proposed in the basin, the *Sueroceras irregulare* and *Mooreoceras zalazarensis* zones, which were referred to the early Permian on the basis of the occurrence of diagnostic mollusks. The *M. zalazarensis* Zone is mainly characterized by the eponymous species, as well as *Glabrocingulum (Stenozone)* Batten, *Eirlysia* Batten (Gastropoda), *Atomodesma* von Beyrich, *Merismopteria* Etheridge, *Netschajevia* Likharev (Bivalvia) and *Castelvenus* Yancey (Scaphopoda). A new record of the nautilid *Amosiceras reticulatum* Sabattini *et al*., a taxon previously described from Piedra Shotel and El Molle localities, is presented herein. The material studied comes from the Río Genoa Formation at Salar de Ferraroti, from levels assigned to the *Mooreoceras zalazarensis* Zone. The associated faunas include the gastropods *Retispira patagoniensis* Pinilla and Sabattini, *Borestus lunatus* Pinilla *et al*., *Glabrocingulum (Glabrocingulum) poperimensis* (Maxwell), *Euphemites chubutensis* Sabattini, *Sinuitina (Spirilira) gonzalezi* Sabattini, *S. (Spirilira) tenuis* Pinilla *et al*., *Eirlysia* sp., *Amaurotoma* sp, *Mourlonia cuneoi* Ferrari and Sabattini, *Austroneilsonia* sp., *Euomphalus* sp. and *Glabrocingulum (Stenozone) argentinus* (Reed), which suggest a Kasimovian-Artinskian age. Since *Amosiceras reticulatum* mostly resembles *Knightoceras pustulum* Unklesbay and *K. oxylobatum* Miller and Downs, from the early Pennsylvanian (Bashkirian) of North America, the age range of the *Mooreoceras zalazarensis* Zone should be reconsidered.

THE SPONGE GENUS *LAOCOETIS* POMEL (HEXACTINOSIDA, CRATICULARIIDAE): A LIVING FOSSIL?

Andrzej Pisera[1] and Konstantin R. Tabachnick[2]

1. Institute of Paleobiology, Polish Academy of Sciences, ul. Twarda 51/55, Warszawa, 00-818, Poland. apis@twarda.pan.pl

2. P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia.

The sponge genus *Laocoetis* Pomel (Hexactinellida, Hexactinosida, Craticulariidae), earlier known as *Craticularia* Zittel, belongs to rare examples of a taxon that is based on fossil forms, and much later its Recent representatives have been found. Due to the fact that sponges belonging to *Laocoetis* are very characteristic in result of the regular pattern of canal openings on their surface, they are easily recognizable even by non specialists, and thus are frequently reported among fossils. The fossil sponges that belong to this genus are very common in the Late Jurassic and Cretaceous rocks of Europe, but were noted also in the Mesozoic rocks of Australia, Argentina and Antarctica. They are also very common in Eocene deposits of Spain and Italy, Miocene of Algeria and in the Pliocene of Sardinia. Morphologically similar forms that may belong to this group were found in Late Devonian rocks of Poland. Despite the fact that these sponges are so common, details of their spiculation (especially ectosomal and gastral spicules) were never described. Taxonomy of fossil forms is thus based on such features as general shape and shape and size of canal openings of the choanosomal skeleton. Recent forms, on the other hand, that were discovered only in the sixties of the previous century belonging to the species *Laocoetis perion* Lévi, are poorly known due to the fact that only small fragments were found and not all spicular components have been observed. The species *L. perion* occurs only in the Indian Ocean around Madagascar. New rich and well preserved finds of recent material of this species from Madagascar allow the study of all spicules content, including microscleres, and their comparison with exceptionally well preserved new Late Jurassic representatives of *Laocoetis* from Poland. The Jurassic specimens, apart from a well preserved choanosomal dictyonal skeleton, have also preserved ectosomal and gastral spicules, although microscleres are missing, as it is usually in the fossil record. Comparison of both, Recent and fossil forms, has shown that due to the differences in their spiculation they represent different species, but these differences are so small that attribution of Recent and fossil forms to the genus *Laocoetis* is entirely substantiated. This shows that we are dealing with a sponge genus that has stratigraphical range of at least 150 Ma, and thus we can speak in this case about a real living fossil.

EVIDENCE OF EXTREME EVENTS (TSUNAMI?) IN THE CHILCATAY FORMATION, PISCO BASIN, PERU

Orlando Poma[1] and Raúl Esperante[2]

1. Center of Resources Geoscience Union Peruvian University, Lima, Peru. opoma@upeu.edu.pe
2. Geoscience Research Institute, Loma Linda, CA, USA.

The Pisco Basin in southern Peru contains a thick sequence of Cenozoic sediments that record at least three marine transgressions characterized by successions of fine sandstones, siltstones, and diatomaceous mudstones, with minor interbedded layers of fine conglomerates, carbonates and phosphate nodules. The sedimentary sequences of the three transgressions correspond, from bottom to top, with the Paracas, Otuma, Chilcatay and Pisco formations. The sequence records certain facies that are typical of high-energy events, including extreme storms, tsunamis and earthquakes. One of those units is located in the Chilcatay Formation (Oligocene to middle Miocene) south of the town of Ocucaje, Peru. The studied deposit is characterized by the presence of two layers of varying thickness. The lower layer, which is in markedly erosive contact with the underlying layer, is a very coarse-grained sandstone, highly sorted and with subrounded to subangular grains. The thickness varies laterally from one to 50 cm. The top layer, which is 40-60 cm thick and exposed for approximately 200 m, consists of a dense matrix of coarse-grained size fragments of molluscs (oysters), barnacles, and lithoclasts. The biogenic matrix contains many igneous (gabbro, granite) and metamorphic cobbles and boulders, and lithic tuffs, clusters of barnacles, and fragments consisting of vermetid gastropods reefs. The abundant igneous and metamorphic cobbles and boulders are rounded and subrounded, with a larger diameter between 3 and 140 cm, and occurring at a density of 3-8 clasts by square meter. The lithic tuffs are subrounded, have an ovoid morphology and a greater diameter between 1 and 44 cm. The vermetid gastropod reefs are 10-25 cm in their larger diameter. All these clasts occur scattered and 'floating' in the bioclastic matrix, randomly oriented and without overlapping. This deposit is underlain by a layer of fine sandstone with abundant barnacle clusters, oysters, vermetid gastropod reefs, and marine mammal skeletons. The characteristics of the studied layer suggest that it was deposited by an extreme event that eroded the area between shoreface and backshore redepositing the materials and leaving a chaotic facies distribution with cobbles and boulders of different lithology. The large waves caused heavy erosion of the sediments in the shallow seafloor and the basement, mixing the biogenic and lithogenic clasts. The large size of these clasts suggests that such an event may have been a tsunami.

EARLY MIDDLE CAMBRIAN TRILOBITES FROM LA LAJA FORMATION, CERRO EL MOLLE, PRECORDILLERA OF WESTERN ARGENTINA

Brian R. Pratt[1] and Osvaldo L. Bordonaro[2]

1. Department of Geological Sciences, University of Saskatchewan, Saskatoon, SK S7N 5E2, Canada. brian.pratt@usask.ca

2. IANIGLA–CONICET, Centro Científico Tecnológico, c.c. 131, 5500 Mendoza, Argentina.

A tectonically nearly undeformed section of the lower part of La Laja Formation is exposed at Cerro El Molle near San Juan, in the Precordillera of western Argentina. It consists of shallow-water, variably argillaceous lime mudstone and sporadically interbedded bioclastic grainstone deposited in an inner shelf setting. El Estero Member and the basal 0.2 m of the Soldano Member contain a trilobite fauna of olenelloids and 'simple' ptychoparioids indicative of the early Cambrian (series 2, stage 4; Dyeran stage of Laurentia). The succeeding 50 m of the lower Soldano Member yield trilobites characteristic of the early middle Cambrian (series 3, stage 5; Delamaran stage of Laurentia). In ascending order of occurrence, *Amecephalus arrojosensis*, *Kochiella maxeyi* and *Eokochaspis nodosa*, along with several other taxa, belong to the traditional lower *Plagiura–Poliella* Biozone. However, while this fauna is similar in composition to that of the Great Basin of western USA, the nominative species of the *Eokochaspsis nodosa* Biozone and overlying *Amecephalus arrojosensis* Biozone erected in southern Nevada occur in reverse order in the Soldano Member. This suggests that the ranges of these species overlap, thereby reducing the temporal resolution in the Precordillera. Argillaceous lime mudstones at the top yield *Mexicella mexicana*, indicative of the *Mexicella mexicana* Biozone recognized in the Great Basin, which is equivalent to the traditional *Albertella* Biozone of Laurentia. The fauna is entirely Laurentian in composition, reinforcing notions of a close proximity of Cuyania to Laurentia during the Cambrian that enabled faunal interchange. The apparent absence of a distinct late early Cambrian to early middle Cambrian hiatus correlative with the Hawke Bay Event, however, suggests no close affinity to the Iapetus-facing margin of eastern Laurentia.

FOSSIL WOODS FROM THE PALAEOCENE OF WESTERN ANTARCTICA (CROSS VALLEY FORMATION): A CONIFER-DOMINATED FOREST WITH ABUNDANCE OF ARAUCARIACEAE

Roberto R. Pujana[1], Sergio A. Marenssi[2] and Sergio N. Santillana[3]

1. CONICET-Museo Argentino de Ciencias Naturales, 470 Ángel Gallardo, Buenos Aires, 1405, Argentina. rpujana@macn.gov.ar

2. CONICET-Departamento de Geología, FCEyN UBA, Intendente Güiraldes 2160, Buenos Aires, 1428, Argentina.

3. Instituto Antártico Argentino, Balcarce 290, Buenos Aires, 1064, Argentina.

A collection of more than 50 fossil woods from the Cross Valley Formation was anatomically studied. This formation crops out in Seymour/Marambio Island, western Antarctica, and it was assigned to the late Palaeocene based on palynological studies. The fossils were analyzed by SEM and acetate peels, and studied using light microscopy. Most samples are permineralized (mostly carbonates), but others are charcoaled. Due to poor preservation in many of the samples only about half of the specimens could be reliable assigned to generic or specific level. Fossil woods were assigned to the conifer families Araucariaceae (*Agathoxylon*), Podocarpaceae (*Phyllocladoxylon* and *Protophyllocladoxylon*) and probably Cupressaceae (*Cupressinoxylon*). *Agathoxylon* is the most common wood, an infrequent feature for the fossil wood assemblages from the Cenozoic. Results are consistent with previous works based on fossil leaves from the same formation, where Araucariaceae and Podocarpaceae leaves were described. Despite angiosperms are apparently common, based on the occurrences of fossil leaves, they are absent in the studied fossil wood collection. Taphonomical processes, angiosperm habit (herbs or small shrubs) and low abundance of angiosperms could explain this discrepancy. Apparently, these conifer-dominated forests have developed under temperate climate (based on the taxonomic composition), acceptable conditions for growing (growth rings are sometimes wide), and under marked seasonality (growth rings are well marked).

A STRANGE NOTHROTHERIID GROUND SLOTH (XENARTHRA, MEGATHERIOIDEA) FROM POMATA-AYTE (MIOCENE-PLIOCENE TRANSITION, BOLIVIA)

François Pujos[1,2], Gerardo De Iuliis[3,4], Sylvain Adnet[5], Ruben Andrade Flores[6], Guillaume Billet[7], Bernardino Mamani Quispe[6], Laurent Marivaux[5], Mercedes B. Prámparo[1] and Pierre-Olivier Antoine[5]

1. IANIGLA, CCT–CONICET–Mendoza, Avda. Ruiz Leal s/n, Parque Gral. San Martín, 5500 Mendoza, Argentina. fpujos@mendoza-conicet.gov.ar

2. IFEA, UMIFRE 17 MAEDI/CNRS USR 3337 - America Latina, Lima 18, Peru.

3. Dept. of Ecology and Evolutionary Biology, Univ. of Toronto, Toronto, M5S 3G5, Canada.

4. Dept. of Palaeobiology, ROM, Toronto, M5S 2C6, Canada.

5. ISE-M, UMR-CNRS 5554, IRD, Univ. Montpellier 2, 34095 Montpellier, France.

6. Dept. de Paleontología, MNHN, Cota Cota, La Paz, Bolivia.

7. CR2P, MNHN, Univ. Paris 6, CNRS-UMR 7207, Paris, France.

The locality of Pomata-Ayte (Oruro department) was first reported by Hoffstetter and colleagues at the end of the 1970s and partially exploited by St-André in the 1990s. New collects have allowed recovering a diverse mammalian assemblage dated between 5.97 ± 0.4 My and 5.42 ± 0.6 My (Montehermosan SALMA, Mio-Pliocene transition). Among the taxa are two native ungulates, the litoptern *Macrauchenia* sp. and the toxodontid *Posnanskytherium* cf. *viscachanense*, a caviomorph rodent, a large phorusrhacoid bird, and six xenarthrans, including three armored cingulates (the pampatheriine *Plaina* sp., a glyptodontid, and a dasypodid) and three ground sloths (the mylodontid *Simomylodon uccasamamensis*, the large megatheriid *Megatherium* (*Megatherium*) *altiplanicum*, and a small nothrotheriid). In the Pomata-Ayte section, this Montehermosan fauna is intercalated between a new early late Miocene fauna with numerous mesotheriid notoungulates and caviomorph rodents (K/Ar dating in progress) and a Late Pleistocene fauna (?Lujanian SALMA) with *Macrauchenia patachonica*, a gomphotheriid, a machairodontine felid, *Megatherium* sp., and *Glyptodon* sp. One of the most interesting Montehermosan mammals is the new nothrotheriid. This small to medium-sized sloth is represented by a complete mandible and several postcranials including humeri of three distinct individuals. Mandibular dentition is strongly hypsodont (Hypsodonty Index= 1.14). It has a small tricuspid caniniform (a character unique among sloths) and three molariforms quadrate and mesiodistally compressed with two transverse lophids (as in megatheriines). There is neither diastema nor apicobasal sulci on m1-m2 (although present on m3). The humerus is quite robust, with an entepicondylar foramen, and a rather massive deltopectoral shelf. The ulna is rectilinear in anterior view and the proximal articular facets differ markedly from those of other nothrotheriids. The calcaneus is massive and comparable in shape to that of *Planops* and *Thalassocnus*. A morphology-based phylogenetic analysis suggests that within the Nothrotheriidae clade, this new taxon is a stem Nothrotheriini, being more advanced over *Pronothrotherium* and *Mionothropus* from the late Miocene of Patagonia and Amazonia.

STANDING ON THE SHOULDER OF NEANDERTHALS: ANALYZING SCAPULAR FORM AND FUNCTION USING FINITE ELEMENT ANALYSIS AND GEOMETRIC MORPHOMETRICS

Thomas A. Püschel[1] and William I. Sellers[1]

1. Faculty of Life Sciences, University of Manchester, Michael Smith Building, Oxford Road, Manchester, M13 9PT, UK.
thomas.puschel@postgrad.manchester.ac.uk

Any behavior extrapolated from skeletal morphology relies on the principle that bone is functionally adapted to its mechanical environment during life. Interestingly, traditional morphometric analyses have shown that the primate scapula mostly reflects functional demands. Neanderthals were a species of the genus *Homo*, closely related to modern humans that became extinct in the late Pleistocene. Based on their shoulder morphology, different and sometimes contradictory behavioral reconstructions have been suggested: a) that they may have hunted by leaping onto their prey; b) that they were not able to throw; c) that they were strong spear "thrusters" and/or d) that they were involved in habitual scraping tasks. However, most of the studies regarding the Neanderthal shoulder function have been mostly restricted to merely morphological comparisons, and infrequently aim to elucidate function from a proper biomechanical perspective. Hence, the goal of the present study was to analyze the Neanderthal scapular form and function by comparing its mechanical performance and shape against a sample of extant hominoids. A series of scapulae CT-scans of all the extant hominoid species and one macaque as out-group were segmented by applying a combination of case-specific thresholding and manual segmentation. One Neanderthal scapula was reconstructed by applying a combination anatomical reconstruction based on fragmented available specimens and morphing from a robust modern human scapula. Then 3D surfaces were generated and each dataset was converted into a finite element mesh to perform a FEA by simulating different loading scenarios. Strain values were extracted at 17 standard anatomical locations and the results were compared using a MANOVA and a pairwise Hotelling's T-squared test with Bonferroni corrections. Furthermore, 17 3D homologous landmarks were collected on the scapular surface at same anatomical locations where the strain values were extracted. A generalized Procrustes analysis was applied to extract the shape variables from the raw landmark data and a principal component analysis of the Procrustes coordinates was applied in order to visualize the scapular shape variation. Finally a PLS analysis of the shape coordinates and strain values matrices was performed in order to understand the covariation pattern between scapular form and function. These results contribute to get a better insight when assessing Neanderthal behavior from scapular morphology by analyzing its mechanical performance and shape against a comparative sample of closely related species.

ORIGIN AND BIOGEOGRAPHY OF SUBGENUS *PODOCARPUS*

María Paula Quiroga[1], Paula Mathiasen[1], Andrea Premoli[1] and Ari Iglesias[1]

1. Laboratorio Ecotono. Instituto de Biodiversidad y Medio Ambiente
CRUB-INIBIOMA-CONICET, Bariloche, Rio Negro, Argentina.
emepequ@gmail.com

The genus *Podocarpus* has a widespread distribution and provides the opportunity to contrast hypotheses of long-distance dispersal and vicariance in the Southern Hemisphere. These have been traditionally tested among different land masses using, for example, genera of austral origin as *Nothofagus*. Given that *Podocarpus* reaches tropical latitudes, it offers the chance to analyze divergence between disjunct forests within all South America and even more, within continents. The genus *Podocarpus* consists of two subgenera, *Foliolatus* found in Asia and Oceania, and *Podocarpus* present in Australia, Africa, New Zealand, New Caledonia, Madagascar, and tropical and temperate South America. We hereby calibrated the phylogeny of genus *Podocarpus*, using Bayesian analysis, including novel DNA sequences and fossil records to unravel the biogeographical history within subgenus *Podocarpus*. Sequences of the chloroplast (rbcL and matK) and two regions of the nuclear (ITS 1 and 2) were obtained by standard sequencing methods. The outgroup consisted of one species of *Araucaria* and also one species for each genus of the Podocarpaceae family. Our results suggest that subgenus *Podocarpus* is organized into two well supported and geographically differentiated clades. One includes Austral species, including those from southern South America, Australia, New Zealand, and New Caledonia. A second clade is composed of two subclades, including species of tropical and subtropical distribution in the Americas and Africa. Surprisingly, our data strongly suggest that those species distributed in subtropical South America are closed affiliated to African species, remaining far differentiated from other monophyletic tropical clade integrated by northern South America and the Caribbean. The molecular dating suggests a minimal age of 87 My for the origin of the genus *Podocarpus*, 30 My older than previously estimated minimal origin. The analysis suggesting disjunctions among southern continent clades are the result of vicariance events due to continental drifting. Disjunctions within South America are associated with vicariance after specifically geographic and climatic episodes happened in Paleogene and Neogene times. The differentiation between tropical-subtropical and southern South American species is probably associated with the presence of an extended and persistent arid barrier that impeded the migration between areas since the Paleogene. [Contribution to BID PICT2010 Nº430].

BRACHIOPOD SHELL-ENCRUSTING COMMUNITIES ACROSS THE UPPER FRASNIAN - LOWER FAMENNIAN INTERVAL IN THE CENTRAL DEVONIAN FIELD, RUSSIA

Michał Rakociński[1], Michał Zatoń[1], Paweł Filipiak[1], Tomasz Borszcz[2], Wojciech Krawczyński[1], Andrey V. Zhuravlev[3] and Elena V. Sokiran[4]

1. University of Silesia, Faculty of Earth Sciences, Będzińska 60, PL-41-200 Sosnowiec, Poland. mrakocin@us.edu.pl

2. Marine Ecology Department, Institute of Oceanology, Polish Academy of Sciences, Powstańców Warszawy 55, PL-81-712 Sopot, Poland.

3. POLARGEO INC., 3-7 24th-Line, St. Petersburg 199106, Russia.

4. All Russia Petroleum Research Exploration Institute, 39 Liteyny Pr., St. Petersburg 191014, Russia.

The majority of studies of hard substrate communities in the Central Devonian Field, Russia, concerned microconchids and associated encrusters present on limited number of early Famennian brachiopods and carbonate cobbles. The aim of the present study was a quantitative comparison of encrusting communities colonizing a wide spectrum of a large number of brachiopod shells derived from the upper Frasnian (Evlanovo Horizon - upper *rhenana* conodont zone at Khlevnoe village) and lower Famennian (Zadonsk Horizon - *crepida* conodont zone and Elets horizon - *rhomboidea* conodont zone at Kamenka village). The shells were randomly collected in particular horizons. The upper Frasnian epibiont assemblage is most diverse and mainly consists of microconchids (42%), foraminifera (31%), and less numerous hederelloids (7%), cornulitids (6%), *Sphenothallus* (5%), enigmatic *Ascodictyon* (4%), productid brachiopods (2%), auloporids (1%), rugosan corals and bryozoans (both 1%) and algae (1%). Hard substrate communities from the lower Famennian Zadonsk Horizon are characterized by their lower diversity. Auloporids, rugose corals, encrusting algae and foraminifera are absent. Microconchids dominate (48%) and numerically outnumber the remaining organisms. The other encrusters present in significant number are cornulitids (21%), trepostome bryozoans (19%) and less numerous hederelloids (8%). The remaining epibionts: *Ascodictyon* (2%), *Sphenothallus* (1%) and productids (1%) are represented as single specimens only. The most impoverished assemblages were observed in the lower Famennian Elets Horizon at Kamenka, where encrusting organisms are clearly dominated by microconchids (60%). Other sclerobionts are represented by less numerous bryozoans (20%) and cornulitids (17%), as well as rare *Sphenothallus* (3%). However, a single sample coming from this horizon is small, thus a real diversity pool and taxonomic composition of encrusters may be underestimated. In comparison to the upper Frasnian, such a dominance of microconchids in the lower Famennian is not random. It is also confirmed by their strong domination on lower Famennian carbonate cobbles from shallower environments as evidenced by moderate correlation of abundance and diversity due to low evenness. A great abundance of microconchids, and simultaneous much lower numbers of other encrusters, is interpreted as a result of opportunistic strategy of these tubeworms. They rapidly colonized and quickly dominated the vacated ecospace following environmental perturbations in the aftermath of the Frasnian-Famennian event, here linked with the marine regression that took place in the Central Devonian Field area. [Supported by the NCN grant no. 2011/01/B/ST10/00576 (MZ) and START scholarship by Foundation for Polish Science (TB)].

A NEW SPECIES OF *CERDOCYON* (CARNIVORA, CANIDAE) FROM THE LUJANIAN OF BUENOS AIRES (ARGENTINA)

Mariano A. Ramírez[1]

1. División Mastozoología, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia",
Av. Angel Gallardo 470, CABA, C1405DJR, Argentina.
ma_ramirezchicco@macn.gov.ar

Cerdocyon Hamilton-Smith is a monospecific genus that in the present inhabits from Colombia and Venezuela to the Parana's delta of the Buenos Aires Province in Argentina. Its fossil record is restricted to the Lujanian of Minas Gerais, Brazil, and some mentions in archeological sites from Rio Grande do Sul in Brazil. In the present contribution a specimen from the Lujanian of the Frías stream in the locality of Mercedes in the NE of Buenos Aires Province is described. The specimen (MCA 1094) shares some characters with the living species *Cerdocyon thous* Hamilton-Smith like a short snout, small canines, a small P4, a well developed subangular lobe of the mandible and a dorsoventrally expanded pterygoid fossa of the angular process of the mandible. Some features of this specimen are different from *Cerdocyon thous,* for example the zygomatic arch is strongly curved in lateral view and not flat as in *Cerdocyon thous*. Another difference is the slope of the frontal region of MCA 1094 which is strongly pronounced in contrast with the frontal region of *Cerdocyon thous* which is slightly pronounced. To test the differences in the shape of the skull in lateral view a geometric morphometry analysis was performed including the MCA 1094 and specimens from the living species *Cerdocyon thous*, using a set of 25 landmarks, performing a procrustes analysis to superimpose the landmark configurations and then a PCA with the specimen aligned. The results of this analysis show differences between the slope of the frontal region of MCA 1094 and the specimens of *Cerdocyon thous*. The phylogenetic relationships of the fossil specimen were tested in a cladistic analysis using the software TNT resulting in one tree of 3788,084 steps. The results of this analysis show that MCA 1094 forms a moderately supported clade (37% GC values, after 1000 replicates of symmetrical resampling (p=33)) with *Cerdocyon thous* with the following synapomorphies: a scarcely developed external auditive meatum, a well developed subangular lobe of the mandible, a quadrangular angular process of the mandible, and a high mandibular condyle that reaches the tip of the trigonid of the m1. These results suggest that the specimen represents a new species of *Cerdocyon*. MCA 1094 also represents the first fossil record of *Cerdocyon* from Argentina and the southernmost record of the genus.

DIVERSITY PATTERNS REVEAL VARYING EVOLUTIONARY DYNAMICS WITHIN JAWLESS VERTEBRATES

Emma Randle [1] and Robert Sansom [1]

1. University of Manchester, Faculty of Life Sciences, Michael Smith Building, Dover Street, Manchester, M13 9PT, United Kingdom. Emma.randle@postgrad.manchester.ac.uk

Fossil jawless fish play a key role in our understanding of vertebrate origins and evolution. Comprising a large proportion of the gnathostome (jawed vertebrate) stem, ostracoderms (armoured jawless vertebrates) first appear in the fossil record during the Ordovician, followed by a very limited fossil record until the late Silurian. For instance, a large gap exists between Ordovician pteraspidimorphs (arandaspids, *Astraspis* and *Eriptychius*) and late Silurian pteraspidimorphs (heterostracans). Most ostracoderm groups appear to originate in the Wenlock exhibiting high initial diversity, with analysis of environmental and geological biases revealing missing evolutionary histories in some ostracoderms groups *i.e.* osteostracans and galaeaspids. An extensive compilation and analysis of heterostracan occurrence data reveals the evolutionary dynamics of the Heterostraci. They are found to exhibit low diversity in the Silurian and reach maximal diversity in the Early Devonian, after which levels begins to drop until their eventual extinction at the Frasnian/Famennian boundary. Unlike ostracoderms more closely related to gnathostomes, generic diversity of heterostracans is not significantly linked to the number of heterostracan bearing horizons, nor are the number of horizons correlated with local sea levels. Heterostracan species diversity shows different patterns. Use of confidence intervals to assess likely origination dates for Heterostraci finds a much more recent origin (Wenlock) compared to more derived ostracoderms (Llandovery or even Ordovician when accounting for sea-level change). These results indicate that different evolutionary dynamics and geological patterns occurred within different clades of jawless vertebrates and that universal models of diversity cannot be applied to these stem-lineages.

CRANIOMANDIBULAR ONTOGENY IN NONAVIAN DINOSAURS: INSIGHTS FROM *MAJUNGASAURUS CRENATISSIMUS*

Nirina O. Ratsimbaholison[1], Ryan N. Felice[2] and Patrick M. O'Connor[3]

1. Department of Paleontology Anthropology Biological, Antananarivo University, Antananarivo 101, Madagascar. ratsimbano@gmail.com

2. Department of Biological Sciences, Irvine Hall, Ohio University, Athens, 45701 USA.

3. Ohio Center for Ecology and Evolutionary Studies, Irvine Hall, Ohio University, Athens, 45701, USA.

Abelisauroid dinosaurs are among the most diverse clade of nonavian theropods from Gondwanan landmasses during the Cretaceous, yet much of our knowledge of the group is based on singleton discoveries for many of the named taxa. Moreover, one of the subclades (Abelisauridae) is characterized by high, short, and broad skulls and a robust cervical skeleton, both of which deviate from typical nonavian theropods body plans. Given that most abelisaurids are established on individual specimens, our knowledge of the ontogenetic development of abelisaurid skull form is virtually nonexistent. Recent field discoveries of multiple partial-to-complete skulls of *Majungasaurus crenatissimus* that span a large size range allow for an unprecedented examination of cranial ontogeny in this species. We used two-dimensional geometric morphometrics to evaluate ontogenetic changes in associated or articulated skulls, representing a partial growth series, in order to assess patterns of shape change in cranial morphology through ontogeny. Ontogenetic shape change in different cranial elements contributes to overall cranial shape in *Majungasaurus crenatissimus*. Three major regions of shape change were identified over the size range examined, including: an increase in both the dorsoventral dimension of the lacrimal process of the jugal and anteroposterior length of the anterior region of the jugal, a decreases in orbit size, and an increase in the dorsoventral dimension of the posterior half of the skull through changes in the postorbital, quadrate, and quadratojugal. These preliminary results indicate that the adult (*i.e.*, near full size) cranial shape in *Majungasaurus crenatissimus* results from modifications of skull shape over the life of an individual, suggesting that other attributes (e.g., craniomandibular biomechanics; feeding behavior) probably shifted though ontogeny as well. For example, the differential increase in the dorsoventral dimension of the quadrate, and by extension the adductor chamber, likely resulted in an increase in fiber length of the adductor musculature through ontogeny. Using extant model systems to inform these inferences, inferred increases in fiber length would have allowed for larger gapes in adult forms of *Majungasaurus*. These findings suggest that juvenile and adult *Majungasaurus* individuals likely exploited different feeding niches and utilized different food items, similar to what has been previously proposed for other theropods based on other anatomical observations. Ongoing work seeks to characterize ontogenetic trends in individual cranial elements in other (*i.e.*, non-abelisauroid) nonavian theropods to elucidate common areas for differential skull growth through ontogeny.

POSSIBLE DISCOIDAL FOSSILS IN NEOPROTEROZOIC ROCKS OF THE BAMBUÍ GROUP, BAHIA, BRAZIL

Carolina Reis[1], Juliana de Moraes Leme[2], Marly Babinski[2], Bruno B. Kerber[3] and M. Liza Alves Forancelli Pacheco[4]

1. CPRM- Serviço Geológico do Brasil - Sureg-SA, Av. Ulysses Guimarães, 2862, Salvador, 41213-000, Brazil. carolina@cprm.gov.br

2. Instituto de Geociências, Universidade de São Paulo, Rua do Lago, 562, São Paulo, 05508-080, Brazil.

3. Programa de Pós-Graduação em Geoquímica e Geotectônica, Instituto de Geociências, Universidade de São Paulo, Rua do Lago, 562, São Paulo, 05508-080, Brazil.

4. Departamento de Biologia, Universidade Federal de São Carlos, Rodovia João Leme dos Santos (SP-264), Km 110, Bairro do Itinga, Sorocaba, 18052-780, Brazil.

The Neoproterozoic is marked by the emergence of megascopic organisms in the fossil record mostly represented by the Ediacara biota. Along that time algae, animals and many soft-bodied macroscopic beings with uncertain taxonomic affinities that represented the first evolutionary, and ecological, constituents of the Ediacara biota arose. Among the oldest *insetae sedis* macroorganisms are the discoidal forms, originally described as cnidarians jellyfishes. However, according to recent interpretations, they might be microbial colonies, marine fungus or anchoring structures of big sessile organisms such as *Charniodiscus*. In Brazil, some possible discoid forms, 15 and 40 mm in diameter, assigned to *Cyclomedusa* and *Charniodiscus*, have been described in the Itajaí Basin, Santa Catarina. Also in Brazil, much bigger and impressive possible discoidal fossils were found in carbonates of the Sete Lagoas Formation – SLF (740-550 Ma), Bambuí Group, Bahia. The carbonate-pelitic sediments of the Bambuí Group were deposited in a foreland basin. The SLF comprises carbonatic rocks, making up 7 facies associations that represent different sedimentary environments on a carbonate ramp. An outer ramp and a cap carbonate characterize the base of the unit, the top represents an inner ramp and/or an intermediate ramp. The possible discoidal fossil here reported is 24.5 cm in diameter and was recovered from the facies association corresponding to the intermediate ramp, in the middle/upper SLF. It includes a smooth central disc (ca 21 cm in diameter) separated by a groove from a radially-ornamented outer annulus that displays a thin edge. Similar structures were described in the Booley Bay Formation, Ireland, and interpreted, based on size and morphology, as an Ediacaran-type fossil. Our discoidal forms can also be interpreted as microbial originated gas domes, discoidal microbial colonies or inorganic in origin. If our discoidal structures are proven to be biogenic, and considering that discs and others fossils of the soft-bodied macroscopic Ediacara biota are mostly found in clastic sediments, they constitute the second occurrence of these forms in carbonates, and are of great importance to understand the morphological variety of the fossils under different environmental conditions. In conclusion, our morphological approach indicates an organic origin to the SLF discoidal forms, however, other analyzes such as thin sections, and high resolution microstructure and chemical composition by SEM or Raman Spectroscopy, should be performed for a more detailed interpretation.

FOSSIL EGGS FROM THE BRAZILIAN CRETACEOUS BASINS

Victor Reis[1], Antonio Fernandes[2] and Ismar Carvalho[1]

1. Universidade Federal do Rio de Janeiro, Departamento de Geologia, CCMN/IGEO, Cidade Universitária-Ilha do Fundão, 21941-916. Rio de Janeiro-RJ, Brazil. victormazzoleni@yahoo.com.br

2. Universidade Federal do Rio de Janeiro, Museu Nacional, Departamento de Geologia e Paleontologia, Quinta da Boa Vista, São Cristóvão, 20940-040, Rio de Janeiro, RJ, Brazil.

Vertebrate fossil eggs and eggshell fragments have been studied in Brazil since the 1950s, from the finding of a dinosaur egg in the Bauru Basin (Marília Formation, Late Cretaceous), which contributed to the advance of paleo-oology in the Brazilian territory. Later in this basin, some eggs and eggshells were also found in the Adamantina Formation. These fossils are generally attributed to dinosaurs, crocodiles and turtles. The materials found in Marília Formation comprehend besides eggs, the geometry of nidification. In the Adamantina Formation there are chelonian, crocodyliforms and avian eggs. The probable chelonian egg is related to the genus *Podocnemis*; the avian egg is similar to those of the genus *Enantiornithes*, and the crocodyliform eggs are attributed to *Campinasuchus dinisi*, *Mariliasuchus amarali* and *Pissarrachampsa sera*. The eggs and eggshell fragments are generally found in deposits of a braided fluvial context. In Lower Cretaceous rocks from Itapecuru Formation (Parnaíba Basin) and Santana Formation (Araripe Basin) other eggshell remains occur. In the Itapecuru Formation (Parnaíba Basin, Albian), some dinosaur eggshells have been identified in a floodplain context. In the Santana Formation (Crato Member, Araripe Basin, Aptian), a well-preserved crocodyliform egg was found in a context of evaporitic lacustrine systems. Although difficult to be preserved due to their fragility, and therefore rare to be found, the fossil eggs provide important data about the diagenetic processes of the fossildiagenesis, paleoclimate, breeding behavior, geochemical and nidification conditions. The egg size reflects the limits imposed by the weight and the breathing necessities of the embryo. Regarding the external morphology, the eggshell is not completely smooth, but constituted by various pores which allow gases (oxygen, carbon dioxide and water vapor) to be exchanged between the embryo and the outer environment, providing characteristics about climate and nesting behavior. The present work, therefore, aims to recognize and characterize the main researches related to the study of fossil eggs and eggshell fragments in Brazil, indicating their morphological and compositional features, and their respective contributions to the paleoenvironmental reconstruction. [Supported by CNPq and FAPERJ].

THE PALEOENTOMOLOGICAL POTENTIAL OF CAMPÁLEO FOSSIL LAGERSTÄTTE

João H. Zahdi Ricetti[1,4], Roberto Iannuzzi[2], Luiz C. Weinschütz[1], Karen Adami[3] and Everton Wilner[1,4]

1. Universidade do Contestado (UnC), Centro Paleontológico (CENPALEO), Av. Pres. Nereu Ramos, 1071, Mafra, 89300-000, Brazil. luizw@unc.br

2. Universidade Federal do Rio Grande do Sul (UFRGS), Depto. de Paleontologia e Estratigrafia (DPE), Instituto de Geociências (IGeo), Porto Alegre, 91.509-900, Brazil.

3. Universidade Federal de Pelotas (UFPel), Núcleo de Estudos em Paleontologia e Estratigrafia (NEPALE) - Centro de Desenvolvimento Tecnológico (CDTec), Praça Domingos Rodrigues, 02, 96010-440, Pelotas, Brazil.

4. Universidade Federal do Rio Grande do Sul (UFRGS), Programa de Pós-Graduação em Geociências (PPGGeo), Av. Bento Gonçalves, 9500, Porto Alegre, P. Box 15001, 91501-970, Brazil.

The base of the Lontras Shale was designed as the Carboniferous-Permian boundary within the upper Itararé Group of the Paraná Basin. This group is known by its glacial depositional context, represented by a succession of diamictites, turbidites and varves with the presence of dropstones, intercalated with three intervals of mud-siltic rocks, rich in fossils, deposited during transgressive intervals, when life bloomed. In the city of Mafra, northern Santa Catarina State, the succession of the Itararé Group is cropping out, making noticeable a layer of fine siltstone inserted in the Lontras Shale. This site is commonly called as "Campáleo", in reference of the maintaining institution of the area, the CENPALEO – Paleontological Center – of the University of Contestado (UnC). During the last decades the excavation of this outcrop has been constant and the paleodiversity recorded in the thin layer of 1.1 m of black siltic-argilite has been increasing in every excavation. The fossils in the CENPALEO's collection, under study by professionals from the UnC and also by several Brazilian and foreign partners, include bony and cartilaginous fishes, gastropods, brachiopods, insects, crustaceans, poriferans, conodonts, scolecodonts and other microfossils, and plant remains among others fossils. The presence of such abundant fauna and flora, with levels with exceptional preservation, made the researchers refer to the Campáleo outcrop as one Carboniferous-Permian Fossil Lagerstätte. Amongst this fossil variability, the insect paleofauna is especially interesting. The species *Anthracoblattina mendesi* Pinto and Sedor, described from this outcrop, is the first Gondwana Anthracoblattina, and may represent one important tool for long-distance geological correlations. There are found, in exception of Blattida, other unpublished specimens of six Insecta orders, as follows: Mecoptera, Diaphanopteroidea, Orthoptera, Hemiptera, Grylloblattida and Eoblattida. Those insects are now under taxonomical study, and the taphonomic analysis already performed shows that the insects have a relation between the size and the preservation form. The basal layers yielded the biggest complete insects, rarely disarticulated, preserved as a thin green pyrite impression. Moving upwards, the insects are rarer and with smaller sizes, there are wings fragments in concretions, and wings and articulated insects preserved in 3D from pyrite and calcium phosphate substitutions. The pursuance of insect investigations will bring more elements to increase our understanding on the Permian deglaciation in Western Gondwana, aiming to the establishment of biozones and a better comprehension on paleoenvironments and paleobiogeography.

CONNECTING THE LATITUDINAL GRADIENT OF DRILLING PREDATION AND SPECIES RICHNESS IN MOLLUSKS ASSEMBLAGES ALONG THE TEMPERATE EAST COAST OF SOUTH AMERICA AND ANTARCTIC PENINSULA

Marcelo M. Rivadeneira[1], Sandra Gordillo[2] and Melisa P. Charó[3]

1. Laboratorio de Paleobiología, Centro de Estudios Avanzados en Zonas Áridas (CEAZA) and Universidad Católica del Norte, Avenida Ossandón 877, Coquimbo, 1781421, Chile. marcelo.rivadeneira@ceaza.cl

2. Centro de investigaciones en Ciencias de la Tierra (CICTERRA, CONICET-UNC), Córdoba, Argentina.

3. Servicio de Hidrografía Naval, Buenos Aires, Argentina.

The analysis of patterns and processes of drilling predation provides a powerful tool to reconstruct the variability of species interactions across geographic and evolutionary time-scales. However, efforts aimed at describing the variation in drilling predation across large latitudinal gradients are still scant. Moreover, its connections with the well-known latitudinal gradient of species richness phenomenon have been little explored. Here we evaluate the existence of a latitudinal gradient of drilling predation and its connection with species richness patterns, synthesizing information gathered over a decade of studies carried out on different mollusk assemblages (bivalves and gastropods), in 62 localities of the Southwestern Atlantic, from Buenos Aires Province to Antarctic Peninsula, spanning over 30 degrees of latitude. The analysis of more than 16,000 shells reveals that the percentage of drilled species decline monotonically towards higher latitudes, from up 50% around Buenos Aires to less than 20% in Antarctica. In contrast, the percentage of drilled individuals showed a non-linear trend, characterized by an abrupt peak of *ca.* 40% at Tierra del Fuego in the southern tip of the continent. These patterns can be linked to the patterns of latitudinal gradient of species richness of bivalves and gastropods observed along the study region. Whereas the fraction of drilled species is more related to the species richness of bivalves (which follow the canonical decline towards higher latitudes), the percentage of drilled individuals is associated with the species richness of gastropods (particularly muricids, but not naticids) characterized by a non-linear latitudinal trend with a large peak of richness at Tierra del Fuego. This suggests that the intensity of predation is related to the availability of both predator and prey species. Whether predation intensity is a cause or consequence of the latitudinal gradient of species richness remains an open question. [PIP-CONICET-114-200801-00260 and PIP-CONICET-114-201101-00238 (to SG), and FONDECYT 1140841 (to MMR)].

SPHENOPHYTE DISTRIBUTION DURING THE PERMIAN IN GONDWANA

Guilherme A. Roesler[1] and Roberto Iannuzzi[2]

1. Universidade Federal do Rio Grande do Sul. Instituto de Geociências, Departamento de Paleontologia e Estratigrafia. Av. Bento Gonçalves, 9500, Porto Alegre, 91.501-970, Brazil.
guilherme.paleonto@gmail.com

2. Universidade Federal do Rio Grande do Sul. Instituto de Geociências, Departamento de Paleontologia e Estratigrafia. Av. Bento Gonçalves, 9500, Porto Alegre, 91.501-970, Brazil.

The Sphenophyta (Arthrophyta) has an extensive record during the Paleozoic, particularly in the Carboniferous of Euroamerica and Angaraland, and in the Permian of Gondwana, being together with the Lycophyta one of the major groups encountered in peat deposits. This group, which survived until the present day (although with only one genus), is usually divided in three orders: Calamitales, Equisetales and Sphenophyllales. The most distinctive characters of the group are: (1) the branching system organized in distinct nodes and internodes; (2) the internodal regions ornamented by ribs and furrows, as a result of its stele organization; (3) the leaves (mostly univeined) organized in whorls and sporangia inserted in sporangiophores (terminal modified axes). During the Permian, Equisetales and Sphenophyllales display a widespread distribution, occurring throughout Gondwana, however, the diversity of these groups can be considered extremely heterogeneous in relation to different regions. In Antarctica, for instance, sphenophytes are represented by a few genera (e.g., *Paracalamites*, *Phyllotheca*, *Umbellaphyllites* and *Schizoneura*) while in other continents, as in India, they exhibit a high diversity, accounting for about 15 genera, including distinct kinds of root-systems, stems, leaves and fructifications. Unfortunately, few contributions have made the partial compilation of the Sphenophyte fossil record during the Permian in Gondwana. The main goal of the present study is to collect all the available data about the Permian Sphenophyta from Gondwnana, and to organize the taxa by its stratigraphic range for every continent in order to recognize biogeographic patterns of distribution and discuss possible evolutionary consequences of the paleobiogeography of the group.

THE LATE PLEISTOCENE MOLLUSCAN ASSEMBLAGE OF LA CORONILLA (EASTERN URUGUAY): PALEOBIOGEOGRAPHY AND PALEOENVIRONMENTS

Alejandra Rojas[1], Fabrizio Scarabino[2,3], Juan Carlos Zaffaroni[3], Sergio Martínez[1] and Martín Ubilla[1]

1. Facultad de Ciencias, Iguá 4225, Montevideo, 11400, Uruguay. martinubilla@gmail.com

2. Dirección Nacional de Recursos Acuáticos, Constituyente 1497, Montevideo, 11200, Uruguay.

3. Museo Nacional de Historia Natural, 25 de Mayo 582, Montevideo, 11000, Uruguay.

Late Quaternary marine fossil assemblages are widespread around the world and many of them show in their faunal composition the effects of the climatic oscillations and sea level fluctuations that characterized this geological period. In Uruguay, late Quaternary deposits outcrop along a thin stripe parallel to the present coastline of the Rio de la Plata and the Atlantic coast, yielding an abundant molluscan content. Late Pleistocene deposits were at first identified by minimum radiocarbon ages and are only represented in three localities, meanwhile Holocene ones are more abundant and geographically widespread along the Uruguayan coast. The fossil assemblage studied crops out in the abrasion platform (normally covered by sand) of the La Coronilla beach in Rocha County (Atlantic coast of Uruguay). The deposit is composed by a greenish-gray sandy claystone, with well preserved fossils, including taxa with delicate shells, some of them in life position. In a recent sampling campaign with the outcrop fully exposed, 91 molluscan taxa were recorded (38 gastropods and 53 bivalves), becoming La Coronilla one of the richest Quaternary molluscan assemblages of Uruguay. For reference, a previous study only registered 22 molluscan taxa. About 32 % of the taxa represent new records for the Quaternary of Uruguay. They are *Anatina anatina*, *Atrina seminuda*, *Bittiolum varium*, *Cerithiopsis* aff. *C. fusiformis*, *Cyclinella tenuis*, *Ennucula uruguayensis*, *Ervilia concentrica*, *Fargoa bushiana*, *Gouldia cerina*, *Lucapinella henseli*, *Olivella defiorei*, *Paralectopecten bavayi*, *Pitar palmeri*, *Tellina aequistriata*, *T. angulosa*, *Turbonilla* aff. *T. farroupilha*, *T. abrupta*, *T. brasiliensis*, *T. deboeri*, *T. multicostata*, *Turbonilla* cf. *T. penistoni*, *T. turris*, along with species of the genus *Cardiomya*, *Gastrochaena*, *Kellia*, *Melanella*, *Musculus* and *Pandora,* as well as specimens assigned to the family Vitrinellidae. All recorded taxa are extant but not all of them live today along the Uruguayan coast, implying a recent northwards range retraction. Among others to be confirmed, the gastropods *B. varium*, *Bulla occidentalis*, *O. defiorei*, *T. brasiliensis*, *T. deboeri*, *T. penistoni, T. turris* and the bivalves *A. anatina, Anomalocardia brasiliana*, *C. tenuis*, *E. concentrica*, *G. cerina*, *Laevicardium* sp., *Nioche subrostrata*, *P. palmeri*, *Scapharca brasiliana*, *T. aequistriata* and *T. angulosa,* live northwards in Brazilian waters. Then, the La Coronilla fossil assemblage represents a highly diverse and biogeographically interesting molluscan fauna that indicates warmer conditions for the Uruguayan coast during the Late Pleistocene. [Contribution to PEDECIBA Biología].

TWO NEW MORPHOTYPES OF ANGIOSPERMS IN THE ANFITEATRO DE TICÓ FORMATION (MID APTIAN), SANTA CRUZ PROVINCE, ARGENTINA

Edgardo J. Romero[1] and Sergio Archangelsky[1]

1. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Angel Gallardo 470, Buenos Aires, 1405, Argentina.
ejromero@macn.gov.ar

Floodplain deposits of the Anfiteatro de Ticó Formation are rich in plant remains. Many species of gymnosperms and pteridophytes, and three morphotypes of medium size angiosperm leaves have already been described. We are reporting two new morphotypes of microphyll angiosperms. Morphotype AR1 has elliptic, symmetrical lamina, 3-4 cm long, wide convex base, entire margin, pinnate brochidodromous venation, 4-5 pairs of secondary veins, spacing irregularly, decreasing towards the base, emerging decurrently at about 45-60º and uniformly curving towards the apex. Third order veins random reticulate. Morphotype AT2 has ovate, symmetrical lamina, 3 cm long, with a large (6 mm) base, decurrent and narrow and straight apex. Entire margin, pinnate brochidodromous venation, with a weak and straight primary vein, and four pairs of secondaries, poorly differentiated from the primary and the tertiaries, increasing towards the base, decurrently emerging at about 40-50º. Secondaries dichotomize, and then run straight towards the margin, abruptly curving and making a fimbrial vein. Third and fourth order veins randomly reticulate. Both morphotypes are Rank I, which is related to early evolution of Angiosperms. Morphotype AT1 is similar to Morphotype 3, from Kachaike Formation (late Barremian to early Cenomanian) though they differ in lamina and secondary venation features. Morphotype AT2 is similar to one of the brochidodromous morphotypes from La Cantera Formation (late Aptian) though they are different in secondary and tertiary venation. The fossils here reported allow concluding that similar angiosperm morphotypes were present in Patagonia (Baqueró and Austral basins) and in San Luis during the Aptian and Albian.

