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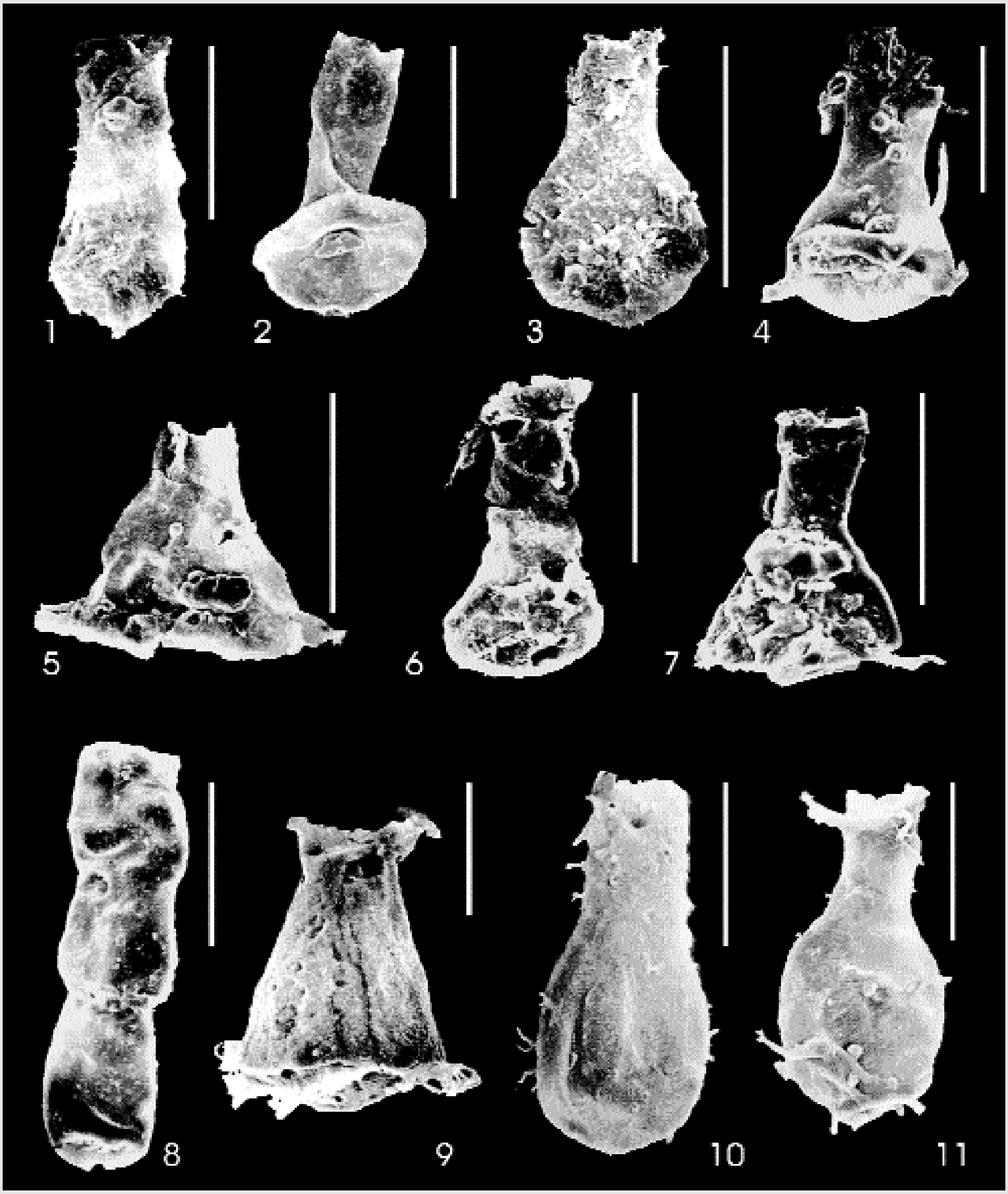

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Portada: Quitinozoos silúrico-devónicos de la cuenca de Chaco-Paraná en Argentina. Microfotografías de Y. Grahn (escala: 100 µm)

Cover: Silurian and Devonian chitinozoans from the Chaco-Paraná Basin in Argentina. Microphotographs by Y. Grahn (scale bar: 100 µm).

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SILURIAN AND DEVONIAN CHITINOZOAN ASSEMBLAGES FROM THE CHACO-PARANÁ BASIN, NORTHEASTERN ARGENTINA AND CENTRAL URUGUAY

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Abstract

The Chaco-Paraná Basin is situated in northeast Argentina and central Uruguay. The basin proper can be subdivided into two sub-basins: the Alhuampa Sub-basin in the northwest, and the Rosario Sub-basin in the southeast. Samples from the Copo, Caburé and Rincón formations in the Alhuampa Sub-basin have yielded diagnostic chitinozoan species. These suggest a Ludlow-early Pridoli age for the Copo Fm., an early Pridoli age for the basal Caburé Fm., and an Eifelian sensu lato-early Givetian age for the Rincón Fm. The upper part of the Caburé Fm. probably is late Lochkovian-early Pragian, and the basal part of the Rincón Fm. can be as old as late Emsian. The evolution of the Rosario Sub-basin was seemingly different, as evidenced by strata in central Uruguay where the Cerrezuelo Fm., equivalent of the Caburé Fm., is overlain by the Early Devonian Cordobés Fm. Further investigations are required in order to confirm whether or not Lower Devonian rocks are present in the Alhuampa Sub-basin.

Keywords: Chaco-Paraná Basin, Chitinozoa, Silurian, Devonian, Argentina, Uruguay.

Resumen

La cuenca de Chaco-Paraná se sitúa en el nordeste de Argentina y centro de Uruguay, y se puede dividir en dos subcuencas: la de Alhuampa en el noroeste y la de Rosario en el sudeste. Las muestras procedentes de las formaciones Copo, Caburé y Rincón en la subcuenca de Alhuampa aportaron especies de quitinozoos diagnósticos que sugieren una edad Ludlow-Pridoli temprano para la Fm. Copo, Pridoli temprano para la base de la Fm. Caburé, y Eifeliense sensu lato-Givetiense temprano para la Fm. Rincón. La parte superior de la Fm. Caburé es probablemente Lochkoviense tardío-Praguiense temprano, y la parte basal de la Fm. Rincón podría ser tan antigua como Emsiense tardío. La evolución de la subcuenca de Rosario fue aparentemente diferente, como se observa en el centro de Uruguay, donde la Fm. Cerrezuelo, equivalente de la Fm. Caburé, subyace a la Fm. Cordobés del Devónico inferior. Hace falta más investigación para confirmar si en la subcuenca de Alhuampa se encuentran rocas del Devónico inferior.

Palabras clave: Cuenca de Chaco-Paraná, quitinozoos, Silúrico, Devónico, Argentina, Uruguay.

INTRODUCTION

Published information about Silurian and Devonian rocks from the Chaco–Paraná Basin is scanty. General information on the Paleozoic pre-Carboniferous rocks was published by Padula *et al*. (1967), Cuerda and Baldis (1971), Mingramm and Russo (1972), Pezzi and Mozetic (1989), Chebli *et al*. (1999), and Milani and Zalán (1999). The lack of outcrops prevented for a long time any information about the geology in the Argentinian part of the Chaco-Paraná Basin. Devonian marine invertebrates from the Chaco-Paraná Basin in Uruguay were first described by Méndez-Alzola (1938), and Lange and Petri (1967) correlated these rocks with Lower Devonian rocks in the Paraná Basin of Brazil. The purpose of this paper is to compare the Silurian and Devonian rocks in Argentina with those of Uruguay and Brazil, which are better known, on the basis of their chitinozoan content.

MATERIAL AND METHODS

The sites of the wells investigated in this paper are shown in Figure 1. A total of 44 samples from the Alhuampa Sub-basin in northeastern Argentina have been examined, and compared with published and unpublished material from the Rosario Sub-basin in Uruguay. The organic residues were studied for chitinozoans using a binocular stereoscopic microscope, and afterwards prepared for miospore and acritarch studies. Representative chitinozoan specimens were picked for scanning electron microscope (SEM) studies in co-operation with BPA (CENPES, Petrobras) in Rio de Janeiro. Sample processing and SEM-preparations were carried out at the Geological Laboratory (LGPA) of the Geological Faculty at Universidade do Estado do Rio de Janeiro (UERJ) according to the techniques described by Laufeld (1974). Photographed materials are stored at the Department of Stratigraphy and Paleontology at UERJ in Rio de Janeiro.

GEOLOGICAL SETTING AND CHITINOZOAN BIOSTRATIGRAPHY

The Chaco-Paraná Basin is an intracratonic basin covering about 500,000 km^2 in northeast Argentina and central Uruguay (Fig. 1). It is also considered as a part of the Paraná Basin sensu lato (see Grahn *et al.*, 2000), and is separated from this basin sensu stricto through the Rio Grande Arch (Fig. 1). Troughs with their axis running ENE – WSW occur in the center of the basin. The Chaco-Paraná Basin is subdivided into two sub-basins separated by the Camilo Aldao High (Fig. 1). These are: the Alhuampa Sub-basin in the northwest, delimited by the Pampean Ranges in the west and Cretaceous basalts in the northeast (Milani and Zalán, 1999), and the Rosario Sub-basin in the southeast (Fig. 1). Sediment accumulation on the basement was initiated by the Early Silurian glaciations recorded by diamictites of the Zapla Formation (Grahn and Gutiérrez, 2001). A SW-NE striking depocenter, the Las Breñas low, is known in the center of the basin (Pezzi and Mozetic, 1989; Milani and Zalán, 1999). The Silurian and Devonian sedimentation expanded the depositional area of the basin beyond its present day extension. A hiatus separates the glacial beds and the transgressive Late Silurian shales of the Copo Formation. Outcrops of Devonian rocks are only known from the Rosario Sub-basin in Uruguay, and these show similarities to those in the Paraná Basin of south Brazil. The Late Silurian and Devonian rocks investigated are described below.

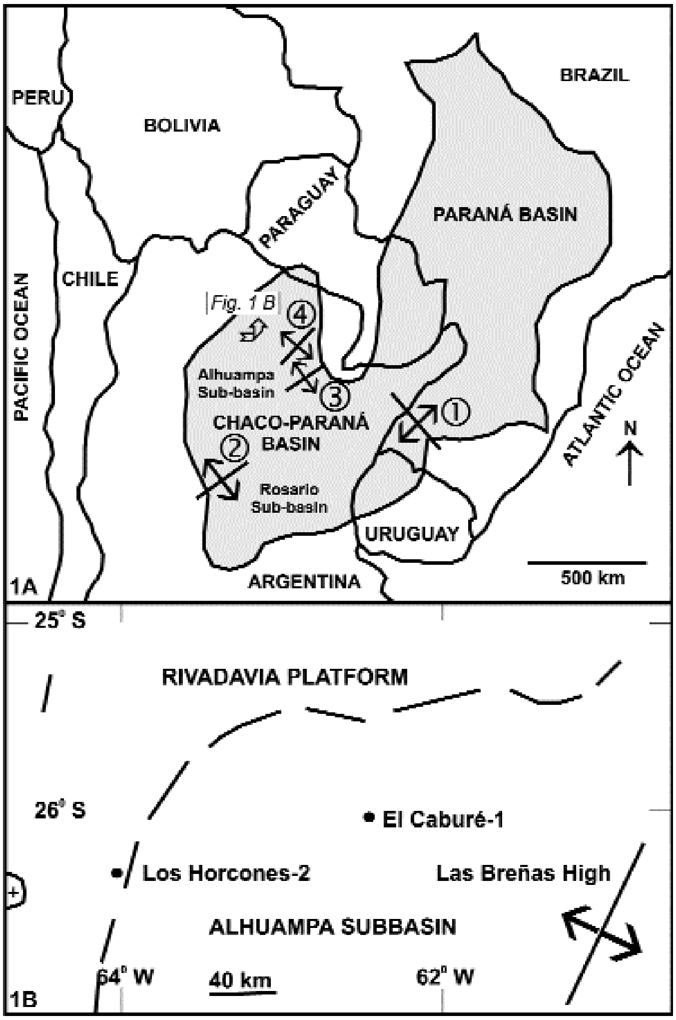


FIGURE 1–A. Map showing the extension of the Paraná and Chaco-Paraná basins in South America. 1. Rio Grande Arch. 2. Camilo Aldao High. 3. Saens Peña High. 4. Las Breñas High. B. Map showing the geographic position of the investigated wells (marked with a black dot). + = presence of igneous and metamorphic rocks. Dashed line shows the outline of upper Paleozoic basin.

Copo Formation.–The Argentinian oil company Yacimentos Petrolíferos Fiscales (nowadays Repsol) defined this formation in 1965 (Padula *et al*., 1967) for a lower shaly part of the Santiago del Estero Group in well Los Horcones-1, situated in Copo County, Province Santiago del Estero. The lithology consists of dark fissile and bituminous shales which yield marine invertebrate fossils (trilobites, brachiopods and orthoceratites) and palynomorphs (acritarchs and chitinozoans) in the upper part. The thickness is estimated to about 350 m (Chebli *et al*., 1999). In well El Caburé-1 (Figs. 1-2), a diagnostic chitinozoan assemblage occurs in the upper Copo Fm., including *Angochitina* sp. (Plate 1, Fig. 1), *Fungochitina kosovensis*? Paris and Kriz, 1984 (Plate 1, Fig. 2), *Angochitina* aff. *A. filosa* Eisenack,1955 (Plate 1, Fig. 3), *Ancyrochitina* n.sp. A (Plate 1, Fig. 4), *Plectochitina*? sp. (Plate 1, Fig. 5), *Ancyrochitina* sp. (Plate 1, Fig. 7), and *Cingulochitina* aff. *C. serrata* (Taugourdeau and Jekhowsky, 1960) (Plate 1, Fig. 8). *F. kosovensis* sensu stricto is a widely distributed species in the early Pridoli strata of the world (Verniers *et al*., 1995), and *Angochitina filosa* sensu stricto is known from late Silurian sensu lato and early Lochkovian beds (Eisenack, 1955; Wrona, 1980). The presence of *Ancyrochitina* n.sp. A suggests a Ludlow age for that part of the Copo Fm. This very characteristic species is known from coeval beds in the Amazonas (unpublished material), Peru-Bolivia (Grahn, 2002) and Tarija (Grahn and Gutiérrez, 2001) basins. The chitinozoans indicate a Ludlow to early Pridoli age for the Copo Fm., which is the same age span of the Kirusillas Fm. in Bolivia and Argentina (Grahn and Gutiérrez, 2001; Grahn, 2002). Pöthe de Baldis (1971, 1974) discussed the palynology of the Copo Formation and suggested a Ludlow age, and Rubinstein (1995, 1997, 2001) revised the acritarch assemblages favouring a late Wenlock age. Coeval beds are not known in Uruguay.

Caburé and Cerrezuelo formations.–The Caburé Fm., defined by Padula *et al*. (1967), constitutes the middle, sandier part within interbedded shales of the Santiago del Estero Group. The Cerrezuelo Fm., defined by Lambert (1939), is a sandstone unit with interbedded shales in Uruguay, and constitutes the lower unit of the Durazno Group (Terra-Arocena and Méndez-Alzola, 1939). The thickness is estimated at 500 m for the Caburé Fm. (Chebli *et al*., 1999) and 210 m for the Cerrezuelo Fm. The latter yields trace fossils and land plant (Rhyniophytes) remains (Sprechmann *et al.*, 1993). Chitinozoans are present in the lower Caburé Formation in well Caburé-1, including *Fungochitina kosovensis*?, *Angochitina* aff. *A. filosa*, *Ancyrochitina* sp., and and *Clathrochitina* sp. A (Plate 1, Fig. 9). This assemblage suggests a probable early Pridoli age for the basal Caburé Fm. Milani and Zalán (1999) compare the Caburé Fm. with the Furnas Formation in the Paraná Basin. The top of Furnas Fm. is dated palynologically as not older than late

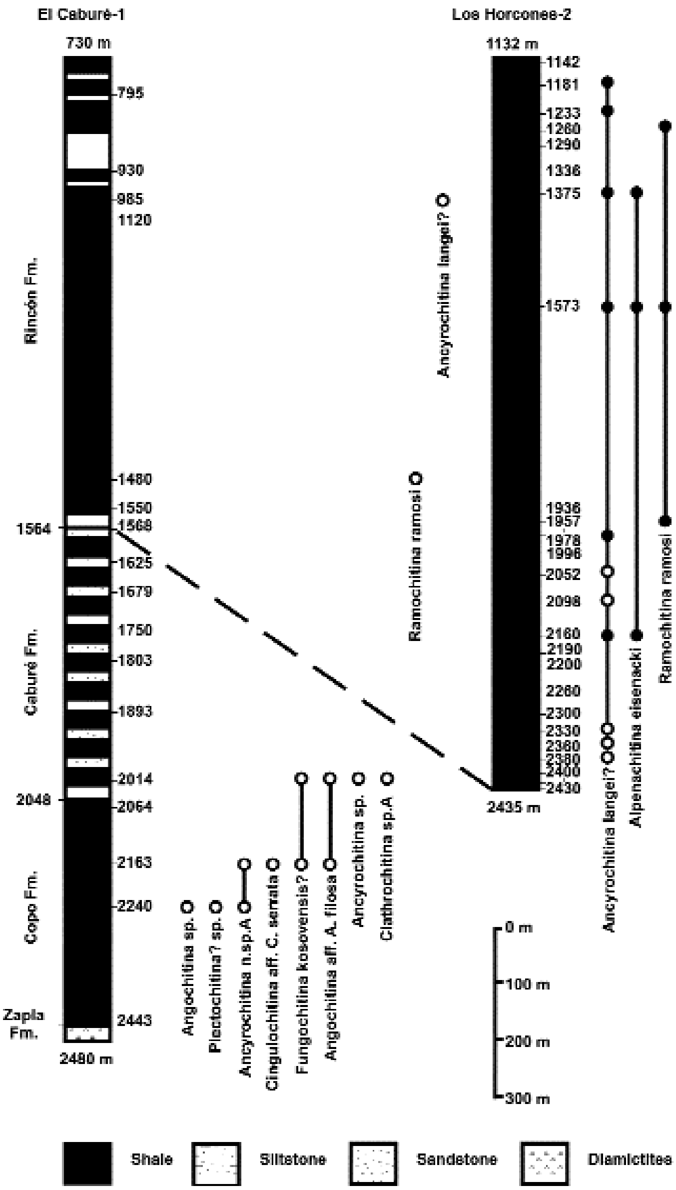


FIGURE 2–Lithologic column and chitinozoan range chart for the El Caburé-1 and Los Horcones-2 wells. Black dots indicate core samples and open circles cuttings. Dashed line shows the correlation of the base of Rincón Formation.

Lochkovian and not younger than early Pragian (Loboziak *et al*., 1995), but the unit's base remains undated. If a correspondence between the Caburé, Cerrezuelo and Furnas fms is accepted, these mainly sandy units range in age from early Pridoli to possibly early Pragian (Fig. 3). Gerrienne *et al*. (2001) dated the uppermost Furnas Formation with spores as early Lochkovian. They extended the Lochkovian age assignment to the overlying unit in the Paraná Basin, the lower Ponta Grossa Fm., since the chitinozoan index species for the Pragian, *Ramochitina magnifica*, occurs together with late Lochkovian spores in well cuttings from the Madre de Dios Basin, north Bolivia (Vavrdová *et al*., 1996), and in cores from well Asuncion-1, east Paraguay (see Grahn *et al*., 2000). A similar age could also be the case for the upper Santa Rosa Formation in south and central Bolivia (see Grahn, 2002). However, *R. magnifica* is present in the lower Icla Formation from the same area (Grahn, 2002) together with Pragian spores (e.g. *Dictyotriletes* cf. *subgranifer*). Furthermore, it occurs above latest Lochkovian chitinozoans (dated as Lochkovian-Pragian transition with miospores in the Solimões Basin by Melo, 2002 and Melo and Lobozioak, in press) in the Puesto el Tigre Formation, northwestern Argentina (Volkheimer *et al*., 1986). *Ramochitina magnifica* therefore probably range from latest Lochkovian to early Pragian.

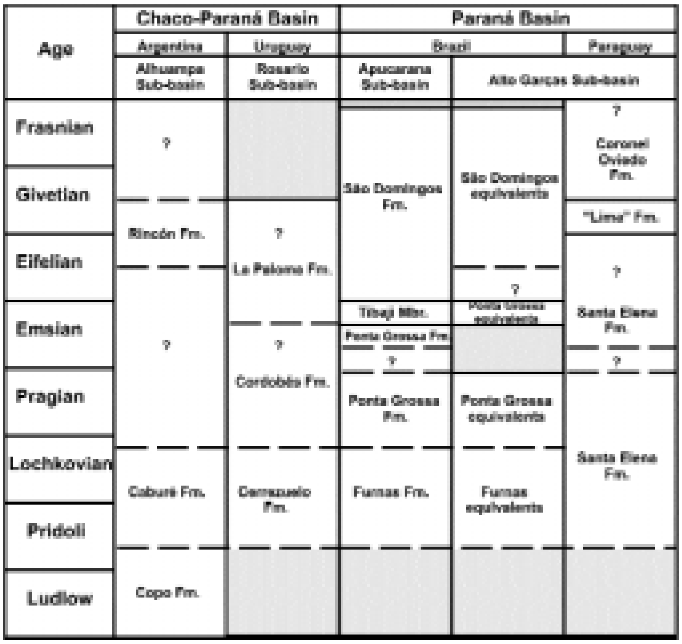


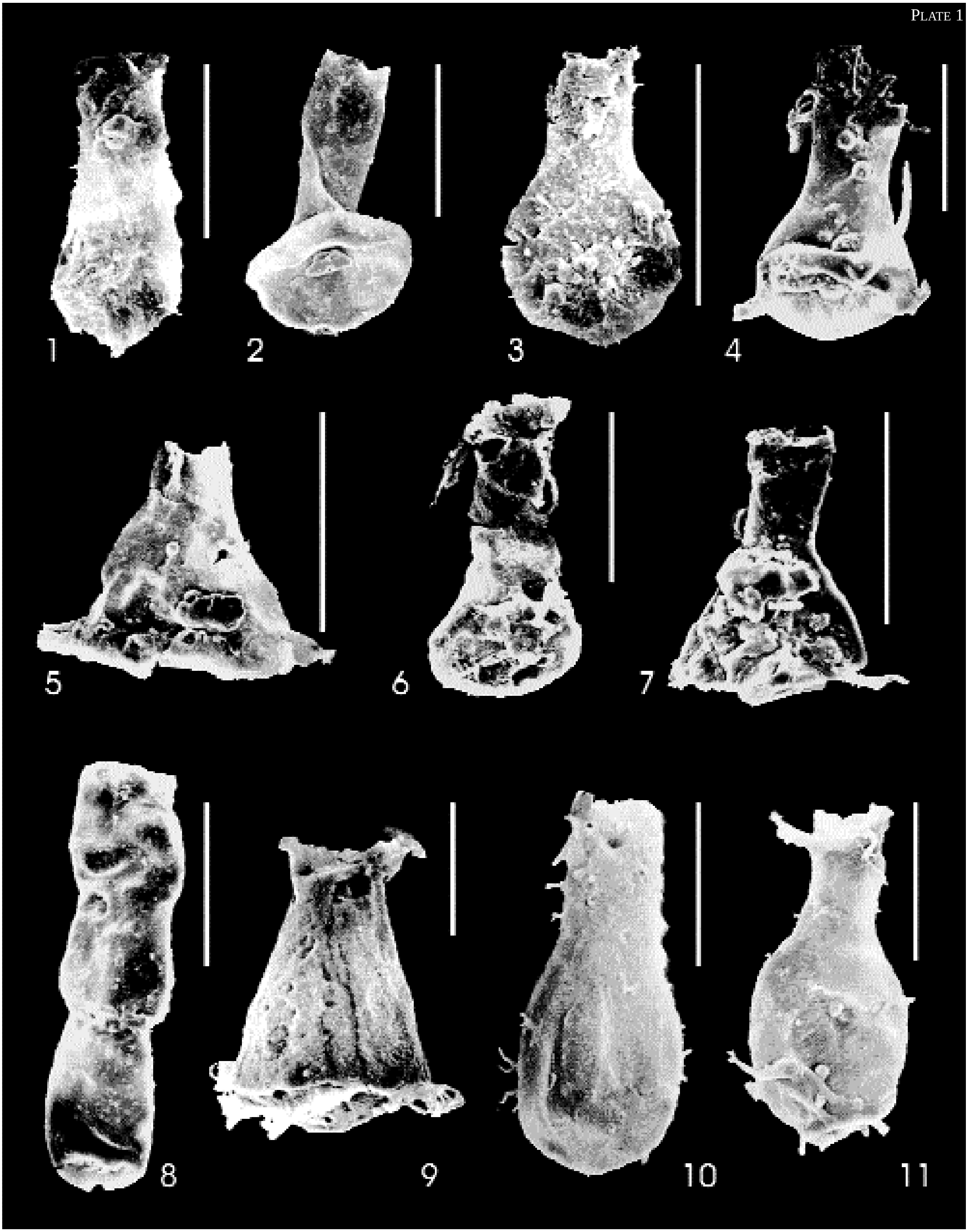
FIGURE 3–Comparison of the chitinozoan biostratigraphy in the Chaco-Paraná and Paraná basins. Undesignated intervals with pale grey background represent stratigraphic hiatuses.

Cordobés Formation.–Cordobés Formation was introduced by Bossi (1966). The lithology consists of grey shales with interbedded levels of siltstone and sandstone. The formation yields a rich marine invertebrate fauna comprising brachiopods, bivalves, tentaculitids, trilobites, conulariids and others (Sprechmann *et al.*, 1993). The maximum thickness is estimated to 117 m. Most of the megafossils are also known from the Ponta Grossa Fm. sensu stricto (Lange and Petri, 1967; Grahn *et al*., 2000) in the Paraná Basin, which suggests a Pragian – Emsian age with non-sedimentation during the early Emsian. This is in agreement with the palynomorphs (Pöthe de Baldis, 1978). Finds of chitinozoans in the lower part of the Cordobés Formation, i.e. *Ramochitina magnifica* by Grahn *et al.* (2000) (= *Alpenachitina eisenacki* later reidentified as *Ramochitina ramosi* by Oliveira and Barbé, 1994, 1997), *Hoegisphaera* cf. *H. glabra* (= *Hoegisphaera* sp. A by Oliveira and Barbé, 1994), and possibly *R. ramosi* (= *Angochitina devonica* by Oliveira and Barbé, 1994. However, *A. devonica* is not known from the Paraná and Chaco-Paraná basins) are identical with those of the lower Ponta Grossa Fm. sensu stricto in Brazil (Grahn *et al.*, 2000). Thus confirming a late Lochkovian-early Pragian age for the lower Cordobés Fm.

→

PLATE 1–Chitinozoan species from the Chaco-Paraná Basin. The scale bars represent 100 µm. *1, Angochitina* sp. Well El Caburé-1, Copo Fm., cuttings 2240 m. *2, Fungochitina kosovensis?* Paris and Kriz, 1984. Well El Caburé-1, Copo Fm., cuttings 2163 m. *3, Angochitina* aff. *A. filosa* Eisenack, 1955. Well El Caburé-1, Copo Fm., cuttings 2163 m. *4, Ancyrochitina* n.sp. A. Well El Caburé-1, Copo Fm., cuttings 2163 m. *5, Plectochitina*? sp. Well El Caburé-1, Copo Fm., cuttings 2240 m. *6, Ancyrochitina langei*? Sommer and van Boekel, 1964. Well Los Horcones-2, Rincón Fm., core 1573 m. *7, Ancyrochitina* sp. Well El Caburé-1, Caburé Fm., cuttings 2014 m. *8, Cingulochitina* aff. *C. serrata* (Taugourdeau and Jekhowsky, 1960). Well El Caburé-1, Copo Fm., cuttings 2163 m. *9, Clathrochitina* sp. A. Well El Caburé-1, Caburé Fm., cuttings 2014 m. *10, Ramochitina ramosi* Sommer and van Boekel, 1964. Well El Caburé-1, Rincón Fm., cuttings 1480 m. *11, Alpenachitina eisenacki* Dunn and Miller, 1964. Well Los Horcones-2, Rincón Fm., core 2160 m.

PLATE 1



La Paloma Formation – Terra-Arocena and Méndez-Alzola (1939) introduced the term “areniscas y conglomerados de La Paloma”, and Bossi (1966) formalized it as the La Paloma Formation. The lithology is predominantly sandstone. Trace fossils and a few tentaculitids (Sprechmann *et al.*, 1993) are known from the formation. The maximum thickness is 55 m. The base of the formation should not be older than latest Emsian in view of its stratigraphic position. No chitinozoan finds have been reported from the formation.

Rincón Formation.–The formation was named by Padula *et al.* (1967) to designate black, laminated and micaceous shales in the upper part of the Santiago del Estero Group. The thickness is at least 1300 m. Trilobites, brachiopods and orthoceratites suggest an Early Devonian age according to Castellaro (1966), but the chitinozoans indicate an Eifelian sensu lato-early Givetian age (Paris *et al.*, 2000) in accordance with Mingramm and Russo (1972). Grahn and Gutiérrez (2001) mentioned, for instance, *Alpenachitina eisenacki* and *Ancyrochitina* n.sp.1 (not found in this study) within the interval 1810-2132 m of the Los Horcones-2 well. Other species present in the Rincón Fm. are *Ramochitina ramosi* Sommer and van Boekel, 1964 and *Ancyrochitia langei*? Sommer and van Boekel, 1964. No Early Devonian age can be established for the lower part of the Rincón Fm, and the stratigraphy above the Caburé Fm. is different from that above the Cerrezuelo Fm. in Uruguay. It should be noted that no core samples were made available from the lower Rincón Fm., and the presence of *Ramochitina ramosi* at 1480 m in the El Caburé-1 well does not exclude a late Emsian age for that part.

CONCLUDING REMARKS

The chitinozoans, like all other palynomorphs, are badly preserved in the Paleozoic pre-Carboniferous beds from the Chaco-Paraná Basin. The chitinozoan assemblages also display low abundance and diversity comparing to the adjacent Peru-Bolivia (Grahn, 2002), Tarija (Grahn and Gutiérrez, 2001) and Paraná (Grahn *et al.*, 2000, 2002) basins. In the Alhuampa Sub-basin two distinct assemblages can be separated, one Ludlow-early Pridoli and another Eifelian sensu lato-early Givetian. In the Rosario Sub-basin also a late Lochkovian-Pragian chitinozoan assemblage is present. The Copo Formation is of Ludlow-early Pridoli age and corresponds to the Kirusillas Fm. in northwest Argentina and Bolivia. The Caburé and Cerrezuelo formations in the Chaco-Paraná Basin are seemingly coeval with the Furnas Fm. in the Paraná Basin, and may therefore be of an early Pridoli-late Lochkovian to early Pragian age. The Rincón Fm. differs in age from the Cordobés Fm in the Rosario Sub-basin and the Ponta Grossa Fm. sensu stricto in the Paraná Basin, the two latter overlies the Cerrezuelo and Furnas fms., respectively. The true nature of the lower Devonian strata in the Alhuampa Sub-basin requires more investigations.

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LATEST DEVONIAN AND EARLY CARBONIFEROUS PTERIDOPHYTIC SPORES FROM THE SEKONDI GROUP OF GHANA

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Abstract

Pteridophytic spores recovered from the Takoradi Shale Formation at Essipon Beach near Sekondi in western Ghana are abundant and diverse. They are mainly trilete spores, both laevigate and sculptured. In all, 36 species are described and illustrated. The spores and the alga *Tasmanites* indicate a freshwater swamp or marsh environment of deposition. Organic-walled microplankton (acritarchs) associated with the spores imply marine or brackish incursions. Stratigraphically significant spore taxa indicate a latest Devonian (Strunian Tn 1a)–Early Carboniferous (Tournaisian Tn 1b) age for the sediments by comparison with similar taxa reported especially from western Europe, the former USSR and North America.

Keywords: Devonian, Carboniferous, Spores, Pteridophytes, Ghana.

Resumen

Se describe la presencia abundante y diversa de esporas de pteridofitas en la Formación Takoradi Shale, en Essipon Beach, en las cercanías de Sekondi, oeste de Ghana. Principalmente son esporas de tipo triletes, lisas y ornamentadas. Se describen e ilustran 36 especies. Las esporas y los restos del alga *Tasmanites* indican la existencia de un medio de deposición de tipo pantano o marisma. La presencia de microplancton de paredes orgánicas (acritarcos) asociado con las esporas indica la existencia de incursiones marinas o salobres. La presencia de determinados taxones de esporas significativas desde el punto de vista estratigráfico indica una edad Devónico Superior (Struniense Tn 1a)–Carbonífero Inferior (Tournaisiense Tn 1b) cuando se comparan con asociaciones similares descritas en Europa occidental, en la antigua URSS y Norteamérica.

Palabras clave: Devónico, Carbonífero, Esporas, Pteridofitas, Gana.

INTRODUCTION

The Takoradi Shale rock samples, which form the basis of this study, belong to the Sekondi Group outcropping onshore in Ghana. The rocks form part of the middle formations of the Sekondi Group exposed along the coastal belt of Ghana as a number of disconnected, block-faulted outcrops between the mouth of the Butre River to the west and Cape Coast to the east. Samples collected were from Essipon Beach northeast of Sekondi (Text-fig. 1). These block-faulted outcrops or horst and graben tectonic blocks are a result of the rifting of the South American continent from the African continent in early Mesozoic times.

