THE TRILOBITE PAPERS 24

An international newsletter for and by trilobite paleontologists
February, 2021

Dedicated to Rolf Ludvigsen

The Trilobite Papers Twenty-Four
February 2021

Editorial:

JUST BECAUSE WE CAN, SHOULD WE?

As an experienced Cambrian trilobite worker, it is not uncommon for people to contact me asking what species they have and including a photograph of the specimen. These photos are commonly of un-whitened specimens, which make it difficult to make an accurate identification. Whitening the specimen with ammonium chloride sublimate or for larger specimens magnesium ribbon smoke is the preferred way of illustration. When the person sending me the photos are avocational collectors, I expect un-whitened photos, given most are unfamiliar with the process or have limited resources to do the whitening. However, there is a trend in professional publications to provide un-whitened specimens and this can be a serious problem.

Whitening provides a photograph of a specimen that shows most of its morphology needed for identification as well as the specimen flaws. For example, Figure 1 shows a silicified specimen of *Elrathina antiqua* Palmer in Palmer and Halley, 1979 with different treatments. Figure 1.1 is the un-whitened, color picture of the specimen, which shows very little detailed morphology. Figure 1.2 is the same picture changed to black and white, with a few more details apparent, but still not very reveling as to the specimen's morphology. Figure 1.3 and 1.4 illustrates the same specimen, now coated with ammonium chloride sublimate. Both the color (1.3) and black and white (1.4) now illustrate the detailed morphology of the entire shield (librigena are missing). Most trilobite workers would have little problem seeing the morphological features needed to identify the taxon. Figure 1.5 and 1.6 are again the same specimen, this time coated with colloidal graphite and then ammonium chloride sublimate. The use of colloidal graphite enhances contrast between the furrows and raised areas (e.g., glabella) and eliminates any color patterns on the specimen. This is my preferred way of illustrating trilobites because it does show the morphological details. For example, in the uncoated specimens you cannot see if

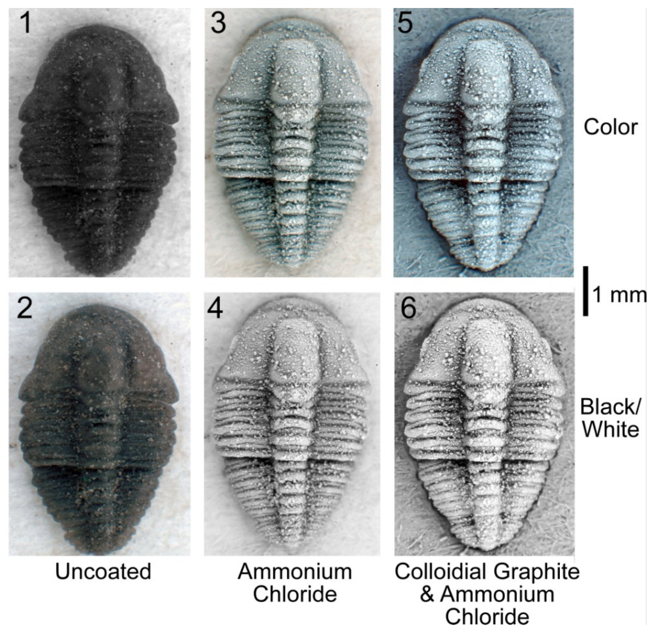


Figure 1. A single specimen of *Elrathina antiqua* Palmer in Palmer and Halley, 1979 from the middle Cambrian of Nevada illustrating the amount of morphological detail provided in 1) un-whitened color photo; 2) same photo as 1 converted to black and white; 3) specimen whitened, color photo; 4) specimen whitened, black and white photo; 5) specimen coated with colloidal graphite and then whitened, color photo; 5) specimen coated with colloidal graphite and then whitened, black and white photo. Specimen is mounted on an index card, silicified, and photographed with a ring light (no directional side light), disarticulated within the thorax, and missing the librigena.

Cover photo: *Bristolia bristolensis* (Series 2, Cambrian) Delamar Shale Member, Pioche Formation, Chief Mountain, Nevada. Photo by Perry Damiani.

there are either glabellar furrows, an ocular ridge or surface ornamentation. In the blackened and whitened specimen, you can see that there is no visible glabellar furrows or ocular ridges and the exoskeleton is smooth (no pits or granules).

When professional publications contain photographs of un-whitened specimens, critical details of the morphology are lost in color patterns (e.g., partial coating by limonite) and/or the fine details of the furrows, surface, articulating rings, course of sutures, etc. are not visible. This inhibits the reader the chance to compare the taxon to other similar taxa. As a reviewer of several trilobite papers for professional journals, I have seen authors use un-whitened specimens and find myself asking if I can really see the morphology that the authors are describing. Sometimes color photos of un-whitened specimens are needed (e.g., to show digestive track) and sometimes the specimen is well enough preserved so that just about every detail is visible. But most of the time, whitening is needed. Just because we can publish in color, we should ask: "Should we?"

Reference

Palmer, A.R., and Halley, R.B., 1979, Physical stratigraphy and trilobite biostratigraphy of the Carrara Formation (Lower and Middle Cambrian) in the southern Great Basin: United States Geological Survey Professional Paper, v. 1047, 131 p.

Fred Sundberg
Show Low, Arizona
sundbergfred@gmail.com

RESEARCH REPORTS

David L. Bruton

As an emeritus, I still have my office at the Natural History Museum, University of Oslo. Of late I have just coordinated a multi-authored publication which was published electronically in 2020. The paper edition has been delayed and will appear in the Norwegian Journal of Geology very soon in 2021.

Rønning, K.J., Bruton, D.L., Harper, D.A.T., Høyberget, M., Maletz, J. & Nakrem, H.A. A Cambrian-Ordovician boundary section in the Rafsnes-Herøya submarine tunnel, Skien-Langesund District, southern Norway. DOI htpps//dx.doi.org/10.17850/ njg. 100-3-3. 30/9/2020.

Abstract. Rock specimens and contained fossils collected in 1976 from a submarine tunnel driven between Herøya and Rafnes in the Skien–Langesund area of southern Norway, have been restudied. The contained fossils include olenid and agnostoid trilobites, graptolites and brachiopods, groups described in detail for the first time from the area and documenting a Cambrian–Ordovician boundary section unique in the district where the upper Cambrian Alum Shale Formation is elsewhere overlain by the Middle Ordovician Rognstranda Member of the Huk Formation (Kundan in terms of Baltoscandian chronostratigraphy). The hiatus at the base of the Huk Formation is thus smaller in the section described herein, beginning at a level within rather than below the Tremadocian. Estimated thickness of the Alum Shale includes 10–12 m of Miaolingian and 20–22 m of Furongian strata with trilobite zones identified, and a Tremadocian section of 8.1 m identified by species of the graptolite Rhabdinopora in the basal 2.6 m and Bryograptus ramosus at the top. The Tremadocian section is preserved in a postulated zone of synsedimentary subsidence along the Porsgrunn–Kristiansand Fault Zone, while at the same time there was extensive erosion across an emergent, level platform elsewhere in the Skien–Langesund District and the southern part of the Eiker–Sandsvær District to the north. Aspects of stratigraphy and tectonics are highlighted together with a discussion on the Cambrian–Ordovician boundary locally and worldwide.

GERD GEYER, Lehrstuhl für Geodynamik und Geomaterialforschung, Institut für Geographie und Geologie, Bayerische Julius -Maximilians-Universität Würzburg, 97074 Würzburg, Germany <gerd.geyer@uni-wuerzburg.de>

In terms of Cambrian research, my work concentrates on the reconstruction of early and middle Cambrian earth history illustrated by rocks from different regions, with trilobites playing a key role. I am trying not to be restricted too much to ordinary systematic descriptions, but also to unravel erroneous assumption in terms of morphology and to revise

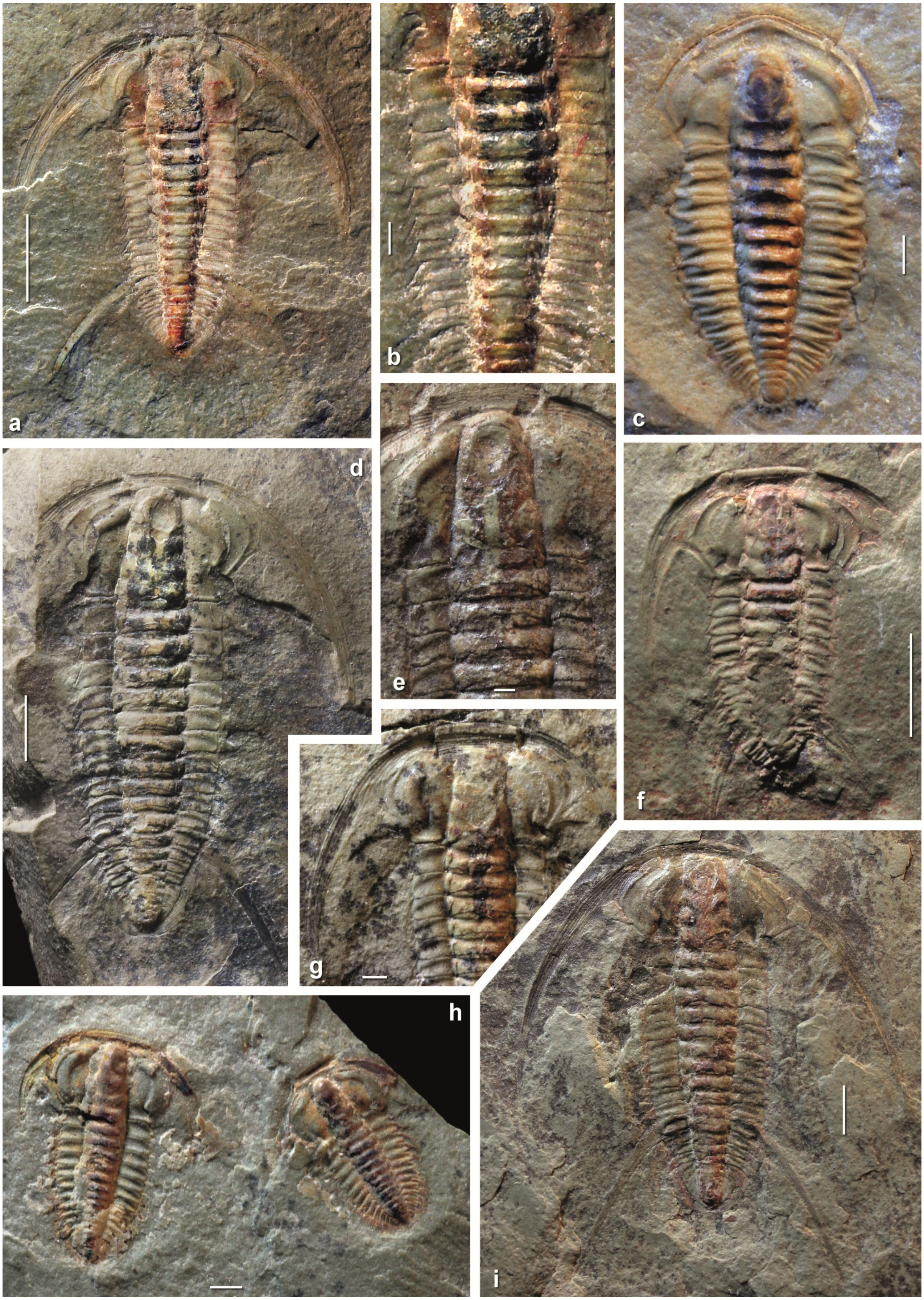


Figure 1. Examples of exceptional preservation of trilobites in the upper Amouslek Formation, *Daguinaspis* Zone, western Anti-Atlas, Morocco, specimens from the Tazemmourt section. a, b, d, e, g, i, *Perrector falloti* (Hupé, 1953). a, b, BOM 2529, internal mould of dorsal exoskeleton with series of paired digestive glands (dark stained, partly connected areas) under the axis of the cephalon and anterior thorax. d, DEV 19.1F, internal mould of dorsal exoskeleton

information on the taxonomy and biostratigraphy of trilobites.

The study of para-/neoredlichiids and despujolsiids (the *Resserops* clade) from the lower Cambrian of Morocco kept me busy for years but is now published in a more or less acceptable way. Ongoing trilobite research deals with the taxonomy of solenopleurids in general; the biostratigraphy and taxonomy of trilobites from the *Ornamentaspis frequens* through *Badulesia tenera* zones in Morocco; a monograph of the trilobites from the Wildenstein Member of the Tannenknock Formation in the Franconian Forest, Germany; newly discovered trilobite assemblages from the late Wuliuan and early Drumian from the Franconian Forest, Germany; and others.

A recent publication in Scientific Reports portrays a long known, but not yet publicly presented fossil lagerstätte from Cambrian Stage 3 strata in the western Anti-Atlas of Morocco, now termed the "Souss Lagerstätte". Trilobite with differently preserved parts of their digestive tracts are certainly the main attractions of the relevant strata. A figure with such specimens is shown below.

Cederström, P., Geyer, G., Ahlberg, P., Nilsson, C. A. & Ahlgren, J., in press. Ellipsocephalid trilobites from Cambrian Series 2 and Stage 4 in Scania, Sweden: taxonomy, morphological plasticity and biostratigraphic significance. Fossils & Strata.

De Baets, K., Budil, P., Fatka, O. & Geyer, G. 2021. Trilobites as Hosts for Parasites: From Paleopathologies to Etiologies. In: K. De Baets, J. W. Huntley (eds.), The Evolution and Fossil Record of Parasitism, Topics in Geobiology 50, pp. 163–191. https://doi.org/10.1007/978-3-030-52233-9_6.

Geyer, G. 2019. A comprehensive Cambrian correlation chart. Episodes, 42 (4): 321–334, 1 Abb., https://doi.org/10.18814/epiiugs/2019/019026.

Geyer, G. 2020. A critical evaluation of the *Resserops* clade (Trilobita: Despujolsiidae, early Cambrian) with remarks on related redlichiacean families. Freiberger Forschungshefte, C 558, *Paläontologie, Stratigraphie, Fazies* 25: 1–107.

Geyer, G., Pais, M. & Wotte, T. 2020. Unexpectedly curved spines in a Cambrian trilobite: considerations on the spinosity in *Kingaspidoides spinirecurvatus* sp. nov. from the Anti-Atlas, Morocco, and related Cambrian ellipsocephaloids. PalZ, 94: 645–660, https://doi.org/10.1007/s12542-020-00514-x.

Geyer, G. & Landing, E. 2020. Cambrian deposition in northwestern Africa: Relationship of Tamlelt massif (Moroccan–Algerian border region) succession to the Moroccan Meseta. Journal of African Earth Sciences 165, 103772, 20 pp., https://doi.org/10.1016/j.jafrearsci.2020.103772.

Geyer, G. & Landing, E. 2021. The Souss lagerstätte of the Anti-Atlas, Morocco: discovery of the first Cambrian fossil lagerstätte from Africa. Scientific Reports, https://doi.org/10.1038/s41598-021-82546-0.

Geyer, G. & Peel, J. S. 2020. *Elrathia hensonensis* nomen novum, new replacement name for *Elrathia groenlandica* Geyer and Peel, 2017 (Trilobita, Ptychopariacea). Journal of Paleontology, 94(5); 1007, doi: 10.1017/jpa.2020.11.

Landing, E., Schmitz, M. D., Geyer, G., Trayler, R. B. & Bowring S. A. 2020. Precise early Cambrian U–Pb zircon dates bracket the oldest trilobites and archaeocyaths in Moroccan West Gondwana. Geological Magazine, 20 pp., https://doi.org/10.1017/S0016756820000369.

Sundberg, F. A., Karlstrom, K. E., Geyer, G., Foster, J. R., Hagadorn, J. W., Mohr, M. T., Schmitz, M. D., Dehler, C. M. & Crossey, L. J. 2020. Asynchronous trilobite extinctions at the early to middle Cambrian transition . Geology, 48 (5): 441–445, https://doi.org/10.1130/G46913.1.

with series of paired digestive glands (blackish stained). e, CGB Tr19a, internal mould of dorsal exoskeleton with impression of hypostome and centrally located alimentary canal running sagittally from the posterior margin of the hypostome to the fourth(?) thoracic segment. g, CGB Tr26, internal mould of dorsal exoskeleton with mineralized, centrally located alimentary canal running from posterior part of the glabella to the third thoracic segment. i, DEV C19.1B, internal mould of dorsal exoskeleton with partly preserved alimentary canal (reddish brown) and some paired digestive glands (dark stained) under the axis of the cephalon and most of the thorax. c, *Daguinaspis ambroggii* Hupé, 1953, MMUW 2019E-001, internal mould of dorsal exoskeleton, first specimen of a fallotaspidid and olenelloid trilobite with club-shaped dark stains under the axial region and anterior thorax, interpreted as remains of paired midgut glands; note extended bilobate shape of the cephalic digestive glands below glabella and dark, iron stained small areas near thoracic spines on the left side. f, *Perrector brevilimbatus* (Hupé, 1953), DEV C19.1P, internal mould of dorsal exoskeleton with subcentrally located alimentary canal underneath glabella and some paired digestive glands. h, *Marsaisia* sp., DEV C19.1Da, C19.1Db, two immature dorsal exoskeletons, largely exfoliated, partly covered with secondary calcite coat; exposed internal moulds show partly limonitized surroundings of the alimentary canal and digestive glands, with paired glands partly visible in the smaller specimens on the right side. Scale bars 5 mm in a, d, f, i, 1 mm in b, c, e, g, h.

THOMAS HEGNA, State University of New York, Fredonia, NY

Last summer, I completed a move from Western Illinois University to SUNY Fredonia in far western New York State. I'm not as active on trilobites as I used to be, but I do still have several active projects on them. Project number 1 is submitting an NSF proposal for a research grade scanning electron microscope at SUNY Fredonia. After a long series of delays, I am finally working on getting my undergrad honors thesis (on some early Silurian trilobites from Missouri) published. With the help of students, I am working on imaging a diminutive silicified fauna of trilobites from the Cambrian Weeks Formation of Utah--it seems to have a very different diversity profile than the famous crackout material. I'm dabbling in a project that examines the effect of different coding strategies in phylogenetic analyses of trilobites. Lastly, I am laying the groundwork for a project on trilobite eyes. Stay tuned!