RELATIONSHIP BETWEEN ANOXIC CONDITIONS AND SIZE IN *POSIDONOTIS* (BIVALVIA) FROM THE LOWER JURASSIC OF THE NEUQUÉN BASIN, ARGENTINA

Sonia Ros-Franch[1], Susana E. Damborenea[1], Aisha Al-Suwaidi[2], Stephen P. Hesselbo[3], Hugh C. Jenkyns[4], Miguel O. Manceñido[1] and Alberto C. Riccardi[1]

1. CONICET; Departamento Paleontología Invertebrados, Museo de Ciencias Naturales La Plata, UNLP, Paseo del Bosque S /N, 1900 La Plata, Argentina. soniaros@fcnym.unlp.edu.ar

2. Petroleum Geoscience Department, Petroleum Institute, PO Box 2533, Abu Dhabi, UAE.

3. Camborne School of Mines, University of Exeter, Treliever Road, Penryn, TR10 9FE, UK.

4. Department of Earth Sciences, University of Oxford, Parks Road, Oxford, OX1 3AN, UK.

The early Toarcian extinction event is frequently linked to the early Toarcian Oceanic Anoxic Event (T-OAE) and/or global warming. Recently, the sedimentary record of the Toarcian OAE was recognized in the Neuquén Basin, Argentina, confirming the event as a global phenomenon. The event was identified chemostratigraphically on the basis of a relative increase in marine organic carbon and a characteristic negative carbon-isotope excursion ($\delta^{13}C_{org}$) in bulk rock and fossil wood. High-resolution sampling and biostratigraphical work was carried out in the late Pliensbachian–early Toarcian interval in the Arroyo Lapa section, where benthonic species are scarce. We present size and abundance data from the Toarcian OAE interval in the Neuquén Basin for the dominant bivalve species, the paper clam *Posidonotis cancellata* (Leanza), and correlate these data with geochemical proxies (TOC and $\delta^{13}C_{org}$). The main results indicate that individual shell size (surface and length) shows a statistically significant increase over levels where $\delta^{13}C_{org}$ was decreasing. As has been suggested for other species in similar conditions, this relationship can be connected with primary productivity. The species disappeared just before the minimum negative carbon-isotope value (OAE *sensu stricto*) and the genus never appeared again in the basin. Although *P. cancellata* was occasionally present before oxygen levels began to decrease, its abundance only increased when the rest of the benthos disappeared, indicating that it was an opportunistic bivalve adapted to low-oxygen conditions. However, when its size frequency distribution was analyzed, we noticed that it is not strictly comparable either to present-day opportunistic bivalve species, or to other species studied for the same time interval in other parts of the world, where most individuals are concentrated in the smaller sizes. Here size distributions indicate that juvenile mass mortality was not evident in any of the populations; on the contrary, in most cases mortality of mature individuals (medium sized) was higher. Therefore, population features of *P. cancellata* as inferred from these shell concentrations do not match strictly those of either opportunistic or equilibrium species. Yet, we can consider this taxon as basically opportunistic with populations primarily controlled by physical rather than biotic resource-limited environmental conditions, where juvenile individuals were more able to resist hostile environments with low oxygen content, as is the case with some living bivalves.

DO THE COUNTING METHODS DISTORT OUR PERCEPTION OF BIVALVE DIVERSITY THROUGH TIME?

Sonia Ros-Franch[1], Borja Cascales-Miñana[2] and Carlos Martínez-Pérez[3]

1. CONICET, Departamento Paleontología Invertebrados, Museo de Ciencias Naturales La Plata, UNLP, Paseo del Bosque s /n, 1900 La Plata, Argentina. soniaros@fcnym.unlp.edu.ar

2. Departamento de Geología, Universidad de Valencia, Avda. Doctor Moliner, 50, Burjassot, Valencia, 46100, Spain.

3. University of Bristol, Wills Memorial Building, Queen's Road, Bristol, BS8 1RJ, UK.

Phanerozoic diversity studies based on bivalves are a persistent target in paleobiology. Such studies are historically performed mainly using diversity curve counting methods based on temporal distribution of taxa, which are severely distorted by incomplete sampling. To overcome these drawbacks, we explore here the bivalve fossil record through a set of sample-in-bin (SIB) diversity measures. We aim to outline the bivalve evolutionary history and recognize major diversity changes through statistics based on sampled taxa and not on range data. Data analysis was conducted through Fossilworks platform (http://fossilworks.org/). Results show that there are three clear groups of extinction magnitude. The first one includes three moments of solid extinction for bivalves: Permian/Triassic, Cretaceous/Tertiary (K/T) and Paleogene/Neogene (P/N). We observed that the K/T is strongly influenced by the sampling probability. Unexpectedly, the SIB metrics showed the P/N extinction appears to have been actually a significant extinction. These three major events are characterized by elevated extinction and low origination rates. The second group, with moderate extinction rates, includes, among others, the remaining traditionally "big five" mass extinctions. For instance, the Toarcian and Cenomanian/Turonian show important diversity drops, which seems to be not driven by sampling changes. The derived profiles indicate that such events are not triggered by elevated extinction alone but also by low origination levels. Finally, the third group may be regarded as background extinction. The steady rise in Phanerozoic diversity observed through range data is not perceived when SIB diversity is considered. These results suggest that the bivalve diversity changes are, in general, overestimated by rangebased counts, and thus, encourage an in-depth revision.

MULTIVARIATE ANALYSIS (PCA) FOR TESTING TAXONOMIC ASSIGNMENT IN CRETACEOUS CONIFER WOODS, NEUQUÉN BASIN, ARGENTINA

Daniela P. Ruiz[1,2], Miguel Martínez-Soler[3], Roberto R. Pujana[1] and Leandro C. A. Martínez[1,2]

1. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Avda. Ángel Gallardo 470, 1405, Buenos Aires, Argentina. ruizdaniela8@gmail.com

2. Facultad de Ciencias Naturales y Museo, UNLP, Paseo del Bosque (s/n), 1900 La Plata, Argentina.

3. Laboratorio de Investigaciones Sensoriales, INIGEM – UBA – Conicet, Avda. Córdoba 2351, 1121, Argentina.

Fosil woods are traditionally classified by anatomical characters. However, the state of preservation of permineralized woods could not always allow a clear assignment. For this reason, Principal Component Analysis (PCA) would be a useful tool for identification of these fossils. The purpose of this study was to test the use of PCA for corroborating the taxonomic assignment based on anatomical characters; then those characters more easily preserved and useful for systematic classification were selected to be applied in bad preserved fossil woods. The studied specimens are Cretaceous conifer woods from three different localities in the Neuquén Basin, Argentina: Bajada del Overo (Bajada Colorada Formation), Cañadón de las Campanas (Huincul Formation), and Yacimiento Lago Barreales (Portezuelo Formation). Twenty-nine well preserved wood samples were used in this analysis. The woods were previously assigned to two genera (Agathoxylon Hartig and Cupressinoxylon Göeppert) and four species based on anatomical characters. In addition, continuous and discrete characters were selected, based on their relevance as a taxonomic indicator. After performing different PCA, we found that the obtained clusters and the previous taxonomic assignment were compatible. Finally, we performed the PCA to classify the specimens where some characters could not be observed because they were not sufficiently preserved.

MEGAFLORA OF THE LAGUNA FLECHA NEGRA LOCALITY, CHON AIKE FORMATION (MIDDLE-LATE JURASSIC), SANTA CRUZ PROVINCE, ARGENTINA

Ana J. Sagasti [1] and Alan Channing[2]

1. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). Facultad de Ciencias Naturales y Museo, División Paleobotánica. Paseo del Bosque s/n, La Plata, B1900FWA, Argentina. anajusagasti@gmail.com

2. School of Earth & Ocean Sciences. Cardiff University. Wales, CF10 3YE, UK.

The Laguna Flecha Negra locality (69º48’7.52’’W – 47º55’13.88”S) is located in the central-western region of Santa Cruz Province, Argentina. The outcrops have been assigned to the ignimbrite-dominated Chon Aike Formation based on their sedimentological characteristics and stratigraphic position. The Chon Aike Formation is part of the volcanic and volcaniclastic Bahía Laura Group, which also includes the tuff-dominated, and very fossiliferous, La Matilde Formation. The major outcrops of the Laguna Flecha Negra locality were investigated during two field trips, and a sedimentological profile was logged. This field work allowed us to identify various outcrops with distinctive fossil content and differing styles of preservation. These are: an *in situ* fossil forest with conifer-like stumps, a chert bed and two fossiliferous levels from which we obtained a large palaeobotanical collection. In the southwestern area of the Laguna Flecha Negra locality there are coarse sandstones with poorly preserved fossils, and massive lacustrine siltstones with an abundant, well preserved, compression-impression taphoflora. Conifers are the dominant component with two types of leafy branches, dispersed ovuliferous scales of *Araucarites* sp. and ovulate cones assignable to *Pararaucaria* sp. The genus *Brachyphyllum* is the most abundant of the leafy branches; it has helicoidally arranged adpressed leaves and two or three orders of shoots in organic connection are commonly observed. Branches assignable to *Pagiophyllum* sp. are a minor element of this taphoflora. Second in abundance are bennettitalean monopinnate leaves of *Otozamites* sp. that appear at the silt horizon in association with *Brachyphyllum* and *Araucarites* and often have cuticular preservation. *Elatocladus* leafy branches, *Sphenopteris* and *Gleichenites* fronds, and small oval-circular conifer strobili with helically arranged sporophylls are minor elements of the assemblage. The elements of this paleofloristic association suggest that the conifers were the dominant group, with an abundance of Araucariaceae and a minor component of Cheirolepidiaceae. Middle to Late Jurassic floras of the Bahía Laura Group have been mostly described from the La Matilde Formation, with only one record from the Chon Aike Formation in the Bajo Pellegrini locality that is composed only of *Dictyozamites* fronds. The study of the Laguna Flecha Negra locality allows an improved knowledge of the Bahía Laura Group paleofloras.

LOWER AND MIDDLE DEVONIAN OSTRACODS FROM SOUTH AMERICA: THEIR PALAEOBIOGEOGRAPHICAL AFFINITIES

María José Salas[1,2]

1. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), CONICET - Universidad Nacional de Córdoba. Av. Vélez Sarsfield 1611, X5016GCA, Córdoba, Argentina. mjsalas@efn.uncor.edu.

2. Centro de Investigaciones Paleobiológicas (CIPAL), Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Argentina.

The knowledge of Paleozoic ostracods from South America is scarce and patchy, and the most recent studies have been almost entirely focused on the Ordovician of Argentina. In turn, the records of Devonian ostracods are included in a series of isolated papers ranging from Lower to Middle Devonian mainly from Bolivia and Argentina, with only one mention from Brazil. A new ostracod association from the Lochkovian horizons of Argentine Precordillera and a review of the Devonian faunas of South America are herein provided. In addition, palaeobiogeographical affinities of all known Devonian ostracods from South America will be evaluated in order to provide new insights into the recognition of the Malvinokaffric Realm. The new association was recorded from the Talacasto Formation (Lochkovian–Pragian). It is composed of endemic taxa like *Keslingiella*? *teresae*, *Pircawayra* n. sp., *Lapazites* n. sp., *Petrisigmoopsis* n. sp. and Gen. nov., with other of a wider distribution like *Bollia* n. sp., *Ulrichia* sp., *Aechmina* sp., and *Thlipsurella* sp. In the South American context the new association is the oldest Devonian fauna except for the Siluro-Devonian species described by Vannier and collaborators. Other known faunas come from the upper Lower Devonian (Emsian) of Argentina (upper levels of Talacasto Formation, lower levels of Punta Negra Formation), Bolivia (Belen Formation) and only one species from Brazil (Ponta Grossa Formation), and from the Middle Devonian (Eifelian-Givetian) of Argentina (Punta Negra Formation) and Bolivia (Iquiri Formation). Although the studies of Devonian ostracods are still limited in number, some common features of the fauna can be recognized. The Devonian ostracods from South America show low diversity until now with 14 genera (dubious genera are not considered) and 35 species belonging to Palaeocopina, Platycopina, Metacopina and Podocopina suborders. This composition is kept throughout the Devonian; however the diversity decreases towards younger levels, reaching only 5 genera in the Eifelian-Givetian. Respect to the paleogeographical affinities, the Lower Devonian ostracod fauna is composed by a 50% of endemic forms, and by Laurentian and cosmopolitan genera. The Middle Devonian, in contrast, is fully composed by endemic forms, that closely resemble coeval ostracods from South Africa. The two regions exhibit a remarkable endemism, not only at generic level, but also at species level. According to these preliminary evidences, the paleobiogeographic pattern shows Lower Devonian ostracods of mixed affinities, while the Middle Devonian fauna exhibits a typical Malvinokaffric association. Based on the ostracod faunas, the Malvinokaffric Realm is clearly recognizable only during the Middle Devonian.

MOLLUSCABASE – WORLD REGISTER OF MARINE SPECIES GOES FOSSIL

Simon Schneider[1], Ruud A. Bank[2], Rüdiger Bieler[3], Phillipe Bouchet[4], Wim Decock[5], Stefanie Dekeyzer[5], Serge Gofas[6], Andreas Kroh[7], Bruce Marshall[8], Thomas A. Neubauer[7], Eike Neubert[9], Gary Rosenberg[10], André F. Sartori[4], Aina Trias-Verbeeck[5], Leen Vandepitte[5] and Bart Vanhoorne[5]

1. CASP, University of Cambridge, West Building, 181A Huntingdon Road, Cambridge CB3 0DH, UK. simon.schneider@casp.cam.ac.uk

2. Chopinlaan 21, 9603 AM Hoogezand, The Netherlands.

3. Field Museum of Natural History, 1400 South Lake Shore Drive, Chicago, IL 60605-2496, USA.

4. Muséum National d'Histoire Naturelle; Systématique, Adaptation, Evolution, 55, Rue Buffon, 75231 Paris Cedex 05, France.

5. Flanders Marine Institute, VLIZ – InnovOcean site, Wandelaarkaai 7, 8400 Oostende, Belgium.

6. Universidad de Málaga; Faculdad de Ciencias, Departamento de Biología Animal, Campus de Teatinos, 29071 Málaga, Spain.

7. Naturhistorisches Museum Wien, Burgring 7, 1010 Wien, Austria.

8. Museum of New Zealand Te Papa Tongarewa, 55 Cable Street, PO Box 467, Wellington, New Zealand.

9. Naturhistorisches Museum Bern, Bernastrasse 15, CH-3005 Bern, Switzerland.

10. Drexel University, Academy of Natural Sciences, 1900 Benjamin Franklin Parkway, 19103 Philadelphia, Pennsylvania, USA.

MolluscaBase, which will be a Global Species Database covering all marine, freshwater and terrestrial molluscs, recent and fossil, was launched on February 6-7, 2014 at the Flanders Marine Institute (VLIZ) at Ostende, host institute of the World Register of Marine Species (WoRMS). Currently, the WoRMS database contains more than 44,000 valid, verified species names of Recent marine Mollusca, which are estimated to represent approximately 95% of all valid species. Beyond catching up with the missing 5%, and keeping up with the yearly established new species, the molluscan component of WoRMS shall be expanded to contain freshwater and terrestrial Mollusca, estimated on *ca.* 28,000 valid species. Adding the aspect of time to the current database, and acknowledging the fossil record as the source of extant diversity, it has been agreed that the list should be extended to include all fossil mollusc taxa. A solid estimate of the number of fossil mollusc species is not available yet. MolluscaBase is a strictly taxonomic database, relying only on published sources. As such, it does not compete with occurrence-based initiatives, like, *e.g.*, the Paleobiology Database, but rather supplements these platforms. WoRMS as a whole has had more than 1,000,000 unique visitors in 2013, and has currently almost 1,500 citations in Google Scholar. Moreover, it is linked to various biodiversity initiatives and repositories and is thus an important component of global biodiversity infrastructure, providing quality control and taxonomic backbone. Going fossil, the existing network shall be extended to link with global, regional or taxon-specific palaeontological databases. The fossil component of MolluscaBase is still in its starting phase, and needs your support! Data input in MolluscaBase is performed by a limited number of taxonomic editors and various corresponding contributors, who may provide datasets to the database management team. If you are a taxonomist, specializing in any group of fossil molluscs, and want to become a contributor to MolluscaBase, let us know! If you are holding your own database and want to join or link it to MolluscaBase, let us know! Please contact the WoRMS team at info@marinespecies.org, or the corresponding author, to find your role in MolluscaBase!

EURHOMALEA EXALBIDA (BIVALVIA): A NATURAL ARCHIVE FOR DISSOLVED INORGANIC CARBON CHANGES IN THE SOUTHWEST ATLANTIC?

Bernd R. Schöne[1], Lina Yan[1], Alexander Arkhipkin[2] and Marina L. Aguirre[3]

1. Institute of Geosciences, University of Mainz, Becherweg 21, 55127 Mainz, Germany.

2. Fisheries Department, Falkland Islands Government, P.O. Box 598, Stanley, Falkland Islands.

3. CONICET; Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, calle 64 Nº3, 1900 La Plata, Argentina.
maguirre@fcnym.unlp.edu.ar

Due to the lack of high-resolution archives, past primary productivity dynamics and temporal changes of the oceanic carbon inventory around southern South America are not well understood. Here, we studied if such information, such as dissolved inorganic carbon (DIC), can be reconstructed from modern shells of *Eurhomalea exalbida* (Dillwyn) (a characteristic Patagonian species assigned by other authors to *Retrotapes*), a fundamental task to calibrate results based on shells from fossil Holocene and Late Pleistocene coastal deposits along the Southwestern Atlantic. Shell growth patterns and $\delta^{13}C$ values of four young, live-collected specimens (Falkland Islands/Malvinas) were compared to instrumental records. With increasing ontogenetic age and slower shell growth, $\delta^{13}C$ becomes increasingly enriched in ^{12}C. Annual increment widths and $\delta^{13}C$ values exhibited a significant negative correlation (R^2=0.80; p<0.0001). Annual $\delta^{13}C$ values decreased from ca. +2 per mil (age one) to ca. -0.5 per mil (age ten). $\delta^{13}C$ values were largely uncoupled from chlorophyll a levels and salinity. However, if the ontogenetic decline was mathematically eliminated, up to 25% of the $\delta^{13}C$ variability was explained by salinity changes. During ontogeny, *E. exalbida* seems to incorporate increasing amounts of respiratory CO_2 in its shell. In agreement with previous interpretations, this is explained with increasing metabolic rates of the mantle with decreasing growth rates. In conclusion, $\delta^{13}C$ of young *E. exalbida* specimens is of limited use for environmental reconstructions. Future studies should analyze, if the metabolic carbon contribution to the shell further increases during later ontogenetic years or reaches a stable value. These studies are of primary importance to understand ocean-atmosphere-palaeoceanographical changes during the most recent glacial-interglacial cycles in the Southwestern Atlantic.

PALEOGENE PHORUSRHACID BIRD (AVES, PHORUSRHACIDAE) FROM THE GUABIROTUBA FORMATION, CURITIBA BASIN, PARANÁ, SOUTH OF BRAZIL

Fernando A. Sedor[1], Eliseu Vieira Dias[2], Renata Floriano da Cunha[3] and Herculano Alvarenga[4]

1. Universidade Federal do Paraná, Setor de Ciências Biológicas, Museu de Ciências Naturais, Campus do Centro Politécnico, Rua Cel. Francisco H. dos Santos 100, Curitiba, 81531-990, Brazil. sedor@ufpr.br

2. Laboratório de Geologia e Paleontologia, Centro de Ciências Biológicas e da Saúde, Universidade Estadual do Oeste do Paraná, UNIOESTE, Rua Universitária 2069, Cascavel, 85819-110, Brazil.

3. Universidade Federal do Paraná, Departamento de Geologia, Curitiba, Campus do Centro Politécnico, Rua Cel. Francisco H. dos Santos 100, Curitiba, 81531-990, Brazil.

4. Museu de Historia Natural de Taubaté. Rua Juvenal Dias de Carvalho 111, Taubaté, 12.070-640, Brazil.

A first occurrence of a giant fossil bird is reported from the Guabirotuba Formation, Curitiba Basin. This unit is located on the southernmost portion of the Southeastern Brazil Cenozoic Rift, showing about 3000 km^2 of Paleogene sediments. The material described herein, a large isolated cervical vertebra and a distal end of a tarsometatarsus, are housed in the paleontological collection of Museu de Ciências Naturais of Universidade Federal do Paraná, Curitiba, Brazil. The cervical vertebra corresponds to the caudal most region of the neck (C7 to C10), measuring 48.20 mm of maximum length and 55.20 mm of anterior width. The ansae costo transversaria are broad, presenting well marked striae along the surface. The processi caroticus are wide and directed ventromedially. The zygapophyses cranialis are oblique with a medial directed slope. The zygapophyses caudalis are wide and directed lateroventrally, and the posterior lacuna interzygapophysialis presents a triangular shape. The tarsometatarsus consists of a distal end and part of the shaft, measuring 54.70 mm at the base of the trochleae. Both incisura intertrochlearis are wide and rounded in contour, the incisura medialis situated slightly more distally than the incisura lateralis. The trochlea metatarsi II is not deflected medially in cranial view and lacks a groove at the articular surface. The trochlea metatarsi III is larger and more distally extended than the trochlea metatarsi II and IV, with its articular surface furrowed by a deep median groove, the medial flange projecting more anteriorly than the lateral. The lateral edge of the trochlea metatarsi IV has a strong posteriorly directed crest. The fovea ligamentum collateralis are wide and deep. The specimens are assigned to Phorusrhacidae by the combination of the following features: vertebra large in size and with pronounced striae along ansae costotranversaria; trochlea metatarsi III large and distally expanded; reduced trochlea metatarsi II with articular surface lacking a longitudinal sulcus, and in cranial view not deflected medially being almost parallel to the trochlea metatarsi III; and deep foveae ligamentum collateralis. To date only two occurrences of Phorusrhacidae were known for the Paleogene of Brazil, and this record contributes to improve the knowledge of fossil vertebrates of Guabirotuba Formation and the giant birds in South America.

HIRNANTIAN?-EARLY SILURIAN BRACHIOPODS FROM THE SIERRA GRANDE FORMATION (NORTH PATAGONIAN MASSIF, RÍO NEGRO PROVINCE, ARGENTINA)

Aron Siccardi[1], Norberto J. Uriz[1], Juan J. Rustán[2] and Carlos Cingolani[1]

1. Geology Department, La Plata Museum, Paseo del Bosque s/n, La Plata, 1900, Argentina. asiccardi_15@hotmail.com

2. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), Centro de Investigaciones Paleobiológicas (CIPAL) (CONICET-Universidad Nacional de Córdoba), Av. Vélez Sarsfield 1611, X5016GCA, Argentina.

The Sierra Grande Formation is composed of mature quartz-rich sandstones interlayered with shales, subordinated wackes, conglomerates, and rich oolithic ironstone horizons.The unit has been interpreted as deposited in an open marine shelf dominated by processes of waves and storms. The majority of the outcrops are located in the eastern margin of the North Patagonian Massif, to the southeast of the Río Negro Province, Argentina. Containing the only one (not re-sedimented) Early Paleozoic fossiliferous record from Patagonia, the Sierra Grande Formation provides relevant insights for the understanding of the palaeogeographic context of Western Gondwana during Paleozoic times. In addition, its paleontological content allows an adjustment of the regional stratigraphic frame among related basins; particularly regarding equivalent units from South America and South Africa. Fossiliferous localities of the Sierra Grande Formation include Loma de los Fósiles and Loma de los Guanacos. This contribution deals with new information on the brachiopods of the first locality, which had been previously considered as old as Wenlockian, based on the tentative presence of *Clarkeia antisiensis*. New fossils come from a dark grey-bluish mudstone bed in Loma de los Fósiles, yet former collections housed in the Museo de La Plata have also been reviewed. The recognized brachiopod association is composed by *Eostropheodonta* aff. *chilcaensis parvula*, *Heterorthella* sp., resselerids (*Dedzetina?* and *Resserella* sp.), rhyncotrematoids (cf. *Rostricellula*, *Rhynchotrema*), *Dalmanella* sp. and leptaenids. After the revision of the previously reported specimens, the presence of *Clarkeia* could not be confirmed. These elements are accompanied by trilobites such as *Eoleonaspis* sp., orthoconic nautiloids, conularids, eotomarids and holopeids gastropods, bivalves, crinoids ossicles, hyolitids and a rugose coral. Preliminary, the fauna seems to be closer to the *Heterorthella precordillerana* assemblage (middle Rhuddanian-early Aeronian) known in the basal levels of the La Chilca Formation (Precordillera of western Argentina), rather than the Hirnantian brachiopod assemblages of the Cedarberg Formation in South Africa. However, the overall faunal composition shows a typical assemblage from the Hirnantian-early Silurian boundary.

LOCKED IN A HUGE EPEIRIC SEA: THE ENDEMIC SOUTH AMERICAN PERMIAN BIVALVES FROM THE ECCA OF SOUTH AFRICA REVISITED

Marcello G. Simões[1], Juliana M. David[2] and Luiz E. Anelli[2]

1. Instituto de Biociências - Universidade Estadual Paulista (UNESP), Rubião Júnior, s/n, Botucatu-SP, 18618-970, Brazil. profmgsimoes@gmail.com

2. Instituto de Geociências - Universidade de São Paulo (USP), Rua do Lago, 562, Cidade Universitária-SP, 05508-080, Brazil.

During the late Paleozoic, large areas of western Gondwana (Paraná Basin, South America, Karoo and Huab basins, South Africa and Namibia) were covered by a huge inland sea. In the early-middle Permian, this large epeiric sea was either isolated or had a restricted connection to the Permian oceans. Benthic marine faunas that thrived in this sea were mainly dominated by shallow burrowing bivalves, and evolved under conditions of extreme geographic isolation. Remarkable morphological disparity is shown, especially by the anomalodesmatans. Rocks of the Permian Passa Dois Group, Brazil, and coeval successions in Uruguay, Paraguay, and Argentina encompass the best records of that endemic fauna. Until the early 70's, at least 24 generic names were applied to the Paranean bivalves, none of these known outside the Paraná Basin. In the early 80's, M.R. Cooper and B. Kensley announced (but not described) the record of the Permian Paranean bivalves outside South America. According to them, at least one conspecific taxon (*Leinzia froesi*) and others apparently congenerics (*Naidopsis*, *Casterella*, *Jacquesia*) were found in delta front deposits of the Waterford Formation, Ecca Group, South Africa. Curiously, the genera from three distinct Permian biozones of the Paraná Basin were amassed in a same hand sample of the South African assemblage. Yet, specimens of the most abundant and widely distributed Paranean genera (*Pinzonella*, *Terraia*, *Plesiocyprinella*) were not found in the South African fauna. Conversely, rare South American forms were reported (*Leinzia*, *Naiadopsis*). In the early 90's, this interpretation was hardly questioned by J.M. Dickins and others. Since then, the record of the endemic South American Permian bivalves in the Main Karoo Basin is questionable, as the South African assemblage remained undescribed. Here we revised the type material studied by M.R. Cooper and B. Kensley, which is reposited in the Iziko Museum of Cape Town, South Africa. Results indicate that their taxonomic interpretations were flaw. Although apparently related to the Plesiocyprinellinae bivalves (the dominant group in the Paranean assemblages), the Karoo ones cannot be confidently assigned to any known South American genera or species. The poorly diversified South African assemblage seems to be a regional variant of that of the Paraná Basin, also represented by their own endemic taxa (at least three distinct genera). Hence, the biocorrelation of the South African assemblage with those of the Permian bivalve biozones of the Passa Dois Group, Brazil, cannot be securely constrained.

THE ORDIAN-TEMPLETONIAN CARBON ISOTOPE EVENT (OETE) AND BIOSTRATIGRAPHY IN THE GILES CREEK DOLOSTONE, AMADEUS BASIN, CENTRAL AUSTRALIA

Patrick M. Smith[1], Glenn A. Brock[1] and John R. Paterson[2]

1. Department of Biological Sciences, Macquarie University, Sydney, New South Wales, 2109, Australia. patrick-mark.smith@students.mq.edu.au

2. School of Environmental and Rural Science, University of New England, Armidale, New South Wales, 2351, Australia.

Recently, a number of large scale multi-authored syntheses have advocated the use of carbon isotope chemostratigraphy in preference to biostratigraphy for national and international correlation for the Cambrian period. Cambrian (especially Terreneuvian) biostratigraphy has long been hindered by high levels of endemism and perceived diachroneity of first appearance datum points (FADs) of key fossil taxa - resulting in difficulties in defining truly global time lines. However, the proposition of using carbon isotopic excursions as the key means for defining regional and global stage subdivisions without adequate biostratigraphic control is fraught with difficulties and potential miscorrelation. We advocate a multiproxy approach to all stratigraphic correlation and provide a cautionary example of the type of misalignment that can happen if correlation is based solely on chemostratigraphy. Detailed regional investigation using stable carbon isotopes across the Ediacaran-Cambrian boundary in central Australia reported the presence of a sharp +4.0 per ml shift in $\delta^{13}C_{carb}$ values in the middle of the Giles Creek Dolostone at Ross River Gorge, Amadeus Basin, Northern Territory. The positive shift in $\delta^{13}C_{carb}$ values through this interval was called the "Ordian-Templetonian Isotope Event (= OETE)", which was very poorly constrained with fossil data. Regionally, the OETE signal matched closely and was correlated with similar positive shifts in drill cores from apparently coeval rocks within the neighbouring Daly, Georgina and Wiso Basins. Previous palaeontological work on these respective cores contained the age diagnostic trilobites *Redlichia* cf. *foraminifera* and *Redlichia gumridgensis*. Based on recent revisions of the Australian Cambrian stage timescale these trilobites and their associated fauna suggest that the OETE in the core material from the Daly, Georgina and Wiso Basins occurs within the Ordian stage (*Xystridura negrina* assemblage zone). However recent documentation of trilobites and associated fauna from the Giles Creek Dolostone in Ross River Gorge indicates this formation belongs in the overlying Templetonian stage (*Pentagnostus anabarensis* or *Ptychagnostus praecurrens* zones). Therefore the isotopic excursion identified in the Giles Creek Dolostone at Ross River Gorge cannot be correlated with OETE reported from the core material within the neighbouring basins. This highlights the importance of a multi-proxy approach with a well constrained biostratigraphy in combination with chemostraigraphy as a means to build confidence in regional and wider correlation. Without a biostratigraphic framework, positive or negative shifts in isotope ratios may appear superficially similar in shape and magnitude, yet be of significantly different ages.

DESCRIPTION AND ARCHEOPYLE ANALYSIS OF A NEW PERIDINIOID "ROUND BROWN" DINOFLAGELLATE CYST, LAKE PANNON, AUSTRIA

Ali Soliman[1] and Joyce Lucas-Clark[2]

1. Geology Department, Faculty of Science, Tanta University, Tanta 31527, Egypt.
2. Clark Geological Inc., 1023 Old Canyon Rd. Fremont, California, USA.
jluclark@comcast.net

In the early late Miocene (*ca*. 11.6 Ma), Lake Pannon arose in the Pannonian basin system, replacing the Central Paratethys Sea. This lake, c. 290,000 km^2, was initially brackish, slowly freshening and becoming slightly alkaline. The fluctuations of the water level and chemistry of the lake caused not only shoreline alterations, but also changes in the associated biota. Ultra high-resolution core samples from Hennersdorf and Mataschen, Vienna and Styria basins respectively, revealed a late Miocene endemic assemblage of dinoflagellate cysts important for, among other things, the possible study of the relationships of morphology and ecology of thin dinoflagellate cysts. The species herein informally described seems to be a low salinity indicator. Among the dinoflagellate cysts of the endemic population we propose a new peridinioid cyst genus and species. It is a thin walled, acavate cyst, spherical to subspherical, lacking horns. It is one of the informal categories of "Round Brown Cysts". The autophragm is densely covered with short, solid, evexate, hair-like projections. Paratabulation is only indicated by the operculum free archeopyle. Our analysis of the tabulation consists mainly of interpreting details of the archeopyle outline such as geniculate "peaks" and also nicks or indentations. Rare, slight changes in the outer ornamentation near the archeopyle have also been helpful. We interpret these details to suggest the presence of plate suture "triple junctions". The archeopyle outline shows a large projection into the center of the archeopyle opening, interpreted to be ventral. At least two other, smaller "peaks" or geniculate plate boundaries project into the center of the archeopyle opening from the lateral edges of the archeopyle. We interpret these two smaller projections as indicating sutures between plates anterior to the archeopyle boundary (missing plates). The slight "nicks" or indentations in the boundary are interpreted as indications of "triple junctions" with sutures posterior to the archeopyle, *i.e.*, sutures between plates of the next posterior series. The simplest resulting interpretation involves the loss of three apical plates, 2′, 3′ and 4′. However, the archeopyle is quite large, and there are, in some specimens, indications that both apicals and intercalaries might be missing. Further investigation of the symmetry and size of the archeopyle may help to determine whether one or both of these archeopyle types are present.

PALEOECOLOGY OF NEW CHONDRICHTHYAN FAUNA FROM MIDDLE MIOCENE (BARSTOVIAN), GADSEN COUNTY, FLORIDA, USA

Luis Soto-Ovalle[1] and Bruce MacFadden[2]

1. Biology Department & Florida Museum of Natural History, University of Florida, P.O. Box 118525 Gainesville, FL 32611, USA.

2. Florida Museum of Natural History, University of Florida, 218 Dickinson Hall Museum Road & Newell Drive Gainesville, FL 32611, USA. bmacfadd@flmnh.ufl.edu

The Torreya Formation crops out in the southern Georgia and northern Florida (approx. 30.6° N, 80.3° W) region of the United States. Within the formation there are preserved specimens from several taxa including mammals, bony fishes, chondrichthyes and invertebrates. The age for this assemblage, based on Sr-ratios and magnetostratigraphy, is between 15.3 to 15.9 Ma, corresponding to the early Barstovian NALMA. Earlier reports have concentrated on invertebrates and mammals, leaving the Chondrichthyes therefore unpublished. This study reports on the chondrichthyan assemblage from the Willacoochee Creek, Florida. Chondrichthyan samples at the Florida Museum of Natural History have been studied to reconstitute this Chondrichthyes assemblage structure. 1588 corporal remains, including teeth, spines, denticles and vertebrae were used for this study. This material documents a moderately diverse fauna with representation from ten genera of sharks and four genera of batoids. Three taxa are numerically the most abundant, including *Carcharhinus* sp. (38.5%), *Myliobatis* sp. (12.8%) and *Negaprion brevirostris* (11.6%); in addition, Myliobatidae (6.6%), *Hemipristis serra* (6.6%) and *Rhizopionodon* sp. (5.7%) have a discreet representation. The remaining species are relatively rare, each representing < 5%, with a collective total of 18.2%. The dominance of corporal remains of relatively medium to small genera like *Carcharhinus* and *Myliobatis* indicates a shallow-water paleoenvironment, thus agreeing with previous paleoecological reconstructions for this area. Along with the previous vertebrate studies, it gives a comprehensive idea of the ancient biodiversity and paleoecological context of the Torreya Formation.

RATES AND CONSTRAINTS IN THE EVOLUTION OF SAUROPTERYGIA

Laura Soul[1] and Roger Benson[1]

1. Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN, UK.
lauras@earth.ox.ac.uk

Sauropterygians were a clade of marine reptiles that were highly abundant and long-lived, spanning over 180 Ma during the Mesozoic, and becoming extinct 66 million years ago at the Cretaceous/Palaeogene boundary. Their evolutionary history was characterised by repeated extinctions, and the repeated, convergent evolution of similar morphotypes. Readily preserved traits such as vertebral count, neck length, and overall body proportion were highly labile in the group, which includes taxa with up to 76 cervical vertebrae, more than any other animal, as well as streamlined, short-necked taxa with large heads. Recent, large and well resolved phylogenetic hypotheses mean that sauropterygians provide an ideal case study for quantitative evaluation of macroevolutionary theories in a phylogenetic framework. An extinction event at the Triassic/Jurassic (Tr/Jr) boundary included all non-plesiosaurian sauropterygians, and was followed by evolutionary innovation and a transition to open water habitats by the remaining lineage (Plesiosauria), making it an interesting focal point. In this study, we tested whether somitogenetic (duplication of axial segments leading to increased vertebral count) or homeotic (lengthening of individual vertebrae) effects were more important in sauropterygian body plan evolution, whether changes in vertebral count affected taxonomic or body plan diversity, and whether phenotypic release of body proportions, caused by adaptation to open water habitats, triggered an adaptive radiation at the Tr/Jr boundary. We collected vertebral counts and summarised variation in body proportions using 31 length measurements, including five functionally relevant metrics, from the skull and post-crania of over 200 specimens representing 80 species and including all major sauropterygian families. We measured phylogenetic and ecomorphological selectivity of extinctions through time using Fritz and Purivs' D and phylogenetic principal components analysis (PCA). Furthermore, to untangle patterns in taxonomic, morphological and functional diversity, we used a maximum likelihood approach that fits Brownian models to estimate ancestral states and rates of evolution of body proportions and vertebral formula. Results show significant phylogenetic selectivity in extinction during the Tr/Jr transition. They also indicate an evolutionary rate increase, combined with increased constraint on limb proportions, coincident with the origin of flippers and transition to open water niches in the Early Jurassic. During this time somitogenetic effects were the initial control on body plan evolution, leading to a wide variety in vertebral counts that show low phylogenetic signal across the clade. This suggests that phenotypic release triggered an increase in morphological, but not taxonomic, diversity.

ORDOVICIAN ATLAS OF ANCIENT LIFE: A TOOL FOR PALEONTOLOGISTS AND THE PUBLIC

Alycia L. Stigall[1], Jennifer E. Bauer[1] and Adriane R. Lam[1]

1. Department of Geological Sciences and OHIO Center for Ecology and Evolutionary Studies, Ohio University, 316 Clippinger Laboratories, Athens, Ohio, 45701, USA. stigall@ohio.edu

Museum collections of fossils, along with their associated locality data, provide millions of records representing data on the temporal and geographic distribution of species in deep time. However, to reach their greatest scientific and educational potential, these collections data need to be available on-line and in formats accessible to both professional scientists and can be utilized by the public. Recent efforts in our research group have focused on digitizing specimens of Late Ordovician (Katian) fossils from the Cincinnati, Ohio, USA region and developing outreach materials for K-16 education and avocational paleontologists. Ultimately, these products are deployed via the www.OrdovicianAtlas.org interface. The initial year (2012-2013) of this NSF funded project focused on digitization (cataloging and georeferencing) of the 13,000 specimen collection housed at Ohio University. This is a newly acquired collection donated by an avocational paleontologist and includes detailed geographic and stratigraphic data for a broadly representative set of taxa. The digitization process resulted in a highly detailed, accurate digital data, which have been made publicly available via the iDigBio portal. By attaching accurately georeferenced latitude/longitude coordinates to each specimen, this collection has generated thousands of mappable data points to augment the digital biogeographic record. The second year of the project (2013-2014) focused on development and content generation for the website (www.OrdovicianAtlas.org). The atlas includes dedicated pages for common species and higher taxa in the Cincinnatian strata. Each species page includes paleoecological data, taxonomic details, stratigraphic occurrences, identification in hand sample information, and published descriptions on the species in question. The goal is to create content useful to both professional and avocational paleontologists. Currently, there are over 80 species and more than 250 higher taxa pages visible to the public. The third year of the project (2014-2015) will focus on developing interactive geographic maps of species and manipulatable 3D renderings for common species. In addition, to creating an identification and systematics reference, the collection has been used to develop lesson plans for K-16 educators (grade school through college). These lessons utilize the well-exposed marine invertebrate fossils of the Cincinnati Arch region to explore concepts in diversity, ecology, and evolution with ties to modern ecosystem function. These lesson plans can be and have been modified for use in grade school to university classrooms as well as in public outreach programs with adults and children.

INTRASPECIFIC VARIATION IN *AETOSAUROIDES SCAGLIAI* CASAMIQUELA (ARCHOSAURIA: AETOSAURIA) FROM THE UPPER TRIASSIC OF ARGENTINA AND BRAZIL: EVIDENCE OF SEXUAL DIMORPHISM?

Jeremías R. A. Taborda[1], Andrew B. Heckert[2] and Julia B. Desojo[1]

1. CONICET, Sección Paleontología Vertebrados, Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', Av. Angel Gallardo 470, C1405DJR, Buenos Aires, Argentina. jtaborda@macn.gov.ar

2. Department of Geology, Appalachian State University, ASU Box 32067, Boone, NC 28608-2067, USA.

Aetosaurs are quadrupedal pseudosuchian armoured archosaurs recovered from Upper Triassic strata across Pangaea. They are characterized by dorsal and ventral carapaces, and appendicular osteoderms, all of them ornamented. Aetosaurs have been proposed as index fossils, but this possibility is complicated due to questions about the taxonomic reliability of osteoderms, which are frequently used to identify taxa. Therefore, it is important to understand the intraspecific variation of osteoderms in aetosaurs. Recent studies of histological sections in osteoderms of *Aetosauroides scagliai* Casamiquela have provided novel information about the growth pattern of the paramedian osteoderms. Furthermore, the absence of remodeling of the osteoderm tissues allows estimation of the ontogenetic age by counting lines of arrested growth (LAGs). Here we describe three types of ornamentation in the dorsal armour of *A. scagliai*, particularly on the medial area of paramedial osteoderms. One of these consists of radial grooves and ridges, with small pits inside the grooves, named the "radial pattern"; the other end member, called the "anastomosing pattern", is composed of anastomosing crests and proportionately larger, more irregular pits. The third pattern is an "intermediate" or "transitional pattern" between the "radial" and "anastomosing patterns". The articulated dorsal armour preserved in specimens PVL 2059 and PVL 2073 exhibit all three patterns of ornamentation, but they differ in the position of each throughout the carapace. Because the specimens are uniformly well preserved, with no indication of damage or resorption of the external surface of osteoderms, and the histological sections also show no evidence of post-mortem damage in these structures, we reject the hypothesis of taphonomic explanations of ornamentation variation. Moreover, the holotype (PVL 2073) is slightly smaller (around 10%), but also ontogenetically younger (5 LAGs), than PVL 2059 (10 LAGs). Because both share other taxonomically informative features (*e.g.* presence of an oval fossae ventral to the neurocentral suture on the lateral sides of the centra), they appear to represent the same species, requiring an explanation for the disparity in size and details of ornamentation patterns. Combining this information with the evidence of ontogenetic state and general body size of all the analyzed specimens, and comparing with living crocodiles (where the male specimens are typically relatively larger than the females at the same age), we conclude that the intraspecific variation in *A. scagliai* is compatible with the hypothesis of sexual dimorphism. These results show the need to explore the sources of intraspecific variation in aetosaurs.

AN UNUSUAL PERIOSTEAL TISSUE IN THE RIBS OF TWO PLESIOSAURS (SAUROPTERYGIA: PLESIOSAUROIDEA) FROM THE UPPER CRETACEOUS OF ANTARCTICA

Marianela Talevi[1] and Marta S. Fernández[2]

1. CONICET -Instituto de Investigación en Paleobiología y Geología, Universidad Nacional de Río Negro, Isidro Lobo y Belgrano, (8332) General Roca, Río Negro, Argentina. mtalevi@urnr.edu.ar

2. CONICET -División Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n, (1900) La Plata, Argentina.

The structure of tissues is generally not preserved in fossils because soft tissues of the vertebrate body usually have no potential to fossilize. However, the inorganic components of bone preserve the spatial orientation of organic components such as osteocyte lacunae, vascular canals, and collagen fibers. Here we examined ribs of two plesiosaurs recovered from the Maastrichtian (Late Cretaceous) of Antarctic Penisula. The primary bone tissue shows dense, longitudinally oriented fibres organized into bundles instead of typical periosteal bone. These fibre bundles are diamond-shaped when cut exactly perpendicular and are surrounded by a distinct sheath. This structural organization is similar to ossified tendons found in ornithopod dinosaurs (e.g., hadrosaurs) and birds, and in cervical ribs in sauropod dinosaurs. In the ossified tendons of dinosaurs the nature of the primary bone matrix indicates that these structures mainly originated through direct mineralization (metaplasia) of tendinous structures. However, as far as we know, this type of histological organization has never been observed in tetrapod dorsal ribs. We hypothesized that this structural organization of the elasmosaurid ribs may have some biomechanical advantage in the retention of the rib curvature and in resistance against crushing. Testing of this hypothesis requires further expand the samples and biomechanical analyses.

A TAXONOMIC AND TAPHONOMIC ANALYSIS OF LATE JURASSIC HORSESHOE CRABS FROM A *LAGERSTÄTTE* IN CENTRAL POLAND

Jessica N. Tashman[1], Rodney M. Feldmann[1] and Błażej Błażejowski[2]

1. Department of Geology, Kent State University, Kent, Ohio 44242, USA.
jtashman@kent.edu

2. Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warsaw, Poland.

A recently-discovered Late Jurassic *Lagerstätte* in central Poland has yielded over 100 specimens of xiphosurid corpses and molts within limestones representing a storm or tsunami deposit. A new species, *Crenatolimulus* n. sp. is described, which is the first representative of the genus in Europe. The Polish specimens exhibit varying degrees of disarticulation and many are broken, which is interpreted to be a result of being tossed about during a mega-storm event; they otherwise demonstrate exceptional detail and preservation. Taphonomic experiments have been conducted on non mineralized molts of the modern analog, *Limulus polyphemus* Müller, that were reintroduced to oxic sea water in order to determine the length of time it can take for molts to disarticulate when vigorously tumbled, simulating sea water movement during a mega-storm. Previously dried molts are analogous to those that have been washed ashore by wave activity and later returned to the sea, and these regain pliability after being reintroduced to water. Other experiments were conducted noting the length of time needed for molts to disarticulate while resting on an oxic ocean floor (excluding bioturbators and scavengers), as well as the effects of compression that lead to prosomal wrinkling. Results indicate that Polish horseshoe crab molts were likely to have disarticulated and broken before being displaced during a storm, and were not buried for days to months after molting their exoskeletons. *Crenatolimulus* n. sp. has been placed in a taxonomic context that includes other genera within the order Xiphosurida. A summary of data regarding living horseshoe crabs and their descendants is discussed, and some taxonomic changes have been made to the classification of xiphosurids. New subordinal taxa are proposed. [Supported by NSF IIA-1307161 and Kent State University AMOCO Alumni Scholarship].

NEW INSIGHTS INTO PERMIAN MARATTIALES OF THE PARNAÍBA BASIN (NORTHEASTERN BRAZIL)

Tatiane M. Vieira Tavares[1], Roberto Iannuzzi[2], Rosemarie Rohn[3], Domingas M. da Conceição[4,5] and Juan C. Cisneros[5]

1. Universidade Federal do Tocantins-UFT, Av. Paraguai, esq. c/Rua Uxiramas, s/nº, Setor CIMBA, Araguaína, TO, 77.824-838, Brazil. tatianetavares@mail.uft.edu.br

2. Universidade Federal do Rio Grande do Sul-UFRGS, Porto Alegre, RS, 91.509-900, Brazil.

3. Universidade Estadual Paulista-UNESP, Av. 24A, no 1515, Rio Claro, SP, 13506-900, Brazil.

4. Universidade Federal de Pernambuco-UFPE, Av. Prof. Moraes Rego, 1235 - Cidade Universitária, Recife, PE, 50670-901, Brazil.

5. Universidade Federal do Piauí-UFPI, Bairro Ininga, Teresina, PI, 64.049-550, Brazil.

Permineralized stems of Marattiales are known in the Permian of the Parnaíba Basin, northern Brazil, since the 19th century (*Psaronius brasiliensis*), but, until the last decade, only few small specimens were described in detail, with no clarification concerning the exact provenance or the stratigraphic levels of the fossils. All permineralized stems were ascribed to the Pedra de Fogo Formation (PdF), a unit interpreted as a shallow marine to coastal deposit. However, recent work in the southern part of the basin (State of Tocantins, Filadélfia Municipality) demonstrated that several permineralized fossil plants also occur in the Motuca Formation (MF), a succession of fine sandstones and mudstones deposited in a semi-arid fluvio-lacustrine paleoenvironment that overly the PdF. The assemblages comprise different tree fern stems (*Grammatopteris freitasii*, *Dernbachia brasiliensis*, mainly *Tietea singularis*, *Psaronius sinuosus*, *Psaronius arrojadoi*), petioles and fertile pinnae (*Buritiranopteris costata*). *Grammatopteris* may evidence a Cisuralian age (this is the age of other occurrences of this genus in France and Germany). On the other hand, the *Psaronius* species and associated pinnae, present in the MF, are not recorded in the Northern Hemisphere, and then, the genus *Tietea* occurs only in the Parnaíba and Paraná basins. Other fossils from both the PdF and MF, such as vertebrates and palynomorphs, are rare and/or still poorly studied. This work reports the discovery of plant remains in two outcrops of the PdF. The first outcrop is located at the margin of the Boa Esperança Dam in the Parnaíba River (Nova Iorque Municipality, State of Maranhão, central Parnaíba Basin). We collected in this place fragmented Marattiales stems (*Psaronius* sp.), fertile pecopterid pinnae, and petioles. Some specimens of *Psaronius* are similar to *P. arrojadoi*. The second outcrop, located in Monsenhor Gil, State of Piauí, yielded a horizon with permineralized fertile pinnae overlaying a bacterial mat. The fern leaves of the Parnaíba Basin, first recorded in the Filadélfia Municipality and in the two new outcrops, are very significant, particularly taking into consideration that all other known pinnae in Western Gondwana have little potential for phylogenetic and paleophytogeographic approaches because they are either poorly preserved or sterile. The next step of our research will be the detailed study of these recently collected samples from the PdF. This will provide a better knowledge of the Permian "pteridophitic" flora in northern Brazil, and may contribute to define with more accuracy the paleophytogeographic, litho- and chronostratigraphic range of these tree-fern taxa.