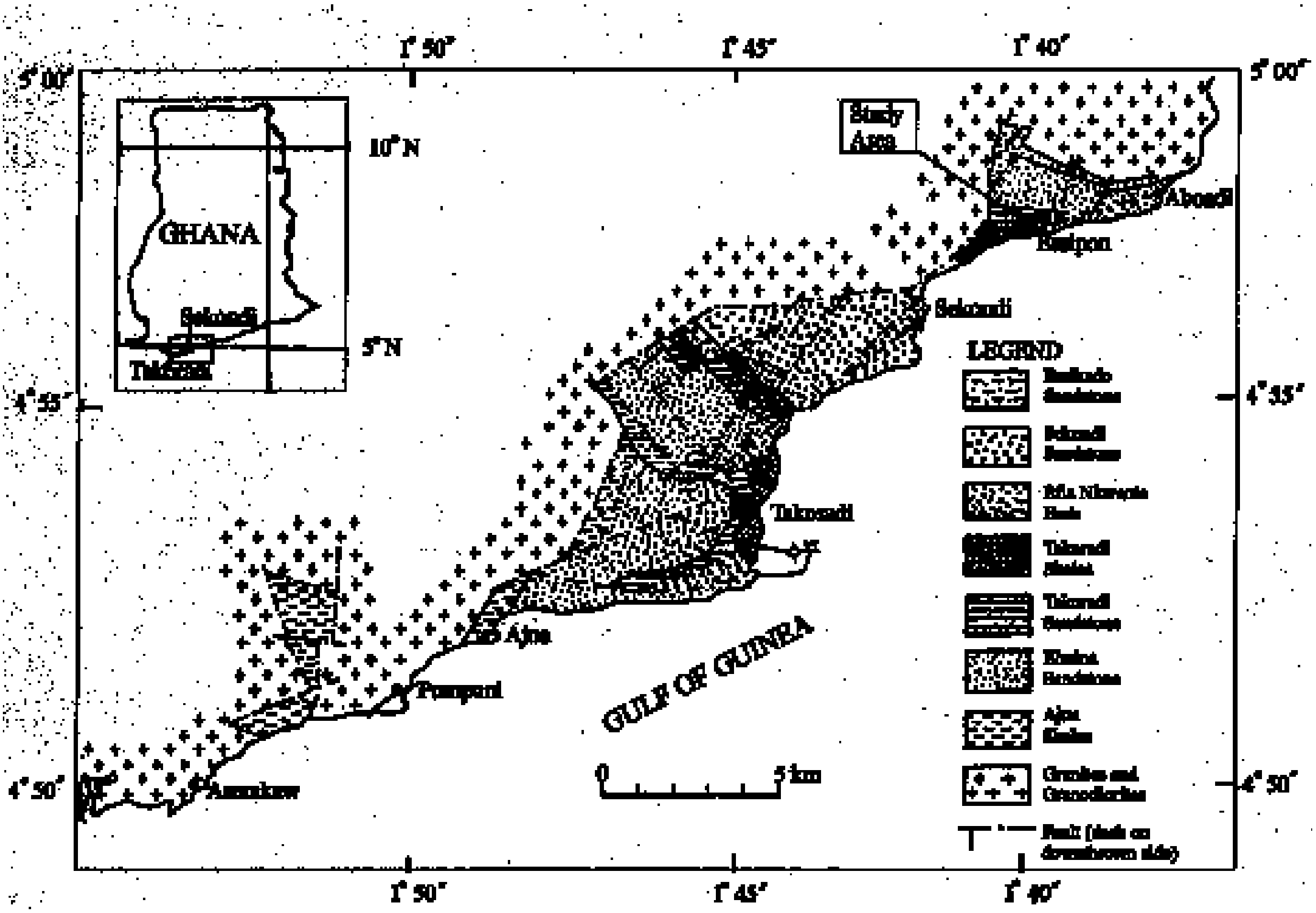
The Takoradi Shales are characteristically black or dark grey compact mudstone and shale rich in carbonaceous matter and pyrite, which is either finely disseminated or occurs as aggregates of cubic crystals. At the base, thin-bedded micaceous sandstones alternate with grey shales. The upper part of the succession shows interbedded grey-green grit bands and nodules of fine, grey lenticular sandstones up to several metres thick. Also included are siderite nodules and gypsum which occurs as thin veins traversing the shale and paralleling bedding planes. The formation contains fish and plant remains as well as molluscs, and is about 200 m thick.

Spores recovered from the the Takoradi Shales at Essipon Beach are described herein, and are used to deduce the depositional environment and age of the strata.

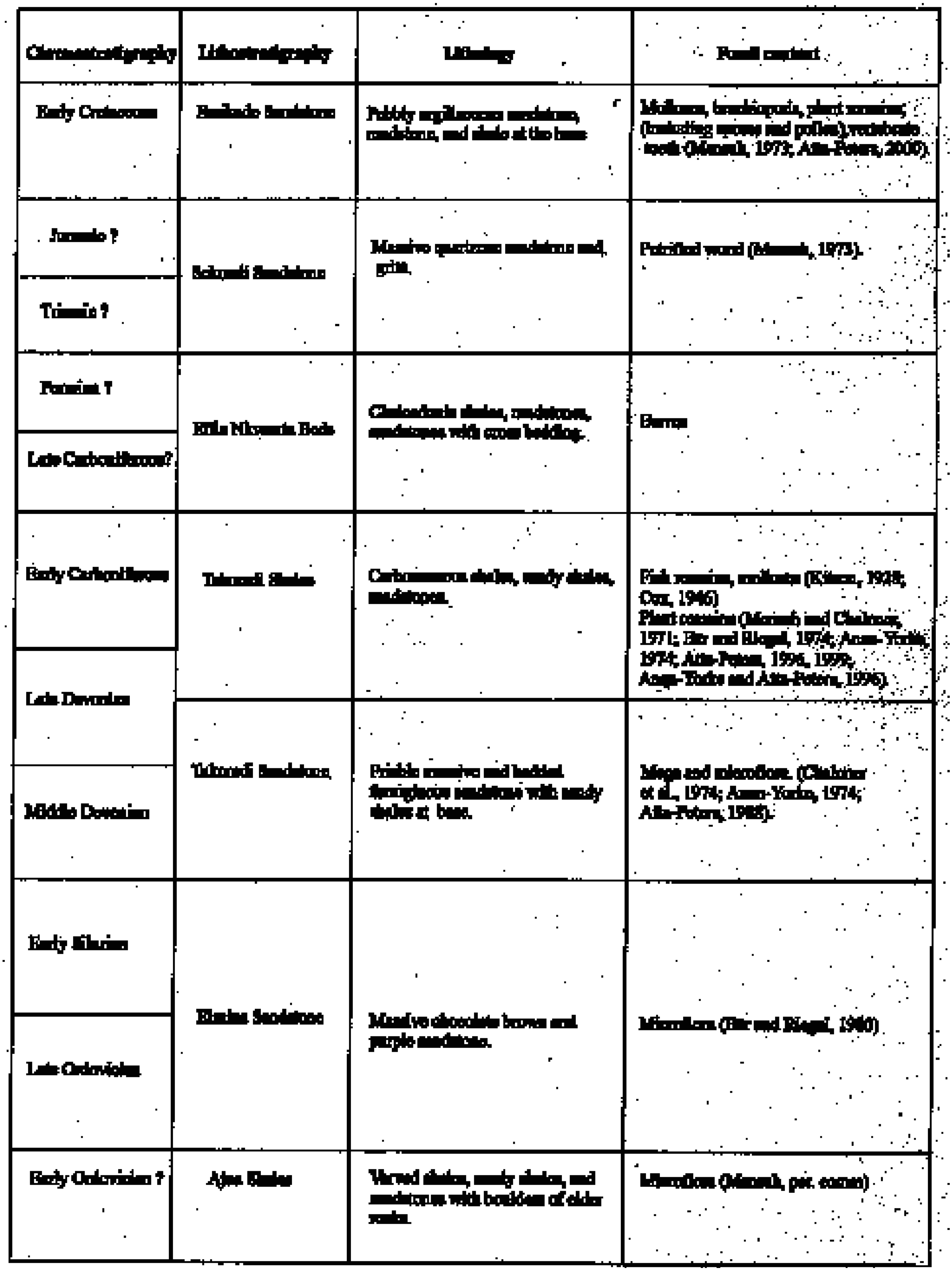
STRATIGRAPHY OF THE SEKONDI GROUP

Mensah (1973) raised the "Sekondi Series" to group status. The group ranges from ?Early Ordovician to Early Cretaceous, and is not confined to the Devonian or Carboniferous as had been assumed by earlier workers. The Sekondi Group covers an area of about 200 km^2 onshore with a thickness of about 1200 m. It consists mainly of feldspathic sandstone, siltstone, and shale resting unconformably on a complex of hornblende granite of the Dixcove type, biotite granite of the Cape Coast type, and schists and granulites which are probably metamorphosed and partly granitized Birimian rocks of Precambrian age.

Crow (1952) recognized six formations within the Sekondi Group. Mensah (1973), however, recognized a seventh unit by proposing the Essikado Sandstone for the upper part of the Sekondi Sandstone. Table 1 summarizes the stratigraphy of the Sekondi Group.



TEXT-FIGURE 1–Geological map of the Sekondi Group, Sekondi-Takoradi area showing study area (modified after Atta-Peters, 2000).



Chronostratigraphy	Lithostratigraphy	Lithology	Fossil content
Early Cretaceous	Essikado Sandstone	Pebbly argillaceous sandstone, sandstone, and shale at the base	Molluscs, brachiopods, plant remains; (including spores and pollen) vertebrate teeth (Mensah, 1973; Atta-Peters, 2000).
Jurassic ?	Sekondi Sandstone	Massive quartzose sandstone and grits.	Petrified wood (Mensah, 1973).
Triassic ?			
Permian ?	Efia Nkwanta Beds	Glaciofluvial shales, sandstones, sandstones with cross bedding.	Burrows
Late Carboniferous?			
Early Carboniferous	Takoradi Shales	Carbonaceous shales, sandy shales, mudstones.	Fish remains, molluscs (Kitson, 1928; Cox, 1946) Plant remains (Mensah and Chaloner, 1971; Bär and Riegel, 1974; Anan-Yorke, 1974; Atta-Peters, 1996, 1999; Anan-Yorke and Atta-Peters, 1996).
Late Devonian	Takoradi Sandstone	Friable massive and bedded ferruginous sandstone with sandy shales at base.	Mega and microflora. (Chaloner et al., 1974; Anan-Yorke, 1974; Atta-Peters, 1988).
Middle Devonian			
Early Silurian	Elmina Sandstone	Massive chocolate brown and purple sandstone.	Microflora (Bär and Riegel, 1980)
Late Ordovician			
Early Ordovician ?	Ajua Shales	Varved shales, sandy shales, and sandstones with boulders of older rocks.	Microflora (Mensah, per. comm)

TABLE 1–Stratigraphy of the Sekondi Group (modified after Atta-Peters, 2000).

MATERIALS AND METHODS OF STUDY

Twenty-three rock samples obtained from Essipon Beach, about 1.6 km east of the Naval Base at Sekondi (see Text-fig. 1), were used for this study. Sandstones, sandy shales and grey to black shales were processed for palynomorphs.

Standard laboratory techniques for the preparation of acid insoluble microfossils were followed, using 32% hydrochloric acid, 60% hydrofluoric acid, Schulze solution, 2% potassium hydroxide, and separation by zinc bromide (S.G. 2.8). The palynomorphs were strew mounted in glycerine jelly and sealed in Canada balsam. Three or four slides (depending on the amount of residue) were made from each sample. Leitz Wetzlar microscope (MM 65/59) and Zeiss Photomicroscope III were used in the study of the palynomorphs and photography.

SYSTEMATIC PALYNOLOGY

The suprageneric classification of spores follows that initiated by Potonié and Kremp (1954), and Potonié (1956, 1958, 1960), and revised in part by Dettmann (1963) and Smith and Butterworth (1967). For nomenclature and rules on priority and typification the International code of Botanical Nomenclature (ICBN Stafleu *et al*., 1978) is followed. The binomial system is adopted for previously, formally named spores whilst only form genus is applied to forms with insufficient characters for specific characterization or identification. No attempt is made in this work to redescribe taxa that have already been adequately described by previous workers.

Anteturma SPORITES H. Potonié, 1893
Turma TRILETES Reinsch emend. Dettmann, 1963
Supersubturma ACAVATITRILETES Dettmann, 1963
Subturma AZONOTRILETES Luber emend. Dettmann, 1963
Infraturma LAEVIGATI Bennie and Kidston *emend.* Potonié, 1956
Genus *Punctatisporites* Ibrahim *emend.* Potonié and Kremp, 1954
Punctatisporites irrasus Hacquebard, 1957
(Pl. 1, Fig. 5)

Dimensions.–Equatorial diameter 68-80 µm, mean 72 µm (12 specimens measured).

Remarks.–The suturae are distinct with narrow labra. Exine is laevigate to scabrate; large compression folds are common. The size of the specimen falls within the ranges 59-98 µm and 50-92 µm recorded by Dolby and Neves (1970) and Higgs *et al*. (1988) respectively.

Occurrence.–LE – VI Biozones.

Genus *Plicatispora* Higgs, Clayton and Keegan, 1988
Plicatispora quasilabrata (Higgs) Higgs, Clayton and Keegan, 1988
(Pl. 1, Fig. 6)

Dimensions.–Equatorial diameter 63-72 µm, mean 67 µm (10 specimens measured).

Remarks.–*P. quasilabrata* is distinguished from other forms of *Plicatispora* by its large distal fold, which is characteristically triradiate.

Occurrence.–LE – VI Biozones.

Genus *Retusotriletes* Naumova *emend*. Streel, 1964
Retusotriletes crassus Clayton, Johnston, Sevastopulo and Smith, 1980
(Pl. 1, Fig. 4)

Dimensions.–Equatorial diameter 60-72 µm, mean 65 µm (6 specimens measured).

Remarks.–This specimen is similar to *Retusotriletes* sp. A of Higgs (1975). *R. crassus* is distinguished from other species of *Retusotriletes* by the characteristically large and uniformly thickened and darkened contact areas.

Occurrence.–LE – VI Biozones.

Retusotriletes incohatus Sullivan, 1968
(Pl. 1, Fig. 3)

Dimensions.–Equatorial diameter 58-75 µm, mean 65 µm (25 specimens measured).

Remarks.–*R. incohatus* has smooth contact areas with suturae terminating in curvatura perfectae. It is very simlar to *R. simplex* Naumova; however, the latter differs in possessing simple suturae, smaller size and absence of equatorial darkenings outside the contact area.

Occurrence.–LE – VI Biozones.

Retusotriletes leptocentrum Higgs, 1975
(Pl. 1; Figs. 1, 2)

Dimensions.–Equatorial diameter 63-74 µm, mean 68 µm (10 specimens measured).

Remarks and comparison.–The size range of the specimen falls within that originally described by

Higgs (1975). *R. leptocentrum* differs from all other previously described forms of *Retusotriletes* by its uniformly thin walled triangular apical zone. *R. Phillipsii,* described by Clendening *et al.* (1980), also has a thin apical area but differs by having fine ribs radiating from the apex.

Occurrence.–LN – VI Biozones.

Infraturma APICULATI Bennie and Kidston *emend.* Potonié, 1956

Subinfraturma VERRUCATI Dybová and Jachowicz, 1956

Genus *Verrucosisporites* Ibrahim *emend.* Smith and Butterworth, 1967

Verrucosisporites mesogrumosus (Kedo) Byvsheva, 1985

(Pl. 1, Figs. 11, 12)

Dimensions.–Equatorial diameter 50-63 µm, mean 55 µm (10 specimens measured).

Remarks.–The low stumpy nature of the irregularly distributed and widely spaced verrucae distinguishes this species from other forms of *Verrucosisporites*.

Occurrence.–VI Biozone.

Verrucosisporites nitidus (Naumova) Playford, 1964

(Pl. 1; Figs. 7, 8)

Dimensions.–Equatorial diameter 56-65 µm, mean 61 µm (15 specimens measured).

Remarks.–The specimen is characterized by closely packed, dome-shaped and regularly spaced verrucae separated by a negative reticulum. Turnau *et al.* (1994) have indicated from palynostratigraphic and other biostratigraphic data that *V. nitidus* first appears in the late Strunian in North America, British Isles, Rheinisches Schiefergebirge, and the Russian Platform.

Occurrence.–LN – VI Biozones.

Verrucosisporites scurrus (Naumova) McGregor and Camfield, 1982

(Pl. 1; Figs. 9, 10)

Dimensions.–Equatorial diameter 58-80 µm, mean 68 µm (10 specimens measured).

Comparison.–This species differs in ornamentation from *V. nitidus,* because the latter has only rounded verrucae, whilst *V. scurrus* has a mixture of verrucae, cones and rugulae with rounded tops.

Occurrence.–VI Biozone.

Subinfraturma BACULATI Dybová and Jachowicz, 1957

Genus *Raistrickia* Schopf, Wilson and Bentall *emend.* Potonié and Kremp, 1954

Raistrickia corynoges Sullivan, 1968

(Text-Fig. 2; 1-2)

Dimensions.–Equatorial diameter (excluding projections) 58-64 µm, mean 60 µm (10 specimens measured).

Comparison.–*R. corynoges* differs from *R. variabilis* Dolby and Neves, 1970 in possessing densely distributed bacula which are often fused at the base, with parallel to tapering sides and rounded to truncated ends.

Occurrence.–VI Biozone.

Raistrickia sp.

(Text-Fig. 2; 3, 5, 6)

Description.–Trilete radial spores; amb subcircular to circular. Suturae simple, straight, extending two-thirds of distance to equator. Exine 2-2.5 µm thick and ornamented with dense pila. Pila 4-10 µm high, and 5-0 µm wide.

Dimensions.–Equatorial diameter (excluding pila) 54-66 µm, mean 59 µm (5 specimens measured).

Remarks.–The pila of this form are comparable to, but considerably longer than those of *R. clavata* (Hacquebard) Playford, 1964.

Occurrence.–VI Biozone.

Infraturma MURORNATI Potonié and Kremp, 1954

Genus *Cordylosporites* Playford and Satterthwait, 1985

Cordylosporites marciae Playford and Satterthwait, 1985

(Pl. 2, Fig. 19)

Dimensions.–Equatorial diameter 68-80 µm, mean 75 µm (7 specimens measured).

Remarks.–Playford and Satterthawait (1985) remarked that spores of this genus should be considered as members of Infraturma Murornati and not Cingulati. This is because the equatorial or subequatorial muri may present a flange-like appearance in a polar compression, but they are entirely comparable morphologically to the muri developed adjacently or distally.

Occurrence.–VI Biozone.

Cordylosporites spathulatus (Winslow) Playford and Satterthwait, 1985
(Text-Fig. 2, 4)

Dimensions.–Equatorial diameter 56-72 µm, mean 65 µm (6 specimens measured).

Comparison.–*C. spathulatus* differs from *Dictyotriletes fimbriatus* (Winslow) Kaiser, 1970 in having an incomplete reticulum and pronounced bacula.

Occurrence.–VI Biozone.

Genus *Convolutispora* Hoffmeister, Staplin and Malloy, 1955

Convolutispora caliginosa Clayton and Keegan in Clayton *et al.*, 1982
(Pl. 1, Fig. 18)

Dimensions–Equatorial diameter 69-88 µm, mean 78 µm (8 specimens measured).

Remarks and comparison.–*C. caliginosa* bears dense ornament of short, rounded to irregularly shaped anastomosing ridges and occasional verrucae. *Convolutispora* sp. A of Playford (1976) is comparable to *C. caliginosa* in its non-reticulate sculpture composed of discrete irregular rugulae and minor verrucae, but has a thicker exine (5– 7 µ) than that of *C. caliginosa* (4–5 µ).

Occurrence.–VI Biozone.

Convolutispora vermiformis Hughes and Playford, 1961
(Pl. 1, Fig. 19)

Dimensions.–Equatorial diameter 60-72 µm, mean 67 µm (10 specimens measured).

Remarks.–The species is characterized by its broad, coarse, irregularly shaped, non-overlapping rugulae that impart a scalloped equatorial outline. They are fairly loosely distributed and sometimes enclose distinct lumina.

Occurrence.–LE – VI Biozone.

Convolutispora sp
(Text-Fig. 2, 8)

Description.–Trilete radial spores; amb rounded. Suturae distinct, straight and simple; length two-thirds of spore radius. Proximal and distal surface ornamented with small closely spaced non-overlapping rugulae and verrucae. Rugulae low, smooth, and simple, 1-2 µm high, 1-2 µm wide; rugulae anastomosing but not forming reticulum. Verrucae discrete, 1-2 µm in basal diameter, smooth-sided but variable in shape and distribution. Exine 1.5-2 µm thick, rarely folded.

Dimensions.–Equatorial diameter 58-65 µm, mean 61 µm (5 specimens measured).

Remarks.–The specimens seem to fall morphologically between *Verrucosisporites* and *Convolutispora*. The nature of the rugulose ornamentation, which also anastomoses, suggests a closer affinity to the latter.

Occurrence.–VI Biozone.

Genus *Corbulisopra* Bharadwaj and Venkatachala, 1961

Corbulispora cancellata (Waltz) Bharadwaj and Venkatachala, 1961
(Pl. 2, Fig. 12)

Dimensions.–Equatorial diameter 68-120 µm, mean 96 µm (10 specimens measured).

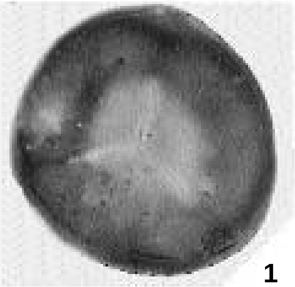
Remarks.–Suturae of *C. cancellata* are characteristically accompanied by prominent labra. The reticulate ornament consists of closely to widely spaced muri enclosing irregularly shaped lumina. Higgs *et al.* (1988) indicated that *C. subalveolaris* (Luber) Sullivan, 1964 is synomymous with *C. cancellata* because their size ranges overlap considerably and there appear no morphological criteria to separate the two species.

Occurrence.–LE – VI Biozones.

→

PLATE 1–All figures × 500 unless otherwise stated. *1, 2, Retusotriletes leptocentrum* Higgs, 1975. *3, Retusotriletes incohatus* Sullivan, 1968. *4, Retusotriletes crassus* Clayton *et al.*, 1980. *5, Punctatisporites irrasus* Hacquebard 1957. *6, Plicatispora quasilabrata* (Higgs) Higgs *et al.*, 1988. *7, 8, Verrucosisporites nitidus* (Naumova) Playford, 1964. *9, 10, Verrucosisporites scurrus* (Naumova) McGregor & Camfield, 1982. *11, 12, Verrucosisporites mesogrumosus* (Kedo) Byvsheva, 1985. *13, 14, Empanisporites rotatus* McGregor, 1961. *15, Emphanisporites hibernicus* Clayton *et al.* 1977. *16, 17, 20, Knoxisporites literatus* (Waltz) Playford, 1963. *18, Convolutispora caliginosa* Clayton *et al.*, 1982. *19, Convolutispora vermiformis* Hughes & Playford, 1961. *21, Triquitrites* sp. *22, 23, Grandispora echinata* Haquebard, 1957. *24, 25, Auroraspora macra* Sullivan, 1968.

PLATE 1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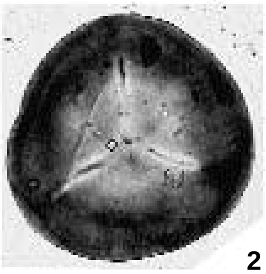
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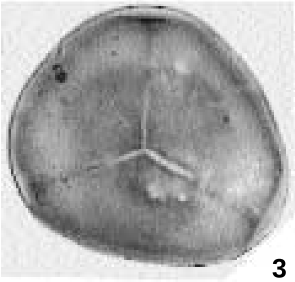
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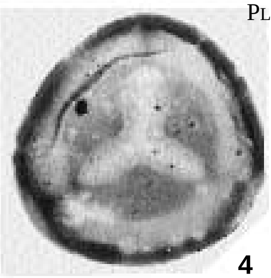
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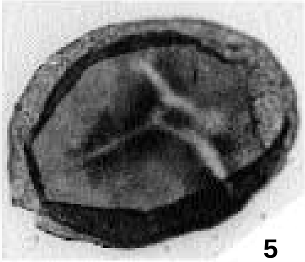
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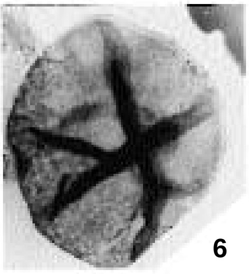
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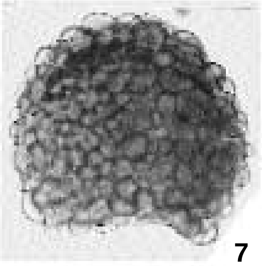
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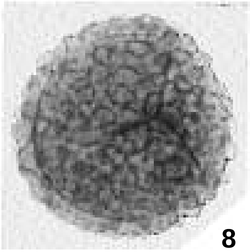
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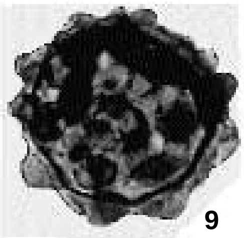
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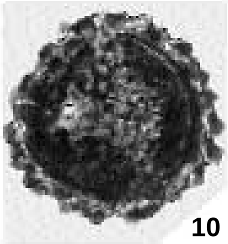
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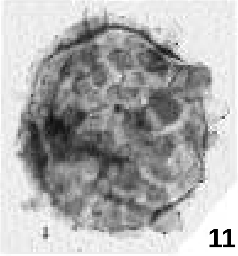
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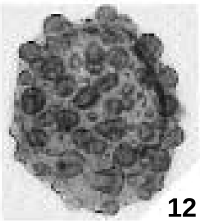
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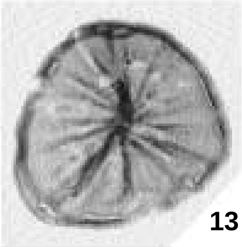
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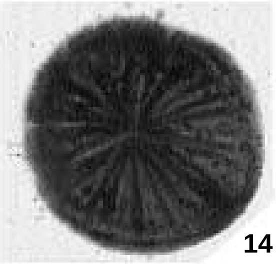
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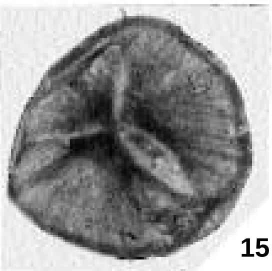
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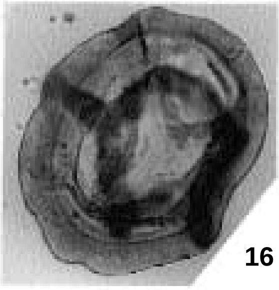
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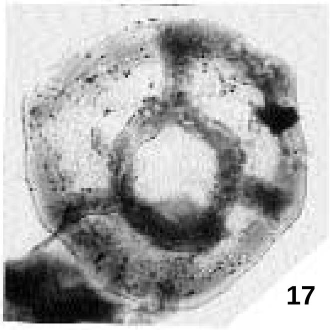
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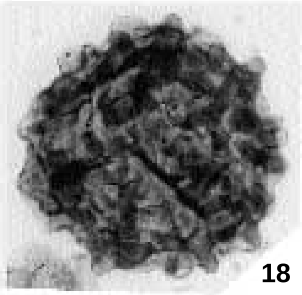
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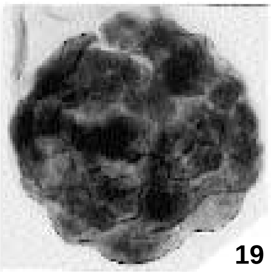
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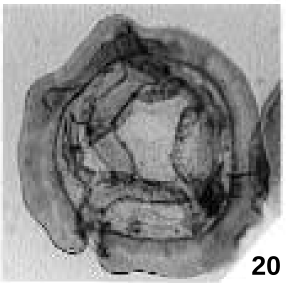
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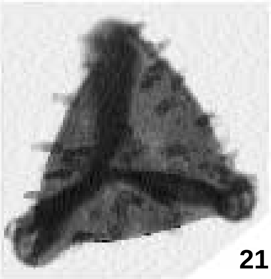
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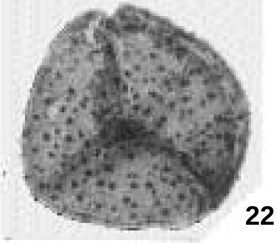
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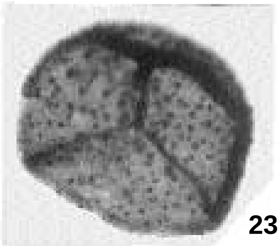
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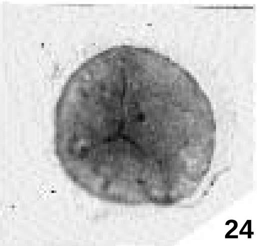
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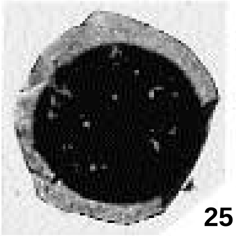
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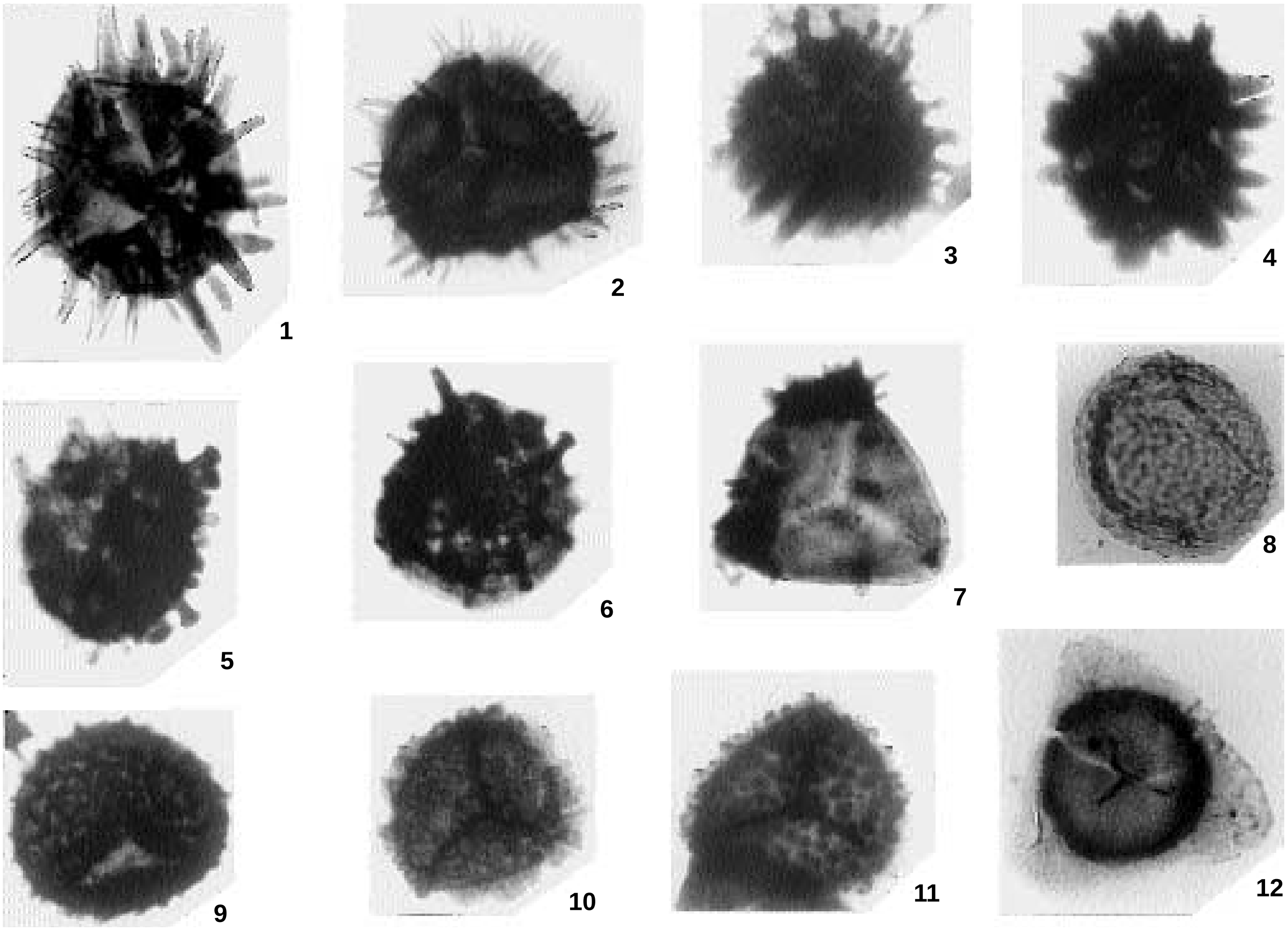


TEXT-FIGURE 2–*1, 2, Raistrickia corynoges* Sullivan, 1968. *3, 5, 6, Raistrickia* sp. *4, Cordylosporites spathulatus* Playford & Satterthwait, 1985. *7, Mooreisporites* sp. *8, Convolutispora* sp. *9, Dictyotriletes trivialis* (Naumova) Kedo, 1963. *10, 11, Cristatisporites* sp. *12, Grandispora* sp. All figures × 500 unless otherwise stated.

Genus *Dictyotriletes* Naumova *emend.* Smith and Butterworth, 1967

Dictyotriletes trivialis (Naumova) Kedo, 1963

(Text-Fig. 2, 9)

Dimensions.–Equatorial diameter 58-75 µm, mean 68 µm (10 specimens measured).

Remarks.–*D. trivialis* is distinguished from other forms of this genus by its close reticulate ornamentation and undulate equatorial margin formed by projecting muri at the equator. According to Streel (1986a), many species of *Dictyotriletes* are characteristic of the late Strunian.

Occurrence.–LE – VI Biozones.

Genus *Emphanisporites* McGregor, 1961

Emphanisporites rotatus McGregor, 1961

(Pl. 1; Figs. 13, 14)

Dimensions.–Equatorial diameter 50-66 µm, mean 60 µm (7 specimens measured).

Remarks.–The radial spoke-like thickenings on the proximal surface characterize this species.

Occurrence.–LE – VI Biozones.

Emphanisporites hibernicus Clayton,
Higgs and Keegan, 1977
(Pl. 1, Fig. 15)

Dimensions.–Equatorial diameter 68 µm (1 specimen measured).