JIM JAGO University of South Australia--STEM, Mawson Lakes, South Australia 5095 jim.jago@unisa.edu.au

Jim Jago is continuing to work on the Cambrian trilobites of Tasmania, South Australia and New Zealand. Current projects include dealing with the New Zealand Cambrian trilobites collected by Roger Cooper (with Patrick Smith and John Laurie), a late Cambrian fauna from the south coast of Tasmania (with John Laurie and Kim Bischoff) as well as trilobites from the Warburton Basin, South Australia (with Sun Xiaowen and Chris Bentley). Jim is involved in the study of the Big Gully biota, a Burgess Shale type fauna from Kangaroo Island. Workers on this project include John Paterson, Diego Garcia-Bellido, Mike Lee, Jim Gehling, Greg Edgecombe, Glenn Brock and Jim Jago. In recent years considerable time has gone into preparing papers for a special issue of the Australian Journal of Earth Sciences on the Flinders Ranges as part of the application for World Heritage status of the Flinders Ranges.

Recent publications:

BENTLEY, C.J., JAGO, J.B. & CORBETT, K.D. 2020. Late Cambrian (Iverian, Jiangshanian) fossils from the Professor Range area, Western Tasmania. Alcheringa 44, 203-216. doi: 10.1080/03115518.2020.1725833

HOLMES, J.D., PATERSON, J.R., JAGO, J.B. & GARCIA-BELLIDO, D.C. (accepted for publication). Ontogeny of the trilobite Redlichia from the lower Cambrian (Series 2, Stage 4) Ramsay Limestone of South Australia. Geological Magazine. doi.10.1017/S0016756820001259

JAGO, J.B., BENTLEY, C.J., PATERSON, J.R., HOLMES, J., LIN, T.R. & SUN, X.W. (accepted for publication). The stratigraphic significance of early Cambrian (Series 2, Stage 4) trilobites from the Smith Bay Shale near Freestone Creek, Kangaroo Island. Australian Journal of Earth Sciences. doi.10.1080/08120099.2020.1749882

JAGO, J.B., GEHLING, J.G., BETTS, M.J., BROCK, G.A., DALGARNO, C.R., GARCIA-BELLIDO, D.C., HASLETT, P.G., JACQUET, S.M., KRUSE, P.D., LANGSFORD, N.R., MOUNT, T.J. & PATERSON, J.R. 2020. The Cambrian System in the Arrowie Basin, Finders Ranges, South Australia. Australian Journal of Earth Sciences 67, 923-948. doi: 10.1080/08120099.2018.1525431.

JAGO, J.B. & KRUSE, P.D. 2020. Significance of the middle Cambrian (Wuliuan) trilobite Pagetia from Yorke Peninsula, South Australia. Australian Journal of Earth Sciences 67, 1003-1008. doi: 10.1080/08120099.2019.1643405.

LANGSFORD, N., RAIMONDO, T. & JAGO, J., 2020. Red crust: evidence for an early Paleozoic oceanic anoxic event. Australian Journal of Earth Sciences 67, 995-1001. doi:10.1080/08120099.2018.1563827

MOUNT, T.J., JAGO, J.B., LANGSFORD, N.R. & DALGARNO, C.R. 2020. Geological setting of the Moorowie Formation, lower Cambrian Hawker Group, Mt Chambers Gorge, eastern Flinders Ranges, South Australia. Australian Journal of Earth Sciences 67, 949-980. doi: 10.1080/08120099.2019.1586771

REID, L., HOLMES, J., PAYNE, J., GARCIA-BELLIDO, D., & JAGO, J. 2020. Taxa, turnover and taphofacies: a preliminary analysis of facies-assemblage relationships in the Ediacara Member (Flinders Ranges, South Australia). Australian Journal of Earth Sciences 67, 905-914. doi: 10.1080/08120099.2018.1488767.

SEUNG-BAE LEE, Geological Musuem, Korea Institute of Geoscience and Mineral Resources, Daejeon, 34132 Republic of Korea <sblee@kigam.re.kr>

In Korea, the lower Paleozoic sedimentary rock unit, the Joseon Supergroup, is distributed in the Taebaeksan Basin, which is subdivided into three groups, i.e. Taebaek, Yeongwol, and Mungyeong groups.

In the Taebaeksan Basin, the base of the Floian has been suggested by the occurrences of a trilobite genus *Kayseraspis* which has been known to occur in the upper part of the Dumugol Formation of the Taebaek Group and in the lower part of the Yeongheung Formation of the Yeongwol Group for more than 20 years.

This study reports the occurrence of a trilobite *Kayseraspis* for the first time from the uppermost part of the Mungok Formation below the Yeongheung Formation, Yeongwol Group, Korea, and attempts to reassess the age of the *Kayseraspis*-bearging faunas of Korea.

The new occurrence of *Kayseraspis* and the comparison between the biostratigraphy of trilobites and graptolites within the Taebaeksan Basin suggest that the *Kayseraspis*-bearing faunas in Korea can be assigned to the upper Tremadocian rather than basal Floian.

The Tremadocian age of *Kayseraspis* seems to be conformable to the trilobite biostratigraphy of North China, although the genus has been reported from Floian strata in many parts of the world.

In order to consolidate the Lower Ordovician chronostratigraphy of the Taebaeksan Basin, additional integrative studies on trilobites, graptolites, and conodonts are further required.

MANSOUREH GHOBADIPOUR, Department of Geology, Faculty of Sciences, Golestan University, Gorgan, Iran

Zhang, Zhiliang, Ghobadi Pour, M., Popov, L.E., Holmer, L.E., Chen, F., Chen, Y., Brock, G.A. and Zhang, Zhifei. 2021. The oldest Cambrian trilobite – brachiopod association in South China. *Gondwana Research*, https://doi.org/10.1016/j.gr.2020.08.009.

John S. Peel
Department of Earth Sciences (Palaeobiology), Uppsala University
SE-75236 Uppsala, Sweden
john.peel@pal.uu.se

I continue working with Cambrian faunas (Series 2 – Miaolingian) from North Greenland, with emphasis on small shelly fossils and molluscs. Two papers on Miaolingian trilobites from North Greenland: While we have recently confirmed the presence of an Ediacaran biota of Doushantuo type [Willman, S., Peel, J.S. Ineson, J.R., Schovsbo, N.H., Rugen, E.J. & Frei, R. Ediacaran Doushantuo-like biota discovered in Laurentia. Communications Biology published online 2020-11-06, https://doi.org/10.1038/s42003-020-01381-7], we have not been able to locate Cambrian faunas earlier than Stage 3.

Peel, J.S. Trilobite fauna of the Telt Bugt Formation (Cambrian Series 2–Miaolingian Series), western North Greenland (Laurentia). Bulletin of the Geological Society of Denmark, 69: 1–33. https://doi.org/10.37570/bgsd-2021-69-01
Abstract: Trilobites dominantly of middle Cambrian (Miaolingian Series, Wuliuan Stage) age are described from the Telt Bugt Formation of Daugaard-Jensen Land, western North Greenland (Laurentia), which is a correlative of the Cape Wood Formation of Inglefield Land and Ellesmere Island, Nunavut. Four biozones are recognised in Daugaard-Jensen Land, representing the Delamaran and Topazan regional stages of the western USA. The basal *Plagiura–Poliella* Biozone, with *Mexicella* cf. *robusta*, *Kochiella, Fieldaspis*? and *Plagiura*?, straddles the Cambrian Series 2–Miaolingian Series boundary. It is overlain by the *Mexicella mexicana* Biozone, recognised for the first time in Greenland, with rare specimens of *Caborcella arrojosoensis*. The *Glossopleura walcotti* Biozone, with *Glossopleura, Clavaspidella* and *Polypleuraspis*, dominates the succession in eastern Daugaard-Jensen Land but is seemingly not represented in the type section in western outcrops, likely reflecting the drastic thinning of the formation towards the northwest. The *Ehmaniella* Biozone, with *Ehmaniella, Clappaspsis*, *Blainia* and *Blainiopsis*, is the youngest recognised biozone. The presence of Drumian Stage strata reported elsewhere in North Greenland and adjacent Ellesmere Island has not been confirmed in Daugaard-Jensen Land. Lower beds of the Cass Fjord Formation, which directly overlie the Telt Bugt Formation, are assigned to the Guzhangian Stage. New species: *Fieldaspis*? *iubilaei*, *Ehmaniella tuperqarfik*.
Peel, J.S. Eldoradia and Acrocephalops (Trilobita: Bolaspididae) from the middle Cambrian (Miaolingian) of northern Greenland (Laurentia). GFF in proof. https://doi.org/10.1080/11035897.2020.1865446

Abstract: The ptychoparioid trilobites Eldoradia Resser, 1935 and Acrocephalops Poulsen, 1927 (Family Bolaspididae) are described from the middle Cambrian (Miaolingian Series) of northern Greenland (Laurentia). Eldoradia, originally described from the Secret Canyon Shale of Nevada, is recorded from south-western Wulff Land, North Greenland, where it occurs together with Modocia and Olenoides. Eldoradia caerulioris n. sp. is established. The occurrence of Eldoradia in the lower part of the Blue Cliffs Formation indicates a minimum late middle Cambrian age (Miaolingian Series, Guzhangian Stage) for the base of the formation. Type material of Acrocephalops, a relative of Eldoradia originally proposed on the basis of material from the Miaolingian Series (Wuliuan Stage) of Inglefield Land, North-West Greenland, is redescribed.

FRED SUNDBERG, Research Associate, Museum of Northern Arizona, Flagstaff, AZ <sundbergfred@gmail.com>

It has been a busy year, again. The morphometic analysis of *Oryctocephalites palmeri* is now published and the papers redefining the Tonto Group of the Grand Canyon and the recognition of overlap between olenellids and paradoxides have been published by Geology and the paper on trilobites from the Lakeview Limestone, Idaho by the Journal of Paleontology. I have been working on the trilobites collected from the Grand Canyon; how much morphological change results in compaction of specimens in shale (morphometric study using landmarks); the non-olenellid fauna from the upper Harkless Formation (with Mark Webster); and a morphometric study of the small eyed ptychopariid trilobites (e.g., *Elrathina*).

Karlstrom, K.E., Mohr, M.T., Schmitz, M., Sundberg, F.A., Rowland, S., Hagadorn, J., Foster, J.R. Crossey, L.J., Dehler, C., Blakey, R., 2020. Redefining the Tonto Group of Grand Canyon and recalibrating the Cambrian timescale. Geology, 48:425-430

Lin, J.P., Sundberg, F.A., Jiang, G., Montañez, I.P., and Wotte, T., 2019, Chemostratigraphic correlations across the first major trilobite extinction and faunal turnovers between Laurentia and South China: Scientific Reports, v. 9:17392, 15 p., doi:10.1038/s41598-019-53685-2. [includes trilobite pictures and discussion in supplemental material]

Noriega-Ruiz, H.A., Cuen-Romero, F.J., Enríquez-Ocaña, L.F., Sundberg, F.A., Monreal, R., Varela-Romero, A., Palafox-Reyes, J.J., Grijalva-Noriega, F.J. 2020. Cambrian stratigraphy (series 2 to Miaolingian) of the El Sahuaral area in central sonora, Mexico: Biostratigraphic implications. Journal of South American Earth Sciences, 103(102797)

Sundberg, F.A. 2020. Trilobite fauna (Wuliuan Stage, Miaolingian Series, Cambrian) of the lower Lakeview Limestone, Pend Oreille Lake, Idaho. Journal of Paleontology Memoir, 94(79):1-49

Sundberg, F. A., Karlstrom, K. E., Geyer, G., Foster, J. R., Hagadorn, J. W., Mohr, M. T., Schmitz, M. D., Dehler, C. M. & Crossey, L. J. 2020. Asynchronous trilobite extinctions at the early to middle Cambrian transition . Geology, 48 (5): 441–445, https://doi.org/10.1130/G46913.1.

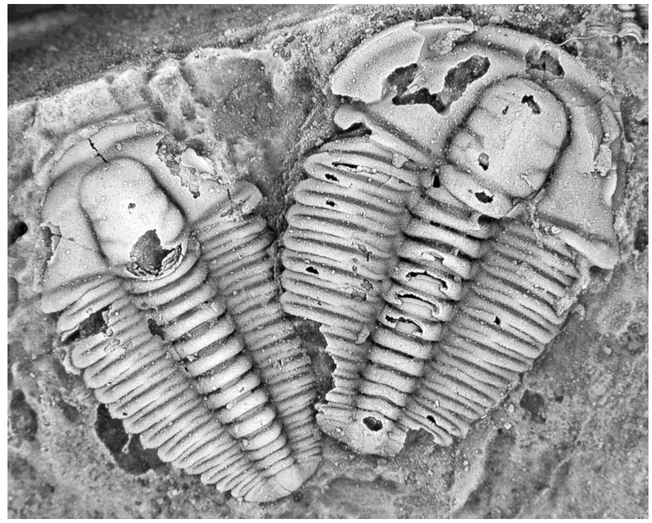


Figure 1. New genus, new species of ptychoparioid trilobite (mid Dyeran) from the Harkless Formation, Clayton Ridge, Nevada.

Sundberg, F. A., & Cuen-Romero, F. J. (2021). Trilobites from the *Crepicephalus* Zone (upper Guzhangian Stage, Miaolingian Series, Cambrian) from northern Sonora, Mexico, and its correlation to Arizona and Texas, USA. Journal of South American Earth Sciences, 103185. https://doi.org/10.1016/j.jsames.2021.103185

Webster, M., and Sundberg, F.A., 2020, Nature and significance of intraspecific variation in the early Cambrian oryctocephalid trilobite *Oryctocephalites palmeri* Sundberg and McCollum, 1997. Journal of Paleontology, 94(1):70-98.

M. FRANCO TORTELLO, División Paleozoología Invertebrados, Museo de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina. tortello@fcnym.unlp.edu.ar

I continue working on latest Furongian-Tremadocian trilobites from the Argentinean Cordillera Oriental, as well as on Cambrian trilobites from the Precordillera, with a focus on systematics and biostratigraphy.

Tortello, M.F. and Esteban, S.B. 2020. Trilobites and sedimentary settings from the Lower Ordovician (Tremadocian; *Bienvillia tetragonalis* Zone) of Iturbe, Jujuy Province, Argentina. Ameghiniana, 57: 9-32.

Tortello, M.F. 2020. Elviniid trilobites from the *Elvinia* Zone (late Cambrian, Furongian) of Mendoza, western Argentina. Journal of Paleontology 94: 852-866.

ALLART P. VAN VIERSEN, Natuurhistorisch Museum Maastricht, the Netherlands. https://www.trilolab.net/ apvanviersen@gmail.com

Little fieldwork has been conducted mainly because of the virus. Several long and short term projects are being pursued instead. One of these is concerned with Devonian members of Phacopidae, in close collaboration with Jens Koppka. It has been suggested that *Morocops* is an evolutionary grade and quite possibly incomplete if the oldest *Geesops* species are not included. Likewise, changes between *Geesops* and the stratigraphically contiguous *Nyterops* are equally progressive (Fig. 1). To some extent this partitioning of *Morocops*, *Geesops* and *Nyterops* might be construed as the artificial product of a gradist approach of taxonomy. Reflected in contemporary classification schemes such purportedly paraphyletic taxa are likely scattered among phacopid ranks but systematics of the group is not necessarily disorderly, as it has been suggested. Cladistic analysis has proved helpful in reconstructing phacopid phylogenies. Unfortunately, many taxa are inadequately documented and these include the type species of large genera. High quality photographs, especially of pygidia (if these are known at all), are often lacking. Also, published specimens have sometimes been misidentified or arbitrarily lumped. The type species of the nominal *Phacops*, *P. latifrons*, is one of the most underrated members of the family even if only considering the staggering amount of incorrect identifications in the published literature (see Basse 2006 for a comprehensive account). All of this could potentially result in unnecessary (preventable) deficiencies of the dataset. As old data on phacopids are being revised and new data

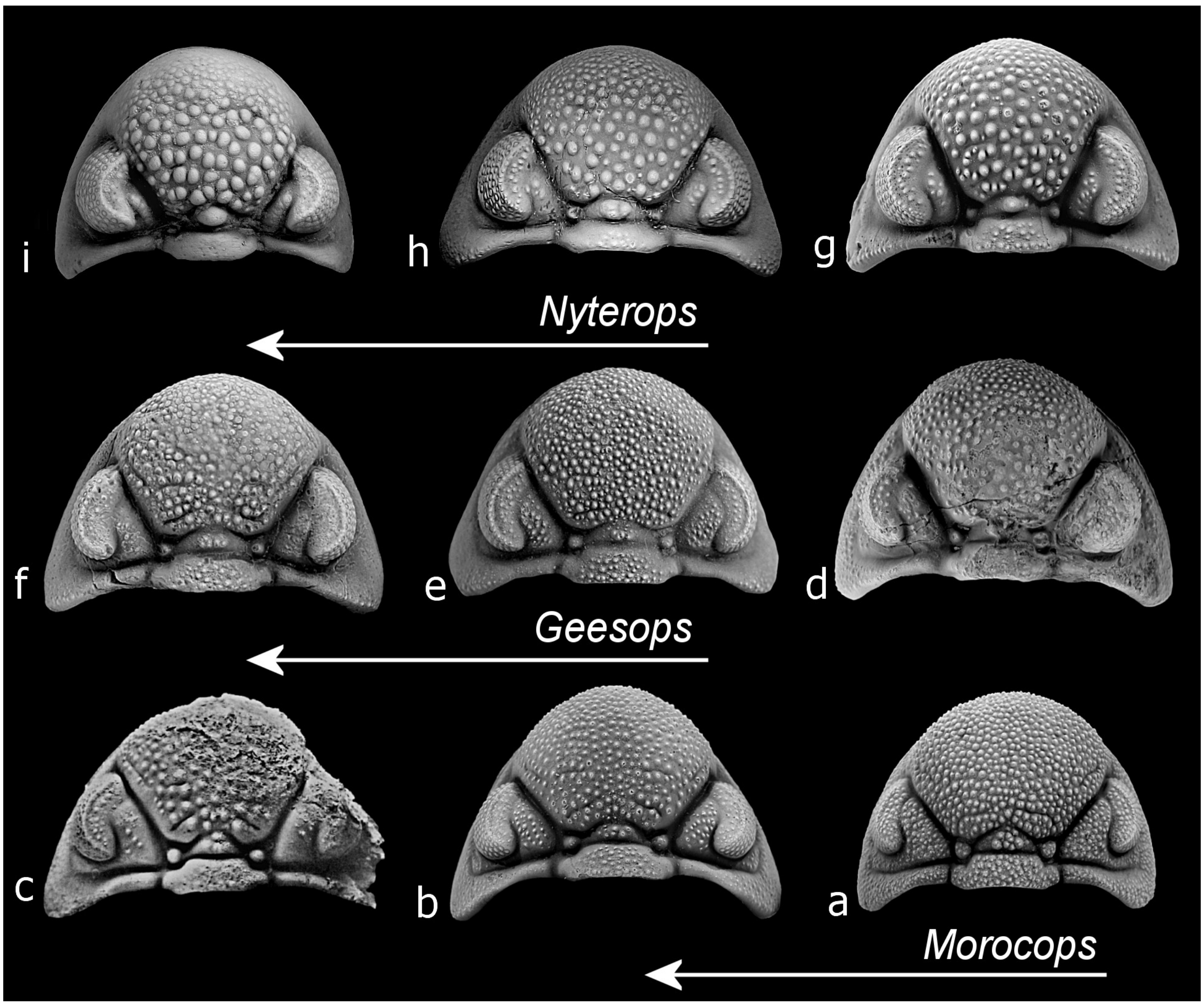


Figure 1. Devonian phacopine trilobites of a possible *Morocops-Geesops-Nyterops* lineage through time. **a)** *Morocops torkozensis* (Schraut, 2000), upper Emsian, Morocco; **b)** *Morocops ovatus* (McKellar & Chatterton, 2009), upper Emsian, Morocco; **c)** holotype of *Morocops struvei* (Schraut, 2000), lower Eifelian, Morocco; **d)** *Morocops lebesus* (Chatterton et al., 2006), lower Eifelian, Morocco; **e)** *Geesops* cf. *icovellaunae* van Viersen et al., 2019, lower Eifelian, Belgium; **f)** holotype of *Geesops icovellaunae*, lower Eifelian, Belgium; **g)** *Geesops schlotheimi* (Bronn, 1825), middle Eifelian, Germany; **h)** holotype of *Nyterops hollandi* van Viersen, 2007, upper Eifelian, Belgium; **i)** *Nyterops nyter* (Struve, 1970), Lower Givetian, Germany.

are becoming available, so we may continue to unravel their phylogeny.