GEODIVERSITY AND PALAEONTOLOGY OF BAJA CALIFORNIA, MEXICO: A RESOURCE FOR A SUSTAINABLE DEVELOPMENT

Miguel A. Téllez Duarte[1], Ivonne A. Posada Ayala[1] and Francisco J. Aranda Manteca[1]

1. Facultad de Ciencias Marinas, Área de Geología, Universidad Autónoma de Baja California. Km 103 carretera Tijuana-Ensenada, Ensenada, Baja California, CP 22860, México.
mtellez@uabc.edu.mx

Geodiversity as a concept combines the variety of abiotic elements of the landscape, first of all geological features, and secondly their relationships with the biotic world, including human activities. Coupled with the biodiversity, is an important tool for the natural and cultural heritage management and nature conservation by its scientific, educational and aesthetic value, in addition as a source of inspiration for the man. Being a relatively new concept compared with biodiversity, still has not been widely applied to protection and management of natural resources, and even less in palaeontology. For instance, in a Google search performed in April 2014, there were 12,800,000 citations on biodiversity, 325,000 on geodiversity, and only 21,300 on palaeontology and geodiversity. The above data show that more effort is needed to include palaeontology as part of geodiversity, since in addition to its role in biological evolution understanding, i.e. biodiversity, possesses a highly scientific, educational, and economic value, which can be focused toward sustainable development activities as geotourism. The extensive open spaces with scarce population in the State of Baja California, México, besides the desert environment of most of the territory, water scarcity, and unpredictability of rainfall, have hindered the economic development of rural communities through activities such as farming, cattle, fishing or mining. On the other hand, tourism has been an important and growing activity focused mostly towards beach destinations, while the palaeontological wealth that forms part of the coastal and inland natural landscape has not valued as geotouristic attraction in rural areas. Since geotourism requires the validation of all the geodiversity elements, including palaeontology, as a resource for touristic attraction, this contribution presents an inventory of the rich palaeontological heritage of the State of Baja California, México, which encompasses a record from late Paleozoic to Holocene. The most important localities are emphasized and valued jointly with other elements of the natural and cultural landscape in order to promote their sustainable use through geotourism promotion. For that, a literature review was conducted to locate potential sites of palaeontological interest, and subsequently checked out with field work to evaluate them qualitatively, along with other relevant elements of the landscape. With the results, a map was designed indicating suggested georoutes in which primarily palaeontological localities are highlighted for its educational and scientific value, besides other geological and cultural elements that make up the landscape geodiversity.

EVOLUTIONARY RELATIONSHIPS OF ATOPOSAURID CROCODYLOMORPHS, AND EVIDENCE FOR ALLOPATRIC SPECIATION DRIVING THEIR HIGH DIVERSITY IN THE LATE JURASSIC OF WESTERN EUROPE

Jonathan P. Tennant[1] and Philip D. Mannion[1]

1. Imperial College London, Princes Consort Road, London, SW7 2BP, United Kingdom.
jonathan.tennant10@imperial.ac.uk

Atoposaurid crocodylomorphs represent an important faunal component of Late Jurassic to Early Cretaceous Laurasian semi-aquatic to terrestrial ecosystems, and persisted until the end-Cretaceous with additional specimens known from North America and possibly from Africa. Despite being consistently recovered at the base of Neosuchia, the major crocodylomorph lineage leading to extant crocodilians, their species-level taxonomy and inter-relationships remain poorly understood. We present a systematic taxonomic review of the group, noting numerous anatomical differences between specimens from geographically discrete localities in the Late Jurassic of western Europe. In particular, we recognise a new species of *Alligatorellus* from Germany, previously referred to the contemporaneous French taxon *Alligatorellus beaumonti*, and synonymise the sympatric *Alligatorium paintenense* with *Alligatorium franconicum*. Additionally, we find that a specimen referred to *Alligatorellus* sp. may represent a new and poorly known species. Finally, we find no uni-directional evidence for *Atoposaurus* representing juveniles of either *Alligatorium* or *Alligatorellus*. A comprehensive species-level phylogenetic analysis of unambiguous atoposaurids (16 OTUs and 450 characters) recovers a clade comprising *Alligatorellus* and *Atoposaurus*. *Theriosuchus* is a monophyletic, diverse, and long-lived genus that, together with *Montsecosuchus*, forms the sister taxon to this clade of atoposaurids. *Alligatorium* is recovered as the basal-most atoposaurid. However, support values for these relationships are low. Our revision of atoposaurids leads us to recognise the existence of three sympatric genera in the Late Jurassic of western Europe, with a distinct species of *Alligatorellus*, *Atoposaurus*, and possibly *Alligatorium* present in both French and German basins. This high diversity of closely related species might have been caused by allopatric speciation, driven by fluctuating highstand sea-levels during an interval when western Europe formed an island archipelago system. It is possible that the small body size of atoposaurids resulted from island dwarfing during this interval, but testing of this idea will have to await the discovery of more basal forms from non-island settings. Future research incorporating putative atoposaurids, such as *Karatausuchus* from the Late Jurassic of Kazakhstan, will be crucial in clarifying these relationships, along with specimens identified as *Theriosuchus* sp. or Atoposauridae indet. from a range of Cretaceous localities in North America and Eurasia. These poorly-known specimens suggest a high cryptic diversity of atoposaurids, and may be crucial in unravelling their relationships and the ascent of Neosuchia.

MICROBIOHERMS IN THE SILURIAN (WENLOCK) MASSIE FORMATION OF SOUTHEASTERN INDIANA, UNITED STATES: STRATIGRAPHIC IMPLICATIONS AND EFFECTS ON SEDIMENTOLOGY AND PALEONTOLOGY

James R. Thomka[1] and Carlton E. Brett[1]

1. Department of Geology, University of Cincinnati, Cincinnati, Ohio 45221, USA.
brettce@ucmail.uc.edu

Small buildups composed primarily of micrite and benthic skeletal remains, termed microbioherms, have been recognized within Silurian strata of eastern and midcontinental United States for well over 75 years; however, previous research has focused nearly entirely on such structures within the upper Wenlock (Homerian) Waldron Shale. An undolomitized section of the lower Wenlock (Sheinwoodian) Massie Formation in Ripley County, southeastern Indiana was studied in order to assess the influence of microbioherms on palaeoecologic, taphonomic, and sedimentologic patterns. Elevated baffling of fine-grained material by organisms composing and/or encrusting buildups is evidenced by muddy sediment containing pascichnial traces surrounding microbioherms. Pelmatozoan attachment structures densely encrust microbioherms, but are swollen by secondary stereomic overgrowths reflecting some form of antagonistic interaction or investment in strong affixation to elevated substrates. Clusters of bumastine trilobite material occur in "pockets" related to cavities within buildups, and otherwise rare spathacalymenid trilobites, often exceptionally preserved, are found in muds in the vicinity of partially buried microbioherms. Coeval sections nearby are nearly unfossiliferous as result of dolomitization, but contain recognizable skeletal material in greatest abundance in microbioherm flank beds. The occurrence of these bodies within the Massie Formation is genetically linked to a major transgressive episode, but also reflects a mid-Silurian climatic/palaeoceanographic change.

NEW RECORDS OF SILURIAN GRAPTOLITES FROM CERRO LA SILLA, SAN JUAN PROVINCE, PRECORDILLERA ARGENTINA

Blanca A. Toro[1], Karen Halpern[1] and Marcelo G. Carrera[1]

1. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), Consejo Nacional de Investigaciones Científicas y Técnicas y Universidad Nacional de Córdoba, Av. Vélez Sarsfield 1611. Córdoba. X5016GCA. Argentina.
btorogr@mendoza-conicet.gov.ar

Several stratigraphic sections bearing Silurian graptolites crop out at the Central Precordillera Argentina. Their records restricted to a few levels from La Chilca and Los Espejos formations (Tucunuco Group), became a useful tool for dating this sequence as ranging through the Ordovician-Silurian boundary to Ludlovian age. This study deals with new records from the Cerro La Silla section, located nearby Jáchal city in San Juan Province. It was considered traditionally a key section to study Ordovician calcareous rocks, but recent fieldwork allowed noticing an overlaying siliciclastic unit composed by siltstones and fine sandstones reaching 10 m thick, which can be assigned to La Chilca Formation. *Glyptograptus persculptus* (Upper Ordovician) and *Atavograptus atavus* (lower Silurian) biozones were firstly recognized across the lower 130 m of the Cerro del Fuerte section. Later on, other assemblages including *G. persculptus*, *Pseuclimacograptus robustus*, *Climacograptus angustus* and *C.* cf. *medius*; *Climacograptus acceptus*, *G. maderi*? and *Raphidograptus* sp.; and *Lagarograptus praeacinaces*, *Talacastograptus leanzai* and *Clinoclimacograptus* sp. indicated the presence of the *Glyptograptus persculptus*, the probable *Parakidograptus acuminatus*, and the possible *Atavograptus atavus* biozones, respectively, in the lower 3.65 m of La Chilca Formation at Talacasto section. The studied deposits at Cerro La Silla bear a well preserved brachiopod assemblage and scarce graptolites, flattened or filled with pyrite preserving partial relief. Slender specimens (reaching 1 mm of maximum width), exhibiting everted apertural theca, gently ondulating median septum and longer tubaria than previously described at the Cerro del Fuerte section (up to 20 mm) could be compared with *Pseudoclimacograptus* (*Clinoclimacograptus*) *cingolani*. This endemic taxon, present in all studied levels, is associated with strong specimens of *Diplograptus* sp. in the lowermost fossiliferous strata, and together with *C. innotatus brasiliensis*, *C. normalis* and *C. rectangularis* in the uppermost association. The stratigraphic range of the last two mentioned species expand through the *P. acuminatus* and *A. atavus* biozones at Talacasto section, but their association with *C. innotatus brasiliensis* and *P.* (*Clinoclimacograptus*) *cingolani*, previously described from the early Llandoverian strata at the Cerro del Fuerte section, constrain the studied assemblage to the *Atavograptus atavus* biozone. As a result a similar (Silurian) age could be suggested for the accompanying *Heterorthella* brachiopod assemblage developed a few meters above, as well as the correlation of the yielding graptolite deposits with the lower levels of La Chilca Formation exposed at Cerro La Chilca, Cerro del Fuerte and Talacasto sections, in which the *Atavograptus atavus* biozone was previously recognized.

PALEOBIOGEOGRAPHIC AFFINITIES OF THE EARLY ORDOVICIAN GRAPTOLITES OF WESTERN GONDWANA

Blanca A. Toro[1], Bárbara A. Vento[2] and Jörg Maletz[3]

1. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA), Consejo Nacional de Investigaciones Científicas y Técnicas y Universidad Nacional de Córdoba, Av. Vélez Sarsfield 1611, Córdoba, X5016GCA, Argentina. btorogr@mendoza-conicet.gov.ar.

2. IANIGLA, CCT-CONICET-Mendoza, Av. Ruíz Leal s/n, Parque General San Martín, c. c. 131, Mendoza, 5500, Argentina.

3. Institut für Geologische Wissenschaften, Freie Universität Berlin, Malteser Str. 74-100, Haus B, Raum 105, Berlin, D-12249, Germany.

The Central Andean Basin (Northwestern Argentina and Southern Bolivia) evolved at the western margin of Gondwana during the Early Paleozoic. A number of analyses dealing with the paleobiogeographic affinities of the Early Ordovician graptolite faunas from Northwestern Argentina were carried out in the last decade. Nowadays it is widely accepted that the region was located in middle to high latitudes, included in the cold water faunal realm. Recent studies used statistic treatments to quantitatively interpret the paleobiogeographical relationships between the different regions of the world. Most of them focused on new records representing taxa from uppermost Tremadocian to Floian deposits, which are extensively exposed in the Cordillera Oriental of Argentina and Bolivia. In contrast, paleobiogeographic affinities of the early and middle Tremadocian graptolite assemblages from the Central Andean Basin are still poorly discussed, as they are composed of a few taxa of worldwide distribution. The present work includes a cluster analysis to deal with the occurrence of 17 graptolite taxa recorded throughout the whole Tremadocian (*Rhabdinopora flabelliformis parabola*, *Anisograptus matanensis*, *R. f. anglica*, *Adelograptus*, *Bryograptus kjerulfi*, *Aorograptus victoriae*, *Kiaerograptus supremus*, *Araneograptus murrayi* and *Hunnegraptus copiosus* biozones) from Northwestern Argentina and Bolivia. The resulting dendrogram, which included five further regions of the world, highlights the remarkable graptolite faunal affinities between Central Andean Basin and Baltoscandia with a similarity index of 0.75. This clade is successively related to Laurentia, with a similarity index of approximately 0.65, and to South China (Jiangnan Region) through an affinity index of 0.55. This fact could be interpreted as a closer relationship with the warm water faunal realm than previously established for the Floian graptolite faunas. On the other main clade, the Yangtze Region and Great Britain appear to be separated from other regions through a low affinity index of 0.40. This noticeable difference to the close relationships previously established between graptolite faunas from Northwestern Argentina and those of the Yangtze Region during the middle-upper Floian could be attributed to the influence of water depth, relating to the different paleoenvironment, in which both Floian and Tremadocian graptolite faunas were respectively developed, rather than to the paleolatitudinal thermal gradient.

A NEW RECORD OF CAMELIDAE FROM THE PLEISTOCENE OF TUCUMÁN PROVINCE, ARGENTINA

Vanessa Torres Carro[1], Daniel A. García-López[1,2] and Pablo E. Ortiz[1,2,3]

1. Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina. vanessatorrescarro@hotmail.com

2. INSUGEO (CONICET-UNT), Miguel Lillo 205, San Miguel de Tucumán, 4000, Argentina.

3. Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Catamarca, Avenida Belgrano 300, planta alta, San Fernando de Catamarca, 4700, Argentina.

The fossil record of late Cenozoic mammals in South America is restricted mainly to the Pampean region of Argentina, establishing the base of the chronologic scale for the last 5 Ma on this subcontinent. Although the record of Quaternary mammals in Northwestern Argentina has been notably increased in the last two decades, the study of camelids in this area is currently in a preliminary stage. Particularly for Tucumán Province, only a few of several fossil mammals recovered from Tafí del Valle Formation have been studied in detail. The fossil camelid here presented (PVL 4741) comes from the area of El Rincón, Tafí del Valle, Tucumán. It consists in an incomplete skull of an adult specimen preserving the palatal region with both post-canine series, most of the right orbit and zygomatic arch, part of the skull vault, and rostrum with the last incisors on each side and the left canine. Among other traits, the skull is characterized by its small size, mesognathic and relatively wide rostrum, deep and narrow posterior palatine notch (choanae), dorsally curved zygomatic body (on jugal), small caniniforms, relatively small premolars, P3 mesiodistally oriented, molars with well-developed styles (particularly the mesostyle), U-shaped lophs, and presence of endostyle on M2. This specimen was compared with known South American camelids. This new record differs from *Eulamaops* by the presence of a deep palatine notch. Moreover, the small skull, mesognathic rostrum, and small caniniforms represent differences of this specimen regarding *Paleolama* and *Hemiauchenia*. Adittionally, it differs from *Paleolama* by its U-shaped lophs, which are similar to *Hemiauchenia*, *Lama*, and *Vicugna*. This skull also differs from *Lama* by its smaller size, mesognathic rostrum, lesser development of the mesostyle and narrower M3 (bucolingually), and differs from *Vicugna* by the greater development of the premaxilla, and the mesiodistal orientation of the P3. Nevertheless, the PVL 4741 resembles *Vicugna* in the small size of the skull and the mesognathic rostrum. Finally, the proportionally wide rostrum and the curved trajectory of the jugal on the zygomatic arch represent singular traits that were not observed on any other South American camelid. These characters suggest the possibility that this specimen represents a new taxon, although closely related to extant forms. This record constitutes an important contribution in sight of the scarce knowledge of the distribution of camelids and other mammals during the Pleistocene in Northwestern Argentina.

A SYSTEMATIC REVISION OF THE LATE FURONGIAN TRILOBITES FROM CERRO PELADO, MENDOZA, ARGENTINA

M. Franco Tortello[1]

1. CONICET, División Paleozoología Invertebrados, Museo de Ciencias Naturales, Paseo del Bosque s/n, La Plata 1900, Argentina. tortello@fcnym.unlp.edu.ar

Late Furongian (late Cambrian) trilobites are described from the black, deep water limestones of the El Relincho Formation in Cerro Pelado, Precordillera of Mendoza, western Argentina. Most of the material studied belongs to the Ángel V. Borrello collections in the Museo de La Plata. In addition, selected type specimens of the Carlos Rusconi collections at the Museo de Ciencias Naturales y Antropológicas J. C. Moyano, Mendoza, are revised. The assemblages are largely dominated by the agnostoid *Lotagnostus peladensis* (Rusconi), which proved to be a species with variably effaced dorsal furrows. Polymeroids include *Mendoparabolina pirquinensis* Rusconi, *Hungaia peladensis* Rusconi, and *Loganellus* cf. *macropleurus* Rasetti, as well as some fragmentary remains of uncertain affinities. Generic occurrences, particularly *Hungaia* Walcott and *Loganellus* Devine, strongly support connections with Laurentia. Although the species identified are endemic to the southern Precordillera, they mostly resemble faunas from the lower *Saukia* zone of western North America, and the *Onchonotus richardsoni* and *Keithia subclavata* faunas of eastern Canada and USA.

LATE-MIDDLE MIOCENE SEA SURFACE CHANGES IN THE COLOMBIAN PACIFIC MARGIN THROUGH MICROFOSSILS

Raúl A. Trejos-Tamayo[1,2], Diego F. Vallejo[1, 2], Angelo Plata[2], Andrés Pardo[1,2], Francisco J. Sierro[3], M. Ángeles Bárcena[3] and José-Abel Flores[3]

1. University of Caldas, Calle 65 No 26-10, Manizales, 275, Colombia.
raul.trejos@ucaldas.edu.co

2. Instituto de Investigaciones en Estratigrafía-IIES, Calle 65 No 26-10, Manizales, 275, Colombia.

3. University of Salamanca, Plaza de los Caídos, Salamanca, 37008, Spain.

Data provided by microfossils (calcareous nannofossils, planktonic foraminifera and diatoms) and sedimentary facies analysis from the Pacific Colombian margin suggest the interaction between tectonic pulses and the establishment of surface water patterns in the Neogene. The input of high latitude currents (California and Chile-Peru currents) and the process of acidification or dissolution are evident in the Eastern Equatorial Pacific for the middle Miocene, coinciding with some tectonic pulses during the Neogene. In the Colombian Pacific, the stratigraphy sequence of Ladrilleros–Juanchaco is composed by marine mudrocks and sandstones. This section is the best-preserved and continuous outcropping Neogene sedimentary sequence in the Pacific coast of the northwestern area of South America. In addition, its biochronologic calibration is one of the most complete for this area. The section, according to its micropaleontological content, covers the Burdigalian (16.27 Ma)-Tortonian (10.88 Ma) interval. The microfossils and sedimentary facies indicate two intervals with ecologic, oceanographic and sedimentologic differences. During the Burdigalian-Langhian period, the bulk of carbonates are mainly composed by well-preserved and highly-abundant calcareous nannofossils and foraminifera. The presence of these microfossils shows a strong relation with stratified ocean waters, prevailing oligotrophic-warm conditions. In contrast, at the Serravallian-Tortonian transition, the diatoms first appeared while specimens with carbonate shell decreased. The assemblage (few calcareous nannofossils and diatoms) suggests cold-eutrophic conditions related to a major increase in the primary productivity. After 12.9 Ma, the microfossiliferous record and sedimentation show important modifications: (1) the recovery of diatoms (*Anellus californicus, Stephanopyxis californicus,* and *Thalassionema nitzschioides*), suggesting the presence of high latitude marine currents; (2) the decline of calcareous nannofossils; (3) the disappearance of almost all planktonic foraminifera; (4) an increase in the sandstones beds frequency; and (5) the tectonic disrupt marked by an abrupt change in the sedimentation rates and the presence of soft-sediment deformation structures (slump and convolute structures). These biotic and sedimentological changes would reflect one of the initial docking events of the Panama-Choco block against the northwestern corner of Colombia. Furthermore, any relation to long time ecological-oceanographic changes as the arrival of the high latitude currents is also possible. At this time, the decline and poor preservation of calcareous microfossils can be associated with oceanic events as acidification in the ocean water, NH_3 hiatuses, and the reduction of calcium carbonate content. This last event is well known as the 'Carbonate Crash'. However, the existence of dilution processes due to the input of terrigenous material from continental areas is not excluded.

THE FIRST EVIDENCE OF NATURAL ENDOCAST OF SNAKES (*DINILYSIA PATAGONICA*) IN THE CRETACEOUS OF PATAGONIA, ARGENTINA

Laura N. Triviño[1] and Adriana M. Albino[2]

1. CONICET- Sección Herpetología, Museo de La Plata, Universidad Nacional de La Plata, Paseo del Bosque s/nº, B1900FWA La Plata, Argentina. lauratrivinio@gmail.com
2. CONICET- Departamento de Biología, Universidad Nacional de Mar del Plata, Funes 3250, B7602AYJ Mar del Plata, Argentina.

Dinilysia patagonica is a well known snake from the Santonian-Campanian of Patagonia. A medium-sized skull of this snake found in rocks of the Bajo de La Carpa Formation near Neuquén city, in Neuquén province (Argentina) includes a rather well preserved natural endocast. This skull, which is deposited in the Museo de La Plata, represents the first endocast fossil record of snakes. The fully closed shape of the skull of snakes makes the skull-brain ratio similar to that of mammals, where the cavity is completely occupied by soft tissue. Given that, the endocast reflects the shape of the cranial cavity with relatively great accuracy. This skull (MLP 79-II-27-1) was prepared in the laboratory by removing parietal, prootic, supratemporal, supraoccipital and exoccipital by artificial means, in order to expose the matrix that filled the cranial cavity. The main mass of the central nervous system that has been preserved is possibly Myelencephalon, Cerebellum and Midbrain. Midbrain keeps laterally the ganglion of the trigeminal nerve. The nervous system has been well preserved. Its surface is smooth, except for two small prominences that make up the cerebellum. Furthermore, on the right side is preserved the cavity of the inner ear, with a greater size than those prominences. The size and shape of the inner ear endocast provide the maximum dimensions for membranous inner ear structures. This cavity is surrounded by well-defined spaces, which would be representing the semicircular canals of the inner ear (lateral, caudal and rostral canal). This general morphology and the size of the inner ear reminds the morphology of the living *Uropeltis*, which could mean or indicate a digger lifestyle in *Dinilysia.*

ON THE PRESENCE OF THE GENUS *RHADINOSUCHUS* IN THE LATE MIDDLE–EARLY LATE TRIASSIC CHAÑARES FORMATION OF NORTHWESTERN ARGENTINA

María J. Trotteyn[1,2], Martín D. Ezcurra[3], María B. von Baczko[2,4] and Julia B. Desojo[2,4]

1. INGEO. Universidad Nacional de San Juan. San Juan, Argentina. jtrotteyn@unsj.edu.ar
2. CONICET, Argentina.
3. School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham, UK.
4. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia". Buenos Aires, Argentina.

Proterochampsians are a group of quadruped, predatory archosauriforms usually considered as one of the potential successive sister-taxa of the crown group Archosauria. This clade is endemic to the late Middle and early Late Triassic of South America, with a total of eight nominal species recovered in the Ischigualasto-Villa Unión Basin of Argentina and the Paraná Basin of Brazil. We report here a new partial proterochampsian skeleton collected in the "Campo El Torcido" locality of the Chañares Formation (late Ladinian–earliest Carnian). This locality is situated approximately 4 km east from the "Chañares type" (= Far East Pocket) locality, which has yielded most of the fossil tetrapod specimens known so far from the formation. The new specimen was collected in the lower member of the unit and in older levels than those of the "Chañares type" locality. The new specimen (CRILAR PV 488) is very well preserved and includes a right maxilla, distal end of right quadrate, partial left dentary, multiple vertebrae from all the vertebral regions, left scapula, right ulna and radius, right ischium, partial right pubis, distal half of left femur, right tibia and fibula, and possible left metatarsal V. CRILAR PV 488 was associated with an isolated cynodont right ilium (CRILAR PV 489) and a partial postcranium of *Gracilisuchus stipanicicorum* (CRILAR PV 490). A quantitative phylogenetic analysis found CRILAR PV 488 more closely related to *Rhadinosuchus gracilis*, from the late Carnian of Brazil, than to other proterochampsians because of the presence of an antorbital fossa immediately below the antorbital fenestra on the horizontal process of the maxilla. In addition, CRILAR PV 488 plus *Rhadinosuchus gracilis* were found as the sister taxon of *Chanaresuchus bonapartei* because of the presence of an anteroposteriorly broad antorbital fossa on the ventral process of the lacrimal. Unfortunately, there are only a few overlapping bones between CRILAR PV 488 and the holotype of *Rhadinosuchus gracilis* (e.g. maxilla, dentary, cervical vertebrae), and we were not able to recognize taxonomically informative differences between both specimens. As a result, we assign CRILAR PV 488 to *Rhadinosuchus* sp. The new specimen reported here improves considerably the anatomical knowledge of *Rhadinosuchus*. CRILAR PV 488 also adds a new faunistic component to the vertebrate assemblage of the Chañares Formation and further increases the taxonomic richness of proterochampsians in the late Ladinian–earliest Carnian of South America.

THE PLAINS VIZCACHA *LAGOSTOMUS MAXIMUS* (DESMAREST) IN THE LATE PLEISTOCENE OF URUGUAY: BIOGEOGRAPHIC AND ENVIRONMENTAL CONSIDERATIONS

Martín Ubilla[1] and Andrés Rinderknecht[2]

1. Facultad de Ciencias, Iguá 4225, Montevideo, 11.400, Uruguay. martinubilla@gmail.com
2. Museo Nacional de Historia Natural de Montevideo, 11.000, Uruguay.

The plains vizcacha *Lagostomus maximus* is a member of the family Chinchillidae (Rodentia, Mammalia) that is widespread today in part of Argentina, southeastern Bolivia and southern Paraguay. It is absent in Holocene beds and living mammal communities of Uruguay. There are mentions for the Pleistocene of Argentina and is frequent in the Holocene of this country, being the taxon guide of the Platan Stage/Age of the Buenos Aires Province. The record of the living *L. maximus* in Late Pleistocene beds of Uruguay (Dolores Formation; Santa Lucía Basin, Pilatos creek, 34°17'27.52''S 55°56'3.29''W) is described based on an almost complete skull, left mandible and postcranial bones mostly articulated of the same specimen (BRA-2-993). From the same level two fragmentary skulls (BRA-2-879, BRA-3-933) were found lacking the postorbital region, presumably belonging to the same species. Optically Stimulated Luminescence and AMS ^{14}C ages of 32 to 25 kyrs correlate with the last phases of Marine Isotopic Stage 3 and the onset of Last Glacial Maximum. Due to *L. maximus* has strong sexual dimorphism and ontogenetic variability, the fossil material was separately compared with male and females including three different ontogenetic stages (young, subadult and adult) (N=33♀, 40♂) of the living *L. maximus*. It was also compared with extinct nominal species of the Pleistocene of Argentina. According to previous available studies on this taxon and qualitative and preliminary quantitative comparisons performed, the material of the Pleistocene of Uruguay belongs to a subadult or young adult and likely a female of the living plains vizcacha. The skull and mandible size matches with a subadult. The temporal crest is slightly developed, rounded and the sagittal crest is relatively short, the vertical ramus of zygomatic arch is thick, character states predominantly observed in subadult and young adult females. We cannot found relevant characters related to the extinct nominal species which are hard to be differentiated from the living one. Mostly open and probably grassland or semi-arid environments are inferred according to the current adaptations of the living *L. maximus*. This is also suggested by the co-ocurrence in the same beds of *Microcavia*, *Galea*, *Chaetophractus*, and *Vicugna* among others. The disappearance of *L. maximus* from Uruguay implies a local extinction or shifting range. Even difficult to be explained, its extinction could be likely influenced by the reduction of the aforementioned environmental contexts in the latest Pleistocene or early to middle Holocene. [Contribution to CSIC-Project-C211-348].

FIRST RECORDS OF PERMIAN TRILOBITES FROM PERÚ

N. Emilio Vaccari[1,2], Edgar Huacallo Pacheco[3] and Beatriz G. Waisfeld[1,4]

1. Centro de Investigaciones en Ciencias de la Tierra (CICTERRA-CONICET-UNC), Av. Vélez Sarsfield 1611, Córdoba, X5016GCA, Argentina. evaccari@efn.uncor.edu

2. Universidad Nacional de La Rioja, Av. René Favaloro s/n, La Rioja, 5300, Argentina.

3. Universidad Nacional San Antonio Abad, Av. De la Cultura 733, Cusco, 084, Peru.

4. Centro de Investigaciones Paleobiológicas (CIPAL), Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Av. Vélez Sársfield 299, Córdoba, 5000, Argentina.

Despite the great thickness and geographic coverage of upper Paleozoic successions of South America, trilobite records are sparse and poorly known. Until not long ago *Australosutura argentinensis* Hahn and Hahn was the only trilobite reported from Carboniferous strata in Argentina (Tepuel-Genoa Basin, Patagonia). Only recently an assemblage composed of the proetine *Pudoproetus* Hessler associated with Cummingellinae indet. of Tournasian age have been recorded in La Rioja Province. In Brazil records of upper Paleozoic trilobites are restricted to three Carboniferous species included in the genus *Ameura* Weller: *A. tapajotensis* (Katzer), *A. plummeri* (Kegel), and *A. duartei* (Kegel) from the Amazon and Parnaíba basins. Furthermore, three taxa are so far known from Bolivia: *Pseudophillipsia (Carniphillipsia) yampupatensis* (Arellano), *Triproetus dereimsi* (Arellano), and *Ditomopyge* sp. indet. that come from the upper Carboniferous -lower Permian Copacabana Formation (Moscovian to Sakmarian). Here we report for the first time Peruvian trilobites derived from the Copacabana Formation exposed in the town of San Salvador in the vicinity of Cusco. In this locality the Copacabana Formation is about 600 m thick and is composed of dominantly massive limestone, alternating with bituminous shales, and subordinate dolomites, siltstones, and sandstones. The early Permian age of this succession has been constrained upon the *Triticites opimus* foraminifera zone. Trilobites are moderately abundant, occur either as isolated sclerites or as articulated specimens, occasionally enrolled, or as moult ensembles. They largely preserve their cuticle in unweathered limestone and occur as external and internal moulds in weathered limestones. Associated fauna include bryozoans, brachiopods, gastropods, and foraminifera. In our preliminary study at least four different taxa have been assessed. Relatively complete material allows the identification of a new species of *Ditomopyge*, and several well preserved pygidia are referred to *Triproetus* cf. *T. dereimsi*. Additional pygidia in the collection suggest the presence of two different morphotypes that still remain unidentified. The presence of *T.* cf. *T. dereimsi* favors a tentative correlation with the Yaurichambi section (La Paz Department, Bolivia). Overall, this finding suggests that trilobite diversity is considerably higher than previously addressed for the Permian of South America. From a paleogeographic viewpoint the taxa so far recorded largely display a widespread distribution; however, the presence of the swollen median preoccipital lobe in *Ditomopyge* n. sp. points to a closer link with the North American *D. scitula* group. Further studies of Peruvian trilobites will be of particular significance to unravel paleogeographic connections of this part of Gondwana during the late Paleozoic.

METACRYPHAEUS TUBERCULATUS KOZLOWSKI (PHACOPIDA, CALMONIIDAE) FROM THE PIMENTEIRA AND CABEÇAS FORMATIONS, DEVONIAN OF THE PARNAÍBA BASIN, BRAZIL

Felipe van Enck Meira[1] and Juliana de Moraes Leme[2]

1. Programa de Pós-graduação em Geoquímica e Geotectônica, Instituto de Geociências, Universidade de São Paulo – USP. Rua do Lago, 562, CEP 05508-080, São Paulo/SP, Brazil. fvemeira@gmail.com

2. Departamento de Geologia Sedimentar e Ambiental, Instituto de Geociências, Universidade de São Paulo – USP. Rua do Lago, 562, CEP 05508-080, São Paulo/SP, Brazil.

The systematics of calmoniid trilobites from the Devonian of the Parnaíba Basin, in the northeast of Brazil, was revised in this study, considering recent works that used the taphonomic modifications and how they affect taxonomy. The present study reinforces the occurrence of *Metacryphaeus tuberculatus* Kozlowski in the Pimenteira Formation based on specimens found in the region of João Costa city, southeastern Piauí State. The species *Metacryphaeus meloi* Carvalho *et al*. from the Cabeças Formation is interpreted as a synonymous of *M. tuberculatus* based on the similarity between it and the Bolivian taxon, and some of the features used to distinguish them – less inflated frontal glabellar lobe, narrower cephalic axial furrows, less conspicuous tubercles on the cephalon and less defined lateral glabellar lobes – are likely artifacts caused by taphonomic processes. The study also presents evidence of genal spines in some cephala of *M. tuberculatus* from the Cabeças Formation. This feature added to wider genae in some specimens and the convexity in the first pygidial axial rings are interpreted as intraspecific variation of this taxon. These findings raise important questions on the stratigraphic relation between the Pimenteira and Cabeças Formation and spread the distribution of *M. tuberculatus*. Finally, a revision of some species included in the "*Metacryphaeus tuberculatus* Group" is here considered advisable.

EARLY PALEOGENE OF MENDOZA: NEW DATA AND BIOSTRATIGRAPHIC IMPLICATIONS

Bárbara Vera[1], Maisa Tunik[2] and Esperanza Cerdeño[1]

1. Paleontología, IANIGLA, Centro Científico Tecnológico CONICET-Mendoza, Av. Ruiz Leal s/n, Mendoza, 5500, Argentina. bvera@mendoza-conicet.gob.ar

2. CONICET-UNRN, Sede Alto Valle, Isidro Lobo y Belgrano, General Roca, Rio Negro, Argentina.

Among the Cenozoic vertebrates of Mendoza Province (Argentina) listed by Pascual and de la Fuente, the authors referred to some fossils collected by the geologist Estanislao Kozlowski in the area named Agua de Flores, Malargüe Department. These remains were considered belonging to the Family Oldfieldthomasiidae (Notoungulata) and are housed in the Museo de La Plata (MLP 96-VIII-15-1, two right mandibles: one with m1-m2 and other with two broken teeth; and MLP 96-VIII-15-2, a calcaneum, an astragalus, and vertebrae). In an unpublished report, Kozlowski described two separated geologic sections in the area, Agua de Flores I and II, and mentioned some isolated mammal bones from the base of the Laguna Blanca Group, a unit considered to be late Oligocene. However, the specimen MLP 96-VII-15-1 was determined as aff. *Peripantostylops* (Henricosborniidae), a notoungulate known in Cañadón Vaca (Chubut Province), a locality considered to represent the Vacan South American Land Mammal Age (lower-middle Eocene). Based on this background, since 2008, we began to explore the outcrops surrounding the area between Puesto Agua de Flores and Puesto Agua de Isaac, distant approximately 8 km from each other and located at the east of Sierra Cara Cura. Recently, near Agua de Isaac, we recovered other isolated specimens from a tuffaceous sandstone 2 m thick, located 108 m above the angular unconformity that separates the Malargüe and Laguna Blanca Groups. This last unit can be correlated with the pre-orogenic sequence of Silvestro and Atencio, previously set on the Oligocene based on the age of overlying basalts. The new fossils (housed in the Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, Mendoza) include a maxillary fragment (IANIGLA-PV 85) bearing two brachydont teeth (P3-P4?) with close roots and a large, irregular central fossette, a mandibular symphysis lacking teeth (IANIGLA-PV 83) and a fragment of bone (IANIGLA-PV 82). Despite their bad preservation, the teeth resemble the morphology of Eocene notoungulates from Patagonia as it happened with MLP 96-VIII-15-1. Besides, the astragalus MLP 96-VIII-15-2 shows also an oldfieldthomasiid appearance. The presence of these notoungulate remains with Eocene affinities would therefore change the span of the pre-orogenic stage of the basin in the Malargüe fold and trust belt. Besides, it constitutes a new record for the Paleogene of Mendoza Province and Argentina, and an interesting novelty for further geologic, paleontological and biostratigraphic studies.

FERNS FROM THE CERRO NEGRO FORMATION (EARLY CRETACEOUS, ANTARCTICA): DIVERSITY, ROLE IN THE PALAEOCOMMUNITY, AND PALAEOCLIMATIC SIGNIFICANCE

Ezequiel I. Vera[1,2]

1. CONICET-Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Av. Ángel Gallardo 470, (C1405DJR) Buenos Aires, Argentina. evera@macn.gov.ar

2. Área de Paleontología, Departamento de Geología, Universidad de Buenos Aires, Pabellón 2 Ciudad Universitaria, (C1428EGA) Buenos Aires, Argentina.

The Cerro Negro Formation is a volcaniclastic non-marine sequence which crops out at Byers Peninsula in Livingston Island, and at President Head in Snow Island (South Shetland Archipelago, Antarctica). Radiometric dating indicate ages of 120.3±2.2, 119.4±0.6, and 119.1±0.8 Ma for deposits near the base, and 120±3 Ma for the youngest exposed levels, restricting the deposition of the unit to the Aptian. A very well preserved palaeoflora has been recovered from this formation. Many studies have been made, focusing on systematics, palaeoecology, and biostratigraphy. The discovery of abundant impression/compression and permineralized fossil plants, allowed a more complete description of the palaeoflora that thrived in this region during the Early Cretaceous. Noteworthy, the new data, when included in previous taxonomic lists, show that ferns represented an important floristic element in these communities. Among this group of plants, Cyatheales are the most diverse, with three fertile fronds (*Sergioa austrina* Césari, *Eocyathea remesaliae* Césari and *Lophosoria cupulata* Cantrill), and four stems (*Alienopteris* Vera, *Yavanna* Vera, and two yet-unnamed taxa), as well as three spore species. Other ferns, such as the Osmundaceae (represented by two species of *Millerocaulis*, sterile fronds, and spores) and Schizaceae (represented only by disperse spores), are also abundant in the unit. The Marattiaceae, a group of ferns with a sparse fossil record after the Jurassic, are also present, by a fragmentary fertile frond, and permineralized pinnules with attached synangia, being both fossils, in account of their comparable morphology and dimensions, most certainly part of a single biological entity. Using Niklas equations for calculating the height of fossil plants, the height for the ferns preserved as permineralized stems was estimated, and the results reveal that some of these forms were probably part of the forest canopy, along with conifers and other gymnosperms. Finally, the presence of abundant and diverse groups of ferns which are nowadays restricted to frost-free climatic conditions (e.g., Cyatheales) support the previously suggested mild climatic conditions for these high latitudes during the Aptian. In addition, the record of Marattiaceae (probably part of the crown-group Marattiaceae due to its similarities with *Marattia* and *Ptisana*) may point to warmer climatic conditions, taking into account that extant representatives of this family live in humid tropical or subtropical environments.

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THE CASE OF THE HOLOCENE '*LAGOSTOMUS MAXIMUS* BIOZONE' AT LOW LATITUDES OUTSIDE THE TRADITIONAL BONARIAN REGION PAMPA NORTE

Raúl I. Vezzosi [1]

1. Laboratorio de Paleontología de Vertebrados, Centro de Investigaciones Científicas y Transferencia de Tecnología a la Producción, Consejo Nacional de Investigaciones Científicas y Técnicas, Materi y España s/n, 3105 Diamante, Entre Ríos, Argentina. vezzosiraul@gmail.com

The chronological scale and continental biostratigraphy of the South American late Cenozoic and mainly the Quaternary of Argentina are based on mammals. Especially, the reliability of the local biostratigraphical units lies on the authenticity of the stratigraphic position of the fossil mammals collected from the traditional Pampean region at the Buenos Aires Province, and the precision of its taxonomic studies. Consequently, the *Lagostomus maximus* biozone is the biostratigraphical unit representative of the local Platan Stage/Age which corresponds to the chronological Holocene Series *sensu lato*. Until the present, paleontological contributions had been scarce, principally consisting of reports of isolated discoveries and preliminary groupings of mammals without a good stratigraphical context. However, the substantial number of geological and stratigraphical studies conducted in the last twenty years, outside of the Bonarian region, has provided a useful basis for new biostratigraphic studies of the Pleistocene in Argentina. The aim of this work is to discuss the biostratigraphical/chronological hypothesis which sets the species *L. maximus* as the fossil guide taxon for the chronological Holocene Series (Platan Stage/Age) in lowlands. However, *L. maximus* is herein reported since the Middle Pleistocene (≈178 ±20 ka AP, LVD 2826 *OSL dating*) to Late Pleistocene-early Holocene (Tezanos Pinto Formation) from Santa Fe Province and surrounding area. In this sense, this new record in a suitable stratigraphical context, and recovered outside of the traditional Bonarian geomorphological province called Pampa Norte, clearly suggests an early ocurrence at low latitudes than that of the Pampean region at Buenos Aires. These new Pleistocene records allow establishing that *L. maximus* is not an accurate regional biostratigraphical indicator to the chronological age Holocene. Therefore, the Platan Stage/Age should be interpreted as a local sequence for the Buenos Aires Province and should not be extrapolated to a regional framework to define and compare lithostratigraphical sequences of Holocene age.

THE SOUTHERMOST UNEXPECTED RECORD OF THE ERETHIZONTID *COENDOU* LINNAEUS FROM THE PLEISTOCENE OF PAMPA NORTE, SANTA FE PROVINCE, ARGENTINA

Raúl I. Vezzosi [1]

1. Laboratorio de Paleontología de Vertebrados, Centro de Investigaciones Científicas y Transferencia de Tecnología a la Producción, Consejo Nacional de Investigaciones Científicas y Técnicas, Materi y España s/n, 3105 Diamante, Entre Ríos, Argentina. vezzosiraul@gmail.com

The American porcupines are systematically grouped in three genera: *Coendou* Lacépède, *Erethizon* Cuvier, and *Sphiggurus* Cuvier, although *Coendou* is considered the valid Neotropical taxon. The semiarboreal *Erethizon dorsatum* (Linnaeus) is the unique extant form that survived in North America after the Great American Biotic Interchange (GABI) (late Pliocene, *ca*. 2.7–2.5 Ma). At present, 13 species live in Central and South America from tropical to subtropical regions. The southernmost occurrence is found in woodland regions from north of Argentina and Uruguay. However, the fossil record of the group had an early beginning in the late Oligocene (Deseadan Stage/Age) from Patagonia and Bolivia, declining its richness and distribution since late Miocene times (Huayquerian Stage/Age). In North America the semiarboreal genus *Erethizon* is known from the Plio-Pleistocene to the extant four species, whereas the trustworthy records of Erethizontidae are restricted to the austral region of South America with *Coendou magnus* (Lund) coming from the Late Pleistocene-early Holocene of Brazil and Late Pleistocene of Uruguay. An additional record from the Late Pliocene of Argentina (Jujuy Province), with uncertain stratigraphical context, is probably the southernmost fossil record of '*Erethizon*' genus. However, a recent revision referred this porcupine to cf. *Coendou* genus. The morphological features and mandible dimensions of the specimen herein analyzed (MFA–Pv 1706) clearly indicate that it is close to the Pleistocene erethizontid *C. magnus*. This material comes from fluvial sediments of the Timbúes Formation (Late Pleistocene) at the geomorphological province of Pampa Norte, outside from the traditional bonaerian Pampean region. Thus, it constitutes the southernmost fossil record of a modern Erethizontidae with reliably stratigraphic context.

DIVERSITY AND ENAMEL EVOLUTION IN MOLARS OF OCTODONTOIDEA (RODENTIA, HYSTRICOGNATHI)

Emma C. Vieytes[1]

1. CONICET – Sección Mastozoología, Zoología Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n, B1900FWA La Plata, Argentina.
cvieytes@fcnym.unlp.edu.ar

Octodontoidea are recorded since the early Oligocene of Patagonia, Argentina and Peru. This superfamily has the greatest morphological diversity and specific richness among South American Hystriconathi rodents and they are represented by the families Octodontidae, Echimyidae, Abrocomidae and the extinct Acaremyidae. The assignment of Oligocene-middle Miocene taxa to a particular family is controversial, since they have very similar dental morphologies with generalized characters. The discovery of a large number of fossil taxa has changed the concept of the basal differentiation of Octodontidae and Echimyidae, and recent cladistic analyses show that several fossil taxa previously classified within octodontoids, would be in fact basal caviomorphs. The aim of this work is to analyze the evolution of the enamel in molars of different lineages of Octodontoidea on phylogenetic hypotheses built on cranio-dental and molecular characters. Two types of enamel were found in this group, radial enamel (RE), and Hunter-Schreger bands (HSB). The schmelzmuster of basal brachyodont taxa is composed of two layers: RE occupying the upper part of the crown (up to 1/2 of the sidewalls) and covering the inner HSB that form the rest of the crown. This plesiomorphic pattern is recognized in brachyodont molars of non-related taxa. With the acquisition of hypsodonty, the upper portion of the crown is lost, including the occlusal RE. The further increase in crown height involves changes in tooth macromorphology as well as in the sidewall schmelzmuster. Despite the fragmentary fossil record, the evolution of the schmelzmuster can be traced in some lineages. The Colhuehuapian (early early Miocene) taxa with slight hypsodonty show RE internal to the HSB, as in Acaremidae and *Protadelphomys-Willidewu*, or external to it as in *Plesiacarechimys* and *Prospaniomys*. The Santacrucian (early Miocene) hypsodont "Adelphomyinae" display a three layer pattern in which the internal RE would be added from a two layer pattern, with external RE and internal HSB as in the Pinturan (pre-Santacrucian) *Prostichomys*. Ctenomyidae, a much diversified lineage but with low morphologic disparity, display the same schmelzmuster since the late late Miocene when they incorporated an external layer of RE. In turn, the Octodontidae, less diversified but with more morphological disparity, present a greater diversity of schmelzmuster. Among Echimyidae, only those taxa with some hypsodonty degree display RE in their schmelzmuster. These results suggest that the schmelzmuster evolved in correlation with changes in the hypsodonty degree, as a response to different functional requirements, strengthening the enamel bands which act as cutting edges.

DIVERSIFICATION TRENDS OF MARINE VERTEBRATES DURING THE NEOGENE ON THE TEMPERATE PACIFIC COAST OF SOUTH AMERICA

Jaime A. Villafaña[1] and Marcelo M. Rivadeneira[2]

1. Laboratorio de Paleobiología, Centro de Estudios Avanzados en Zonas Áridas (CEAZA), Chile.
jaime.villafana@ceaza.cl

2. Universidad Católica del Norte, Larrondo 1281, Coquimbo, 1781421, Chile.

Despite the fact that Neogene outcrops along the Temperate Pacific coast of South America harbor a rich marine vertebrate fossil record to date there are no studies aimed at understanding the diversification patterns of these taxa. Here we analyze diversification trends based on the stratigraphic ranges of 86 genera of marine vertebrates, including sharks, rays, chimaeras, marine mammals and seabirds. The richness of genera shows a hump-shaped trend, with maximum values around the late Miocene, driven by a large pulse of origination during mid-Miocene and higher extinction rates during the Pliocene. Trends were markedly different among taxa and departed largely from expectations based on global diversification patterns. Moreover, these trends cannot be explained solely as a sampling artifact derived from sampling intensity (*i.e.*, number of occurrences) or sedimentary rock availably (*i.e.*, number of geologic maps). A large fraction of genera (42%) went globally extinct by the late Pliocene-Pleistocene, and the extinction was highly selective according to different ecological and life history traits. A random forest analysis showed that taxonomic structure and the geographic mid-point of distribution could explain up to 83% of extinction of genera. The extinction was taxonomically clumped (i.e., disproportionally high in Cetacea and very low in Carcharhiniformes), and it was higher in those taxa living in the northern area of the Temperate Pacific coast of South America. Our results suggest that the particular paleogeographic, paleoclimatic and paleoceanographic events that took place during the Neogene along the Temperate Pacific coast of South America had a deep impact on the structure of marine biodiversity. [Funded by FONDECYT grants 1110582 and 1140841].

STOMATAL SIZE AS A TOOL FOR ESTIMATING RELATIVE GENOME SIZE OF AN EARLY DEVONIAN LYCOPOD FROM THE RHYNIE CHERT (SCOTLAND, UK)

Zuzanna Wawrzyniak[1], Carlos A. Góis Marques[2] and Paul Kenrick[3]

1. Department of Palaeontology and Stratigraphy, Faculty of Earth Science, University of Silesia, Będzińska 60 St, Sosnowiec, 41-200, Poland. zuza.wawrzyniak@gmail.com

2. Universidade da Madeira, Grupo de Botânica da Madeira, Centro de Ciências da Vida, Campus Universitário da Penteada, Funchal, 9020-105, Portugal.

3. Department of Earth Sciences, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK.

Changes in genome size are thought to have played a major role in plant evolution, and a recent survey concluded that the earliest land plants had exceptionally large genomes. To test this hypothesis, we investigated genome size in the 407 Ma lycopod *Asteroxylon mackiei* from the Rhynie Chert, using the correlation between genome size (GS) and stomatal guard cell length (GCL), which is well-established in living plants. We measured 528 stomata on leaves and stems. Measurements showed an approximate normal distribution but a very broad range of values (mean GCL 62 µm; min 39 µm; max 92 µm). To calibrate our results for *Asteroxylon* against living plants, we tested for the first time GCL vs GS method in living lycopods (Selaginellaceae and Lycopodiaceae). We used *Selaginella kraussiana* (Selaginellaceae) in different polyploidy stages. A positive correlation between GS and GCL was present in 4 of 5 specimens, but further verification is desirable. *Selaginella* has one of the smallest known plant genomes (c. 1C= 0.16 pg), and this is reflected in the GCL of *S. kraussiana* (mean 27 µm; min 15 µm; max 41 µm). Also a positive correlation between GCL and GS was shown in all measured Lycopodiaceae: *Diphasiastrum tristichyum* (GCL= 35.8 µm; GS of 1C= 2.63 pg), *Lycopodium clavatum* (GCL= 38.5 µm; GS of 1C= 2.86 pg), *D. complanatum* (GCL = 42.3 µm; GS of 1C= 2.88 pg) and *Huperzia lucidula* (GCL= 49.5 µm; GS of 1C= 5.64 pg). From the living lycopods the GCL of *Huperzia selago* (mean 61.5 µm) is closest to that of *A. mackiei* (62 µm), however the range of values in *H. selago* (min 40 µm; max 83 µm) is narrower. Unfortunately, GS in *H. selago* is currently unknown, but it is expected to be greater than that of *H. lucidula*. We conclude that the relative genome size of *Asteroxylon mackiei* was large but comparable to some modern Lycopodiaceae. Mean guard cell length of *A. mackiei* and *H. selago* are similar, but the range of values in *Asteroxylon* is much broader than in living plants. That might indicate the presence of different ploidy levels in *Asteroxylon*.