Remarks.- This species is distinguished by thin, sometimes imperceptible ribs that are arranged in a kink-like pattern to the suturae.

Occurrence.- LE – VI Biozones.

Subturma ZONOTRILETES Waltz, 1935
Infraturma AURICULATI Schopf *emend.*
Dettmann, 1963
Genus *Triquitrites* Wilson and Coe *emend.*
Potonié and Kremp, 1954
Triquitrites sp
(Pl. 1, Fig. 21)

Description.–Trilete radial spores; amb subtriangular with convex to straight sides and rounded club-like apices. Suturae distinct with broad lips extending almost to the apices. Exine, 1.5-2 µm thick bearing sparse discrete bacula mostly on distal surface. Bacula 3-9 µm high, 3-5µm wide at base.

Dimensions.–Equatorial diameter 60-66 µm, mean 63 µm (2 specimens measured).

Occurrence.–VI Biozone.

Genus *Mooreisporites* Neves, 1958
Mooreisporites sp
(Text-Fig. 2, 7)

Description.–Trilete radial spores; amb subtriangular with convex to straight sides and bluntly rounded apices. Suturae distinct, straight, simple and extending one half or more of distance to equator. Amb apices bear bacula or blunted cone-like projections with bases fused together into a thickened bar or pad at the equatorial margin. Projections 4-10 µm high, 3-5 µm wide at base, distributed irregularly on proximal and distal faces.

Dimensions.–Equatorial diameter 63 µm (1 specimen measured).

Comparison.–*Triquitrites* has simple, and less pronounced baculate processes than *Mooreisporites*.

Occurrence.–VI Biozone.

Infraturma CINGULATI Potonié and Kremp *emend.*
Dettmann, 1963
Genus *Knoxisporites* Potonié and Kremp *emend.*
Neves and Playford, 1961
Knoxisporites literatus (Waltz) Playford, 1963
(Pl. 1; Figs. 16, 17, 20)

Dimensions.–Equatorial diameter 63-81 µm, mean 68 µm (15 specimens measured).

Remarks and comparison.–*K. literatus* has broad labra and distal ornamentation of subcircular to polygonal ring-shaped thickening encircling the distal pole and linked to the cingulum by three or four muri. *K. hederatus* (Ishchenko) Playford, 1963 differs from *K. literatus* by possessing a wider evenly thickened cingulum and no labra.

Occurrence.–LE – VI Biozone.

Genus *Tumulispora* Staplin and Jansonius, 1964
Tumulispora variverrucata (Playford) Staplin and
Jansonius, 1964
(Pl. 2; Figs. 20, 21, 22)

Dimensions.–Equatorial diameter 50-68 µm, mean 60 µm (8 specimens measured).

Remarks.–Because of doubts concerning the cingulate nature of the type species of *Lophozonotriletes*, some palynologists transferred it and similar taxa to *Tumulispora*. Avchimovitch *et al.* (1988) confirmed that *Lophozonotriletes* is indeed acingulate and thus preferred to use *Tumulispora* for cingulate/verrucate taxa. *T. variverrucata* is distinguished by its granulate exine and abundant verrucae of varying sizes distributed around the inner margin of the cingulum.

Occurrence.–LE – VI Biozone

Genus *Densosporites* Berry *emend.* Butterworth,
Jansonius, Smith and Staplin, 1964
Densosporites sp.
(Pl. 2; Figs. 11, 14)

Description.–Trilete radial spores; amb convexly triangular with rounded to pointed apices. Suturae distinct, straight, and extending to the inner margin of the zona or cingulum with narrow labra. Exoexine extended equatorially to form a uniform prominent dark cingulum up to 12 to 15 µm wide. Distal exoexine and cingulum sculptured with spinae that are discrete or fused at base. Spinae 2-5 µm high, 1-3 µ wide at base. Intexine perceptible to distinct, laevigate.

Dimensions.–Equatorial diameter 63-90 µm, mean 75 µm (12 specimens measured).

Remarks.–The species compare closely to *D. aculeatus* Playford, 1963 but differs by possessing larger spinae which rarely fuse at their bases.

Occurrence.–LN – VI Biozone.

Genus *Indotriradites* Tiwari *emend.* Foster, 1979
Indotriradites explanatus (Luber) Playford, 1991
(Pl. 2, Fig. 13)

Dimensions.–Equatorial diameter 60-85 µm, mean 70 µm (10 species measured).

Remarks.–Playford (1991) newly combined *Hymenozonotriletes explanatus* with *Indotriradites*. According to him *Hymenozonotriletes* can no longer be regarded as a feasible repository for this species, based on all pertinent sculptural and structural grounds. *Indotriradites* is two-layered with the exoexine extended equatorially to form a zona which is relatively thick around its inner margin. Distal sculptural elements are discrete coni, spinae, low bacula, and verrucae.

Occurrence.–LE – VI Biozone.

Genus *Vallatisporites* Haquebard, 1957 *emend.*
Sullivan, 1964
Vallatisporites pusillites (Kedo)
Dolby and Neves, 1970
(Pl. 2; Figs. 6, 10)

Dimensions.–Equatorial diameter 50-75 µm, mean 68 µm (20 species measured).

Remarks.–According to Avchimovitch *et al.* (1988), the Russian concept of this species embraces only forms with small and somewhat sparsely distributed spinae (1-3 µ high). The coarsely ornamented forms with spinae higher than 3 µm, which were included in this species by western European palynologists (e.g., Dolby and Neves, 1970), have been assigned to *V. hystricosus* (Winslow) Byvsheva, 1985.

Occurrence.- LL – LN Biozone.

Vallatisporites vallatus Hacquebard, 1957
(Pl. 2; Figs. 17, 18)

Dimensions–Equatorial diameter 59-70 µm, mean 65 µm (15 specimens measured).

Remarks.–*V. vallatus* is distinguished from other representatives of this genus by its dense ornament of coni and subordinate grana and spinae.

Occurrence.–VI biozone

Vallatisporites verrucosus Hacquebard, 1957
(Pl. 2; Figs. 15, 16)

Dimensions.–Equatorial diameter 50-72 µm, mean 65 µm (15 specimens measured).

Remarks.–*V. verrucosus* differs from *V. vallatus* only in the style of ornamentation. The former is dominantly verrucate with elements occasionally fusing at their base to form short rugulae.

Occurrence.–LE – VI Biozone.

Vallatisporites hystricosus (Winslow) Byvsheva, 1985
(Pl. 2; Figs. 7, 8)

Dimensions.–Equatorial diameter 65-78 µm, mean 70 µm (10 specimens measured).

Remarks.–This species of *Vallatisporites* accommodates forms possessing spinae and galeae, 3–16 µm in height.

Occurrence.–LE – VI Biozone.

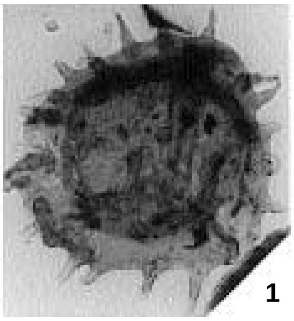
Supraturma PSEUDOSACCITITRILETES Richardson, 1965
Infraturma MONOPSEUDOSACCITI Smith and
Butterworth, 1967
Genus *Auroraspora* Hoffmeister,
Staplin and Malloy, 1955
Auroraspora macra Sullivan, 1968
(Pl. 1; Figs. 24, 25)

Dimensions.–Equatorial diameter 45-60 µm, mean 55 µm (15 specimens measured).

→

PLATE 2–All figures × 500 unless otherwise stated. *1, 2, Grandispora senticosa* (Ischenko) Byvsheva, 1985. *3, 4, Spelaeotriletes balteatus* (Playford) Higgs, 1996. *5, 9, Retispora lepidophyta* (Kedo) Playford, 1976. *6, 10, Vallatisporites pusillites* (Kedo) Dolby & Neves, 1970. *7, 8, Vallatisporites hystricosus* (Winslow) Byvsheva, 1985. *11, 14, Densosporites* sp. *12, Corbulispora cancellata* (Waltz) Bharadwaj & Venkatachala, 1961. *13, Indotriradites explanatus* (Luber) Playford, 1991. *15, 16, Vallatisporites verrucosus* Haquebard, 1957. *17, 18, Vallatisporites vallatus* Haquebard, 1957. *19, Cordylosporites marciae* Playford & Sattertwait, 1985. *20, 21, 22, Tumulispora variverrucata* (Playford) Staplin & Jansonius, 1964. *23, Tasmanites* sp. (× 250).

PLATE 2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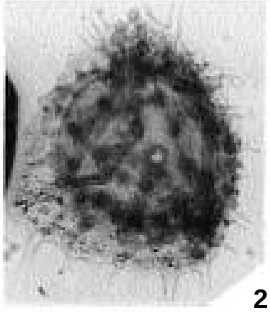
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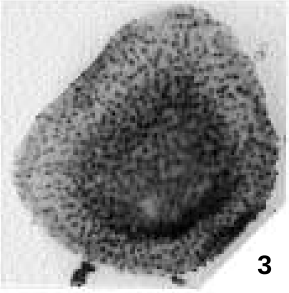
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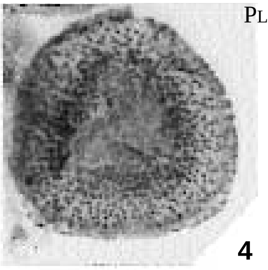
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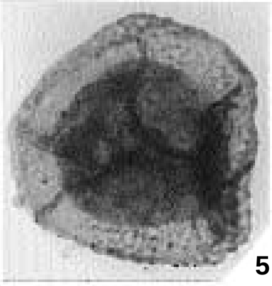
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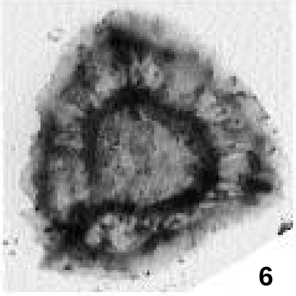
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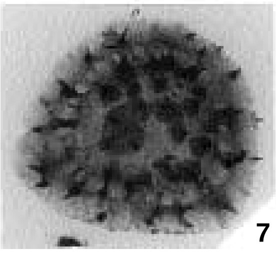
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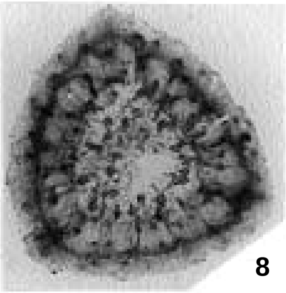
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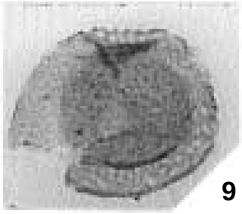
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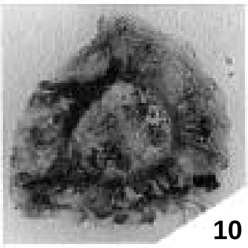
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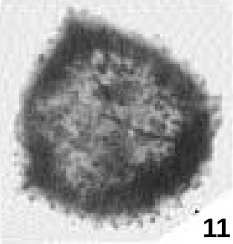
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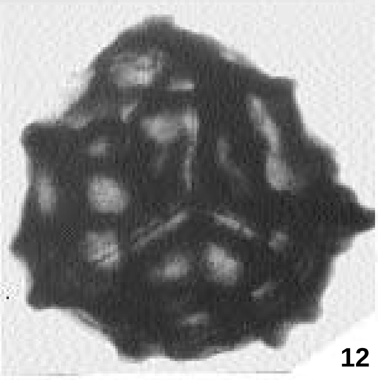
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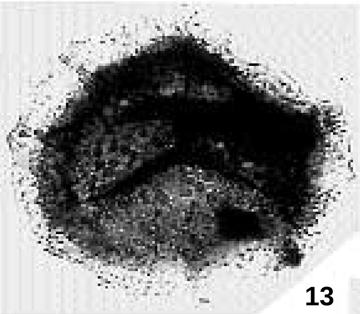
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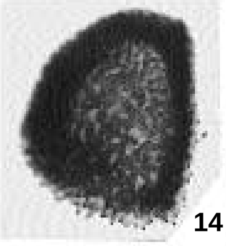
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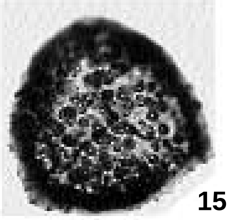
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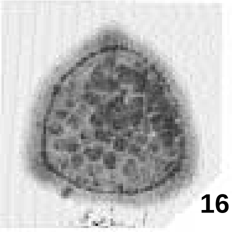
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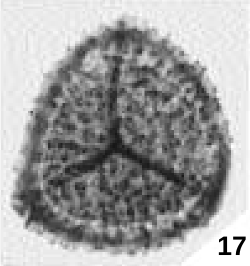
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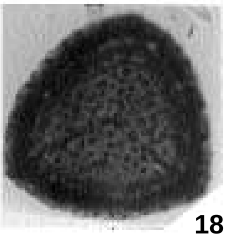
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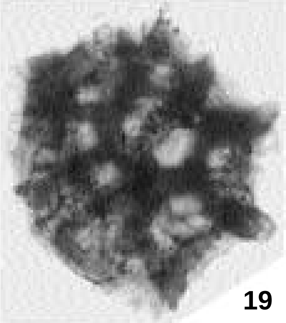
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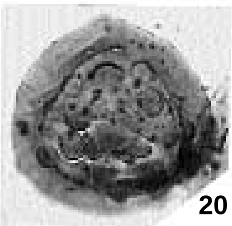
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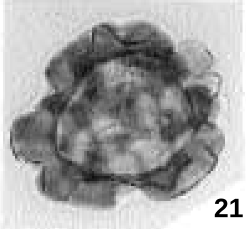
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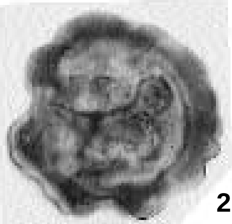
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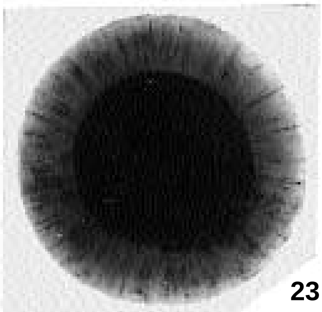
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Remarks.–*Auroraspora macra* is distinguished by its well-defined, laevigate intexine (slightly smaller in diameter than exoexine) and finely and densely structured exoexine with an equatorially darkened zone. *A. hyalina* (Naumova) Streel *in* Becker *et al*., 1974 is closely comparable to *A. macra*, but is slightly smaller and possesses a thin filmy exoexine.

Occurrence.–VI Biozone.

Genus *Retispora* Staplin, 1960
Retispora lepidophyta (Kedo) Playford, 1976
(Pl. 2; Figs. 5, 9)

Dimensions.–Equatorial diameter 55-70 µm, mean 60 µm (4 specimens measured).

Remarks.–This species is the best example of a few globally distributed miospore species. It has been found on all continents except Antarctica with a relatively short stratigraphic range (Famennian Fa 2d to early Tournaisian Tn 1). Its consistent stratigraphic exit at or very close to the Devonian–Carboniferous boundary emphasizes its international importance as the pre-eminent palynological marker of the systemic boundary.

Occurrence.–LE – LN Biozones.

Genus *Grandispora* Hoffmeister, Staplin and Malloy *emend.* McGregor, 1973
Grandispora echinata Hacquebard, 1957
(Pl. 1; Figs. 22, 23)

Dimensions.–Equatorial diameter 58-72 µm, mean 63 µm (15 specimens measured).

Remarks.–The regularly spaced ornament of small spinae and coni characterize this species.

Occurrence.–LE – VI Biozones.

Grandispora senticosa (Ishchenko) Byvsheva, 1985
(Pl. 2; Figs. 1, 2)

Dimension.–Equatorial diameter 60-76 µm, mean 67 µm (12 specimens measured).

Remarks.–*Spinozonotriletes uncatus* Hacquebard, 1957 is distinguished from *G. senticosa* by possessing a wide equatorial flange, which is an extension of the exoexine, and more densely distributed spinae.

Occurrence.–LE – LN Biozones.

Grandispora sp.
(Text-Fig. 2, 12)

Description.–Trilete radial spores; amb triangular with rounded apices and convex to straight sides. Suturae distinct, simple and straight to slightly sinuous with narrow lips extending to the intexine radius and beyond. Exoexine infragranulate, distally and equatorially bearing irregular spinae 3-6 µm high, 1-2 µm wide at base. Intexine subcircular in polar outline, laevigate, 2-3 µm thick. Intexinal body centrally placed; diameter one- to two-thirds of exoexine diameter.

Dimensions.–Equatorial diameter 63-84 µm, mean 71 µm (6 specimens measured).

Occurrence.–VI Biozone.

Genus *Spelaeotriletes* Neves and Owens, 1966
Spelaeotriletes balteatus (Playford) Higgs, 1996
(Pl. 2; Figs. 3, 4)

Dimensions.–Equatorial diameter 58-90 µm, mean 72 µm (15 specimens measured).

Remarks.–The species is distinguished by the small broad-based spinae and subordinate coni and grana, which sometimes fuse at their bases forming low rugulae.

S. obtusus Higgs, 1975 is comparable but differs in possessing non-apiculate processes.

Occurrence.–VI Biozone.

Genus *Cristatisporites* Potonié and Kremp *emend.* Butterworth *et al.,* 1964
Cristatisporites sp
(Text-Fig. 2; 10-11)

Description.–Trilete radial spores; amb subtriangular to subcircular. Suturae distinct, straight, extending almost to equatorial margin. Spore ornamented distally with discrete, closely packed coni and spinae 3-8 µm high, 3-6 µm wide at base. Equatorial flange irregular, lobate to dentate due to projecting coni and spinae.

Dimensions.–Equatorial diameter 55-63 µm, mean 60 µm (6 specimens measured)

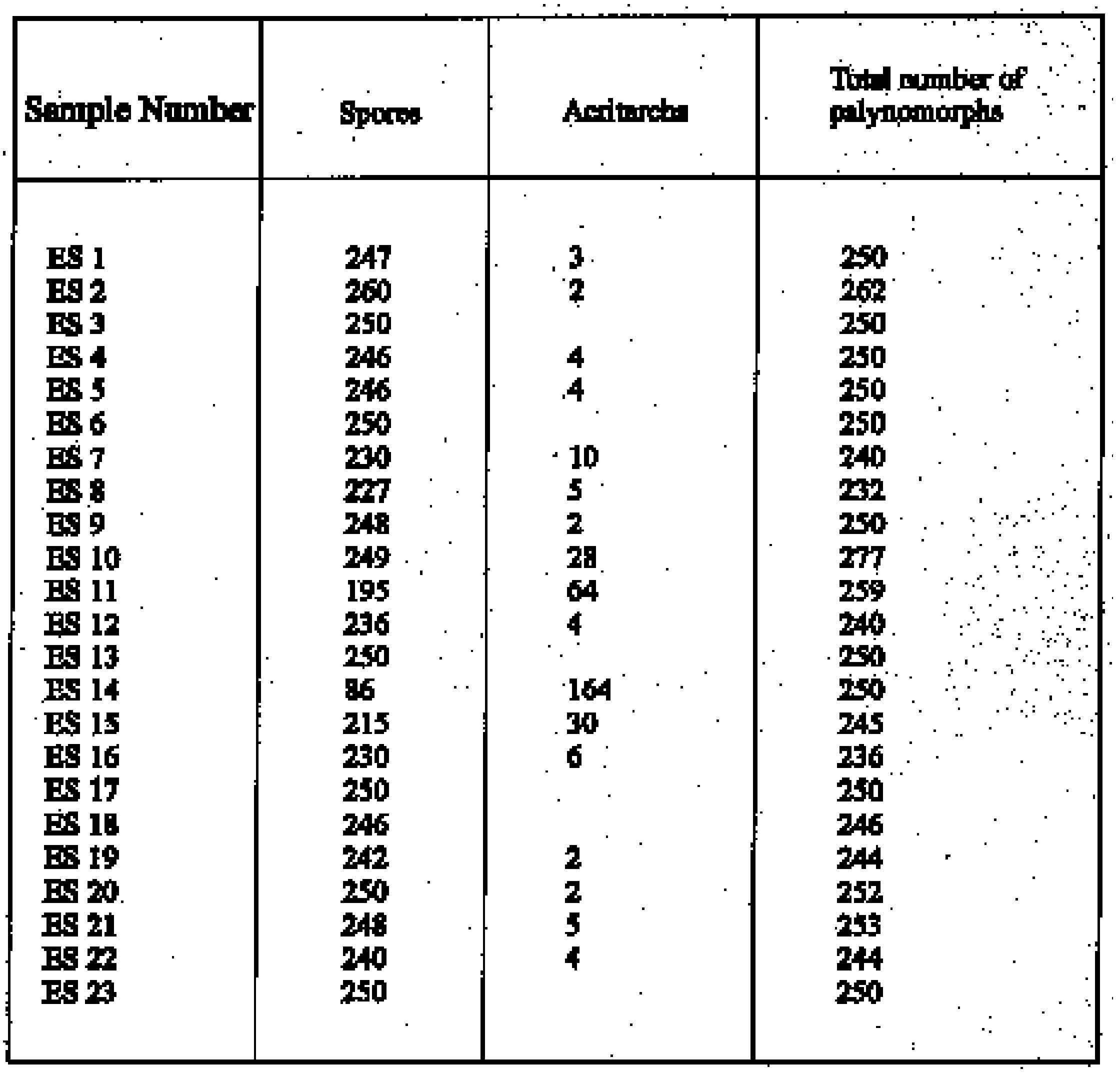
Remarks.–The species is similar to, but larger than, *C. orcadensis* recorded by Richardson (1960) from the Middle Old Red Sandstone from Cromarty, Scotland.

Occurrence.–LN – VI Biozone.

PALYNOSTRATIGRAPHIC DISCUSSION

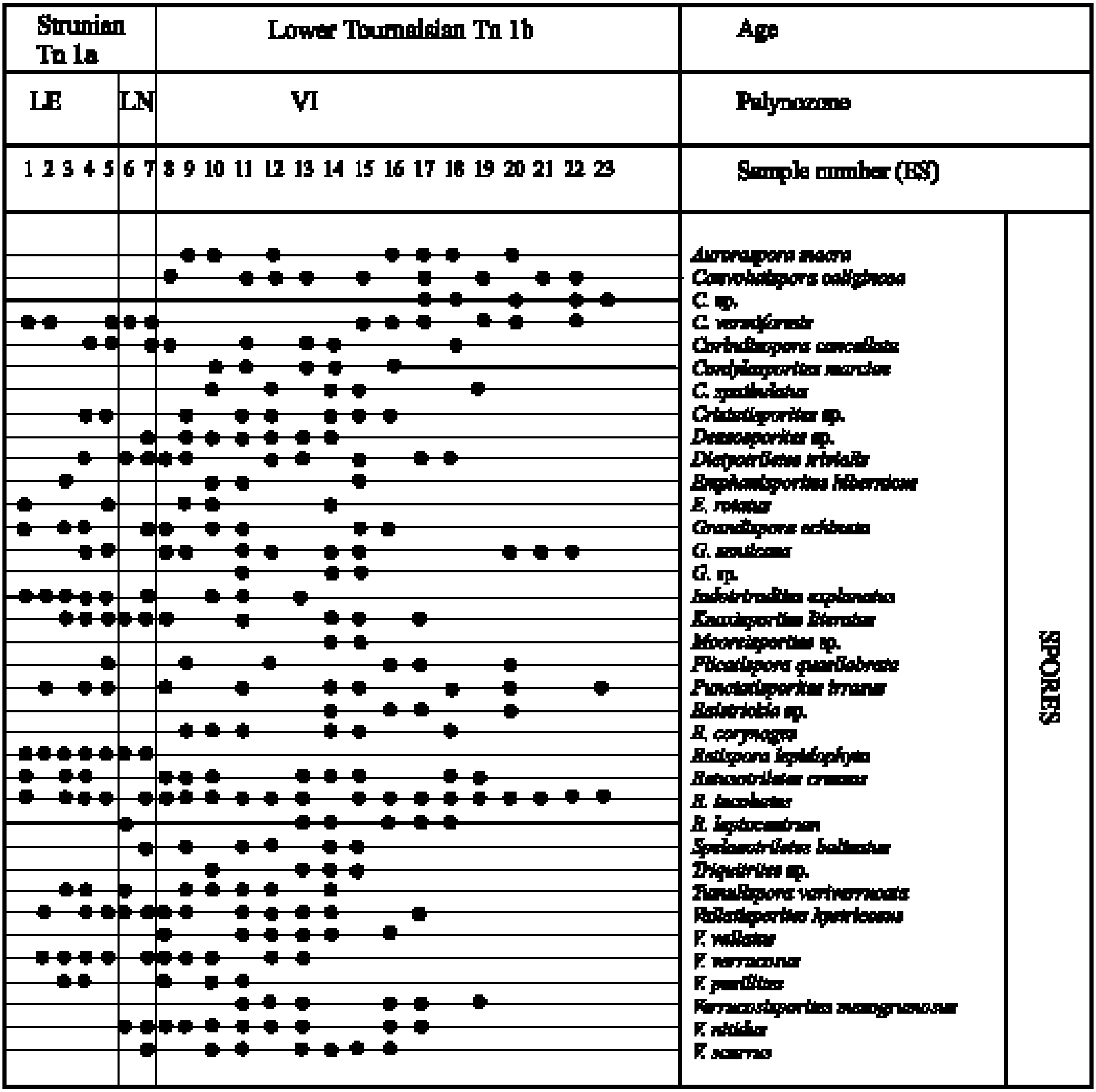
The spore assemblage from the Late Devonian–Early Carboniferous sediments of the Sekondi Group at Essipon Beach is diverse, abundant, and well-preserved. About 200-300 specimens of palynomorphs were counted from each sample for percentage calculation. Table 2 shows the proportion of spores to acritarchs in each sample. The spores and other organic matter are dark-brown to brown in colour, an indication of maturity of organic matter. The spores are essentially pteridophytic, laevigate and sculptured with other forms that are less signigicant. The spores are assignable to several taxa that have also been reported from Late Devonian–Early Carboniferous sediments in other parts of the world. Text-fig. 3 shows distribution of spores in the section studied.

Atta-Peters (1996) recognized three palynozonal assemblages, which he correlated with the Irish miospore zonation scheme of Higgs *et al.* (1988) with an age range of latest Devonian (Strunian) to Early Carboniferous (Tournaisian). The zones are: *Retispora lepidophyta–Indotriradites explanatus* (LE), *Retispora lepidophyta–Verrucosisporites nitidus* (LN), and *Vallatisporites verrucosus–Retusotriletes incohatus* (VI) zones. The characteristic species for this age range (identifiable with other taxa recorded from other parts of the world) include: *Corbulispora cancellata*, *Dictyotriletes trivialis*, *Verrucosisporites nitidus*, *Indotriradites explanatus*, *Tumulispora variverrucata*, *Knoxisporites literatus*, *Grandispora senticosa*, *Auroraspora macra*, *Retispora lepidophyta*, *Vallatisporites hystricosus*, *V. verrucosus*, *V. vallatus*, and *V. pusillites*.



Sample Number	Spores	Acritarchs	Total number of palynomorphs
ES 1	247	3	250
ES 2	260	2	262
ES 3	250		250
ES 4	246	4	250
ES 5	246	4	250
ES 6	250		250
ES 7	230	10	240
ES 8	227	5	232
ES 9	248	2	250
ES 10	249	28	277
ES 11	195	64	259
ES 12	236	4	240
ES 13	250		250
ES 14	86	164	250
ES 15	215	30	245
ES 16	230	6	236
ES 17	250		250
ES 18	246		246
ES 19	242	2	244
ES 20	250	2	252
ES 21	248	5	253
ES 22	240	4	244
ES 23	250		250

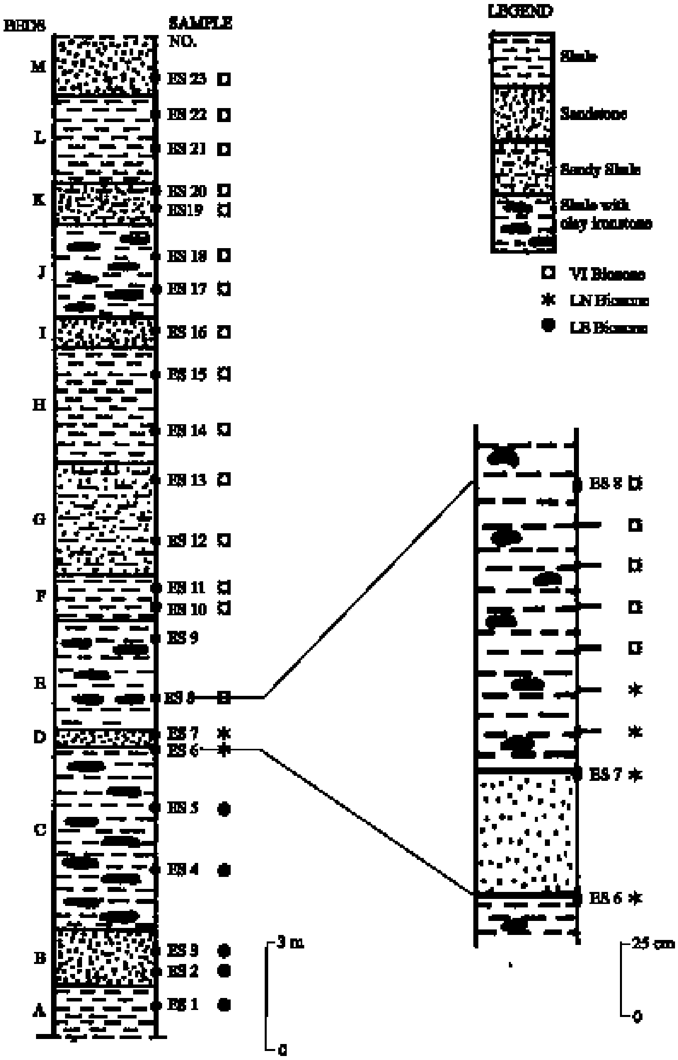
TABLE 2–Numerical frequency counts of palynomorphs for relative frequency of palynomorphs plotted in Text-Figure 5.



TEXT-FIGURE 3–Miospore distribution in Takoradi Shale Formation at Essipon Beach (modified after Atta-Peters, 1996).

Similar spore zonation schemes for Devonian–Carboniferous boundary strata have been identified and correlated with these zones in Western Europe (Streel, 1966, 1969; Paproth and Streel, 1970; Neves *et al.*, 1972, Richardson, 1974; Clayton *et al.*, 1974, 1977, 1978; Higgs and Streel, 1984; Higgs *et al.*, 1988; Avchimovitch *et al.*, 1988; Higgs, 1975; Dolby, 1970; Neves and Dolby, 1967; Higgs *et al.*, 1992a, 1992b; Higgs and Clayton, 1984; Keegan, 1977; Richardson and McGregor, 1986; Streel and Loboziak, 1994; Vigran *et al.*, 1999), former USSR (Byvsheva, 1976, 1985; Byvsheva *et al.*, 1984; Avchimovitch, 1986, 1993), North America (Sandberg *et al.*, 1972; Warg and Streel, 1973; Streel and Traverse, 1978; Utting, 1987), Brazil (Loboziak *et al.*, 1991), and north Africa (Lanzoni and Magloire, 1969).

The operational definition of the Devonian–Carboniferous boundary places it at the first appearance of the conodont *Siphonodella sulcata* within the evolutionary lineage from *S. praesulcata* to *S. sulcata* (Paproth and Streel, 1984; Streel, 1986 a,b; Paproth *et al.*, 1991). This first appearance precedes the entry of the goniatite *Gattendorfia* at Hönnetal, which hitherto was regarded as the systemic boundary. It has been documented, especially in Western Europe, that this boundary almost coincides with the disappearance of *R. lepidophyta* at the top of the LN zone (Avchimovitch *et al.*, 1988; Higgs and Streel, 1984; Owen and Richardson, 1971; Owens and Streel, 1967; Clayton *et al.*, 1974; Richardson and McGregor, 1986, Higgs *et al.*, 1992).



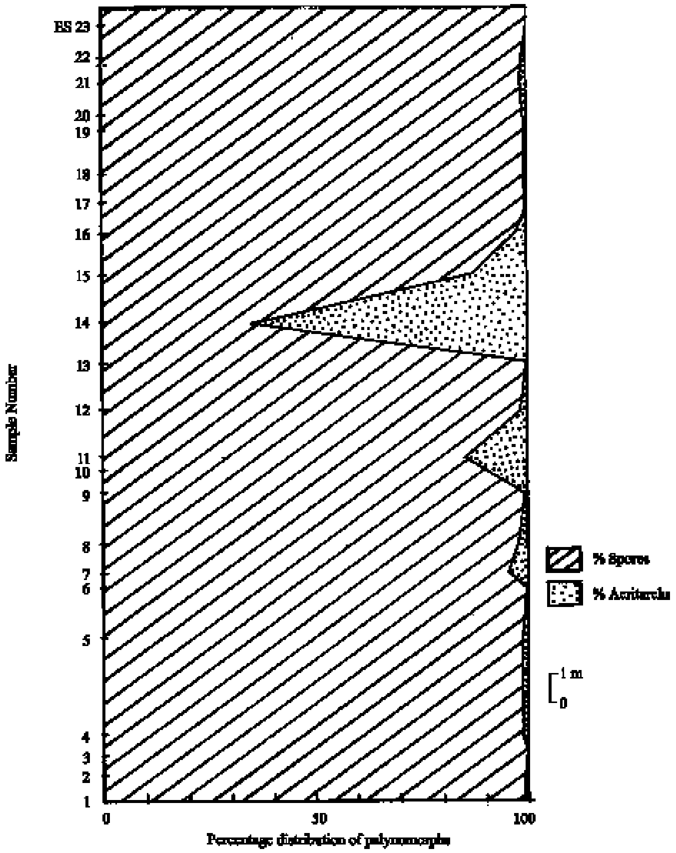
TEXT-FIGURE 4–Palynology of the Takoradi Shales at Essipon Beach (modified after Atta-Peters, 1996).