Alberti & van Viersen (2020) have revisited the spiny Early Devonian homalonotid *Arduennella* from the Ardenno-Rhenish Mountains subsequent to a reappraisal of the type species by van Viersen & Taghon (2020). Van Viersen & Lelubre (2020) described an earliest Middle Devonian trilobite fauna from Belgium with affinities to the famous "Mur des douaniers" locality near Vireux-Molhain, northern France. Van Viersen & Lerouge (in press) elaborated on the possible life mode of a new *Timsaloproetus* species from the Devonian of southern Morocco as a semi-endobenthic carnivore. A study of Siluro-Devonian proetines hypothesises on relationships of *Gerastos* and allied genera (van Viersen, accepted). Still, a lot of work lies ahead and this concerns especially the "coniproetids", which Frederik Lerouge and I have begun with. Lastly, two systematic papers dealing respectively with members of Acastidae and Odontopleuridae are starting to take shape.

Alberti, M. & Viersen, A.P. van, 2020. Eine neue Art von Arduennella Wenndorf, 1990 (Trilobita, Homalonotinae). Mainzer geowissenschaftlichen Mitteilungen, 48: 33-46.

Viersen, A.P. van & Lelubre, D., 2020. Découverte d'une faune de trilobites de type "Vieux Moulin" dans le Dévonien Moyen d'Hargimont, Sud-Est de la Belgique. Fossiles, 44: 42-47.

Van Viersen, A.P. & Taghon, P., 2020. A poorly diversified trilobite association from the lower Emsian (Lower Devonian) in the Sankt Vith area (East Belgium). Geologica Belgica, 23: 19-28.

Mark Webster
Department of the Geophysical Sciences, University of Chicago, 5734 South Ellis Avenue, Chicago, IL 60637 <mwebster@geosci.uchicago,edu>
Web Pages:
http://geosci.uchicago.edu/~mwebster/
http://geosci.uchicago.edu/~mwebster/sites/ics/Institute_for_Cambrian_Studies_index.html

My research straddles the fields of evolutionary developmental biology, systematics/phylogenetics, and biostratigraphy, and has three major goals: (1) to determine whether and how development constrains morphological diversification, and on what timescale such developmental constraints operate; (2) to improve understanding of the initial radiation of trilobites during the Cambrian, and thus to provide insight into the nature of major evolutionary radiations; and (3) to refine the resolution at which biotic and environmental change can be studied within the Cambrian System, a time of exceptional evolutionary significance.

My primary study system is the Trilobita, a group offering outstanding opportunities for studying the details of morphological evolution in a tightly constrained phylogenetic, environmental, and temporal framework at microevolutionary and macroevolutionary scales. The work involves employing cutting-edge methods in morphometrics in order to conduct detailed comparative analyses of the morphological variation, ontogenetic development, and developmental biology of trilobite species. This results in unprecedented insight into evolutionary mechanisms and constraints in fossil organisms. High-resolution (sub-meter scale) stratigraphic collecting permits patterns of morphological evolution to be framed within paleoenvironmental and sequence stratigraphic context, thus producing an integrative approach to stratigraphic paleobiology. The research has far-reaching implications for the broader fields of evolutionary developmental biology, paleobiology, and the integration of stratigraphy and morphometrics with phylogenetic analysis, and also forms important contributions to Cambrian paleontology and biostratigraphy.

Recent Publications:

Hughes, N. C., J. M. Adrain, J. D. Holmes, P. S. Hong, M. J. Hopkins, J.-b. Hou, A. Minelli, J. Peng, .T.-Y. Park, J. R. Paterson, J. Peng, M. Webster, X.-G. Zhang, X.-L. Zhang, and G. Fusco. 2020. Articulated trilobite ontogeny: suggestions for a methodological standard. *Journal of Paleontology*. Published online, DOI: https://doi.org/10/1017/jpa.2020.96

Moore, J. L., S. M. Porter, M. Webster, and A. C. Maloof. 2019. Chancelloriid sclerites from the Dyeran-Delamaran ('Lower-Middle' Cambrian) boundary interval of the Pioche-Caliente region, Nevada, USA. *Papers In Palaeontology*. Published online; doi:10.1002/spp2/1274

Webster, M. 2019. Morphological homeostasis in the fossil record. *Seminars in Cell and Developmental Biology* **88**: 91-104.

Webster, M., and F. A. Sundberg. 2020. Nature and significance of intraspecific variation in the early Cambrian oryctocephalid trilobite *Oryctocephalites palmeri* Sundberg and McCollum, 1997. *Journal of Paleontology* **94** (1): 70-98.

MUSEUM INTERNSHIPS, TRAVEL GRANTS

Funding is available to support paid collections internships and travel grants at the Denver Mu-

seum of Nature & Science (DMNS). Pending COVID-19 related restrictions, in 2021 the DMNS anticipates hiring one or two interns for up to 24 weeks to work in the paleontology collections, where they will sort, inventory, and database locality information for the Stew Hollingsworth Collection (see picture below), which is predominantly trilobites. Interns will receive a modest stipend ($514/wk), a bus/rail pass, and will have the opportunity to engage in a diverse array of collections and outreach activities while growing their museum experience in an large outwardly focused institution. Ideal candidates will be graduate students or recent graduates who have interest or experience with trilobites and their contemporary fossils, and/or are looking to expand their experience with museum collections and database work. In 2022 and 2023, the DMNS intends to hire additional interns, and will have travel and lodging funding to bring visiting researchers (at any career stage) to use the collection for their scholarship.

Please contact James Hagadorn to learn more at jwhagadorn@dmns.org.

FIELD NOTES

Three Ontario Devonian Sites

KANE X. FAUCHER, Ph.D., Assistant Professor, MIT (Faculty of Information and Media Studies) Local Government Program, Dept of Political Science Western University, Management and Organizational Studies (Huron University College)

After a very short and mild winter, and a refreshingly early spring amid the COVID-19 outbreak that sent so many of us home on lockdown, I was able to capitalize on a series of new prospecting sites in Ontario, including one location that has yielded an abundance of *Terataspis sp.* material. However, one site of note amidst a whirlwind of locations has produced several interesting trilobite fauna, one of which may be an undescribed species of *Odontocephalus* (Fig. 1). This report will outline three specific Devonian spots of interest.

Site 1: Woodstock, Ontario

The site in question contains a very rare glimpse into a unique and somewhat fissile horizon in the otherwise iron-hard Dundee Formation. Aided in part by being submerged under water for most of the year, this highly fossiliferous material would be roughly equivalent to the Moorehouse Member in New York state. The biota is comprised of excessively numerous examples of very large rostroconchs, giant brachiopods, and gastropod steinkerns, suggestive of a shallow, tidal environment that is fairly well sorted. Among the trilobite taxa that appear include the above-named *Odontocephalus,* the large dalmanitid *Coronura aspectans* (Fig. 2), numerous *Pseudodechenella*, a single specimen of *Crassiproetus crassimarginatus*, *Trypaulites* sp., as well as a single specimen of *Mystrocephala ?stummi* (Fig. 3) which has previously been restricted to the Formosa Reef, Amherstburg Formation.

Figure 1. *Odontocephalus* sp., pygidia—Possibly a new species

Figure 3. *Mystrocephala*? *stummi*

What I initially assumed would be *Anchiopsis anchiops* lacked the continuous caudal spine, and instead appears notched, similar to *Coronura aspectans*. Other associated pieces of cephalon show the distinctive dentition-style preglabellar ornamentation that is the trademark of *Odontocephalus*. Sadly, the conditions are not favourable to finding complete body fossils, and so moults and disarticulated fragments are more the norm as it is very much dominated by an exceptionally diverse brachiopod fauna.

Figure 2. *Coronura aspectans*.

Figure 4. *Terataspis* sp. (?*grandis*) cranidia (10 cm).

Figure 5. *Terataspis* sp. hypotome.

Figure 6. *Terataspis* sp. genal spine. Prepared by Malcolm Thornley. ~ 10 cm.

Figure 7. *Calymene platys* .

At present, the site is now once again submerged and thus access will not resume until autumn or next spring. More specimens will be collected once conditions improve.

Site 2: Hagersville, Ontario

In material from the Bois Blanc Formation, I came upon a very hummocky horizon with numerous coral, but an intriguing paucity of brachiopods and other usual Devonian fauna. In this material appear (in the more micritic zones) the large *Calymene platys* (Fig. 7), scarce examples of *Burtonops cristata* and *Anchiopsis anchiops*. But the real excitement is in having found a staggering abundance of *Terataspis* sp. (Figs. 4-6) fragments which, in some of the rocks, are stacked like autumn leaves. Nearly every rock has a piece of this sensational lichid, and nearly all of them are in the 30-45 cm range if we extrapolate their full size. Fully robust cranidia, pustolose librigenae, pygidial fragments, and occasionally the thinner thoracic segments are quite common in what was likely a shallow, tidal region or lagoon. Whether this speaks to tidal drift or a moulting ground remains an open question.

The material is also exceptionally difficult to prepare given the hard chert and a stubborn resistance to the separation between fossil and matrix. Currently, myself and another preparator have an abundance of material to work with (about 30 distinct examples), but which will take considerable time and patience before they are

Figure 8. *Pseudodechenella* sp.

Figure 9. *Crassiproetus crassimarginatus*.

Figure 10. *Acanthopyge contusa* .

Figure 11. *Acanthopyge contusa* .

fully camera ready. I supply just a few of the pieces in progress. Sadly, the site where these are found is slated for housing development, and access is no longer possible, so any further investigation will not occur.

Site 3: Ingersoll, Ontario

Material from this area cuts deep into the Dundee Formation and other underlying formations of the Lucas and Amherstburg. The Lucas Formation is mostly dominated by worm burrows, scatterings of small *Amphigenia* brachiopods, colonies of pipe coral, and large stromatoporoids. Trilobites are exceedingly scarce, although I did find an almost complete *Pseudodechenella* sp. missing its cheeks. It is in the brown Amherstburg Formation material where more trilobites can be found. These appear in a sequence from the more bituminous, toppled corals at the top, to a thin bedding horizon with numerous rostroconchs, brachiopods, ramose and fenestrate bryozoans in sometimes quite spectacular completion and preservation. The fossils are heavily silicified, giving them a kind of milky, chalky appearance, and the presence of grey chert nodules is suggestive of the presence of siliceous sponges. There is not much literature on the Amherstburg Formation material outside of the Formosa Reef (cf. the excellent works of Fagerstrom and Ludvigsen), as much of the material outside these bioherms tends to be more or less blank dolomite. However, at this location there are some fossiliferous horizons suspended

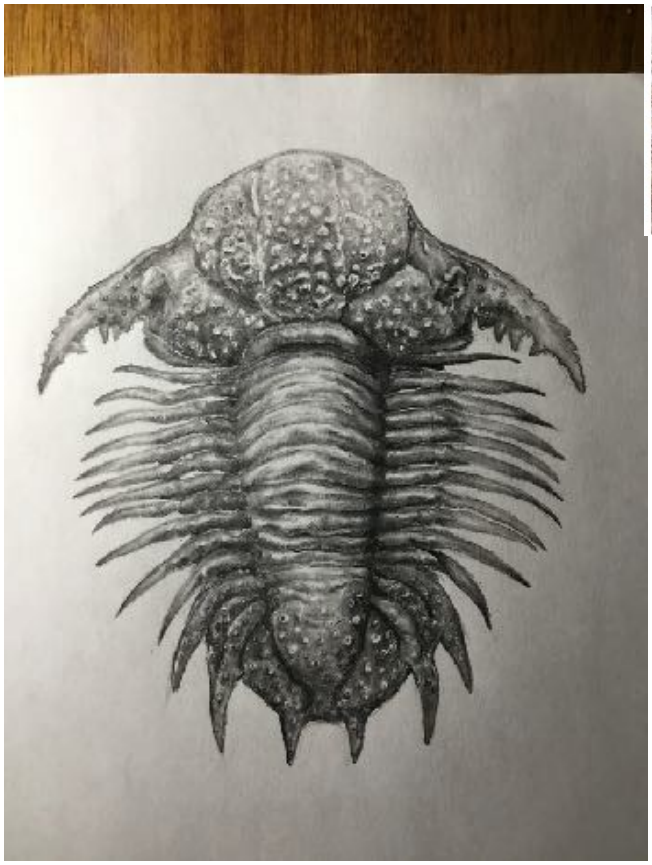


Figure 12. Based on the numerous fragments I collected, my attempt at a reconstruction of *Acanthopyge contusa* .

Figure 13. *Mystrocephala stummi*.

Figure 14. *Echinolichas eriopis* (note the stout pygidial spines).

Figure 15. Lichid hypostome (possibly *Echinolichas* sp.

Figure 16. *Echinolichas* sp. (possibly *E. hispidus*)

in otherwise sandy, blank material that is notoriously dense and difficult to split.

Among the trilobites found in this material would be, by order of most abundant to least, *Pseudodechenella* sp. (Fig. 8), very large and inflated pygidia of *Crassiproetus crassimarginatus* (Fig. 9), relatively numerous *Acanthopyge contuse* (Figs. 10-12), the occasional *Trypaulites* sp., a few scarce and diminutive pygidia of *Mystrocephala stummi* (Fig. 13), and a handful of the lichid *Echinolichas eriopis* (Fig. 14, 15?), which was last reported in Ontario by Stauffer in 1915. Over a hundred visits to this location has resulted in exhausting the material's potential.

Overall, no complete body fossils have been found at any of these locations, but the nature of

Ontario's Devonian outside of the Widder Formation (home of complete *Greenops widderensis*) simply does not favour their preservation. Collecting in southern Ontario in general has become ever more of a challenge due to development, conservation area assignment that prohibits collecting activities, sites that have been virtually exhausted, and quarries that no longer permit access to collectors and researchers due to liability issues. This means prospecting new sites, however small, and performing due diligence in collecting as many examples of what could be new species.

The presence of some of these species in a few of the formations discussed above may present some challenges in terms of questioning chronological range as is known in the literature. It has been my task this year to visit established and new locations in the preparation of a Devonian trilobites field guide that I hope to complete in the next year.

TRILOBITE MEMORIES

Fieldwork with John ("Jake") Shergold in the outback

Richard Fortey

John Laurie (Trilobite Papers 2007) has provided a detailed account of the many paleontological achievements of my late friend John Shergold, who died in 2006. Readers of this online version of our trilobite newsletter might be interested to read about our joint fieldwork in the center of the outback of Australia thirty years earlier, which eventually led to the publication of the Ordovician trilobites of the Nora Formation (Fortey and Shergold 1984).

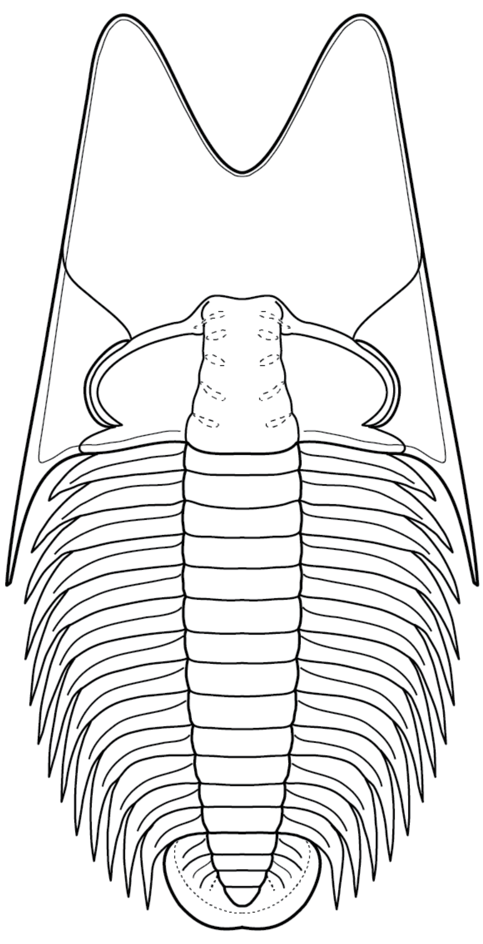
The country on the edge of the Simpson Desert in north Queensland and the southern part of the Northern Territories is extraordinarily remote. I had completed my PhD thesis on the Ordovician trilobites collected from the shores of northern Spitsbergen, and considered myself quite the adventurer, but nothing prepared me for the extent and loneliness of the Australian outback in 1976. After the two of us left the tiny town of Boulia driving westwards there was – as Shergold proclaimed dramatically – "absolutely nothin'". Dirt roads were rutted and often thick with "bull dust", a fine red powder that coated you completely by the end of the day. The only part that was not red was the area under your sunglasses that were left comically white, as if you were a clown made up for a Christmas performance. Shergold sported a black beard at the time, so he soon resembled a comic book villain. We were part of a major expedition sponsored by the Bureau of Mineral Resources in Canberra (BMR), bound to explore the Cambro-Ordovician rocks of a huge area that had previously only been collected in a preliminary way. In the coming decades Shergold would make the Cambrian strata his own, partly inspired by the great Estonian paleontologist A .A. Opik, who had been given employment in the Bureau after fleeing during WW2. For the Ordovician, the sample collections indicated that the Nora Formation would be an attractive prospect. Reaching the field area was fraught with difficulties. Even the clear tracks ran out once the Georgina Basin was reached, it was more a case of leaning out of the window looking for ancient tire marks across stretches of gibber plain (stony desert). The last cattle station at Glenormiston soon seemed far away. A field camp for the whole party was made by Lake Wanditta, one of the depressions that temporarily fill after rains came to the semi-desert. There we dined on yellow bellies, a kind of carp that grew to full size in the lake, and could be caught simply by wading in and grabbing them by the tail. The party dispersed to their various tasks: Ed Druce to collect limestone for conodonts, John Draper for trace fossils, Shergold and Fortey to the Ordovician. We were to keep in touch with base camp by means of shortwave radios that worked off the car battery. We were many hours away from each other.