REGRESSIVE-TRANSGRESSIVE CYCLES OF THE ITARARÉ GROUP AND MACROFOSSILIFEROUS ASSOCIATION ON THE EASTERN BORDER OF THE PARANA BASIN, PARANA AND SANTA CATARINA, BRAZIL

Luiz C. Weinschütz[1], João H. Zahdi Ricetti[1,2], Everton Wilner[1,2] and Camila Cassiano de Moura[1]

1. Universidade do Contestado (UnC), Centro Paleontológico (CENPALEO), Av. Pres. Nereu Ramos, 1071, Mafra, 89300-000, Brazil. luizw@unc.br

2. Universidade Federal do Rio Grande do Sul (UFRGS), Programa de Pós-Graduação em Geociências (PPGGeo), Av. Bento Gonçalves, 9500, Porto Alegre, P. Box 15001, 91501-970, Brazil.

The Itararé Group, Paraná Basin, was originated in the great glaciation that affected Gondwana during the Permo-Carboniferous. In the northern of the Santa Catarina (SC) and southern of Paraná States, eastern border of the basin, it is possible to recognize four transgressive-regressive cycles for the Itararé Group. The first cycle (Campo do Tenente Fm.), is considered strictly continental. The second cycle (lower portion of the Campo Mourão Fm.) is *ca.* 90 m thick, and includes, from base to top, varvites, sandstones/siltstones, diamictites, and siltstones/shales, followed by transgressive deglaciation facies, and culminating with a fossiliferous siltstone containing sponges, inarticulated brachiopods and gastropods. The third cycle (upper part of the Campo Mourão Fm.) is *ca.* 100 m thick, and consists, from base to top, of thick sandy deposits, succeeded by deglaciation deposits, and the "Lontras Shale", reflecting the development of a large marine platform built in high base level conditions. A rich, fossiliferous black-shale with bony and cartilaginous fishes, conodonts, escolecodontes, brachiopods, porifera, crustaceans, insects, and plant remains is present in the area of Mafra, SC. The fourth cycle (Taciba Fm.), is *ca.* 130 m thick and starts with a thick basal diamictite (product of deglaciation), followed by deltaic and glacio-marine horizons, a thick sectioof turbidites (lower sea tract), diamictites, sandy-clay rhythmites, a fossiliferous siltstone yielding bivalves and brachiopods (deglaciation system), and thick offshore marine shale deposits. The succession described above highlights the relationships between occurrences of macrofossils and marine transgressions (produced by the relative base level increase as a consequence of heating periods during the Gondwana glaciations) in the Itararé Group.

PHANEROZOIC BRACHIOPODA FROM BRAZIL IN NUMBERS

Carolina Zabini[1] and Laisa E. Menin[1]

1. Universidade Tecnológica Federal do Paraná, UTFPR, Campus Dois Vizinhos. Estrada para Boa Esperança, km 4, Comunidade São Cristóvão, Dois Vizinhos, Paraná, PR 85660-000, Brazil.
carolinazabini@utfpr.edu.br

The data presented on this review derives from a bibliographical research on papers and non-published monographs of (most of them) Brazilian authors that work and have worked with brachiopods. A research at major periodical sites and databases was also performed. Within the Brazilian continental area there are around 47 sedimentary basins; however only four of them have fossil brachiopods recorded (three with Paleozoic records and one with a Cenozoic record). The aim of this research is to gather information on the actual diversity of Brachiopoda in Brazil. In the Amazonas Basin, there are 2 Silurian genera cited (*Orbiculoidea* and *Lingula*), 15 Devonian genera (*Acrospirifer*, *Amphigenia*, *Camarothoechia*, *Chonetes*, *Derbyina*, *Discomyorsthys*, *Megastrophia*, *Pustulatia*, *Patriaspirifer*, *Podolella*, *Platyorthis*, *Plicoplasia*, *Protoleptostrophia*, *Tropidoleptus* and *Schuchertella*), and 7 Carboniferous genera (*Buxtonoides*, *Amazonoproductus*, *Linoproductus*, *Anthracospirifer*, Spiriferidae gen. and sp. indet., *Neospirifer*, *Cleithyrydina*). At the Parnaíba Basin there are 17 Devonian genera cited (*Australocoelia, Clarkeia, Chonetes, Cranaena, Derbyina, Montsenetes cf., Mucrospirifer, Orbiculoidea, Paranaia, Pleurochonetes, Plicoplasia, Pustulatia, Scaphiocoelia?, Schuchertella, Spirifer, Strophomena, Tropidoleptus*) and only 1 Pennsylvanian genus (*Orbiculoidea*) and 4 Brachiopoda families (Productidae, Cyrtospiriferidae, Spriferida and Strophomenida) cited. The Paraná Basin bears 2 Silurian genera (*Orbiculoidea* and *Scaphiocoelia*/*Stricklandia?*), and 10 Devonian genera (*Chonetes*, *Coelospira*, *Cryptonella*, *Derbyina*, *Leptocoelia*, *Lingula*, *Orbiculoidea*, *Schuchertella*, *Spirifer*, *Lingulepis*). Carboniferous strata in the Paraná Basin have only 1 genus (*Langella*). Finally, the Sergipe-Alagoas Basin has 1 brachiopoda genus (*Lingularia*) described and illustrated. Many of these papers do not have a taxonomic focus, and only cite these genera, not describing or illustrating them. *Lingula*, ?*Langella* (Linguloidea, Lingulidae), ?*Schizobolus* (Discinoidea, Trematidae), *Discradisca* and *Lingulodiscina* (Discinoidea, Discinidae) are the only Linguliformea genera cited in the 1997 Brachiopoda Treatise as occurring in Brazilian –or at South American– strata. Treatise data on the Order Lingulida show that there are 90 genera around the globe, and only two of these genera occurs in Brazil (*Lingula* and *Langella*). However, Paleobiology Database points the presence of 137 Lingulida genera around the world, and, in Brazil, it shows the presence of 4 genera (*Lingula, Dignomia, Lingularia* and *Orbiculoidea*). This data shows a severe disconnection between the data already published and the one available on the databases. It also shows that Brachiopoda taxonomy is an undertaken subject in Brazil, and that a post-collection bias is overshadowing our knowledge on the group.

THE CYCADALEAN SEED *CYCAS RUMPHII* AS A MODEL FOR THE LARGER CARBONIFEROUS MEDULLOSALEAN OVULES

Erwin L. Zodrow[1] and José A. D'Angelo[1, 2]

1. Carboniferous Palaeobiology Laboratory, Cape Breton University, B1P 6L2, Sydney, Nova Scotia, Canada.
2. IANIGLA-CCT-CONICET-MENDOZA and Área de Química, ICB, Universidad Nacional de Cuyo, M5502JMA, Mendoza, Argentina.
joseadangelo@yahoo.com

Much has been written about the larger Carboniferous petrified/coalified medullosalean ovules/seeds, and separately about the genus *Cycas* Linnaeus. It has been commonly conjectured, however tenuous the evidence, that the cycads ascended from a stock of Carboniferous seed ferns. However, the question of occurrence of fossil cycadaleans in rocks of late Pennsylvanian/Late Triassic age is still controversial, and thus the hypothesis of evolutionary pteridosperm/cycadalean lineage is at a stalemate at best. Our continuing studies of coalified medullosalean ovules prompted us to search the literature for morphological/analytical comparisons between extant larger cycadalean and extinct medullosalean ovules, however without success. On request, Dr. D. Stevenson (The New York Botanical Garden) kindly supplied particularly seed specimens of *Cycas rumphii* Miquel which we propose as a biological model for the larger Permo/Carboniferous trigonocarpalean/pachytestal ovules. For the methodological modeling approach, two evidential lines are appropriated, one of which involves direct observation and measurement, and the other inferences. The first includes physical aspects of the seeds/ovules and the endosperm (=female gametophyte), attachments of the former to stalks, and comparisons of microstructure and micromorphology (nucellii and their epidermises). Particularly emphasized is the similarity in numbers of resistant tissues the fossil and extant ovules share, *i.e.*, seven. Also considered are pollen and pollination characteristics. Inferences are based on comparing oxidative reactions, the spectrochemistry, including atomic mass units, and elemental analyses with published results of the medullosalean ovules. On balance, the sum-total evidence favors *C. rumphii* as a suitable model as stipulated, which does not imply exclusivity. Details to this effect, and implications thereof, will be published at a future date.

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DEVONIAN GLOBAL EVENTS IN THE MOROCCAN MESETA – AN UPDATE

R. Thomas Becker[1] and Z. Sarah Aboussalam[1]

1. Institut für Geologie und Paläontologie, WWU, Corrensstr. 24, D-48149 Münster, Germany.
rbecker@uni-muenster.de

The Paleozoic of the Moroccan Meseta consists of a complex arrangement of tectonic blocks with different sedimentary history and faunas of adjacent units. The regional recognition of well-established global events is strongly influenced by the locally variable overprint due to subsidence, uplift, block tilting, submarine erosion, and re-sedimentation in the course of strong Eovariscan crust movements. The search for event signatures, therefore, has to concentrate on episodically stable blocks and on settings, where they are easy to recognize by sudden changes of facies and biota. Daleje Shale Equivalents can be recognized above lower Emsian reefs of the Oued Cherrat Zone and in the allochthonous NE Jebilet below *Sellanarcestes* Limestones. The latter succession resembles the Anti-Atlas, which includes the Skoura region at its northern margin. The dark-grey shales with *Anarcestes simulans* of the Rahal Formation (Rabat-Tiflet-Zone) are slightly younger and follow a basal upper Emsian deepening indicated by thin-bedded limestones. The lower Eifelian is characterized in many regions (Ben Slimane, Oued Cherrat, Al Attamna, Mdakra Massive, Oulmes, Azrou to Mrirt, NE Jebilet) by a next younger deepening, which is roughly correlated with the Chotec Event. The Kacak Event has a very poor distribution but was first clearly recognized as shale intercalation above limestones with *Tortodus kockelianus* in a quarry near Tiflet. The Taghanic Biocrisis is mostly "hidden" in thick reefal successions that lasted until the top Givetian (Frasnes Event Interval, Oued Cherrat) or to the Timan/Middlesex drowning at the lower/middle Frasnian boundary (Coastal Block, Oulmes region). The isolated small Devonian outcrop at Immouzer-al-Kander south of Fes is exceptional because it contains a unique, hypoxic "Taghanian plant shale" at the top of the middle Givetian and evidence for a reworked middle Frasnian reef, followed by transgressive, basal upper Frasnian goniatite shales. An equivalent drowning that may correlate with the *semichatovae* Transgression can be recognized in the western Mdakra, north of Benahmed. Typical Kellwasser Limestones are restricted to the allochthonous Devonian near Mrirt and of the southern Variscan suture zone east of Tinerhir. The regressive Condroz Events are weekly manifested in the condensed, pelagic successions of Oulmes, Moulay Hassane, and Mrirt but overprinted by thick Eovariscan clastic wedges in regions to the W/SW. The Ben Slimane area is special because a small-sized, pyritic ammonoid fauna allows to recognize the Famennian (VI, ?Strunian deepening). Two distinctive dark shale intervals interrupt the heavily slumped and brecciated Famennian "griotte" of Azrou; precise dating is in progress.

THE SIGNIFICANCE OF THE EARLY DEVONIAN D3B PALYNOSUBZONE TO REGIONAL CORRELATIONS AND SEQUENCE STRATIGRAPHY OF THE JAUF FORMATION, SAUDI ARABIA

Pierre Breuer[1]

1. Saudi Aramco, Geological Technical Services Division, Biostratigraphy Group, 31311 Dhahran, Saudi Arabia.
pierre.breuer@aramco.com

Detailed palynostratigraphic study, such as the one presented here, is a powerful and inexpensive tool for interpretation of sedimentary successions that significantly improves our understanding of sequence stratigraphic relationships and helps reduce risk on expenditure in exploration drilling. The Early Devonian Jauf Formation changes in character from marine in Northwestern Saudi Arabia to marginal marine/continental to the east. Lithologically, the major difference between the two regions is the presence of the limestone-dominated Hammamiyat Member, which represents a significant Early Devonian marine flooding event. In Eastern Saudi Arabia, equivalent sediments are dominantly siliciclastic and cannot easily be correlated lithologically with the northern Jauf Formation orbe subdivided into the members recognized in the north. The distinctive spore marker species associated with the leiospheres typifying the D3B Palynosubzone, which caps the Jauf Reservoir in Eastern Saudi Arabia, allow precise correlation between the two regions. D3B represents palynologically defined parasequences, which appear to match the 4th order depositional cycles recognized in their orbital-forcing depositional sequence of the Jauf Formation interpreted from outcrops.

LOCHKOVIAN (LOWER DEVONIAN) CONODONT STRATIGRAPHY OF THE CARNIC ALPS (ITALY-AUSTRIA)

Carlo Corradini[1], Maria G. Corriga[1], Erika Kido[2], Monica Pondrelli[3], Hans Peter Schönlaub[4], Luca Simonetto[5], Claudia Spalletta[6] and Thomas Suttner[2]

1. Dipartimento di Scienze Chimiche e Geologiche, Università di Cagliari, via Trentino 51, I-09127 Cagliari, Italy. corradin@unica.it

2. University of Graz, Institute for Earth Sciences (Geology & Paleontology), Heinrichstrasse 26, A-8010 Graz, Austria.

3. International Research School of Planetary Sciences, Università d'Annunzio, viale Pindaro 42, I-65127, Pescara, Italy.

4. Austrian Academy of Sciences, Center for Geosciences, Dr. Ignaz Seipel-Platz 2, A-1010 Vienna, Austria.

5. Museo Friulano di Storia Naturale, via Marangoni 39-41, I-33100 Udine, Italy.

6. Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Alma Mater Studiorum Università di Bologna, via Zamboni 67, I-40126 Bologna, Italy.

The Carnic Alps are located across the Italian-Austrian border. Here one of the best exposed and most complete Palaeozoic succession in the world, ranging from Upper Ordovician to Upper Permian, occurs. Lochkovian deposits are represented either by carbonatic or pelitic units, reflecting a sedimentary environment from shallow water to basin in a ramp-type margin. The Seekopf Fm. (= former neritic Rauchkofel Lst), mainly constituded by bioclastic limestone, sedimented in the shallower part of the basin. The intermediate carbonate facies are mainly represented by well bedded limestones of the Rauchkofel and La Valute formations, that grade into the Kellerwand and Findenig Fm. respectively during the upper Lochkovian; the Nölbling Fm. is made by alternating shales and limestone, while the most distal part consists of pelitic rocks that belong to the Bischofalm Formation. Several sections have been sampled in all the calcareous units in order to achieve detailed biostratigraphic constraints of all the lithostratigraphic units. Conodonts are well documented from all the units, apart from the black shales of the Bischofalm Fm. In general they are more abundant and better preserved in the pelagic carbonate facies of the Rauchkofel and La Valute formations, than in shallow and deeper environments. Also there is a difference between the rich associations of lower and middle Lochkovian, and the upper Lochkovian, when the abundance decreases drastically. In the lower Lochkovian the *Icr. hesperius* and the *Icr. postwoschmidti* zones are documented; in the middle Lochkovian the *Ad. carlsi*, *Ad. transitans*, *L. eleanorae* and *Ad. trigonicus* zones are discriminated; in the upper Lochkovian, due to the poor fauna, it is not possible to apply the more recent zonation schemes and only a *P. pesavis* Zone of older stratigraphic schemes is reported.

THE DECLINE OF THE MALVINOKAFFRIC STALKED ECHINODERMS FAUNA (CRINOIDEA; BLASTOIDEA) FROM PARANÁ BASIN (PONTA GROSSA AND SÃO DOMINGOS FORMATIONS), STATE OF PARANÁ, BRAZIL

Ana P. S. Franciso[1] and Sandro M. Scheffler[2]

1. UNIFESP - Campus Diadema, Rua Prof. Artur Riedel, 275, Jardim Eldorado, Diadema, SP, 09972-270, Brazil.
2. Laboratório de Paleoinvertebrados - LAPIN, Departamento de Geologia e Paleontologia, Museu Nacional, UFRJ, Quinta da Boa Vista, São Cristóvão, Rio de Janeiro, RJ, 20940-040, Brazil.
schefflersm@gmail.com.br

The stalked echinoderms represent a group of echinoderms which present a cup-shaped body with a stalk that allows it live attached to the substrate. This group, informally called pelmatozoans, was predominant in carbonate platforms during Paleozoic. They were abundant in siliciclastic environments and had a large number of classes, among which stands out the crinoids and blastoids. During the last decade, a great variety of forms have been described for the Ponta Grossa Formation (Praguian-Emsian) in Paraná State (Brazil); however, only recently have been cited for Sao Domingos Formation in Givetian. This citation was the result of intense research work by "Palaios group - stratigraphic paleontology" in outcrops located at BR-153, Km 180-190. The fauna of the basal part of the São Domingos Formation (Eifelian) is similar to the Ponta Grossa Formation, but impoverished, and lacking many malvinokaffrics groups. This is due to the large extinction occurred in the Emsian. Thereafter, the global extinction event KAČÁK, during Eifelian–Givetian transition, caused a collapse in the endemic malvinokaffrics communities. In order to understand the magnitude of these two extinction events, we should remember from more than 30 morphological types of pelmatozoans described for the Praguian and Emsian of the Ponta Grossa Formation none were recorded in Givetian of the São Domingos Formation. The São Domingos Formation has only two species of crinoids described and they occur in low abundance: *Salairocrinus*? sp. and *Marettocrinus* sp. C. The main characteristic of *Salairocrinus*? sp. is a strongly starring lumen; on the other side, *Marettocrinus* sp. C is characterized by a very large areola and crenularium forming a narrow ring near of the periphery. *Marettocrinus* sp. C was described in the Maecuru Formation (middle Eifelian) of the Amazon Basin. This could be another indication that Amazon and Paraná basins were connected, at least after the Eifelian-Givetian transition. Plus, this is another indication that inflow of warmer waters from the north was the responsible for the final decline of the Malvinokaffric Devonian fauna. The register of only two alien species, combined with the absence of taxa and morphological types of stalked echinoderms known for Malvinokaffric fauna in the Paraná state, demonstrates a great change in the pelmatozoans communities. Later, the fauna become composed by elements that seem to have migrated from other areas and occupy the vacant niches after the crisis. [CNPq, process 474952/2013-4; MEC, PET (Programa de Ensino tutorial) Ciências Biológicas UNIFESP].

MAXIMUM COMPLETENESS EPIBOLE – A NEW TYPE OF TAPHONOMIC EPIBOLES FROM LATE VISEAN (LATE MISSISSIPPIAN) BASINAL SETTINGS IN GERMANY

Hans-Georg Herbig[1], Michael R. W. Amler[1] and Christian J. Nyhuis[1]

1. Universität zu Köln, Institut für Geologie und Paläontologie, Zülpicher Str. 49a, Köln, D-50674, Germany.
herbig.paleont@uni-koeln.de

The Early Carboniferous (Mississippian) Rhenohercynian foreland basin of the Variscan Orogen in Germany is characterized by basinal muddy, siliceous and calciturbiditic sediments, overlain by synorogenic greywackes. This is the typical Kulm Facies of the Rhenish Massif and the Harz Mountains. The upper Viséan succession is punctuated by two major transgressive intervals, which culminate in maximum flooding bioevents. The late Asbian *crenistria* Event resulted in deposition of three goniatite limestone beds. They can be traced across the Rhenohercynian Zone from Germany to Southern Portugal and are herein regarded as an ecological epibole, resulting in the outburst of *Goniatites crenistria* Phillips, probably due to fading of fine-grained terrigenous input and concomitant changes in nutrient supply. The mid-Brigantian *Actinopteria* Black Shale Event, known from the Harz Mountains and the Rhenish Massif, is named after the bivalve *Ptychopteria* (*Actinopteria*) *lepida* (Goldfuss). The taxon enters two ammonoid zones below the *Actinopteria* Event in the Brigantian and ranges through the Pendleian (early Serpukhovian). However, it forms "mass occurrences" within that black shale, restricted to few distinct bedding planes within a centimetric interval. Mud turbidites with erosive basal boundaries and of different microfacies predominate in the *Actinopteria* Shale. Various, but simple ichnofabrics and agglutinating foraminifers indicate mostly dysoxic conditions of the soupy sediment. However, episodic colonization of the substrate by *Ptychopteria* – a colonization epibole – is ruled out due to palaeobiological constraints of that epibyssate pterineid. This refers to missing particles for byssal attachment, to misfunction of the gills due to mud-clogging, and to missing morphological adaptions for resting on the unstable soupground; larval or juvenile shells are missing. Therefore, a pseudoplanktic life style and settling after death is stressed. That seems to be incompatible with the non-statistic distribution in the *Actinopteria* Shale, but key is the microfacies. The flimsy shells of that "paper pecten" (sic!) were eroded by the mud turbidites and only preserved in the most fine-grained parautochthonous sediment layers on top or in autochthonous basinal muds, providing sufficient time for accumulation. Remnants of such layers are preserved as dark, clay-rich muds within *Planolites* burrows, restricted to the *Ptychopteria*-bearing interval. Thus, the "mass occurrence" is a function of preservation by non-erosion in the interval with the most complete sedimentary record. This new variant of a taphonomic epibole is termed "maximum completeness epibole". It differs fundamentally from known taphonomic epiboles caused by obrution and early diagenetic effects. In the case of the *Actinopteria* Shale, it is related to maximum flooding with minimum sedimentary influx and minimum turbiditic redistribution.

NEW PALAEONTOLOGICAL DATA FROM THE DEVONIAN OF TURKEY

Ulrich Jansen[1], Nihat Bozdoğan[2], Rainer Brocke[1], Kaya Ertuğ[3], Robert M. Finks[4], Helga Groos-Uffenorde[5], Raimund Haude[5], Hüseyin Kozlu[2], Gonça F. Nalcıoğlu[7], Atike Nazik[6], Recep Özkan[2], R. Hayrettin Sancay[6], D. Gülnur Saydam-Demiray[7], Eberhard Schindler[1], Emine Şeker[6], Karsten Weddige[1], Achim Wehrmann[8], Volker Wilde[1], M. Namık Yalçın[9] and Isak Yılmaz[9]

1. Senckenberg Research Institute, Senckenberganlage 25, D-60325 Frankfurt am Main, Germany. Ulrich.Jansen@senckenberg.de
2. Turkish Petroleum Corporation (TPAO), Söğütözü Mahallesi 2180. Cadde, 86, TR-06100Ankara, Turkey.
3. Saudi Aramco, P.O. Box 5000, Dhahran 31311, Saudi Arabia.
4. Union College, 07 Union St, Schenectady, NY 12308, USA.
5. Geoscience Center University of Göttingen (GZG), Goldschmidtstraße 1-3, D-37077 Göttingen, Germany.
6. Çukurova University, Dept. of Geological Engineering, TR-01330 Adana, Turkey.
7. General Directorate of Mineral Research and Exploration (MTA), Ankara, Turkey.
8. Senckenberg am Meer, Südstrand 40, D-26382 Wilhelmshaven, Germany.
9. Istanbul University, Dept. of Geological Engineering, TR-34850 Avcılar-Istanbul, Turkey.

In the frame of two multidisciplinary Turkish-German cooperation projects (DEVEC-TR, DECENT) focussing on the Devonian of S and NW Turkey, sections in the Eastern and Central Taurides and the Western Pontides have been measured and sampled. The works have resulted in a continuous flow of new data from several fossil groups (mainly conodonts, ostracodes, palynomorphs, foraminifers, brachiopods), refinements of stratigraphy and correlation of the sections, recognition of global events and reconstruction of palaeoenvironments and palaeo(bio)geography in space and time. Some results are presented: Loboliths of scyphocrinoids (Echinodermata) are described for the first time from Turkey (Halevikdere Section, Eastern Taurides); in combination with other fossils they allow to delineate the Silurian-Devonian boundary. Middle Devonian carbonates in the same section contain a previously unknown, almost monotypic occurrence of vermiform to slightly funnel-shaped calcareous fossils which most probably represent a new taxon of hypercalcified demosponges living in a restricted environment. In the Upper Devonian, rich and very well preserved organic-walled microfossils enable stratigraphical correlations and the distinction of facies types reflecting marine to terrestrial palaeoenvironments. With regard to palaeobiogeography, ostracod and brachiopod faunas from both Pontides and Taurides show clear European and North African relationships. Some Early Devonian brachiopod taxa from the Pontides suggest closer palaeogeographical connections to North Gondwana than to Avalonia. The new data indicate the presence of a narrow Rheic Ocean during the Devonian. Foraminiferid faunas, on the other hand, point to close relationships to the Russian Platform ascribed to a similar palaeoenvironment developed there.

CLIMATE CHANGE AND BIODIVERSITY PATTERNS IN MID-PALAEOZOIC (IGCP 596) – INTRODUCTION AND REPORT

Peter Königshof[1], Thomas, J. Suttner[2], Iliana Boncheva[3], Nadya G. Izokh[4], Ta Hoa Phuong[5], Thasinee Charoentitirat[6], Johnny Waters[7], Wolfgang Kiessling[8] and Erika Kido[3]

1. Senckenberg Research Institute and Natural History Museum, Senckenberganlage 25, 60325 Frankfurt, Germany. peter.koenigshof@senckenberg.de

2. Austrian Academy of Sciences c/o University of Graz, Institute of Earth Sciences, Heinrichstraße 26, A-8010 Graz, Austria.

3. Bulgarian Academy of Sciences, Geological Institute, Department of Palaeontology and Stratigraphy, G. Bonchev Str. Bl. 24, Sofia 1113, Bulgaria.

4. Institute of Petroleum Geology and Geophysics, Siberian Branch of Russian Academy of Sciences, 630090 Novosibirsk, Russia.

5. Hanoi University of Science, 334 Nguyen Trai Street, Thanh Xuan Dist, Hanoi, Vietnam.

6. Department of Geology, Faculty of Sciences, Chulalongkorn University, Thailand.

7. Department of Geology, Appalachian State University, Boone, NC28608, U.S.A.

8. Institute of Palaeontology, Loewenichstraße 28, 91054 Erlangen, Germany.

IGCP 596 is specifically interested in the interaction between climate change and biodiversity in the Devonian and Carboniferous Periods (416 – 299 million years ago) when the terrestrial ecosystems experienced a biodiversity boom and oceanic ecosystems suffered catastrophic extinctions. Greenhouse climates dominated the Early and Middle Devonian (416 – 385 Ma) world, but changed to icehouse conditions in the Late Devonian (385 – 359 Ma). The Early Carboniferous world was relatively warm until cooling in the early Late Carboniferous (318 – 299 Ma) resulted in a huge polar ice shield in the southern hemisphere that covered most of Gondwana. The Mid-Paleozoic was also a time of very high plate tectonic activity that caused major paleogeographic changes which finally led to the supercontinent Pangea. As the continental landmass grew, vascular plants, arthropods, hexapods and first tetrapods spread on land. Their radiation formed the base of new terrestrial ecosystems unknown before the Devonian Period. The success of terrestrial invaders, as documented by the fossil record, culminated with the development of vast forests consisting of tree-like forms like *Calamites* (Order Equisetales), lycophyte trees (e.g. *Lepidodendron*, *Sigillaria*) and other rooted plants that covered huge areas during the Carboniferous. That unique rise among land plants and the formation of top-soil led to distinctive changes in environmental conditions. Based on proxy-data, we can show that the rapid rise of land plants was coupled with strongly decreasing atmospheric CO_2 values from 4000 ppm to nearly present day values of about 350 ppm during the latest Devonian. Increased weathering activity and soil formation by rooted plants lead to intensified run-off and changed water chemistry, which seriously affected marine communities globally. The tectonic and climate history of the Devonian and Carboniferous as well as the novelty of soil-formation due to the explosion of life on land, and other processes, some of which are not yet fully understood, are linked with a series of ecological turnovers and extinction events primarily in the oceans. Results of this project should help to clarify whether climate change (e.g. interaction of CO_2 and temperature) from greenhouse conditions during the Early-Middle Devonian to icehouse conditions during the Late Devonian-Early Carboniferous represents a major trigger for variations in biodiversity or if a combination of multiple factors is responsible for such changes. We will give an overview of the activities of the project during the last years and what's coming up.

CORRELATIONS OF THE EUROPEAN DEVONIAN-CARBONIFEROUS BOUNDARY SUCCESSIONS: AN INTEGRATED STRATIGRAPHIC APPROACH

Tomas Kumpan[1], Ondrej Babek[1,2], Jiri Kalvoda[1], Tomas Matys Grygar[3] and Jiri Fryda[4,5]

1. Department of Geological Sciences, Masaryk University, Kotlářská 2, 611 37, Brno, Czech Republic. kumpan.tom@gmail.com
2. Department of Geology, Palacký University, 17. listopadu 12, 772 00, Olomouc, Czech Republic.
3. Institute of Inorganic Chemistry AS CR, v.v.i., 250 68, Řež, Czech Republic.
4. Czech Geological Survey, Klárov 3/131, 118 21, Prague 1, Czech Republic.
5. Department of Environmental Geosciences, Czech University of Life Sciences, Kamýcká 129, 165 21, Prague, Czech Republic.

The revision of the Devonian–Carboniferous boundary (DCB) definition and GSSP is recently one of the prime tasks of the Subcommission on Carboniferous Stratigraphy. Integrated stratigraphic approach has been proposed as the most helpful in solving of the DCB problem, which is connected with its current biostratigraphic definition. Our working group has focused on the chemostratigraphic (element analysis by XRF, $\delta^{13}C_{carb}$), petrophysical (gamma-ray spectrometry, magnetic susceptibility) and biostratigraphic (conodonts, foraminifers) high-resolution survey of fourteen DCB sections across Europe. They are located in the Montagne Noire (France), Rhenish Slate Mountains (Germany), Ardennes (Belgium), Carnic Alps (Austria), Pyrenees (France) and Moravian Karst (Czech Republic). The multiphase Hangenberg Event (HE) connected with the biotic and carbonate crisis was regarded by previous authors as a natural DCB. The Hangenberg Black Shale Event (HBSE) and the Hangenberg Sandstone Event (HSE) phases are distinguished. The well-known global positive $\delta^{13}C_{carb}$ excursion, which coincides with the HBSE event starts at the base of the *costatus-kockeli* conodont Interregnum and continues up to the *kockeli* Zone. This HBSE $\delta^{13}C_{carb}$ excursion is generally accompanied by the increase in Mn/Al and decrease in Th/U ratios and, where carbonate sedimentation persisted, also by the reduced contents of terrigenous elements. Excess of Mn and U, which are inversely sensitive to redox changes (Mn is mobile and U is fixed in reducing environment) is explained by rapid fluctuations of zone of oxygen depletion within the wide "bath-tube ring" zone. These features are, however, absent or slightly variable in some sections. Sharp increase in magnetic susceptibility and detrital supply proxies (e.g. Zr/Al and "clay-gamma ray") and/or stratigraphic gap are characteristic for the overlying HSE in the upper part of the *costatus-kockeli* Interregnum. This feature was recognised at all studied sections, both in deep- and shallow-water facies. The onset of the $\delta^{13}C_{carb}$ excursion is connected with a transgressive pulse of abrupt but diachronous nature. Moreover, its stratigraphic range is wide (two conodont zones) and the correlation potential is therefore limited. On the other hand, the HSE, well distinguished globally, is related to the glacioeustatic sea-level fall, which is considered as globally synchronous and hence would be a possible option for the new DCB boundary definition. [Supported by the Czech Science Foundation – grant P210/11/1891].

APPLICATION OF THE INTENDED GIVETIAN SUBDIVISION (MIDDLE DEVONIAN) SENSU SDS IN THE SPANISH CENTRAL PYRENEES: SUPPORT FOR GLOBAL CORRELATIONS

Jau-Chyn Liao[1,2] and José I. Valenzuela-Ríos[2]

1. Department of Paleontology, Complutense University of Madrid; c/ José Antonio Novais 12, 28040 Madrid, Spain.

2. Department of Geology, University of Valencia, c/ Dr. Moliner 50; 46100 Burjasot, Spain.
jose.i.valenzuela@uv.es

The International Subcomission on Devonian Stratigraphy (SDS) has positively voted the subdivision of the Givetian Stage into three parts by means of the defining taxa of globally recognized conodont zones. The base of the Lower Givetian coincides with the base of the Givetian and is defined at the base of the *hemiansatus* Zone, with the entry of the nominal taxon, *Polygnathus hemiansatus*. The base of the Middle Givetian coincides with the base of the *rhenanus/varcus* Zone, defined by the entry of either *P. rhenanhus* or *P. varcus*. The base of the Upper Givetian corresponds with the base of the *hermanni* Zone, which is defined by the income of *Schmidtognathus hermanni*. The throughout study of six selected sections (Ampriú, Basibé, Renanué, Compte, La Guàrdia d'Ares and Villech), from three different palaeogeographical units (the first two from Subfacies Sierra Negra, section Renanué from Subfacies Renanué and the last three from Subfacies Compte) in the Spanish Central Pyrenees, demonstrates one of the best upper Eifelian-Middle Frasnian conodont successions around the world. This succession consists of 86 taxa, whose sequential occurrence allows recognition and further characterization of all globally relevant conodont zones. For the Givetian Stage the following conodont zones (and subzones) are recognized: *hemiansatus, timorensis, rhenanus/varcus, ansatus, semialternans/latifossatus,* Lower *hermanni,* Upper *hermanni,* Lower *dengleri,* Upper *dengleri* and *norrisi*. The recorded Spanish conodont succession allows very fine correlations with most of the North-American, European, Asian and North-African sequences and thus, supports the SDS proposal of subdividing the Givetian into three substages, increases the worldwide Givetian database and facilitates global correlations. Finally, the established high-resolution framework in the Pyrenees shows the great potential of this region for future multidisciplinary studies.

THE FRASNIAN-FAMENNIAN MASS EXTINCTION

John E. A. Marshall[1] and Olga P. Tel'nova[2]

1. University of Southampton, National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK. jeam@noc.soton.ac.uk

2. Institute of Geology, Komi Scientific Center, Ural Branch, RAS, Pervomaiskaya, 54, Syktyvkar, 167982, Russia.

In 2009 a scientific borehole was drilled through a marginal Frasnian-Famennian boundary section at Sosnogorsk, near Ukhta, Komi Republic, Russia. This revealed a remarkably well preserved 8 m thick interval of unconsolidated grey mudstone which contains pristine carbonate crystals preserved within the clay matrix. Spores show this mudstone interval to be within the interval of the Upper Kellwasser level. Above this level there are a series of regressive horizons with emergent surfaces and Famennian spores. Most of the grey mudstone contains organic matter including spores and hence a record of land plant extinctions through the event. Analysis of pyrite framboid diameters (from smear slides) and %S content gives a proxy for the incursion of euxinic waters in the marginal shelf environment. Measurement of TOC's and calcite contents reveals a pattern of orbital forcing and hence a time framework and rates of change. Isotope analysis gives an integrated record of stable $\delta^{13}C_{org}$, $\delta^{13}C_{CaCO3}$ and $\delta^{18}O_{CaCO3}$. High resolution isotope results from the key interval show 2 negative excursions in $\delta^{13}C_{org}$ and a single excursion in $\delta^{13}C_{CaCO3.}$ Additional analysis of separated kerogen components (spores and AOM) from single samples integrated with the pyrite framboid measurements and %S content enables us to identify when upwellings of euxinic water occurred. These map onto the record of palaeotemperature change as determined from the oxygen isotopes. Analysis of the palynological record shows a progressive impoverishment of spore diversity and abundance through the event. Comparison with a terrestrial record of the F-F boundary interval from East Greenland including a correlative $\delta^{13}C_{org}$ curve demonstrates a match between the pattern of continental palaeoclimate change and the marginal marine record. The ultimate driver of the F/F extinction event will be discussed based on both the isotope results and the spore record.

DEVONIAN FLORA SUCCESSION IN GONDWANA: STATE OF ART IN SOUTH AMERICA

Willian M. K. Matsumura[1], Mercedes Di Pasquo[2], Roberto Iannuzzi[1], Sol Noetinger[3] and Elvio Bosetti[4]

1. Universidade Federal do Rio Grande do Sul, Instituto de Geociências UFRGS, Av. Bento Gonçalves, 9500, Porto Alegre, RS, 91.509-900, Brazil. williammatsumura@gmail.com

2. Laboratorio de Palinoestratigrafía y Paleobotánica, CICyTTP-CONICET, Diamante, Argentina.

3. Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", CONICET, Buenos Aires, Argentina.

4. Universidade Estadual de Ponta Grossa, Departamento de Geociências, UEPG, Av. Carlos Cavalcanti 4748, Ponta Grossa, PR, 84030-900, Brazil.

The Devonian paleobotanical record in South America has recently been described in Argentina, Bolivia, Brazil, Chile, Colombia, Falkland Islands, Uruguay and Venezuela. This study aims to describe a pattern of floristic succession observed in the Devonian strata bearing primitive land plants mainly in Argentina, Bolivia and Brazil from Lochkovian to Frasnian deposits dated with palynomorphs. In the early Devonian (Lochkovian) the paleofloras are composed of bryophytes (*Hostinella* sp.), psilophytes and cooksonioids (including *Cooksonia paranenses*, *C. hemispherica* and *Aberlemnia caledonica*), recorded in Argentina (Villavicencio and Talacasto Fms.), Bolivia (Santa Rosa Fm.), Brazil (Furnas Fm.) and Uruguay (Cerrezuelo Fm.). These assemblages comprising herbaceous plants, simple organization, naked stems (leafless) and terminal sporangia, are named herein *Cooksonia*-like Flora (Embryobiota). This flora is associated to the *Dictyotriletes emsiensis* (Ems) Zone Grahn from Brazil (Lochkovian-Emsian). From the Middle-to-Late Devonian (Eifelian to Frasnian), herbaceous lycopsids (*Haplostigma* sp. and *Haskinsia* sp.) became dominant and especially during the Eifelian/Givetian interval, *Haplostigma* is widely documented in the South American floras. These plants, with a more complex organization, are recorded in Argentina (Chinguillos Gr.; Lolén, Punta Negra, Los Monos and Pescado Fms.), Bolivia (Huamapampa, Los Monos and Iquiri Fms.), Brazil (São Domingos Fm.), Chile (El Toco Fm.) and Venezuela (Campo Chico Fm.). The latter are grouped herein in the *Haplostigma* Flora. Its age is akin to *Grandispora permulta* (Per) and *Geminospora lemurata-Chelinospora* ex *Gr. ligurata* (LLi) Zones Melo and Loboziak from Brazil. It is noteworthy that the genus *Haplostigma* is also recorded in South Africa, Antarctica and Australia from a later interval, i.viz. Givetian to Famennian. The interval between the *Cooksonia*-like and *Haplostigma* floras is mainly hidden, due to marine transgression occurred during the Pragian/Emsian interval. The predominance of marine facies during Late Early Devonian is also attested by the domain of paleomicroplankton (i.e., acritarchs, quitinozoans) in palynological assemblages and great abundance and diversity of marine invertebrates of Malvinokaffric Realm. [CNPq 141979/2011-9, PQ309211/2013-1, 150239/2011-4, 401796/2010-8, 479774/2011-0, 402873/2012-2, and CONICET PIP 0305 (2011-2013)].

LAND PLANT ASSEMBLAGE TAPHOFACIES IN MIDDLE DEVONIAN OF PARANÁ BASIN, SOUTHERN BRAZIL

Willian Matsumura[1], Roberto Iannuzzi[1], Rodrigo S. Horodyski[1] and Elvio Bosetti[2]

1. Universidade Federal do Rio Grande do Sul, Instituto de Geociências UFRGS, Av. Bento Gonçalves, 9500, Porto Alegre, RS, 91.509-900, Brazil. williammatsumura@gmail.com

2. Universidade Estadual de Ponta Grossa, Departamento de Geociências, UEPG, Av. Carlos Cavalcanti 4748, Ponta Grossa, PR, 84030-900, Brazil.

Taphonomic and sedimentological analysis of outcrops containing land plant remains have enabled the paleoenvironmental interpretation of depositional systems and the establishment of sedimentological contexts in which taphofloras were preserved. The overwhelming majority of studies on fossil plant taphonomy addresses primarily deposits of fully terrestrial or transitional deposits, being few studies of them carried out in fully marine environments. This study aims to describe the taphonomic signatures and sedimentological characteristics of fossiliferous assemblages bearing herbaceous early land plants (e.g. *Haplostigma*, *Palaeostigma*, *Spongiophyton* and plant debris) preserved in marine (shoreface to offshore) within Ponta Grossa and São Domingos formations, in Paraná Basin, southern Brazil. Ten outcrops within three surface stratigraphical sections located at Tibagi County, in the Paraná state, were described. The taphonomic analysis included the relationship between the plant material and sediment, the arrangement of the axes within beds (parallel or perpendicular to the bedding), degree of packing of the assemblages (concentrated or dispersed), orientation and fragmentation degrees of plant remains. Six different lithofacies, conglomeratic sandstone (SS-gr), coarse to medium sandstone (SS-hcs), fine-grained sandstone (SS-f), coarse to medium sandy siltstone (SL-hcs), fine-grained siltstone (SL-p) and mudstones (SH) indicatives of most proximal to distal depositional systems and three allochthonous plant remains assemblages [Plant Axe Assemblage (PAA), Plant Fragment Assemblage (PFA) and Plant Debris Assemblage (PDA)] were identified. PAAs preserved within SS-f facies were deposited mainly in upper to middle shoreface settings under low energy context. PFAs preserved within SS-hcs to SL-p facies were deposited mainly in shoreface to transitional offshore settings in moderate and high-energy contexts. Finally, PDAs preserved within SS-f to SH facies were deposited mainly in shoreface to offshore settings under low and high-energy contexts. This early land plants grew the wetlands near shorelines and were transported during storms associated with Highstand deposits or rise in the sediment inputs caused by flood events basinwards. [CNPq 141979/2011-9; PQ309211/2013-1; 150239/2011-4; 401796/2010-8; 479774/2011-0].

SYSTEMATICS OF THE MIDDLE DEVONIAN ICRIODIDS RELATED TO *I. ORRI* KLAPPER ET BARRICK: AN EXAMPLE OF TAXONOMIC PROBLEMS INVOLVED IN DEFINITION OF CONODONT SPECIES

Katarzyna Narkiewicz[1]

1. Polish Geological Institute, Reasearch National Institutes, Warsaw, Poland.
katarzyna.narkiewicz@pgi.gov.pl

Conodonts are an extinct group with still uncertain systematic position but very useful for biostratigraphic purposes. The taxonomy of these tooth-like microfossils is based on elements composing probably a feeding apparatus in the oral cavity of the animal. Particularly, the morphology of the platform (P_1) elements is important for defining genera and species. Nevertheless, the morphological features, no matter how variable and complex, are not yet understood in terms of functionality in the apparatus. Thus, their taxonomy is usually based on purely descriptive criteria, arbitrarily stressing some features while downplaying others. The problems involved in conodont systematics are discussed referring to Eifelian forms related to the species *Icriodus orri* established by Klapper and Barrick based on material from Iowa (USA). The authors assigned to the species rather variable forms sharing as a common feature the broadly expanded basal cavity. At the same time, however, they included specimens either possessing (A) or lacking (B) a characteristic posterior depression on the upper surface, a feature typical for *I. retrodepressus* Bultynck. A closer analysis of the type material of *I. orri* allows recognizing also a third morphotype showing a poorly developed depression and a characteristic wide, droplike spindle outline (C). It also appeared that the form B (= *orri* morphotype) has characteristic transversal ridge-like denticles. The study of similar Eifelian forms found in collections from the Michigan Basin (USA), from Belarus, and from published data supports the recognition of the above mentioned morphotypes A, B and C. In order to verify that they could potentially represent different species, their biogeographic and stratigraphical distribution was analysed. It appears that whereas forms A and B occur widely in Euramerican faunas, the C morphotype is confined to N America, which supports its separate species identity. The stratigraphic ranges of the three forms are distinctive, A comprising nearly the entire Eifelian, C appearing later and continuing into the Late Eifelian, and B showing a short range in the Late Eifelian. These different patterns further support the taxonomic distinction between the three forms that consequently were attributed to three species – *I. retrodepressus* (form A), *I. orri* (B), and *I. michiganus* n. sp. (C). The results of the present study stress the need for a comprehensive approach to conodont taxonomy, based on diagnostic morphological features, but supplemented by biogeographic and stratigraphical analysis. [Polish National Research Centre, Project 2011/03/B/ST10/05468].

MIDDLE DEVONIAN SCOLECODONTS OF THE EIFEL AREA, GERMANY

Petra Tonarová[1,2], Ole Hints[2], Peter Königshof[3],Thomas J. Suttner[4], Erika Kido[4], Anne-Christine Da Silva[5] and DamianPas[5]

1. Czech Geological Survey, Geologická 6, 152 00 Prague 5, Czech Republic.
petra.tonarova@geology.cz
2. Institute of Geology at Tallinn University of Technology, Ehitajate 5, 19086 Tallinn, Estonia.
3. Senckenberg Research Institute and Natural History Museum, Senckenberganlage 25, 60325 Frankfurt, Germany.
4. University of Graz, Institute of Earth Sciences, Heinrichstraße 26, A-8010, Austria.
5.University of Liege, Sedimentary Petrology, B 20, Sart-Tilman, B-4000 Liege, Belgium.

Scolecodonts (polychaete jaws) are common and diverse microfossils in many types of Palaeozoic marine sediments. They bring useful information on phylogeny of polychaete annelids and can be used as palaeoenvironmental indicators, and to a lesser degree in biostratigraphy. The number of studies on Devonian scolecodonts is, however, rather limited and in most cases single-element-based classification (parataxonomy) has been used. Here we report a well preserved assemblage of scolecodonts from the type Eifel area, Germany. The studied section lies within the Blankenheim syncline, between the villages of Blankenheim and Blankenheimerdorf. It comprises shallow shelf mixed carbonate and siliciclastic facies of Eifelian age (*kockelianus* and *ensensis* conodont Biozones, beginning of the Kačák Event Interval) that were accumulated in near shore settings on the southern margin of the former Avalonia microcontinent. The family-level composition of the recovered Eifelian polychaete fauna is generally similar to the Silurian associations known from Baltica, Laurentia and Perunica, predominated by polychaetaspids, particularly of the genus *Oenonites*, mochtyellids (*Mochtyella*) and paulinitids (*Kettnerites*). However, characteristic of the Eifelian fauna is the occurrence of kielanoprionids (*Kielanoprion*), a family that is unknown from the pre-Devonian. In the studied samples kielanoprionids reach up to 20% of the assemblage. Representatives of atraktoprionids, skalenoprionids and tetraprionids are much less common. Comparison with contemporaneous polychaete faunas from other regions is complicated due to limited number of studies. However, the Eifelian assemblage seems to be very similar to those described previously from the Middle Devonian of North America and Upper Devonian of Poland. This suggests that many Devonian polychaetes were both long-ranging and geographically widespread. Good preservation of specimens at hand brings also new information on poorly known jawed polychaete taxa and helps to elucidate some aspects of the phylogeny of the group. [Supported by the Czech Science Foundation (project P210/12/2018), the European Union (European Social Fund – Mobilitas grant MJD407) and FWF P 23775-B17 (Austrian Science Fund)].

ECHINODERM COMMUNITY EVOLUTION IN THE LATE DEVONIAN AND MISSISSIPPIAN

Johnny A. Waters [1]

1. Department of Geology, Appalachian State University, Boone, NC 28608, USA.
watersja@appstate.edu

Crinoids and blastoids reached an apex in generic richness and abundance during the Mississippian, which is often called ‘The Age of Crinoids”. This explosion of echinoderms was the result of one or more of the following: 1. rising biodiversity of advanced cladids during the transition from the Middle Paleozoic to the Late Paleozoic Crinoid Macroevolutionary Fauna, 2. establishment of widespread carbonate ramps after the demise of Late Devonian reef communities, 3. response to declining predation pressure caused by extinctions of major groups preying on crinoids at the Hangenberg extinction event, and 4. the rise of bacterioplankton in the wake of mass extinction of acritarchs in Late Devonian time coincident with a major drop of atmospheric CO_2. Although the causes of the Mississippian crinoid explosion are multifaceted, climatic events in the Devonian played a major role in both the demise of Devonian reef communities and the massive changes in the composition of marine plankton. Crinoid and blastoid generic richness was high in the Early Devonian reflecting the success of the camerate-dominated Middle Paleozoic Crinoid Macroevolutionary Fauna during an interval of greenhouse climate conditions and widespread reefs. Throughout most of the Devonian, crinoid diversity paralleled reefal diversity. This pattern changed after Late Devonian extinction events. Famennian echinoderm communities are dominated by cladid crinoids and more closely resemble Late Paleozoic rather than Middle Paleozoic Crinoid Macroevolutionary Faunas. The demise of reef communities in the Late Devonian led to the development of widespread carbonate ramps in the Mississippian and for a time the resurgence of the camerate-dominated MPCMF. Although much work remains to understand the dynamics of echinoderm community evolution in the Devonian, dramatic climate change had a major impact. Crinoid communities were able to be successful both in the Lower Devonian greenhouse world and in the Mississippian icehouse world because different clades were able to adapt to changing climates and the demise of reef ecosystems and flourish.