Atta-Peters (1996) recognized the LN/VI Biozone boundary which is regarded as almost corresponding to the Devonian–Carboniferous boundary in the section at Essipon Beach. This was based on the last occurrence of *R. lepidophyta* at the top of the LN zone. He thus placed the boundary between samples No. ES 7 and ES 8. Detailed sampling from the present study indicates that the LN/VI biozonal boundary lies within the 0.30-0.45 m interval above sample ES 7 in Bed E (Text-Fig. 4).

PALEOECOLOGICAL NOTES

The palynomorph assemblage of the Takoradi Shale Formation allows diverse paleoecological interpretations. Some samples contain small cuticles and few spores, which suggests sorting and possible recycling. Others have large cuticles with abundant and well-preserved spores, which may indicate that they have not moved much from their original habitat. Algal spores are rare to common. The fairly large preponderance of trilete (largely pteridophytic) spores is indicative of swamp vegetation. This environment was evidently subject to occasional flooding by marine or brackish water, thereby incorporating some organic-walled microplankton (acritarchs) in the accumulating sediments. The observed intermixing of miospores and acritarchs, together with various sizes of cuticles and algal spores, strongly suggests that the sediments are marginal marine. The local relative abundance of acritarchs at some horizons suggests the incursion of marine waters into swamps or marshes. The expansions and contractions within the miospore and acritarch spectra (Text-Fig. 5) mark regressive-transgressive facies and vice versa. These fluctuations between acritarchs and miospores represent changes within the depositional environment, that are of stratigraphic and/or paleoecological significance. Incidences of relatively low miospores and high acritarchs mark probable points of shift in the swamp or mangrove associations.

The trilete spores are morphologically similar to some of the extant forms of the families Cyatheaceae, Polypodiaceae, and Lycopodiaceae, some of which are known to inhabit fresh water swamps or marshes. The presence of algal microfossils like *Tasmanites* supports further a freshwater swamp or marsh association. The generally infrequent occurrences of acritarchs suggest a brackish water influence.



TEXT-FIGURE 5–Relative frequency of palynomorphs through the section studied.

Following Krauskopf (1967), the nodules of siderite recovered from the shales indicate a reducing environment of deposition. Krauskopf (1967) reported that siderite precipitates where there is a large supply of ferrous iron and/or a reducing environment maintained by organic matter, such as in deltaic swamps or marshes and mangroves. Anan-Yorke (1974) has indicated that regression of the Devonian sea in the area was followed by deltaic or brackish water conditions.

CONCLUSIONS

The trilete miospore assemblage recovered from the Takoradi Shale Formation at Essipon Beach, is abundant and diverse. Stratigraphically significant palynomorph taxa, indicating a latest Devonian (Strunian Tn 1a)–Early Carboniferous (Tournaisian Tn 1b) age, include *Vallatisporites hystricosus*, *V. vallatus*, *V. verrucosus*, *Retispora lepidophyta*, *Auroraspora macra*, *Grandispora senticosa*, *Knoxisporites literatus*, *Indotriradites explanatus*, *Dictyotriletes trivialis*, *Corbulispora cancellata* and *Verrucosisporites nitidus*. The acritarch content is strictly subordinate to that of the spores.

The three miospore zones assigned to the Devonian–Carboniferous boundary strata (LE, LN, VI) are those recognized in Ireland, elsewhere in Western Europe and in the former USSR.

Detailed sampling has shown that the Devonian–Carboniferous boundary lies in Bed E 0.30-0.45 m above sample ES 7.

The spores indicate freshwater swamp or marsh environment of deposition. This is further supported by the presence of the algal form *Tasmanites*.

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MIOSPORAS DE LOS NIVELES SUPERIORES DE LA SUCESIÓN DE LA PLAYA DE LA HUELGA (CARBONÍFERO DEL E DE ASTURIAS, ESPAÑA)

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Resumen

En este trabajo se presentan los primeros datos palinológicos obtenidos en la Sección de la Playa de La Huelga, situada en el sector nororiental de la Unidad del Ponga, Zona Cantábrica, NO de España. Se trata probablemente de la sección más completa y mejor expuesta de esta región, y de la que ya se han publicado numerosos trabajos sobre fósiles diversos. Aquí se analiza el contenido palinológico de doce muestras procedentes de dos afloramientos de las intercalaciones detríticas más altas de la sucesión. Todas ellas han resultado positivas, destacando la riqueza de las muestras recogidas en el afloramiento inferior, en cada una de las cuales se han identificado más de 100 especies distintas, pertenecientes a unos 60 géneros. Las formas identificadas más abundantes son las características de las asociaciones del Westfaliense. Cabe destacar la presencia de esporas monoletas, de los géneros *Laevigatosporites*, *Punctatosporites*, *Speciososporites* y *Thymospora*. También se han encontrado abundantes pólenes monosacados, ocasionalmente algunos pólenes bisacados y palinomorfos resedimentados. A partir de los datos obtenidos se ha podido relacionar niveles estudiados en la sección de la Playa de La Huelga con algunas escalas biostratigráficas establecidas en distintas áreas de Europa Occidental, fundamentalmente con la Cuenca Carbonífera Central de Asturias, las Islas Británicas y la Cuenca de Sarre Lorena, así como con el esquema zonal general establecido para el conjunto de Europa Occidental. Con todo ello se ha podido establecer una edad Westfaliense D temprano para los niveles estudiados, que junto con la presencia de fusulinas propias del Podolskiense en niveles situados inmediatamente por encima y por debajo de los estudiados proporcionan datos para la correlación entre las escalas estratigráficas de Europa Occidental y de la antigua Unión Soviética.

Palabras clave: Carbonífero, Westfaliense D, miosporas, biostratigrafía, Zona Cantábrica, España.

Abstract

[*Miospore assemblages of the Playa de La Huelga Section (upper Carboniferous from Asturias, NW Spain)*]. The first palynological data from the section of the Playa de La Huelga (Northeast of the Ponga Unit, Cantabrian Zone, N of Spain) are given here. The Playa de La Huelga Section is among the most complete, best exposed and most fossiliferous sections of the Ponga Unit. Although the abundant fossil fauna of these rocks has been the subject of several papers published in recent years, the palynomorphs were not yet studied. Twelve samples, from two terrigenous intercalations in the upper part of this mainly calcareous succession, have yielded palynomorphs. Samples from the lower part of this interval are especially rich, with more than 100 species belonging to 60 genera. The most abundant palynomorphs are spores that are known to be frequent in Westphalian assemblages. The occurrence of *Laevigatosporites*, *Punctatosporites*, *Speciososporites* and *Thymospora*, the abundance of monosaccate pollen, the occasional occurrence of bisaccates and the presence of some reworked palynomorphs characterise these assemblages. The assemblages found in the Playa de La Huelga section are compared with those of the biostratigraphic units described from different areas in western Europe (Central Asturian Coalfield of Northwest Spain, the British coalfields and the Saar-

Lorraine Basin), and placed in the general biozonation of western Europe. The palynomorphs from the upper part of the Playa de La Huelga Section suggest an early Westphalian D age for these rocks. The occurrence of Podolskian fusulinids in strata both below and above the rocks containing the palynomorphs confirms that Westphalian D and Podolskian are at least partly equivalent.

Keywords: Carboniferous, Westphalian D, miospores, biostratigraphy, Cantabrian Zone, Spain.

INTRODUCCIÓN

La sucesión de la Playa de La Huelga se considera como la más completa y mejor expuesta de las secciones de la parte N de la Unidad del Ponga (una de las unidades geológicas mayores de la Zona Cantábrica, Fig.1). Incluye materiales carboníferos cuya edad abarca desde el Tournaisiense hasta el Myachkoviense (Moscoviense superior), en su mayor parte calizas, depositados en distintos ambientes sedimentarios.

La abundancia de fósiles marinos, conocidos ya desde Barrois (1882), ha determinado que éstos hayan sido objeto de estudio en diversas publicaciones en los últimos años, braquiópodos (Martínez Chacón, 1979, 1990, 1991), foraminíferos (Villa, 1985, 1995), corales (Rodríguez, 1984; Rodríguez y Ramírez, 1987), briozoos (González y Suárez, 1999, 2000a, 2000b), ostrácodos (Sánchez de Posada y Bless, 1999; Sánchez de Posada y Fohrer, 2001), bioconstrucciones (Minwegen, 2001). Por el contrario, los palinomorfos han sido olvidados, a pesar del interés que tienen para la datación en términos de la escala de Europa Occidental y de los datos que pueden proporcionar para la correlación entre las escalas estratigráficas de Europa Occidental y de la antigua Unión Soviética (Rusia y Ucrania).

En este trabajo se dan a conocer los resultados de la investigación palinológica realizada en las intercalaciones detríticas que existen en la parte alta de la sucesión, dentro de niveles que, de acuerdo con los datos proporcionados por los fusulináceos (Villa, 1985, 1995), tienen una edad Podolskiense (Moscoviense superior).

SECCIÓN DE LA PLAYA DE LA HUELGA. SITUACIÓN DE LAS MUESTRAS ESTUDIADAS

La Sección de la Playa de La Huelga aflora a lo largo de los acantilados comprendidos entre la Playa de San Antolín y el pequeño Cabo de Castro Molina, aproximadamente 1 km al NE del pueblo de Hontoria (Llanes), hoja 31 (Ribadesella) del mapa Geológico de España, escala 1:50.000 (Fig. 1). La sucesión está situada en la Unidad del Ponga.

La sección comprende aproximadamente 1.000 m de materiales carboníferos cuya edad abarca desde el Tournaisiense hasta el Myachkoviense (Fig. 2). El Pensilvánico está representado fundamentalmente por calizas masivas bioclásticas que ocasionalmente presentan intercalaciones margosas y detríticas (éstas en la parte alta de la sección). Una descripción detallada puede encontrarse en Navarro *et al*. (1986), quienes apuntan un ambiente sedimentario de plataforma carbonatada somera. Bahamonde *et al*. (1997) proporcionan información relevante acerca de los ambientes sedimentarios en que se depositaron los distintos tramos de la sucesión.

Las doce muestras estudiadas en este trabajo (Fig. 2) proceden de las intercalaciones detríticas más altas, que quedan expuestas en dos pequeños afloramientos de areniscas, lutitas, limolitas, margas calcáreas y una capa de carbón. Se considera que estos materiales corresponden a aportes terrígenos en la plataforma. Las muestras Ag1 a Ag5 fueron recogidas en la más baja de estas intercalaciones, que se sitúa en las proximidades de una antigua cetárea. Allí están expuestos unos 25 m de lutitas y limolitas. Las muestras Ag6 a Ag12 proceden del afloramiento más alto, en el que afloran unos 23 m de areniscas, lutitas, limolitas, en general bioturbadas, y un pequeño carbonero. Este último afloramiento se sitúa en una pequeña bahía aproximadamente 65 m sobre el anterior, inmediatamente por debajo de los niveles con braquiópodos y ostrácodos.

CONTENIDO PALINOLÓGICO

En general, las muestras estudiadas contienen abundantes palinomorfos en buen estado de conservación. En algunos casos, la diagénesis temprana de la pirita ha producido algunos daños, de modo especial en los granos sacados y pseudosacados

(*Florinites* y *Endosporites*, respectivamente) y en aquellas formas con exina más fina, como es el caso de *Calamospora*. El efecto de la piritización parece más fuerte en las muestras de limolitas (muestras Ag1 a Ag5) que en las otras litologías.

Por término medio, cada muestra ha proporcionado más de 60 especies. Casos extremos son las muestras Ag9 y Ag12, en las que sólo se han identificado alrededor de 20 especies, y las muestras Ag1 a Ag5 (tomadas todas ellas en el primer afloramiento) y Ag10, con más de 100 especies cada una.

Las formas más persistentes y abundantes en el conjunto de los niveles investigados son *Lycospora pusilla*, *Densosporites* spp., *Calamospora* spp. y *Punctatisporites punctatus*, que aparecen en todas las muestras. Siguen en abundancia *Cingulizonates loricatus*, *Densosporites anulatus* y *Endosporites globiformis*, que se han identificado en once de ellas y *Calamospora hartungiana*, *Crassispora kosankei*, *Cyclogranisporites aureus*, *Laevigatosporites desmoinesensis*, *Raistrickia fulva*, *Vestispora fenestrata*, *Apiculatisporis abditus*, *Ahrensisporites guerickei*, *Calamospora mutabilis*, *Calamospora pedata*, *Densosporites faunus*, *Endosporites zonalis*, *Florinites pellucidus*, *Leiotriletes adnatoides*, *Lundbladispora gigantea*, *Microreticulatisporites fistulosus*, *Punctatosporites rotundus*, *Triquitrites* spp. y *Torispora securis*, que aparecen en la mayoría de las muestras (Fig. 3).

Hay otro grupo de miosporas que, a pesar de ser menos abundantes y tener una presencia discontinua a lo largo de la sección estudiada, deben ser mencio-

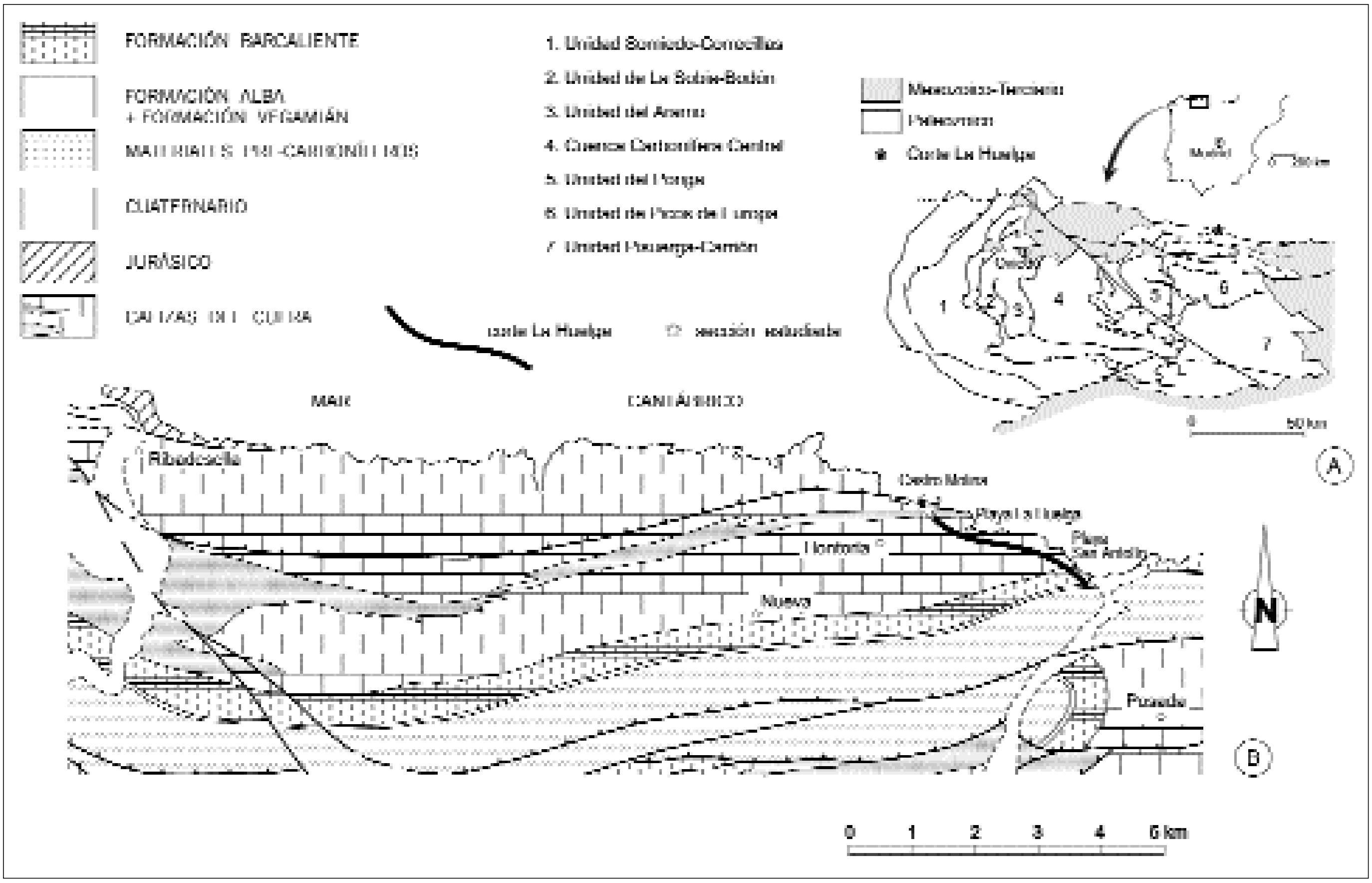

FIGURA 1–A. Esquema general de la Zona Cantábrica en el que se muestra la localización de la Sección de la Playa de La Huelga dentro de la Unidad del Ponga, y la situación de esta última respecto a las principales unidades tectónicas y estratigráficas. B. Esquema geológico general regional con la situación de la Sección de la Playa de La Huelga (Navarro *et al*., 1986, redibujado).

FIGURE 1–A. General sketch showing the main geological units of the Cantabrian Zone and the location of the Playa de La Huelga section in the Ponga Unit. B. Geological sketch of the area around Playa de La Huelga section (mainly from Navarro *et al*., 1986, modified).

nadas puesto que son características de la asociación encontrada y representativas del Westfaliense. Es el caso de *Apiculatisporis* spp., *Cirratriradites saturni*, *Convolutispora* spp., *Cristatisporites solaris*, *Cristatisporites indignabundus*, *Dictyotriletes reticulocingulum*, *Granulatisporites microgranifer*, *Knoxisporites cinctus*, *Knoxisporites triradiatus*, *Grumosisporites varioreticulatus*, *Leiotriletes convexus*, *Leiotriletes sphaerotriangularis*, *Pustulatisporites pustulatus*, *Raistrickia* spp., *Schopfipollenites ellipsoides*, *Simozonotriletes intortus*, *Savitrisporites nux*, *Verrucosisporites verrucosus*, *Lycospora pellucida*, *Reticulatisporites reticulatus* y *Vestispora pseudoreticulata*, entre otras.

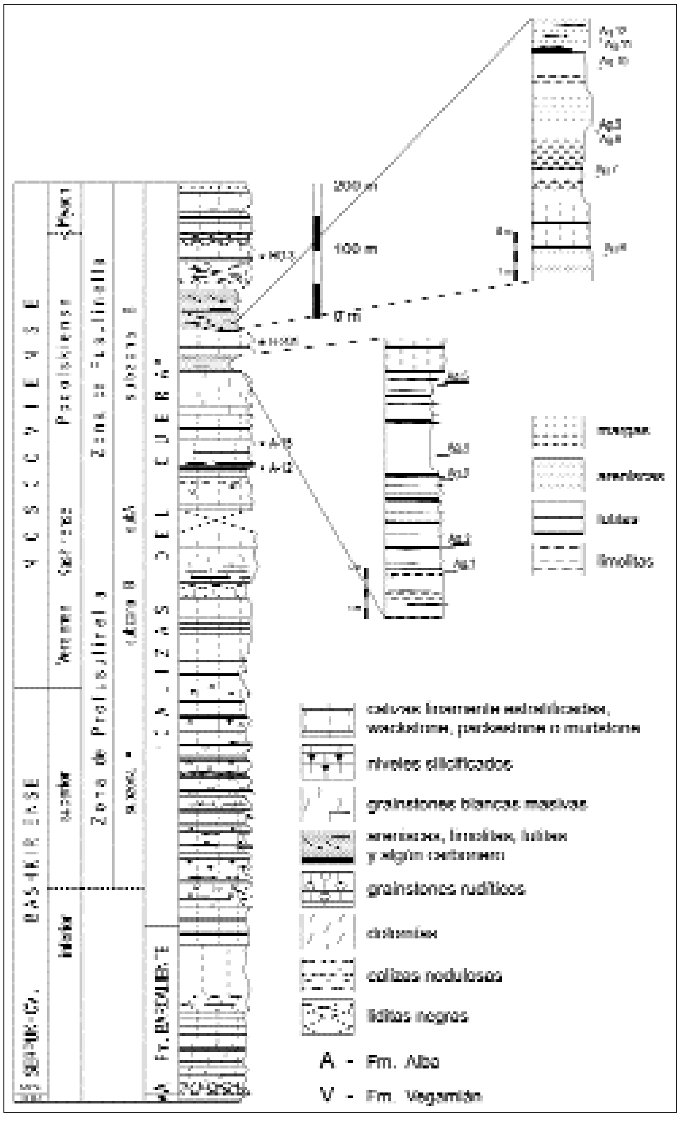

FIGURA 2–Columna estratigráfica de los materiales carboníferos de la Sección de la Playa de La Huelga, con la posición de las muestras estudiadas en este trabajo (muestras Ag.1 a Ag.12), y la posición de algunas muestras con fusulináceos (muestras A-14, A-15, H-201, HO-3) (según Villa, 1995, simplificada).

FIGURE 2–Stratigraphic log of the Playa de La Huelga section with the position of the more relevant palynological (Ag.1 to Ag.12) and fusulinaceans (A-14, A-15, H-201, HO-3) samples. (After Villa, 1995, simplified).

Cabe destacar la presencia de monoletas, entre las que son abundantes las formas laevigadas del género *Laevigatosporites*. Las pequeñas esporas monoletas ornamentadas, aunque no muy abundantes, tienen notable importancia estratigráfica. Entre ellas las más frecuentes son las granuladas del género *Punctatosporites*; siendo en cambio escasas las verrugosas del género *Thymospora*, que tan sólo se han encontrado en alguna de las muestras estudiadas.

En cuanto a los pólenes encontrados hay una gran variedad de especies del género *Florinites*, como *F. pumicosus*, *F. dissacoides*, *F. ovalis*, entre otros. Ocasionalmente se han hallado algunas formas de bisacados no estriados y *Pityosporites*.

Aunque no son muy abundantes, en las asociaciones de la Sección de la Playa de La Huelga aparecen algunos palinomorfos reelaborados. En general tienen peor conservación que el resto, lo que en algunos casos dificulta su identificación. Entre ellos pueden mencionarse *Diatomozonotriletes ubertus* (que no sobrepasa el Viseense), *Reinschospora triangularis* (Duckmantiense) o *Radiizonates aligerens* (especialmente abundante en el Langsettiense). Debe subrayarse, sin embargo, el buen estado de algunos, como *Emphanisporites rotatus* (conocido desde el Frasniense al Tournaisiense) y *Retusotriletes incohatus* (Fameniense-Viseense superior).

BIOSTRATIGRAFÍA

Los datos obtenidos durante la realización del presente trabajo permiten relacionar las asociaciones encontradas en la Sección de la Playa de La Huelga con las asociaciones propias de algunas escalas bioestratigráficas establecidas en distintas áreas de Europa Occidental, fundamentalmente con la Cuenca Carbonífera Central de Asturias, las Islas Británicas, la Cuenca de Sarre Lorena en Francia, así como con la zonación establecida por Clayton *et al.* (1977), referida al conjunto de Europa Occidental.

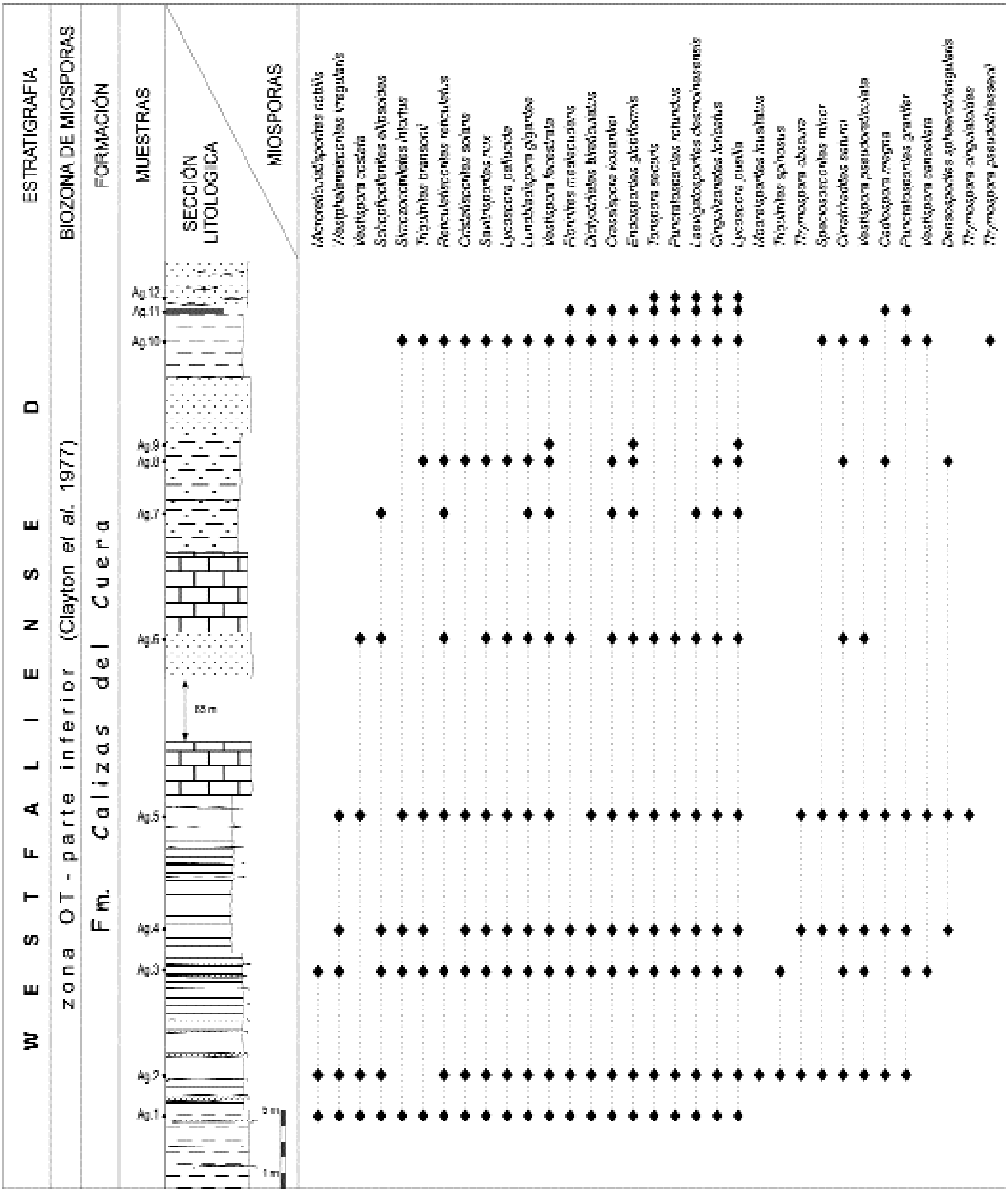

FIGURA 3–Distribución de miosporas seleccionadas a lo largo de la sección estudiada.
FIGURE 3–Distribution of selected miospores along the stratigraphic interval studied in this paper.

1. Relaciones con la Cuenca Carbonífera Central de Asturias

Dentro del Carbonífero de España, los trabajos palinológicos más generales de materiales comparables en edad a los estudiados en este trabajo son los realizados en la Cuenca Carbonífera Central de Asturias.

Chateauneuf (1973) dividió la sucesión estratigráfica, a partir del paquete Caleras (“Calizas”, en el trabajo mencionado), en cuatro zonas palinológicas que dicho autor hace corresponder con otras establecidas en la Cuenca de Sarre-Lorena.

La imprecisión en la definición de las bases de algunas biozonas hace bastante difícil su utilización en este trabajo. Por otra parte, no puede descartarse que, de acuerdo con los datos actuales, algunas especies que dicho autor considera de alto valor biostratigráfico tengan, incluso dentro de la región, una distribución más amplia que la supuesta en el trabajo de Chateauneuf (1973).

Sáenz de Santa María *et al.* (1985), por su parte, establecen tres zonas palinológicas desde el paquete Tendeyón hasta el techo de la sucesión carbonífera en la Cuenca Central. Nuestras muestras podrían equipararse con su zona I, que se caracteriza por una asociación constituida por *Cingulizonates loricatus*, *Vestispora cancellata* (o *V. costata*) y *V. pseudoreticulata*, todas ellas presentes en nuestras muestras, en las que además se identificó *Thymospora pseudothiessenii*, que para Sáenz de Santa María *et al.* solo está presente a partir de la biozona II, aunque con otros taxones (*Angulisporites splendidus*, *Savitrisporites camptotu*s, *Schopfites cristatus*, *Verrucosisporites pergranulus* y *Polymorphisporites laevigatus*) que no aparecen en estas muestras.

La zona I de Sáenz de Santa María *et al.* (1985) comprende los paquetes Tendeyón, Caleras, Generalas y parte baja de San Antonio.

Aunque en el texto del trabajo mencionado se afirma que la primera aparición de *Angulisporites splendidus* coincide con la base de la zona II, lo cierto es que en el cuadro I su primera aparición se representa en la parte alta de la zona I, en la base del paquete San Antonio. Habida cuenta de la ausencia de esta forma en nuestras muestras, creemos, como ya hemos expresado, que el intervalo estratigráfico estudiado podría correlacionarse con niveles estratigráficos situados por debajo de dicho paquete.

La comparación con los datos obtenidos por Luque *et al.* (1985) nos lleva igualmente a suponer que los niveles estudiados se corresponden con niveles situados por debajo del paquete San Antonio. En efecto, estos autores mencionan en el corte de La Inverniza-El Cabo especies de singular relevancia estratigráfica, como *Angulisporites splendidus*, *Savitrisporites camptotus* y *Schopfites cristatus*, ninguna de las cuales aparece por debajo del mencionado paquete. Ninguna de estas especies fue encontrada en las muestras aquí analizadas, por lo que es de suponer que los niveles que tratamos en este artículo podrían equipararse con niveles correspondientes, probablemente, a los paquetes Caleras o Generalas.

2. Relaciones con las Islas Británicas

Smith y Butterworth, 1967, basándose en el contenido de los carbones de distintas cuencas británicas, establecieron una sucesión de once “asociaciones” de miosporas, numeradas de I a XI y que abarcan desde el Viseense al Westfaliense D (o quizás al Estefaniense temprano).

El intervalo estratigráfico estudiado en este trabajo puede asimilarse a la “asociación” XI (de *Thymospora obscura*) de los autores citados, con la que presenta fuertes semejanzas.

La base de dicha “asociación” fue establecida en la primera aparición de alguna de las siguientes especies: *Cadiospora magna*, *Schopfites dimorphus*, *Triquitrites spinosus*, *Mooreisporites inusitatus*, *Alatisporites hoffmeisterii*, *Alatisporites trialatus*, *Punctatosporites oculus*, *Thymospora obscura* y *Thymospora pseudothiessenii.*

Aunque algunas de estas formas no sean abundantes y unas pocas estén ausentes, la mayoría de ellas aparecen en nuestras muestras. Smith y Butterworth (1967) advirtieron que los taxa que aparecen en la base de cada asociación tienden a no ser muy abundantes, que en ocasiones presentan un registro discontinuo, y que las especies “características” presentes varían de una cuenca a otra (así, *Alatisporites hoffmeisterii*, *A. trialatus*, *Cadiospora* y *Schopfites* sólo aparecen en algunos de los cortes de Gran Bretaña). Por ello no resulta sorprendente que algunas formas características de la “asociación” XI, como *Cadiospora magna* (hallada en Ag2, Ag4, Ag5, Ag8 y Ag11), *Mooreisporites inusitatus* (encontrada tan sólo en Ag2), *Thymospora obscura* (identificada en Ag2, Ag4 y con dudas en Ag5), *T. pseudothiessenii* (identificada sólo en Ag10) o *Triquitrites spinosus* (presente en Ag2 y Ag3) tengan una presencia discontinua y no sean abundantes. Tampoco debe extrañar que otras formas “características” de la “asociación” XI (*Schopfites dimorphus*, *Alatisporites hoffmeisterii*, *A. trialatus* y *Punctatosporites oculus*) no hayan sido encontradas en los niveles estudiados.

Otros rasgos considerados por Smith y Butterworth como relevantes de la “asociación” XI y que se observan en nuestras muestras son los siguientes: (1) presencia de pequeñas esporas monoletas, incluyendo formas verrugosas (*Thymospora obscura*, *T. cingulatoides* y *T. pseudothiessenii*), todas ellas escasas, aunque son más abundantes las puntuadas de tipo *Punctatosporites*. En este sentido puede destacarse el hallazgo de *Punctatosporites rotundus*, una forma que, según Smith y Butterworth, cuando se encuentra en abundancia es representativa del Westfaliense D. (2) Presencia persistente y abundancia relativa, como un elemento común, de *Triquitrites* (incluyendo *T. spinosus* y *T. bransonii)*. Las muestras Ag1 a Ag5 contienen hasta diez especies de este género, siendo algunas de ellas muy frecuentes. (3) Presencia de *Densosporites sphaerotriangularis* (no muy común en el material de la Playa de La Huelga), *Florinites mediapudens* (bastante frecuente) y *Crassispora kosankei* (presente en casi todas las muestras que hemos analizado), (4) abundancia en algunas muestras de *Endosporites globiformis* y *Florinites* spp. y existencia de *Lycospora* spp. y *Calamospor*a spp., especies comunes y muchas veces dominantes en las muestras palinológicas del Westfaliense.

En el material estudiado hay presencia frecuente de algunas formas cuya aparición caracteriza la “asociación” X de Smith y Butterworth (“Asociación” de *Torispora securis*), pero que persisten en la “asociación” XI, pudiendo incluso llegar a ser abundantes. Es el caso de *Torispora securis*, *Vestispora fenestrata*, *Punctatosporites granifer, Microreticulatisporites sulcatus*, *Triquitrites bransonii*, *Florinites mediapudens*, *Densosporites* spp. y *Cristatisporites solaris*.

Basándose en la aparición de *Thymospora obscura* (que es de escasa a común), *T. pseudothiessenii* (que puede llegar a estar ausente, aparecer ocasionalmente o tener una presencia significativa) *y Triquitrites spinosus* (siempre presente en pequeño número), Smith y Butterworth definieron la “asociación” XI, de edad Westfaliense D, haciendo coincidir la base de la “asociación” con la base de este piso.