This was long before the days of GPS, and we had to use maps to find our way. The trouble was that the landscape was virtually featureless, and the marked tracks had mostly been obliterated. So we effectively had to drive into the middle of nowhere for days on end. Fortunately, the occasional boreholes had wind pumps that could be located on the map. Many had discouraging names like "dribbling bore." More were marked as "arsenical", so no drinking allowed. We carried a beef carcass wrapped in damp sacks on top of the vehicle, and every night a slice was lopped off for supper and the meat got softer as it got riper over the coming days. Shergold loved it all, and in the cool evenings as the steak sizzled on the iron plate on the fire I got to hear of his taste in music, which was at the austere end of the modern Viennese school, like Anton Webern, and how his English PhD supervisor, Jack Shirley (who published on calymenids) was such a difficult character. I learned that the BMR was not exactly a happy family, either, fraught as it was with internal rivalries. He collected classic cars, and knew all about their workings. He bore me no ill will, even though I had landed the "BM" job that he had also applied for. In the following years I got to know John (he was never Jake to me) and his wife Judy as we met almost every year. Judy gave quiet, but indefatigable support to John in all his endeavors, and accompanied him on most of his geological trips around the world, often bringing their daughter Julia along for the ride. Though the Georgina Basin was too much, even for Judy.

The old Landrover was equipped with water tanks, and we carried a good deal of extra petrol: it was a tough working vehicle. It had one failing. Where bush fires had passed through in the semi-desert, spikes of wood as tough as metal were left behind, and they could easily penetrate the tires. These were old-fashioned numbers with an inner tube that could be mended if it were gashed, but the tire had to be removed from the vehicle and the outer tread removed by "breaking the bead" to get at the inner tube. This was a difficult job, usually achieved by removing the punctured tire, replacing it with the spare, and then driving over the one that needed mending until the tire came away from the tube. On one occasion we drove into a small creek hidden in the bush, and the unthinkable happened – *two* tires spiked at the same time. The usual system was stymied. We had to call base camp for help. The radio was plugged into the battery. Our attempts to reach our fellow scientists were rewarded only with strange croaks and whistles. We were out of radio contact. There must have been dust storm between us and our mates. I have never felt so alone. A spooky wind called a "willy willy" spiraled up from nowhere as if to point up our isolation. Plenty of people had died taking the outback for granted, their bodies discovered years later. John Shergold became strangely silent. It was not a good night.

We did eventually succeed in breaking the bead with the help of concerted effort with tire levers; it took us most of the following morning. Then we used some of our precious water to locate the split in the deflated inner tube. Once the tube had dried, a special patch was placed over the split, ignited, and it sealed safely. After a while the tube could be reinflated inside the tire, and we would be good to go. We did finally reach the remote outcrops of the Ninmaroo and Nora formations, a place so remote that the dingoes had apparently never seen humans before and gathered around us as night fell. The heat was relentless, but we had to collect the rock sections we had come so far to see that cropped out over the hillsides. There was the thrill of collecting Floian species that nobody had seen before. The curious, blind *Prosopiscus* was a little known form, and the shallow-water, calcareous rocks had asaphids carrying tubercles - something that Valdar Jaanusson had once told me was never to be found in the family. The Trilobita can always spring a surprise. The collection boxes were filled.

The journey back was scarcely less eventful. I managed to fall on to a fencing spike at one of the most remote cattle stations en route. My leg turned blue. I think by now I had acquired a reputation as a Jonah. Since I was obviously not dying I was placed at a stiff angle in the back of the Landrover as we drove eastwards back into the tamer part of Queensland, and finally to Brisbane. When I finally got to see the 'doc' he told me that I had severed a femoral vein and if the skin had broken I would "have gone off like a geyser." It seems that punctures of all kinds were the obstacles on that expedition. John Shergold and I remained good friends. He could on occasion be described as 'crusty', and his opinions were indeed strongly held and directly expressed. He coped with a major cancer operation in 1981 with characteristic aplomb. Having lived with the endless spaces of the outback for so many years it was both sad and ironical that when he retired to France (accompanied by Judy and his vast Cambrian library) he developed a kind of agoraphobia, of all things. Undaunted, he continued to publish on trilobites almost to the end.



Phantaspis auritus **Sun et al 2020**
Order Ptychopariida
Family uncertain
Cambrian (Miaolingian, Wuliuan)
Mantou Formation, Honghe Member
Shandong Province, North China

Line drawing by Dr. Sam Gon III (webmaster [http://www.trilobites.info)](http://www.trilobites.info)

TRILOBITE HALL OF FAME

ÁNGEL V. BORRELLO AND THE LA PLATA MUSEUM TRILOBITE COLLECTIONS

M. FRANCO TORTELLO, CARLOS A. CINGOLANI and NORBERTO J. URIZ
Museo de La Plata, Argentina

The La Plata Museum holds a natural heritage of vital interest for trilobite palaeontologists. Throughout the 1960s, Professor Ángel V. Borrello (1918-1971; Fig. 1) collected numerous Cambrian and Ordovician invertebrate remains from different geologic provinces of Argentina. These collections include thousands of trilobite specimens of great value for the biostratigraphy and paleobiogeography of the Precordillera, the Cordillera Oriental and the Famatina Range. Although Borrello reached to make substantial contributions to the knowledge of these faunas, his studies were interrupted by his sudden unexpected death in 1971, at the age of 53.

Ángel Borrello was a multifaceted geologist that promoted key disciplines for Argentinian academic and economic development. He got his PhD degree in stratigraphy and tectonics at the University of La Plata in 1942. For several years, he worked actively in YPF and YCF (Argentinian energy companies engaged in the exploration and production of oil, gas and coal) and became an eminent international specialist in solid fuels. In addition, Borrello was a professor in geotectonics and, towards the end of the 1950s and the beginning of the 1960s, he started the first laboratory of Rb-Sr geochronology in

Fig. 1: Ángel V. Borrello in the academic life. In the lower photography, he is accompanied, among other colleagues, by Dr. Armando Leanza (third from left).

his country, in line with two similar previously-created centres in USA and Brazil, allowing dating of magmatism within the tectonic interpretations of different South American regions.

Borrello was an important promotor of geotectonic and biostratigraphic studies. As a professor of Historical Geology in the University of La Plata and head of the División Geología of La Plata Museum, he carried out intense field work in Buenos Aires Ranges and along the pre and Andean mountain chain (Figs. 2-4), occasionally accompanied by respected Professor Dr. Jean Aubouin (Sorbonne, Paris). These studies were complemented with fossil collecting, principally ichnofossils (*Cruziana*, *Rusophycus*, etc.; Fig. 5) from the Balcarce Formation in the Lower Paleozoic of Tandilia (Río de la Plata craton, Buenos Aires Province) and a large number of trilobite remains from the Cambrian-Ordovician of northwestern and western Argentina (Fig. 6).

Fig. 2: Borrello doing field work (left). One of the first accurate geologic maps of the Argentinian Precordillera by R. Stappenbeck in 1910 (right); many fossils were collected from Sierra de Villicúm, Sierra Chica de Zonda, Canota, El Totoral, Cerro Pelado, and west of Mendoza city.

In the Precordillera of San Juan (Fig. 2), he formally described an emblematic lithostratigraphic unit of the Cambrian (La Laja Formation), collected trilobites from Sierra Chica de Zonda and Sierra de Villicúm, and published the first records of lower Cambrian olenellids from the region (Borrello, 1962, 1963, 1971). He also visited the most important Cambrian fossil localities of the Precordillera of Mendoza (Cerro El Solitario -Canota; El Totoral; Cerro Pelado; San Isidro areas about 15 km west of Mendoza city), on which there were previous data provided by Rusconi (e.g., 1945a, 1945b, 1956, among many others), Leanza (1947), Poulsen, V. (1958) and Poulsen, Ch. (1960). Most of the times, colleagues from the División Geología (MLP) like Alfredo Cuerda, Osvaldo Schauer, Eduardo Méndez, Raúl Scanavino and Carlos Cingolani, were part of the explorations.

Borrello initiated the study of the trilobites from Mendoza with enthusiasm. Part of this material, consisting of about 4000 well preserved samples, was examined in collaboration with Pierre Hupé (Sorbonne, Paris), who made a study visit to the Museo de La Plata in 1967 and prepared rubber casts of the most representative specimens. It was also fruitful an epistolary contact with Christina Lochman-Balk (New Mexico, USA). Unfortunately, these collaborative studies were dashed by the death of Borrello. At present, the casts made by Hupé are probably housed, together with the rest of Hupé collections, at the Université de Rennes and/or the Muséum d`Histoire Naturelle du Havre, France.

Recent and current revisions have largely confirmed the high systematic, biostratigraphic and paleobiogeographic value of the trilobites collected by Borrello from the Cambrian of Mendoza. For example, materials from Cerro El Solitario and El Totoral include representative agnostoids of the early Guzhangian *Lejopyge laevigata* Zone (e.g., *Agnostus microcephalus*, *Ammagnostus beltensis*, *Kormagnostus seclusus*, *Tomagnostella nepos, Clavagnostus calensis, Lejopyge*, among others) in association with polymeroids that are likewise typical of the same zone (*Cedaria*, *Bolaspidella*, *Talbotinella*, *Elrathia*, *Hysteropleura* (*Verditerrina*), among many others). The trilobites from Cerro Pelado constitute a very interesting assemblage of the lower *Saukia* Zone (late Furongian), comprising species of *Lotagnostus*, *Pseudorhaptagnostus*, *Hungaia*, *Mendoparabolina* and *Loganellus*. Additionally, the trilobites from the San Isidro area are very diverse and come from different Cambrian levels. There, the Wuliuan (lower middle Cambrian) is well represented by *Glossopleura*-*Athabaskia*-*Kootenia* associations; the Guzhangian (upper middle Cambrian; *Lejopyge laevigata* Zone) is clearly typified by the occurrence of *Agnostus microcephalus*, *Ammagnostus beltensis*, *Diplagnostus planicauda*, *Clavagnostus calensis*, *C. repandus*, *Tomagnostella nepos*, *Lejopyge laevigata* and *L. armata*; and the upper Furongian is characterized by species of *Micragnostus*, *Hungaia, Rasettia, Tatonaspis* and *Phoreotropis*?. In general, the trilobites identified strongly support Laurentian affinities. In this regard, it should be noted that recent revisions of the Borrello collections allowed us to recognize the first records of several "North American" genera (e.g., *Cedaria*, *Modocia*, *Hysteropleura*, *Tatonaspis*, *Phoreotropis*) in Mendoza (Tortello and Cingolani, 2016, and references therein).

Fig. 3: Fossil localities from the Cordillera Oriental and Famatina visited by A. V. Borrello.


Fig. 4: Partial view of the Borrello collections at the División Geología of Museo de La Plata.

As noted above, Borrello also made expeditions to several Ordovician localities of northwestern Argentina (e.g., Purmamarca; road Salta-Jujuy; Cerro San Bernardo). Preliminary studies have shown that among the trilobites collected from the Cordillera Oriental of Salta and Jujuy there are representative species of the *Jujuyaspis keideli* (lower Tremadocian), *Kainella meridionalis* (middle Tremadocian), *Notopeltis orthometopa* (lower upper Tremadocian) and *Thysanopyge* (upper Tremadocian) zones. Furthermore, the collections include some equally important specimens from the Tremadocian and Floian of the Famatina Range in La Rioja and Catamarca Provinces.

Fig. 5: Ichnofossils from Tandilia, Buenos Aires Province.

Apart from his persistent interest in enlarging the fossil collections, Ángel Borrello made constant efforts to achieve comprehensive bibliographic information on diverse geologic issues, leaving a valuable legacy of scientific documents of the time. The Museo de La Plata and the División Geología (MLP) libraries hold rich sets of his books, magazines, papers, catalogues and unpublished works, which are regularly consulted by experts on a great variety of topics.

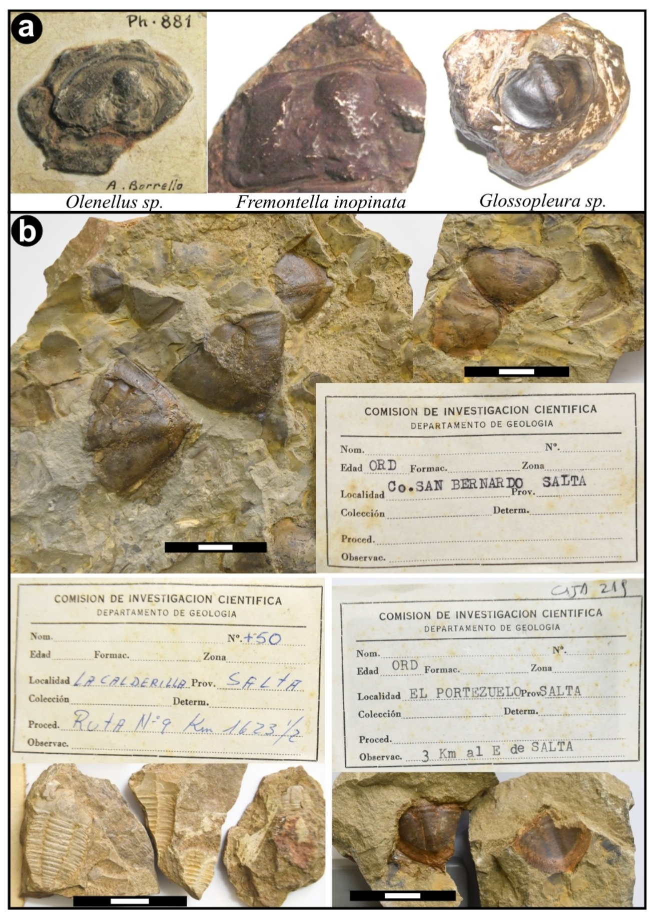


Fig. 6: Some trilobite specimens from Precordillera (a) and northwestern Argentina (b).

References

Borrello, A.V. 1962. Caliza La Laja (Cámbrico Medio-San Juan). Notas de la Comisión de Investigaciones Científicas de la Provincia de Buenos Aires 2: 3-8.

Borrello, A.V. 1963. *Fremontella inopinata* n.sp. del Cámbrico de la Argentina. Ameghiniana 3: 51-55.

Borrello, A.V. 1971. The Cambrian of South America. In *Cambrian of the New World*, ed. C. Holland, 385–438. Wiley Interscience, London.

Cingolani, C.A. 2016. La historia de la geocronología en La Plata: El "Proyecto Borrello". IV Congreso Argentino de Historia de la Geología, Revista Museo de La Plata, Volumen 1, Número Especial: 86-102. La Plata.

Leanza, A.F. 1947. El Cámbrico medio de Mendoza. Re-

vista del Museo de La Plata (nueva serie) 3 Paleontología 17: 223-237.
Poulsen, C., 1960. Fossils from the late Middle Cambrian *Bolaspidella* Zone of Mendoza, Argentina. Matematisk-fysiske Meddelelser, Det Kongelige Danske Videnskabernes Selskab 32(11): 1-42.
Poulsen, V. 1958. Contributions to the Middle Cambrian paleontology and stratigraphy of Argentina. Museum Mineralogy Geology University Copenhague, Comunication Paleontology 103: 1-22.
Rusconi, C. 1945a. Trilobites Silúricos de Mendoza. Anales de la Sociedad Científica Argentina 139: 216-219.
Rusconi, C. 1945b. Nuevos trilobites del Cámbrico de Mendoza. Boletín Paleontológico de Buenos Aires 19: 1-3.
Rusconi, C. 1956. Lista de los géneros y especies fundadas por Carlos Rusconi. Revista del Museo de Historia Natural de Mendoza 9: 121-156.
Tortello, M.F. and Cingolani, C.A. 2016. Los trilobites de Ángel Borrello. Claves para descifrar enigmas del pasado. Revista Museo 28: 5-10.

FIELD REPORTS

The trilobite layers at Jebel Ou Driss, Morocco

LEROUGE, FREDERIK, PXL University College, Hasselt (Belgium)
<frederik.lerouge@gmail.com>
KESSELAER, IVO, Brunssum (The Netherlands)
www.trilolab.net

The Jebel Ou Driss syncline is a southwestern outlier in the Ma'der basin (Morocco), adjacent to the Zagora graben. The locality provides an interesting window into the Early and Middle Devonian. On both sides of the syncline, a well-exposed and accessible sequence of layers ranging from the upper Emsian to the Lower Givetian can be sampled over a stretch of about 8 km. Many of these layers contain rich fossil faunas, including trilobite remains.

Despite its relatively remote location, the stratigraphy of Jebel Ou Driss has been well studied and described based on conodonts by Belka, Kaufmann, & Bultynck (1997) and Bultynck (1989) among others, and megafaunal elements by Hollard as early as 1974. The locality was even suggested as a possible Global Stratotype Section and Point (GSSP) for the Eifelian – Givetian boundary (Bultynck, 1989). Eventually Jebel Mech Irdane was selected for the GSSP (Walliser, Bultynck, Weddige, Becker, & House, 1995). Nonetheless, the research potential at Ou Driss remains unequivocally high because of the sheer number of interesting layers and their accessibility over a large continuous stretch.