THE *ANNULATA* EVENTS IN THE MORAVIAN KARST – REMARKS ON STRATIGRAPHY (FAMENNIAN, CZECH REPUBLIC)

Tomáš Weiner[1] and Jiří Kalvoda[1]

1. Masaryk University, Department of Geological Sciences, Kotlářská 2, 611 37 Brno, Czech Republic.
tomasweiner@volny.cz

The *Annulata* events are supposed to reflect a short-term sea-level rises in the middle Famennian, which were connected with deposition of hypoxic or anoxic sediments, commonly containing abundant fauna, especially ammonoids (e.g. *Platyclymenia*, *Prionoceras*), orthocone nautiloids, epiplanctonic bivalves and ostracods. These transgressive event beds might be overlain by the richly fossiliferous regressive Wagnerbank marlstone or its equivalents (e. g. *Annulata* limestone). These horizons were placed to the Upper *Palmatolepis rugosa trachytera* zone in the most recent works. Based on the previous studies from Germany, Poland and Morocco, the Lower *Annulata* event can be biostratigraphically recognized due to the presence of several conodont taxa which became extinct below the Upper *Annulata* event (e.g. *Palmatolepis glabra lepta*, *Palmatolepis rugosa trachytera*). The Moravian Karst belong to the Rhenohercynian Zone of the Central European Variscides. Conodont samples were taken from four condensed sections of the Křtiny Limestones of the Líšeň Formation near Ochoz u Brna, Mokrá and Hostěnice villages. The event bed in the vicinity of Ochoz u Brna provided a rich conodont fauna including *Palmatolepis glabra lepta*, *Palmatolepis minuta minuta* and *Palmatolepis rugosa trachytera*, which enable the correlation with the Lower *Annulata* event. The event beds exposed in two outcrops near the village of Hostěnice provided rather poor conodont fauna. Stratigraphically significant taxa such as *Palmatolepis glabra lepta* and *Palmatolepis rugosa trachytera* were recorded below the event beds only. Thus, it remains unclear whether the event beds near Hostěnice represent the Lower and/or the Upper *Annulata* events. The sample from the event bed in the western Mokrá quarry provided rather poor conodont fauna including *Palmatolepis glabra lepta* indicating the Lower *Annulata* event. All mentioned Moravian sections were measured by the field gamma-ray spectrometer. Higher values of uranium corresponding to the event beds probably reflect anoxic or hypoxic conditions. This is in accord with the previously published data from the Kowala quarry in the Holy Cross Mountains, Poland.

NEW INSIGHTS INTO THE STRATIGRAPHIC FRAMEWORK OF THE MIDDLE-UPPER DEVONIAN TRANSITION IN THE MICHIGAN BASIN, U.S.A.

Jay Zambito[1] and Jed Day[2]

1. Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, 3817 Mineral Point Road, Madison, Wisconsin 53705, USA. jay.zambito@wgnhs.uwex.edu

2. Illinois State University, Department of Geography-Geology, Normal, Illinois 61790-4400, USA.

High-resolution stratigraphic correlation of Middle and Upper Devonian strata in the Michigan Basin is hindered by a lack of extensive outcrops, complex lithofacies changes across the basin, and limited previous work on conodont and brachiopod biostratigraphy. We present new bio-, sequence- and chemostratigraphic data from both core and outcrop (including many type-sections) located in the central, northern, and western portions of the basin, and our resulting working-model chronostratigraphic framework. Stratigraphic units included in this study are the constituent formations of the upper Traverse Group in Michigan, the Thiensville and Milwaukee formations of Wisconsin, and the overlying Antrim Shale Formation which is found throughout the extent of the basin. The recognition of third- and, possibly, fourth-order depositional sequences in different facies allows tentative stratigraphic correlations across depositional strike in the Michigan Basin. A key stratigraphic datum in our correlations is the Taghanic Onlap, a late Middle Devonian transgression that has been recognized globally. Preliminary carbonate carbon isotope data has resulted in the identification of positive excursions within the presumed Michigan Basin Taghanic Biocrisis-equivalent deposits. While new conodont and brachiopod biostratigraphic data has led to an improved stratigraphic framework, more work is needed to reconcile discrepancies. The replacement of endemic taxa by invasive paleoequatorial brachiopods associated with the Taghanic Onlap apparently occurs later in the Michigan Basin than expected in comparison to the better-studied Appalachian Basin; however, this is probably an artifact of the incompletely constrained conodont biostratigraphic framework currently available rather than the Michigan Basin serving as a temporary refuge for endemic taxa. Furthermore, but not unexpectedly, the onset of black shale deposition that typifies the Upper Devonian succession in the Michigan Basin appears to begin in the center of the basin during the latest Middle Devonian and to have expanded to the basin margin by the early Late Devonian. This integrated stratigraphic approach on a combination of outcrop and core material holds promise for placing Middle-Upper Devonian Michigan Basin deposits within the global chronostratigraphic framework.

BIODIVERSITY OF RUGOSE CORALS FROM THE FAMENNIAN TO VISEAN SUCCESSION OF BELGIUM: DYNAMICS AND CONTROLLING FACTORS

Markus Aretz[1], Julien Denayer[2,3], Elise Nardin[1] and Edouard Poty[2]

1. Géosciences Environnement Toulouse (OMP), Université de Toulouse, CNRS, IRD, 14 avenue Edouard Belin, 31400 Toulouse, France. markus.aretz@get.obs-mip.fr
2. Paléontologie animale, Université de Liège, Allée du 6 Août, 4000 Liège, Belgium.
3. University of Queensland, School of Earth Sciences, St Lucia, QLD 4072, Australia.

In Belgium, rugose corals are abundant in the upper Famennian to Viséan shallow water successions in the Namur-Dinant Basin and in the Campine Basin. They have been intensively studied in the last decades. The temporal and spatial distribution of 169 species regrouped in 64 genera has been compiled. Determinations have been validated by the last authors, thus the dataset is considered to be taxonomically unbiased. Intra- and interspecific variabilities have been jugged the same way for all specimens. The sample positions of all specimens are precisely known, and thus detailed data on facies, biostratigraphy and lithostratigraphy are available. Specific diversity varies considerably through time, from the lowest value of 3 to the highest value of 57, when calibrating to biozones. The highest diversity is found in the Warnantian (late Viséan), which on a global scale represents a diversity peak for rugose corals. In Belgium, it can be mainly explained by important speciation events among several colonial families. Major lows occur during the Ivorian (early Tournaisian) and the latest Moliniacian (early Viséan). Main extinction events and distinct faunal turnovers are observed at the Devonian-Carboniferous boundary and at the base of the Viséan, and to a lower degree at the base of the Livian. These turnovers can be used to separate individual faunal and possibly evolutionary assemblages in the Devonian (Strunian), the Tournaisian and in Viséan, with the latter probably divided into two sub-assemblages. It is interesting to note that the highest diversities are always reached at the end of the stages and that diversification starts rather long before the diversity peaks are reached. The important sea-level fluctuations documented in the platform carbonates have a large influence on coral abundance and distribution. Up to the latest Tournaisian, the strata considered to belong to transgressive system tracts (TST) show a higher diversity than the strata of the highstand system tract (HST) of the corresponding 3rd order sequence, whereas in Viséan times the opposite is observed. This change cannot be explained so far. The spatial distribution shows the highest abundances of rugose corals in the Visé and Condroz sedimentation areas. These maxima are largely bound to the well-exposed Warnantian strata in these regions, which enable the documentation of the global late Viséan peak. Facies influence abundances, but a clear correlation between a distinct facies and its coral abundance cannot be proposed so far, and factors like the evolutionary dynamics seem to be superimposed.

RUGOSE CORALS AT THE TOURNAISIAN-VISEAN TRANSITION IN THE CENTRAL TAURIDES (S TURKEY) – PALAEOBIOGEOGRAPHY AND PALAEOCEANOGRAPHY OF THE GONDWANA MARGIN

Julien Denayer[1,2]

1. Service de Paléontologie animale et humaine, Départememt de Géologie, B18, Allée du Six-Août, Sart Tilman, B-4000 Liège, Belgium. julien.denayer@ulg.ac.be

2. School of Earth Science, the University of Queensland, St-Lucia, QLD 4068, Australia.

The Rugose corals association of the upper Tournaisian-lower Visean Yaricak Formation in the Aladag Unit, Central Taurides (South Turkey) is composed of fifteen species belonging to twelve genera. The corals are stratigraphically distributed in four assemblages. The two lower assemblages, typical of the upper Tournaisian, are composed of widely distributed taxa (*Uralinia*, *Caninia*, *Proheterelasma*, *Zaphrentites*). The assemblage crossing the Tournaisian-Visean boundary is characterized by Eurasian and cosmopolitan taxa (*Calmiussiphyllum*, *Siphonophyllia*, *Bifossularia Amygdalophyllum*, *Caninophyllum*, *Keyserlingophyllum*) or Asian taxa (*Kueichouphyllum*, *Eokoninckocarinia*). The youngest assemblage is Moliniacian (Lower Visean) in age. These assemblages form a low diversity bottom-level community typical of the South Palaeotethys '*Kueichouphyllum* Zone' extending along the Asian margin of Gondwana (Cimmerian Terrane) during early Carboniferous times. Such an assemblage is interpreted as a temperate-water coral fauna. As in the other Cimmerian blocks (in Caucasus, Iran, Afghanistan, Tibet) all the corals are solitary and colonial taxa are virtually absent. This absence is tentatively explained by the high latitude (c. 50°) position of the Cimmerian Terrane in the southern part of the Palaeotethys Ocean for this time slice. Cold-water palaeocurrents running eastward along the Gondwana margin might also be considered as it possibly could explain the global distribution of the *Kueichouphyllum* fauna, restricted to the east of Africa in the southern coast of the Palaeotethys. A longitudinal physical barrier is considered with a query.

NEW DATA ON UPPER DEVONIAN BLACK SHALE EVENTS IN THE EASTERN PART OF THE CENTRAL MOROCCAN MESETA

S. Hartenfels[1] and R. T. Becker[1]

1. Westfälische Wilhelms-Universität, Institut für Geologie und Paläontologie, Corrensstr. 24, D-48149 Münster, Germany. shartenf@uni-muenster.de

In the main Famennian the two *Annulata* Events are the most pronounced transgressive events, which are characterized by global overturns of ammonoid faunas and the wide and sudden distribution of black shale or limestone intercalations. At species level, very few ammonoids of UD III survived into the Lower *Annulata* Event beds, suggesting significant extinction and re-population by immigration. The eustatic pulse of the hypoxic/anoxic Lower *Annulata* Event allowed the spread of *Platyclymenia* and *Prionoceras* faunas, which define the base of UD IV-A of the ammonoid scale. In thick successions of the Moroccan Anti-Atlas, both *Annulata* Events are separated by a better oxygenated interval with one or two micrite subcycles, called *Annulata* Intralimestones. In condensed sections there may be only one black shale, marl and/or limestone interval. In the international conodont scale, the *Annulata* Events fall in the upper part of the *Ps. granulosus* Zone (= upper part of Upper *trachytera* Zone). The Upper *Annulata* Event is overlain by regressive and often very fossiliferous cephalopod limestones, the "Wagnerbank" of Thuringia (Germany), and its micritic or marly equivalents. In the Moroccan Meseta the evidence of the *Annulata* Events is sparse. Data from Sidi Bettache Basin and Mdakra Massive suggest the presence of *Annulata* Events in the western Meseta. In the eastern part of the central Meseta, a single violet shale interrupting sharply a thick sequence of nodular limestone as the possible *Annulata* Event at Ziyyar I was described. The section is situated in a road cut between Aguelmous (northwest) and Khenifra (southeast). We re-sampled the section and provide a more detailed bed-by-bed measurement. A lower (18 cm thick) and upper event (48 cm thick) are recognizable above a pre-event succession of grey, middle Famennian "griotte" and are developed in a dark brown shale facies. However, in the basal part of both layers, thin black shales indicate anoxic conditions. Characteristic blooms of specific opportunistic ammonoids or of the bivalve *Guerichia* are locally absent. Lower and upper event horizons are separated by a 33 cm thick sequence of grey "griotte" and greenish-grey shales, sandwiching a 10 cm thick, solid, micritic, grey limestone. A subsequent, fossiliferous, grey nodular limestone (3 cm thick) yielded the rare goniatite *Praeglyphioceras* (UD III-C to V A). The overlying cyclic succession consists of greenish-grey shales with intercalated grey nodular limestones.

SHALLOW WATER FACIES SETTING AROUND THE KACAK EVENT – A MULTIDISCIPLINARY APPROACH

Peter Königshof[1], Anne-Christine Da Silva,[2] Thomas J. Suttner[3], Erika Kido[3], Johnny Waters[4], Sarah K. Carmichael[4], Ulrich Jansen[1], Damien Pas[2], Simo Spassov[5] and Michael M. Joachimski[6]

1. Senckenberg Research Institute and Natural History Museum, Senckenberganlage 25, 60325 Frankfurt, Germany. peter.koenigshof@senckenberg.de
2. Sedimentary Petrology, B 20, University of Liege, Sart-Tilman, B-4000 Liège, Belgium.
3. University of Graz, Institute of Earth Sciences, Heinrichstraße 26, A-8010 Graz, Austria.
4. Department of Geology, Appalachian State University, Boone, NC28608, U.S.A.
5. Royal Meteorological Institute of Belgium, Centre de Physique du Globe, Section de Magnétisme Environmental, Belgium.
6. GeoZentrum Nordbayern, University of Erlangen-Nuremberg, Schlossgarten 5, 91054 Erlangen, Germany.

West of the river Rhine, the Eifel area (Eifel synclines) is the dominating structural unit interpreted as N-S trending axial depression of the Rheinisches Schiefergebirge (RSG). Siliciclastic material was delivered from the north during the Early Devonian and early Middle Devonian (Eifelian) but diminished during Givetian times when shallow subtropical carbonates were established over much of the region. A depositional model of the Eifel area with a N-S trending basin surrounded by landmasses was established, considered as the so-called "Eifel Sea Street". In contrast to this model, other authors defined three facies belts in the Eifel synclines with later modifications, based on detailed microfacies studies which gave evidence of rhythmic development of a carbonate platform during the early Eifelian and of a flat shelf lagoon during the late Eifelian and early Givetian, affecting the eastern part of the Eifel synclines. During the Givetian this facies differentiation broke down to some degree and mainly stromatoporoid/coral biostromes extended over the entire area. The studied section lies within the Blankenheim syncline, between the villages of Blankenheim and Blankenheimerdorf and comprises shallow shelf mixed carbonate and siliciclastic facies of Middle Devonian age (Eifelian) accumulated on the southern margin of the former Avalonia microcontinent. A recent paper is focussing on microfacies and bryozoan diversity. Based on the huge diversity of fossils found in deposits around the Kačák Event we will present results of a multidisciplinary approach in order to verify the hypothesis of a fundamental sedimentological gap ("Great Gap" sensu Struve) in the late Eifelian (Junkerberg / Freilingen Fms).

THE DEVONIAN/CARBONIFEROUS BOUNDARY IN SARDINIA (ITALY)

Angelo Mossoni[1], Carlo Corradini[1] and Claudia Spalletta[2]

1. Dipartimento di Scienze Chimiche e Geologiche, Università di Cagliari, via Trentino 51, I-09129 Cagliari, Italy. ang.mossoni1@studenti.unica.it

2. Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Alma Mater Studiorum Università di Bologna, via Zamboni 67, I-40126 Bologna, Italy.

In Sardinia the Upper Devonian-Lower Carboniferous rocks consists mainly of grey massive limestones, known as "Clymeniae limestone", cropping out in the southeastern part of the island. The total thickness likely is 50–70 m, but a precise estimation is difficult due to the strong Variscan tectonic which affected the area. The age of the unit has been provided on the basis of the rich conodont fauna as late Frasnian (Upper *hassi* Zone)–early Tournaisian (Upper *duplicata* Zone). Two sections exposing rocks across the Devonian/Carboniferous boundary are known: the Monte Taccu and the Bruncu Bullai sections. In both these localities a narrow dark shale interval, a few cm thick, interpreted as a Hangenberg Shale equivalent, interrupts the limestone sequence. It has been dated to the Lower *praesulcata* Zone. Above, the sequence continues with less of a metre of limestone. Conodonts just above the shale level are of Carboniferous age, and therefore the Upper *praesulcata* Zone is not present. However there are differences in the age of the oldest Carboniferous bed in the two sections: *sulcata* Zone at Bruncu Bullai section, Lower *duplicata* at Monte Taccu. The difference may be explained with the difficulty to provide a detailed biostratigraphy in the Bruncu Bullai section because *Siphonodella* is not present across the DCB and enters only higher, in the Lower *duplicata* Zone. Beside conodont biostratigraphy and biofacies, magnetosusceptibility and geochemical analysis have been carried on in the two sections.

LATE EIFELIAN ICHTHYOFAUNA OF BELARUS

Dmitry P. Plax[1]

1. Belarusian National Technical University, Nezavisimosti Avenue, 65, 220013, Minsk, Belarus.
agnatha@mail.ru

The Upper Eifelian deposits are widely distributed in the Eastern European Platform, including Belarus area. According to the current Stratigraphic Chart of the Devonian of Belarus (2010) they comprise the clayey-aleuritic, carbonate-clayey and carbonate facies of the Kostyukovichi Regional Stage, mostly of the epicontinental marine origin. They contain common remains of scolecodonts, molluscs, brachiopods, echinoderms, conodonts, miospores and vertebrates. Conodonts obtained from the lower part of the Kostyukovichi strata point to the Upper Eifelian age. Vertebrates, including both agnathans and fishes occur frequently, with the dominant taxa represented by the placoderm *Asterolepis* sp., acanthodians *Cheiracanthus brevicostatus* Gross, *C. longicostatus* Gross, *Haplacanthus marginalis* Agassiz, *Ptychodictyon sulcatum* Gross, *Nostolepis kernavensis* Valiukevičius, *Acanthoides?* sp., sarcopterygians Osteolepididae gen. indet., *Onychodus* sp., *Glyptolepis* sp., actinopterygian *Orvikuina vardiaensis* Gross and agnathans (heterostracan) *Schizosteus striatus* (Gross). Stratigraphically most important taxa include placoderm *Coccosteus cuspidatus* Miller et Agassiz and acanthodians *Nostolepis kernavensis*, *Cheiracanthus intricatus* Valiukevičius, *C. talimae* Valiukevičius, *Cheiracanthoides proprius* Valiukevičius, *Markacanthus costulatus* Valiukevičius, *Rhadinacanthus balticus* Gross and *Ptychodictyon sulcatum.* Of lesser stratigraphic importance are heterostracan *Schizosteus striatus* and sarcopterygian *?Gyroptychius grossi* Vorobyeva. The Kostyukovichi strata can be attributed to the placoderm *Coccosteus cuspidatus* Zone, and to the acanthodian *Nostolepis kernavensis* Zone, which allows correlating them with coeval deposits of adjacent territories of Ukraine, Poland, Russia, the Baltic States and, to a lesser degree, with the Western Europe. The range of these ichthyozones corresponds to the conodont *ensensis* zone. In palaeozoogeographic terms the Kostyukovichi ichthyo assemblage belongs to the Baltic Province. In Belarus, local endemic taxa comprise heterostracan genus *Ganosteus*, acanthodians *Archaeacanthus*, *Homacanthus* and *Haplacanthus*, chondrichthyans *Lugalepis* and *Karksilepis*, and actinopterygian *Orvikuina.* Provincial endemic taxa comprise heterostracan genus *Pycnosteus*, placoderms *Asterolepis*, *Byssacanthus*, acanthodians *Minioracanthus*, *Markacanthus.* Among them *Asterolepis* is characterized by the widest palaeogeographic distribution. The didemic taxa *Actinolepis*, *Homostius?*, *Coccosteus*, *Ptychodictyon*, *Glyptolepis* and *Cheirolepis* show zoogeographical affinities to the Laurentian territories (Scotland, Spitsbergen, Greenland). The most widely distributed polydemics are represented by *Schizosteus*, *Holonema*, *Diplacanthus*, *Rhadinacanthus*, *Cheiracanthus*, *Ohiolepis*, *?Gyroptychius* and *Dipterus*, and were encountered in Scotland, Greenland, Czechia, Germany, U.S.A. and Australia. The cosmopolitan forms are represented by acanthodians *Cheiracanthoides*, *Nostolepis*, *Acanthoides?* and osteichthyans *Moythomasia?* and *Onychodus* from which dominant are *Nostolepis*, *Acanthoides?* and *Onychodus* in the territory of Belarus. [Polish National Research Centre, Project 2011/03/B/ST10/05468].

THE LOCHKOVIAN (LOWER DEVONIAN) CONODONT SEQUENCE IN THE SPANISH CENTRAL PYRENEES: A REFERENCE FOR GLOBAL STUDIES ON PELAGIC FACIES

José I. Valenzuela-Ríos[1]

1. Department of Geology, University of Valencia; c/Dr. Moliner 50; 46100 Burjasot, Spain.
jose.i.valenzuela@uv.es

Seven selected sections in the Spanish Central Pyrenees have provided one of best conodont successions in pelagic facies in the world. This succession chiefly consists of cosmopolitan conodonts that often occur together with relevant endemic conodonts from neritic facies; thus, direct intrafacial correlations are possible for many of the Lochkovian time-slices. The Pyrenean succession starts with *Icriodus woschmidti* in a bed together with lobolites of *Scyphocrinites*; this joint record has to be close to the Silurian/Devonian boundary. Above follows its descendent *I. transiens*, which shortly after is joined by *I. angustoides* and *Ancyrodelloides carlsi*. These two latter taxa show an almost coincident range in all the studied sections and together with the icriodid sequence aforementioned furnished ties with other sections developed in neritic environments (i.e., the Iberian Chain successions). Following the entry of *A. carlsi* a radiation of this genus and of the genus *Lanea* permits one of the finest Lochkovian successions worldwide and foster detailed correlations around the world. The successive entries of *Ancyrodelloides* start with *A. transitans*, from which two main branches developed. A branch with *A. trigonicus, A. kutschery* and *A. sequeirosi* that, except for the latter species, is identified in many of the relevant sections in the world and a less widespread, but not exclusive of the Pyrenees, branch composed of *A. cruzae* and *A. murphyi*. To these, *A. asymmetricus* is an additional taxon recorded in the Pyrenean strata and elsewhere in similar stratigraphical position. The *Lanea* radiation starts with *L. omoalpha* and continues with *L. eoeleanorae, L, eleanorae* and *L. telleri.* Most of these species from the two genera have been used for detailed correlations within European sequences and between the Pyrenean and the North-American successions enabling the subdivision on the Lochkovian Stage into three parts and establishing further subdivisions within the middle Lochkovian. The entry of *Flajsella* and its radiation is an extraordinary tool for further global correlations. An evolutionary event within *Masaraella,* the outcome of *M. pandora* beta, marks the beginning of the upper Lochkovian. The upper Lochkovian conodont richness decreases in the Pyrenean (and in many European sections), but the radiation within the genus *Pedavis* stands out and the sequential entry of *P. robertoi* and *P. gilberti* is used for further subdivision and global correlations.

NEW DATA ON MISSISSIPPIAN TRILOBITES FROM THE MORAVIAN KARST (CZECH REPUBLIC)

Tomáš Weiner[1], Jiří Kalvoda[1], Peter Müller[2] and Hedvika Poukarová[1]

1. Masaryk University, Department of Geological Sciences, Kotlářská 2, 611 37 Brno, Czech Republic. tomasweiner@volny.cz

2. Waldstr. 8, D-56459 Langenhahn, Germany.

The Moravian Karst is a part of the Rhenohercynian Zone of the Central European Variscides. The Mississippian trilobites from carbonate facies in the Moravian Karst were previously described especially from Tournaisian strata. The trilobites presented in this contribution were obtained from a newly discovered fossiliferous bed in the section of the Hády-Říčka Limestones (Líšeň Formation) exposed in an abandoned quarry S of Brno-Líšeň. The lower part of the Viséan stage is indicated by foraminiferal fauna of the MFZ 10 zone and conodonts of the *Gnathodus homopunctatus* zone. Trilobites *Bollandia* cf. *persephone*, *Carbonocoryphe* (*Winterbergia*) cf. *parahahnorum*, *Gitarra* cf. *gitarraeformis*, *Liobole* aff. *galaxaura*, *Liobole* cf. *glabroides*, ?*Namuropyge* sp., *Proliobole* cf. *nitida holzapfeli* and ?*Waribole* sp. were determined. Although the material need further systematic study, it is obvious that most of these species were previously unknown from the Moravian Karst. As suggested by the previous studies, Mississippian trilobite associations from the Moravian Karst are similar to that known from other European areas. The currently studied trilobites show the similarity especially with the taxa known from the Erdbach Limestones in the Rhenish Mountains and in the Harz Mountains (Germany) but also with the taxa known from other areas (e. g. Cantabrian Mountains, Spain). The previously described lower Viséan trilobites from the Moravian Karst were mostly restricted to aleuropelitic facies of the Březina Formation. These lower Viséan trilobite associations are characterized by the occurence of the genera *Archegonus*, *Spinibole*, *Liobole*, *Chlupacula* and *Carbonocoryphe*.

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Continental Crises
of the Jurassic

THE MAIN FLORAL EVENTS DURING THE JURASSIC (SOUTHERN PART OF EAST SIBERIA AND RUSSIAN FAR EAST)

Eugenia V. Bugdaeva[1] and Valentina S. Markevich[1]

1. Institute of Biology and Soil Science FEBRAS, Prosp. 100-letiya, 159, Vladivostok 690022, Russia.
bugdaeva@ibss.dvo.ru

The Lower, Middle and Upper Jurassic sediments of marine and continental origin have a widespread distribution in southern part of East Siberia and Russian Far East. During the transition between the Early Jurassic - Middle Jurassic a plant mass accumulation took place, in the Pribaikalye region which resulted in coal formation. These swamp plant communities forming the coal chiefly consisted of cyatheaceous and osmundaceous ferns, conifers, ginkgoaleans, czekanowskialeans, as well mosses. The taxonomical composition of upland plant communities considerably differs. They are represented by gnetaleans, ginkgoaleans, czekanowskialeans, and in a less degree ferns, conifers, mosses, and club-mosses. The Upper Jurassic strata of southern part of East Siberia and Russian Far East were deposited in volcanic and brackish coastal environments. The former were distributed on the territories of recent Transbaikalia. The depleted vegetation existed under conditions of active volcanism. The plant communities were dominated by czekanowskialeans, cyatheaceous and osmundaceous ferns. The development of vegetation was repeatedly suppressed by ash-falls, explosions, and lahar flows. *Czekanowskia* ex gr. *rigida* Heer appeared as pioneer plant, colonizing new formed land and played important role in recruitment of plant population. The Upper Jurassic deposits of southern part of Russian Far East accumulated in brackish coastal environments. Mainly, this region was represented by sea-side swampy plains with abundant vegetation. Horsetails, bryophytes, osmundaceous and cyatheaceous ferns, cycadophytes, ginkgoaleans, czekanowskialeans and conifers made up plant communities of this age. The burials are dominated by ginkgoaleans and czekanowskialeans, the amount of ferns and cycadophytes is rather high. *Pseudotorellia angustifolia* Doludenko was the main coal-forming plant. This plant continued to play similar role and during the Early Cretaceous. We emphasize that distinctions between compositions of palynospectra from coal seams and intermediate clastic sediments of this region were not revealed, what is meant that vegetations occupied both lowland and upland were similar, whereas intracontinental lowland and upland plant communities were different. The floristic changes across the Jurassic-Cretaceous boundary consisted in the increase of ferns and cheirolepidiaceous gymnosperms, which might be related to the marginal uplift and a drier climate.
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NEW ADVANCE IN CONTINENTAL TR/J BOUNDARY OF SOUTH CHINA

Shenghui Deng[1], Yuanzheng Lu[1], Xin Li[1] and Ru Fan[1]

1. Research Institute of Petroleum Exploration & Development PetroChina, Beijing 100083, China.
dsh63@petrochina.com.cn

As the Upper Triassic and the Lower Jurassic in China are dominated by non-marine sediments and the placement of the continental Triassic/Jurassic (Tr/J) boundary in China is still controversial due to lack of marine fossils and other definite evidences. In 2010, the Tr/J boundary GSSP was ratified by the IGU and placed at the Kuhjoch section, Northern Calcareous Alps, Austria. The boundary coincides with the first appearance of the ammonite *Psiloceras spelae* Guex subsp. *tirolicum* Hillebrandt & Krystyn and approximate co-occurrences with a brief negative excursion in organic carbon isotopes and the first appearance datum of the pollen species *Cerebropollenites thiergartii* (Rhul *et al*.). Both the carbon isotope anomaly and the palynological markers are valuable for determination of the continental Tr/J boundaries. Many well developed Tr/J boundary sections are located in Sichuan and Yunnan Provinces of Southwestern China. In the Sichuan Basin, the Late Triassic and Jurassic strata are generally continuously developed and well exposed. The Tr/J boundary in this basin was previously placed at the base of the Zhengzhuchong Formation, marked by the first appearance of red colored beds or by a quartzitic sandstone bed (Wang *et al*.). However, as a result of our investigation of a dozen outcrop sections and numerous borehole sections in recent years, the Tr/J chronostratigraphical boundary in northern Sichuan Basin should be placed within the black shale beds of the upper part of the coal-bearing formation within the Xujiahe Formation, which previously has been assigned to the Upper Triassic. This boundary is chiefly determined by palynological and palaeobotanical evidences and organic carbon isotope excursion. Below the boundary, the palynological assemblage is characterized by Triassic elements, such as *Dictyophyllidites*, *Kyrtomisporis*, *Lunzisporites* and *Taeniaesporites*, while above the boundary the palynological assemblage changes significantly. There is a sharp increase in the abundance of *Classopollis* and of the fern spore *Cyathidites*, while the Triassic elements significantly decline. The flora from the beds under the boundary are dominated by dipteridaceous ferns and Cycadopsida, showing a Late Triassic age, and the typical Jurassic fern *Coniopteris* occurs several meters above the boundary. A negative organic carbon isotopic excursion is evident coinciding with the biostratigraphical Tr/J boundary markers, and a marked positive excursion occurs several meters above the boundary, which can be correlated with the Hettangian carbon isotopic excursion in marine carbonate rocks.

THE EARLIEST JURASSIC CONTINENTAL TO MARINE SYN-CAMP CARBONATE-RICH SEQUENCES OF MOROCCO AND THEIR RELATIONSHIP TO COEVAL STRATA IN NORTH AMERICA.

Mohammed Et-Touhami[1], Paul E. Olsen[2] and Jessica H. Whiteside[3]

1. Département de Géologie, Faculté des Sciences, Université Mohamed Ier, BP 717, Oujda, 60000, Morocco. mohammed_et_touhami@yahoo.com
2. Department of Earth and Environmental Sciences, Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W, Palisades, NY 10964-1000, USA.
3. Ocean and Earth Science, National Oceanography Centre, University of Southampton, Southampton, SO17 1BJ, UK.

Moroccan continental rift basins preceding the Jurassic opening of the central Atlantic were initiated within the Late Permian and finished in the Early Jurassic. All of these basins exhibit clastic to evaporitic red bed-dominated sequences and up to four basaltic intrusion and extrusion units of the Central Atlantic Magmatic Province (CAMP). The terrestrial end-Triassic extinction (ETE) marked by the turnover in sporomorph taxa is placed in Morocco at the base of, or within, the oldest CAMP unit above which sedimentary strata contain several limestone-rich intervals. These syn-CAMP limestones stand out as extremely unusual in an otherwise siliclastic-dominated system. They are probably the result of a super-greenhouse effect caused by the massive basaltic eruptions and/or simply the weathering products of vast drainage areas newly floored by relatively Ca-rich basalt. Preliminary macrofossil collections of vertebrates, plants, and mollusks in western Morocco demonstrate lacustrine conditions, while the collection of new mollusks and echinoderms from the easternmost basin has resulted in the ecologically significant determination that euhaline and polyhaline conditions existed, thereby documenting a marine connection from western-most Tethyan basins during at least part of the rift sequence in Morocco. In eastern North America, lacustrine limestone sequences are found in the same stratigraphic position above the initial basalts, offering the possibility to examine directly the link between the classic basalt-bearing continental rift sequences in North America and the marine strata of the classic Tethyan realm.

TERRESTRIAL CARBON-ISOTOPE STRATIGRAPHY AND TERRESTRIAL ECOLOGICAL TURNOVERS THROUGH THE LATEST TRIASSIC TO EARLY JURASSIC, NORTH TARIM BASIN, NW CHINA

Linhao Fang[1], Yuanzheng Lu[2], Stephen Hesselbo[3] and Shenghui Deng[2]

1. State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum-Beijing, 102249, China. linhao.fang@gmail.com

2 Research Institute of Petroleum Exploration and Development, PetroChina, Beijing, 100083, China.

3 Camborne School of Mines, University of Exeter, Penryn Campus, TR10 9FE, UK.

The latest Triassic to Early Jurassic is a key moment in Earth history with global carbon-cycle perturbations and terrestrial carbon-isotope stratigraphy has proven a powerful approach to stratigraphic correlations, evolution of $\delta^{13}C$ of atmospheric CO_2 and palaeoenvironmental reconstruction during the episode. However, few records of long-term continuous carbon-isotope data have been reported from entirely terrestrial successions for this period. The Tarim Basin located in NW China as an inland basin since the Mesozoic and provides an exceptional opportunity to explore the terrestrial carbon-isotope stratigraphy through the latest Triassic, Triassic–Jurassic boundary, and Early Jurassic. Macrofossil wood samples were largely collected from alluvial conglomerate, associated braided-fluvial sandstone and siltstone, and bulk organic matter were collected from coal seams, organic-rich mudstone and laminated shales were additionally used as a supplement. On the basis of the biostratigraphy and potential Stage/Age (sub-) boundaries implied by biological turnovers, the terrestrial carbon-isotope stratigraphy in the Kuqa section is well correlated with both terrestrial and marine carbon-isotope stratigraphic records from UK through the Early Jurassic. A bed with the character of soft-sediment deformation and its occurrence at the Triassic–Jurassic boundary recalls the similar phenomena in NW Europe, where the strata are marked by the uniquely widespread (across > 250,000 km^2 in the shallow marginal marine strata in UK) seismites inferred as evidence for bolide impacts. For the Triassic–Jurassic boundary, positive and negative carbon-isotope excursions at the Kuqa section could also be found at other nearly synchronous strata globally. The carbon-isotope stratigraphy significantly improves the terrestrial stratigraphic resolution at the Kuqa section. An exact position of the Triassic–Jurassic boundary at the Kuqa section is proposed and an approximate correlation is made with global Tr-J boundary successions. In light of the biostratigraphy and the carbon-isotope stratigraphy obtained in the present study, an updated age assignment of the lithostratigraphic units is proposed to Age/Stage level in the Early Jurassic across the Northern Tarim Basin.

PALEOBIOLOGIC IMPLICATIONS OF THE AFRO-BRAZILIAN DEPRESSION DURING JURASSIC AGE

Paulo R. de Figueiredo Souto[1] and José A. Ferreira Gomes de Andrade[2]

1. Universidade Federal do Estado do Rio de Janeiro, Departamento de Ciências Naturais, Av. Pasteur, 458, sala 405, Rio de Janeiro, RJ, cep: 22290-040, Brazil. prfsouto@ig.com.br

2. Centro de Pesquisas Paleontológicas da Chapada do Araripe, Departamento Nacional de Produção Mineral, Praça da Sé, 105, Crato, CE, cep: 631000-440, Brazil.

During the Mesozoic era much of the eastern shore of Brazil suffered strong tectonic influence due to the process of fragmentation of the Gondwanan continent. However, the increasing studies of geodynamics and paleontology related to the initiation of the formation of marginal basins have shown that the Reconcavo-Tucano-Jatoba, Sergipe-Alagoas, and inland basins of Souza and Araripe in Brazil, are associated with the formation of the African-Brazilian depression process. This has changed previous interpretations that instead considered interruption of sedimentation processes during the Jurassic. Recent discoveries of fossil traces of marine tetrapod have indicated that this region in particular, had environmental conditions favorable for development of life, due to formation of deep lakes, with deposition of dark shales, rich in organic matter, meandering fluvial system with turbidities possibly produced by cyclic sedimentation subaluvial fans with chains of turbidities that adduced sand to the deeper parts of the lakes, shaping alluvial deposits advancing to the lower areas due because marine ingression of the proto-Atlantic ocean from the south-southeast added to a increasing seasonality arid to humid have a influence on this region. The fossil concentration provides a parameter for faunal abundance and community dominants, when depositional and taphonomic processes are accounted for. Examination of large-scale shifts in faunal abundance and community dominants is a key in evaluating the extent of ecological change within an ecosystem. Assessing the ecological changes associated with the Late Jurassic and Early Cretaceous fossil concentrations that consist of massive to laminated reddish-brown chalks and calciferous shales of the northeast Brazilian outcrops were examined. These beds formed in a shallow-water, soft substrate environment within a single depositional process under broadly similar environmental conditions permit the preservation of different fish genus among which *Hybodus*, *Mawsonia*, *Lepidotes* (Missão Velha Fm of Araripe Basin; Aliança Fm of Jatoba Basin and Tucano Basin). The vertebrate fossil remains analysis are represented by disarticulated bones and free scales and teeth in association with abundant coprolites, also the registration of exclusively non-marine fossil forms of conchostracheans and ostracods, suggest that all lithostratigraphic units represent an unique tectonic-sedimentary cycle with continental sedimentation with the paleocurrent flux dispersion pattern for SE and SW toward to the south under control of Afro-Brazilian Depression.

DINOSAURS FROM THE JURASSIC AND CRETACEOUS SYSTEMS OF PAKISTAN: THEIR PALEOBIOGEOGRAPHIC LINK

M. Sadiq Malkani[1]

1. Geological Survey of Pakistan, Sariab Road, Quetta, Pakistan.
malkanims@yahoo.com

The first dinosaur fossils in Pakistan were identified as late as year 2000. The Pakistan dinosaur fossils are found in the Indus Basin which is further subdivided into the Upper Indus (Kohat and Potwar), Middle Indus (Sulaiman) and Lower Indus (Kirthar) basins. In the Lower Indus (Kirthar) Basin, a few and poorly recognized body fossils of a titanosaurian sauropod (*Brohisaurus kirthari*) were found from the Late Jurassic Sembar Formation in Balochistan, Pakistan. In the Upper Indus (Kohat and Potwar) Basin, trackways of a herd of more wide gauge titanosaurian sauropods (*Malakhelisaurus mianwali*) confronted by a running narrow gauge theropod (*Samanadrinda surghari*) have been reported from the Middle Jurassic Samanasuk Limestone, Punjab, Pakistan. In Middle Indus (Sulaiman) Basin, about 3000 fossils were collected from more than 30 localities in fluvial successions represented by red mud stones alternated by two sandstone beds of Vitakri Formation. The fossils include the taxa *Khetranisaurus barkhani*, *Sulaimanisaurus gingerichi*, and *Pakisaurus balochistani* of herbivorous Pakisauridae (slender) and *Marisaurus jeffi* and *Balochisaurus malkani* of herbivorous Balochisauridae (stocky), *Gspsaurus pakistani*, *Saraikimasoom vitakri*, *Maojandino alami and Nicksaurus razashahi* titanosaurian sauropods, large bodied *Vitakridrinda sulaimani* of abelisaurian, and *Vitakrisaurus saraiki* of Vitakrisauridae noasaurian theropods, and *Sulaimanisuchus kinwai* of Sulaimanisuchidae, *Pabwehshi pakistanensis* and *Induszalim bala* of Induszalimidae carnivorous mesoeucrocodiles, and *Saraikisaurus minhui* of pterosaur (Pterodactyloidea, Saraikisauridae, Saraikisaurinae). The Sor Muzghai-an ichno type site of less wide gauge titanosaurs (*Pashtosaurus zhobi*) has been found in the Latest Cretaceous Vitakri Formation from the western extremity of Sulaiman basin and eastern extremity of Western Indus Suture, Zhob district, Balochistan, Pakistan. These footprints are very significant due to common body fossils in same basin and same formation. Further the location of this ichnosite is very significant due to its regional contact with Laurasian lands in the Latest Cretaceous just after first collision of Indo-Pakistan with Asia. The titanosaurian sauropods, abelisaurian and noasaurian theropods show a closer resemblance to Gondwanaland than Laurasia. The Pakistan represents both Gondwanan as well as Laurasian geo-heritage and bio-heritage which need protection as national and global geoparks. This would provide important avenues for the sustainable development of Pakistan. The Indo-Pakistan subcontinent is presently a Peninsula but during the Jurassic it was a part of Gondwanaland, and duringthe Cretaceous (136 to 67 Ma) it remained on northward journey as a large island/subcontinent, and during the Latest Cretaceous (67 Ma) its northwestern part collided for first time with the Afghan block of Asia.

MIDDLE JURASSIC-EARLY CRETACEOUS DINOFLAGELLATE ASSEMBLAGES FROM THE DINOSAUR MEMBERS, TENDAGURU FORMATION, SOUTHERN COASTAL TANZANIA.

Emma S. Msaky[1]

1. Tanzania Petroleum Development Corporation, BWM Tower A, 51/52, Azikiwe/ Jamhuri Street, P. O. Box 2774, Dar es Salaam, Tanzania. msaki@tpdc-tz.com

Middle Jurassic to Early Cretaceous dinoflagellate species are retrieved from the Dinosaur members of the Tendaguru Formation, southern coastal Tanzania. The Lower Dinosaur Member yielded typical Bajocian-Callovian dinoflagellate cysts including *Dissilodinium caddaense*, *Durotrigia filapicatum*, and *Nannoceratopsis gracilis*. The *Nerinella* Member (Oxfordian) yielded a good, relatively high diverse dinoflagellate cyst assemblage consistently dominated by *Rigaudella aemula* and *Chytroeisphaeridia chystroeides*. The Oxfordian age which is assigned to the *Nerinella* Member is supported by *Fistulacysta simplex*, *Egmontodinium elongatum*, *Komewuia* sp. A, and data concerning associated ammonites and ostracodes. The Middle Dinosaur Member yielded a miospore-rich assemblage with a few statigraphically important dinoflagellate cysts of early Kimmeridgian age, such as, *Dingodinium tuberosum*; this species is associated with *Barbatacysta creberbarbata*. The *Indotrigonia africana* Member yielded rich and diverse Late Jurassic dinoflagellate suite consisting of *Dingodinium swanense, Wanaea tendaguruensis, Scriniodinium luridum*, and *Limbodinium patulum*; these species, inter alia, *Dingodinium swanense*, suggest a Kimmeridgian age for this member, further supported by associated ammonites. Although the palynofloral assemblage documented from the Upper Dinosaur Member is poor, a few stratigraphically important dinoflagellate cyst species of Tithonian-Early Cretaceous age, such as *Circulodinium compta*, are documented from this member. This Tithonian-Early Cretaceous age is in part consistent to data pertaining to ammonites.

THE VALUE OF QUANTITATIVE PALYNOLOGY AND GEOCHEMISTRY IN PROVIDING NEW INSIGHTS INTO REGIONAL TECTONO-STRATIGRAPHIC DEVELOPMENT AND CLIMATIC EVOLUTION; AN EXAMPLE FROM THE LATE JURASSIC OF THE NETHERLANDS

Dirk Munsterman[1], Roel Verreussel[1], Sander Houben[1], Susan Kerstholt-Boegehold[1] and Nico Janssen[1]

1. TNO, Princetonlaan 6, Utrecht, 3584CB The Netherlands.
Dirk.Munsterman@tno.nl

The pre-Quaternary Stratigraphic Nomenclature of the Netherlands as compiled by Van Adrichem Boogaert and Kouwe in 1993 provided a consistent framework for use by the Dutch geological community. The combination of non-marine to shallow marine lateral facies changes, repetitive log and facies characteristics in time, sea-level and climate change, salt tectonics and structural compartmentalisation hamper straightforward seismic interpretation and log correlation. On-going development of new and more integrated stratigraphic techniques, including marine- and terrestrial palynology, sedimentology and stable isotope analyses together with an ever-increasing resolution and spatial coverage provide the opportunity to disentangle this complexity. Over the past decades, this integrated approach has led to increased stratigraphic detail for the Upper Jurassic of the Southern North Sea Basin, to a level at which high-order changes can be related to global climate- and sea level changes. As a next and ensuing step, stable carbon isotope analyses are providing another means for calibration of the regional stratigraphic insights to the global standard. Eventually, the integrated insights are now applied as an interpretive model in the complex inverted, truncated and compartmentalized basins of the area. Here we present how this integrated stratigraphic approach has led to a new tectono-stratigraphic multi-basin model that has a relevant level of detail for well planning and de-risking.

A FRAMEWORK FOR CORRELATING JURASSIC TO EARLY CRETACEOUS NON-MARINE MOLLUSCAN ASSEMBLAGES IN EUROPE

Martin C. Munt[1], Graciela Delvene[2], Luis Alcalá[3], Laura Piñuela[4] and José Carlos García-Ramos[4]

1. Dept Earth Sciences, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK. m.munt@nhm.ac.uk

2. Museo Geominero (Instituto Geológico y Minero de España). C/ Ríos Rosas 23. 28003 Madrid. Spain.

3. Fundación Conjunto Paleontológico de Teruel-Dinópolis Avda. Sagunto s/n, Teruel E-44002, Spain.

4. Museo del Jurásico de Asturias (MUJA). 33328 Colunga, Asturias, Spain.

The European Jurassic to Early Cretaceous successions are primarily dominated by fossil-rich marine sediments. However, there are also many, geographically and stratigraphically dispersed, non-marine deposits, frequently with rich mollusc faunas ranging from the Bathonian to Aptian-Albian. Within the United Kingdom these are stratigraphically very well defined. These deposits range from Northwest Scotland to southern Spain. Thick Bathonian deposits occur in the British Isles; however, it is the extensive 'Purbeck- Wealden' Late Jurassic to Early Cretaceous in England, Germany and France which is best known and frequently used as a reference point for similar aged deposits around the world. In the Iberian Peninsula interdigitated Kimmeridgian and younger marine and non -marine sediments occur in the Asturian and Lusitanian basins, with extensive Early Cretaceous fluvial and lacustrine deposits in continental basins such as Teruel, Las Hoyas (Cuenca) and Cameros (La Rioja). It was recognised in the 1960's that similarities existed in Early Cretaceous molluscan faunas between North Africa, Spain and southern England. More recently the significance of these has been reviewed and strengthened with correlations being recognised not just within Europe but also to the Far East, with the recognition of Trigonoioidid bivalves in Barremian deposits on the Isle of Wight (England), and at Las Hoyas (Spain), Aptian sediments from Cameros Basin (Spain) and Berriasian and Albian rocks from different basins at Teruel (Spain). Significant fossil groups for this study include gastropods belonging to the Cassiopidae and Viviparidae and bivalves of the Unionoida, minor taxa such as the Bathonian Praemytilus (Bivalvia) could also prove significant to this study. In interdigitating sequences Trigonid and Corbiculid bivalves are important for correlation. As a contribution to IGCP 632, a correlative framework is being developed for European Jurassic-Cretaceous non marine molluscan faunas. Critical to this work is firstly, the recognition of taxa found in inter-digitising sequences as seen in Asturias and their occurrence in other freshwater settings. Secondly, the significance of palaeogeographical factors affecting the ranges of taxa including endemism in lacustrine settings (Cameros, Teruel and Las Hoyas); thirdly, the development of a definable succession of non marine mollusks for Europe, and fourthly, wider geological correlations beyond Europe.

THE COLORADO PLATEAU CORING PROJECT (CPCP): CHRONOSTRATIGRAPHIC CONTEXT FOR TRIASSIC-JURASSIC EARTH SYSTEM EVENTS AND PROCESSES

Paul Olsen[1], John Geissman[2], George Gehrels[3], Randall Irmis[4], Dennis Kent[5, 1], Roland Mundil[6], and William Parker[7], Jingeng Sha[8], Roberto-Molina Garza[9], Wolfram Kürschner[10] and Gerhard Bachmann[11].

1. Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, 10968 USA. polsen@ldeo.columbia.edu

2. University of Texas at Dallas, Richardson, TX, 75080 USA.

3. University of Arizona, Tucson, AZ, 85721 USA.

4. University of Utah, Salt Lake City, UT, 84112 USA.

5. Rutgers University, Piscataway, NJ, 08854 USA.

6. Berkeley Geochronology Center, Berkeley, CA, 94709 USA.

7. Petrified Forest National Park, Petrified Forest, AZ, 86028 USA.

8. Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, 210008, China.

9. Universidad Nacional Autónoma de México, Juriquilla 76230, Querétaro, México.

10. University of Oslo, 0316 Oslo, Norway.

11. Martin-Luther-Universität, Halle-Wittenberg Institut für Geowissenschaften,D-06120 Halle (Saale), Germany.

The CPCP seeks to provide a rigorous geochronologic framework for the rich biotic assemblages of early Mesozoic strata of the American West by providing complete stratigraphic sections sampled largely by coring. With unambiguous superposition, time can be assessed at problem-appropriate resolution, and events, fossil occurrences, and environmental records can be temporally linked across geography and facies with a globally-exportable time scale based on paleomagnetic polarity stratigraphy and high-resolution U-Pb zircon dates. Coring for Phase 1 of the project was completed during December, 2013 in Petrified Forest National Park, AZ, USA and was funded by US-NSF and ICDP. A total of 840 m of core from two sites, separated by 31 km, was recovered spanning the lower Owl Rock Member of the Chinle Fm. to the base of the formation (Late Triassic), and all of the Moenkopi Fm. (nominally Early and early Middle Triassic), terminating in the Permian Coconino Fm. The 2.5 in dia. cores were drilled inclined from the vertical to maximize expression of the paleomagnetic reversal pattern. The main paleobiological questions addressed include: 1) was the largest identified medial Late Triassic biotic turnover synchronous with the giant Manicouagan impact? 2) were continental biotas of tropical Pangea radically different than those from higher latitudes despite the geographic contiguity? 3) how does the new exportable timescale inform our understanding of existing biostratigraphic correlations? 4) what was the tempo and mode of continental biotic recovery from the Permian-Triassic extinctions in west-central Pangea?; and 5) what was the biotic context for the interval before the end Triassic extinction (ETE). Phase II of the CPCP is planned to recover longer cored sections that span the Early Jurassic and Late Triassic, overlapping with cores from Phase I and sampling the end Triassic extinction and the subsequent biotic recovery at several sites. The main paleobiological issues addressed by these cores will include: 1) the nature and chronology of the ETE subsequent recovery in west-central Pangea; 2) the interplay between global environmental change and apparent climate change driven by tectonic plate translation across zonal climate zones and effects on the biota; and 3) the chronostratigraphic context for the rise to ecological dominance of the dinosaurs. Phase III of the CPCP, still in the early planning stages, is aimed at providing the chronostratigraphic and paleoclimatic context for the famous Late Jurassic biotic assembles from western North America. [Partly supported by UNESCO-IUGS IGCP Project 632].