3. Relaciones con la Cuenca de Sarre-Lorena

Las relaciones de nuestras asociaciones con las de la Cuenca de Sarre Lorena (Francia) revisten especial significado, dado que en dicha cuenca se ha situado la localidad tipo del Westfaliense D (comparar Wagner *et al*. 2002).

La Cuenca de Sarre Lorena ha sido objeto de un número considerable de trabajos palinológicos, a partir fundamentalmente del trabajo de Alpern (1963), al que han seguido otros, como los de Alpern y Liabeuf (1966, 1967), Alpern *et al.* (1967), Alpern *et al*. (1969) y Alpern y Streel (1972). Tras varias modificaciones en la nomenclatura (v. Alpern *et al*., 1969), en este trabajo estos autores distinguieron cuatro zonas en Sarre-Lorena, tres de ellas (SL3, SL2 y SL1, en orden ascendente) por debajo del conglomerado de Holz y una (SL0) por encima del mismo. En esta nomenclatura las notaciones SL3, SL2 y SL1 reemplazan a las notaciones previas W3, W2 y W1 y la notación SL0 a la S1-S2. Al objeto de comprender el alcance de algunos criterios empleados en la definición de sus zonas debe advertirse que el término biozona, tal como lo utilizan los autores mencionados, no se ajusta al concepto establecido en la Guía Estratigráfica Internacional (Salvador 1994). Según Alpern y Liabeuf (1966), “la biozone correspond à l´ensemble des strates dans lesquelles une espèce et présent (Hedberg, 1954)”.

Por lo que respecta a los materiales estudiados en el presente trabajo, cabe mencionar la ausencia de *Spinosporites spinosus* y la rareza de *Thymospora*, de la que se han hallado únicamente tres especies en tan sólo cuatro de las muestras estudiadas, siendo, además, su presencia esporádica. La ausencia de la primera de las formas mencionadas y la escasez de la segunda son consideradas por Alpern y Liabeuf, 1967 (p.2) como características de niveles situados por debajo de la base de la zona SL1. De este modo, los niveles estudiados se encuentran por debajo de dicha zona, cuya base coincide con la base de la epíbole de *Thymospora* y con la primera aparición de monoletas espinosas (género *Spinosporites*). Por otra parte, la base de la zona SL2 (denominada zona d por Alpern y Liabeuf, 1966) está marcada por “la base de las epíboles de *Torispora securis* y *Punctatosporites granifer*” (Alpern y Liabeuf, 1966, p.168). Los niveles investigados en la sección de la Playa de La Huelga presentan abundancia considerable de estas formas que, además, aparecen en casi todas las muestras estudiadas. A pesar de los problemas que tiene la utilización de las epíboles en correlaciones detalladas, y aunque en propiedad tampoco podemos asegurar de modo taxativo que nos encontremos en niveles correspondientes a las epíboles de ambas especies (ya que no se han realizado estudios cuantitativos), la persistencia y abundancia de estas formas nos mueven a suponer que estamos por encima de la base de SL2 y, por tanto, de acuerdo con lo dicho anteriormente en esta última zona. Además pueden señalarse los siguientes hechos: (1) presencia constante, pero no abundante, de *Cingulizonates loricatus*. El techo de la epíbole de esta especie se encuentra en el límite SL2/SL3, (2) En la zona SL2, *Microreticulatisporites nobilis* no es muy abundante ni frecuente, al igual que ocurre en nuestras muestras (sólo se identificó en Ag1, Ag2 y Ag3), (3) *Westphalensisporites irregularis* tiene su máxima presencia en la zona SL2 y es una especie abundante y persistente en nuestros niveles.

Alpern y Liabeuf (1966) y Alpern *et al.* (1969) dividieron la zona SL2 en un conjunto de subzonas. Definieron la base de la subzona SL221 (o sus equivalentes W221 y d2) como la base de la "biozona de monoletas verrugosas" y la base de la epíbole de *Vestispora fenestrata*. Como se ha dicho, en la sección de la Playa de La Huelga se ha comprobado la existencia desde las muestras inferiores de monoletas verrugosas (*Thymospora*), y hay abundancia de *Vestispora fenestrata*. Todo ello nos hace suponer que estando en la zona SL2 nos encontramos por encima de la base de SL221. Un hecho un poco anómalo es la presencia de *Vestispora costata*, aunque tanto esta especie como *Lophotriletes* spp. aparecen de modo esporádico y sólo en las muestras más bajas. Estos autores definieron la base de la subzona SL21 (inmediatamente por encima de la subzona SL221) por la desaparición de Cristatisporites. Sin embargo, esta forma es conocida en otras cuencas en niveles considerablemente más altos (incluidos algunos niveles estefanienses), por lo que su presencia en la Sección de La Huelga no puede ser utilizada como un criterio de correlación temporal con la cuenca de Sarre-Lorena. En cualquier caso, los niveles de la sección estudiada en este trabajo deben corresponder a tramos comprendidos entre la base de la subzona SL221 y la base de la zona SL1, siendo por tanto equivalentes a la parte alta de la zona de Forbach o a la parte baja de la zona de St. Avold, pertenecientes ambas a la Assise de La Houve (Fig. 4).

4. Relaciones de conjunto con Europa Occidental (zonación de Clayton *et al.*, 1977)

Como resultado de la investigación palinológica de numerosas áreas de Europa Occidental, Clayton *et al.* (1977) han propuesto una escala estratigráfica de 24 zonas que cubren el lapso temporal comprendido entre el Devónico terminal y el Pérmico basal.

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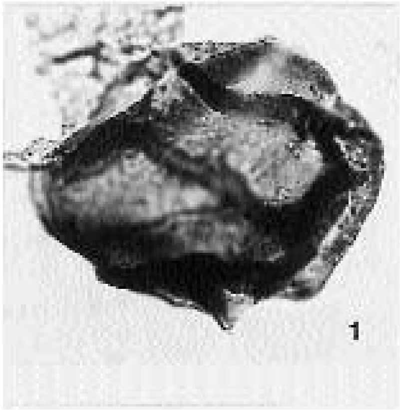
Lámina 1–*1, Calamospora hartungiana* Schopf 1944. Ag5-2A, 35.2/109.0. *2, Lophotriletes mosaicus* Potonié and Kremp 1955. Ag8-1A, 29.0/106.3. *3, Microreticulatisporites nobilis* (Wicher) Knox 1950. Ag10-1A, 43.2/99.2. *4, Cadiospora magna* Kosanke 1950. Ag12-1A, 42.2/107.3. *5, Calamospora breviradiata* Kosanke 1950. Ag8-1A, 40.0/109.4. *6, Cirratriradites saturni* (Ibrahim) Schopf, Wilson and Bentall 1944. Ag5-2A, 20.6/108.7. *7, Cingulizonates loricatus* (Loose) Butterworth, Jansonius, Smith and Staplin 1964. Ag8-1A, 21.0/108.2. *8, Dictyotriletes reticulocingulum* (Loose) Smith and Butterworth 1967. Ag5-1A, 35.0/104.8. *9, Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy 1955. Ag9-1A, 44.3/102.2. *10, Densosporites anulatus* (Loose) Schopf, Wilson and Bentall 1944. Ag8-1A, 38.2/110.0. *11, Densosporites sphaerotriangularis* Kosanke 1950. Ag1-1A, 25.0/113.4. *12, Cristatisporites solaris* (Balme) Butterworth and Smith 1964. Ag8-1A, 46.0/106.3. *13, Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp 1954. Ag12-1A, 41.9/99.7. *14, Savitrisporites nux* (Butterworth and Williams) Smith and Butterworth 1967. Ag10-1A, 39.0/107.2. *15, Emphanisporites rotatus* (McGregor) McGregor 1973. Ag8-1A, 30.2/101.1. *16, Westphalensisporites irregularis* Alpern 1958. Ag8-1A, 37.8/98.3. *17, Lycospora pellucida* (Wicher) Schopf, Wilson and Bentall 1944. Ag5-1A, 32.0/112.7. *18, Crassispora kosankei* (Potonié and Kremp) Bharadwaj 1957. Ag12-1A, 42.3/99.8. *19, Reticulatisporites reticulatus* (Ibrahim) Ibrahim 1933. Ag10-1A, 26.6/94.6. *20, Reinschospora triangularis* Kosanke 1950. Ag12-1A, 42.0/94.9. *21, Lundbladispora gigantea* (Alpern) Doubinger 1968. Ag11-1A, 29.8/99.6. *22, Lycospora pusilla* (Ibrahim) Schopf, Wilson and Bentall 1944. Ag9-1A, 24.3/98.3. *23, Simozonotriletes intortus* (Waltz) Potonié and Kremp 1954. Ag8-1A, 46.6/100.5.

Plate 1–*1, Calamospora hartungiana* Schopf 1944. Ag5-2A, 35.2/109.0. *2, Lophotriletes mosaicus* Potonié and Kremp 1955. Ag8-1A, 29.0/106.3. *3, Microreticulatisporites nobilis* (Wicher) Knox 1950. Ag10-1A, 43.2/99.2. *4, Cadiospora magna* Kosanke 1950. Ag12-1A, 42.2/107.3. *5, Calamospora breviradiata* Kosanke 1950. Ag8-1A, 40.0/109.4. *6, Cirratriradites saturni* (Ibrahim) Schopf, Wilson and Bentall 1944. Ag5-2A, 20.6/108.7. *7, Cingulizonates loricatus* (Loose) Butterworth, Jansonius, Smith and Staplin 1964. Ag8-1A, 21.0/108.2. *8, Dictyotriletes reticulocingulum* (Loose) Smith and Butterworth 1967. Ag5-1A, 35.0/104.8. *9, Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy 1955. Ag9-1A, 44.3/102.2. *10, Densosporites anulatus* (Loose) Schopf, Wilson and Bentall 1944. Ag8-1A, 38.2/110.0. *11, Densosporites sphaerotriangularis* Kosanke 1950. Ag1-1A, 25.0/113.4. *12, Cristatisporites solaris* (Balme) Butterworth and Smith 1964. Ag8-1A, 46.0/106.3. *13, Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp 1954. Ag12-1A, 41.9/99.7. *14, Savitrisporites nux* (Butterworth and Williams) Smith and Butterworth 1967. Ag10-1A, 39.0/107.2. *15, Emphanisporites rotatus* (McGregor) McGregor 1973. Ag8-1A, 30.2/101.1. *16, Westphalensisporites irregularis* Alpern 1958. Ag8-1A, 37.8/98.3. *17, Lycospora pellucida* (Wicher) Schopf, Wilson and Bentall 1944. Ag5-1A, 32.0/112.7. *18, Crassispora kosankei* (Potonié and Kremp) Bharadwaj 1957. Ag12-1A, 42.3/99.8. *19, Reticulatisporites reticulatus* (Ibrahim) Ibrahim 1933. Ag10-1A, 26.6/94.6. *20, Reinschospora triangularis* Kosanke 1950. Ag12-1A, 42.0/94.9. *21, Lundbladispora gigantea* (Alpern) Doubinger 1968. Ag11-1A, 29.8/99.6. *22, Lycospora pusilla* (Ibrahim) Schopf, Wilson and Bentall 1944. Ag9-1A, 24.3/98.3. *23, Simozonotriletes intortus* (Waltz) Potonié and Kremp 1954. Ag8-1A, 46.6/100.5.

LÁMINA 1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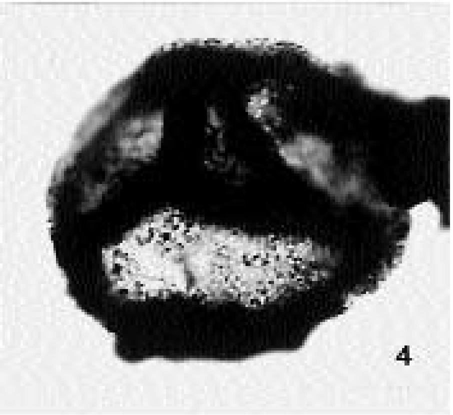
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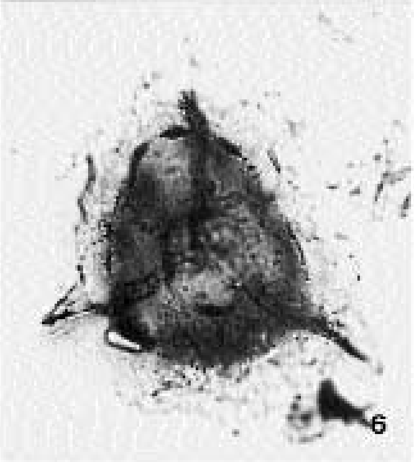
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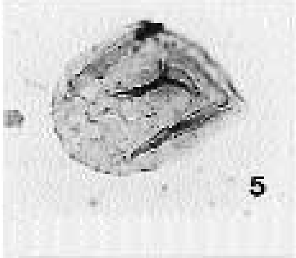
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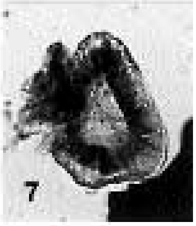
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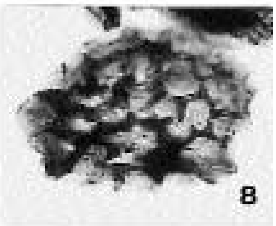
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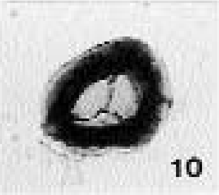
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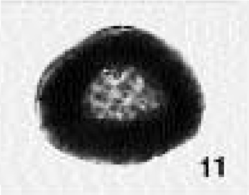
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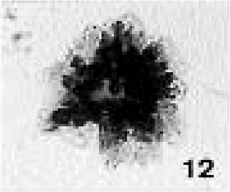
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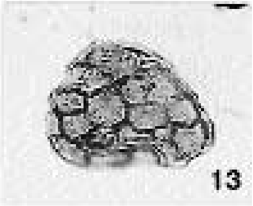
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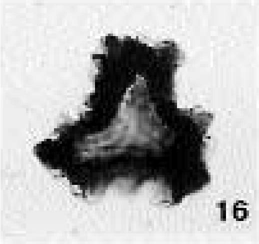
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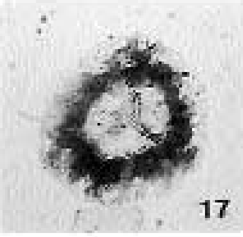
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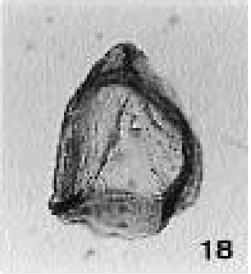
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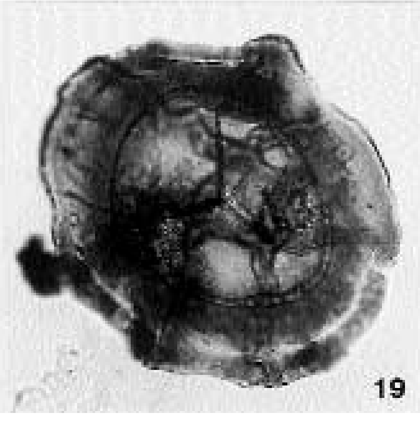
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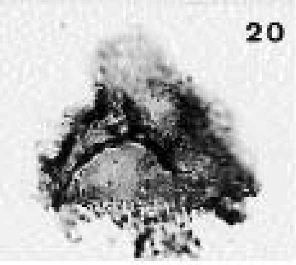
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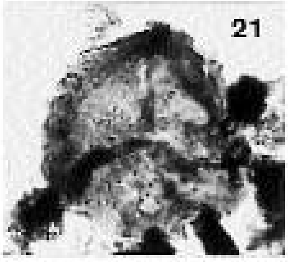
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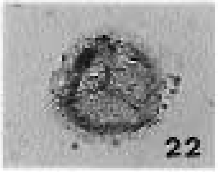
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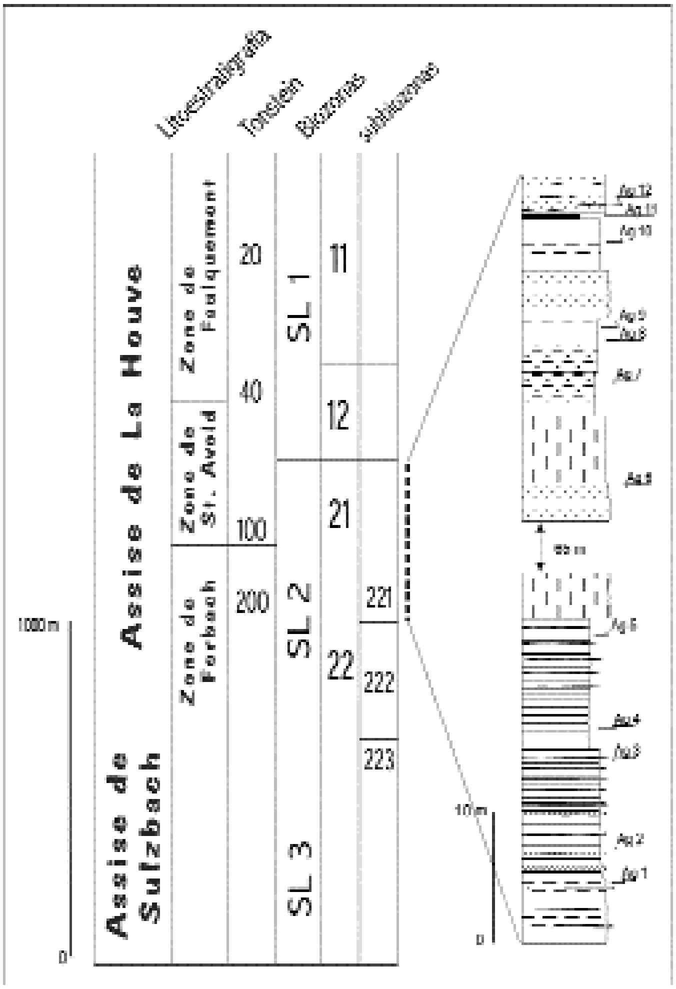

FIGURA 4–Esquema de correlación entre la biozonación establecida por Alpern y Liabeuf, 1967, para la cuenca Sarre Lorena (Francia), y la Sección de la Playa de La Huelga, aquí estudiada, según el contenido palinológico.

FIGURE 4–Suggested correlation between the Playa de La Huelga section and the sucession of Saar-Lorraine basin, France (Alpern and Liabeuf, 1967).

El análisis del contenido de las muestras de la sección de la Playa de La Huelga permite afirmar que el intervalo estratigráfico estudiado se sitúa dentro de la zona OT (zona de *Thymospora obscura-thiessenii*). En efecto: (1) aunque de forma esporádica, en las muestras Ag2, Ag4, Ag5 y Ag10 se ha identificado el género *Thymospora*. De acuerdo con Clayton *et al*. (1977), su aparición marca el límite inferior de la zona mencionada. (2) *Reticulatisporites reticulatus* y “*Vestispora costata-cancellata*”, aunque con presencia débil son especies representadas prácticamente a lo largo de todo el corte. Su mayor presencia se da en las muestras estratigráficamente más bajas. La base de la zona OT coincide, según Clayton *et al*. (1977), con el techo de las epíboles de estas formas. (3) La base de la biozona siguiente (zona ST, *de “Angulisporites splendidus-Latensina trileta*”) viene marcada por la aparición de *Angulisporites splendidus* y *Cheiledonites* spp. No hemos encontrado ninguno de estos elementos en nuestro material. Tampoco aparece *Latensina trileta*, que tiene una presencia más o menos constante a partir de la base de la zona ST.

Las muestras analizadas permiten precisar, además, que los tramos analizados se sitúan en la parte baja o media de la zona OT, como se desprende de los siguientes hechos: (1) *Dictyotriletes bireticulatus* y *Cingulizonates loricatus* son formas relativamente abundantes en nuestro material. La extinción de estos elementos se da en la parte inferior de la zona OT. Habría, no obstante, que advertir que algunos autores señalan la desaparición de *Cingulizonates loricatus* en niveles más altos (dentro del Cantabriense), Coquel y Rodríguez, 1994, 1995. (2) La abundancia de *Crassispora kosankei* nos hace suponer que probablemente nos encontremos en la epíbole de la especie, que no sobrepasa la parte media de la zona OT. (3) En las muestras estudiadas no se encuentran las especies *Spinosporites spinosus*, *Savitrisporites camptotus* y *Polymorphisporites* spp. La aparición de las mismas se localiza, de acuerdo con Clayton *et al*. (1977), siempre por encima del límite basal de la zona OT.

CONSIDERACIONES CRONOSTRATIGRÁFICAS

La asignación de los materiales estudiados a la parte baja de la zona OT de Clayton *et al*. (1977) indica una edad Bolsoviense superior o Westfaliense D inferior, sin que existan datos que permitan discriminar entre una y otra. Algo semejante sucede cuando se comparan nuestros materiales con los de la Cuenca Carbonífera Central de Asturias. Los resultados del presente estudio permiten correlacionar los niveles investigados con tramos situados por debajo del paquete San Antonio (con Caleras o Generalas). Según Sáenz de Santa María *et al*. (1985), el paquete Tendeyón corresponde ya al Westfaliense D. Sin embargo, este hecho es discutido por Wagner y Álvarez Vázquez (1991), que sitúan el inicio de este piso con la base en un nivel próximo a la base de Caleras.

Más precisión parece arrojar la comparación con la sucesión de Sarre-Lorena. Como se indicó, los niveles estudiados parecen ser asimilables a la subzona SL221 o a la subzona SL21, que corresponden a la parte alta de la zona de Forbach y a la parte baja de la zona de St. Avold pertenecientes ambas a la Assise de La Houve. Según Alpern y Liabeuf, estos tramos están comprendidos entre los tonstein 200 y un nivel situado por encima del tonstein 100, que contienen *Neuropteris ovata* y, por tanto, de edad Westfaliense D. De acuerdo con Laveine (1974, 1977) la primera aparición de *Neuropteris ovata* en la cuenca de Sarre Lorena se da precisamente entre los tonsteins 200 y 100, por lo que la edad de los niveles estudiados en este trabajo debe corresponder probablemente a un Westfaliense D bajo.

CONCLUSIONES

Los palinomorfos encontrados en los tramos superiores de la Sección de la Playa de La Huelga permiten determinar la edad de estos niveles, situarlos en el contexto de diversas biozonas establecidas en diferentes áreas carboníferas y correlacionarlos con las sucesiones de la Cuenca Carbonífera Central de Asturias (España) y de la Sarre Lorena (Francia). Por otra parte, su ubicación contigua a niveles con fusulinas proporciona algunos datos acerca de la correlación entre las escalas estratigráficas de Rusia y Europa Occidental.

A juzgar por las asociaciones de palinomorfos, los niveles estudiados tienen una edad Westfaliense D temprano, y son asimilables a la zona I (Sáenz de Santa María *et al*., 1985) de la Cuenca Carbonífera Central de Asturias, a la “asociación” XI (Smith y Butterworth, 1967) de las Islas Británicas, a la zona SL2 (probablemente a su parte media) de la Sarre Lorena y a la parte baja (pero no basal) de la zona OT de Europa Occidental (Clayton *et al*., 1977). Los niveles objeto de investigación parecen correlacionarse con paquetes situados por debajo del paquete San Antonio (probablemente con el paquete Caleras o Generalas) de la Cuenca Carbonífera Central de Asturias y con la parte alta de la zona de Forbach (Assise de La Houve) de Sarre-Lorena.

La presencia de fusulinas propias del Podolskiense en niveles situados inmediatamente por encima de los estudiados apuntan a una equivalencia al menos parcial del Westfaliense D con el Podolskiense. Este último hecho está en sensible concordancia con la correlación propuesta por Wagner y Winkler Prins (1997) para materiales de esta edad.

AGRADECIMIENTOS

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Lámina 2–*1, Mooreisporites trigallerus* Neves 1961. Ag8-1A, 19.7/102.5. *2, Vestispora fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala 1963. Ag8-1A, 19.0/101.0. *3, Vestispora costata* (Balme) Bharadwaj 1957. Ag8-1A, 29.8/98.8. *4, Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall 1944. Ag8-1A, 18.0/107.7. *5, Ahrensisporites guerickei* (Horst) Potonié and Kremp 1954. Ag8-1A, 27.7/94.5. *6, Laevigatosporites desmoinesensis* (Wilson and Coe) Schopf, Wilson and Bentall 1944. Ag12-1A, 40.8/109.8. *7*, Punctatosporites rotundus* Bharadwaj 1957. Ag12-1A, 45.0/110.9 (×1000). *8*, Punctatosporites granifer* Potonié and Kremp 1956. Ag12-2A, 23.6/101.8 (×1000). *9, Endosporites ornatus* Wilson and Coe 1940. Ag8-1A, 28.7/100.0. *10, Triquitrites spinosus* Kosanke 1943. Ag9-1A, 31.5/99.0. *11, Triquitrites bransonii* Wilson and Hoffmeister 1956. Ag11-1A, 32.6/99.8. *12*, Torispora securis* (Balme) Alpern, Doubinger and Horst 1965. Ag11-1A, 28.0/106.7 (×1000). *13*, Torispora securis*. Ag8-1A, 15.8/101.2 (×1000). *14*, Thymospora cingulatoides* (Alpern) Alpern and Doubinger 1971. Ag12-1A, 42.4/96.0 (×1000). *15*, Speciososporites minor* Alpern 1958. Ag11-2A, 37.7/93.8 (×1000). *16*, Torispora perverrucosa* Alpern 1959. Ag11-2A, 27.6/108.3 (×1000). *17*, Torispora verrucosa* Alpern 1958. Ag12-2A, 36.0/108.8 (×1000). *18*, Thymospora obscura* (Kosanke) Wilson and Venkatachala 1963. Ag5-1A, 40.0/109.2 (×1000). *19*, Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp 1954. Ag9-1A, 40.0/107.0 (×200). *20, Pityosporites* spp. (Seward) Manum 1960. Ag5-1A, 36.4/114.7. *21, Florinites mediapudens* (Loose) Potonié and Kremp 1956. Ag5-2A, 34.3/93.2. *22, Florinites eremus* Balme and Hennelly 1955. Ag8-1A, 32.6/110.2.

Las coordenadas corresponden a un microscopio LEIZT DM RBE. Todas las fotos están ampliadas ×400, excepto en los casos marcados con un asterisco (*) en los que se indica la ampliación.

Plate 2–*1, Mooreisporites trigallerus* Neves 1961. Ag8-1A, 19.7/102.5. *2, Vestispora fenestrata* (Kosanke and Brokaw) Wilson and Venkatachala 1963. Ag8-1A, 19.0/101.0. *3, Vestispora costata* (Balme) Bharadwaj 1957. Ag8-1A, 29.8/98.8. *4, Endosporites globiformis* (Ibrahim) Schopf, Wilson and Bentall 1944. Ag8-1A, 18.0/107.7. *5, Ahrensisporites guerickei* (Horst) Potonié and Kremp 1954. Ag8-1A, 27.7/94.5. *6, Laevigatosporites desmoinesensis* (Wilson and Coe) Schopf, Wilson and Bentall 1944. Ag12-1A, 40.8/109.8. *7*, Punctatosporites rotundus* Bharadwaj 1957. Ag12-1A, 45.0/110.9 (×1000). *8*, Punctatosporites granifer* Potonié and Kremp 1956. Ag12-2A, 23.6/101.8 (×1000). *9, Endosporites ornatus* Wilson and Coe 1940. Ag8-1A, 28.7/100.0. *10, Triquitrites spinosus* Kosanke 1943. Ag9-1A, 31.5/99.0. *11, Triquitrites bransonii* Wilson and Hoffmeister 1956. Ag11-1A, 32.6/99.8. *12*, Torispora securis* (Balme) Alpern, Doubinger and Horst 1965. Ag11-1A, 28.0/106.7 (×1000). *13*, Torispora securis*. Ag8-1A, 15.8/101.2 (×1000). *14*, Thymospora cingulatoides* (Alpern) Alpern and Doubinger 1971. Ag12-1A, 42.4/96.0 (×1000). *15*, Speciososporites minor* Alpern 1958. Ag11-2A, 37.7/93.8 (×1000). *16*, Torispora perverrucosa* Alpern 1959. Ag11-2A, 27.6/108.3 (×1000). *17*, Torispora verrucosa* Alpern 1958. Ag12-2A, 36.0/108.8 (×1000). *18*, Thymospora obscura* (Kosanke) Wilson and Venkatachala 1963. Ag5-1A, 40.0/109.2 (×1000). *19*, Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp 1954. Ag9-1A, 40.0/107.0 (×200). *20, Pityosporites* spp. (Seward) Manum 1960. Ag5-1A, 36.4/114.7. *21, Florinites mediapudens* (Loose) Potonié and Kremp 1956. Ag5-2A, 34.3/93.2. *22, Florinites eremus* Balme and Hennelly 1955. Ag8-1A, 32.6/110.2.

The coordinates are from a LEIZT DM RBE microscope. All magnifications are ×400 unless otherwise stated indicated as asterisk (*).

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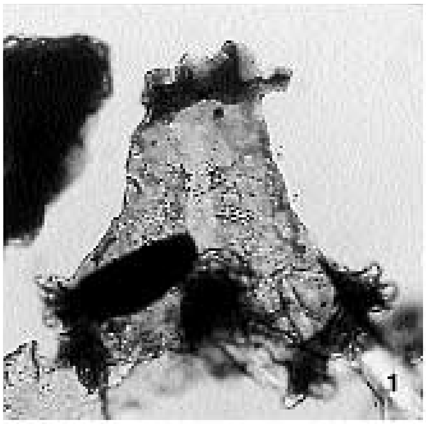
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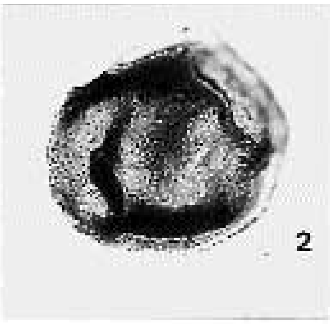
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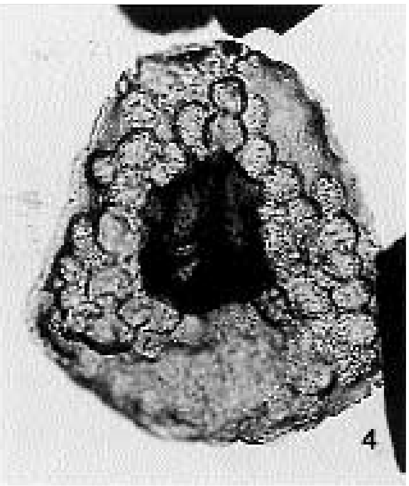
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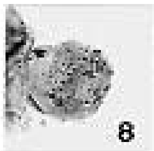
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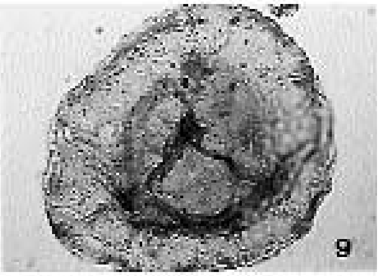
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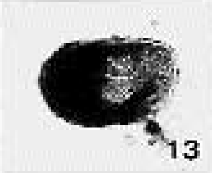
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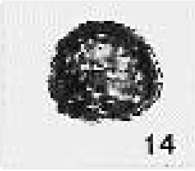
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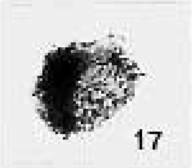
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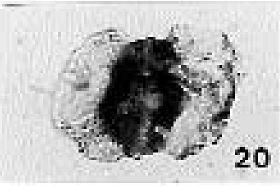
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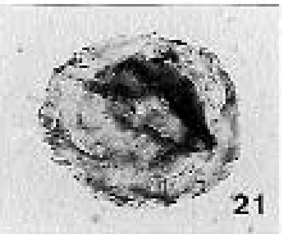
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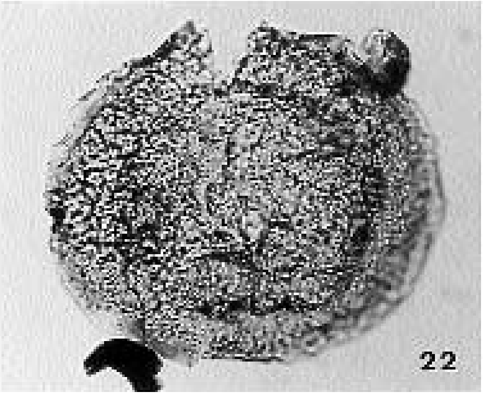
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A NEW FORAMINIFERAL GENUS (MILIOLINA) FROM THE EARLY JURASSIC OF THE SOUTHERN ALPS (CALCARI GRIGI FORMATION, NORTHEASTERN ITALY)

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Abstract

The new genus *Meandrovoluta* gen. nov. (type-species *Meandrovoluta asiagoensis* gen. et sp. nov.), a microbenthic porcelaneous foraminifer, is herein described. It has been recorded from the Lower Jurassic (Liassic) Calcari Grigi formation (Trento Platform, Southern Alps, Northeastern Italy). *Meandrovoluta* gen. nov. has been placed in the family Cornuspiridae Schultze (Miliolina).

Keywords: Foraminifera, New Genus, Cornuspiridae, Liassic, Systematics, Southern Alps, Northeastern Italy.

Resumen

Se describe el nuevo género *Meandrovoluta* gen. nov. (especie-tipo *Meandrovoluta asiagoensis* gen. et sp. nov.), un foraminífero microbentónico aporcelanado. Ha sido registrado en la Formación Calcari Grigi del Jurásico Inferior (Lías) (Plataforma de Trento, Alpes Meridionales, noreste de Italia). *Meandrovoluta* gen. nov. ha sido asignado a la familia Cornuspiridae Schultze (Miliolina).

Palabras clave: Foraminíferos, Nuevo Género, Cornuspiridae, Lías, Sistemática, Alpes Meridionales, Noreste de Italia.