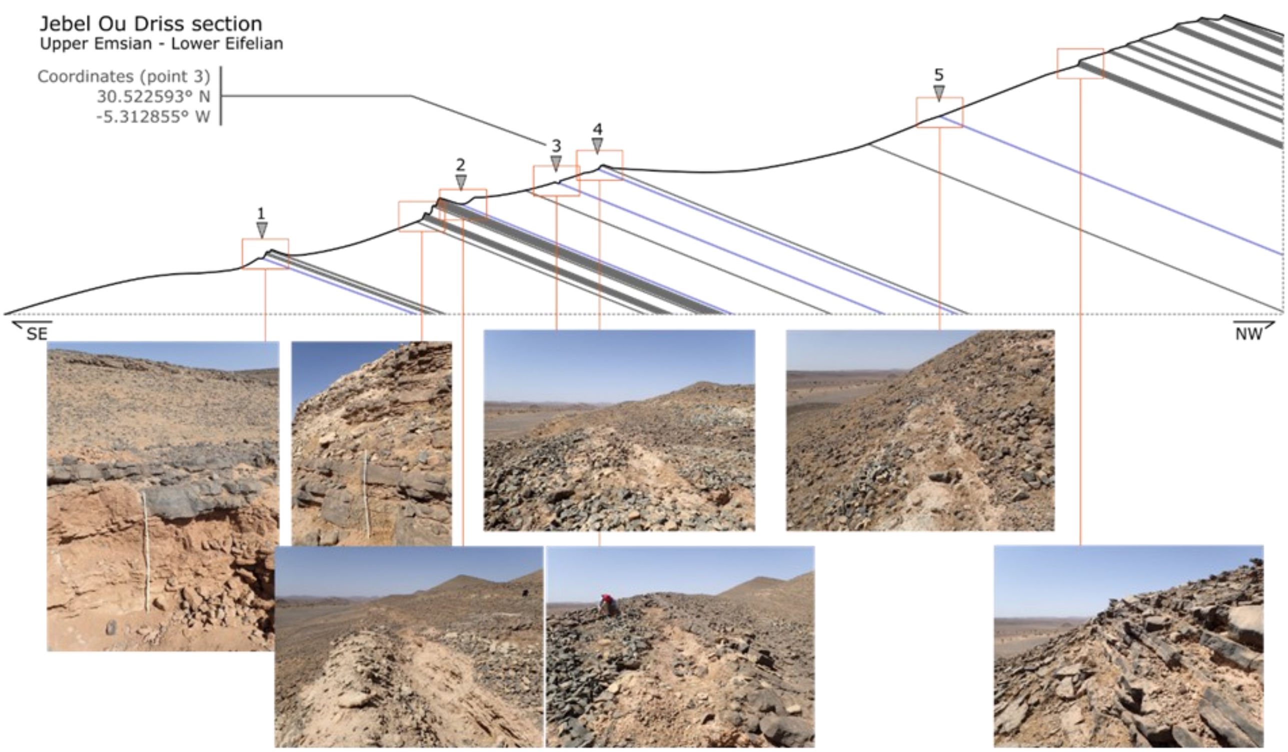


Figure 1. Schematic drawing of part of the Jebel Ou Driss section exposing layers from the upper Emsian to lower Eifelian, southeastern flank of Jebel Ou Driss.

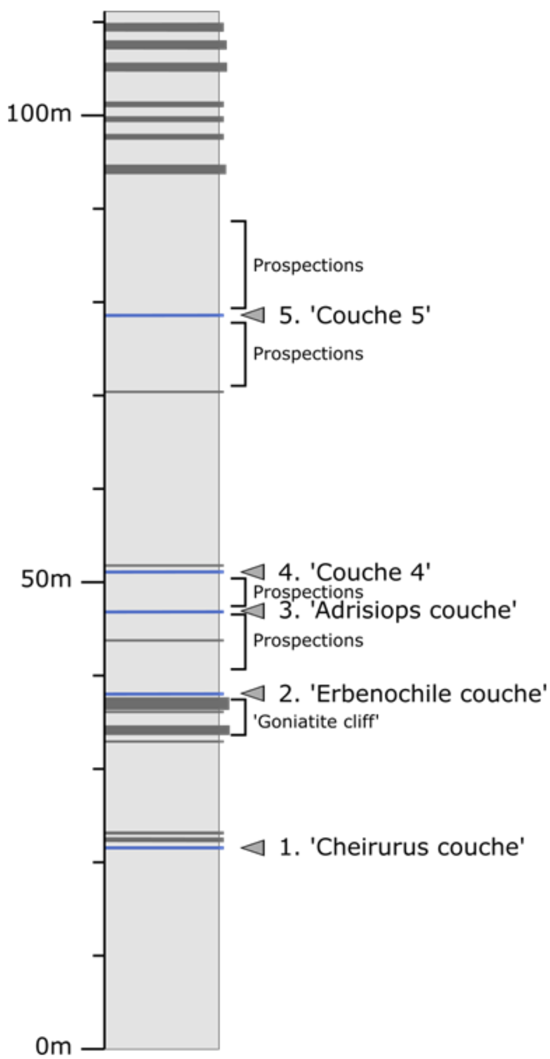


Figure 2. Simplified profile of the studied section.

days for in situ collecting in a number of layers, prospecting and taking basic measurements to draft a basic reference profile of part of the section (Figure 3). Although we spent some limited time at the 'Radiaspis' layer, situated in the Taboumakhlouf Formation just above the Eifelian – Givetian boundary (*Hemiansatus* conodont zone), most of the collecting was done in the upper Emsian – lower Eifelian section (El Otfal formation) of the southeastern flank. Here, we were told by local contacts, was a layer containing *Adrisiops weugi* van Viersen, Holland, & Koppka, 2017. This species, assigned to a new genus by its authors, was first discovered at a small spot in an isolated hill at the base of Jebel Issoumour in the Ma'der basin, and was referred to by local diggers as 'smiley Phacops' because of the ventrally deflected anterior cephalic border, giving it somewhat of a grin. However, the type locality of *A. weugi* at the base of Jebel Issoumour, which is generally Pragian or early Emsian in age, did not match the associated fauna and lithology of the latter and instead, was indicative of a late Emsian age. Therefore, the authors argued that the small hill was in fact a large chunk of the top of Jebel Issoumour which had been displaced by a massive landslide. At

In particular the upper Emsian to lower Eifelian parts of the Jebel Ou Driss section are densely packed with trilobite-bearing beds. Some of these can be interpreted as turbidites bearing complete specimens. Such layers are called *couches* (French for layer) by local diggers, and often named after the most sought-after trilobite in that respective layer.

We visited the site on two occasions in 2016 and 2017, spending a couple of

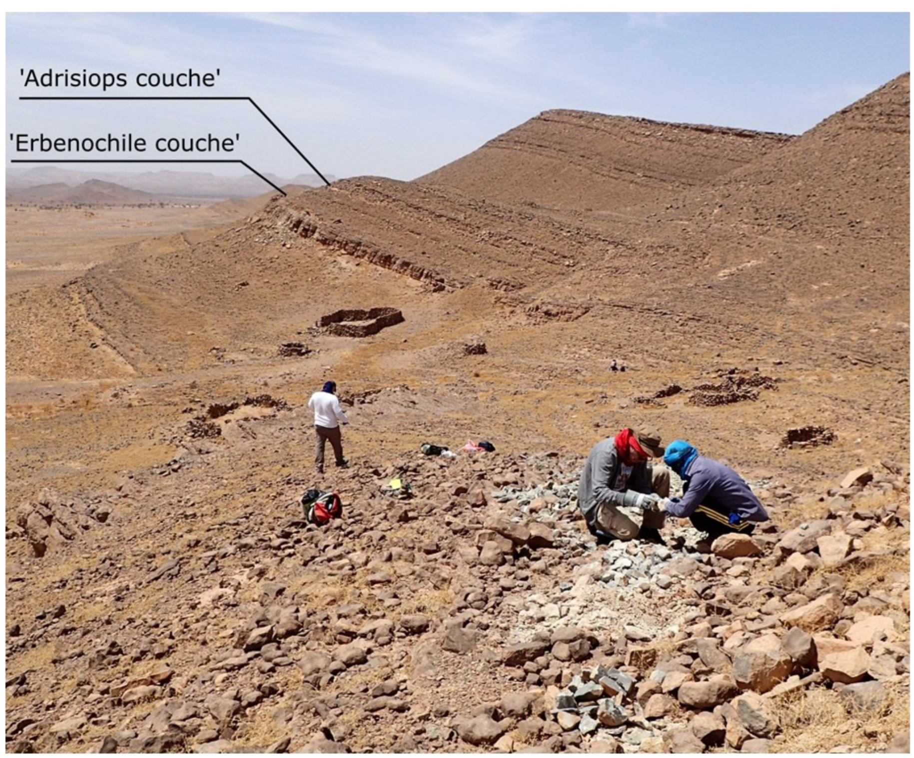


Figure 3. Fieldwork in an unexplored part of the Adrisiops couche at Jebel Ou Driss.

Figure 4. *Adrisiops weugi* from Ou Driss, found and prepared by Trilolab.

the time of our first visit Jebel Ou Driss in 2016, the publication describing *A. weugi* was close to submission, and it seemed opportune to try and confirm the late Emsian age of this trilobite.

At the southeastern flank of the Ou Driss locality, several trilobite couches could easily be recognized because they were mined by local diggers to a considerable extent: a '*Cheirurus*' layer near the base of the section reportedly containing *Paralejurus*, *Cyphaspis*, phacopids and a cheirurid trilobite (Fig. 1 & Fig. 2, layer 1); An *'Erbenochile'* layer lying immediately on top of a markedly thick goniatite-bearing limestone unit. This layer yields *Psychopyge*, *Walliserops*, *Koneprusia*, *Harpes*, *Hollardops*, *Diademaproetus*, *Adrisiops*, *Cyphaspis* and *Ceratarges* and has been most extensively mined for trilobites at this locality (Fig. 1 & Fig. 2, layer 2); The '*Adrisiops'* layer bearing *A. weugi*, *Hollardops*, *Acastoides*, *Koneprusia*, *Diademaproetus*, *Harpes* and *Thysanopeltis* (Figure 1 & Figure 2, layer 3); A fourth layer was discovered and sampled by our party, and contains complete specimens of *Diademaproetus*, *Gerastos*, *Thysanopeltis*, *Cyphaspis*, a phacopid and possibly *Harpes* (Figure 1 & Figure 2, layer 4); and finally a fifth layer was recognised containing *Ceratarges* fragments, as well as complete specimens of *Diademaproetus*, *Cyphaspis*, *Leonaspis* and a phacopid. It should be noted that none of these lists are exhaustive. In between several of the aforementioned layers, we observed numerous small prospection pits, made by trilobite diggers in search for new promising layers (Figure 2, indicated with 'prospections'). Many loose rocks on the surface show cross sections of trilobites. It is likely that more interesting trilobite-bearing layers will be discovered and mined by local trilobite diggers in the years to come.

In general, the preservation of the trilobites at Ou Driss is excellent (Figure 4) and we managed to secure some dozens of complete and high-quality trilobites. These specimens, collected in situ and prepared and documented by the Trilolab team, are invaluable to our research since their exact stratigraphic origin is known. Our observations were consistent with a late Emsian age of the type locality of *A. weugi* by pinpointing its stratigraphic occurrence in Ou Driss (Figure 2 & Figure 3), and the field visits yielded a lot of good study material for the years to come.

Elrathina **Discoveries in the Trilobites of the Metaline Formation**

Glen Scholfield

Identified outcrops of the Metaline Formation are in Northeastern Washington State, and similar carbonate lithologies extend into British Columbia. Fossils were known from the Metaline Formation some-time between 1905 and 1913, as Inland Portland Cement developed quarries near present Metaline Falls, Washington. Lafarge North America now owns the quarries. The age of the Formation was identified as Middle Cambrian by Park and Cannon (1943) and more specifically to the *Bathyuriscus/Elrathina* biozone by McLaughlin and Enbysk (1950). Deformation and slight recrystallization in the Paleozoic lithologies have been studied leading to more detailed study of the trilobites and the Formation by Diestler (1997) and Schofield (1973, 2011). It is in the later studies that trilobites were discovered that changed the age from

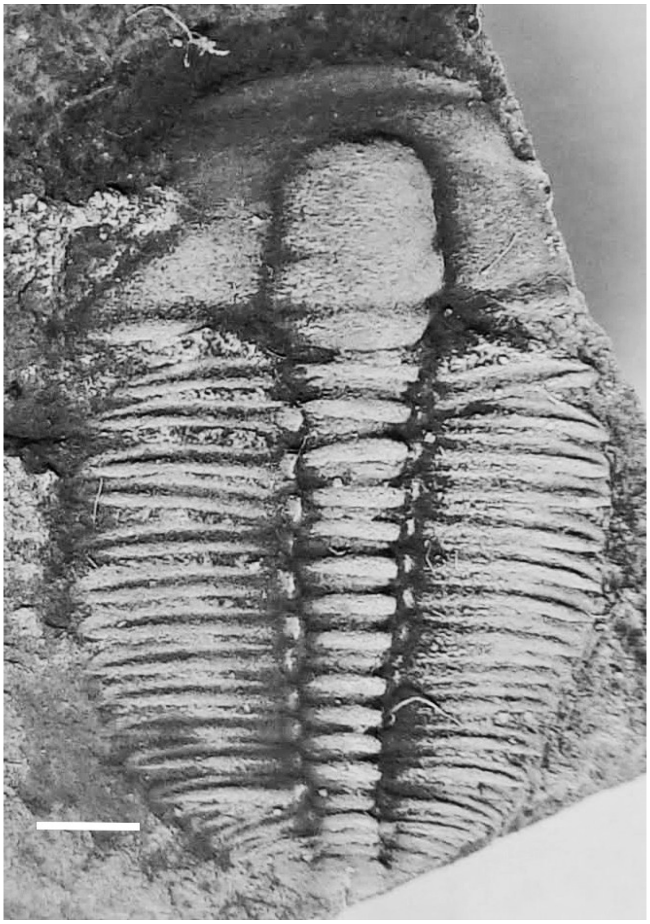


Figure 1. *Elrathina* sp. from the Metaline Formation. Scale bar = 1mm.

Bathyuriscus/Elrathina biozone to *Albertella* biozone.

A slight facies change occurs between the two Lafarge quarries near the bottom of the fossiliferous zone of the lower member of the Metaline Formation. Most of the 750 specimens examined come from this two- to three-meter-thick interbedded unit. The upper quarry has thicker shales interbedded with limestone and abundant *Ogygopsis* in death assemblages. The lower quarry has thicker limestone interbeds with disarticulated *Ogygopsis* in the shales, and *Elrathina* (Fig. 1) in the death assemblages. Two different *Elrathina* in slightly different lithologies are found in the interbedded sequence.

A recent study by Geyer and Peel (2017) of *Elrathina* have aided the identification of many of the Metaline Formation ptychopariid trilobites. Deformation and slight recrystallization make identification challenging locally. Specimens of the highest quality that also had genal spines and pygidia were chosen for identification.

Elrathina antiqua Palmer in Palmer and Halley, 1979 (Fig. 2) is common in the shales of the upper quarry, associated with *Ogygopsis klotzi.* This *Elrathina* is also present in the lower quarry, usually in thin shale beds. The deflected genal spine and very-small pygidia are features that identify it, (Palmer and Halley, 1979, Sundberg, 2020). The small pygidium often contributes to a rapidly tapering thorax.

Elrathina idahoensis? (Resser, 1938; Fig. 3) is common in the lower quarry limestone beds and is often associated with *Poliella. Elrathina ida-*

Figure 2. *Elrathina antiqua*? from the Metaline Formation. Scale bar = 2mm.

Figure 3. *Elrathina idahoensis*?. From the Metaline Formation. Scale bar = 2mm.

hoensis? is also present in the upper quarry, and often in or on the limestone beds of the interbedded unit. Somewhat long genal spines that parallel the axis and laterally pointed pleural fields of the pygidia are features that identify it, (Sundberg, 2020).

A special thanks is given to Fred Sundberg for his input in photographing and identification. Also, thanks for LaFarge N.A. for access to the quarries.

References

Diestler, K.A., 1997, Deformed Trilobites and Strain Features from the Metaline Formation, Pend Oreille County, Washington, pages 18-30, Masters of Science in Geology, Washington State University.

Dings, M.G., and Whitebread, D.H., 1965, Geology and Ore Deposits of the Metaline Zinc-Lead District Pend Oreille County, Washington, U. S. G. S. Prof. Paper 489, pages 9, and 45-48.

Geyer, G., and Peel, J.S., 2017, Middle Cambrian Trilobites from the Ekspedition Brae Formation of North Greenland, with a Reappraisal of the Genus *Elrathina,* Journal of Paleontology, 91(2), pages 271-291.

McLaughlin, K.P., and Enbysk, B.B., 1950, Middle Cambrian Trilobites from Pend Oreille County, Washington, Journal of Paleontology, Vol. 24, No. 4, pp. 466-471.

Palmer, A.R., and Halley, R.B. 1979, Physical Stratigraphy and Trilobite Biostratigraphy of the Carrara Formation (Lower and Middle Cambrian) in the Southern Great Basin, U. S. G. S. Prof. Paper 1047, pages 103-104, pl. 15.

Park, C. F. Jr., and Cannon, R. S. Jr., 1943, Geology and Ore Deposits of the Metaline Quadrangle, Washington, U. S. G. S. Prof. Paper 202, page 19.

Resser, C.E., 1938, Middle Cambrian fossils from Pend Oreille Lake, Idaho, Smithsonian Misc. Collections, vol. 97, no. 3, pp 1-29.

Schofield, G.J., 1973, Paleontology, With Finite Strain Determination of the Metaline Limestone, North East Washington, pages 8-19, paper for Master of Science in Geology credit, Washington State University.

Schofield, G.J., 2011, Trilobite Fauna Corrects Age Assignment for Lower Metaline to *Albertella* Biozone, G.S.A., Rocky Mountain (63rd. Annual) and Cordilleran (107th Annual) Joint Meeting (18-20 May 2011), Paper No. 7-5.

Sundberg, F.A., Trilobite fauna (Wuliuan Stage, Miaolingian Series, Cambrian) of the lower Lakeview Limestone, Pend Oreille Lake, Idaho, Journal of Paleontology, vol. 94, Memoir 79, 2020, pp 1-49.