CLIMATIC CHANGES DURING THE TOARCIAN OCEANIC ANOXIC EVENT (EARLY JURASSIC) RECORDED IN LAND-DERIVED ORGANIC MATTER IN MARGINAL-MARINE SHALES IN POLAND

Grzegorz Pieńkowski[1], Marta Hodbod[2] and Clemens V. Ullmann[3]

1. Polish Geological Institute – National Research Institute, Rakowiecka 4, PL-00-975 Warszawa, Poland. grzegorz.pienkowski@pgi.gov.pl

2. Polish Geological Institute – National Research Institute, Rakowiecka 4, PL-00-975 Warszawa, Poland.

3. University of Copenhagen, Department of Geosciences and Natural Resource Management, Øster Voldgade 10, 1350 Copenhagen K, Denmark.

The formation of black mudstones, rich in total organic carbon (TOC) is associated with anoxic marine bottom waters, most prominently connected with Oceanic Anoxic Events (OAEs). One of the best-documented and most severe of these events is the Early Toarcian OAE (T-OAE, ~183 Ma ago) that lasted for c. 300 – 500 kyr (Boulila et al., 2014). The T-OAE is associated with a high rate of organic burial, coincident with a prominent negative carbon isotope excursion (CIE), expressed in series of stratigraphically abrupt steps reaching magnitudes of ~6 ‰. However, coincidence between coeval global carbon isotope perturbations and anoxia in seas is not always obvious. In particular, the manifestation of this major carbon cycle perturbation in non-marine and marginal marine environments is still poorly constrained. In the Polish basin, strata coeval to marine black shales of the T-OAE are represented by poorly consolidated green/grey mudstones, claystones and siltstones ("verdine" facies), with subordinate sandstone intercalations (Ciechocinek Formation), deposited in a large embayment/lagoon. The organic matter studied in 420 samples is strongly dominated by terrestrial type III kerogen, showing very low thermal maturity. Carbon-isotope data from the separated woody organic matter in Toarcian successions of the Polish Basin (Hesselbo and Pieńkowski, 2011) show negative carbon isotope excursions (CIEs), which occurred in major steps, reproducing observations on CIEs in marine successions and recently correlated to c. 30 - 34 kyr obliquity forcing of climate (Boulila et al, 2014). Contrary to the open marine basins, where negative $\delta^{13}C$ values are associated with high total organic carbon (TOC) content, in the Polish Basin sediments deposited during the negative CIEs show lowest TOC contents. Furthermore, colour and elemental geochemistry contradict anoxic conditions in the whole Lower Toarcian in Poland. Absence of indication for anoxic conditions is attributed to the general shallowness of the basin and destruction of the halocline. Palynodiagrams of three selected borehole sections reflect the composition of standing vegetation, showing conspicuous plants' response to the climatic perturbations. Changes of palynofacies also reflect climate changes, which are evidenced also by other data - kaolinite content and CIE steps. Of particular significance is climatically controlled degradation of terrestrial organic matter. The organic carbon pool in soils and its destruction may have played an important role in the carbon cycle during the T-OAE. [Partly financed by the Polish National Science Centre, granted on the basis of decision no. DEC-2012/06/M/ST10/00478].

THE TOARCIAN IN MOROCCAN ATLASIC DOMAIN: EVENTS GEODYNAMIC, SEDIMENTARY AND PALAEONTOLOGICAL - COMPARISON WITH THE PARIS BASIN (REGION OF LUXEMBOURG)

Driss Sadki[1] and Robert Weis[2]

1. Department of Geology, Faculty of Science, Moulay Ismaïl University, BP. 11 201 Zitoune, Meknes, Morocco. driss.sadki@gmail.com

2. Palaeontological Department, National Museum of Natural History Luxembourg, 25, rue Münster, 2160 Luxembourg, Luxembourg.

The Toarcian (Early Jurassic) allows the understanding of geodynamic and sedimentologic processes as well as the worldwide faunistic renewal. The opening of the northwestern branch of the Tethys Ocean (prefiguring the opening of the «Atlantic Ocean») is one of the major elements to determine a faunal segregation of marine organisms, and in particular ammonites, resulting in two palaeobiogeographic domains («Tethyan and European»). Located on the southwestern margins of the Tethys, the Atlasic domain constitutes an intracratonic chain covering all the Maghreb area from Morocco to Tunisia. On this margin the Toarcian is characterised by major geodynamic, sedimentologic and faunal changes. On the other hand, the Paris Basin represents a «classic» study area for faunas of «European» (Boreal) composition and provides a suitable comparative area for the Maghrebid fauna, witnessing palaeogeographic and environmental affinities. **Geodynamics and sedimentology**: the Toarcian represents an episode of accelerated palaeogeographic differentiation in the Atlasic domain. The previously carbonatic sedimentation (during Sinemurian-Pliensbachian) is replaced by a marly sedimentation from the lowermost Toarcian onwards. These changes in deposit conditions are accompanied by sedimentary perturbations at the base and at the top of the Toarcian. In the Lower Toarcian they are evidenced by erosion and absence of deposits on the structural highs and the deposit of marls, sometimes allodapic, in the basin centers. In the Upper Toarcian, stratigraphic gaps and/or extreme condensation accompanied by iron oolite deposition characterise the ridges and the basin margins. **Palaeontology**: In Morocco, as in other parts of the Maghrebide Basin, the Toarcian is characterised by an ammonite fauna of Mediterranean affinity. The Mirabile Subzone shows the appearance of *Eodactylites* and the persistence of late Pliensbachian genera *Lioceratoides* and *Protogrammoceras*. The Semicelatum Subzone comprises the genera *Orthodactylites*, *Kedonoceras* and *Protogrammoceras*. The Levisoni Zone is characterised by *Harpoceratoides* in its lower part and *Harpoceras* in its upper part. The Bifrons Zone shows an ubiquitous fauna represented by *Hildoceras*, also well known in Europe. In contrast, the Gradata Zone shows a marked Mediterranean affinity, possibly a consequence of the «Variabilis crisis» event in north-western Europe, whose effects are tangible until the Meneghinii Zone. During this time interval, the fauna of Morocco, as well as those of the entire Mediterranean Tethys, is composed by taxa of a strictly Mediterranean distribution. The top of the upper Toarcian is marked again by the homogeneity of the fauna: the Aalensis Zone is consequently employed in both the European and the Mediterranean domains.

ELEVATION OF THE TIANSHAN MOUNTAINS AND PALEO-HYDROLOGICAL RECORDS OF THE JUNGGAR BASIN, NORTHWEST CHINA, DURING THE LATEST JURASSIC TO EARLY CRETACEOUS

Takashi Sakai[1], Gang Li[2], Hromichi Hirano[3], Thoru Ohta[3] and Takeshi Kozai[4]

1. Department of Earth and Planetary Sciences, Kyushu University, Hakozaki 6-10-1, Higashiku, Fukuoka, 812-8581, Japan. taku@geo.kyushu-u.ac.jp

2. Nanjing Institute of Geology and Palaeontology, 39East Beijing Road, Nanjing 210008, China.

3. Department of Earth Sciences, School of Education, Waseda University, Nishiwaseda 1-6-1, Shinjyuku, Tokyo, 169-8050, Japan.

4. Department of Geosciences, Naruto University of Education, Nakashima 748, Takashima, Naruto, 772-8502, Japan.

Collision of the Lhasa Block with the Asian Continent elevated the Tianshan Mountains during the end of the Jurassic, and subsequently created some major non-marine foreland basins during the Early Cretaceous. An abrupt appearance of the mountains within the mid-latitude high-pressure zone resulted in a significant climate change in the Junggar Basin with a rain shadow zone behind it. The paleo-hydrological records in the Kalazha Megasequence were examined in detail based on sedimentary facies, sequence stratigraphic boundaries, evaporite and paleosole horizons, and paleocurrent directions. The Kalazha Formation is of a latest Jurassic age and the basal part of the megasequence consists of alluvial fan deposits (wadi) deposited under desert condition and is underlain unconformably by the Upper Jurassic Qiqu Formation deposited during wet conditions. The Kalazha Formation is followed by Lower Cretaceous lacustrine successions, the Qingsuihe, Hutubei, Shenjinkou and Lianmuqin formations in ascending order. Two T-R cycles bounded by flooding surfaces were discernible in the lacustrine successions. Each of them consists of sand/mud couplets in the lower and vari-colored shale in the upper and might be controlled by the change of tectonic subsidence rate and an amount of precipitation. It is noteworthy that river-related facies such as fan-delta and mouth bars were not detectable entirely through the megasequence and that almost of sandstones were transported by wind-driven drift currents exclusively. Stormy winds attaining to 20-50m/s could be inferred from sheeted and mega-rippled sandstones showing sub-parallel lamination and low-angle cross-lamination internally. In addition to the development of evaporite and paleosol, paleo-current analysis suggests that westerly dry winds nearly parallel to the lacustrine axis have been prevailing through the Early Cretaceous. High-precipitation, on the other hand, is recorded in the lower part of the T-R cycles as a development of multi-graded siltstones and rhythmites that were transported by mesopycnal flow and suspension cloud in stratified lacustrine. It is clear that the elevation of the Tianshan Mountains strengthened atmospheric circulations and controlled the paleo-hydrological environments of the Junggar Basin. Such sedimentological records seem to be consistent well with the atmospheric GCM-models that take in simulation high surface temperature (30°C) of the equatorial Tethys Sea and altitude of 1,500 meters for the Tianshan Mountains.

DISTRIBUTION PATTERN OF SINEMURIAN MARINE–BRACKISH-WATER BIVALVE *WAAGENOPERNA* IN CHINA AND ITS PALAEOGEOGRAPHIC IMPLICATIONS

Jingeng Sha[1], Yanhong Pan[1], Yaqiong Wang[1], Xiaolin Zhang[1], Siwei Chen[1] and Cai Huawei[1]

1. LPS, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China.
jgsha@nigpas.ac.cn

Waagenoperna is a group of epi-byssate marine–brackish-water bivalves. However, it has been recently recognized that the Early Jurassic (Sinemurian) *Waagenoperna lilingensis*-*W. mytiloides*-*W. pernoformis* assemblage-bearing intercalations have a wide distribution in the areas southwest of the line of Shanghai-Altay, including southeastern, southern, southwestern and south-central China. They are intercalated with non-marine strata which generally yield coal. Such geographic and stratigraphic distribution patterns of *Waagenoperna* can not only correlate the Sinemurian non-marine coal-bearing strata, but also particularly demonstrate that transgressions occurred, flooding the areas southwest of Shanghai-Altay, during the Sinemurian. These extensive transgressions influenced the climate and changed the palaeo-topography of southwestern Shanghai-Altay: ensured a humid climate and resulted in the formation of marsh and even paralic swamp environments. These environments allowed the plants and animals to thrive and led to the accumulation of large quantities of organic matter, that eventually formed coal and probably oil as well. Furthermore, the transgressions would have altered the salinity of lakes and changed the overall ecosystem, causing extinction of some fauna while others adapted and evolved. [Supported by UNESCO-IUGS IGCP Project 632].

THE PALYNOLOGICAL AND CARBON ISOTOPE SIGNALS ACROSS THE TRIASSIC–JURASSIC BOUNDARY SUCCESSIONS OF JUNGGAR BASIN, NORTHWESTERN CHINA

Vivi Vajda[1], Jingeng Sha[2], Linda Larsson[1], Yanhong Pan[2], Yaqiong Wang[2], Xiaolin Zhang[3] and Xiaogang Yao[2]

1. Department of Geology, Lund University, SE-22362 Lund, Sweden.
Vivi.vajda@geol.lu.se

2. LPS, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China.

3. CAS Key Laboratory of Crust-Mantle Materials and Environments, School of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, China.

The Triassic–Jurassic (Tr–J) boundary marks a major event, that c. 200 Ma resulted in global extinctions of fauna and flora both in the marine and terrestrial realms. A 1113 meter thick section along the southern margin of the Junggar Basin of northern Xinjiang Uyghur Autonomous Region, northwestern China spanning the Tr-J boundary was sampled for a multidisciplinary study and in this talk we focus on the palynology and carbon isotope data from the studied succession. The sediments yield well preserved palynofloral assemblages and 60 miospore taxa were identified. Based on the presence of key-species and abundance calculations of spores and pollen, three zones were identified. They are, in ascending order, the *Perinopollenites*–*Alisporites* assemblage of Haojiagou Formation, indicativeof a Late Triassic (Rhaetian) age, the *Perinopollenites*–*Pinuspollenites* assemblage of the Badaowan Formation interpreted as Early Jurassic (Hettangian) and finally the *Perinopollenites*–*Cycadopites* Assemblage dated to Sinemurian. Additionally, ca. 40 samples were analyzed for organic carbon isotopes in order to link the palynological signal to changes in the organic carbon isotope ratio. Significant changes were identified, possibly linked to the changes in the global carbon cycle as an effect of the biotic turnover associated with the end Triassic event. A second, high-resolution palynological study of the boundary interval is presently carried out and the results will be presented together with the results on the carbon isotope excursion during in this session. [Partly supported by UNESCO-IUGS IGCP Project 632].

REVISITING THE RECORD OF GENUS *ATAXIOCERAS* IN MEXICO

Ana B. Villaseñor[1], Luis Moliner[2] and Federico Olóriz[3]

1. Universidad Nacional Autónoma de México, Instituto de Geología, Depto. Paleontología, México D.F., 04510, Mexico. anab@unam.mx

2. ENSAYA Laboratory, Aneto nº 8, Cuarte de Huerva, Zaragoza, 50410, Spain.

3. University of Granada, Dept. Stratigraphy and Paleontology, Av. Fuentenueva s/n, Granada, 18071, Spain.

Early Kimmeridgian ammonites of the subfamily Ataxioceratinae are largely known from epicontinental deposits in Europe and northwestern Africa. Valid early Kimmeridgian genera were described since the late nineteen century (*Ataxioceras* Fontannes; *Orthosphinctes* Schindewolf; *Parataxioceras* Schindewolf; *Progeronia* Arkell; *Crussoliceras* Enay; *Garnierisphinctes* Enay; *Lithacosphinctes* Olóriz; *Ardescia* Atrops; *Schneidia* Atrops; *Olorizia* Moliner; and *Geyericeras* Moliner & Olóriz). These taxa correspond to ammonites that mainly inhabited epicontinental seas in the northern and southern margins of western Tethys, and less commonly in west-central Tethys. Phenotypes with less complicated sculpture have also been recorded in more or less condensed deposits from the respective epioceanic fringes, but those showing more specialized ribbing are typical in epicontinental rhythmites. Outside Europe and North Africa, *Ataxioceras* has been reported from India, Tibet, Japan, and Mexico. The scarce Indian and Tibetan records were reported from ammonite assemblages of late but not latest Oxfordian age. The age interpretation of Japanese records is controversial, fluctuating between late Oxfordian, according to radiolarian biostratigraphy, and a rather imprecise early to middle Kimmeridgian age. Since ammonites associated to Japanese records have been interpreted as the Oxfordian genus *Euaspidoceras*, their Kimmeridgian age must be precluded. Hence, Indian, Tibetan and Japanese records rather point to homeomorphism. In Mexico, ammonites interpreted as belonging to the genus *Ataxioceras* were first reported during the late sixties of the twenty century on the basis of fragmented subsurface material, while specimens from surface outcrops were increasingly known since the early nineties. Sections providing precise records of ammonite assemblages including these ammonites occur in north-eastern, north-central and central-eastern Mexico. The biostratigraphic interpretation of the so-called Mexican *Ataxioceras* has been debated, moving from the Hypselocyclum Zone to the upper Platynota Zone of the secondary biochronostratigraphic standard scale for Europe. Their paleobiogeographic interpretation alternatively refers to a western, Late Jurassic Panthalassa (i.e., the paleo-Pacific) source, or to an eastern, western Tethys source via the Hispanic Corridor. Research in progress favors the interpretation of the so-called Mexican *Ataxioceras* as genus *Schneidia* Atrops, with age ranging from the late Platynota to the early Hypselocyclum chrones. As commonly has been reported for Late Jurassic ammonites from Mexico, the interpretation at the species level points to the relevant role of endemism. On the basis of the inconsistent reports of true *Ataxioceras* from India, Tibet and Japan, a western Tethyan source via the Hispanic Corridor seaway is interpreted for Mexican *Schneidia*. [Contribution within MINECO project CGL2012-39835, Spain, and UNESCO-IUGS IGCP Project 632].

THE EARLY JURASSIC SEQUENCES AND FLORAL DIVERSITY IN SHENZHEN OF GUANGDONG, SOUTHERN CHINA

Yongdong Wang[1,2], Xiangwu Wu[1], Xiaoju Yang[1], Wei Duan[3] and Liqin Li[1,4]

1. Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China. ydwang@nigpas.ac.cn
2. Key Laboratory of Economic Stratigraphy and Palaeogeography, Chinese Academy of Sciences, Nanjing 210008, China.
3. Shenzhen Mesozoic Culture Communication Co., LTD, Shenzhen 518081, China.
4. University of Chinese Academy of Sciences, Beijing 100049, China.

Investigations of major marine and non-marine geologic and biotic events across the Triassic-Jurassic transition rely predominantly on detailed stratigraphic frameworks and biodiversity analyses. The alternating sequences of marine and terrestrial Triassic-Jurassic formations in the Guangdong Province represent one of the most remarkable coal-bearing series in southern China. The Lower Jurassic Jinji Formation is widely distributed in Guangdong, with continuously outcropped sections and rich marine and non-marine fossil fauna. However, as little research has been conducted on fossil plant remains in the Jinji Formation, it is difficult to understand the systematics, diversity, and floral aspects of the Jurassic. Here we report on the recent collection of rich fossil plants from the Jinji Formation in the Dapeng area of Shenzhen, southern Guangdong Province. Our studies demonstrate taxonomical affiliations, preservation status, and diversity features of these plant fossils, which are marked by the close association of densely preserved, pinnae and rachis connected leaves, and the bennettitalean reproductive organs of *Williamsoniella*, which may represent an Early Jurassic plant community dominated by *Otozamites* of the Bennettitales. This work not only represents the first discovery of fossil plants in the Shenzhen area, but is also the first documentation of Jurassic plants in Guangdong and the Pearl River Delta regions. Research related to these plant fossils will be helpful in the correlation of the Early Mesozoic coal-bearing strata in Guangdong, and will provide a deeper understanding of variations in plant diversity across the Triassic and Jurassic transition in southern China. Additionally, it will provide evidence of terrestrial plants for future investigations on Jurassic palaeoecology, palaeoclimatology, and palaeogeography of southern China.

NEW REMAINS OF GIANT BASILOSAURIDAE (ARCHAEOCETI, CETACEA, MAMMALIA) AND GIANT BALUCHITHERE (RHINOCEROTOIDEA, PERISSODACTYLA, MAMMALIA) FOUND FROM PAKISTAN

M. Sadiq Malkani[1] and M. Shahid Ishaq Dhanotr[1]

1. Geological Survey of Pakistan, Sariab Road, Quetta, Pakistan.
malkanims@yahoo.com

Dinosaurs, the largest land vertebrates ruled the continents during the Jurassic and Cretaceous, and their extinction at the end of Mesozoic provided the chance for the giant basal whale (Basilosauridae) to rule in the Tethys Sea and giant rhinoceros (Baluchithere, Rhinocerotoidea) to rule on the Eurasian continent during Early Cenozoic. The most complete vertebral column of a giant basal whale (*Sulaimanitherium dhanotri*) was found in the middle Eocene Drazinda Formation of the Indus basin in Pakistan. This genus of Basilosauridae is the third finding in Asia. Besides the remains of Basilosauridae, the Drazinda Formation has also yielded sea cows (*Protosiren*), whales (Protocetidae) and gastropods. The bifurcations of the neural canal, ventral and dorsal keel on lumbar/caudal centrum, and many other characters distinguish the *Sulaimanitherium dhanotri* from other Basilosauridae such as *Basilosaurus drazindai, Basilosaurus cetoides (Zeuglodon cetoides)*, and *Basiloterus hussaini*. The complete vertebral skeleton of *Sulaimanitherium* provides extensive knowledge on the swimming patterns and evolution of Basilosauridae. This will clarify the swimming behavior due to the finding of the most complete vertebral/axial column/skeleton. The remains of new giant baluchitheres, representatives of the largest land mammals, *Pakitherium shagalai* and *Buzdartherium gulkirao* were found in the Lower-middle Eocene strata of the Shagala Formation in Balochistan Province. They have further been identified from the Oligocene Chitarwata Formation in the Sulaiman Basin and Punjab Province, respectively, but these are fragmentary and seem to be associated and consist of cranial skeleton such as tusk/canine-like thick and long teeth and some postcranial skeleton. The holotype and referred specimens are housed in the Museum of Geological Survey of Pakistan, Quetta. The baluchithere fossils from the Shagala area are the first finding from Balochistan Basin. These fossils are significant for our understanding of depositional environments, baluchithere early evolution and paleobiogeography. Baluchitheres are among the largest land mammals ever and were widespread during the Eocene to Oligocene in Asia (Pakistan, China, Mongolia, Kazakhstan) and southeastern Europe (Yugoslavia, Bulgaria, Romania, Turkey and Georgia) and were endemic to Eurasia. These giant rhinocerotoids show a Eurasian affinity and migrated from Eurasia to the Indo-Pakistan subcontinent or vice versa via the Paleo Indus River systems, after the first collision of Indo-Pakistan subcontinent with Asia.

BIOFACIES CHARACTERIZATION: THE FIRST STEP TOWARDS PROPERTY PREDICTION IN SHALE GAS EXPLORATION. AN EXAMPLE FROM THE POSIDONIA SHALE (TOARCIAN) IN THE NETHERLANDS.

Roel Verreussel[1], Suzanne Nelskamp[1], Sander Houben[1] and Dirk Munsterman[1]

1. TNO, Princetonlaan 6, Utrecht, 3584CB The Netherlands.
Dirk.Munsterman@tno.nl

A key factor in shale gas exploration is the ability to predict the reservoir properties. Unfortunately, most organic-rich shales are heterogeneous in a vertical and horizontal sense. The first step towards property prediction is biofacies characterization. A palynological and geochemical study was carried out on three wells on an onshore-offshore transect. Based on the results it is concluded that anoxia lasted 1.5 million years longer in the proximal location. The main driver for stratification of the water column appears to be fresh water influx. The most intense water column stratification, associated with the highest TOC, occurs around the so-called Early Toarcian Carbon Isotope Event. The palynological results indicate a rapid change in climate from warm and arid to humid, and a gradual return to arid again. Two types of algae dominate the Posidonia Shale: *Tasmanites*, with a high Hydrogen Index (HI), and “sphericals” with a low HI. *Tasmanites* marks the transition from normal marine to stratified marine conditions and are more abundant in the distal setting. The “sphericals” dominate the most intensely stratified marine intervals. The “sphericals” are probably better adapted to prolonged low salinity conditions. The next step is to link biofacies to physical properties and construct a predictive property model.

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USING PALYNOLOGY TO TEST SEISMIC CORRELATIONS AND DETERMINE THE AGE OF REWORKED SEDIMENTS IN UPPER CRETACEOUS STRATA OF THE MACKENZIE VALLEY, NORTHWEST TERRITORIES, CANADA

Kimberley M. Bell[1,2] and Thomas Hadlari[2]

1. Department of Geoscience, University of Calgary, 2500 University Dr NW, Calgary, T2N 1N4, Canada. kmbell@ucalgary.ca

2. Geological Survey of Canada (Calgary), 3303 33 St NW, Calgary, T2L 2A7, Canada.

Canada's energy future will be moving north, necessitating the evaluation of unconventional petroleum potential in the Mackenzie Valley. An established geologic framework is critical for successful resource assessment. The Mackenzie Valley is filled with palynomorph bearing Upper Cretaceous strata of the Trevor (Albian-Cenomanian), Slater River (Albian-Coniacian), Little Bear (Santonian-Campanian) and East Fork (Campanian-Maastrichtian) formations. In this region, seismic and well log data allow for multiple complex correlations of Upper Cretaceous strata. Palynomorph biostratigraphy offers a potential solution by the accurate definition of sediment age enabling lateral correlation of petroleum bearing rock units, which is essential to developing a robust geologic framework. If high resolution palynomorph biostratigraphy is successful, then it will aid in constraining the age of syndepositional structures. Additionally, the maturation of organic matter in Upper Cretaceous rocks of the Mackenzie Valley, as indicated by Rock-Eval pyrolysis (T_{max}), provides constraints on potential oil generation. Existing data indicate that either Cretaceous strata generated hydrocarbons in the Paleogene or that Cretaceous strata are actually immature with extensive recycling and high T_{max} values derived from reworked organic material. The origin of these T_{max} data has huge implications for the oil and gas potential in the region as it determines the timing of hydrocarbon generation. The objectives of this study are to 1) test the potential seismic correlations, thereby determining the best subsurface correlation model, 2) develop a profile of precise stratigraphic ages of the Little Bear Formation and determine the location of unconformities in order to constrain the ages of syndepositional structures and 3) determine the age and extent of reworking using relative changes in the quantity of reworked palynomorphs as a proxy. Seventy samples from the Sah Cho L-71 exploration well, spanning strata of the Slater River, Little Bear and East Fork formations, are currently available for palynological analysis. This well was selected for stratigraphic and geographic coverage and its potential as a palynostratigraphic reference section. Preliminary results indicate that there is extensive Devonian, Carboniferous and Permian/Early Triassic reworking in the uppermost Cretaceous strata of this well. Therefore, the high T_{max} values were likely produced from reworked organic material rather than generated by *in situ* organic material. The implications of this study for organic geochemistry and thermal maturity will provide insight on the timing of hydrocarbon generation, and the age determinations will show the timing of structural trap development, which is critical for resource assessment.

A REVIEW OF DINOFLAGELLATES AND THEIR PREFERRED HABITATS

Jamie L. Boyd[1], Alan M. Haywood[1], Jim B. Riding[2], Matthew J. Pound[3], Vanessa C. Bowman[4], Ruža F. Ivanović[1] and Bridget S. Wade[5]

1. School of Earth and Environment, University of Leeds, Leeds, UK.
ee08jll@leeds.ac.uk
2. British Geological Survey, Kingsley Dunham Centre, Nottingham, UK.
3. Department of Geography, Northumbria University, Newcastle, UK.
4. British Antarctic Survey, Cambridge, UK.
5. Earth Sciences, UCL, Gower Street, London, UK.

Dinoflagellate cysts are used as palaeoenvironmental indices because of their high proxy potential. They preserve well and their preferred habitats are influenced by multiple factors; such as sea surface temperature, salinity, ice cover and nutrient content. Because dinoflagellate cysts make such good proxies, it is possible to utilise them to see how the conditions of the oceans have changed over time. We have chosen to study the Neogene (23.03–2.59 Ma) in order to better understand the changes that led to the making of the modern world. It was a time of significantly warmer climates than today and witnessed dramatic climate transitions. If recognisable patterns from the past can be established from proxy data, then these could be used to interpret modern and future climate change. The newly created Tertiary Oceanic Parameters Information System (TOPIS) is the first database of dinoflagellate cyst data from the Neogene. The current database consists of 500 globally distributed sites from 274 peer-reviewed publications recorded on three forms, and is growing. The forms collect information on location, age and dating method as well as a list of taxa found for each site. It also contains the sediment and aquatic setting in order to determine what environmental factors affect the assemblage diversity and distribution. Much of the literature also provided information on the preferred temperature and salinity conditions for specific dinoflagellate cysts, ranging from temperate to tropical and fresh water to fully marine. Combining these Neogene habitat preferences with information on modern dinoflagellates has facilitated the construction of figures allowing for accurate interpretation of the data. There is information on the climate preferences (116 species) and oceanic preferences (115 species) of both extinct and extant dinoflagellates. Crucially, this review of previously published information shows inconsistencies in the interpretation of the collected data. It highlights how contradicting interpretations produce inconsistent results, casting doubt on previously established biogeographic ranges.

PALYNOZONATION OF THE PERMIAN OF BOLIVIA AND PERU

Mercedes Di Pasquo[1], George W. Grader[2], Peter Isaacson[2] and Gordon Wood[3]

1. Laboratorio de Palinoestratigrafía y Paleobotánica, CICYTTP-CONICET, Dr. Materi y España s/n, Diamante (E3105BWA), Entre Ríos, Argentina. medipa@cicyttp.org.ar
2. Department of Geological Sciences, University of Idaho, Moscow, Idaho 83844, USA.
3. IRF Group, Inc., 24018 Seventh Heaven, Katy, Texas 77494, USA.

The Cisuralian Vitiacua Formation in southern Bolivia is partially time-correlative with the upper Copacabana Formation from north- and western Bolivia and Peru. Palynological information here analyzed comes from Apillapampa, Yesera, Canaletas, Iglesiani and Angosto de Beu in Bolivia, and Cuzco in Perú. Also, new information from sections at Morochata and Via Molino (Bolivia), and Pongo de Mainique (Perú) is provided in this study. Forty-one selected Permian species recovered from at least two of the 13 sections analyzed support the palynozonation proposed herein. Long-ranging species (13 spores and 36 pollen grains and 8 microplankton), documented in most of the sections, and 56 species (20 spores, 32 pollen grains and 4 microplankton) found at single localities were not considered. Ten selected taxa appeared in the oldest *Vittatina* Zone (*VZ*), such as the Permian species *Vittatina costabilis, V. subsaccata*, *V. vittifera*, *Marsupipollenites striatus, Pakhapites fusus, Pakhapites ovatus,* and *Striatopodocarpites cancellatus*. This zone is found in the Copacabana Formation at Apillapampa, Via Molino, Angosto de Beu and Pongo de Mainique. The appearance of *Lueckisporites virkkiae* and other species of this genus supports the homonymous *Lv* Zone, which is subdivided in the *Lv* (*sensu stricto*) and the *Lv-Hamiapollenites karrooensis-Polypodiisporites mutabilis* (*Lv-Hk-Pm*) Subzones. The former is characterized by the appearance of 18 species such as *Lueckisporites nyakapendensis, Lunatisporites noviaulensis, Lunatisporites pellucidus, Pakhapites fasciolatus, Protohaploxypinus rugatus*, *Protohaploxypinus samoilovichii, Protohaploxypinus varius, Striatopodocarpites phaleratus, Striomonosaccites cicatricosus, Vittatina corrugata,* and *Weylandites* spp. The *Lv-Hk-Pm* Subzone is defined by the appearance of 13 species, with abundant monolete (e.g., *Polypodiisporites mutabilis*, *Reticuloidosporites warchianus*, *Thymospora rugulosa*) and trilete spores (*Lundbladispora braziliensis, Convolutispora uruguaiensis*) and few pollen grains (e.g., *Hamiapollenites karrooensis*, *Scheuringipollenites circularis*). Two assemblages of the Vitiacua Formation at Iglesiani are attributed to the *Lv* Zone. The *Lv* (*s.s.*) Subzone occurs in the Vitiacua Formation at Yesera, Canaletas, and two more sections at Canaletas and Narváez, and in the Copacabana Formation at Apillapampa and Via Molino. The *Lv-Hk-Pm* Subzone is documented in the Vitiacua Formation at West Yesera, and the Coal Member of the Copacabana Formation at Apillapampa, Morochata, Pongo de Mainique and Cuzco. The *Vittatina* (Asselian) and the *L. virkkiae* (late Asselian-?Guadalupian) Zones are similar in composition and correlated with the Brazilian *V. costabilis* (Asselian-mid Artinskian) and *L. virkkiae* (middle Artinskian-Wuachiapingian) Zones of Paraná Basin and the Argentinian *Pakhapites fusus-Vittatina subsaccata* (Asselian-Artinskian) and *Lueckisporites – Weylandites* (middle Artinskian-Wuachiapingian) Zones of western basins. [PIP CONICET 0305].

LATE TO MIDDLE RHUDDANIAN (EARLY SILURIAN) CHITINOZOANS FROM THE QUSAIBA MEMBER OF THE QALIBAH FORMATION OF CENTRAL SAUDI ARABIA AND THEIR APPLICATION TO HYDROCARBON EXPLORATION AND GLOBAL CORRELATION

Kaya Ertug[1], Marco Vecoli[1], Pierre Breuer[1], Christian Cesari[1] and Hani Boukhamsin[1]

1. Biostratigraphy Group, Geological Technical Services Division, Saudi Aramco, Dhahran, 31311, Saudi Arabia.
kaya.ertug@aramco.com

Exensive palynological analyses were conducted on cuttings, sidewall core and core samples from four exploratory wells in Central Saudi Arabia, penetrating the shale-dominated Early Silurian Qusaiba Member of the Qalibah Formation, aiming to provide a chitinozoan palynozonation scheme at the highest possible stratigraphic resolution through the Qusaiba Member. The Rhuddanian section of the Qusaiba Member is of particular interest for exploration, because it contains the well-known earliest Silurian "hot shales" at its base, as well as several younger intervals of organically enriched shales known as "warm shales." These Rhuddanian organic-rich shales not only are the most important source rock intervals for Paleozoic-sourced conventional reservoirs, but also constitute primary targets for unconventional hydrocarbon exploration. A high-resolution biostratigraphic scheme is therefore extremely important for subsurface fingerprinting and correlation of "sweet spots" during exploratory and production stages. In the Rhuddanian of Central and North Saudi Arabia, a chitinozoan palynozonation based on successive FDOs (First Downhole Occurrences) of selected chitinozoan species has been developed. This is based on the analysis of continuously cored borehole sections, which are directly correlated to the standard graptolite zonation as follows: *Ancyrochitina udayanensis* Zone (correlated with the *cyphus-revolutus* graptolite zones); *Lagenochitina nuayyimensis* Zone (correlated to the lower *revolutus* to *acinaces* graptolite zones); *Belonechitina postrobusta* Zone (correlated with the *atavus* and upper part of *acuminatus* graptolite zones); and *Spinachitina fragilis* Zone (correlated with the *acuminatus-ascensus* graptolite zones). This study focuses on the *Lagenochitina nuayyimensis* palynozone of middle to late Rhuddanian age, corresponding to a warm shale facies interval, which is interpreted as deposited in a relatively shallow marine palaeoenvironment. The analysis of rich and diverse, well-preserved chitinozoan assemblages from this interval indicates the possibility of further subdividing the palynozone; a new species of *Spinachitina* is established, which has potential as an index species, and is found to occur in other localities of the Northern Gondwanan domain, allowing regional to global correlation to be proposed.

BIOSTRATIGRAPHIC CORRELATION OF THE WESTERN AND EASTERN MARGINS OF THE LABRADOR-BAFFIN SEAWAY

Robert Fensome[1], Henrik Nøhr-Hansen[2] and Graham Williams[1]

1. Natural Resources Canada, Geological Survey of Canada (Atlantic) Bedford Institute of Oceanography P.O. Box 1006 Dartmouth, Nova Scotia B2Y 4A2, Canada. Rob.Fensome@NRCan-RNCan.gc.ca

2. Geological Survey of Denmark and Greenland, GEUS, Øster Voldgade 10, Dk-1350 Copenhagen K, Denmark.

New analyses of the palynological assemblages of 13 offshore wells on the Canadian Margin and six on the West Greenland Margin, in conjunction with existing onshore data, has led to a new biostratigraphic framework for Cretaceous–Cenozoic strata of the Labrador Sea-Davis Strait-Baffin Bay (Labrador-Baffin Seaway) region and the first broad biostratigraphic correlation of Canadian and Greenland margins. Detailed biostratigraphic evidence has confirmed seven regional hiatuses: pre-Barremian, Upper Campanian–Upper Danian, Selandian, Upper Ypresian-Lutetian and Rupelian-Chattian on both sides of the Seaway; and Aptian/Albian–Turonian and Middle to Upper Miocene on the western side. Palynomorph assemblages show that most Barremian to Albian sediments were deposited in marginal marine to lagoonal palaeoenvironments, punctuated by an early shallow-marine episode in the Aptian. A marine transgression starting in the Cenomanian–Turonian led to the most oceanic palaeoenvironments in the Campanian–Lutetian, before the onset of shallowing, probably in the late Lutetian, continued through to the Rupelian, when marginal-marine to inner-neritic palaeoenvironments predominated. Throughout the rest of the Cenozoic, inner neritic palaeoenvironments alternated with marginal-marine conditions. These observations more or less parallel the evolution of the Seaway, with rift conditions prevailing from the Barremian through to the early Paleocene, followed by drift through much of the Paleocene and Eocene, and post-drift from Oligocene to the present. Dinocysts and Azolla indicate that climatic conditions in the Labrador-Baffin Seaway region were relatively temperate in the Cretaceous, but varied dramatically in the Cenozoic. The early Paleocene was a time of increasingly warmer climate, a thermal maximum being reached around the Paleocene-Eocene boundary. Warm to hot conditions prevailed throughout the Ypresian, but began to cool in the Lutetian and cooling accelerated in the Priabonian and Rupelian. Throughout the Neogene, temperatures generally remained temperate, until the major cooling of the Pleistocene Ice Age.

PALYNOLOGY OF THE SILURIAN-EARLY DEVONIAN IN THE PRECORDILLERA, SAN JUAN PROVINCE: BIOSTRATIGRAPHY, PALAEOBIOGEOGRAPHY AND PALAEOENVIRONMENTS

Victoria J. García Muro[1]

1. IANIGLA, CCT CONICET Mendoza, Av. Ruiz Leal s/n, Parque General San Martín, Mendoza, M5502IRA. Argentina.
vgarcia@mendoza-conicet.gob.ar

Palynological assemblages of the La Chilca and Los Espejos formations, Precordillera Central, Argentina, were studied as part of the PhD thesis. These formations had been dated as Late Ordovician-Early Devonian based mainly on graptolite and brachiopod faunas. The aims were to accurately constrain the age of the stratigraphic units, proposing a new biostratigraphic scheme, and to pinpoint the Silurian/Devonian limit, as well as to analyze the biodiversity trends of marine and terrestrial palynomorphs. The purpose was also to contribute to the understanding of the palaeogeographical and the palaeoenvironmental scenarios. Sixty-three samples from Río Jáchal, Río de Las Chacritas, Cerro La Chilca and Quebrada Ancha localities yielded acritarchs, clorophytes, trilete spores and cryptospores with variable abundance, diversity and preservation. The Devonian Talacasto Formation showed a low number of poorly preserved palynomorphs, which led to enquire for the first time into a palynofacies analysis, including 15 levels of the upper section of the unit, at the Loma de Los Piojos locality. In the La Chilca Formation 105 species of marine and terrestrial palynomorphs were recorded, 48 of them constitute first records for Argentina. From palynological results, the base is dated as probably Hirnantian, subsequently upwards Llandovery, and Wenlock. The Los Espejos Formation yielded 271 species, 116 of them are recorded for the first time in Argentina. A Wenlock age is proposed locally, followed by the Ludlow, Pridoli, and Lochkovian. The palynological assemblages, mainly the miospores, allowed the recognition of the Silurian/Devonian boundary in Río Jáchal, the northernmost locality studied. This boundary has been poorly documented worldwide, especially by marine phytoplankton, because they are very rare or absent. The marine and terrestrial assemblages show strong similarities to those from other paleocontinents, indicating that provincialism was less significant than supposed before, even since the Lower Silurian. Strikingly, the La Chilca Formation, dated as Llandovery-Wenlock, presented rich and abundant phytoplankton diversity, but did not yield trilete spores in the whole unit. In the Los Espejos Formation the abundance and diversity of the terrestrial and marine palynomorphs throughout the studied sections, match fairly well with the sedimentary record. The marine phytoplankton is more abundant and diverse in the lower levels of the sections, considered as offshore facies. The miospores increase, in general, to the top of the sections, interpreted as a shoreface environment. The palynofacies analysis in the upper section of Talacasto Formation allowed the determination of a transition from suboxic marine to proximal marine environment.

PALYNOLOGY OF SUB-SAHARAN KAROO BASINS: KEY TO DECIPHER GONDWANA'S PERMIAN CLIMATE HISTORY

Annette E. Götz[1] and Katrin Ruckwied[2]

1. Department of Geology, Rhodes University, Grahamstown 6140, P.O. Box 94, South Africa.
a.gotz@ru.ac.za

2. Shell International Exploration and Production, 200 North Dairy Ashford, Houston, Texas 77079, USA.

The palynological record is crucial to our understanding of changes in land plant communities and vegetational patterns related to climate change and thus provides significant data for high-resolution palaeoclimate reconstructions in deep time. The Permian coal-bearing formations of the Sub-Saharan Karoo basins play a crucial role in the study and for the understanding of Gondwana's climate history and biodiversity in this time of major global changes in terrestrial and marine ecosystems. Recent palynological investigations on Permian coals of South Africa and Mozambique document major changes in palaeoclimate. The spore/pollen ratios are used as a proxy for humidity changes, stratal variations in the composition of the pollen group (monosaccate/bisaccate taeniate/bisaccate non-taeniate pollen grains) indicate warming and cooling phases. Amount, different sizes and shapes of phytoclasts reflect changes in transport and weathering. The detected palaeoclimate signals are used for high-resolution correlation on basin-wide, intercontinental and intra-Gondwanic scales. A new Permian climate curve based on the palynological record is presented.

THE HANGENBERG CRISIS AND PALYNOLOGICAL EXTINCTIONS FROM A HIGH PALAEOLATITUDE SECTION IN BOLIVIA

Jon A. Lakin[1], John E.A. Marshall[1], Ian Troth[2] and Ian Harding[1]

1. Ocean and Earth Science, University of Southampton, National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK. J.Lakin@noc.soton.ac.uk

2. BG Group plc. 100 Thames Valley Park Drive, Reading, Berkshire RG6 1PT, UK.

The end-Devonian Hangenberg Crisis is characterised by mass-extinction and significant changes in eustasy and climate. There was an initial anoxic event, represented by the Hangenberg Black Shale, which was immediately followed by a sea-level fall of ≤ 100 m. Miospore and acritarch/prasinophyte extinctions post-date the sea-level fall in Europe. These global effects are related to widespread polar to temperate continental glaciations. Successions in Bolivia, Brazil and Peru contain well-exposed sequences of glacial diamictites from what was then the high southern palaeolatitudes. Palynological methods have the potential to integrate the South American diamictite successions to the wider record of global-change, due to the cosmopolitanism of certain end-Devonian miospore taxa. This has allowed for current interpretations of the Hangenberg Crisis to be compared against the direct, high-palaeolatitude record of glaciation. For this reason a stratigraphic field study was conducted in the Bolivian Altiplano near Lake Titicaca. Sedimentary logs were measured and claystones sampled every 3-9 m for miospores, acritarchs/prasinophytes and $\delta^{13}C_{org}$. The sequence comprises shallow-marine siliciclastic sediments and includes an incised, 100 m thick palaeovalley system of glacial origin. The palaeovalley contains a single glacial-cycle and is overlain by ~150 m of marine claystones, which were deposited during a post-glacial marine-transgression. There is a positive shift of 2‰ in the $\delta^{13}C_{org}$ record through the post-glacial transgression, likely related to global burial of organic carbon in a warming climate. The glacial-cycle and initial post-glacial transgression has been dated to within the LN (*Retispora lepidophyta-Verrucosisporites nitidus*) biozone; the last Devonian miospore zone. The D-C boundary is placed at the last occurrence of *R. lepidophyta*, which occurs 25 m above the top palaeovalley surface. It is synchronous with significant changes in the acritarch/prasinophyte assemblages and a steep decline in their overall diversity. This study represents the first multi-disciplinary stratigraphic record of the Hangenberg Crisis from a glacial high-palaeolatitude sequence. Evidence for anoxic conditions could not be determined purely on the lithofacies. The palaeovalley system represents the glacio-eustatic control on the 100 m of sea-level fall observed globally. The extinction of *R. lepidophyta* and the collapse of the acritarch/prasinophyte assemblages occur within the post-glacial transgression and warming global-climate, which persisted into the lowermost Carboniferous.

CLIMATIC VARIATIONS DURING THE MID MIOCENE: A PALYNOLOGICAL AND ORGANIC GEOCHEMICAL POINT OF VIEW

Stephen Louwye[1], Willemijn Quaijtaal[1], Timme Donders[2] and Stefan Schouten[3]

1. Department Geology and Soil Science, Research Unit for Palaeontology, Ghent University, Gent, Belgium. stephen.louwye@ugent.be
2. Department of Physical Geography, Palaeoecology, Utrecht University, Utrecht, Netherlands.
3. Department of Marine Organic Biogeochemistry, Royal Netherlands Institute for Sea Research (NIOZ), Texel, Netherlands.

The mid Miocene is characterized by a relatively warm climate. Highest temperature were reached during the Middle Miocene Climatic Optimum (MMCO, 17-14.5 Ma), and this period is considered the warmest since the Oligocene. The climate deteriorated after the MMCO and was characterized by several short-lived cooling events expressed as benthic oxygen isotope excursions: the so-called Mi-events. The intense and global Mi-3 cooling event started around 14 Ma and is generally related to the growth of the East Antarctic Ice Sheet. Several causal mechanisms have been advanced for the climatic deterioration such as large-scale changes in oceanic circulation, massive burial of organic carbon, and minima in both eccentricity and obliquity amplitude modulation. The causal mechanisms are still debated, and new high-resolution records in the time interval considered are needed for elucidation of the tempo and mode of the cooling events. IODP leg 307 recovered a 150 m long middle Miocene sequence from Site 1318 off southwestern Ireland. A high resolution palynological analysis with organic-walled palynomorphs (dinoflagellate cysts, arcritarchs, prasinophytes, pollen grains) was carried out, together with an organic geochemical analysis of the same samples (TEX_{86} and $U^{K'}_{37}$) for an assessment of paleotemperatures around the Mi-events. Dinoflagellate cyst analysis is an excellent tool for the reconstruction of paleoenvironmental parameters such as temperature and productivity. The dinoflagellate cyst proxies show a distinct turnover around the Mi-3 and Mi-4 events, caused by a sea-level lowering and combined cooling, corroborated by the organic geochemical analysis. Results also indicate changes in wind patterns, as well as changes in precipitation on the continent, and testify of the profound effect of the Mi-3 event on both the continental and marine realm.

PALYNOLOGY OF THE MULGA ROCK DEPOSITS, SOUTHERN GUNBARREL BASIN, WESTERN AUSTRALIA

Charlotte Mack[1] and Lynne Milne[1]

1. Dept. of Applied Geology, EIGG Curtin University GPO Box U1987 Perth, WA 6845 Australia.
charlotte.mack@postgrad.curtin.edu.au

Late Eocene palynomorph assemblages have been recovered from carbonaceous sediments within a tenement centred on the Mulga Rocks uranium deposits in central southern Western Australia (WA). Many of the species present, and the concentrations at which they occur, set these assemblages apart from most southeastern Australian palynoassemblages of similar age that are dominated by affiliates of the Gondwanan *Nothofagus*, the Antarctic Beech, and largely interpreted as representing a mesothermal rainforest environment. Common in the assemblages are species aligned with the sclerophyllous families Casuarinaceae, Myrtaceae and Proteaceae, now ubiquitous in the vegetation of WA, with representatives of the xeromorphic *Banksia* being prominent amongst the proteaceous species. The prominence of these taxa, and their co-occurrence, suggest that sclerophylly and xeromorphy were more prevalent in the Late Eocene of southwestern Australia than in southeastern Australia at that time. The Late Eocene Mulga Rocks deposits occur in the Cretaceous southern Gunbarrel Basin which overlies the Neoproterozoic to Late Devonian southern Officer Basin, Western Australia. This study describes the palynomorph assemblages recovered from drill core from exploratory drilling at Mulga Rocks and discusses these in relation to current biostratigraphic zones, the depositional environments of the sediments and the relationships with other assemblages of the same or similar ages in southern Australia.

BIOSTRATIGRAPHY AND PALEOENVIRONMENT OF THE UPPER TRIASSIC SUCCESSION (CARNIAN TO RHAETIAN) ON HOPEN, ARCTIC NORWAY

Gunn Mangerud[1], Niall W. Paterson[1], Atle Mørk[2,3], Claudia Cetean[4] and Pål T. Mørkved[1]

1. Department of Earth Science, University of Bergen, Allégaten 41, 5007 Bergen, Norway. Gunn.Mangerud@geo.uib.no
2. Department of Geology and Mineral Resources Engineering , Norwegian University of Science and Technology, 7491 Trondheim , Norway.
3. SINTEF Petroleum Research, Geophysics and Reservoir Technology, S. P. Andersens veg 15 A, 7031 Trondheim, Norway.
4. Robertson Limited, Llandudno, North Wales LL30 1 SA, UK.