INTRODUCTION

The present study deals with the record of a new genus, *Meandrovoluta* gen. nov. (type species: *Meandrovoluta asiagoensis* gen et sp. nov., Family Cornuspiridae, Subfamily Meandrospirinae) which has been identified in the Early Jurassic of the Southern Alps. In the literature concerning the foraminifera of the Liassic Tethys, specimens which are herein ascribed to this new genus were often regarded as possessing a finely agglutinated wall and frequently assigned to the genus *Glomospira* Rzehak, 1885 (Ammodiscidae Reuss, 1862).

The studied material comes from different stratigraphic sections (Fig. 1) of the Calcari Grigi formation, which is a Liassic shallow water carbonate succession deposited on the Trento Platform, a palaeogeographic unit located between Lake Garda and Monte Grappa. The Calcari Grigi are constituted by four members (Lower, Middle, Rotzo and Massone Members; Bosellini & Broglio Loriga, 1971; Krautter, 1985, 1987; Beccarelli Bauck, 1988) among which the Rotzo Member represents the most fossiliferous unit as far as terrestrial and marine fossils are concerned (i.e. continental flora of Rotzo, De Zigno, 1856-1885; *Lithiotis* facies, Broglio Loriga & Neri, 1976). This formation overlies the Dolomia Principale (Norian-Rhaetian), a succession of perytidal cycles (Bosellini & Hardie, 1985) and is directly overlain by the Toarcian-Aalenian San Vigilio Group or by the Upper Bajocian-Tithonian Rosso Ammonitico.

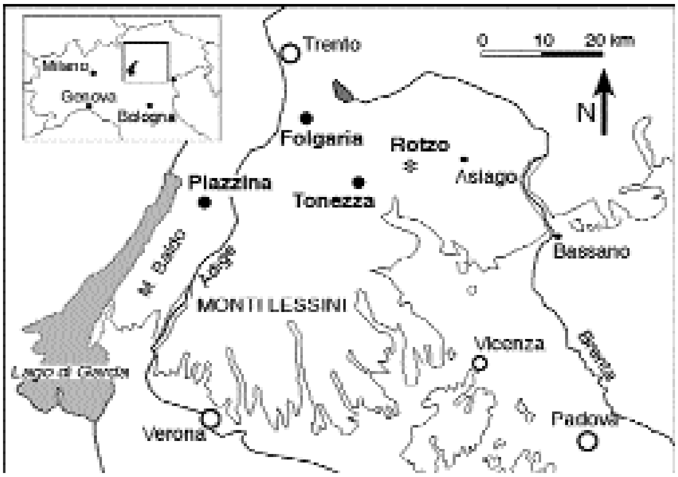


FIGURE 1–Geographic map showing the sampling localities in the Southern Alps. *= type locality.

The genus *Meandrovoluta* gen. nov. was found at the top of the Middle Member and throughout the Rotzo Member which are both considered to span the Sinemurian *p.p.*–Domerian interval as documented by the recognition of the *Orbitopsella* and *Lituosepta compressa* biozones (Fugagnoli & Loriga Broglio, 1998; Fugagnoli, 1998; Fig. 2) in the stratigraphic succession which yielded the type-material. The foraminiferal assemblages associated with *Meandrovoluta* gen. nov. are quite diversified consisting of small foraminifera with a wide stratigraphic range such as textulariids, valvulinids, *Duotaxis metula* Kristan, 1957 and larger foraminifera such as *Orbitopsella* spp., *Pseudocyclammina liasica* (Hottinger, 1967) Septfontaine, 1984, *Lituosepta compressa* Hottinger, 1967 which have a relevant biostratigraphic value.

Systematic comparison evidentiated synonimies with specimens recorded from the Apennines, Sicily (Parisi, oral comm.), Dinarids, Morocco and Spain which extend the distribution of the genus *Meandrovoluta* gen. nov. up to the Toarcian age (Chiocchini, 1977; Monaco *et al.*, 1994).

MATERIAL AND METHODS

The specimens examined in this study were recorded from different stratigraphic sections of the Middle and Rotzo Members of the Calcari Grigi formation cropping out in the Altopiano di Asiago (Rotzo, Vicenza), Altopiano di Tonezza del Cimone (Valle Valbona, Vicenza), in the Altopiano di Folgaria (Val Gola, Trento) and in the Monte Baldo area (Piazzina, Trento) (Fig. 1).

They were found only in cemented carbonate rocks and were therefore studied in random thin sections. Specimens are deposited in the Museo di Paleontologia e Preistoria “P. Leonardi” of the Dipartimento delle Risorse Naturali e Culturali, University of Ferrara. Suprageneric classification adopted in this work follows that of Loeblich & Tappan (1992).

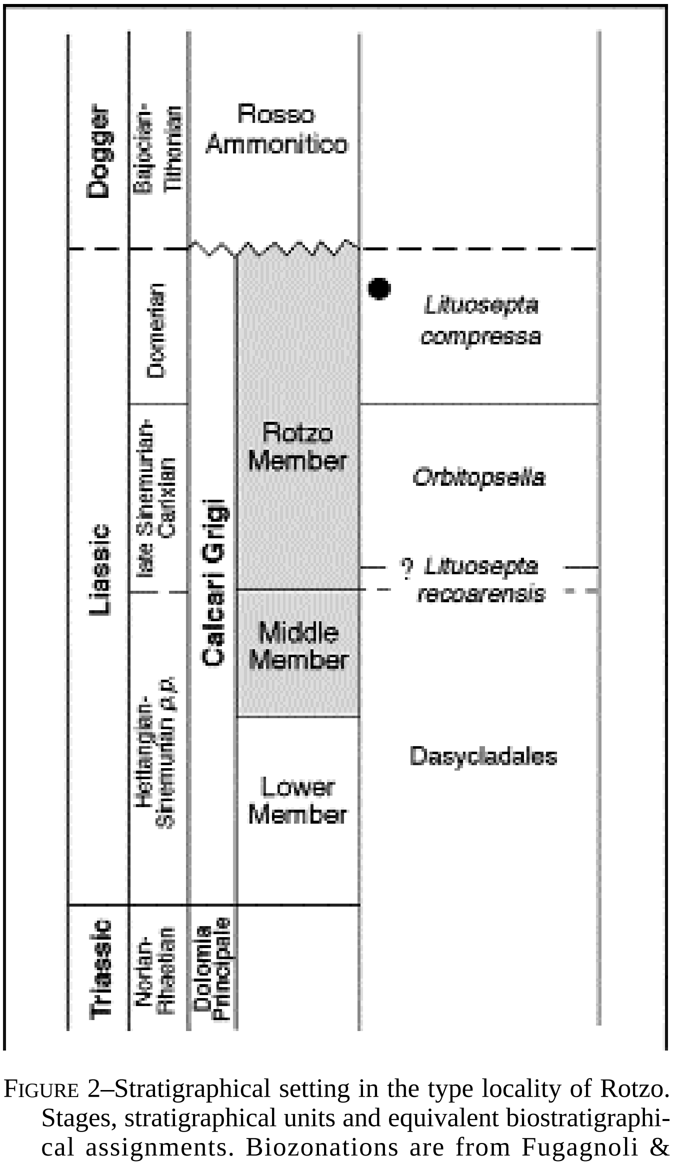


FIGURE 2–Stratigraphical setting in the type locality of Rotzo. Stages, stratigraphical units and equivalent biostratigraphical assignments. Biozonations are from Fugagnoli & Loriga Broglio (1998) and Fugagnoli (1998). The black point indicates the type level of *Meandrovoluta asiagoensis* gen. nov., sp. nov.

SYSTEMATIC DESCRIPTION

Class FORAMINIFEREA Lee, 1990
Order MILIOLIDA Lankester,1885 (as MILIOLIDEA nom. corr. Calkins, 1909)
Suborder MILIOLINA Delage & Hérouard,1896
Superfamily CORNUSPIRACEA Schultze, 1854
Family CORNUSPIRIDAE Schultze, 1854
Subfamily MEANDROSPIRINAE Saidova, 1981
Genus *Meandrovoluta* Fugagnoli & Rettori gen. nov.
Type-species: *Meandrovoluta asiagoensis* Fugagnoli & Rettori gen. et sp. nov.

Derivatio nominis.–After the meandroid convolutions of the tubular second chamber.

Description.–Test free, small, globular proloculus followed by an undivided tubular second chamber. In the early stage the second tubular chamber bends back and forth in zig-zag bends while coiling, as in *Meandrospira* Loeblich & Tappan, 1946. Later the tube becomes slightly undulated, describing wide arched zig-zag bends (meanders) perpendicular to those of the *Meandrospira*-like stage and disposed on oscillating planes, giving to this part of the test a fan-like shape.

The zig-zag bends sometimes overlap due to undulation of the tubular chambers and oscillation of planes, therefore meanders appear in section not regularly aligned.

In the final stage, which is not always present, the tubular chamber is not meandering and planispirally coiled. The first planispiral whorl sharp changes in direction, so that the axis of coiling is nearly perpendicular to that of the early *Meandrospira*-like stage; when present, a second planispiral whorl is with 90° change in plane of coiling with respect to the previous one.

Dimorphism probably occurs and is reflected by a smaller size of the test and a reduction of the second stage in the megalospheric generation.

The wall is calcareous, dark, imperforate, porcelaneous; aperture at the open end of the tube. Monotypic.

Stratigraphic and geographic distribution.–Lower Jurassic, Liassic, Sinemurian to Toarcian of Southern Alps, Northern and Central Apennines, Sicily, Dinarids, Morocco, Spain.

Remarks.–The genus *Meandrovoluta* gen. nov. can be distinguished from the genus *Palaeomiliolina* Antonova, 1959 (Spiroloculinidae Wiesner, 1920) because the latter lacks an early *Meandrospira*-like stage and has a multilocular test.

The genus *Meandrovoluta* gen. nov. differs from *Glomospira* Rzehak, 1885 (Ammodiscidae Reuss, 1862) in having a porcelaneous wall. Moreover, tangential and/or oblique sections of *Meandrovoluta* gen. nov. make possible to confuse it with sections of *Glomospira* Rzehak, 1885 (Ammodiscidae Reuss, 1862) even if this latter is characterized by a coil arranged like a ball of string, which tends to become irregular.

Meandrovoluta gen. nov. differs from *Glomospirella* Plummer, 1945 (Ammodiscidae Reuss, 1862) as in this genus the later stage becomes always planispirally enrolled, the test is discoidal, and the wall is finely agglutinated.

The genus *Meandrovoluta* gen. nov. is somewhat similar in outline to the Triassic genus *Semimeandrospira* Urosevic, 1988 (Fischerinidae Millett, 1898), but the original description given by the author just describes the genus as "... wound in an irregular zig-zag manner and the last coil is rapidly enlarged and elevated..." (Urosevic, 1988, p. 379).

The first *Meandrospira*-like stage is also present in the Carboniferous genus *Plummerinella* Cushman & Waters, 1928 (Cornuspiridae Schultze, 1854) but this Paleozoic genus is attached and the meandrospiral stage is followed by a tubular chamber which enlarges rapidly in the later part, and finally spreads widely. In Monaco *et al.* (1994) some specimens of *Meandrovoluta* gen. nov. have been ascribed to the genus *Planiinvoluta* Leischner, 1961 (Cornuspiridae) but this genus, which is also attached, does not show any morphological feature which can ascribe it to *Meandrovoluta* gen. nov.

Meandrovoluta asiagoensis
Fugagnoli & Rettori gen. et sp. nov.
(Pl. 1, Figs. 1-12; Pl. 2, Figs. 1-5?, 6-16)

? 1966 *Glomospira*. Radoicic, Pl. 92, Fig. 2.
1966 *Glomospira* sp. Radoicic, Pl. 111, Fig. 2.
1966 *Glomospira*. Radoicic, Pl. 124, Fig. 1-2.
1971 "*Meandrospira*" sp. González-Donoso *et al.*, Pl. 1, Figs. 5, 6.
1971 *Glomospira* sp. Bosellini & Broglio Loriga, Pl. 2, Figs. 3, 5.
1975 *Glomospira* sp. Clari, Fig. 34, G, H.
1977 *Glomospira* sp. n.? Chiocchini, Pl. 9, Figs. 5, ? 6, ? 7.
1978 *Glomospira*. Gusic & Velic, Pl. 10, Fig. 3.
1978 *Glomospira* sp. Gusic & Velic, Pl. 10, Fig. 5.
1994 *Planiinvoluta* aff. *P. carinata* Leischner. Monaco *et al.*, Pl. 1, Figs. 6, 9; Pl. 3, Figs. 2, 3.

1994 *Planiinvoluta* (?). Monaco *et al.*, Pl. 2, Fig. 3.
1994 *Planiinvoluta* sp. Monaco *et al.*, Pl. 2, Figs. 11-13.
1995 *Glomospira* sp./*Glomospirella* sp. Scheibner, Pl. 11, Figs. 7, ? 8.
?1995 *Glomospira* sp./*Glomospirella* sp. Scheibner, Pl. 11, Fig. 8.
1998 *Planiinvoluta* sp. Fugagnoli & Loriga Broglio, Fig. 9, n. 12.
1998 *Glomospira* sp. Fugagnoli, Pl. 29, Figs. 8, 9, 11.
1998 *Planiinvoluta* sp. Fugagnoli, Pl. 29, Figs. 1, 6, 7.
?1999 *Glomospira* sp./*Glomospirella* sp. Scheibner & Reijmer, Pl. 17, Fig. 8.

Derivatio nominis.–After the name of Asiago which is main village in the area of the Rotzo type locality (Vicenza; Trento Platform, Northeastern Italy).

Holotype.–Specimen illustrated in Pl.1, Fig. 1, sample R9526.

Type locality.–Rotzo, Altopiano di Asiago (Vicenza; Trento Platform, Northeastern Italy) (Fig. 1).

Type level.–Sample R9526, wackestone/packstone with foraminifera, bioclasts, peloids and intraclasts. Rotzo Member, Calcari Grigi, *Lituosepta compressa* zone, Liassic (Domerian), Early Jurassic.

Material.–About 80 specimens in thin section deposited at the Museo di Paleontologia e Preistoria “P. Leonardi”, Dipartimento delle Risorse Naturali e Culturali of Ferrara University, Italy.

Description.–The test of *Meandrovoluta asiagoensis* gen. et sp. nov. is free, small, made up by a globular proloculus followed by an undivided tubular second chamber enlarging rapidly in the second and final stages. In the early stage the second tubular chamber bends back and forth in zig-zag bends while coiling (2 whorls), as in *Meandrospira* Loeblich & Tappan, 1946. In the subsequent stage of development, the tube becomes slightly undulated, describing 2 to 4 wide arched zig-zag bends (meanders) perpendicular to those of the *Meandrospira*-like stage and disposed on oscillating planes. This arrangement of the tube, together with such a disposition of planes, determines a distinctive fan-like shape in this part of the test.

The zig-zag bends sometimes overlap due to undulation of the tubular chambers and oscillation of planes, therefore meanders appear in section not regularly aligned.

A further final stage can be present, in which the tubular chamber is not meandering but describes 1 to 2 planispirally coiled whorls. The first planispiral whorl sharp changes in direction, so that the axis of coiling is nearly perpendicular to that of the early *Meandrospira*-like stage; when present, a second planispiral whorl is with 90° change in plane of coiling with respect to the previous one.

Dimorphism is present due to the recognition of two forms which may be ascribed to megalospheric and microspheric generations. By comparison with microspheric forms, the megalospheric ones (Pl. 2, Figs. 1a, 2, 3, 5, 6-16) exhibit a noticeable change in overall size, which is smaller, an increase of the meandrospiroid first part and a reduction of the fan-like shaped stage.

The wall is calcareous, dark, imperforate, porcelaneous; aperture at the open end of the tube.

Dimensions.–Microspheric forms - diameter of the test: 200-400 µm; height of the tubular chamber in the last planispiral whorl: 25-30 µm. Megalospheric forms-diameter of the test: 80-120 µm; diameter of the proloculus: 30-35 µm.

Remarks.-Meandrovoluta asiagoensis gen. et sp. nov. is the only species of the new genus *Meandrovoluta*. The structural characters defining the genus are therefore diagnostic for its type species.

Stratigraphic and geographic distribution.–Lower Jurassic, Liassic, Sinemurian to Toarcian of Southern Alps, Northern and Central Apennines, Sicily, Dinarids, Morocco and Spain.

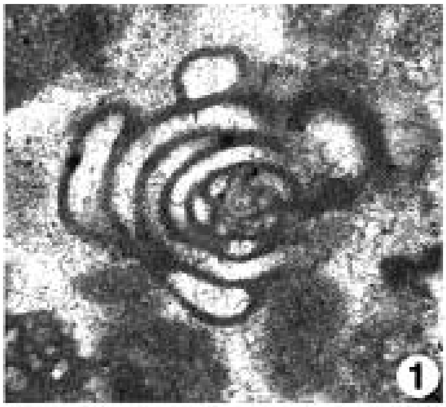
ASSOCIATION

At the top of the Middle Member *Meandrovoluta* gen. nov. occurs together with *Duotaxis metula* Kristan, 1957,

→

PLATE 1–*1-12, Meandrovoluta asiagoensis* gen. nov., sp. nov. *1.* Holotype, R9526, transversal to slightly oblique view in which is well visible the section of the last two planispiral whorls perpendicular one another. *2-12.* Specimens almost all visible in oblique/tangential and oblique centered sections. *2.* R951; *3.* R9522; *6, 8.* P22; *4, 11.* R9516; *7, 5, 9.* R9516; *10.* R9521; *12.* R9515. Scale bar: 100 µm.

PLATE 1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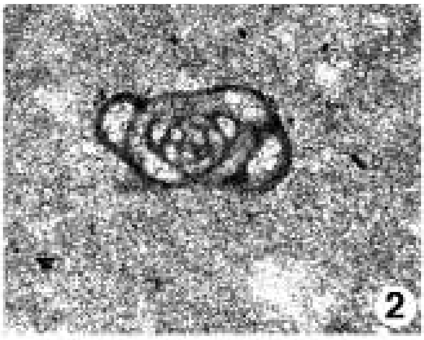
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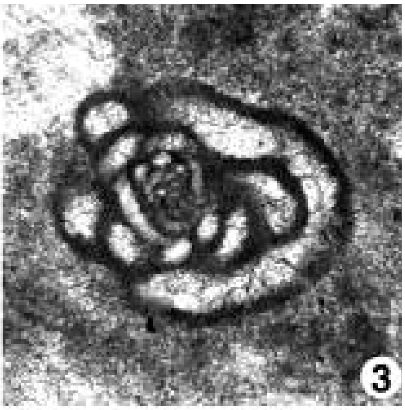
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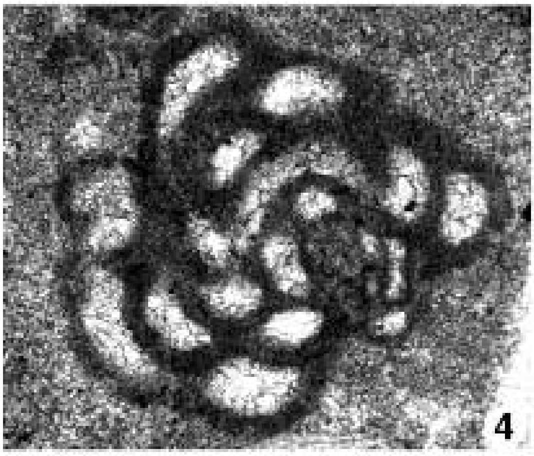
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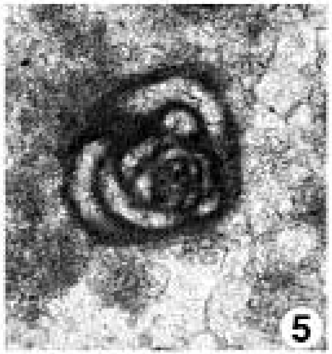
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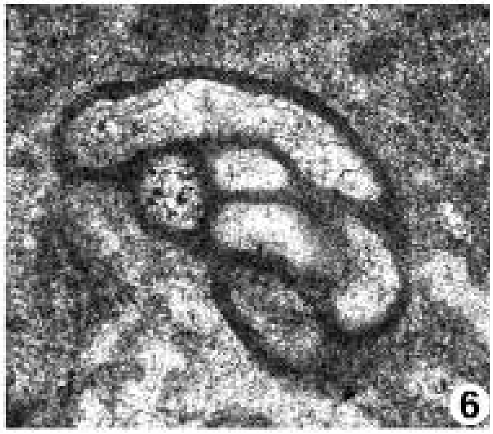
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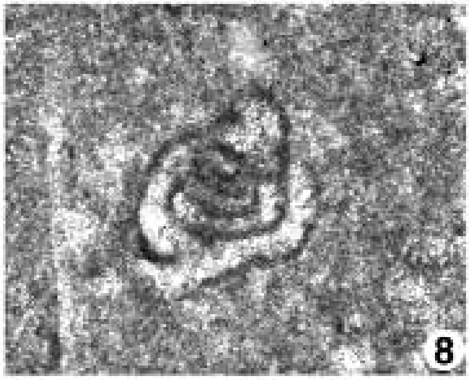
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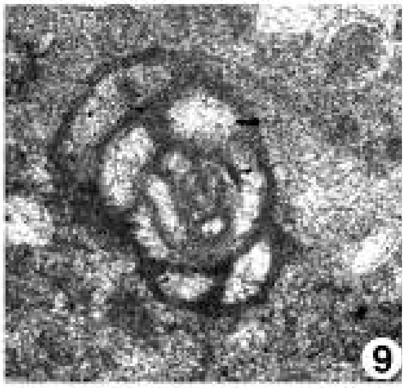
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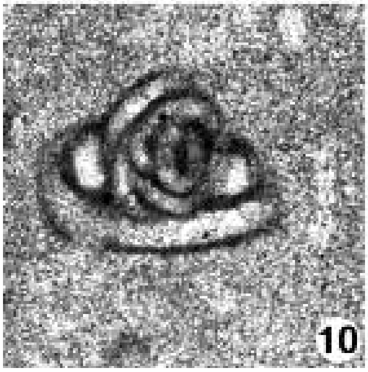
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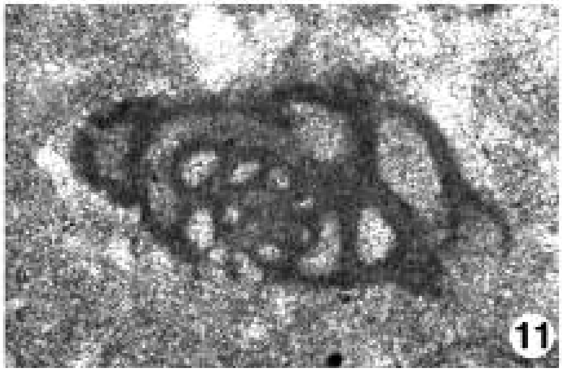
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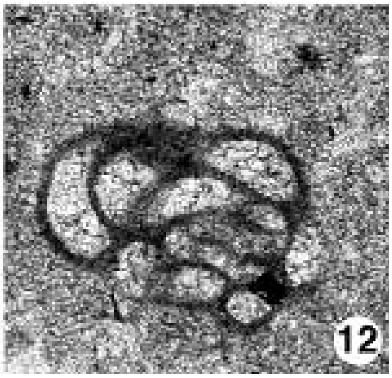
12

Mesoendothyra sp., ?*Paleomayncina termieri* (Hottinger, 1967), *Ammobaculites* sp., valvulinids, textulariids, *Ophthalmidium* sp. and dasycladacean algae.

In the Rotzo Member interval corresponding to the *Orbitopsella* zone, *Meandrovoluta* gen. nov. is associated with *Orbitopsella primaeva* (Henson, 1948), *O. praecursor* (Gümbel, 1872), *Duotaxis metula*, *Pseudopfenderina* cf. *butterlini*, *Siphovalvulina variabilis* Septfontaine, 1988, *Haurania deserta* Henson,1948, *Amijiella amiji* (Henson, 1948*)*, *Lituosepta recoarensis* Cati, 1959, *Everticyclammina praevirguliana* Fugagnoli, 2000, *Pseudocyclammina liasica* 1984, *Paleomayncina termieri* (Hottinger, 1967), *Mesoendothyra* sp., valvulinids, textulariids, *Earlandia* sp., *Planiinvoluta* sp., and dasycladacean algae.

In the upper part of the Rotzo Member, corresponding to the *Lituosepta compressa* zone, the new species is associated with *Lituosepta compressa*, *Duotaxis metula*, *Siphovalvulina variabilis*, *Haurania deserta*, *Paleomayncina termieri*, *Pseudocyclammina liasica*, *Amijiella amiji*, valvulinids, textulariids, *Earlandia* sp., and dasycladacean algae.

As a whole, megalospheric specimens are typically found from the Middle Member and the base of the Rotzo Member in oolithic grainstones, sometimes with bioclasts. Megalospheric specimens are much more abundant in the foraminiferal, bioclastic and peloidal wackestones/packstones of the Rotzo Member, related to a lagoonal paleoenvironment.

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Grateful thanks are due to C. Herrero (Complutense University, Madrid) and A. Grigelis (Lithuanian Academy of Sciences) for revising the paper.

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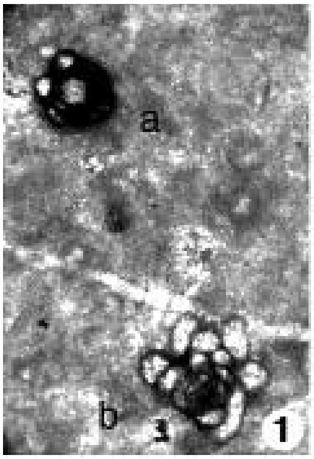
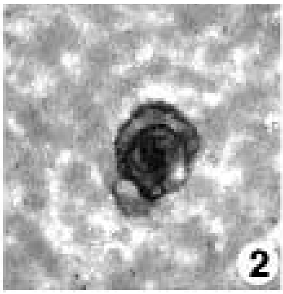
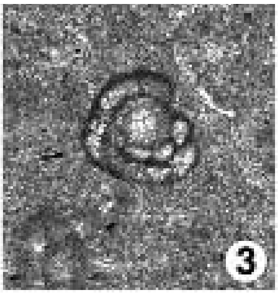
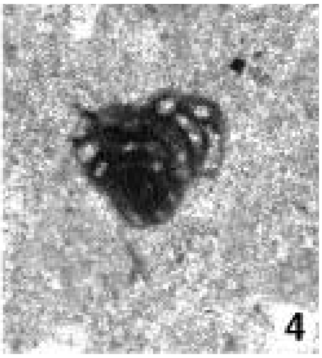
PLATE 2–*1-16*, *Meandrovoluta asiagoensis* gen. nov., sp. nov. Specimens visible in oblique/tangential and oblique centered sections. *1.* VG002; *2, 16.* VG020; *3, 5.* R955; *4, 8.* VG005; *6, 7.* AVB121b; *9, 10, 12.* 2B26b; *11, 13, 15.* AVB263b; *14.* AVB826b. *1a, 2, 3, 5, 6-16*, megalospheric forms. Scale bar: 100 µm.

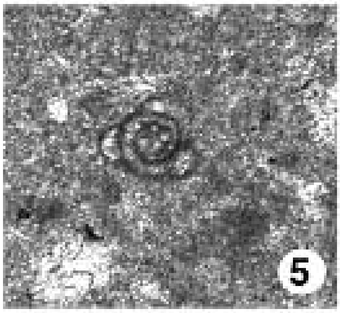
PLATE 2

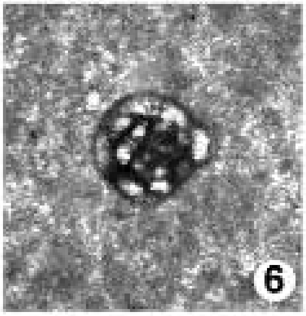


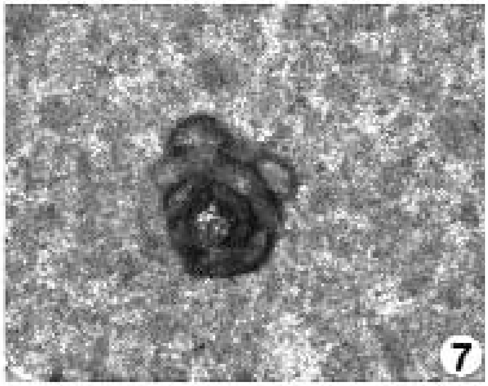












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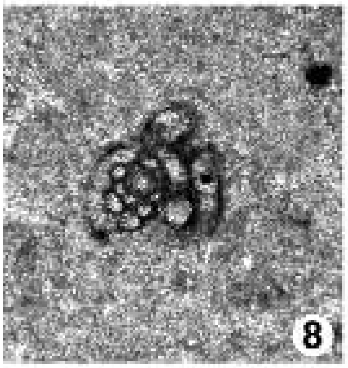

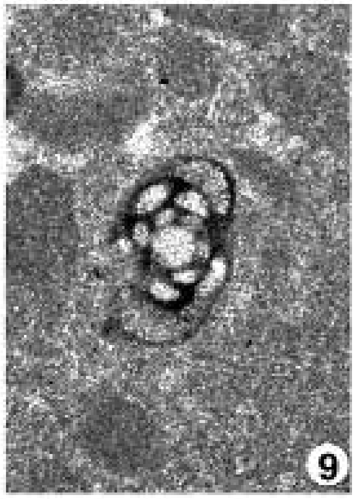

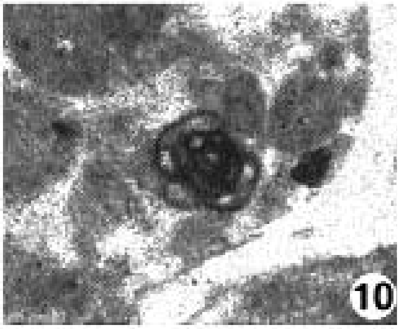

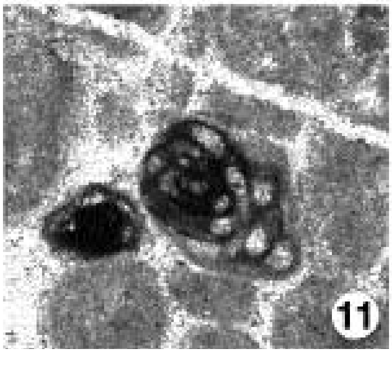

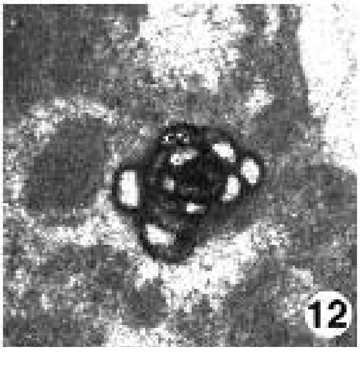

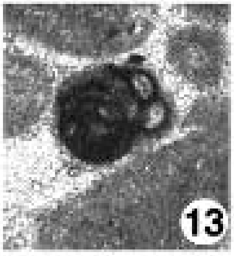

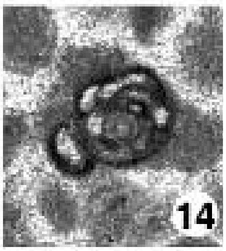

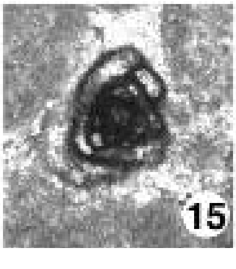

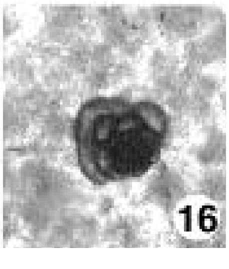

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PALINOESTRATIGRAFÍA DEL TITHONIANO-HAUTERIVIANO DEL CENTRO-OESTE DE LA CUENCA NEUQUINA, ARGENTINA

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Resumen

Se presenta una palinozonación preliminar para el intervalo Tithoniano-Hauteriviano en el centro-oeste de la Cuenca Neuquina. Teniendo en cuenta las apariciones masivas de taxones continentales y marinos y la presencia de palinomorfos con valor cronológico se reconocieron para el Tithoniano tardío-?Berriasiano temprano las zonas de *Dichadogonyaulax culmula* y *Aptea notialis* y la Zona de *Microcachryidites antarcticus.* La Zona 1 (Berriasiano tardío-?Valanginiano temprano), correlacionable con la Zona de *Callialasporites-Contignisporites-Staplinisporites* de Patagonia Austral, está caracterizada por la abundancia de *Callialasporites* y ausencia de *Cyclusphaera.* Se reconoció la Zona de *Cyclusphaera psilata-Classopollis* asociada a especies de microplancton, como C*elyphus rallus*, *Leiosphaeridia* y *Leiofusa*, para el Valanginiano tardío (Zona 2). Se da una evaluación paleoambiental para el intervalo estratigráfico en estudio, considerando la relación de palinomorfos continentales *versus* marinos.

Palabras clave: Palinoestratigrafía, Tithoniano-Hauteriviano, Cuenca Neuquina, Argentina.

Abstract

[*Palynostratigraphy of the Tithonian-Hauterivian interval, West-Central Neuquén Basin, Argentina*]. A preliminary approach to a zonal definition for the Tithonian-Hauterivian interval of the West-Central Neuquén Basin is presented. The limits of the zone as well as the first and last appearance data of index species are located. There were recognized the *Dichadogonyaulax culmula*, *Aptea notialis* and *Microcachryidites antarcticus* zones for the Late Tithonian-?Early Berriasian. Due to the great abundance of *Callialasporites* and the absence of *Cyclusphaera*, Zone 1 (Late Berriasian-?Early Valanginian) is correlated with the *Callialasporites-Contignisporites-Staplinisporites* Zone of Patagonia Austral. It was recognized the *Cyclusphaera psilata-Classopollis* Zone associated with *Celyphus rallus*, *Leiosphaeridia* and *Leiofusa* among others for the Late Valanginian (Zone 2). Taking into account the terrestrial-marine relationships, paleoenvironmental conditions for the studied interval are discussed.