Dechenella neptuni KAYSER of PFEIFFER (1888), backgrounds of a Nomen nudum

Martin Basse

Introduction

Though much is meanwhile known about Devonian trilobites from the Rhenohercynian Zone of the German Variscides, there are still any problems waiting for solutions. One of them is described herein. In the year 1888, Father Anselm Pfeiffer of Kremsmünster Observatory published a catalogue of the Paleozoic arthropods, i.e. trilobites, ostracods, and Crustacea, deposited in the fossil collection of the observatory. The majority of finds belongs to the Class Trilobita, represented mainly by specimens from the Czech Republic, due to generous donations by Czech collectors. A very low number of taxa, not more than four, respectively, comes from Gotland, the USA, and the German Eifel region. Hirschwehr (1982) described and figured 27 Czech trilobite taxa of the species group (of more than 100 listed by Pfeiffer). His work is progressive in so far as modern nomenclature has partly been applied. Basse (2009) and Lemke (2020) mentioned *Dechenella neptuni* being a Nomen nudum. This is a very short history of investigation for this interesting collection.

The Eifel region is represented by the following taxa: *Dechenella neptuni* Kayser, *Homalonotus crassicauda* Sandberger & Sandberger [= *Digonus crassicauda*], and *Phacops latifrons* (Bronn), the latter two still waiting for revision. The species name of the dechenelline is the only new name provided by Pfeiffer (1888). However, it is not available because it does not fulfil relevant ICZN paragraphs, i.e., neither descriptions nor figures nor indications have been provided. The combination with the author name Emanuel Kayser, a leading German geologist and specialist for German trilobites at that time, may indicate that Kayser had opportunity to investigate the finds, which he regarded as new species and intended to publish later. However, a related publication has never been identified. It is unlikely that it has been overlooked because in 1912, even Rudolf Richter, a student of Kayser, in his monograph of the dechenellines did not mention it. It is interesting that Richter never referred to that name.

Taxonomical aspects

In the year 1888, only two species of *Dechenella* in current taxonomical sense, *D. verneuili* (Barrande) from the German Eifel and *D. striata* Stainier from the Belgian Ardennes, both of early Givetian age, were known. They differ markedly from the two species hidden in *Dechenella neptuni*. Therefore, Kayser was right in assigning the Kremsmünster finds to a new species. However, he overlooked that *D. neptuni* includes two morphospecies, herewith: *Dechenella* sp. P_1 (Figs 1b, 3) and sp. P_2 (Figs 1a1, 1c, 1d, 4, 5). Today, more than 40 morphospecies of *Dechenella* are known from the Ardenno-Rhenish area, many of them are difficult to differentiate from one another. *Dechenella neptuni* is represented only by five pygidia (Fig. 1) which are not that well preserved. This makes it difficult to compare *D. neptuni* fully with other species.

Fig. 1. Overview showing all original slabs bearing four pygidia and a relic of a fifth of *Dechenella neptuni*, no types, and the related original label (“Dechenella Neptuni Kayser, Mitteldevon der Eifel, Stryngocephalen Schichten bei Pelm-Gerolstein”) as housed in the Kremsmünster Observatory. a1, c, d. *Dechenella* sp. P_2. b. *Dechenella* sp. P_1. Label handwriting possibly of A. Pfeiffer, but definitely not of E. Kayser, who never used the old-fashioned writing “Stryngocephalen beds”, but always its corrected version, Stringocephalen beds. All photographs are property of Kremsmünster Observatory. Scale: mm.

An important feature to differentiate dechenellines appears to be the dorsoventral height of the pygidial ribs. Basse (2002) tried an informal grouping, groups A to E, based mainly on this character. In *Dechenella* sp. P_1 the ribs are dorsoventrally moderately low reminding of

Fig. 2. Back of slab 1a1. Arrow pointing to an incomplete eye of the phacopine *Nyterops* sp., which is, in combination with *Dechenella* if numerous, indicative for the

species of group B rather of the similar group A, where they are almost flat. Further, pygidial outline is wide (tr.), pygidial axis and pleural fields are comparatively wide (tr.) anteriorly, nine well-developed ribs are followed by a relic of a tenth one close to the pygidial axis, posterior border furrow is weak, and posterior border is mesially wider (sag.) than anteriorly (tr.), the latter much less than in *D. verneuili*.

Most similar is *Dechenella* sp. 5 (Basse 2002: Pl. 18, fig. 375a) from the Wotan Member of the Loogh Formation, early Givetian of mapsheet Üxheim, Eifel Synclines, in which, however, the pygidial ribs are dorsoventrally higher (group D). Among the species of group B hitherto

Fig. 3. *Dechenella* sp. P_1, close-up of slab 1b. Calcified exoskeleton, left and middle anterior portions somewhat eroded. Scale: mm.

known, none matches all features of *Dechenella* sp. P_1, which thus may represent a new morphospecies.

Dechenella sp. P_2 differs markedly from *D*. sp. P_1 in having a shorter (tr.) pygidial outline, dorsoventrally higher ribs (groups C or D), and only seven well-developed ribs dorsally (Fig. 4), in one case followed by relics of two further ones (Fig. 5) (whereas nine and one are expressed in the internal mold). In this form, this kind of differentiation is unique among Ardenno-Rhenish dechenellines hitherto known. This clearly demonstrates two morphospecies being hidden in *neptuni*.

Fig. 4. *Dechenella* sp. P_2, close-up of slab 1d. Left pleural field and rachis

Locality

Pelm town near Gerolstein town is part of mapsheet Hillesheim (1 : 25.000), Eifel Synclines. There, *Dechenella* has been reported from many sites, the most famous of which is the type locality of *Dechenella verneuili*, type species of *Dechenella*. Since no details have been provided, the exact whereabouts of *D. neptuni* have to remain enigmatic. At least, it can be excluded that the finds come from this type locality.

Fig. 5. *Dechenella* sp. P_2, close-up of slab 1a1.Calcified exoskeleton. Note low number of dorsally fully individualized ribs. Scale: mm.

Stratigraphy

Stryngocephalen beds (of E. Beyrich) include Loogh and Cürten up to Rodert Formations of the Eifel Standard Zonation, early Givetian, up to late Givetian Formations. Since the two taxa hidden in *D. neptuni* are new and their exact whereabouts are unknown, they do not provide any stratigraphic data yet. However, morphologically similar dechenellines appear to have their maximum frequency in the Loogh and Cürten Formations. More interesting is a relic, incomplete eye, of the phacopine *Nyterops* sp. found on the same slab as one *Dechenella* sp. P_2 (Fig. 2). Associations of numerous dechenellines with *Nyterops* are characteristic for the Loogh and Cürten Formations. Lithologically, there is no clue for further differentiation since isolated finds of limestones of the two beds can be indistinguishable. Further, it has to remain undecided whether or not *Dechenella* sp. P_2 comes from the same site, or bed, as *D.* sp. P_1.

Acknowledgements

Mag. Dr. Father Amand Kraml, director of Kremsmünster Observatory, Kremsmünster, Austria, kindly provided photographs of *neptuni* and permitted their publication. Mag. Matthias Svojtka, faculty of Botany of Vienna University, Austria, initiated the contact with Kremsmünster and provided rare literature.

References

Basse, M. (2002): Eifel-Trilobiten 1. Proetida. – 152 pp.; Korb (Goldschneck-Verlag).
Basse, M. (2009): Catalogus typorum trilobitorum Germaniae: I. Trilobites Cambrici, Ordovicici et Silurici – saxa erratica inclusa. II. Trilobites Devonici et Infracarbonici. – In: Fossilium Catalogus I: Animalia. Pars **147**. – 380 pp.
Hirschwehr, H. (1982): Die Trilobiten der Sternwarte Kremsmünster. – Hausarbeit zur Erlangung des akademischen Grades eines „Magisters der Philosophie“. Universität Salzburg. Institut für Geowissenschaften. – 108 pp. (Unpublished.)
Lemke, U. (2020): Updated catalogue of available names and non-available names of the species and subspecies of Trilobita. Approximately 30.000 names, November 2020. – 545 pp.; Wetter/Nordrhein-Westfalen (U. Lemke). (Available via Research Gate.)
Pfeiffer, A. (1888): Die palaeozoischen Arthropoden in der Sternwarte zu Kremsmünster. – 14 pp.; Kremsmünster.
Richter, R. (1912): Beiträge zur Kenntnis devonischer Trilobiten. 1. Die Gattung *Dechenella* und einige verwandte Formen. – Abhandlungen der senckenbergischen naturforschenden Gesellschaft, **31**: 239–340.

The importance of the Cambrian and the trilobites of Mexico

Francisco J. Cuen-Romero and Frederick A. Sundberg

The Cambrian outcrops in Mexico are scarce and controversial because they occur in an isolated and sporadic way; however, they have a relatively well-preserved fossil biota (Cuen-Romero et al., 2018). The state of Sonora is the only entity that has Cambrian outcrops with trilobites, which have been studied since the middle of the last century (Lochman, 1948), while there are other states for which the presence of the Cambrian is controversial (Robison & Pantoja-Alor, 1968). High-resolution trilobite-based biostratigraphy is an essential tool during the Cambrian (Webster, 2011) because the biostratigraphic column for this system is built based on ranges of trilobites due to their abundance and

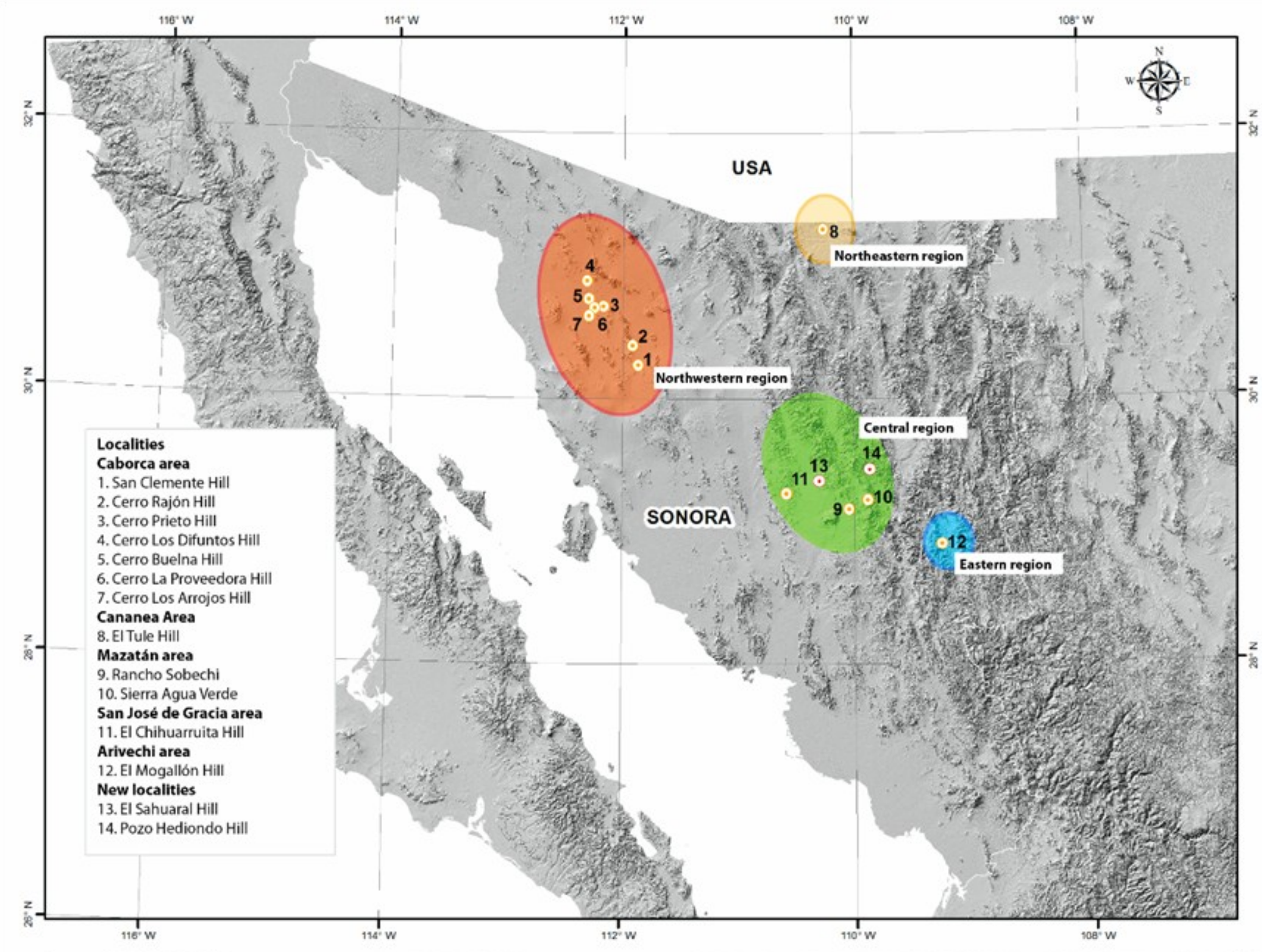


Fig. 1. Cambrian deposits from Sonora, Mexico.

wide geographic distribution (Lochman-Balk & Wilson, 1958). On the other hand, trilobites correspond to the dominant marine fauna during the Cambrian-Ordovician, occupying important ecological niches from their first appearance during the Cambrian until their extinction during the Permian (Fortey, 2014).

The Cambrian trilobite faunas of the state of Sonora were divided into four regions according to their geographical location (Cuen-Romero et al., 2018; Fig. 1): 1) the northwestern region comprises the deposits of the Caborca, Cerro San Clemente, and Cerro Rajón, where the Cerro Rajón, Puerto Blanco, Proveedora, Buelna, Cerro Prieto, Arrojos and El Tren formations emerge. 2) the northeastern region comprises the deposits of the Cananea area, mainly El Tule and Mesteñas hills, where the Bolsa and Abrigo formations outcrop. 3) the central region includes deposits in the Mazatán area (Sierra Agua Verde and Rancho Sobechi) and San José de Gracia, where the Proveedora, Buelna, Cerro Prieto, El Gavilán, and El Tren formations emerge. 4) the eastern region includes the Arivechi deposits, where the La Sata, El Mogallón, La Huerta, and Milpillas formations outcrop.

The Cambrian outcrops with trilobites from Sonora, Mexico are important because of the following:

1. They have a historical value for the country because, although approximately 80 years have passed since the pioneering studies of the Cambrian in Mexico (1941), there are still many unexplored localities.

2. The Cambrian outcrops of Sonora represent the southernmost deposits of the craton in North America today, while during the Cambrian, they were deposited in the western part of Laurentia; thus, they are closely related to the deposits of

Arizona, Nevada, California (USA) and possibly British Columbia (Canada).

3. Numerous species of trilobites, which currently represent Cambrian biozones, were first described in Mexico, for example, *Amecephalus arrojosensis* and *Mexicella mexicana*.

4. There are numerous areas of opportunity because although the trilobite faunas of the Cambrian of Sonora have been recently retaken by (Sundberg & Cuen-Romero, 2021), there are still numerous areas to investigate and/or update.

5. The Cambrian deposits of Sonora also conform to the Robison (1976) paleogeographic model, where it is possible to differentiate between faunas of the inner platform and/or outer platform, with the presence of agnostic and polymeric trilobites.

References:
Cuen-Romero, F. J., Valdez-Holguín, J. E., Buitrón-Sánchez, B. E., Monreal, R., Enríquez-Ocaña, L. F., Aguirre-Hinojosa, E., Ochoa-Granillo, J. A., & Palafox-Reyes, J. J. (2018). Trilobite-based biostratigraphy (arthropoda-trilobita) and related faunas of the Cambrian from Sonora, Mexico. Journal of South American Earth Sciences, 83, 227-236. https://doi.org/10.1016/j.jsames.2018.03.002
Fortey, R. (2014). The palaeoecology of trilobites. Journal of Zoology, 292(4), 250-259. https://doi.org/10.1111/jzo.12108
Lochman, C. (1948). New Cambrian Trilobite Genera from Northwest Sonora, Mexico. Journal of Paleontology, 22(4), 451-464.
Lochman-Balk, C., & Wilson, J. L. (1958). Cambrian Biostratigraphy in North America. Journal of Paleontology, 32(2), 312-350.
Robison, R.A., (1976), Middle Cambrian Trilobite Biostratigraphy of the Great Basin: Geology Studies, Brigham Young University, 23(2), 93–109
Robison, R. A., & Pantoja-Alor, J. (1968). Tremadocian Trilobites from the Nochixtlán Region, Oaxaca, Mexico. Journal of Paleontology, 42(3), 767-800.
Sundberg, F. A., & Cuen-Romero, F. J. (2021). Trilobites from the Crepicephalus Zone (upper Guzhangian Stage, Miaolingian Series, Cambrian) from northern Sonora, Mexico, and its correlation to Arizona and Texas, USA. *Journal of South American Earth Sciences*, 103185. https://doi.org/10.1016/j.jsames.2021.103185
Webster, M. (2011). Trilobite biostratigraphy and sequence stratigraphy of the Upper Dyeran (traditional Laurentian "Lower Cambrian") in the southern Great Basin, USA. Museum of Northern Arizona Bulletin, 67, 121-154.

Great field find of *Olenellus fowleri* Palmer, 1998, lower Cambrian, Pioche Shale, Ruin Wash, Nevada. Picture from John Foster.