As part of a research project aiming at improved dating, resolution and paleogeographic understanding of the Upper Triassic succession in the Norwegian Arctic, a multidisciplinary approach to the Upper Triassic succession from the island of Hopen (76° 30′ N, 25° E), Svalbard archipelago are presented. These floras, revealing significantly different composition to those from the extensively documented studies of the Germano-Alpine realm therefore provides new, important understanding of the paleogeography of the northern rim of Pangea. With the dense lateral and vertical spacing of samples, this study is among the most comprehensive palynological studies in this region and provides a unique insight into the subsurface geology of the Barents Sea, representing an uplifted analogue. Three formations are recognized on Hopen: the De Geerdalen Formation forming part of a huge delta system, being overlain by the marine Flatsalen Formation and with an erosional contact on top: the tidally influenced Svenskøya Formation. Based on an extensive palynological study from eight sections together with sedimentological mapping, micropaleontological and carbon isotope analyses we are able to relatively preciously date the succession as well as reconstruct the depositional environment and place it in a paleogeographic context. A completely spore dominated assemblage in the mid to early Carnian reflecting dominance of a pteridophyte vegetation, is taken over by occasional marine influence with an increasing number of bisaccate pollen including *Protodiploxypinus* spp. in the upper part. In the Flatsalen Formation an early Norian circum-marine transgression is detected both in the palynology, the micropaleontology and calibrated to earlier ammonoid records. At the base of the formation, barren samples of micropaleontology are followed by a sudden first superabundant occurrence of foraminifera, representing the beginning of a marine transgression. Assemblages are dominated by small specimens of *Trochammina* and *Ammodiscus* species, characteristic of deposition in shallow delta-influenced shelf to deltaic palaeoenvironments. Higher in the section, an acme of radiolaria followed by an acme of dinoflagellates (in which *Rhaetogonyaulax rhaetica* is particularly dominant) is observed, indicating a maximum flooding surface and the establishment of fully normal marine conditions. This represents a crucial correlative event, and is also the very first record of abundant dinoflagellate occurrence in the geological record of this region before more diverse associations develop in the Early Jurassic. A return to non-marine conditions and assemblages dominated by bryophyte and pteridophytes spores in combination with conifer pollen is seen in the upper parts of the Flatsalen Formation and the Rhaetian assemblage recorded from the Svenskøya Formation.

CRETACEOUS DINOFLAGELLATE STRATIGRAPHY OF THE MAGALLANES BASIN, OFFSHORE TIERRA DEL FUEGO, SOUTHERN ARGENTINA.

Daniel Michoux[1]

1. TOTAL, Avenue Larribau, 64000 Pau, France.
daniel.michoux@total.com

Exploration wells from the Magallanes Basin, offshore Tierra del Fuego provide an insight into the opening of the South Atlantic during Early Cretaceous times, and elements of correlation with Western Australia. The first sedimentary rocks overlying the volcanic tuffs of the Tobifera Fm. are fluvial deposits, containing terrestrial palynological assemblages. Transitional deposits (Arcillas Intermedias) yielded dinocyst assemblages interpreted as freshwater or restricted-marine. These contain genera described by Backhouse in the Perth Basin of Western Australia, including *Mooridinium* and *Gagiella*. The inception of marine conditions in the Springhill Formation is marked by the appearance of fully marine dinocyst assemblages: members of the *Phoberocysta neocomica* plexus, *Aprobolocysta galeata*, *Kleithriasphaeridium fasciatum*, *Avelodinium lepidum*. This dinocyst suite shows affinities with the *Kaiwaradinium scrutillinum* Zone of Backhouse and *Senoniasphaera tabulata* Zone of Helby *et al*. A Late Valanginian to Early Hauterivian age is proposed for this interval, which shows a low Marine vs. Continental ratio (less than 10%). An upward increase in marine palynomorph frequency (from 10 to 30% or more) coincides with the appearance of common *Muderongia*, *Batioladinium micropodum* and *Cernicysta helbyi*. *Cassiculosphaeria magna* can be locally abundant in the upper part of the Springhill. This predominantly siliciclastic unit is overlain by the shales of the Inoceramus Inferior Fm., whose deposition corresponds to a shift towards deeper sedimentation. *Phoberocysta neocomica* becomes extinct near the top of the Inoceramus Inferior Fm. This is an intra-Barremian event located within the *Muderongia australis* Zone of Helby *et al*. The transition between the Inoceramus Inferior Fm. and the overlying Margas Verdes Fm. is marked by an acme of *Ascodinium* sp. and the appearance of *Heerendinia postprojecta*. This is thought to correspond to the *Ascodinium cinctum* Zone of Helby *et al.*, which straddles the Barremian-Aptian boundary. The top of the Aptian is taken at the top of *Sentusisdinium aptiense.* The highest occurrence of abundant *Oligosphaeridum dividuum* is an intra-Aptian event. The Albian is recognised by the occurrence of *Canninginopsis intermedia, Canninginopsis denticulate, Protoellipsodinium spinosicristatum, Carpodinium granulatum* and *Discorsia nanna*. It is possible to subdivide the Albian into a lower and an upper interval using extinction events: the boundary corresponds to the extinction of the last representatives of the genus *Muderongia, Dingodinium cerviculum* and *Canninginopsis intermedia.* In Australia *D. cerviculum* and *C. intermedia* become extinct in the *Muderongia tetracantha* Zone of Helby *et al*., which is the basal zone of the Albian in this zonation scheme.

A NEW PALYNOLOGICAL ZONATION FOR THE CRETACEOUS OF EAST GREENLAND

Henrik Nøhr-Hansen[1]

1. Geological Survey of Denmark and Greenland (GEUS), Ministry of Climate, Energy and Building, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark. hnh@geus.dk

A new palynological zonation of the entire Cretaceous succession of East and North-East Greenland is proposed based on the studies of samples from shallow boreholes and numerous Cretaceous surface sections. The biostratigraphy is primarily based on dinoflagellate cysts (dinocysts), which are present in all marine sections except when the sediments are thermally altered e.g. by intrusions or subsidence. The Cretaceous succession is divided into 17 biozones and intervals. A more refined stratigraphy is obtained by subdividing 5 of the zones into 18 subzones and by the recognition of more than 100 stratigraphical events representing more than 70 stratigraphic levels. The average zone in the new biostratigraphy spans less than 5 My, compared with 80 My for the duration of the Cretaceous System. Four new zones are suggested for the lowermost Cretaceous succession. The stratigraphy for the remaining Lower Cretaceous is based on an updated and refined version of the previous zonation. The marine Lower Cretaceous palynological assemblages of East Greenland differ markedly from the non-marine to brackish-water miospore and dinocyst assemblages from the Nuussuaq Basin, central west Greenland. The biozonation of the Upper Cretaceous is all new apart from the uppermost biostratigraphic units where the stratigraphy of West Greenland is recognised and applied to North-East Greenland. Several of the Cretaceous stratigraphic units are also recognised in the Kangerlussuaq area, South-West Greenland. New $\delta^{13}C_{org}$ measurements have been carried out in order to support biostratigraphic recognition of the Cenomanian – Turonian boundary.

EVIDENCE FOR MYCORRHIZA-MEDIATED COMPETITION BETWEEN PLANTS AND DECOMPOSERS DRIVING CARBON STORAGE IN THE FOSSIL RECORD

Jennifer M. K. O'Keefe[1]

1. Department of Earth and Space Sciences, Morehead State University, Morehead, KY, USA.
j.okeefe@moreheadstate.edu

Wetland soils, preserved as carbonaceous mudrocks or coal seams provide a record of carbon cycling through preserved plant and fungal remains since at least the Devonian. Recent work has demonstrated that understanding the dynamics of this carbon cycling in modern wetland environments is more complicated than previously suspected and is fundamentally controlled by the delicate balance between arbuscular mycorrhizal (AM) and ectomycorrhizal and ericoid mycorrhizal (EEM) fungi. This balance is driven by nitrogen availability, as EEM fungi are more able to access organic nitrogen sources than AM fungi, and results in greater carbon storage in settings dominated by EEM fungi. Modern studies use mixed methods models to examine mycorrhizal type impact on soil carbon content in the context of mean annual temperature (MAT), mean annual precipitation (MAP), net primary production (NPP), and soil clay content for each defined biome type. Replicating this type of study in the fossil record is complicated by the inability to directly assign mycorrhizal types by observation of the dominant plant species present. Recent work has demonstrated that this information can be obtained through fungal palynology and organic petrography of fractions of the same sample. MAT and MAP can be determined through the nearest-living-relative method as applied to tree pollen recovered from the samples. NPP and soil clay content are estimated geochemically and petrographically. The present study utilizes a robust palynological, petrographical, and geochemical data set obtained from lignite and clay collected from the upper middle Eocene aged Carlisle Clay Pit in the Jackson Purchase Region of Kentucky to demonstrate the feasibility of conducting this type of study in the fossil record. The model obtained is then applied to data sets from Texas and Kentucky where detailed geochemistry is lacking but carbon content is known.

PALYNOLOGY OF THE SOUTHEASTERN BORDER OF THE LLANOS BASIN (COLOMBIA): A DISCONTINOUS RECORD RANGING FROM THE ORDOVICIAN TO THE NEOGENE

Andrés Pardo-Trujillo[1], Angelo Plata[1], Millerlandy Romero[1] and Thomas Servais[2]

1. Universidad de Caldas, Instituto de Investigaciones en Estratigrafía-IIES, calle 65# 26-10, Manizales, Colombia. andres.pardo@ucaldas.edu.co

2. Université Lille 1, CNRS UMR 8217 Géosystèmes, UFR des Sciences de la Terre, Bâtiment SN5, France.

The palynological study of two wells in the SE border of the Eastern Llanos Basin (N of Guaviare River, Colombia) allowed establishing the age and paleoenvironments of its sedimentary fill. Ninety-six samples including cuttings and sidewall cores were analyzed. The samples show a rich and diverse association of palynomorphs (acritarchs, pollen grains, spores, dinoflagellate cysts and freshwater algae). A total of 17100 palynomorphs were counted, and more than 250 morphotypes were recognized, ~60 of which correspond to traditional biostratigraphic markers used in northern South America. The biostratigraphic data indicate a discontinuous sedimentary record that begins in the Early-Middle Ordovician (Floian-Dapingian), with an association dominated by acritarchs, composed by *Coryphidium bohemicum*, ?*Dicrodiacrodium* sp., ?*Arbusculidium* sp. and *Striatotheca*, among others. Over these deposit, a succession of ca. 95 m of Late Cretaceous beds (Turonian-Santonian) were identified, where *Droseridites senonicus* and *Monocolpopollenites spheroidites* are abundant. Cenozoic deposits have ~500 m in thickness. The Oligocene beds are characterized by the co-occurrence of *Foveotricolporites etayoi, Cicatricosisporites dorogensis*, and the abundance of *Magnastriatites grandiosus, Jandufouria seamrogiformis* and *Mauritidites franciscoi*. The Early-Middle Miocene (Aquitanian-Burdigalian) is identified by the First appearance datum (FAD) of *Clavainaperturites microclavatus, Bombacacidites baculatus, Bombacacidites muinenaeorum, Rugotricolporites intensus* and *Grimsdalea magnaclavata* and the Last Appearance Datum (LAD) of *Horniella lunarensis, Retistephanoporites minutiporus* and *Foveotricolporites etayoi*. In the Ordovician deposits marine palynomorphs are dominant. Similar ages of marine deposits have been described in wells of the western sector of the Llanos Basin (the Negritos-1 and Heliera-1 wells). The late Cretaceous *D. senonicus* and *M. spheroidites* are characteristic of the northern portion of the Palm Province, which includes Africa and South America. Although dominated by terrestrial palynomorphs, the presence of dinoflagellate cysts (e.g. *Dynogymnium* sp.) in the Cretaceous beds allows recognizing the easternmost coastal deposits reported so far in the Cretaceous of Colombia. Similarly, the presence of dinoflagellate cysts along the Oligocene-early Miocene beds suggests a marine influence on sedimentation and supports the existence of an inland sea in the South American continent over this period.

LATE TRIASSIC (CARNIAN) PALYNOLOGY OF KONG KARLS LAND, SVALBARD

Niall W. Paterson[1], Gunn Mangerud[1], Bjørn A. Lundschien[2] and Atle Mørk[3,4]

1. Dept. of Earth Science, University of Bergen, Bergen, Norway. niall.paterson@geo.uib.no
2. Norwegian Petroleum Directorate, Stavanger, Norway.
3. Dept. of Geology & Mineral Resources Engineering, Norwegian University of Science & Technology, Trondheim, Norway.
4. SINTEF Petroleum Research, Geophysics & Reservoir Technology, Trondheim, Norway.

Preliminary data are presented from a palynological investigation of a shallow core (7830/5-U-1), drilled offshore Kong Karls Land, in the northern Barents Sea. Very few palynological studies of the Upper Triassic succession of the northern Barents Sea have been conducted due to the remoteness of the region. In 2005, the Norwegian Petroleum Directorate drilled 5 shallow stratigraphic cores through Middle to Late Triassic strata offshore eastern Kong Karls Land at approximately N 78°, E 30°. The cores encompass the Botneheia, Tschermakfjellet and Snadd formations and comprise a near complete composite section (approximately 400 m thick) through the Mid–Late Triassic stratigraphy. This study focuses on 47 samples from the youngest core (7830/5-U-1), which spans 127 m of the Snadd Formation (De Geerdalen Formation equivalent). Palynological samples yielded well-preserved and taxonomical diverse assemblages dominated by gymnosperm pollen and pteridophyte spores. Acritarchs and prasinophytes are relatively rare but are consistently present in assemblages. Spore taxa recorded include: *Aratrisporites macrocavatus*, *Camarozonosporites rudis*, *Leschikisporis aduncus*, *Krauselisporites cooksonae*, *Semiretisporis barentzii*, *Striatella seebergensis* and *Zebrasporites fimbriatus*. Pollen includes: *Angustisulcites klausii*, *Aulisporites astigmosus*, *Chasmatosporites* spp., *Illinites chitinoides*, *Podosporites amicus*, *Protodiploxypinus* spp., *Staurosaccites quadrifidus* and *Triadispora verrucata*. The palynomorph association indicates a middle to early late Carnian age for the core. The consistent occurrence of acritarchs and prasinophytes in assemblages dominated by terrestrial palynomorphs indicates deposition in a paralic environment. The results of this study provide important insights into the Late Triassic palynostratigraphy and paleogeography of the northern rim of Pangaea.

MESOZOIC DINOFLAGELLATE CYST BIOSTRATIGRAPHY AND PALAEOBIOLOGY IN THE SOUTHERN HEMISPHERE

James B. Riding[1]

1. British Geological Survey, Keyworth, Nottingham NG12 5GG, United Kingdom.
jbri@bgs.ac.uk

Triassic, Jurassic and Cretaceous dinoflagellate cysts have been extensively reported from the Southern Hemisphere. There are major publications from Antarctica, Arabia, Australia, Brazil, India, Madagascar, New Zealand and Papua New Guinea. Most of the data concerning Triassic dinoflagellate cysts are from Australia. The oldest unequivocal fossil dinoflagellate, *Sahulidinium ottii*, is present in the Middle Triassic (Ladinian) of the North West shelf of Australia. The majority of the Triassic forms are, however, of Late Triassic (Norian-Rhaetian) age. Abundant and diverse dinoflagellate cyst associations have recently been recovered from the Late Triassic of the offshore Carnarvon Basin in Australia. Some cosmopolitan taxa such as *Beaumontella langii*, *Rhaetogonyaulax rhaetica* and *Suessia swabiana* were recognised, together with significant numbers of undescribed species. The latter include forms of *Dapcodinium, Hebecysta, Heibergella, Noricysta, Rhaetogonyaulax, Suessia* and *Sverdrupiella*. It appears that diverse Triassic dinoflagellate cysts have a bipolar distribution, with provinces in the high northerly latitudes and around Australia. Early Jurassic dinoflagellate cysts from Gondwana are not well-known and this association, the *Luehndea* Assemblage, is low in diversity. This flora corresponds to a eustatic rise. By contrast, Middle and Late Jurassic marine microplankton from Australia, New Zealand and Papua New Guinea are diverse, and the associations include many forms with restricted stratigraphical extents. Several of the dinoflagellate cyst biozones established for Australia have recently been found to be slightly older than originally envisaged. Many of these Middle and Late Jurassic species are endemic, but a relatively small proportion of the biotas are cosmopolitan. The diverse Callovian to Tithonian floras are dominated by Austral endemic taxa. By contrast, Middle Jurassic (Callovian) floras from the Neuquén Basin in west-central Argentina are dominated by typically European species. Early Cretaceous floras from Australia are diverse, and many distinctive and biostratigraphically important species are present. There are relatively few bioevents and taxa in common with the Northern Hemisphere. The scheme of dinoflagellate cyst biozones established in Australia for the Late Cretaceous can be applied over much of Gondwana. Several species of cavate peridinioids are of regional stratigraphical significance in the Santonian to Maastrichtian interval. These include *Isabelidinium cretaceum, Isabelidinium korojonense, Manumiella druggii, Nelsoniella aceras* and *Xenikoon australis*. These Late Cretaceous assemblages are also dominated by Southern Hemisphere endemics.

MICRO VS. MACRO: A QUANTITATIVE COMPARISON OF PALYNOLOGICAL AND PLANT MACROFOSSIL ASSEMBLAGES FROM A JURASSIC PLANT BED

Sam M. Slater[1] and Charles H. Wellman[1]

1. Department of Animal and Plant Sciences, Alfred Denny Building, University of Sheffield, Western Bank, Sheffield, S10 2TN, UK. bop11sms@sheffield.ac.uk

Sporomorph (spores and pollen) and plant macrofossil assemblages from a Middle Jurassic (Aalenian) plant bed from Hasty Bank, North Yorkshire, UK display significant inconsistencies in temporal diversity and abundance variation. High-resolution sampling methods are used to compare sporomorph records with previously published quantitative plant macrofossil data from the same section. The data set comprises 66 sporomorph taxa recorded from 50 samples taken at 10 cm intervals through the plant bed. Combined multivariate analysis (correspondence, principal components and nonmetric multidimensional scaling) of palynofacies and sporomorph abundance and occurrence data shows lithology is the dominant factor controlling sample variation. Our results demonstrate sporomorph samples capture a more complete floral composition, however the elevated diversity of wind blown taxa suggest sporomorph assemblages represent a significantly larger catchment area than plant macrofossil data. Temporal variation in sporomorph assemblages is interpreted to be the result of depositional change between claystone and siltstone lithologies while ecological causes for variation are determined to be minimal. *Lycopodium* spiked samples show claystone samples are significantly richer in palynomorphs than siltstone samples. Preferential preservation of sporomorphs and equivalent parent plants is a consequence of a complex array of biological, taphonomic, geographical and depositional factors that act inconsistently between and within respective fossil assemblages, which results in significant discrepancies between data sets. Conflicting sporomorph and plant macrofossil records suggest a multidisciplinary approach is considerably more informative when making local vegetation reconstructions.

LATE PALAEOZOIC PALYNOLOGY OF THE MIDDLE EAST: A REVIEW

Michael H. Stephenson[1]

1. British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK.
mhste@bgs.ac.uk

The Carboniferous and Permian contain some of the most important oil and gas reservoirs in the Middle East, from the giant glaciogenic reservoirs of the Al Khlata Formation in Oman to the continental reservoirs of the Unayzah Formation in Saudi Arabia, to the carbonates of the Khuff Formation which form the largest non-associated gas reservoir in the world in the Arabian Gulf. The stratigraphy of the core area in the Arabian Peninsula is echoed in sequences outside the Gulf area in Yemen, Pakistan and Jordan such that exploration is turning to these regions for petroleum systems of the Arabian type. Palynology has played a key role in correlating these rocks at international, basinal and reservoir scale, building on deep understanding of the palynological sequences of the core area, gained from decades of work supporting exploration and production. Much of this knowledge is encapsulated within the OSPZ (Oman and Saudi Arabia Palynological Zonation) established in 2003, and this zonation has been used to correlate rocks as far apart as Oman, Pakistan and Yemen in the Pennsylvanian to Cisuralian, and Saudi Arabia, Oman, Pakistan, Jordan and Turkey in the Wordian to latest Permian. The zones have also been used to resolve stratigraphic problems in basins that cross international borders allowing stratigraphy to be unified and resolved, for example between Oman and Saudi Arabia. Refined high resolution subdivisions of the zonation (often proprietary) offer the ability to correlate at metre-scale across reservoirs and even to fingerprint horizons within complex mixed clastic continental sequences to support drilling decisions, for example in the Middle and Upper Gharif members in central Oman. Apart from correlation, Middle Eastern palynological sequences have also offered a window on the world of Pennsylvanian to Cisuralian climate change and glaciation, allowing insights into Tethyan oceanic currents and climate gradients, and rates of atmospheric and palaeoenvironmental change in deglaciation. Just recently palynology developed in the Arabian Peninsula also helped to identify and distinguish latest Permian fluvial palaeoenvironments in Jordan. In this talk I will outline some of the reasons why Carboniferous and Permian palynology has been so successful in the Middle East and illustrate through case studies some of its applications.

PALEOPALYNOLOGY AND EARLY PALEOZOIC PLANT EVOLUTION

Paul K. Strother[1]

1. Boston College, Department of Earth and Environmental Sciences, Weston MA 02493, USA.
strother@bc.edu

Spore-like microfossils (cryptospores *s.l.*) from near-shore Cambrian and Ordovician deposits in Laurentia possess some features that appear to have a direct bearing on the evolutionary transition from fully aquatic (charophyte) algae to the true land plants (Embryophyta). Laminated sporoderm in the early lineages appears to be associated primarily with spore dyads and this association with rhyniophytiods persists through the Silurian. The topological structure of Cambrian and Early Ordovician cryptospores is quite different from the tetrahedral tetrads begin in the Middle Ordovician (Darriwilian) and characterize simultaneous meiosis in embryopytes today. Detailed morphological studies of the Late Cambrian cryptospore, *Agamachates*, indicate these spores formed via successive nuclear divisions followed by delayed cytokinesis and spore wall formation. Reduction division in such fossils parallels DNA endoreduplication and delayed cytokinesis which occurs in zoospore formation in extant *Coleochaete*. Quadralobing and other details of sporogenesis in extant bryophytes have been shown to be evolutionarily derived through timing shifts in nuclear division and cell wall formation. Heterochrony has also been invoked as the primary mechanism in the d*e novo* origin of the plant sporophyte from gametophyte ancestors. This antithetic hypothesis, originally proposed over a century ago by Bower, posits that that vegetative tissues of the subaerial sporophyte evolved in coordination with a timing delay in the onset of meiosis. Sheets of packets of spore-like cells occur in the Middle Ordovician Kanosh Shale at Fossil Mountain, Utah, USA. The packets form small dorsientral thalli that occur either as radially-aligned rosettes (like *Coleochaete*) or as palmelloid sets similar to the chlorophyte *Prasiola*. These spore clusters are clearly organized as if they were the result of vegetative algal growth, yet the individual cells themselves are clearly spore-like. This serves as a possible model for the early evolution of a vegetative sporophyte which co-opted the genetic basis for vegetative growth of the gametophyte thallus and applied it to the sporpohytic phase combined with a delay in spore development. Cambrian deposits in Laurentia include additional small tissue fragments that hint at algal (gametophytic) adaptations to subaerial conditions. These include small geometrically regular spore packets and thickened coverings associated with cryptospore masses. None of these fossils has a direct counterpart in the modern flora. Instead, they yield a tantalizing glimpse into the possibility that the heterochronous sporogeneous may have been a core evolutionary process during the *de novo* origin of the plant sporophyte.

A PALYNOLOGICAL RECORD OF BATHONIAN MARINE AND TERRESTRIAL PALAEOENVIRONMENTS FROM THE GREAT OOLITE GROUP OF WOODEATON QUARRY, OXFORDSHIRE, UK

Stephen Stukins[1]

1. Department of Earth Sciences, The Natural History Museum, London. SW7 5BD, United Kingdom.
s.stukins@nhm.ac.uk

Exposures at Woodeaton Quarry, Oxfordshire, UK, have yielded a diverse and well preserved palynoflora through the Late Bathonian of the Great Oolite Group. Three successions from around the quarry were sampled through the largely carbonate-rich Charlbury, Taynton Limestone, Rutland and White Limestone formations. The aim of this study is to examine the well preserved assemblages, assess their taxonomic content and apply statistical techniques to make conclusions about the terrestrial and marine palaeoecologies in the Bathonian of central England. Preliminary analysis shows mixed and diverse assemblages of dinoflagellate cysts, acritarchs, spores/pollen as well as other miscellany (for example, Prasinophyceae, foram test linings, etc.). The marine element of the assemblages is dominated by dinoflagellate cysts genera such as *Meiourogonyaulax, Pareodinia* and *Valensiella* with significant numbers of other taxa such as *Ctenidodinium, Jansonia* and *Gonyaulacysta*. The sporomorph content consists of high numbers of monosaccate and bisaccate pollen grains with varying quantities of *Classopollis* spp. and trilete spores. *Quadraeculina annaeliformis* is present throughout, in association with other typical sporomorphs, such as *Lycopodiacidites baculatus Callialasporites* spp. and *Cerebropollenites* spp., confirming an age no younger than Late Bathonian. The palynological analysis is supplemented with microfaunal assemblage and XRF geochemical data. This extra data provides evidence for fluctuations in fresh/saline water in the depositional environment and for nutrient values in the terrestrial run-off into this largely marginal marine setting. It is envisaged this type of study will progress the understanding of palaeoecological/geographical/environmental dynamics during the Middle Jurassic of North-western Europe.

THE BAJOCIAN RADIATION OF DINOFLAGELLATES: NEW RECORDS FROM THE SWABIAN ALB, SOUTHERN GERMANY

Nickolas J. Wiggan[1], James B. Riding[2] and Matthias Franz[3]

1. Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK. njw56@cam.ac.uk

2. British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK.

3. Regierungsprasidium Freiburg– Dept. 9, State Authority for Geology, Mineral Resources and Mining, Albertstraße 5, Freiburg D-79104, Germany.

The age of the modern eukaryotic phytoplankton began in the Triassic with the first appearance of coccoliths and dinoflagellate cysts in the fossil record, but it was not until the Jurassic that these groups diversified. During the Bajocian (Middle Jurassic, 170.3–168.3 Ma), dinoflagellates underwent an explosive radiation, resulting in ~55 new dinoflagellate cyst species appearing by the end of this interval. At around this time diversification occurred within the important coccolithophore genus *Watznaueria* and, in the Late Bajocian, the first planktonic foraminifera appeared. These events are indicative of a major evolutionary innovation in plankton. In northern France the dinoflagellate family Gonyaulacaceae rapidly radiated around the Early-Late Bajocian transition. This was a two-step burst of inceptions in the *humphriesianum* and *niortense* ammonite zones, with a secondary event in the latest Bajocian. However, this section is highly condensed, with the *humphriesianum* and *niortense* zones being thin, which obscures some first appearance data from this critical interval. To circumvent this issue, material has been collected from coeval strata of the Swabian Alb, south-west Germany. In this region the Bajocian is expanded and complete; the lithotypes include mudstones, marls and oolitic limestones. Age control in the area is excellent and all samples are accurately correlated to ammonite zones. A total of 187 samples were collected, 52 from 12 field outcrop localities covering the uppermost Aalenian- *niortense* zone of the Upper Bajocian and 135 from 3 boreholes spanning the entire stage. Of these, 109 were collected from the borehole B404-2, located ~40 km south east of Stuttgart, which spans the uppermost Aalenian to lowermost Bathonian with the entire Bajocian present. The *humphriesianum* and *niortense* zones are particularly well represented and 37 samples were collected from across these zones to provide data for this critical interval in dinoflagellate evolution. Early work shows that the latest Aalenian to Early Bajocian is characterised by low diversity assemblages dominated by *Nannoceratopsis gracilis*, along with *Pareodinia halosa* and *Escharisphaeridia*. The Early-Late Bajocian transition is typified by more diverse gonyaulacoid assemblages, characterised by the appearance of genera such as *Durotrigia* and *Meiourogonyaulax*. The radiation continues in the Late Bajocian-Early Bathonian with the first appearances of taxa such as *Ctenidodinium, Dissiliodinium* and *Korystocysta*.

NEW TAXA AND COMPREHENSIVE OVERVIEW OF DEVONIAN PALYNOMORPHS FROM THE OXY-MOBIL PANDO X-1 CORE, MADRE DE DIOS BASIN, BOLIVIA

Gordon D. Wood[1], Mercedes di Pasquo[2], Peter E. Isaacson[3] and George W. Grader[3]

1. The IRF Group, inc., 24018 Seventh Heaven, Katy, Texas, 77494, USA. gdw.geoscience@gmail.com
2. Laboratorio de Palinoestratigrafía y Paleobotánica, Centro de Investigaciones Científicas y Transferencia de Tecnología, CICYTTP-CONICET, Materi y España s/n, Diamante (3105), Entre Ríos, Argentina.
3. Department of Geology, University of Idaho, Moscow, Idaho, 83844, USA.

Recently analyzed palynological mounts from the Pando X-1, in combination with previously published information, affirm an excellent stratigraphic hierarchy of tops and bases. This summary integrates spore, acritarch, prasinophyte, and chitinozoan data to create a new palynofacies and stratigraphic framework applicable to thick subsurface sections and possible unconventional (shale-gas) plays. The Pando core yielded a well preserved assemblage that ranges from the ?Silurian through Upper Devonian. The stratigraphic intervals assigned to the ?Silurian-Lower Devonian and Middle-Upper Devonian are the Tequeje and Tomachi formations, respectively. Another unit, the Upper Devonian-Lower Carboniferous Toregua, is a challenge to interpret because of the impact of recycled organic-walled microfossils related to glacial processes in the area during deposition. The Tequeje Formation assemblage ranges from ?Silurian to Lower Devonian, and contains several undescribed (?endemic) forms. The species from this stratigraphic unit include *Brochotriletes hudsonii*, *Retusotriletes maculatus*, *Leiofusa bernesgae*, *Onondagaella asymmetrica*, *Ozotobrachion furcillatus*, *Pterospermella circumstriata*, *Riculasphaera fissa*, *Schizocystia pilosa*, *S. saharica*, *Thysanoprobolus polykion*, *Cingulochitina serrata*, *Lagenochitina navicula*, *Margachitina catenaria*, *Pterochitina megavelata*, and *Urochitina* spp. Diagnostic species from the Tomachi Formation include *Camptozonotriletes caperatus*, *Clivosispora verrucata*, *Cristatisporites triangulatus*, *Geminospora lemurata*, *Verrucosisporites bulliferus*, *Ammonidium garrasioni*, *Duvernaysphaera angelae*, *Evittia sommeri*, *Horologinella horologia*, *Maranhites mosesii*, *Multisplicisphaeridium escobaides* (*Pyloferites pentagonalis*), *Tunisphaeridium tentaculaferum*, and *Umbellasphaeridium saharicum*. The assemblage includes new forms, some with morphologies uncommon in Devonian sections (e.g., an acritarch with a diacrodian-like process distribution). The Toregua Formation assemblage include abundant spore species, such as *Ancyrospora langii*, *Auroraspora macra*, *Chelinospora cocinna*, *Lophozonotriletes grumosus*, *L. lebedianensis*, *Retispora lepidophyta*, and *Tumulispora rarituberculata*. Also present are the acritarchs/prasinophytes *Maranhites* spp., *Puteoscortum polyankistrum*, and *Umbellasphaeridium* spp. Previous studies of this well have concentrated primarily on bases (first occurrence) and assemblage zones. The present study combines published information with new taxa and palynofacies insights reported here, and focuses on palynomorph tops (first downhole occurrence). This approach can be used when analyzing cuttings samples from Gondwanan exploration and production wells to constrain stratigraphic architecture.

LATE JURASSIC TO EARLY CRETACEOUS DINOFLAGELLATE CYSTS FROM THE EASTERN GULF OF MEXICO

Stephanie Wood[1], Charles Wellman[1], Katrin Ruckwied[2] and Iain Prince[2]

1. Dept. of Animal and Plant Sciences, Alfred Denny Building, University of Sheffield, Western Bank, Sheffield, S10 2TN, UK. selw89@gmail.com

2. Shell Exploration and Production, Woodcreek Research Facility, 200 North Dairy Ashford, Houston, Texas, 77079-1101, USA.

The Late Jurassic to Early Cretaceous deposits of the Eastern Gulf of Mexico (EGoM) are one of the world's major hydrocarbon reserves. However, there is a distinct lack of published studies on dinoflagellate cysts from these strata. Instead hydrocarbon companies have relied on published European biostratigraphy to correlate with the biostratigraphy from the EGoM. Such a technique lacks accuracy. This research aims to rectify this issue and produce a higher resolution dinoflagellate cyst biostratigraphy from data collected from three deep water wells around the EGoM. The Gulf of Mexico is a structurally complex area in terms of its tectonic setting. During the Late Jurassic carbonate deposits with small interspersed and interbedded shales and red sandstone bodies accumulated in the EGoM. At the same time oceanic crust emerged in the centre of the Gulf of Mexico (GoM) basin, while the Yucatan Block rotated counter clockwise to the south-east of the basin. Marine transgression followed the production of oceanic crust, and as the GoM basin crust cooled and thermally subsided relative sea level rose. Thermal subsidence continued into the Early Cretaceous and a carbonate shelf margin platform prograded. Thermal subsidence of the lithosphere controlled the sedimentation rates and architecture of the GoM basin. The unusual tectonic setting of this locality therefore requires a well age-constrained stratigraphy to be established to link formations and structures further around the EGoM basin. 175 samples collected from three offshore wells have yielded rich assemblages of well-preserved palynomorphs. These are dominated by dinoflagellate cysts but also include subsidiary spores/pollen. After preparing the samples using normal palynological preparation techniques, the samples have been analysed using light and scanning electron microscopy. The dinoflagellate cysts have then been systematically described and quantitative data concerning their occurrence/abundance collected. Palynofacies counts have also been collected for each sample. Together these data sets will be utilised in a detailed analysis of the biostratigraphy, palaeoecology, palaeoenvironments and palaeogeography of the deposits. The count data will then be analysed using the statistical package PAST and Fuzzy C means, and will be presented using STRATABUGS. Further hydrocarbon exploration and development are a priority to ensure energy security. Development of a robust biostratigraphic model for the EGoM basin will greatly facilitate future exploration and development activities in this basin, as well as mitigating deep water drilling risks.

CYST AND OPERCULUM FORMATION IN CAMBRIAN-ORDOVICIAN GALEATE ACRITARCHS FROM ESTONIA: IMPLICATIONS FOR THE ALGAL PHYLOGENY AND BLOOMS IN THE EARLY PALEOZOIC

Heda Agić[1], Małgorzata Moczydłowska[1] and Donald E. Canfield[2]

1. Department of Earth Sciences, Uppsala University, Villavägen 16, 752 36 Uppsala, Sweden. heda.agic@geo.uu.se
2. Nordic Centre for Earth Evolution (NordCEE) and Institute of Biology, University of Southern Denmark, DK-5230 Odense, Denmark.

Unicellular organic-walled microfossils have been recovered from the Cambrian Lükati Formation and the Tremadocian Varangu Formation exposed in northern Estonia. Due to a combination of main morphological and biochemical characters, mainly a) excystment opening, b) processes, c) acetolysis-resistant vesicle wall, microfossils have been interpreted as reproductive cysts of green algae. Both microfossil assemblages reflect the evolutionary patterns through the early Palaeozoic: from the Cambrian radiation of morphologically innovative taxa to increasing in diversity and more disparate Ordovician forms. Combined light transmitted and scanning electron microscopy on the Middle Cambrian to Tremadocian galeate plexus acritarchs *Caldariola*, *Priscogalea* and *Stelliferidium*, revealed exceptionally preserved morphological elements and rare structure among fossil and extant microbiota – an opening with operculum (lid) in reproductive cyst, in addition to lavish vesicle ornamentation and sculpture. Operculum formation model is reconstructed from fossils at different stages of operculum position and attachment. Comparative morphology shows strong similarity of galeates to the reproductive cysts of the extant algae of Dasycladales (Chlorophyta), where the lid covering the cyst opening is determined by an intrinsic lid-forming apparatus during the organism's reproductive stage. Opercula in Cambro-Ordovician galeate acritarchs and Dasycladales may be considered a homologous character. Unique morphology of the operculum-bearing microbiota would have required a degree of intracellular sophistication for its development, suggesting advanced intracellular machinery present already in the early Palaeozoic phytoplankton. Additionally, a new species of minute, sphaeromorphic and aggregated eukaryotic microfossils is recorded. It possesses a vesicle wall with corrugated sculpture and perforated by nano-scale pores. These minute early Cambrian microfossils have diagnostic characters of prasinophyte algae.

A DINOFLAGELLATE CYST ACME IN THE LATE CRETACEOUS OF ANTARTICA: A CONSEQUENCE OF PALAEOCLIMATE OR NUTRITION?

Cecilia R. Amenábar[1,2], Soledad Candel[3,4], James B. Riding[5], Vanessa Bowman[6] and Raquel Guerstein[3,4]

1. Instituto Antártico Argentino, Balcarce 290, C1064AAF, Buenos Aires, Argentina.
2. Instituto de Estudios Andinos Don Pablo Groeber-CONICET, Universidad de Buenos Aires, Departamento de Ciencias Geológicas. Intendente Guiraldes 2160, C1428EGA, Ciudad Universitaria, Buenos Aires, Argentina. amenabar@gl.fcen.uba.ar
3. Consejo Nacional de Investigaciones Científicas y Técnicas, Instituto Geológico del Sur, Departamento de Geología, Argentina.
4. Universidad Nacional del Sur, San Juan 670, Bahía Blanca, B8000ICN, Argentina.
5. British Geological Survey, Nottingham NG12 5GG, United Kingdom.
6. British Antarctic Survey, Cambridge, CB3 0ET, UK.

Some Late Cretaceous Antarctic sections have yielded the small chorate dinoflagellate cyst *Impletosphaeridium clavus* in extremely high proportions. The Upper Campanian–Lower Maastrichtian Snow Hill Island Formation of Ekelöf Point, James Ross Island, includes an abundance peak of *Impletosphaeridium clavus* representing 73.5% of the marine palynomorphs. In younger strata, specifically 250 m below the Cretaceous/Paleogene (K/Pg) boundary in the López de Bertodano Formation of Seymour Island, *Impletosphaeridium clavus* comprises 99% of the marine assemblage. It has been suggested that the acmes of *Impletosphaeridium clavus* are asssociated with the presence of Antarctic winter sea-ice during the Maastrichtian. In this hypothesis, the sea-ice influenced blooms of the parent dinoflagellate and hence the *Impletosphaeridium clavus* acmes. An alternative hypothesis invokes nutrient availability and the physico-chemical properties of marine waters. The latter theory appears consistent with the *Impletosphaeridium clavus* acme at Ekelöf Point which does not seem to be associated with ice-sea cover. However, the Maastrichtian acmes appear to probably have been sea-ice driven. During most of the Late Cretaceous–Eocene greenhouse interval, ice sheets were ephemeral, situated well inland and did not reach the coast (thereby keeping it relatively warm). *Impletosphaeridium clavus* is in the Order Gonyaulacales due largely to its apical archaeopyle (type 4A). Another hypothesis is that *Impletosphaeridium clavus* is related to the heterotrophic round brown spiny cysts (RBSCs). Autotrophic dinoflagellates produce both all gonyaulacalean cysts. By contrast, heterotrophic dinoflagellates produce peridinialean and gymnodinialean cysts. The cyst walls produced by autotrophic dinoflagellates are composed by cellulose-like glucan, while heterotrophic forms produced a nitrogen-rich glycan. This implies that nutritional strategy, not phylogeny, is the primary factor determining wall cyst composition. Wall composition differences between autotrophic and heterotrophic dinoflagellates and dinoflagellate cysts can be determined by fluorescence; autotrophic forms and their cysts exhibit autofluorescence and the heterotrophic ones do not. It is possible that the dinoflagellates which produced *Impletosphaeridium clavus* may have been heterotrophs, which are consistent with environments with high nutrient availability and ones cold enough to produce sea-ice. The nutrients could have been provided by melting of ice sheets during the Late Campanian-Early Maastrichtian generating acmes of *Impletosphaeridium clavus*. Close to the K/Pg boundary, short-term regressions and/or ocean cooling have been recongnised globally. The regression could have produced ephemeral sea-ice and erosion of land sediments proving marine nutrients to the sea and hence causing successive *Impletosphaeridium clavus* acmes.

PALYNOSTRATIGRAPHY OF LOWER MIOCENE SEDIMENTS WITHIN GOBUSTAN REGION (AZERBAIJAN)

Shafaq Bayramova[1]

1. Institute of Geology of Academy of Sciences of Azerbaijan,119 H.Javid av., Baku, AZ1143, Azerbaijan.
shafaqbayram@rambler.ru

The Lower Miocene sediments of the Upper Maykop Formation are widely distributed within territory of Azerbaijan. Eight palynological zones of vegetation distribution in above-mentioned sediments have been distinguished according to results of the detailed palynological investigations. All palynozones are confined to earlier identified stratigraphycal units of Caucasian, Sakaraulian, Kozakhurian regio-stages (Akvitan-Burdigal). Palynozones 1 and 2 are of Caucasian age, palynozone 3 comprises upper part of Caucasian and lower part of Sakaraulian ages, palynozones 4, 5, 6 and 7 are of Sakaraulian age, palynozone 8 are of Kozakhurian age. Paleogeograpahic and paleoclimatic conditions are described based on the pollen analyses. Forests were the predominant vegetation type during early Miocene. There were coastal, marine on swamped soils represented by cypress, bayberry and palm probably growing along sandy coastlines; polydominant multitier coniferous and broad-leaved represented by beech, oak, walnut, chestnut, hickory, magnolia, birch with lesser contribution from ginkgo, cedar, hemlock, redwoods; and flood-plain forests with different types of alder, willow, hornbeam, bayberry. Sporadic presence of grass pollen grains indicates insignificant role of open spaces. Presence of beech forests, which are exacting to summer moisture and unbearable to long drought, and availability of hygrophytes (taxodeacea, bayberry) indicate that these forests existed in wet enough conditions with practically even distribution of annual precipitation. Presence of indicator species with narrow distribution areal (ginkgo, palm, sago fern) says about warm conditions with medium-winter temperature in foothills no less than 15ºC.

NEW SPECIES OF THE BIPOLAR ACRITARCH *BIMERGA* IN THE LOWER DEVONIAN OF URUGUAY: STRATIGRAPHICALLY RESTRICTED AND REGIONALLY CORRELATIVE PALYNOLOGICAL EVENTS IN THE COOL-WATER MALVINOKAFFRIC REALM

Gloria Daners[1], Alain Le Hérissé[2] and Gerardo Veroslavsky[1]

1. Dpto. de Evolución de Cuencas, Facultad de Ciencias, Universidad de la República, Iguá 4225, 11400-Montevideo, Uruguay. lagluar@gmail.com

2. Université de Brest, UMR 6538 CNRS, Institut Universitaire Européen de la Mer, France.

Two new species of the acritarch genus *Bimerga* Wood, *Bimerga acharii* Daners & Le Hérissé sp. nov, *Bimerga nuda* Daners & Le Hérissé, sp. nov – and additional forms showing affinities with *Bimerga*, are described from the lower Devonian Cordobés Formation, Norte Basin (Southernmost portion of the Parana Basin), Uruguay. They are well differentiated from the type species *Bimerga bensonii* Wood, described from the Middle Devonian, and they exemplify the oldest representatives of the *Bimerga* lineage at that time. *Bimerga* is restricted to the Devonian in Malvinokaffric areas of South America and West Africa, and is characterized by a very peculiar morphology, bipolar, with axial symmetry, an elongated or fusiform vesicle, one or several processes at the poles and specific microsculptural elements on the surface. *Bimerga* was originally described as having an elongate bilaterally symmetrical vesicle with poles bisected into two broad-based processes, and a surface ornamented with grana and/ or striations. The generic diagnosis is emended to fully document the multiplicity in ornamentation types and the significant variation in size, as well as the processes' variation in number and relation with the vesicle body. The new species of *Bimerga* have been encountered in a short interval of Achar Well in sediments belonging to the Devonian Cordobés Formation, interpreted as the principal petroleum source rock in the Norte Basin. *B. acharii* has a fusiform to naviform elongated vesicle, bearing a thick wall ornamented by positive elements, with polar ends drawing out to one to three short smooth processes opened to vesicle interior that are usually bi or trifurcated distally. This species has been also identified in few samples of La Paloma Well in sediments belonging to the same formation. *B. nuda* has an elongated, bilaterally symmetrical, thin walled, smooth vesicle with polar ends developing two homomorphic smooth processes distally simple and opened to vesicle interior. The meaning of the specific morphology of *Bimerga* is uncertain, but the recurrence of the bipolar symmetry among acritarchs in the Devonian of South America, represent important palynological events, stratigraphically restricted and regionally correlative. In the Cordobés Formation, the *Bimerga* species are associated with other acritarchs, chitinozoa, and miospores. The miospores assemblage is comparable to a miospores assemblage previously described in the lower part of the Ponta Grossa Formation of the Paraná Basin, Brazil, and confirms a late Pragian-early Emsian age span.

CHITINOZOANS THROUGHOUT THE ORDOVICIAN/ SILURIAN BOUNDARY IN NORTHWESTERN ARGENTINA, WESTERN GONDWANA

G. Susana de la Puente[1]

1. CONICET – Departamento de Geología y Petróleo, Facultad de Ingeniería, Universidad Nacional del Comahue, Buenos Aires 1400, Q8300IBX, Neuquén, Argentina. sudelapuente@gmail.com

Chitinozoans across the Ordovician/Silurian boundary from different regions of Northwestern Argentina, at the southern end of the Central Andean Basin, are analysed. The unit containing the uppermost Ordovician deposits is traditionally described as the glacial Zapla Formation, and locally named as Caspalá Formation or Mecoyita Formation. The Silurian deposits are described as the Lipeón Formation, and record the postglacial event in its basal part. The glacial deposits of the Zapla, Caspalá and Mecoyita formations have been related to the Late Ordovician glaciation. Chitinozoans from the glacial Caspalá Formation of the Sierra de Zenta, in the middle part of the basin, are reworked. The youngest indentified species is *Tanuchitina fistulosa*, an index species for the middle Katian of Northern Gondwana. Chitinozoans from the overlaying Lipeón Formation in this area are abundant and indicate a Telychian age for this postglacial deposit. In the Sierra de Zapla, to the eastward, the Zapla Formation glacial horizon contains *Spinachitina* cf. *oulebsiri*. *S. oulebsiri* is assigned to the late Hirnantian in Northern Gondwana. This glacial unit is succeeded by a transgressive basal conglomerate of the lowermost Lipeón Formation. The conglomerate is overlain by a condensed section composed of bioturbated greenish shales, and several basin-wide oolitic ironstones that record high-frequency sea-level fluctuations. This 5m thick condensed section contains chitinozoans that allow identifying, for the first time in the area, Rhuddanian, Aeronian and Telychian ages. The sequence continues with pervasively bioturbated siltysandy shales containing abundant Telychian and probably Sheinwoondian chitinozoans in its uppermost part. In the Puna region, to the west of the basin, the Salar del Rincón Formation probably spans the Ordovician/ Silurian limit, although glacial deposits are not observed. This unit is deposited between two regional unconformities which separate it from the Lower Ordovician and the Carboniferous deposits. The chitinozoan associations, with common species of *Spinachitina*, *Ancyrochitina* and *Cyathochitina*, could indicate the postglacial event of the latest Hirnantian-earliest Silurian. Chitinozoans from Western Gondwana indicate that the glacial and postglacial intervals of the Ordovician/Silurian boundary could have been deposited in similar conditions as contemporaneous peri-Gondwanan regions, where ironstones and hot shales characterize the postglacial stratigraphy, and the presence of the earliest Silurian deposits evidence that they were proximal to the Hirnantian ice-cap. Chitinozoans are demonstrated to be a useful biostratigraphic tool for the Central Andean Basin, allowing a high-resolution in the determination of the ages, and the better understanding of the regional and global events.

NEW FINDINGS OF THE *LUECKISPORITES VIRKKIAE* ZONE (LATE CISURALIAN-GUADALUPIAN) IN THE SERRA DO RIO DO RASTRO AND NEIGHBORING LOCALITIES (PARANÁ BASIN) IN SANTA CATARINA, BRAZIL

Mercedes Di Pasquo[1] and Paulo A. Souza[2]

1. Laboratorio de Palinoestratigrafía y Paleobotánica, CICYTTP-CONICET (Consejo de Investigaciones Científicas y Tecnológicas), Dr. Materi y España SN, Diamante, E3105BWA, Entre Ríos, Argentina. medipa@cicyttp.org.ar

2. Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul. Caixa Postal 15.001, CEP 91.501-970, Porto Alegre, RS, Brazil.