Keywords: Palynostratigraphy, Tithonian-Hauterivian, Neuquén Basin, Argentina.

INTRODUCCIÓN

La estratigrafía del intervalo Tithoniano-Hauteriviano de la Cuenca Neuquina ha tenido un gran avance en los últimos años, sobre todo a partir de la aplicación de técnicas de estratigrafía secuencial y nuevos conceptos en sedimentología. A modo de ejemplo, Gulisano *et al*. (1984) propusieron una nueva posición y significado estratigráfico para la Formación Mulichinco (Valanginiano tardío), desvinculándola definitivamente de las unidades clásticas continentales equivalentes a las formaciones Quintuco y Vaca Muerta. Más recientemente, Zavala (2000) propuso un nuevo ordenamiento secuencial para la Formación Mulichinco, discutiendo asimismo su evolución paleoambiental y relaciones entre clima, tectónica y sedimentación. No obstante estas contribuciones, no existe hasta el presente un estudio detallado del contenido palinológico del intervalo y una discusión de las implicaciones paleoclimáticas de él derivadas. El presente trabajo tiene como objetivo reconocer palinozonas previas y proponer palinozonas informales para el lapso Tithoniano–Hauteriviano temprano en el centro-oeste de la Cuenca Neuquina y comparar la misma con la información provista por biozonaciones previas y por el análisis secuencial en el intervalo estratigráfico en estudio. Forma parte de un estudio mucho más amplio llevado a cabo en el ámbito centro-occidental de la Cuenca Neuquina con muestras de afloramiento y subsuelo realizado durante 1997 y 1998, y del cual se han publicado parcialmente resultados en Zavala (2000) y Quattrocchio *et al.* (1999, 2002). Se presentan aquí los resultados del análisis palinológico efectuado a muestras de afloramientos distribuidas en 8 localidades correspondientes a las formaciones Vaca Muerta, Quintuco, Mulichinco y Agrio. Constituye éste un aporte para el conocimiento de la Formación Mulichinco, ya que hasta el presente son muy escasos los datos palinológicos publicados. Se incluyen además los datos provenientes de trabajos previos para el Jurásico tardío/Berriasiano del área de Mallín Quemado (Quattrocchio y Volkheimer, 1985), así como también de la localidad Puente Arroyo Picún Leufú correspondiente al Tithoniano tardío (Quattrocchio y Sarjeant, 1992) en las figuras 12-14 y en la lista sistemática de especies.

La palinología del Jurásico y Cretácico de la Cuenca Neuquina ha sido ampliamente estudiada, pudiendo mencionarse las aportaciones de Volkheimer y Quattrocchio (1981), Quattrocchio y Volkheimer (1990), Quattrocchio y Sarjeant (1992) y Quattrocchio *et al.* (1996). Respecto a las formaciones involucradas en este trabajo o sus equivalentes en otras localidades, la producción científica en materia palinológica es muy numerosa. Para la Formación Vaca Muerta pueden destacarse Volkheimer y Quattrocchio (1975a, 1975b, 1977), Quattrocchio (1980) y Quattrocchio y Volkheimer (1985). La Formación Picún Leufú en su localidad tipo ha sido estudiada por Quattrocchio y Volkheimer (1983) y Quattrocchio y Sarjeant (1992). Para la Formación Mulichinco es muy escasa la información palinológica publicada hasta el presente; sólo se hace una mención en Volkheimer *et al.* (1976), Volkheimer (1980) y más recientemente en Quattrocchio *et al.* (1999, 2002).

Las aportaciones de Volkheimer *et al.* (1976), Volkheimer y Sarjeant (1993), Peralta (1996, 1997), Peralta y Volkheimer (1997), Prámparo y Volkheimer (1996, 1999), Aguirre-Urreta *et al.* (1999) y Peralta y Volkheimer (2000), entre otros, han contribuido al conocimiento de la Formación Agrio.

ÁREA DE ESTUDIO, ESTRATIGRAFÍA, EDAD Y ANTECEDENTES

El área de estudio (Fig. 1) se localiza en el centro-oeste de la Cuenca Neuquina, entre el norte de la Sierra de la Vaca Muerta y la zona de Chos Malal.

Existen numerosas contribuciones referidas a la sedimentología y evolución estratigráfica de la Cuenca Neuquina, entre las cuales se destacan los trabajos de síntesis de Gulisano *et al.* (1984), Legarreta y Gulisano (1989) y Gulisano y Gutiérrez Pleimling (1995).

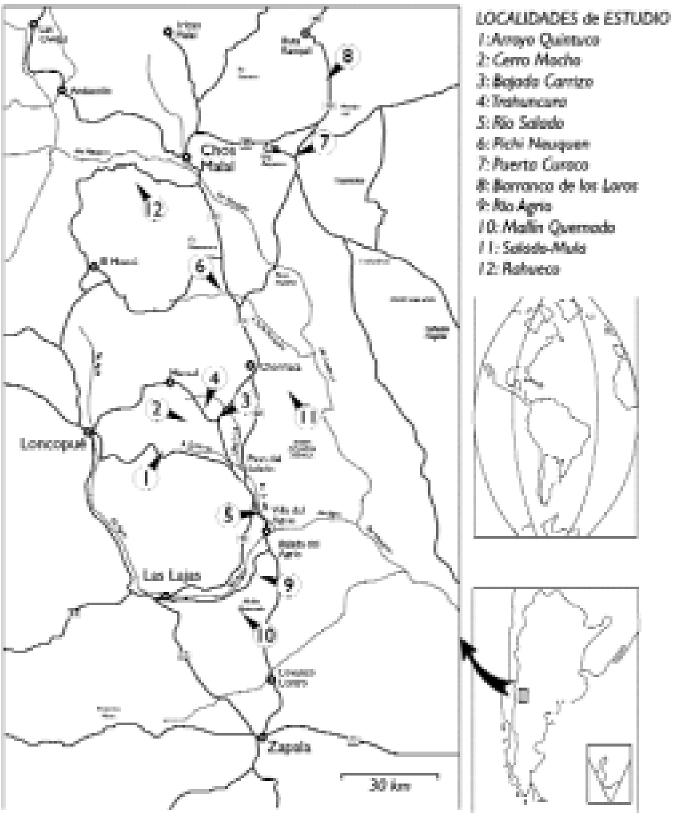


FIGURA 1–Mapa de ubicación de las localidades de estudio.
FIGURE 1–Location map of the studied localities.

Los depósitos del Jurásico terminal corresponden a una cuenca marina con fondo euxínico (Formación Vaca Muerta; Leanza y Hugo, 1978; Legarreta *et al*., 1981; Veiga y Orchuela, 1988), circundada por un cinturón nerítico sometido a sedimentación carbonática [Fm. Quintuco = Calcárea (Digregorio, 1972), Fm. Picún Leufú (Leanza 1973, 1993)] y terrígena. (Legarreta y Uliana, 1999).

El Tithoniano es ampliamente transgresivo sobre depósitos de distinta edad, y está estrechamente relacionado con el suprayacente Neocomiano, al cual pasa transicionalmente tanto desde el punto de vista sedimentológico como faunístico. Durante el Berriasiano se mantuvo el carácter general de los sistemas deposicionales instaurados en el Tithoniano. En el pasaje Berriasiano-Valanginiano se verifica, en cambio, un neto corte faunístico (Leanza, 1981; Quattrocchio *et al*., 2002).

Más recientemente, Zavala (2000), utilizando técnicas de análisis secuencial, determina para la Formación Mulichinco (Valanginiano) en el área de estudio seis secuencias deposicionales (M1 a M6) limitadas por discontinuidades (U1 a U7), distribuidas en tres intervalos: inferior (secuencias M1 a M2), medio (secuencias M3 a M5) y superior (M6); en conjunto muestran unas características grano y estrato decrecientes. Las rocas de esta unidad están constituidas por depósitos clásticos, de fluvio-lacustres a marino-marginales, los que apoyan discordantemente (discordancia Intravalanginiana) sobre pelitas de plataforma de la Formación Vaca Muerta (Tithoniano temprano-Valanginiano temprano) y por depósitos marino-marginales de la Formación Quintuco. Esta última unidad en las secciones Río Agrio y Mallín Quemado está representada por facies de sistemas de river-delta, con evidencias de procesos de difusión por olas y mareas. Durante el Hauteriviano, y como consecuencia de una nueva transgresión marina, se depositan pelitas con intercalaciones menores de calizas y areniscas calcáreas asignadas a la Formación Agrio (Hauteriviano-Barremiano) (Fig. 2).

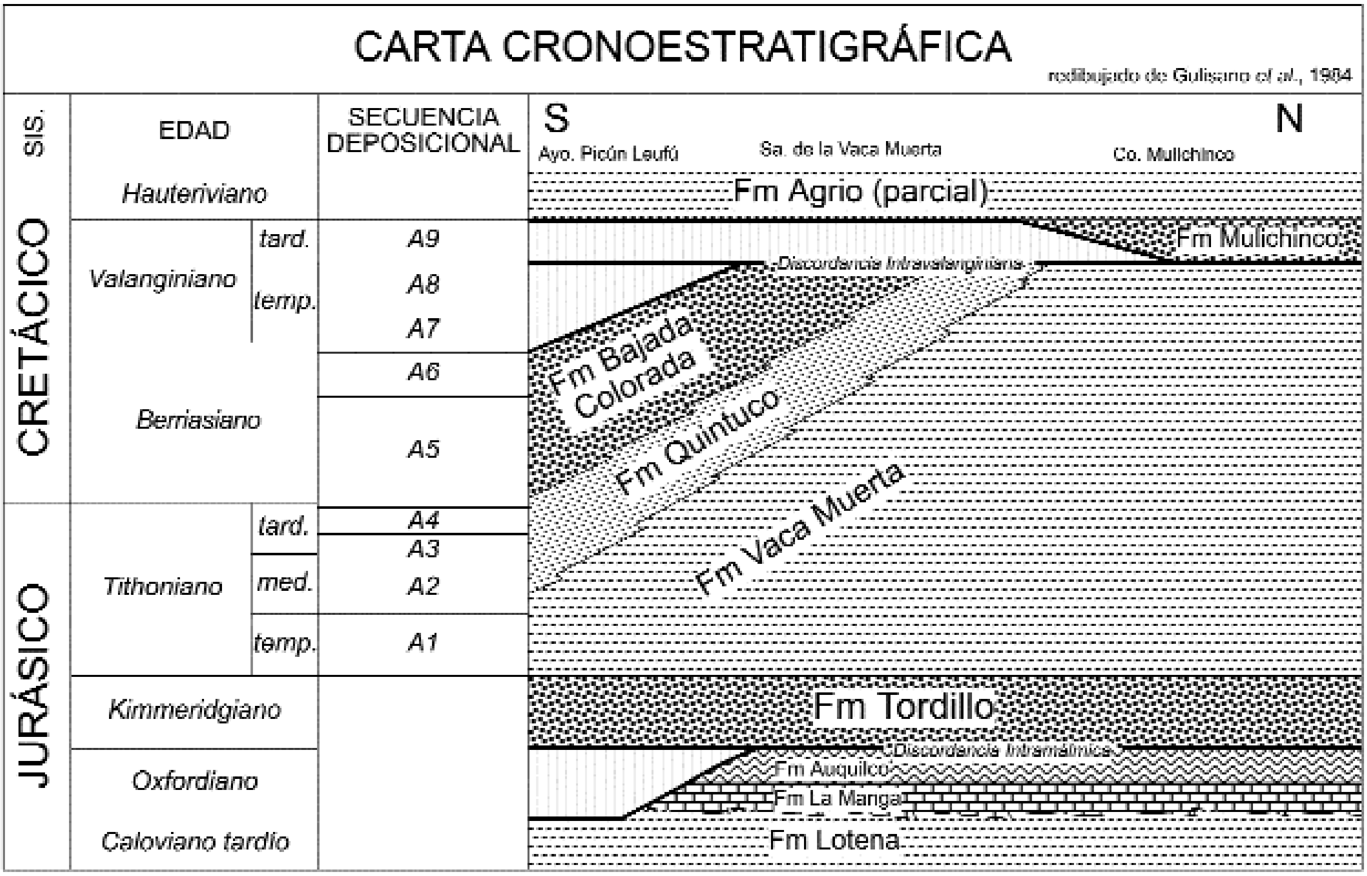


FIGURA 2–Cuadro cronoestratigráfico para el intervalo Caloviano tardío-Hauteriviano entre el Arroyo Picún Leufú y el Cerro Mulichinco, en el oeste de la Provincia de Neuquén.

FIGURE 2–Chronostratigraphic chart for the Late Callovian-Hauterivian interval, between Arroyo Picún Leufú and Cerro Mulichinco, in the western part of the Neuquén Province.

METODOLOGÍA

El trabajo de campo supuso el análisis sedimentológico y estratigráfico secuencial de la Formación Mulichinco a lo largo de más de 200 km, entre el norte de la Sierra de la Vaca Muerta y la zona de Chos Malal, mediante el estudio de 12 secciones estratigráficas de detalle (Zavala, 2000) (Figs. 1 y 3). De las mismas se seleccionaron 7 secciones: Pichi Neuquén, Puerta Curaco, Barranca de los Loros, Río Agrio, Mallín Quemado, Salado Mula y Rahueco. Se anexa información de Las Coloradas, no incluida en la Figura 1 por estar fuera de escala (68 km al suroeste de la ciudad de Zapala).

Fueron procesados para análisis palinológico un total de 89 niveles estratigráficos con el siguiente detalle: 7 pertenecientes a la Formación Vaca Muerta, 28 a la Fm. Quintuco, 49 a la Fm. Mulichinco y 5 a la Fm. Agrio. En el apéndice figura la distribución de las muestras en las distintas secciones.

La extracción físico-química de las muestras fue realizada utilizando las técnicas convencionales de Volkheimer y Melendi (1976). Los preparados palinológicos están depositados en el Laboratorio de Palinología de la Universidad Nacional del Sur, con las siglas UNSP, seguido de las siglas correspondientes a cada localidad: Barranca de los Loros (BL), Puerta Curaco (PC), Pichi Neuquén (PN), Salado Mula (SM), Rahueco (R), Mallín Quemado (MQ), Río Agrio (RA) y Las Coloradas (LC). El estudio de las muestras se realizó mediante técnicas de microscopía de luz transmitida, utilizando un microscopio Olympus BH 2 N° 100786. En las Láminas 1 y 2 se presentan taxones seleccionados de esporomorfos y microplancton, los cuales fueron fotografiados con una cámara Olympus y película Agfa BN de 100 ASA.

En las Figuras 4-11 se muestra la distribución de los taxones identificados y el ambiente deposicional deducido en cada una de las secciones analizadas sobre la base de la diversidad específica y la abundancia relativa. En las mencionadas figuras se representan solamente las unidades litoestratigráficas/secuenciales con estudio palinológico. Para el análisis palinoestratigráfico se utilizó el concepto de *biohorizonte* como una superficie donde se producen cambios bioestratigráficos o que tiene un carácter bioestratigráfico distintivo, como por ejemplo son

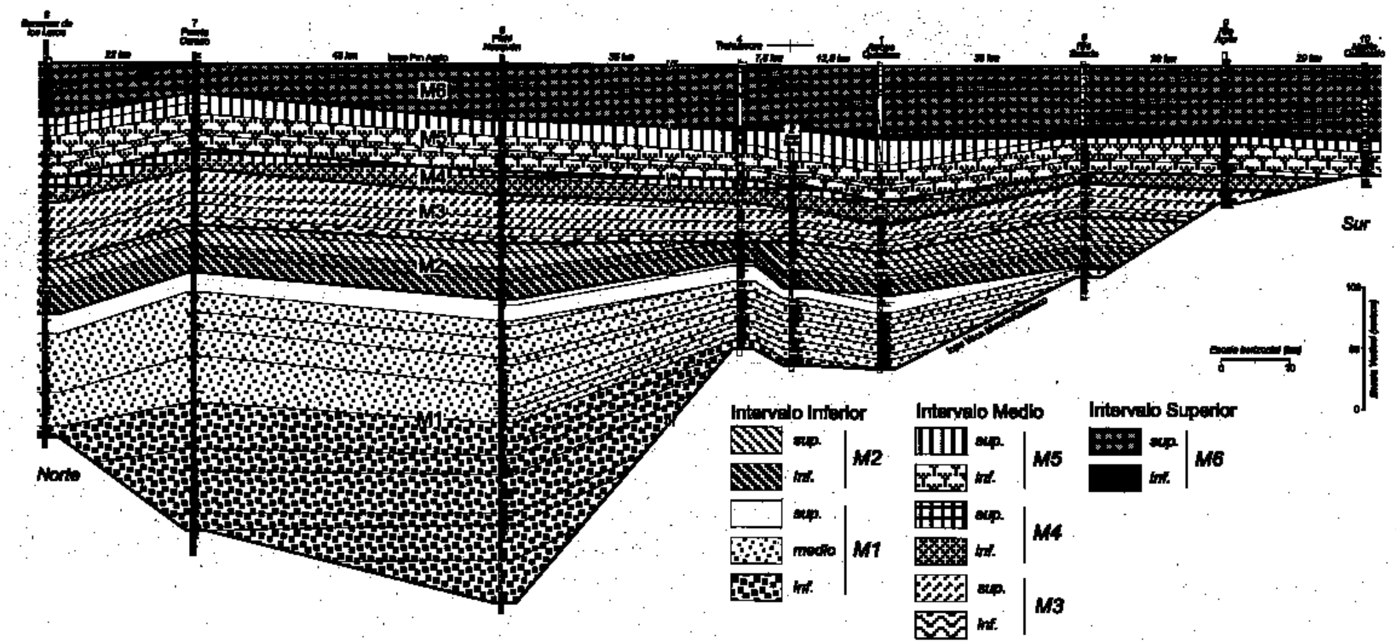


FIGURA 3–Corte estratigráfico de la Formación Mulichinco en el centro-oeste del Neuquén, entre Barranca de los Loros y Mallín Quemado.

FIGURE 3–Stratigraphic section of the Mulichinco Formation in west-central Neuquén, between Barranca de los Loros and Mallín Quemado.

las primeras apariciones de taxones (en Stover *et al*., 1996, p. 647). Esto último no significa que algunos de ellos no tengan registros previos en la cuenca, se los analiza considerando su aparición/desaparición en los perfiles analizados. Teniendo en cuenta los datos recogidos en las Figuras 4-11 se representaron la totalidad de palinomorfos identificados según sus primeras apariciones (Figs. 12 y 13). En la Figura 14 los límites de las zonas se realizaron considerando las apariciones masivas de taxones continentales y marinos y la presencia de palinomorfos de valor cronológico; para ello se siguieron las biozonaciones realizadas para la Cuenca Neuquina por Quattrocchio *et al*. (1996), Quattrocchio y Sarjeant, (1992) y Quattrocchio y Volkheimer (1990); así como también Volkheimer (1980) y para la Cuenca Austral, Archangelsky *et al*. (1984). En algunos taxones el grado de madurez térmica y/o corrosión del material estudiado impidió la asignación a nivel género y/o especie, por ejemplo: Flia. Ceratiaceae, *Aptea* spp. etc.

En aquellos niveles donde se identificaron palinomorfos estratigráficamente diagnósticos pudo realizarse una determinación de edad, en caso contrario la misma pudo ser determinada por posición en la secuencia y correlación. La información proveniente de otras cuencas del mundo ha sido tomada de PALYNODATA (datafile versión 5.1, 1999). Teniendo en cuenta las proporciones relativas de palinomorfos continentales y marinos presentes en cada nivel se asoció un ambiente deposicional característico independientemente del propuesto mediante el análisis de facies: *continental* (presencia exclusiva de esporomorfos: palinomorfos continentales), *transicional* (similar proporción de esporomorfos y paleomicroplancton, se infieren condiciones marinas, próximas al área de aporte terrígeno) y *marino* (predominio de paleomicroplancton, se infieren condiciones marinas distales al área de aporte terrígeno).

ANÁLISIS PALINOESTRATIGRÁFICO

1.–Formación Vaca Muerta: identificada en los perfiles Barranca de los Loros, Puerta Curaco, Pichi Neuquén, Salado Mula y Rahueco (Figs. 4-8). Las asociaciones microflorísticas reconocidas son:

Continental: *Classopollis simplex*-*Classopollis* spp.-*Cycadopites adjectus*-*Inaperturopollenites* spp.-esporas trilete y monocolpados indeterminados-esporas e hifas de hongos.

Marino: *Aptea* spp.-*Batioladinium* spp.-*Escharisphaeridia pocockii*-quistes de dinoflagelados indeterminados.

Se sugieren ambientes deposicionales de tipo continental a transicional (Rahueco), transicional (Salado Mula, Rahueco y Puerta Curaco) y marino (Barranca de los Loros).

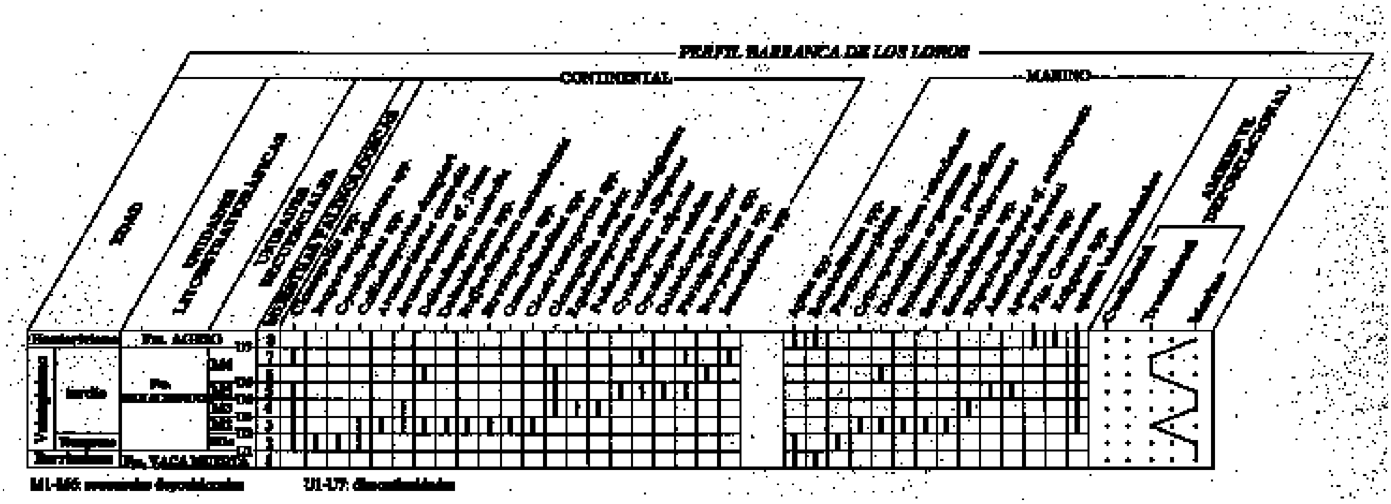


FIGURA 4–Distribución de los palinomorfos y ambiente deposicional inferido para el perfil Barranca de los Loros.
FIGURE 4–Palynomorphs distribution and depositional environments inferred of the Barranca de los Loros section.

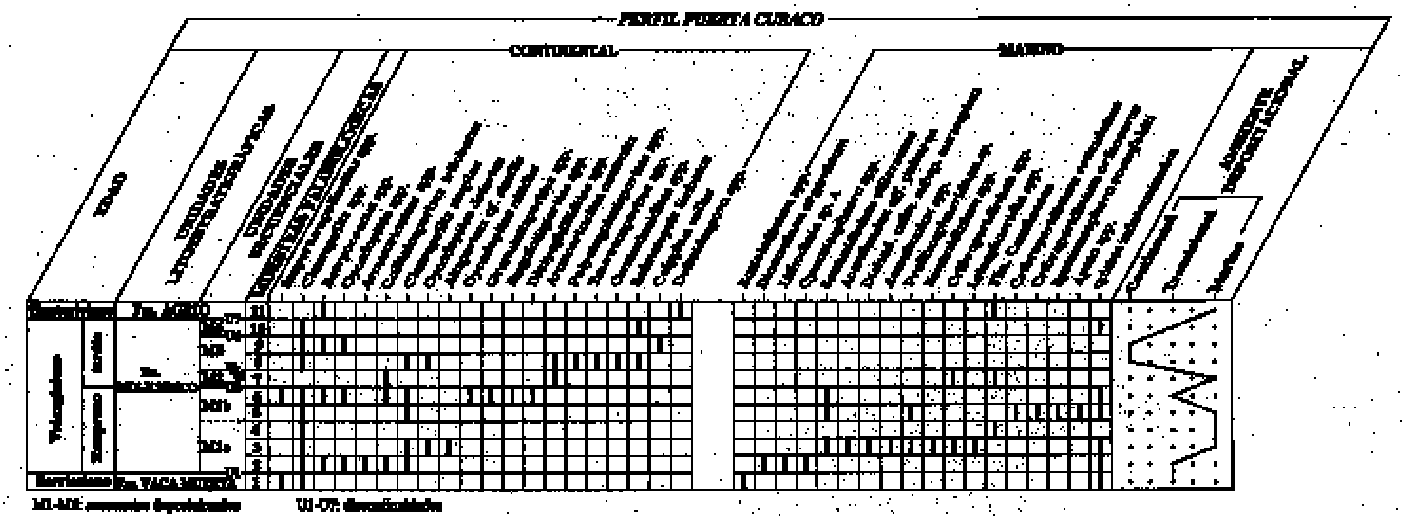


FIGURA 5–Distribución de los palinomorfos y ambiente deposicional inferido para el perfil Puerta Curaco.
FIGURE 5–Palynomorphs distribution and depositional environments inferred of the Puerta Curaco section.

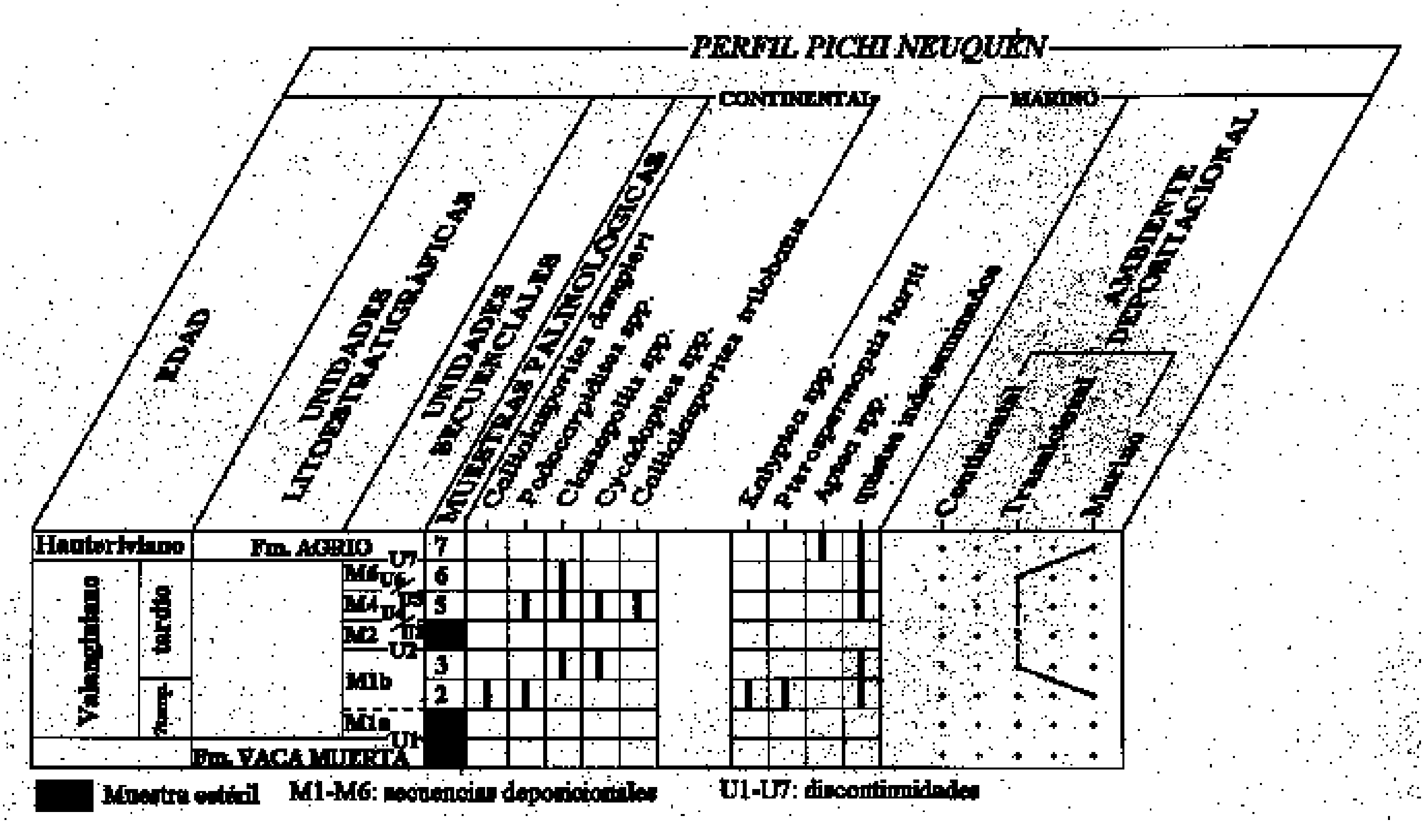


FIGURA 6–Distribución de los palinomorfos y ambiente deposicional inferido para el perfil Pichi Neuquén.
FIGURE 6–Palynomorphs distribution and depositional environments inferred of the Pichi Neuquén section.

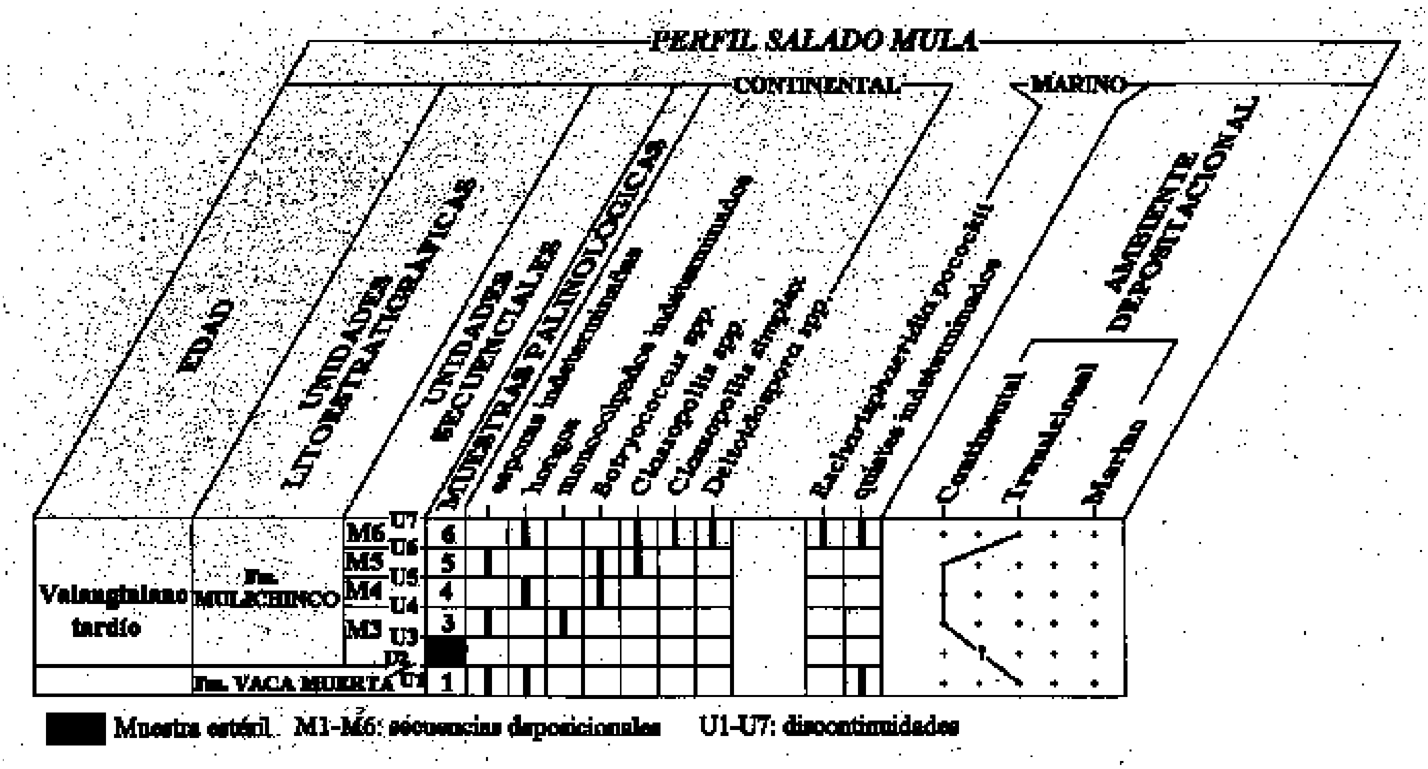


FIGURA 7–Distribución de los palinomorfos y ambiente deposicional inferido para el perfil Salado Mula.
FIGURE 7–Palynomorphs distribution and depositional environments inferred of the Salado Mula section.