Gabriceraurus mifflinensis
Ordovician
Platteville Formation
Mufflin Member
Grant County, Wisconsin
(Prepared by Ben Cooper;
Photo from Don Bissett)

2020–2021 TRILOBITE REFERENCES

Scott Morrison

Adrain, J.M., Karim, T.S., McAdams, N.E.B. 2020. Atlanticalymene, a new genus of Middle Ordovician (Darriwilian) calymenine trilobites, and revision of the calymenoidean genus Protocalymene Ross. Zootaxa, 4859(1):1-55

Ahlberg, P., Lundberg, F., Calner, M., Lehnert, O., Dahlqvist, P., Joachimski, M.M. 2021. Miaolingian (Cambrian) trilobite biostratigraphy and carbon isotope chemostratigraphy in the Tingskullen drill core, Öland, Sweden. Estonian Journal of Earth Sciences, 70(1):18-35

Álvaro, J.J. and Esteve, J.2020. Reply to Comment on: Álvaro JJ, Esteve, J. & Zamora, S. 2019. Morphological assessment of the earliest paradoxidid trilobites (Cambrian Series 3) from Morocco and Spain [Geological Magazine] by Geyer G, Nowicki J, Żylińska A & Landing E. Geological Magazine, 157 (12):1971-1982

Alberti, M. 2020. Die Mitteldevonischen Rupbach-Schiefer von Gutenacker. [The Middle Devonian Rupbach Shale from Gutenacker.] Fossilien, 2020 (6):10-21

Ameri, H. 2020. Early Silurian (Llandovery) Trilobite fauna from Kopeh-Dagh, North East Iran. Journal of Sciences, Islamic Republic of Iran, 31(2)155-164

Armstrong, M., Westrop, S.R., Eoff, J.D. 2020. Systematics of a survivor: the Cambrian kingstoniid trilobite Blountia Walcott, 1916 across the Marjuman–Steptoean (Guzhangian–Paibian) extinction interval in Laurentian North America. Zootaxa, 4804(1):1-79

Basse, M. 2020. Trilobita (einschließlich Agnostida) 2019. [Trilobita (including Agnostida) 2019] Zentralblatt für Geologie und Paläontologie, Teil-II, 2020:1-33

Basse, M., Lemke, U. 2020. Class Trilobita in the Wocklum Limestone of the northern Rhenish Massif east of the Rhine (late Famennian, Late Devonian) - Part 1. Phillipsiidae and Proetidae. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 298:203-233

Basse, M., Müller, P., Müller, M. 2020. Erster artikulierter vollständiger Psychopyge aus Deutschland. [First articulated complete specimen of Psychopyge from Germany.]Fossilien, 2020(2):62-63

Bault, V., Crônier, C., Allaire, N., Monnet, C. 2021. Trilobite biodiversity trends in the Devonian of North Africa. Palaeogeography, Palaeoclimatology, Palaeoecology, 565(110208)

Beech, J. 2020. Where the harpetids are: paleobiogeography, diversity, and mass extinction in an enigmatic trilobite order. Geological Society of America Abstracts with Programs, 52(6):50-2

Bentley, C.J., Jago, J.B., Corbett, K.D. 2020. Late Cambrian (Iverian, Jiangshanian) fossils from the Professor Range area, Western Tasmania. Alcheringa, 44 (2):203-216

Bicknell, R.D.C., Holland, B. 2020. Injured trilobites within a collection of dinosaurs: Using the Royal Tyrrell Museum of Palaeontology to document Cambrian predation. Palaeontologia Electronica, 23(2) a33:1-11

Bicknell, R.D.C., Holmes, J.D., Edgecombe, G.D., Losso, S.R., Ortega-Hernández, J., Wroe, S., Paterson, J.R. 2021. Biomechanical analyses of Cambrian euarthropod limbs reveal their effectiveness in mastication and durophagy. Royal Society of London, Proceedings, Series B, 288(20202075):1-8

Bicknell R.D.C., Pates S. 2020. Exploring abnormal Cambrian-aged trilobites in the Smithsonian collection. PeerJ, 8(e8453):1-20

Bignon, A., Vaccari, N.E., Waisfeld, B.G., Chatterton, B.D.E. 2020. Reassessment of the Order Trinucleida and its phylogeny and systematics at familial level. Danmarks og Grønlands Geologiske Undersøgelse Rapport, 21:11

Bignon, A., Waisfeld, B.G., Vaccari, N.E., Chatterton, B.D.E. 2020. Reassessment of the Order Trinucleida (Trilobita). Journal of Systematic Palaeontology, 18 (13):1061-1077

Bond, A.D., Edgecombe, G.D. 2020. Phylogenetic response of naraoiid arthropods to early–middle Cambrian environmental change. Palaeontology (in press)

Borowski, T., Daniszewski, P. 2021. New location of the well-known Ordovician trilobite Asaphus expansus (Wahlenberg, 1821) from north-western Poland. World News of Natural Sciences, 34:82-87

Boyce, W.D. 2020. Bathyurus perplexus Billings, 1865: Distribution and Biostratigraphic Significance. Newfoundland and Labrador Department of Natural Resources Geological Survey, Current Research Report, 20(1):1-27

Bradley, A. 2020. Politicurus and a related genus of Hintzecurine Trilobites from the late Skullrockian (Tremadocian: Early Ordovician) of Western Utah and Southeastern Idaho. MSc Thesis, University of Iowa, 185 pp.

Budil, P., Fatka, O. 2020. Ordovician trilobites with soft-parts in African West Gondwana, European peri-Gondwana and Avalonia: a review. Geological Society, London, Special Publications, 485 (in press)

Bushuev, E.V., Komlev, D.A., Kupin, A.V. 2020. New Finds of Lower Cambrian Trilobites Eodiscoidea at Kulyumbe River Section (North-West of the Siberian Platform). VSEGEI – Paleontological Society at the Russian Academy of Sciences, 66:27-29

Carvalho, C.N.D., Baucon, A., Bayet-Goll, A., Abioui, M. 2020. Feeding behavior of giant trilobites from the Penha Garcia Ichnological Park (UNESCO Naturtejo Global Geopark, Portugal). International Journal of Earth Sciences, 109:2825–2827

Cederström, P., Geyer, G., Ahlberg, P., Nilsson, C.A., Ahlgren, J. 2020. Ellipsocephalid trilobites from Cambrian Series 2 and Stage 4 in Scania, Sweden: taxonomy, morphological plasticity and biostratigraphic significance. Fossils & Strata, (in press)

Chacaltana, C. , Tejada, L. 2020. Catálogo de Fósiles Característicos de la Era Paleozoica del Perú. [Catalog of Characteristic Fossils of the Paleozoic Era of Peru.] INGEMMET: Boletín Serie D: Estudios Regio-

nales, 33:1-181
Chatterton, B.D.E. 2020. Mid-Furongian trilobites and agnostids from the Wujiajiania lyndasmithae Subzone of the Elvinia Zone, McKay Group, southeastern British Columbia, Canada. Journal of Paleontology, 94(4):653-680
Chatterton, B.D.E., Gibb, S., McKellar, R.C. 2020. Species of the Devonian aulacopleurid trilobite Cyphaspides from southeastern Morocco. Journal of Paleontology, 94(1):99-114
Chirivella Martorell, J.B., Liñán, E., Dies Álvarez, M.E., Gozalo, R. 2020. Systematic and biostratigraphy of the genera Parasolenopleura, Badulesia, and Pardailhania in the Iberian Chains: a useful zonation for the Miaolingian Series (former middle Cambrian) in the Mediterranean region. [Sistemática y bioestratigrafía de los géneros Parasolenopleura, Badulesia y Pardailhania en las Cadenas Ibéricas: una zonación útil para la Serie Miaolingiense (antiguo Cámbrico medio) en la región Mediterránea]. Spanish Journal of Palaeontology, 35(1):1-28
Cílek, V., Sůvová, Z., Turek, J., Meduna, P., Mikuláš, R., Štorch, P., Hladil, J., Mudra, P., Keřka., J., Svoboda, J., Lizoňová, D., Hanák, A. 2020. The Region of Joachim Barrande: A Journey into the Prehistory of the Czech Lands. Dokořán Publishing House, 336 pp.
Clements, D., Fortey, R.A. 2020. Rediscovery of Ordovician and Silurian trilobites from the Nares Arctic Expedition of 1875-6 from Ellesmere Island and western Greenland. Proceedings of the Geologists' Association, 131(2):112-120
Collantes, L., Mayoral, E., Gozalo, R., Liñán, E. 2020. Olenellid Trilobites from the Marianian (Cambrian Series 2) of Sierra de Aracena, Sw Spain. 2nd Palaeontological Virtual Congress, Book of Abstracts, p. 107
Collantes, L., Mayoral, E., Liñán, E., Gozalo, R. 2020. First occurrence of the Laurentian Trilobite Pseudatops reticulatus (Walcott) from the Marianian (Cambrian Series 2) of the Iberian Peninsula. Geological Society of America Abstracts with Programs, 52 (6):113-8
Collantes, L., Mayoral, E., Liñán, E., Gozalo, R. 2020. Atopidae (Trilobita) in the upper Marianian (Cambrian Series 2, Stage 4) of Iberia. Journal of Paleontology, 95:123-132
Corrales-García, A., Esteve, J., Lopez-Pachon, M. 2020. Burrowing assessment of Illaenus sarsi Jaanusson, 1957 and Megistaspis extenuata (Wahlenberg, 1821) from the Middle Ordovician of Sweden. Danmarks og Grønlands Geologiske Undersøgelse Rapport, 21:15
Corrales-García, A., Esteve, J., Zhao, Y., Yang, X. 2020. Synchronized moulting behaviour in trilobites from the Cambrian Series 2 of South China. Nature Scientific Reports, 10(14099):1-11
Corbacho, J., López-Soriano, F.J., Morrison, S., Hammond, K. 2020. New Data Obtained with CT Scanning on Platypeltoides cuervoae (Corbacho & López-Soriano, 2012) Nileidae from the Lower Ordovician; Western Anti-Atlas, Morocco. Earth Sciences, 9(2):76-81
Crônier, C., Ariuntogos, M., Königshof, P., Waters, J.A., Carmichael, S.K. 2020. Late Devonian (Famennian) phacopid trilobites from western Mongolia. Palaeobiodiversity and Palaeoenvironments, (in press) 17 pp.
Cuen-Romero, F.J., Noriega-Ruiz, H.A., Buitrón-Sánchez, B.E. 2020. Euagnostus interstrictus (White, 1874) (Trilobita: Agnostida) del Cámbrico medio (Miaolingiano-Wuliuano) del cerro El Sahuaral, Sonora central, México. [Euagnostus interstrictus (White, 1874) (Trilobita: Agnostida) of the Middle Cambrian (Miaolingian-Wuliuan) from El Sahuaral hill, Central Sonora, Mexico.] Paleontología Mexicana, 9(1):31-39
De Baets, K., Budil, P., Fatka, O., Geyer, G. 2020. Trilobites as Hosts for Parasites: From Paleopathologies to Etiologies. The Evolution and Fossil Record of Parasitism: Coevolution and Paleoparasitological Techniques. Topics in Geobiology, 50(6)
Denayer, J., Prestianni, C., Mottequin, B., Hance, L., Poty, E. 2020. The Devonian–Carboniferous boundary in Belgium and surrounding areas. Palaeobiodiversity and Palaeoenvironments, (in press)
Du, G.Y., Peng, J., Wang, D.Z., Wen, R.Q., Liu, S. 2020. Morphology and trunk development of the trilobite Arthricocephalus chauveaui from the Cambrian series 2 of Guizhou, South China. Historical Biology, (32):174-186
Drummer, K.Y., Gishlick, A.D. 2020. Fork Structure Allometry in the trilobite Walliserops trifurcatus correlates with a sexually selected function. Geological Society of America, Abstracts with Programs, Paper No. 40-5(345456)
Ebbestad, J.O.R., Fortey, R.A. 2020. Late Ordovician trilobites from the Taimyr Peninsula, Arctic Russia. Journal of Systematic Palaeontology, 18(1):1-135
Edgecombe, G.D. 2020. Arthropod Origins: Integrating Paleontological and Molecular Evidence. Annual Review of Ecology, Evolution, and Systematics, 51:1-25
Esteve J., López-Pachón M. 2020. Swimming and enrolment in a mesopelagic trilobite: new ecomorphological advantages in the Middle Ordovician Ocean. Danmarks og Grønlands Geologiske Undersøgelse Rapport, 21:21
Esteve, J., Marcé-Nogué, J., Pérez-Peris, F., Rayfield, E. 2021. Cephalic biomechanics underpins the evolutionary success of trilobites. Palaeontology (in press)
Fatka, O., Budil, P., Laibl, L. 2020. Cases of possible shell disease syndrome in Ordovician trilobites (Arthropoda). Journal of Invertebrate Pathology (in submission)
Fatka, O., Budil, P., Toman, J. 2020. Paleogeography and Stratigraphy of *Placoparia* and "odontochilinid" Trilobites. OSF Preprint – Paleobiological Working Paper
Feist, R., Cornée, J.J., Corradini, C., Hartenfels, S., Aretz, M., Girard, C. 2020. The Devonian–Carboniferous boundary in the stratotype area (SE Montagne Noire, France). Palaeobiodiversity and Palaeoenvironments, (in press) 17 pp.
Geyer, G. 2020. A critical evaluation of the *Resserops* clade (Trilobita: Despujolsiidae, early Cambrian)

with remarks on related redlichiacean families. Freiberger Forschungshefte, C558:1-107

Geyer, G., Landing, E. 2020. Cambrian deposition in northwestern Africa: Relationship of Tamlelt massif (Moroccan–Algerian border region) succession to the Moroccan Meseta. Journal of African Earth Sciences, 165(103772):1-20

Geyer, G., Landing, E. 2021. The Souss lagerstätte of the Anti-Atlas, Morocco: discovery of the first Cambrian fossil lagerstätte from Africa. Nature Scientific Reports, 11(3107):1-8

Geyer, G., Pais, M.C., Wotte, T. 2020. Unexpectedly curved spines in a Cambrian trilobite: considerations on the spinosity in *Kingaspidoides spinirecurvatus* sp. nov. from the Anti-Atlas, Morocco, and related Cambrian ellipsocephaloids. Paläontologische Zeitschrift, 94:645-660

Geyer, G., Peel, J.S. 2020. *Elrathia hensonensis* nomen novum, new replacement name for *Elrathia groenlandica* Geyer and Peel, 2017 (Trilobita, Ptychopariacea). Journal of Paleontology, 94(5):1007

Greenberger, R.E. 2020. Investigating Rare Biomineralization Structures in Trilobites. MSc Thesis, University of Alabama, 58 pp.

Gutiérrez-Marco, J.C., Lorenzo, S., Pereira, S., Rábano, I. 2020. Nuevos hallazgos de fósiles ordovícicos en el Dominio de Obejo-Valsequillo (provincias de Badajoz y Córdoba, suroeste de España). [New occurrences of Ordovician fossils from the Obejo–Valsequillo Domain (provinces of Badajoz and Córdoba, Southwestern Spain).] Sociedad Geológica de España, Geogaceta, 67:71-74

Hofmann, R., Kehl, J.P. 2020. Diversity patterns and palaeoecology of benthic communities of the Kanosh Formation (Pogonip Group, Utah, Western USA). Palaeobiodiversity and Palaeoenvironments, 100:993-1006

Holloway, D.J., Smith, P.M., Thomas, G. 2020. The trilobites *Prophalaron* gen. nov. (Calymenidae) and *Dicranurus* (Odontopleuridae) from the Upper Ordovician of New South Wales. Alcheringa, 44(2):253-264

Holmes, J.D., Paterson, J.R., García-Bellido, D.C. 2020. The Trilobite *Redlichia* from the lower Cambrian Emu Bay Shale Konservat-Lagerstätte of South Australia: systematics, ontogeny and soft-part anatomy. Journal of Systematic Palaeontology, 18(4):295-334

Holmes, J.D., Paterson, J.R., García-Bellido, D.C. 2020. The post-embryonic ontogeny of the early Cambrian trilobite *Estaingia bilobata* from South Australia: trunk development and phylogenetic implications. Papers in Palaeontology, (in press) pp. 1-20

Holmes, J.D., Paterson, J.R., Jago, J.B., García-Bellido, D.C. 2020. Ontogeny of the trilobite *Redlichia* from the lower Cambrian (Series 2, Stage 4) Ramsay Limestone of South Australia. Geological Magazine (in press)

Hopkins, M.J. 2020. A simple generative model of trilobite segmentation and growth. Peer Community in Paleontology, PaleorXiv, 2020:1-27

Hopkins, M.J. 2020. Ontogeny of the trilobite *Elrathia kingii* (Meek) and comparison of growth rates between *Elrathia kingii* and *Aulacopleura koninckii* (Barrande). Papers in Palaeontology. (in press) 18 pp.

Hughes, N.C., Adrain, J.M., Holmes, J.D., Hong, P.S., Hopkins, M.J., Hou, J.B., Minelli, A., Park, T.Y.S., Paterson, J.R., Peng, J., Webster, M. 2020. Articulated trilobite ontogeny: suggestions for a methodological standard. Journal of Paleontology, (in press)

Jago, J.B., Bentley, C.J., Paterson, J.R., Holmes, J.D., Lin, T.R., Sun, X.W. 2020. The stratigraphic significance of early Cambrian (Series 2, Stage 4) trilobites from the Smith Bay Shale near Freestone Creek, Kangaroo Island. Australian Journal of Earth Sciences (in press)

Jago, J.B., Kruse, P.D. 2020. Significance of the Middle Cambrian (Wuliuan) Trilobite *Pagetia* from Yorke Peninsula, South Australia. Australian Journal of Earth Sciences, 67(7):1003-1008

Karlstrom, K.E., Mohr, M.T., Schmitz, M., Sundberg, F.A., Rowland, S., Hagadorn, J., Foster, J.R. Crossey, L.J., Dehler, C., Blakey, R., 2020. Redefining the Tonto Group of Grand Canyon and recalibrating the Cambrian timescale. Geology, 48:425-430

Kempf, H. 2020. Literature Review on the Ultrasructural Variation in Trilobite Exoskeletons. University of Wisconsin-Milwaukee, Virtual Undergraduate Research Symposium.

Kim, D.H., Choi, D.K. 2020. Tremadoc Trilobites from the Mungog Formation, Yeongweol, Korea. Stratigraphy

Klug, C. 2020. Deep insights into trilobite development. Peer Community in Paleontology, PaleorXiv, 2020:1-2

Kowalewska, A. 2020. Trilobites and associated fauna from Baltoscandian erratic boulders at Orłowo Cliff, Northern Poland. Fragmenta Naturae, 53:17-26

Kraft, P., Bruthansová, J., Mikuláš, R. 2020. Feeding traces related to shells from the Prague Basin, Czech Republic (Tremadocian to early Darriwilian, Ordovician). Palaeogeography, Palaeoclimatology, Palaeoecology, 537(109399):1-21

Korovnikov, I.V. 2020. Paleobiogeography of Cambrian Trilobites (Western and Northern side of the Siberian Paleo Basin). VSEGEI – Paleontological Society at the Russian Academy of Sciences, 66:85-87

Krylov A.V. 2020. Trilobites of Kanonerskiy Island and other Technogenic Localities of the Late Holocene of the Environments Saint Petersburg Town and Leningrad Region. Relief and Quaternary formations of the Arctic, Subarctic and North-West of Russia, 7:300-310

Laibl, L., Maletz, J., Olschewski, P. 2020. Post-embryonic development of *Fritzolenellus* suggests the ancestral morphology of the early developmental stages in Trilobita. Papers in Palaeontology, (in press)

Landing, E., Ripperdan, R.L., Geyer, G. 2020. Uppermost Cambrian carbon chemostratigraphy: the HERB and undocumented TOCE events are not synonymous. Geological Magazine, 157(8):1373-1377

Landing, E., Schmitz, M.D., Geyer, G., Trayler, R.B., Bowring, S.A. 2020. Precise early Cambrian U–Pb zircon dates bracket the oldest trilobites and archaeocyaths in Moroccan West Gondwana. Geological Magazine, (in press) pp. 1-20

LaVine, R.J. 2020. The Role of Developmental Constraints in Shaping Macroevolutionary Patterns of Disparity in Agnostine Arthropods. PhD Thesis, University of Chicago, Department of Geophysical Sciences, 133 pp.