New palynological data are documented from some deposits of the Passa Dois Group (Irati, Serra Alta, Teresina and Rio do Rasto formations), in Santa Catarina, Brazil. The well constrained Irati Formation (basis of the Passa Dois Group) is akin to the late Artinskian by different paleontological (including palynology) and radiometric data. Although, the overlying units are palynological poorly known, comprising few citations of pollen grains with no illustrations or description, mainly due to the rarity of these occurrences, as well as their poor preservation. A comprehensive sampling has been done from the Serra Alta, Terezina and Rio do Rastro formations in the Serra do Rio do Rastro and neighboring region in Santa Catarina State, revealing new records with biostratigraphic significance. The Serra Alta Formation is transitionally deposited over the Irati Formation and well exposed at the Point 9 of the classic White´s Column in the way to the top of the Serra do Rio do Rastro. Currently there is a mining development of slabs from a thick section (ca. 30 meters) composed of mudstones, shales, siltstones and sandstones. Eleven of the twenty two samples collected yielded fairly well preserved palynomorphs. The whole assemblage is dominated by pollen grains and subordinated spores and *Botryococcus*. Diagnostic species of the *Lv* Zone in the Paraná Basin were recorded (e.g. *Corisaccites alutas*, *Guttulapollenites hannonicus*, *Klausipollenites schaubergerii*, *Lueckisporites virkkiae*, *Lueckisporites* spp., *Marsupipollenites striatus*, *Staurosaccites* spp., *Vittatina* spp., *Weylandites lucifer*, and the spores *Convolutispora uruguaiensis*, *Polypodiisporites mutabilis* and *Reticuloidosporites warchianus*). Other sections exposed in the Urubici region, stratigraphically below the Botucatu Formation were also sampled (Corvo Branco Hill and Sete Quedras localities, both in Urubici Municipality). From the first locality, the palynoassociation is well preserved and dominated by pollen grains (e.g., *Corisaccites alutas*, *Lueckisporites virkkiae*, *Lueckisporites* spp., *Lunatisporites variesectus*, *Protohaploxypinus varius*, *P. limpidus*, *Scheurigipollenites ovatus*, *Staurosaccites* spp., *Vittatina* spp., *Weylandites lucifer*), and subordinated spores (*Convolutispora uruguaiensis*, *Polypodiisporites secoensis*, *Lophotriletes* cf. *parryensis*) and *Botryococcus.* Scarce and poor preserverd palynomorphs were retrieved from four samples from Sete Quedas at Urubici. These new records are very similar to the Serra Alta Formation association, and are assigned to the *Lueckisporites virkkiae* Zone. [CNPq Project 402873/2012-2].

PALEOPALYNOLOGICAL DIVERSITY OF THE EL CIEN FORMATION (UPPER OLIGOCENE-LOWER MIOCENE), BAJA CALIFORNIA SUR, MEXICO

Iris G. Galván-Escobedo[1], Elia Ramírez-Arriaga[1], Alfonso Valiente-Banuet[2] and Enrique Martínez-Hernández[1]

1. Laboratorio de Palinología, Departamento de Paleontología, Instituto de Geología, UNAM, Ciudad Universitaria, 04510, Coyoacán, México, D.F., Mexico.
sirigales@gmail.com

2. Departamento de Ecología de la Biodiversidad, Instituto de Ecología, UNAM, Ciudad Universitaria, 04510, Coyoacán Mexico, D.F., Mexico.

El Cien Forrmation (ECF) (upper Oligocene-lower Miocene) is located in Cerro Colorado and San Juan de la Costa, southern La Paz municipality, Baja California Sur, Mexico. The ECF is divided in two members: 1) the basal San Juan Member and 2) the upper Cerro Colorado Member. The San Juan Member consists of siltstones, fine-grained sandstone, limestone, phosphatic mudstone, diatomite, coquinas and interbedded granular phosphorite layers. The Cerro Colorado Member consists of fine-grained clastic sediments, argillaceous siltstones, sandstones, tuffs and coquinas. ECF borehole SJC-187, 103.90 m deep, was studied by means of paleopalynological analysis, as part of the PAPIIT-IN114914-3-DGAPA project. Tuffaceous sandstones were sampled at the top of the borehole in order to date through the U-Pb (Uranium-Lead) method in zircons. Zircon age yields 27.50 Ma (Upper Oligocene). A total of 72 samples were taken, and 52 of them contain abundant palynomorphs. Preliminary analysis indicates a shallow marine environment with an assemblage dominated by marine palynomorphs with 97% (n=25,477), while continental palynomorphs represent 3% (n=755). The assemblage is dominated by acritarchs and *Leiosphaeridia* spp. (90%) (n=22,842). Dinoflagellate cysts represent 5% (n=1,371) with a richness of 19 taxa. The most abundant dinoflagellate cysts taxa are *Spiniferites ramosus* (n=4-452), *Achomosphaera* sp. (n=1-111) and *Operculodinium* sp. (n=1-59). Finally, in the continental assemblage richness is 117 taxa. Angiosperms represent 71% (n=535), from which 81% (n=435) are dicotyledoneae and 1% (n=40) monocotyledoneae. Gymnosperms constitute 24% (n=185) and 5% (n=35) are spores. The most abundant taxa are *Chenopodipollis* spp. (n=1-36), *Pinuspollenites* sp. (n=1-79), *Graminidites* sp. (n=3-30), *Leguminosaepites* spp. (n=1-49) and *Ephedripites claricristatus* (n=1-9). These results suggest that the common local vegetation type in La Paz region would correspond to tropical deciduous forest.

FIRST PALYNOLOGICAL RECORD OF THE SILURIAN/DEVONIAN BOUNDARY IN THE SAN JUAN PRECORDILLERA, ARGENTINA

Victoria J. García Muro[1], Claudia V. Rubinstein[1] and Philippe Steemans[2]

1. IANIGLA, CCT CONICET Mendoza, A. Ruiz Leal s/n, Parque General San Martín, Mendoza, M5502IRA. Argentina. vgarcia@mendoza-conicet.gob.ar

2. Palaeogeobiology – Palaeobotany – Palaeopalynology, Allée du 6 Août, Bât. B-18, parking 40, University of Liège, Liège 1, B-4000, Belgium.

The Silurian/Devonian boundary in the Precordillera has been scarcely fossil-dated because of the lack of accurate markers. The complexity of the Silurian and Devonian deposits in western Gondwana is a result of the tectonic events related to the development of a foreland basin in the active margin. Acritarch diversity declined worldwide during late Silurian and Devonian time, probably in response to extrinsic changes in seawater chemistry. Otherwise, terrestrial palynomorphs are broadly used to constrain the Silurian/Devonian boundary. The aim of this work is to present the miospore and phytoplankton assemblages recorded in the upper part of the Los Espejos Formation and the lower part of the Talacasto Formation in Río Jáchal section. Furthermore, this work serves the purpose of reporting the identification of the Silurian/Devonian boundary within the Los Espejos Formation, so far uncertainly defined in the San Juan Precordillera, because mostly the 100 ms of the top of the Los Espejos Formation were palynologically barren (*e.g.* Cerro del Fuerte and Loma de Los Piojos sections). Ten samples were collected from the upper section of the Los Espejos Formation and nine from the lower section of the Talacasto Formation. The lowest studied level of the Los Espejos Formation contains *Chelinospora* cf. *cantabrica*, which is an accessory species of the *reticulata-sanpetrensis* (RS) and *hemiesferica* (H) biozones from Spain, pointing out a Ludfordian-Pridoli? age. Towards the top of the unit, some Devonian badly preserved phytoplankton and spores species have been recognized, such as cf. *Latosporites ovalis*, *Estiastra culcita*, and cf. *Thysanoprobolus polykion*. Below the top of the Los Espejos Formation, at 6.25 m from it, a single specimen of *Streelispora* cf. *newportensis* was found, representing the second record of this species in Gondwana. Its presence could allow the identification of the Silurian/Devonian boundary in the Central Precordillera, supporting the previous suggested age based on brachiopods. Also, at 4.75 m and 2.5 m below the top the Los Espejos Formation, *Cymbosporites proteus* and *Dictyotriletes* cf. *emsiensis* Morphon were recorded. These species could also support a Lochkovian age. Above the base of the Talacasto Formation, at 8-16 m, *Dictyotriletes* cf. *emsiensis* Morphon, cf. *Dibolisporites echinatus*, and cf. *Zonotriletes* sp. were found, which could confirm that the Early Devonian age reaches this level. Based on palynological record, it is possible to assign a Ludlovian/Pridoli? to Lochkovian to the studied section. Moreover, the Silurian/Devonian boundary could be identified for the first time in the Argentine Precordillera.

THE GNETALES (GYMNOSPERMOPHYTA) IN THE FOSSIL RECORD OF THE CRETACEOUS SAN LUIS BASIN, ARGENTINA: SYSTEMATIC ASPECTS

María A. Gómez[1], Gabriela G. Puebla[2], Mercedes B. Prámparo[2] and Ari Iglesias[3]

1. Facultad de Química, Bioquímica y Farmacia. Universidad Nacional de San Luis. CCT CONICET San Luis. Chacabuco 917, 5700 San Luis, Argentina. gomezmarian80@gmail.com

2. Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, CCT CONICET Mendoza. Av. Adrián Ruiz Leal s/n, Parque General San Martín, 5500 Mendoza, Argentina.

3. Universidad Nacional del COMAHUE. Instituto de Investigaciones en Biodiversidad y Medioambiente INIBIOMA-CONICET, Quintral 1250 - San Carlos de Bariloche 8400, Río Negro, Argentina.

The Gnetales currently include three genera of seeds plants: *Ephedra*, *Gnetum* and *Welwitschia*, with an evolutionary history still poorly known. Extant species are considered a remnant of a wider biodiversity due to their divergent morphology and wide ecological range of life forms, and by the palaeontological record (diverse and abundant polyplicate pollen grains). The phylogenetic relationships between Gnetales and other spermatophytes have been debated as an important evolutionary problem until recently. The present debate includes several different phylogenetic hypotheses, alternatively relating them to different groups of gymnosperms or basal angiosperms, which has led to a growing interest in their study. In the La Cantera Formation (Late Aptian), San Luis Basin, central-western Argentina, a palynological assemblage, including abundant pollen grains, as well as macroremains assigned to this group, were recovered. Polyplicate pollen grains constitute more than 40% of the total of palynomorphs recorded in some levels of the type section and are associated also with well-preserved macroremains. Among the pollen grains there are morphological varieties with over 20 different morphological types assigned to different fossil genera with gnetalean affinity: *Ephedripites*, *Steevesipollenites*, *Gnetaceaepollenites*. Pollen grains are elliptical, inaperturate and polyplicate with a wide range of variation in pollen size and twisted spiral or longitudinal plicae (similar to *Ephedra*). Some polyplicate grains show a longitudinal aperture, similar to *Welwitschia* pollen grains. The macroremains include leaves, stems, cones and seeds, and are comparable to *Ephedra*. Striated stems and branches with whorled leaves have been identified among the studied material. Specimens with two leaf types were recognized: one type with two linear leaves in opposite arrangement and the second type represented by scale-like leaves, with threemerous whorled arrangement, with fused bases and triangular apex. Female cones are ovate in shape, with thin bracts in three whorls: three to five small bracts at the first whorl, three broad bracts at the second whorl, and three larger bracts at the third whorl were preserved. The margins of bracts have lateral flanks extension (wings). Two ovoid seeds per cone with outer papillate envelope were distinguished. Some specimens have a good preservation and exhibit cuticles and organic remains that have enabled us to visualize in detailed anatomical features typical of these structures. A detailed study on these fossils will provide new relevant information to the understanding of homologies in reproductive structures of the Gnetales and its relationship with gymnosperms and angiosperms.

DINOFLAGELLATE CYST PALEOBIOGEOGRAPHY DURING THE MIDDLE EOCENE IN SOUTHERN SOUTHWEST ATLANTIC OCEAN

M. Sol González Estebenet[1], G. Raquel Guerstein[1] and Marta I. Alperin[2]

1. Instituto Geológico del Sur, Departamento de Geología, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, 8000, Argentina. sol.gonzalezestebenet@uns.edu.ar.

2. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Calle 64 s/n e/ Bv. 120 y Diag. 113, La Plata, 1900, Argentina.

The middle Eocene in high latitudes of the Southern Hemisphere is characterized by an Antarctic endemic assemblage of organic-walled dinoflagellate cysts. The distribution of these microfossils responds to a surface ocean circulation patterns with broad clockwise gyres surrounding Antarctica. During the Oligocene the deepening of the Tasman Gateway and the Drake Passage would have generated a circumpolar water flow responsible for the disruption of the local gyre system which caused the extinction of the endemic assemblage. Recently it has been suggested that during the middle Eocene, shallow water flows developed through incipient openings of the Tasman Gateway. As for the Drake Passage, the time for its opening and deepening is still being discussed, with ages ranging from the middle Eocene to the early Miocene. Recently some authors proposed an early opening for this passage, with tectonic and oceanic characteristics similar to those proposed for the Tasmania Gateway. In this work we compared the middle Eocene dinoflagellate cysts in the Drake area using multivariate analysis. The results show two clusters: one cluster comprises the localities to the north of the passage, from the Austral Basin, and the other cluster includes the localities to the south of the passage at the Peninsula Antarctica and Scotia Sea. In this way, our results allow us to determine a latitudinal dinoflagellate cyst differentiation that could be related to an early development of shallow water flows through the Drake Passage during the middle Eocene.

MIDDLE EOCENE DINOFLAGELLATE CYSTS OF THE AUSTRAL BASIN: BIOSTRATIGRAPHIC AND PALEOCEANOGRAPHIC IMPLICATIONS

M. Sol González Estebenet[1], G. Raquel Guerstein[1], Marta I. Alperín[2] and Martín Rodríguez Raising[1]

1. Instituto Geológico del Sur, Departamento de Geología, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, 8000, Argentina. sol.gonzalezestebenet@uns.edu.ar

2. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. Calle 64 s/n e/ Bv. 120 y Diag. 113, La Plata, 1900, Argentina.

Reconstruction of palaeoenvironmental and paleoceanographic evolution of the southwestern Atlantic Ocean during the Paleogene is prevented by the lack of bioestratigraphic tools to date and correlate the sedimentary units. During the middle Eocene a regional transgression covered the Austral Basin represented in the southwest of Santa Cruz province by the upper member of the Río Turbio Formation (UMRTF). These marine deposits contain well preserved organic-walled dinoflagellate cyst (dinocyst) assemblages dominated by Antarctic endemic assemblage species with important biostratigraphic and paleoenvironmental indicators. In this contribution we correlate the assemblages of the UMRTF from two outcrop sections and three cores drilled close to the Río Turbio locality using Statistical Compositional Analysis. The results show two well-defined clusters. One cluster comprises the samples of the lower part of UMRTF from all the localities and the other includes the samples of the upper part of the UMRTF. The comparison of our results with the high-resolution Southern Pacific Ocean dinoflagellate cyst zonation for middle-late Eocene allows us to date some of the dinoflagellate events recorded in UMRTF. The first abundant occurrence of *Enneadocysta dictyostila* (Menéndez) Fensome et al. and the presence of *Hystrichosphaeridium truswelliae* Wrennand Hart and *Arachnodinium antarcticum* Wilson and Clowes in the lower part of the UMRTF endorse its correlation with the dinocysts's zones SPDZ11 and SPDZ12 and indicate an age between 45.5 and 39 Ma. Upwards, the dominance of *E. dictyostila* is replaced in all the sections by *Vozzhennikovia apertura* Wilson showing the transition from a distal setting in an inner-shelf environment with relatively warm waters to an intertidal deltaic plain with eutrophic shallow marine waters. A brief interval dominated by *Imagidinium* spp. coincides with the maximum flooding surface. In the upper part of the UMRTF the first common occurrence of *Spinidinium macmurdoense* (Wilson) Lentin and Williams is recorded at 37 Ma and correlates with the Zone SPDZ13. Therefore the UMRTF ranges in age from late Lutetian to early Priabonian. The abundance of *V. apertura* and the increasing amount of non-marine palynomorphs towards the top of the sections indicate the transition from a tide-dominated deltaic to a continental environment. This paleoenvironmental reconstruction agrees with the proposed by the sequence stratigraphical analysis. The presence of the endemic dinocyst assemblages throughout the UMRTF suggests this unit was deposited during the early opening of the Drake Passage before the emplacement of an unrestricted Antarctic circumpolar flow.

MIDDLE EOCENE DINOFLAGELLATE CYST DISTRIBUTION IN THE SOUTHWESTERN ATLANCTIC OCEAN: PALEOCLIMATIC AND PALEOCEANOGRAPHIC IMPLICATIONS

G. Raquel Guerstein[1], M. Sol González Estebenet[1], Gloria Daners[2], Eduardo Premaor[3], Elizabete Pedrão Ferreira[4] and Alexandra Belgaburo[5]

1. Instituto Geológico del Sur (CONICET), Departamento de Geología, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, 8000, Argentina. raquel.guerstein@uns.edu.ar
2. Facultad de Ciencias, Departamento de Evolución de Cuencas, Iguá 4225,11400-Montevideo, Uruguay.
3. Universidade Federal do Rio Grande do Sul, Departamento de Paleontologia e Estratigrafia, Programa de Pósgraduação em Geociências, Brazil.
4. Centro de Pesquisas e Desenvolvimento Leopoldo A.M.Mello, Petrobras, Ilha Fundão, Av. Horácio Macedo 950, Prédio 32, Rio de Janeiro, RJ, Brazil.
5. Departamento de Geología, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, 8000, Argentina.

The Middle Eocene dinoflagellate cyst organic walled assemblages from Southwest Atlantic basins are represented by Antarctic-endemic components including species of *Enneadocysta, Deflandrea, Vozzhennikovia, Spinidinium* and *Arachnodinium*. In sections from Southern Hemisphere high latitudes (~50°S) the Middle Eocene Climatic Optimum (MECO) corresponds with an increase of *Enneadocysta dictyostila* (Menéndez) Fensome *et al*. Based on its positive correlation with $CaCO_3$ percentages we assume that this form is the unique member of the endemic assemblage apparently tolerant to warm surface waters. This assumption is consistent with a significant representation of *Enneadocysta dictyostila* in samples from Colorado (~38°S), Punta del Este (~36°S), Pelotas (~30°S), Jequitinhonha (~17ºS) and Sergipe (~11°S) basins. Previous research developed in the Tasman area has related the presence of endemic taxa at mid latitudes to a strong clockwise subpolar gyre ("cold trap") favoured by the continental blockage of the Tasmanian Gateway. We propose that the dinoflagellate cyst distribution in the Southwest Atlantic basins can be explained by a similar dynamical mechanism forming a proto- Weddell Gyre. Results from climatic model simulations indicate that the blockage of the Tasmanian Gateway and a partially-open Drake Passage both contributed to the formation of a strong western-intensified clockwise gyre. Morever, the same simulations showed that the gyre intensified after the MECO. Therefore, we hypothesize that during the MECO the species tolerant to warm waters flourished in high latitudes, while the subsequent drop of temperature intensified the proto-Weddel Gyre and transported the endemic components northward along the Southwestern Atlantic Shelf.

MELISSOPALYNOLOGICAL STUDY OF *APIS MELLIFERA* (APIDAE) HONEY AND POLLEN LOADS IN CENTRAL AND NORTHERN GUERRERO STATE, MEXICO

Enrique Martínez-Hernández[1], Angélica Martínez-Bernal[2], Nadia Ramírez[2] and Elia Ramírez-Arriaga[1]

1. Laboratorio de Palinología, Departamento de Paleontología, Instituto de Geología, UNAM, Ciudad Universitaria, 04510, Coyoacán, Mexico, Distrito Federal, Mexico. emar@unam.mx.

2. Departamento de Biología, División de CBS, Universidad Autónoma Metropolitana. San Rafael Atlixco, Núm. 186, Colonia Vicentina, Iztapalapa, 09340, Distrito Federal, Mexico.

Both diverse flora and climate regimes in Mexico have triggered the production of honey showing a rich array of organoleptic variation. Melissopalynological research allows floral origin characterization of honey and pollen load samples, and is also considered for worldwide quality control. The present study contributes the botanic and geographic origin of six *Apis mellifera* honey and pollen load samples collected through November-December, 2005 and March, 2006 in central and northern Guerrero state, both regions of beekeeping importance. Samples were processed by standard methods, and permanent slides were added to the palynological collection of the Geology Institute, Universidad Nacional Autónoma de México. Melissopalynological analysis showed a total of 43 pollen types belonging to 27 families. Only 15 native taxa were considered of importance: *Cosmos sulphureus, Dyssodia papposa, Taraxacum officinale, Tithonia tubaeformis* and *Vernonia* sp. (Asteraceae); *Coutoubea* sp. (Gentianaceae); *Dalea* sp. and *Leucaena leucocephala* (Fabaceae); *Quercus* sp. (Fagaceae); *Miconia* sp. (Melastomatacea); *Pisonia* sp. (Nyctaginaceae); *Dodonaea viscosa* and *Paullinia* sp. (Sapindaceae); *Solanum* sp. (Solanaceae); and *Heliocarpus donnell-smithii* (Tiliaceae); furthermore, *Zea mays* (Poaceae) is extensively cultivated in the region. Two oligofloral and four multifloral honey samples were characterized. Diversity indexes varied from 1.7 to 2.3 in honey samples, and the pollen loads registered a diversity range of 1.6 to 2.1. The evenness index in honey samples varied from 0.8 to 0.9, while pollen load samples registered a range of 0.6 to 0.9. Hence, *Apis mellifera* showed polylectic behavior in which the herbaceous stratum was the most foraged, followed by tree and shrub strata.

PALYNOFACIES CHARACTERISATION OF DEEP-MARINE DEPOSITIONAL ENVIRONMENTS: AN OUTCROP EXAMPLE FROM THE CHANNELIZED ROSARIO FORMATION, BAJA CALIFORNIA, MEXICO

Adam D. McArthur[1], Paulo A. Souza[1], Benjamin C. Kneller[2] and Matthew I. Wakefield[3]

1. Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS 91501-970, Brazil. adam.mcarthur@ufrgs.br

2. Department of Geology & Petroleum Geology, University of Aberdeen, Aberdeen, AB24 3UE, UK.

3. BG Energy Holdings Limited, Thames Valley Park Drive, Reading, RG6 1PT, UK.

Palynofacies is a key tool in the study of terrestrial and shallow-marine depositional systems, with variations in the abundance of different palynodebris corresponding to different environments. However, palynofacies has been under employed in deep-marine studies, it being assumed that amorphous organic matter (AOM) will homogenize assemblages in deep-marine settings. Here we present the initial findings of an integrated palynological and sedimentological investigation from outcrops of a deep-marine channel-levee complex, which aims to characterize sub-environments of the deep-marine system based upon their palynofacies. The studied Upper Cretaceous–lowermost Palaeocene Arroyo San Fernando channel-levee system of the Rosario Formation, crops out in Baja California, Mexico. The depositional sub-environments are well constrained sedimentologically, allowing certainty in placement within the channel complex. In conjunction with sedimentological logging of the Arroyo San Fernando, three hundred samples were collected for palynofacies study from mudstones in the channel axis, terrace, internal and external levees, debris flows and hemipelagic drapes. 10 g from each sample were processed with hydrochloric and hydrofluoric acid and sieved at 10 µm. A count of 300 pieces of palynodebris per slide was made and the characteristics and the size of phytoclasts were also recorded. Samples are not dominated by AOM, instead displaying a range of palynodebris, with a variety of allochthonous terrestrial material and also relatively autochthonous materials, inferred to have been produced in the marine environment. Initial results show a decrease in sorting of palynodebris away from the channel axis, where assemblages are dominated by dense humic material (e.g. degraded wood). Less dense particles (e.g. cuticle and miospores) were retained in suspension at lower energy, being concentrated in channel distal settings. Terrestrial material was delivered to the deep-marine by turbidity currents and the primary mechanism inferred for the sorting of palynodebris is hydrodynamic sorting. This result demonstrates the role of primary sediment dispersal mechanisms in controlling the distribution of organic matter in channel-levee systems. From the variation observed in palynodebris in the various architectural elements, a palynofacies classification scheme can be developed that enables recognition of sub-environments within the deep-marine system. Importantly, this scheme can be applied to sub-surface samples to assist exploration and characterisation of reservoir stratigraphic hierarchy, understanding of which is crucial for correct hydrocarbon well planning.

CENOZOIC PALYNOLOGY ON THE CAUCA-PATIA VALLEY BASIN (WESTERN COLOMBIA): A TROPICAL RECORD ASSOCIATED WITH VOLCANISM AND ANDEAN UPLIFT

Andrés Pardo-Trujillo[1], Andrés Díaz[1], Jhonatan M. Martínez[1], Edwin A. Ramírez[1], Angelo Plata[1], Raúl Trejos[1] and Felipe Vallejo[1]

1. IIES- Instituto de Investigaciones en Estratigrafía, Universidad de Caldas, Departamento de Ciencias Geológicas, Calle 65 n° 26-10, Manizales, Colombia. Andres.pardo@ucaldas.edu.co

The Cauca river valley corresponds to a narrow depression with N-S direction and ~700 km in length, separating the Central and Western Cordilleras of Colombia. In this area a ~2000 m thick Cenozoic sedimentary cover was accumulated on a Cretaceous volcano-sedimentary basement. The Cenozoic deposits are mainly fluvial-lacustrine with local marine influence. Practically there are no published paleontological studies of these rocks, despite their potential for macro and microfossil preservation. Currently palynological studies are conducted in different sectors of the basin in order to pinpoint the age and composition of the vegetation and its possible relation to volcanism and tectonics. Sedimentologic and palynological data indicate that deposition began in the Eocene?-Oligocene in swamps and bogs, associated with fluvial channels and floodplains. Locally foraminifera and calcareous units indicate marine influence. In these environments *Cicatricosisporites dorogensis* (Schizaeaceae), *Magnaperiporites spinosus* (Convolvulaceae?), *Spirosyncolpites spiralis* (Passiflorae?, Bignoniaceae), *Striatopollis catatumbus* (Fabaceae), *Mauritiidites franciscoi* (Palmae: *Mauritia), Magnastriatites grandiosus (Ceratopteris), Foveotriletes ornatus*, *Cyclusphaera scabrata* (Araucariaceae), *Foveotricolporites etayoi*, *Concavissimisporites fossulatus*, *Retistephanoporites minutiporus*, *Crassoectoapertites columbianus*, *Psilaperiporites minimus*, and *Multimarginites vanderhammeni* (*Sanchezia klugii*: Acanthaceae) were found. The lower Miocene deposits are composed of fluvial-lacustrine deposits where *Clavainaperturites microclavatus (Hedyosmum:* Cloranthanceae*)*, *Concavissimisporites fossulatus*, *Retitriletes sommeri* (Lycopodiaecae?), *Fovetriletes ornatus*, *Mauritidites franciscoi*, *Polypodiaceoisporites pseudopsilatus (Pteris:* Pteridaceae), *Polypodiisporites usmensis* (Polypodiaceae), *Striatopollis catatumbus*, *Retitricolporites simplex* (*Sapium:* Euphorbiaceae), *Crassiectoapertites columbianus* and *Perisyncolporites pokornyi* (Malpighiaceae) are common. In the Middle Miocene (~15-13 Ma) volcanic activity increased and alluvial-fan, conglomerates associated to Andean uplift are common which complicates palynomorph recovery. *Bombacacidites* aff. *araracuarensis* (*Ceiba:* Bombacaceae), *Clavainaperturites* aff. *microclavatus*, *Concavissimisporites fossulatus*, *Cyatheacidites annulatus* (Dicksoniaceae), *Echiperiporites akanthos*, *Echitricolporites spinosus* (Compositae), *Foveotriletes ornatus*, *Kuylisporites waterbolkii* (*Hemitelia/Cnemidaria:* Cyatheaceae), *Monoporopollenites annulatus* (Poaceae), *Nijssenosporites fossulatus* (*Pityrogramma:* Adianthaceae), *Retistephanoporites crassiannulatus* and *Retitriletes sommeri* were found in local lacustrine beds. The Pliocene deposits were accumulated in fluvial and lacustrine environments with a marked volcanic influence. In lignite beds (~2.9-3.0 Ma U/Pb in zircon) located at 1960 m of elevation in the Central Cordillera, the palynoflora is dominated by spores (*Laevigatosporites*, *Psilatriletes*, *Polipodiisporites*) and palynomorphs characteristic of the Andean forest: *Hedyosmum*, *Ilex*, *Podocarpus*, *Sapium*, Asteraceae, Ericaceae, Poaceae, Cyatheacea. In less proportion lowland tropical forest and sub-andean forest palynomorphs such as Bombacaceae, Palmae and Malpighiaceae are reported. These data, although discontinuous, allow studying Cenozoic evolution of the palynoflora in western Colombia for the first time.

AGE AND ENVIRONMENTS OF THE NEOGENE SERIES FROM MADRE DE DIOS BASIN AN INTERPRETATION BASED ON PALYNOSTRATIGRAPHY, PALYNOFACIES AND MICROPALOENTOLOGICAL CONTENT

Francisco Javier Parra[1], Martin Roddaz[1], Melanie Louterbach[1-3], Patrice Baby[1], Pierre-Oliver Antoine[4] and Ysabel Calderon[5]

1. Géosciences-Environnement Toulouse, Université de Toulouse; UPS (SVT-OMP); LMTG; CNRS; IRD; 14 Avenue Édouard Belin, F-31400 Toulouse, France. franciscoparra@unal.edu.co
2. Bassins-Réservoirs-Ressources, Institut Polytechnique Lasalle Beauvais, Département Géosciences, 19 rue Pierre Waguet, BP 30313, F-60026 Beauvais Cedex, France
3. REPSOL Exploracion S.A., Calle Méndez Álvaro 44, 28045 Madrid, Spain.
4. Institut des Sciences de l'Évolution (ISE-M, UMR - CNRS 5554), c.c. 64, Université Montpellier 2, Place Eugène Bataillon, F-34095 Montpellier Cedex 05, France.
5. PERUPETRO S.A., Luis Aldana 320 - San Borja, Lima, Peru.

During field missions with the direction and sponsorship of IRD in the context of some PhD theses (University of Toulouse III, France), Neogene stratigraphic sections exposed in the Salvation Syncline and the Pantiacolla Anticline (Madre de Dios Basin, South Peru) were studied for determining the Neogene sedimentary evolution of this part of the Amazon basin based on facies analysis and biostratigraphy, 42 of which are the subject of this essay. The Madre de Dios Basin is part of the South Amazonian Foreland Basin, located at its southern end between the 12° and 14° of South latitude and the 69° and 72° West longitude. In the Sub-Andean Zone (SAZ), foreland basin is filled with Neogene sediments whose maximum thickness is close to 3000 m. Preliminary studies by biostratigraphy of microfossils (foraminifera and Ostracods), palynostratigraphy and palynofacies of 28 samples of the section by the Inambari River and 14 samples section Congo de Poñeq, revealed ages between early terminal Miocene and Plio-Pleistocene and fluvial sedimentary environments and at least four intervals with influence of salinity type swamp and lagoon, which together document a regressive cycle of Neogene age. Three main types of palynofacies were distinguished. The first type indicates mixed terrestrial and shallow marine depositional conditions and characterizes lithological Unit 1 from the Inambari river section. The presence of some stratigraphically significant spores and pollen grains and some microforaminifers indicates a Late Oligocene to Early Miocene for Unit 1. The second, third and fourth type are present at Congo de Poñeq and Inambari sections. These types are found in most samples of Unit 1, where spores, pollen grains, and non-diversified dino-cysts and linings foraminifera were identified. The second type of palynofacies reveals strong terrestrial depositional conditions and characterizes lithological Unit 1 and Unit 2. The occurrence of stratigraphically significant spore, pollen grains, argues for a late Early Miocene to Middle Miocene for both Unit 1 and Unit 2. The third type indicates interposition from terrestrial and shallow marine depositional conditions and characterizes lithological Unit 3. The presence of some stratigraphically significant spores and pollen grains argues for a Late Miocene to early Pleistocene age for Unit 3. There are not palynofacies indicatives of exclusively marine environmental conditions, and palynomorphs oldest than Late Oligocene and/or youngest than Pleistocene into sample sets analyzed. The Pleistocene consists sharply in palynofacies type continental fluvial. Through Neogene the biofacies and age are heterotopic and heterochrones.

BIOSTRATIGRAPHIC AND PALEOECOLOGICAL SIGNIFICANCE OF AN ALGAL ASSOCIATION DOMINATED BY *PEDIASTRUM BORYANUM* VAR. *LONGICORNE*-TYPE IN THE MIDDLE PALEOCENE OF COLOMBIA, SOUTH AMERICA

Diego Pinzón[1], Joanna Lenarczyk[2] and Felipe De la Parra[3]

1. Instituto Colombiano del Petróleo, ECOPETROL – ICP, CGA LTDA, Colombia. diegopinzon1@gmail.com
2. W. Szafer Institute of Botany, Polish Academy of Sciences, Krakow, Poland.
3. Instituto Colombiano del Petróleo, ECOPETROL – ICP, Colombia.

In this study, a Paleocene association dominated by *Pediastrum* sp., present in several sections in Colombia, South America, is taxonomically analyzed and its importance as a biostratigraphic and paleoecological tool is highlighted. Data from four localities, distributed in different basins in Colombia were palynologically analyzed. The palynomorph assemblage suggests an age that can be correlated to the T-02 palynological zone of Jaramillo et al., between 61.9-60 Ma. High abundances of *Pediastrum boryanum* var. *longicorne*-type, *Pediastrum boryanum* var. *boryanum*-type and *Pediastrum duplex* are characteristic of all of the studied deposits. The *Pediastrum duplex* occurrence in those levels indicates that the radiation of perforated forms might occur from the Paleocene. Based on the modern ecological characteristics of these species, the sediments of the studied sections were deposited in large fresh water lakes. The biostratigraphic implications of this algal association that was synchronically deposited in all of the sections may be relevant in a regional scale, and could be established as a new stratigraphic event if new sections in these and other basins can be put together. The comprehensive analysis of this information along with other proxies (e.g. sedimentology and geochemistry) will refine the importance of *Pediastrum broyanum* var. *longicorne*-type as a paleoecological marker.

PALYNOMORPHS FROM TEHUACÁN-CUICATLÁN VALLEY TRAVERTINE ROCKS WITH ARTIODACTYLA ICNITES, MEXICO

Elia Ramírez Arriaga[1], Enrique Martínez-Hernández[1], Mercedes B. Prámparo[2] and Ángel Nieto-Samaniego[3].

1. Instituto de Geología, Universidad Nacional Autónoma de México, Av. Universidad 3000, Ciudad Universitaria C.P. 04510, Coyoacán, Distrito Federal, Mexico. elia@unam.com

2. Unidad de Paleopalinología, IANIGLA-CCT CONICET, Mendoza. Argentina.

3. Geología, Centro de Geociencias, Universidad Nacional Autónoma de Mexico, Juriquilla, Querétaro, Mexico.

Although travertine rocks are isolatedly distributed, they are well exposed in the Tehuacán-Cuicatlán Valley. Two quarries are well known: one close to Tehuacán city, in Santiago Miahuatlán, Puebla (SMP) and the other in Teotitlán of Flores Magón, Oaxaca. Some authors considered them to be Pliocene–Quaternary in age. However, other authors such as Martínez-Amador et al. reported a Miocene age and considered them as part of the Tehuacán Formation. The purpose of this work is to reconstruct past vegetation through the analysis of the palynomorphs which were deposited during Villa Alegría travertine rock formation. This research is part of a large PAPIIT- IN-114914-3 project aimed towards reconstructing the evolution of plant communities throughout the Paleogene and Neogene in the Tehuacán-Cuicatlán Valley. Samples for palynological studies were recovered from stratified reddish and yellow travertine rocks in an exposed section at Villa Alegria, Tehuacán village, Puebla. They are composed of micrite and recrystallized calcite, with microfossils and Artiodactylaicnites. One to three slides per sample were scanned in order to characterize the palynomorph occurrence. Slides are deposited in the palynological collection of the Institute of Geology, Universidad Nacional Autónoma de México (UNAM). Preliminary palynological analysis registered the presence of highland elements such as *Myrtaceidites*, *Liquidambarpollenites*, *Alnipollenites* and *Fraxinuspollenites* as part of cloud forest. On the other hand, there are some lowland elements; such as: *Graminidites* and *Tubulifloridites*. Moreover, the presence of *Aglaoreidia cyclops*, a fossil taxon associated with upper Eocene to lower Oligocene freshwater deposits in Europe and North America and recently also identified in Australia, would suggest a Paleogene instead of Plio-Pleistocene age as had been reported by several authors.

CAESALPINIOIDEAE AND MIMOSOIDEAE (LEGUMINOSAE) POLLEN GRAINS RECOVERED IN CENOZOIC BASINS OF MEXICO

Elia Ramírez-Arriaga[1], Enrique Martínez-Hernández[1], Rosaura Grether[2] and Alfonso Valiente-Banuet[3]

1. Instituto de Geología, Universidad Nacional Autónoma de México, Av. Universidad 3000, Ciudad Universitaria C.P. 04510, Coyoacán, Distrito Federal, Mexico. elia@unam.com

2. Departamento de Biología, Universidad Autónoma Metropolitana. San Rafael Atlixco, 186, Colonia Vicentina, Iztapalapa, C.P. 09340, Distrito Federal, Mexico.

3. Departamento de Ecología de la Biodiversidad, Instituto de Ecología, Universidad Nacional Autónoma de México, Ciudad Universitaria C.P. 04510, Coyoacán, Distrito Federal, Mexico.

Leguminosae is the third largest family of flowering plants and is included in the Fabales order. It is divided into the Caesalpinioideae, Mimosoideae and Faboideae subfamilies. In Mexico, there are about 140 genera and 1,850 species, whose diversification may have occurred predominantly during the Cenozoic era. In this study, pollen morphology of Caesalpinioideae (*Margocolporites* spp.) and Mimosoideae (*Mimosa* type, *Calliandra* type and *Polyadopollenites* sp.) recovered from Paleogene and Neogene basins (1) the Mequitongo Formation (lower to middle Eocene, Puebla State), (2) the Pie de Vaca Formation (upper Eocene–lower Oligocene, Puebla State), (3) the Cuayuca Formation (upper Eocene–lower Oligocene, Puebla State), (4) the Tehuacán Formation (middle Miocene), and (5) the San Gregorio Formation (upper Oligocene–lower Miocene, Baja California Sur State) are presented. Our results show diverse Eocene *Margocolporites* (Caesaplinioideae) in the Mequitongo Formation. The octad *Mimosa* type and *Polyadopollenites*, both Mimosoideae, are also present. Fossil pollen records from upper Eocene to lower Oligocene (Pie de Vaca and Cuayuca Formations) report the presence of *Margocolporites* (Caesalpinoideae), as well as a tetrad of the *Mimosa* type and *Polyadopollenites* (Mimosoideae). Pollen assemblages from the Tehuacán Formation give evidence of a new Legume genus present in the Middle Miocene: *Calliandra*, an octad of Mimosoideae, in excellent preservation. According to these Mexican Cenozoic palynological assemblages (the Pie de Vaca, Cuayuca, Tehuacán and Mequitongo formations), it has been inferred that Leguminosae were part of tropical deciduous forests as it occurs at the present. [PAPIIT financial support to project IN-114914-3].

PALYNOLOGY AND ALLUVIAL ARCHITECTURE IN THE PERMIAN UMM IRNA FORMATION, DEAD SEA, JORDAN

Michael Stephenson[1] and John Powell[1]

1. British Geological Survey, Keyworth, Nottingham, NG12 5GG, United Kingdom.
mhste@bgs.ac.uk

A series of lithofacies associations are defined for the Permian Umm Irna Formation indicating deposition in a fluvial regime characterised by low-sinuosity channels with deposition on point bars, and as stacked small-scale braided channels. Umm Irna Formation floodplain interfluves were characterised by low-energy sheet-flood deposits, shallow lakes and ponds, and peaty mires. Floodplain sediments, where not waterlogged, are generally pedogenically altered red-beds with ferralitic paleosols, indicating a fluctuating groundwater table and humid to semi-arid climate. The Dead Sea outcrop provides a field analogue for similar fluvial and paralic depositional environments described for the upper Gharif Formation alluvial plain 'Type Environment P2' in the subsurface in Oman and the upper the basal clastics of the Khuff Formation at outcrop and in the subsurface in central Saudi Arabia. Coarse-grained clasts within channel sandstones are mineralogically immature; their palaeocurrent directions and new evidence of glaciogenic sediments from central Saudi Arabia suggests derivation from Pennsylvanian-Early Permian glaciofluvial outwash sandstones located to the east-south east. The palynology of the Umm Irna Formation is remarkably varied. Samples from argillaceous beds of fluvial origin appear to contain a palynomorph representation of the wider hinterland of the drainage basin of the river including floodplain plants and more distant communities. In restricted water bodies like oxbow lakes or other impermanent stagnant floodplain ponds and peaty mires (immature coals), a higher proportion of purely local palynomorphs appear to be preserved in associated sediments. The presence of *Protohaploxypinus uttingii* suggests an age range of Middle to early Late Permian for the Umm Irna Formation. The quantitative character of the Umm Irna Formation assemblages is very close to those of the basal Khuff clastics in the central Saudi Arabian wells Dilam-1, Nuayyim-2 and Haradh-51. The lithological character and palynology of the transition between the Sa'ad and Arqov formations in the West Bank, west of the Dead Sea are similar to those of the transition between the Umm Irna Formation and overlying Ma'in Formation in Jordan.

A TAXONOMIC REVISION OF THE PALEOGENE DINOFLAGELLATE SUBFAMILY WETZELIELLOIDEAE: THE "HOLE" STORY

Graham A. Williams[1], Sarah Damassa[2], Robert A. Fensome[1] and G. Raquel Guerstein[3]

1. Natural Resources Canada, Geological Survey of Canada (Atlantic) Bedford Institute of Oceanography P.O. Box 1006 Dartmouth, Nova Scotia, B2Y 4A2, Canada.

2. 3 Ridge St. Winchester, Massachussetts, 01890, USA.

3. Instituto Geológico del Sur - CONICET. Departamento de Geología. Universidad Nacional del Sur. San Juan 670. 8000 Bahía Blanca, Argentina. raquel.guerstein@uns.edu.ar

Fossil dinoflagellate cysts of the Paleogene peridiniacean subfamily Wetzelielloideae have a stable tabulation pattern similar to that of other fossil peridiniaceans, but distinguished by a dorsal epicystal tabulation focussed around a four-sided (quadra), rather than a six-sided (hexa) 2a plate. For morphological features aside from tabulation, wetzelielloideans show great variability, especially in horn development and ornamentation, but also in degree of cavation. This diversity has distracted attention from the morphological variation of the archeopyle, which is always formed through loss of the 2a plate only and which we consider to be the most important feature in unravelling the group's phylogeny. Critical factors are the shape and relative dimensions of the archeopyle and whether the operculum is attached (adnate) or detached. These parameters allow us to define five archeopyle types: equiepeliform, hyperepeliform, hypersoleiform, latiepeliform and soleiform. Based on archeopyle type, we can recognize six genera with an equiepeliform archeopyle, five with a soleiform archeopyle, four with a hyperepeliform archeopyle, three with a latiepeliform archeopyle and one with a hypersoleiform archeopyle. We have generally used ornamentation type and distribution as a secondary defining criterion for genera. The earliest-known wetzelielloideans, which occur around the Thanetian-Ypresian (Paleocene-Eocene) boundary, have an equiepeliform archeopyle. Other archeopyle types evolved rapidly; taxa with hyperepeliform, latiepeliform and hypersoleiform types are known from the Ypresian. Latiepeliform and hyperepeliform types are restricted to the Ypresian and Lutetian. Forms with a soleiform archeopyle appear in the late Lutetian, but are rare until the Bartonian, when they come to dominate wetzelielloidean assemblages and are the exclusive types in Priabonian and younger strata. The subfamily became extinct in the middle Oligocene. As part of our revision of the Wetzelielloideae, we propose 12 new genera and numerous new combinations.

PALYNOLOGICAL IMPLICATION FOR DEPOSITIONAL ENVIRONMENTS AND CLIMATE CHANGES IN THE YEONGSAN LOWER REACH, SOUTHWEST COAST OF THE KOREAN PENINSULA OVER THE LAST 20,000 YEARS

Sangheon Yi[1], Jin C. Kim[1] and Sei-Sun Hong[1]

1. Korea Institute of Geoscience and Mineral Resources, Daejeon 305-350, Korea.
shyi@kigam.re.kr

A palynological study of core YAL-10 obtained from the Yeongsan lower reach, southwest coast of the Korean Peninsula was carried out to reconstruct the depositional environments and the climate changes. The core YAL-10 with 16 m long consists of three distinct lithological intervals: lower interval (16–14 m depth, 22,000–20,000 yr BP) of yellowish sand, middle interval (14–2 m depth, 20,000–1300 yr BP) of dark grey mud and upper interval (2–0 m depth, 1300 yr BP–) of surface disturbed soil. OSL- and AMS-dates indicate the sedimentary sequence was spanned over the past 20,000 years. Age-controlled palynological assemblage reflects the vegetation dynamics and marine dinoflagellate ecological responding to the climate oscillation and the sea-level change, respectively, during the time of deposition. The palynological assemblage of the lower interval (16–14 m depth) consisting mainly of sand, appeared to be barren or rare, resulting in no paleoenvironmental interpretation. During the 20,000–10,000 yr BP (14–10.3 m), the palynological assemblage is characterized by the pollen grains derived from aquatic or riverine, suggesting the fluvial-flood plain environments. Also, coniferous forests dominated by cold-tolerant conifers of fir (*Abies*), spruce (*Picea*) and pine (*Pinus*) were flourished in association with a xerophytic mugwort (*Artemisia*), reflecting cold and dry conditions during the last glacial period. Pollen assemblage from 10,000 to 9000 yr BP suggests the depositional environments were under transitional conditions. Subsequently, during 8000–5000 yr BP the former transition changed into the inter-tidal environments due to sea-level rise, evidenced by the occurrences of salt marsh pollen grains and marine dinocysts. Moreover, subtropical to warm temperate evergreen broad-leaved tree pollen grains increased during this period indicate the Mid-Holocene optimum. After 4000 yr BP, about climate changes with 1500-yr cycle were identified by pollen records.

AGE DETERMINATION AND PALEOENVIRONMENTS OF THE ULLEUNG BASIN, EAST SEA, SINCE THE LATE PLIOCENE, INFERRED FROM PALYNOLOGICAL ASSEMBLAGES

Sangheon Yi[1], Dong-Geun Yoo[1] and Jang-Jun Bahk[1]

1. Korea Institute of Geoscience and Mineral Resources, Daejeon, 305-350, Korea.
shyi@kigam.re.kr

The samples of drilling cores of UBGH1-9, UBGH1-10 and UBGH2-1-1 in the Ulleung Basin, East Sea, were taken for palynological analysis to reconstruct the age determination in Pliocene/ Pleistocene sequence boundary and paleoenvironmental reconstruction since the late Pliocene. The palynological study provides a consistent local palynological stratigraphy. The palynological assemblages are composed of terrestrial-derived pollen and marine dinoflagellates. UBGH cores (1-9, 1-10 and 2-1-1) that contain the late Pliocene aged-diagnosis pollen and dinocysts can suggest the Pliocene-Pleistocene sequence boundary in the Ulleung Basin. The reference for this study, the eco-indicators pollen and dinocyst from the interval of 2.38-2.48 Ma of ODP Site 798B providing the history of the paleoclimate and paleoceanography, has compared with those of UBGH cores. Among the dinocysts, the reciprocal proportion between cold-water species (e.g., *Operculodinium centrocarpum* and *Lejeunecystą* sp.) and warm-water species (e.g., *Tuberculodinium vancampoae* and *Lingulodinium machaerophorum*) seems to be corresponding to relative intensity of surface currents such as Kuroshio Warm Current and Liman Cold Current during the time of deposition. Especially, high frequency percentage in warm-water species may indicate that the Kuroshio Warm Current had intermittently prevailed into the East Sea through the Korea Strait.

PALEOCENE POLLEN OF *CLASSOPOLLIS* (PFLUG) POCOCK AND JANSONIUS FROM CENTRAL PATAGONIA, ARGENTINA

María C. Zamaloa[1] and Liliana Villar de Seoane[2]

1. Depto. de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires – IEGEBA (CONICET-UBA). Int. Güiraldes 2620. C1428EHA. Buenos Aires. Argentina.

2. CONICET - División Paleobotánica, Museo Argentino de Ciencias Naturales "B. Rivadavia". Av. A. Gallardo 470. 1405. Buenos Aires. Argentina. lilianaseo@yahoo.com.ar

The distinctive genus *Classopollis* is traditionally regarded as conifer pollen produced by members of the extinct family Cheirolepidiaceae. *Classopollis* pollen grains are typically monoporate, oblate and have a circular equatorial outline. A pre-equatorial groove or rimula, with internal striations (endostriae), is a characteristic feature. The proximal pole has a triangular scar that may possess a trilete mark. A thinning of the exine with circular outline (pseudopore) is present in the distal pole. The pollen is frequently found as tetrads or dyads. *Classopollis* has a long geologic history. This pollen type was recorded since the Late Jurassic to the Late Cretaceous, being widespread and often dominant in the Jurassic and Cretaceous palynofloras worldwide. Remarkably, in central Patagonia *Classopollis* seems to have persisted at least until the earliest Paleocene, as previous and more recent studies have demonstrated. In order to test the abundance and morphological diversity of the latest members of *Classopollis* so far known, sediments belonging to the Salamanca Formation, in the San Jorge Basin, central Patagonia, were studied by means of light and scanning electron microscopy. The palynological samples come from Palacio de los Loros and Ormaechea sections, that were recently dated as early Danian (65.7–63.5 Ma), based on multi-disciplinary geochronologic and biostratigraphic studies. The study under LO microscopy allows gross differentiation at species level, and SEM observations produced six different pollen types. Ultrastructurally, the Patagonian Paleocene representatives of *Classopollis* lack the trilete scar and the sporopollenine filaments that often surround it. In both poles (proximal and distal) there is a thinning of the exine or a large and circular pore (pseudopore). All of the pollen grains are found as monads. The mentioned features are shared by the six recognised types and possibly represent an evolutionary tendency of the genus during the Paleocene. This study also demonstrates that: 1) *Classopollis* producers survived and were widespread until the early Paleocene in central Patagonia; 2) Danian *Classopollis* was abundant and diverse in the studied sections; and 3) *Classopollis* species richness persisted close to the time of the extinction of the genus.