Lee, S.B. 2020. *Kayseraspis* (Trilobita) from the Mungok Formation in Yeongwol area and its significance for the Lower Ordo-vician biostratigraphy and chronostratigraphy of the Taebaeksan Basin, Korea. Geosciences Journal, 24:351-357

Lei, Q.P., Liu, Q. 2020. Two species of *Tsinania* (Trilobita, Corynexochida) from upper Furongian (Cambrian) of northern Anhui, China and their intraspecific variation. Palaeoworld (in press)

Lerosey-Aubril, R., Kimmig, J., Pates, S., Skabelund, J., Weug, A., Ortega-Hernández, J. 2020. New exceptionally preserved panarthropods from the Drumian Wheeler Konservat-Lagerstätte of the House Range of Utah. Papers in Palaeontology, 6(4):501-531

Liebermann, S. 2020. Drei neuerworbene (und neupräparierte) lichide Trilobiten aus Marokko. [Three newly acquired (and newly prepared) lichid trilobites from Morocco.] Fossilien & Geschiebe, 5:1-5

Liñán, E., Gámez Vintaned, J.A., Palacios, T., Gozalo, R. 2020. The lower Ovetian Stage (lower Cambrian Stage 3) trilobite zonation in Spain and correlation with West Gondwana. GFF, 142:100-114

Losso, S.R.1, Ortega-Hernández, J. 2020. Recent developments in the paleobiology and taphonomy of trilobites from the Walcott-Rust Quarry (Upper Ordovician). Danmarks og Grønlands Geologiske Undersøgelse Rapport, 21:34

Mángano, M.G., Buatois, L.A., Waisfeld, B.G., Muñoz, D.F., Vaccari, N.E., Astini, R.A. 2021. Were all trilobites fully marine? Trilobite expansion into brackish water during the early Palaeozoic. Royal Society of London, Proceedings, Series B: 288:(202022630)

Månsson, K., Clarkson, E.N.K. 2020. A revised ontogeny of the early Ordovician trilobite *Leptoplastides salteri* (Callaway, 1877). Earth and Environmental Science: Transactions of the Royal Society of Edinburgh, 111 (1):1-16

Makarova, A.L., Komle, D.A. 2020. New Data on Trilobites from Oraktinskaya Suite at Kulyumbe River Section (Transition Layers of Mid-Upper Cambrian). VSEGEI – Paleontological Society at the Russian Academy of Sciences, 66:103-105

Mendonça, A., Moreira, J., Viegas, V. 2020. Alterações Climáticas – O caso das Trilobites de Arouca. Encontro Nacional sobre Investigação em Alterações Climáticas, Faculdade de Ciências da Universidade de Lisboa. [Climate Change - The case of Arouca Trilobites. National Meeting on Climate Change Research, Faculty of Sciences, University of Lisbon]

Moliner-Oliveros, L. 2020. Fósiles con Nombre Aragonés. [Fossils with Aragonese Names.] Sociedad de Amigos del Museo de Ciencias Naturales de la Universidad de Zaragoza, Trilobita pp. 140-155, 280, 283, 294-295, 305

Morgan, C.A., Henderson, C.M., Pratt, B.R.2020. Cambrian Correlation: the use of quantitative biostratigraphy as a test of the traditional trilobite biostratigraphic framework. GeoConvention 2020

Mychko, E.V. 2020. New rare Arthropods (Trilobites and Cyclids) from Carboniferous and Permian of Russia. European Geosciences Union General Assembly – Abstracts Programme

Nanglu, K., Caron, J.B., Gaines, R.R. 2020. The Burgess Shale paleocommunity with new insights from Marble Canyon, British Columbia. Paleobiology, 46 (1):58-81

Nielsen, A.T., Høyberget, M., Ahlberg, P. 2020. The Furongian (Upper Cambrian) Alum Shale of Scandinavia: revision of zonation. Lethaia, 53(4):462-485

Noriega-Ruiz, H.A., Cuen-Romero, F.J., Enríquez-Ocaña, L.F., Sundberg, F.A., Monreal, R., Varela-Romero, A., Palafox-Reyes, J.J., Grijalva-Noriega, F.J. 2020. Cambrian stratigraphy (series 2 to Miaolingian) of the El Sahuaral area in central sonora, Mexico: Biostratigraphic implications. Journal of South American Earth Sciences, 103(102797)

Paterson, J.R. 2020. The trouble with trilobites: classification, phylogeny and the cryptogenesis problem. Geological Magazine, 157(1):35-46

Peel, J.S. 2020. Middle Cambrian trilobites (Miaolingian, *Ehmaniella* Biozone) from the Telt Bugt Formation of Daugaard-Jensen Land, western North Greenland. Bulletin of the Geological Society of Denmark, 68:1-14

Peel, J.S. 2021. Trilobite fauna of the Telt Bugt Formation (Cambrian Series 2–Miaolingian Series), western North Greenland (Laurentia). Bulletin of the Geological Society of Denmark, 69:1-33

Peel, John S. 2020. *Polypleuraspis* (Arthropoda, Trilobita) from the middle Cambrian (Miaolingian Series) around Kane Basin (Nunavut and Greenland). Canadian Journal of Earth Sciences, 57:16-24

Peng, S.C., Babcock, L.E., Ahlberg, P. 2020. Trilobites. [Subchapter 3A: pp. 36-42] In: Gradstein, F.M., et al. 2020. Geologic Time Scale 2020. Elsevier Publishing, 1357 pp.

Peng, S.C., Babcock, L.E., Ahlberg, P. 2020. The Cambrian Period. [Chapter 19: pp. 565-629] In: Gradstein, F.M., et al. 2020. Geologic Time Scale 2020. Elsevier Publishing, 1357 pp.

Peng, S.C., Yang, X.F., Liu, Y., Zhu, X.J., Sun, H.J., Zamora, S., Mao, Y.Y., Zhang, Y.C. 2020. Fulu biota, a new exceptionally-preserved Cambrian fossil assemblage from the Longha Formation in southeastern Yunnan. Palaeoworld, 29(3):453-461

Pereira, S., Rábano, I., Gutiérrez-Marco, J.C. 2020. The trilobite assemblage of the "*Declivolithus* Fauna" (Katian) of Morocco: a review with new data. Danmarks og Grønlands Geologiske Undersøgelse Rapport, 21:36

Pulsipher, M.A., Schiffbauer, J.D., Jeffrey, M.J., Huntley, J.W., Fike, D.A., Shelton, K.L. 2021. A meta-analysis of the Steptoean positive carbon isotope excursion: The SPICEraq database. Earth-Science Reviews, 212 (103442):1-23

Randolfe, E.A., Rustán, J.J., Bignon, A. 2020. A taxonomic revision of the Early Devonian dalmanitid trilobite *Kasachstania* Maksimova, 1972 from central Kazakhstan. Journal of Paleontology, 94(4):681-695

Rustán, J.J., Waisfeld, B.G., Vaccari, N.E. 2020. The homalonotid trilobite *Burmeisteria* Salter, 1865 in the Lower Devonian of Argentina: new data in the context of southwestern Gondwana. Journal of Paleontology, 94(3):498-512

Saleh, F., Vidal, M., Laibl, L., Sansjofre, P., Gueriau, P., Pérez-Peris, F., Lustri, L., Lucas, V., Lefebvre, B., Pittet, B., El Hariri, K., Daley, A.C. 2020. Large trilobites in a stress-free Early Ordovician environment. Geological Magazine (in press) 10 pp.

Schoenemann, B., Clarkson, E.N.K. 2020. Insights into a 429-million-year-old compound eye. Nature Scientific Reports, 10(12029):1-8

Schöning, H. 2020. Einige Funde von *Heliomera* (Trilobita, Cheiruridae) aus mittelordovizischen Geschieben baltoskandischer Herkunft. [Some specimens of *Heliomera* (Trilobita, Cheiruridae) from Middle Ordovician glacial erratics of Baltoscandian origin.] Archiv für Geschiebekunde, 8(2):94-108

Sepúlveda, A., Zamora, S., Gozalo, R. 2020. The Ontogeny of Cambrian Series 2 Ellipsocephalidae Trilobite *Strenuaeva incondita* Sdzuy 1961 from Purujosa (Iberian Chains, Ne Spain). 2nd Palaeontological Virtual Congress, Book of Abstracts, p. 111

Singh, B.P., Bhargava, O.N. 2020. Cambrian of the Himalaya and the Peninsular India-Biozonation, Depositional Environments and Biogeographic Provinces. Episodes, 43(1):429-437

Singh, B.P., Singla, G., Bhargava, O.N., Kaur, R., Stopden, S. 2020. Miaolingian transgression and the *Oryctocephalus indicus* biozone in the Sumna Valley (Spiti), Himalaya, India. Comptes Rendus Geosciences, 352(2):157-168

Smith, P.M., Ebach, M.C. 2020. A new Ordovician (Katian) calymenid, *Gravicalymene bakeri* sp. nov., from the Gordon Group, Tasmania, Australia. Alcheringa (in press)

Sommers, M.J., Gingras, M.K., MacNaughton, R.B., Fallas, K.M., Morgan, C.A. 2020. Subsurface analysis and correlation of Mount Clark and lower Mount Cap formations (Cambrian), Northern Interior Plains, Northwest Territories. Bulletin of Canadian Petroleum Geology, 68(1):1-29

Song, Z., Xiao, Y., Xiao, C. 2020. Biodiversity changes of the Ordovician trilobites in the middle Yangtze region of South China. Proceedings of the Geologists' Association (in press)

Spalletta, C., Corradini, C., Feist, R., Korn, D., Kumpan, T., Perri, M.C., Pondrelli, M., Venturini, C. 2020. The Devonian–Carboniferous boundary in the Carnic Alps (Austria and Italy). Palaeobiodiversity and Palaeoenvironments, (in press) pp. 1-19

Sun, Z., Zeng, H., Zhao, F. 2020. A new Middle Cambrian trilobite with a specialized cephalon from Shandong Province, North China. Acta Palaeontologica Polonica, 65(4):709-718

Sundberg, F.A. 2020. Trilobite fauna (Wuliuan Stage, Miaolingian Series, Cambrian) of the lower Lakeview Limestone, Pend Oreille Lake, Idaho. Journal of Paleontology Memoir, 94(79):1-49

Sundberg, F.A., Cuen-Romero, F.J. 2021. Trilobites from the *Crepicephalus* Zone (upper Guzhangian Stage, Miaolingian Series, Cambrian) from northern Sonora, Mexico, and its correlation to Arizona and Texas, USA. Journal of South American Earth Sciences (in press)

Sundberg, F.A., Karlstrom, K., Geyer, G., Foster, J.R., Hagadorn, J.W., Mohr, M., Schmitz, M., Dehler, C., Crossey, L., 2020. Asynchronous trilobite extinctions at the early-middle Cambrian transition. Geology, 48:441-445

Terentiev, S.S., Gorshenina, V.V. 2020. Trilobites from biohemal carbonate buildups of the Volkhov Regional Stage (Middle Ordovician) in North-Western Russia. Proceedings of the Paleontological Society of the Russian Academy of Sciences, 3:44-55

Tinn, O., Meidla, T., Ainsaar, L. 2020. Diving with Trilobites: Life in the Silurian–Devonian Seas. pp. 345-366. In: Nature Through Time: Virtual Field Trips Through the Nature of the Past. Springer Textbooks in Earth Sciences, Geography and Environment, 462 pp.

Tortello, M.F. 2020. Elviniid trilobites from the Elvinia Zone (late Cambrian, Furongian) of Mendoza, western Argentina. Journal of Paleontology, 94(5):852-866

Tortello, M.F., Esteban, S.B. 2020. Trilobites and sedimentary settings from the Lower Ordovician (Tremadocian; *Bienvillia tetragonalis* biozone) of Iturbe, Jujuy Province, Argentina. Ameghiniana, 57 (1):9-32

Vannier, J., Vidal, M., Marchant, R., El Hariri, K., Kouraiss, K., Pittet, B., El Albani, A., Mazurier, A., Martin, E, 2020. Author Correction: Collective behaviour in 480-million-year-old trilobite arthropods from Morocco. Nature Scientific Reports, 10(1842):1-2

Van Viersen, A.P. 2020. Nouveaux trilobites dévoniens du Mur des Douaniers (Nord de la France) et quelques associations connexes de Belgique. [New Devonian trilobites from the Mur des Douaniers (Northern France) and several related associations from Belgium.] Fossiles, Revue Française de Paléontologie, 42:42-50

Van Viersen, A.P., Alberti, M. 2020. Eine neue Art von *Arduennella* WENNDORF, 1990 (Trilobita, Homalonotinae). [A new species of *Arduennella* WENNDORF, 1990 (Trilobita, Homalonotinae).] Mainzer Geowissenschaftliche Mitteilungen, 48:33-46

Van Viersen, A.P., Lerouge, F. 2020. Cornuproetine (proetide) trilobites with nine thorax segments from the Devonian of Morocco, Germany and the Czech Republic. Paläontologische Zeitschrift, 94:227-254

Van Viersen, A.P., Taghon, P. 2020. A poorly diversified trilobite association from the lower Emsian (Lower Devonian) in the Sankt Vith area (East Belgium). Geologica Belgica, 23(1-2):19-28

Vodička, J., Laibl, L., Budil, P., Fatka, O., Toman, J. 2020. Morphology of Dacryoconarida and Landmarking of *Placoparia* and "odontochilinid" Trilobites. OSF Preprint – Paleobiological Working Paper

Wang, Y., Peng, J., Wang, Q., Wen, R., Zhang, H., Du, G., Shao, Y. 2020. Moulting in the Cambrian oryctocephalid trilobite *Arthricocephalites xinzhaiheensis* from Guizhou Province, South China. Lethaia, (in

press)
Wang, Z., Chen, J., Liang, T., Yuan, J., Han, C., Liu, J., Zhu, C., Zhu, D., Han, Z. 2020. Spatial variation in carbonate carbon isotopes during the Cambrian SPICE event across the eastern North China Platform. Palaeogeography, Palaeoclimatology, Palaeoecology, 546(109669):1-11
Webster, M., Sundberg, F.A. 2020. Nature and significance of intraspecific variation in the early Cambrian oryctocephalid trilobite *Oryctocephalites palmeri* Sundberg and McCollum, 1997. Journal of Paleontology, 94(1):70-98
Welch, K.F. 2020. Cambrian trilobites from the Steptoean –Sunwaptan boundary interval (Jiangshanian), Nevada and Utah. MSc Thesis, University of Oklahoma, 176 pp.
Wendruff, A.J., Babcock, L.E., Kluessendorf, J., Mikulic, D.G. 2020. Paleobiology and taphonomy of exceptionally preserved organisms from the Waukesha Biota (Silurian), Wisconsin, USA. Palaeogeography, Palaeoclimatology, Palaeoecology, 546(109631):1-16
Wernette, S.J. 2020. Late Cambrian (Furongian) and Lower Ordovician (Tremadocian) trilobites of Sibumasu. PhD Thesis, University California, Riverside
Wernette, S.J., Hughes, N.C., Myrow, P.M., Sardsud, A. 2020. *Satunarcus*, a new late Cambrian trilobite genus from southernmost Thailand and a reevaluation of the subfamily Mansuyiinae Hupé, 1955. Journal of Paleontology, 94(5):867-880
Wernette, S.J., Hughes, N.C., Myrow, P.M., Sardsud, A. 2020. The Furongian (late Cambrian) trilobite *Thailandium*'s endemicity reassessed along with a new species of *Prosaukia* from Ko Tarutao, Thailand. Thai Geoscience Journal, 1(1):63-82
Xu, L., Zhao, Y. 2020. A Preliminary Study of *Mufushania nankingensis* Lin,1965 from the Cambrian "Tsinghsutung Formation" of Balang Village, Jianhe County, Guizhou. Journal of Guizhou University, Natural Sciences, 2020(2):13-17+27
Yuan, J., Gao, J., Ren, G.Y., Wu, T. 2020. Discussion on the Cambrian genus *Shanchengziella*. Acta Palaeontologica Sinica, 59(3):277-284
Yuan, W.W., Zhou, Z.Q., Zhou, Z.Y., Li, Q.J. 2020. Proetid trilobites from the middle Telychian (Llandovery, Silurian) Ningqiang Formation, Shaanxi, China. Palaeoworld, 29(4):672-681
Zhang, Z., Ghobadi Pour, M., Popov, L.E., Holmer, L.E., Chen, F., Chen, Y., Brock, G.A., Zhang, Z. 2021. The oldest Cambrian trilobite – brachiopod association in South China. Gondwana Research, 89:147-167
Zhao, J., Li, Y., Selden, P.A., Cong, P. 2020. New occurrence of the Guanshan Lagerstätte (Cambrian Series 2, Stage 4) in the Kunming area, Yunnan, southwest China, with records of new taxa. Alcheringa, 44 (3):343-355
Zhao, W., Liu, J., Bicknell, R.D.C. 2020. Geometric Morphometric Assessment of Guanshan Trilobites (Yunnan Province, China) reveals a limited diversity of Palaeolenid Taxa. Palaeontologia Electronica, 23 (A22):1-15
Zhao, X.Y., Zhao, Y.L., Xu, L.E., Chen, S.G. 2020. The discovery of the *Bathynotus holopygus* (Hall, 1859) in the Cambrian Kaili Formation of Balang in Jianhe, Guizhou. Acta Palaeontologica Sinica, 59(3):265-276
Zong, R.W. 2020. Coupled exuviae of the Ordovician *Ovalocephalus* (Pliomeridae, Trilobita) in South China and its behavioral implications. PeerJ, 8 (e10166):1-12
Zong, R.W. 2020. Abnormalities in early Paleozoic trilobites from central and eastern China. Palaeoworld (in press)