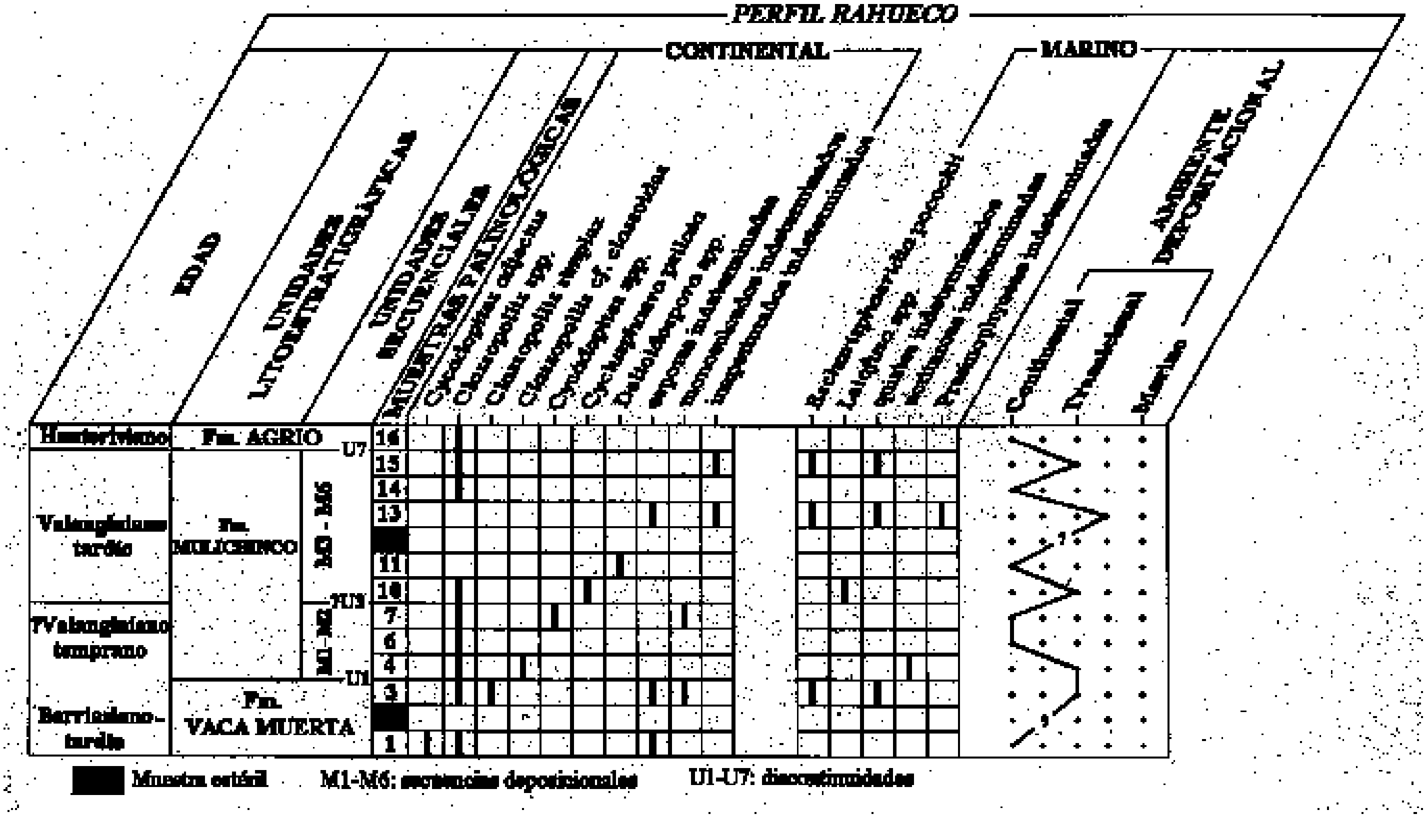


FIGURA 8–Distribución de los palinomorfos y ambiente deposicional inferido para el perfil Rahueco.
FIGURE 8–Palynomorphs distribution and depositional environments inferred of the Rahueco section.

2.–Formación Quintuco: en el área de estudio esta formación ha sido identificada en los perfiles Mallín Quemado (Fig. 9) y Río Agrio (Fig. 10). Las asociaciones microflorísticas reconocidas son:

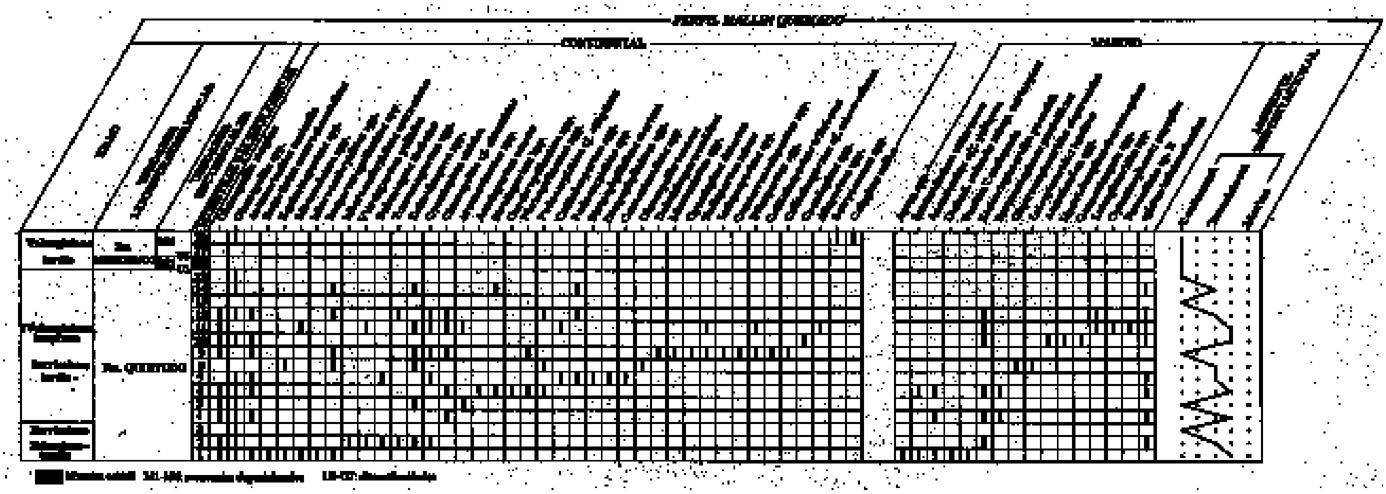


FIGURA 9–Distribución de los palinomorfos y ambiente deposicional inferido para el perfil Mallín Quemado.
FIGURE 9–Palynomorphs distribution and depositional environments inferred of the Mallín Quemado section.

Continental: *Alisporites* spp.-*Antulsporites saevus*-*Araucariacites australis*-*Araucariacites* spp.-*Balmeiopsis limbatus*-*Biretisporites* spp.-*Botryococcus* spp.-*Callialasporites* cf. *microvelatus*-*Callialasporites trilobatus*-*Callialasporites* spp.-*Cerebropollenites* spp.-*Classopollis* cf. *classoides*-*Classopollis simplex*-*Classopollis torosus*-*Classopollis* spp.-*Converrucosisporites* spp.-*Cycadopites deterius*-*Cycadopites nitidus*-*Cycadopites* spp.-*Deltoidospora neddeni*-*Deltoidospora* spp.-*Dictyophyllidites mortoni*-*Dictyophyllidites* spp.-*Equisetosporites* spp.-*Inaperturopollenites* spp.-*Ischyosporites* spp.-*Microcachryidites antarcticus*- *Microcachryidites* spp.-*Monosulcites* spp.-*Osmundacidites* spp.-*Phrixipollenites* spp.-*Pilasporites* spp.-*Podocarpidites* cf. *ellipticus*-*Podocarpidites* spp.-*Polycingulatisporites* spp.-*Retitriletes* spp.-*Retitriletes austroclavatidites*-*Taurocusporites* spp.-*Todisporites minor*-*Vitreisporites pallidus*.

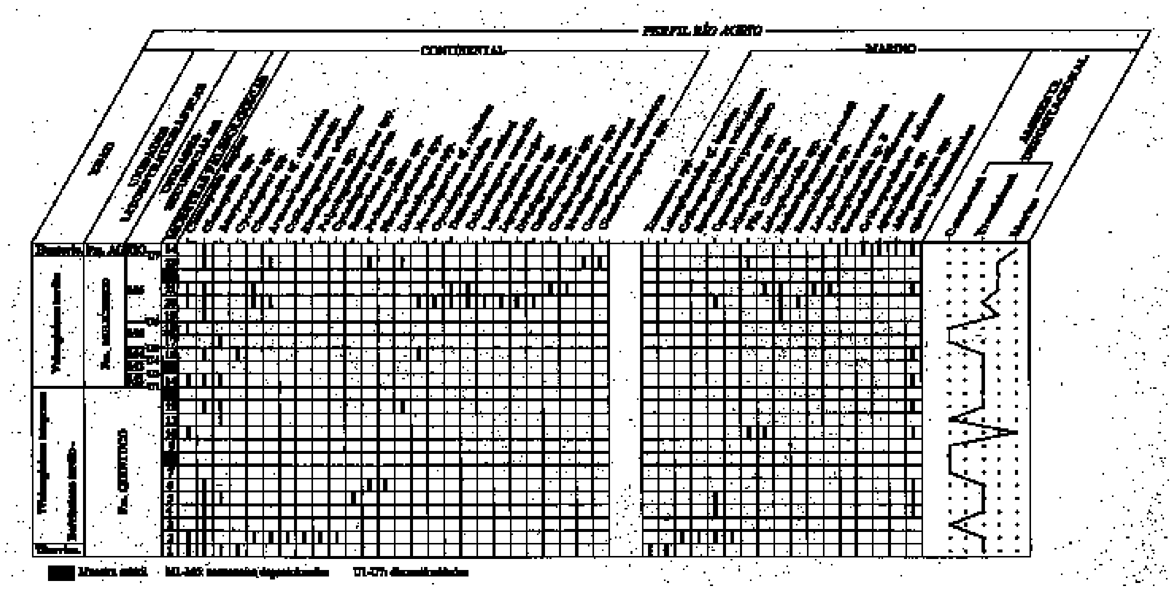


FIGURA 10–Distribución de los palinomorfos y ambiente deposicional inferido para el perfil Río Agrio.
FIGURE 10–Palynomorphs distribution and depositional environments inferred of the Río Agrio section.

Marino: *Acanthaulax* aff. *paliuros*-*Acanthaulax* spp.-*Aptea* spp.-*Chytroeisphaeridia chytroeides*-*Cribroperidinium reticulatum*-*Cymatiosphaera eupeplos*-*Cymatiosphaera* spp.-*Dichadogonyaulax culmula* subsp. *curtospina*-*Escharisphaeridia pocockii*-*Gonyaulacysta* spp.-*Hystrichosphaerina neuquina*-*Leiosphaeridia hyalina*-*Leiosphaeridia* cf. *hyalina*-*Leiosphaeridia* spp.-*Micrhystridium* spp.-*Pareodinia* sp. B-*Sentusidinium villersense*-*Systematophora penicillata*-*Tasmanites* spp.-Familia Ceratiaceae-quistes de dinoflagelados indeterminados.

Se sugieren condiciones ambientales de tipo continental y transicional.

3.–Formación Mulichinco: ha sido identificada en todas las localidades de estudio (Figs. 4-11). Se presenta la distribución de los palinomorfos considerando las secuencias deposicionales y su agrupación en intervalos en las distintas secciones según Zavala (2000):

Intervalo inferior: se integraría por las secuencias M1 y M2.

Secuencia M1a (equivalente al intervalo inferior de la sec. M1)

- *Pichi Neuquén*: estéril

- *Puerta Curaco*: (Ambiente transicional a marino)

Continental: *Alisporites* cf. *similis*-*Araucariacites* spp.-*Botryococcus* spp.-*Callialasporites trilobatus*-*Classopollis simplex*-*Classopollis* spp.-*Cycadopites deterius*-*Cycadopites* spp.

Marino: *Acanthaulax* aff. *paliuros*-*Acanthaulax* spp.-*Cymatiosphaera* spp.- *Cribroperidinium* spp.-*Diacanthum argentinum*-*Dichadogonyaulax culmula* subsp. *curtospina*-*Leiosphaeridia* spp.-*Prolixosphaeridium* sp.-*Sentusidinium villersense*-*Sentusidinium* spp.-*Lithodinia* sp. A-Flia. Ceratiaceae.

- *Barranca de los Loros*: (Ambiente marino)

Continental: *Callialasporites dampieri*-*Classopollis* spp.-*Cycadopites* spp.-*Inaperturopollenites* spp.

Marino: *Aptea* spp.-Partitomorphitae.

Secuencia M1b (equivalente al intervalo medio-superior de la sec. M1)

- *Pichi Neuquén*: (Ambiente marino a transicional)

Continental: *Callialasporites dampieri*-*Classopollis* spp.-*Cycadopites* spp.-*Podocarpidites* spp.

Marino: *Kalyptea* spp.-*Pterospermospsis hartii*-quistes de dinoflagelados indeterminados.

- *Puerta Curaco*: (Ambiente marino a transicional)

Continental: *Callialasporites trilobatus*-*Clasoppollis simplex*-*Classopollis* spp.-*Cycadopites nitidus*-*Cycadopites* spp.-*Botryococcus* spp.-*Dictyophillidites* spp.-*Granulatisporites* spp.-*Inaperturopollenites* spp.-*Rugulatisporites* spp.

Marino: *Cribroperidinium orthoceras*-*Cribroperidinium reticulatum*-*Prolixosphaeridium* sp.-*Sentusidinium villersense*-*Systematophora rosenfeldii*-quistes de dinoflagelados indeterminados.

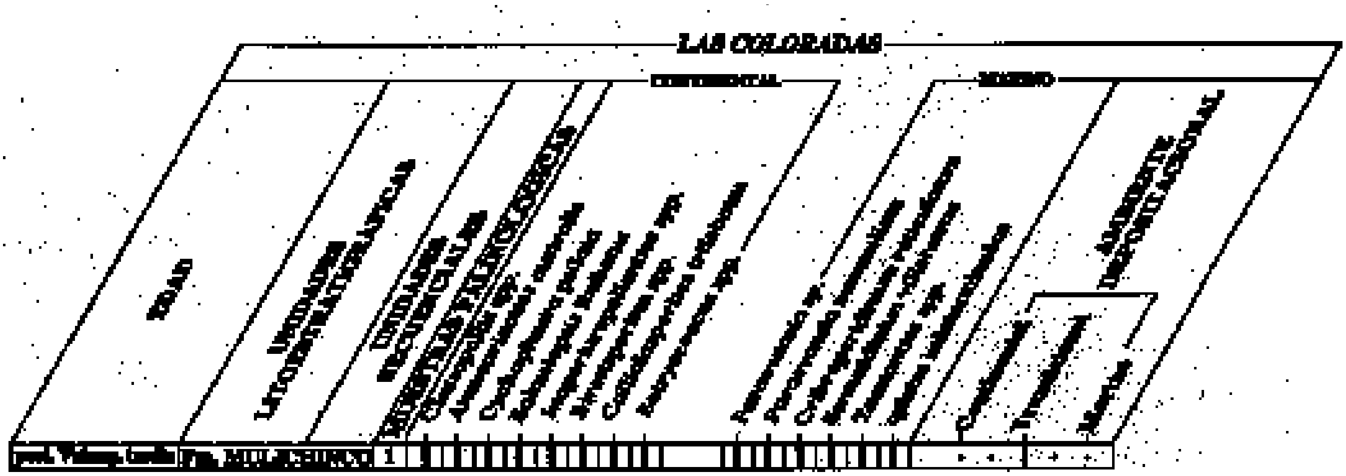


FIGURA 11–Distribución de los palinomorfos y ambiente deposicional inferido para la localidad de Las Coloradas.
FIGURE 11–Palynomorphs distribution and depositional environment inferred of Las Coloradas locality.

Secuencia M2

- *Pichi Neuquén*: estéril

- *Puerta Curaco*: (Ambiente marino)

Continental: *Araucariacites australis-Callialasporites trilobatus*.

Marino: *Cribroperidinium* spp.-Flia. Ceraticeae.

- *Barranca de los Loros*: (Ambiente transicional)

Continental: *Araucariacites australis-Araucariacites* cf. *fissus-Callialasporites dampieri-Cicatricosisporites* spp.-*Classopollis* spp.-*Biretisporites* spp.-*Deltoidospora australis-Deltoidospora* spp.-*Osmundacidites* spp.-*Ruffordiaspora australiensis*.

Marino: *Cribroperidinium reticulatum-Diacanthum argentinum-Sentusidinium villersense-Sentusidinium* spp.- *Systematophora penicillata*-quistes de dinoflagelados indeterminados.

- *Río Agrio*: (Ambiente transicional)

Continental: *Botryococcus* spp.-*Classopollis simplex-Classopollis* spp.

Marino: quistes de dinoflagelados indeterminados.

En el perfil Rahueco (Fig. 8) se identifica el intervalo inferior (M1 y M2) con la siguiente asociación microflorística:

Continental: *Classopollis* cf. *classoides-Classopollis* spp.-*Cycadopites* spp. y monosulcados indeterminados.

Marino: acritarcos indeterminados.

Se sugieren condiciones ambientales transicionales para dicha asociación.

Intervalo medio: estaría integrado por las secuencias M3 a M5.

Secuencia M3

- *Barranca de los Loros*: (Ambiente marino)

Continental: *Araucariacites* cf. *fissus-Classopollis simplex-Classopollis* spp.-*Equisetosporites caichigüensis-Podocarpidites ellipticus*.

Marino: *Rhynchodiniopsis* cf. *setcheyensis*-quistes de dinoflagelados indeterminados.

- *Río Agrio*: estéril

- *Salado Mula*: (Ambiente continental)

Continental: esporas trilete y monocolpados indeterminados.

Secuencia M4

- *Pichi Neuquén*: (Ambiente transicional)

Continental: *Callialasporites trilobatus-Clasopollis* spp.-*Cycadopites* spp.-*Podocarpidites* spp.

Marino: quistes de dinoflagelados indeterminados.

- *Río Agrio*: (Ambiente transicional)

Continental: *Classopollis* spp.- *Cycadopites* spp.-*Nevesisporites* cf. *radiatus*.

Marino: quistes de dinoflagelados indeterminados.

- *Salado Mula*: (Ambiente continental)

Continental: *Botryococcus* spp.-esporas e hifas de hongos.

Secuencia M5

- *Puerta Curaco*: (Ambiente continental)

Continental: *Araucariacites australis-Balmeiopsis limbatus-Botryococcus* spp.-*Celyphus rallus-Classopollis simplex-Classopollis* spp.-*Cycadopites deterius-Cycadopites* spp.-*Osmundacidites* spp.-*Polycingulatisporites* spp.-*Taurocusporites* spp.

- *Barranca de los Loros*: (Ambiente marino-transicional)

Continental: *Classopollis simplex-Classopollis* spp.-*Cycadopites adjectus-Cycadopites nitidus-Deltoidospora minor-Phrixipollenites* spp.

Marino: *Acanthaulax downiei-Apteodinium* spp.-quistes de dinoflagelados indeterminados.

- *Río Agrio*: (Ambiente continental)

Continental: *Botryococcus* spp.-*Classopollis simplex*.

- *Salado Mula*: (Ambiente continental)

Continental: *Botryococcus* spp.-*Classopollis* spp.-esporas trilete indeterminadas.

- *Mallín Quemado*: estéril

Intervalo superior: estaría integrado exclusivamente por la secuencia M6.

Secuencia M6

- *Pichi Neuquén*: (Ambiente transicional)

Continental: *Classopollis* spp.

Marino: quistes de dinoflagelados indeterminados.

- *Puerta Curaco*: (Ambiente transicional)

Continental: *Classopollis* spp.- *Balmeiopsis limbatus.*

Marino: quistes de dinoflagelados indeterminados.

- *Barranca de los Loros*: (Ambiente transicional)

Continental: *Botryococcus* spp.-*Classopollis simplex*-*Classopollis* spp.-*Cycadopites nitidus*-*Deltoidospora australis*-*Interulobites* spp.-*Phrixipollenites* spp.

Marino: *Diacanthum argentinum*-quistes de dinoflagelados indeterminados.

- *Río Agrio*: (Ambiente transicional a marino)

Continental: *Araucariacites australis*-*Biretisporites potonieai*-*Callialasporites* spp.-*Cerebropollenites* spp.-*Cicatricosisporites* spp.-*Classopollis* cf. *classoides*-*Classopollis simplex*-*Classopollis* spp.-*Contignisporites cooksoniae*-*Cycadopites nitidus*-*Deltoidospora australis*-*Deltoidospora neddeni*-*Deltoidospora* spp.-*Divisisporites* spp.-*Leptolepidites major*-*Leptolepidites* spp.-*Nevesisporite*s cf. *radiatus*-*Podocarpidites* spp.

Marino: *Escharisphaeridia pocockii*-*Cymatiosphaera* spp.-*Leiosphaeridia menendezii*-*Leiosphaeridia* sp. B-*Leiosphaeridia* spp.-*Sentusidinium* spp.-Flia. Ceratiaceae-quistes de dinoflagelados indeterminados.

- *Salado Mula*: (Ambiente transicional)

Continental: *Classopollis simplex*-*Classopollis* spp.-*Deltoidospora* spp.-esporas e hifas de hongos.

Marino: *Escharisphaeridia pocockii*-quistes de dinoflagelados indeterminados.

- *Mallín Quemado*: (Ambiente continental)

Continental: *Botryococcus* spp.-*Celyphus rallus*-*Classopollis* spp.-esporas trilete, monocolpados e inaperturados indeterminados-esporas e hifas de hongos.

En el perfil Rahueco (Fig. 8) no se reconoce claramente el tránsito del intervalo medio al superior (M3 a M6). Las asociaciones microflorísticas identificadas (se sugieren ambientes deposicionales continentales y transicionales) se caracterizan por:

Continental: *Classopollis* spp.-*Cyclusphaera psilata*-*Deltoidospora* spp.-esporas e inaperturados indeterminados.

Marino: *Escharisphaeridia pocockii*-*Leiofusa* spp.-quistes de dinoflagelados y Prasinophyceae indeterminados.

En la localidad de Las Coloradas (ambiente transicional) ha sido colectada una muestra inmediatamente por debajo de las calizas correspondientes a la Formación Agrio (Fig. 11), identificándose una asociación microflorística del siguiente tipo:

Continental: *Araucariaciates australis*-*Callialasporites trilobatus*-*Classopollis* spp.-*Cyclusphaera psilata*-*Balmeiopsis limbatus*-*Biretisporites* spp.-*Botryococcus* spp.-*Inaperturopollenites* spp.

Marino: *Cribroperidinium reticulatum*-*Sentusidinium villersense*-*Paraevansia mammillata*-*Paraevansia* sp.-*Tasmanites spp.*-quistes de dinoflagelados indeterminados.

4.–Formación Agrio: ha sido identificada en los perfiles Rahueco, Río Agrio, Barranca de los Loros, Puerta Curaco y Pichi Neuquén (Figs. 4-6 y 8). A partir del análisis palinológico se deduce para todas las secciones estudiadas un ambiente deposicional de tipo netamente marino (excepto en el perfil Rahueco, con ambiente continental). Las asociaciones microflorísticas están representadas por:

Continental: *Botryococcus* spp.-*Classopollis* spp.-*Deltoidospora* spp.

Marino: *Aptea* spp.-*Apteodinium* spp.-*Athigmatocysta* spp.-*Batioladinium* spp.-*Cribroperidinium delicatum*-*Kalyptea* spp.-*Sentusidinium villersense*-Flia. Ceratiaceae.

EDAD SOBRE LA BASE DE PALINOMORFOS

En las Figuras 12 y 13 se ha representado la distribución de los palinomorfos identificados, ordenados según sus primeras apariciones, con la información de los perfiles estudiados en este trabajo y registros previos (Quattrocchio y Volkheimer, 1985; Quattrocchio y Sarjeant, 1992).

Tithoniano tardío

Se reconoce una asociación de quistes de dinoflagelados característicos: *Acanthaulax* aff. *paliuros*, *Aptea* spp., *Diacanthum* cf. *hollisteri*, *Dichadogonyaulax culmula subsp. culmula*, *Dichadogonyaulax culmula subsp. curtospina*, *Dissiliodinium volkheimeri*, *Pilosidinium cactosum* y *Sentusidinium villersense,* entre otros. Esta asociación corresponde a la Zona de *Dichadogonyaulax culmula* var. *curtospina* y Zona de *Aptea notialis* (Quattrocchio y Sarjeant, 1992).

Dentro de los palinomorfos continentales se reconoce: *Microcachryidites antarcticus* y *Equisetosporites* spp. correspondientes a la Zona de *Microcachryidites antarcticus* (Quattrocchio *et al*., 1996).

?Berriasiano temprano

Dentro del microplancton siguen presentes, del Tithoniano tardío, *Aptea* spp. y Ceratiaceae y aparecen *Batioladinium* spp., *Leiosphaeridia* cf. *hyalina* y *Tasmanites* spp.

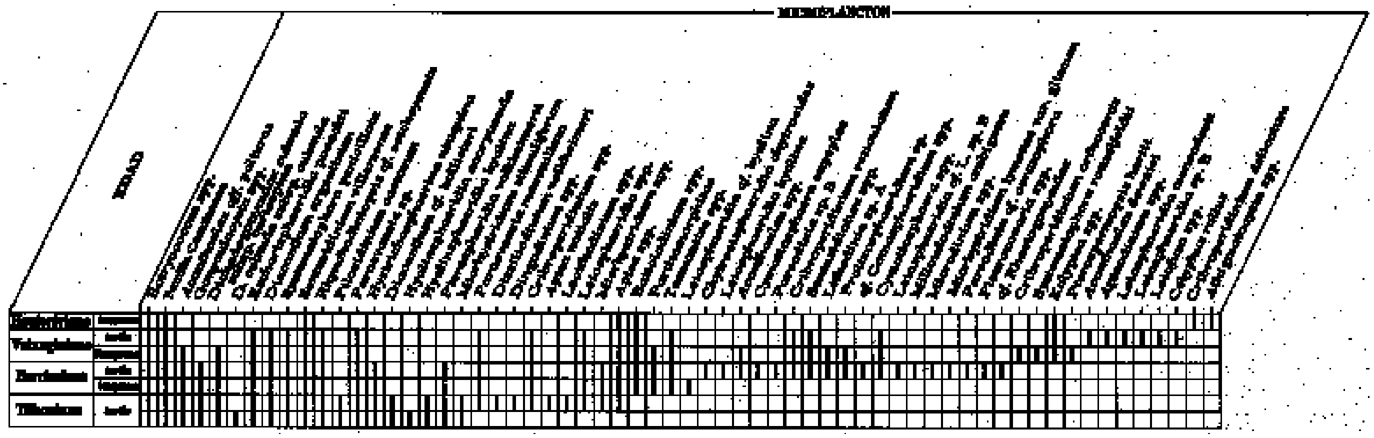


FIGURA 12–Distribución de especies de paleomicroplancton ordenadas según sus primeras apariciones.
FIGURE 12–Distribution of paleomicroplankton species ordered according to first appearance data.

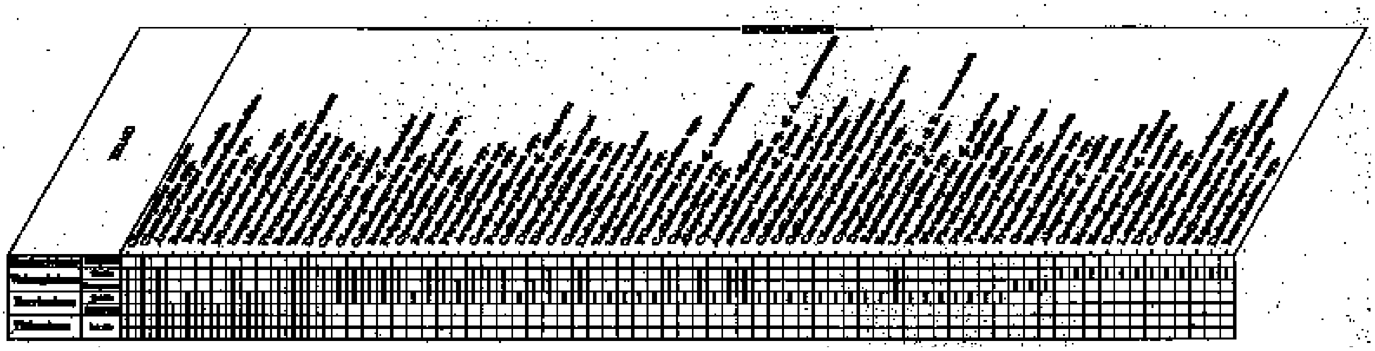


FIGURA 13–Distribución de especies de esporomorfos ordenadas según sus primeras apariciones.
FIGURE 13–Distribution of sporomorphs species ordered according to first appearance data.

Los palinomorfos continentales coinciden con los del Tithoniano tardío, sin embargo y como fuera mencionado en Volkheimer (1980), la diversidad de especies correspondientes al Berriasiano temprano es menor que la correspondiente al Jurásico tardío.

Berriasiano tardío

Las microfloras identificadas presentan grandes similitudes con las descriptas por Quattrocchio y Volkheimer (1985) para el Berriasiano tardío en la localidad Mallín Quemado.

Los palinomorfos terrestres se caracterizan por la presencia de: *Alisporites* cf. *similis, Callialasporites* cf. *microvelatus*, *Cerebropollenites* spp., *Converrucosisporites* spp., *Phrixipollenites* spp. y *Pilasporites* spp.

Se identificó una asociación de quistes de dinoflagelados caracterizada por la presencia de: *Prolixosphaeidium* sp., *Sentusidinium villersense* y *Systematophora penicillata*. Otras especies reconocidas son: *Acanthaulax* spp., *Hystrichosphaerina neuquina*, *Milloudodinium ambiguum*, *Pareodinia* cf. *ceratophora* y *Cribroperidinium reticulatum* (especie endémica según Quattrocchio y Volkheimer, 1990). La mayoría de las especies mencionadas están presentes en la parte superior de la Formación Vaca Muerta en la localidad de Mallín Quemado (Quattrocchio y Volkheimer, 1985, 1990). La presencia de *Spiticeras damesi* (Steuer) (Leanza, 1973, 1981) permite su asignación al Berriasiano tardío.

?Valanginiano temprano

Se considera en este trabajo a la sección estratigráfica correspondiente a M1 a y b, como perteneciente al Valanginiano temprano, por debajo de la Zona de *Olcostephanus curacoensis* Leanza (1945), asignada al Valanginiano tardío (tomado de Riccardi *et al.*, 1999).

Dentro de las especies terrestres identificadas pueden mencionarse: *Alisporites* cf. *similis*, *Araucariacites* spp., *Botryococcus* spp., *Callialasporites dampieri*, *Callialasporites trilobatus*, *Classopollis* cf. *classoides*, *Classopollis simplex*, *Cycadopites deterius*, *Cycadopites nitidus*, *Dictyophillidites* spp., *Granulatisporites* spp., *Inaperturopollenites* spp. y *Rugulatisporites* spp. La asociaciones marinas se caracterizan por la presencia de: *Cribroperidinium orthoceras*, *Cribroperidinium reticulatum*, *Diacanthum argentinum*, *Dichadogonyaulax culmula* subsp. *curtospina*, *Prolixosphaeridium* sp., *Pterospermopsis hartii*, *Sentusidinium villersense* y *Systematophora rosenfeldii*.

Hasta el presente, la Fm. Mulichinco sólo se menciona en Volkheimer *et al*. (1976), Dellapé *et al*. (1978) y Volkheimer (1980).

Valanginiano tardío

La presencia de *Olcostephanus curacoensis* en niveles correspondientes al límite M1b/M2, en el Perfil Barrranca de los Loros, permitiría asignarlos a la Zona de Asociación de *Olcostephanus curacoensis*, que caracteriza a los niveles más altos de la Formación Vaca Muerta en Neuquén y a las Formaciones Mulichinco y Chachao del sur de Mendoza (Riccardi *et al*., 1999) de edad valanginiana.

Se identificaron palinomorfos terrestres asignados a la Zona de *Cyclusphaera psilata*-*Classopollis* (Volkheimer, 1980): *Cyclusphaera psilata*, *Classopollis simplex*, *Classopollis* cf. *classoides*. Otras especies reconocidas son: *Araucariacites australis*, *Araucariacites* cf. *fissus*, *Balmeiopsis limbatus*, *Biretisporites potonieai*, *Callialasporites dampieri*, *Cicatricosisporites* spp., *Contignisporites cooksoniae*, *Cycadopites nitidus*, *Deltoidospora australis*, *Equisetosporites caichigüensis*, *Nevesisporites* cf. *radiatus*, *Podocarpidites* cf. *ellipticus* y *Ruffordiaspora australiensis*, entre otras.

Dentro del microplancton marino pueden mencionarse: *Acanthaulax downiei*, *Apteodinium* spp., *Cribroperidinium reticulatum*, *Leiosphaeridia* sp. B, *Leiosphaeridia menendezii*, *Paraevansia mammillata* y *Rhynchodiniopsis* cf. *setcheyensis*. Especies mayormente con registros previos dentro de la Cuenca Neuquina (Quattrocchio y Volkheimer, 1990).

Hauteriviano

Los niveles estratigráficos estudiados corresponderían a la parte basal de la Formación Agrio por correlación estratigráfica con niveles de similar composición palinológica del Hauteriviano medio (Zona de *Holcoptychites neuquensis*; Gerth, 1925) (Quattrocchio y Volkheimer, 1990) y al sur del área en estudio (Peralta y Volkheimer, 2000), localidad Cerro Negro, con las zonas de *Holcoptychites neuquensis* y *Lyticoceras pseudoregale* (Gerth, 1925) del Hauteriviano temprano a medio.

Se reconoce una asociación paleomicroflorística similar a la citada para la Formación Agrio en: Volkheimer (1980), Quattrocchio y Volkheimer (1990), Volkheimer y Sarjeant (1993), Peralta (1996) y Prámparo y Volkheimer (1996).

Dentro del microplancton se identificaron: *Aptea* spp., *Athigmatocysta* spp., *Batioladinium* spp., *Cribroperidinium delicatum*, *Kalyptea* spp. y *Sentusidinium villersense*.

Peralta y Volkheimer (2000) mencionan para depósitos de la Fm. Agrio la presencia del grupo *Oligosphaeridium* (*Oligosphaeridium* junto a los géneros *Kleitriasphaeridium* y *Surculosphaeridium)* como indicadores de condiciones neríticas externas, siguiendo la distribución de quistes de dinoflagelados en diferentes paleoambientes de Wilpshaar y Leereveld (1994). La ausencia de este grupo en los niveles estudiados indicaría la no existencia de condiciones neríticas externas. Aguirre-Urreta *et al*. (1999), para el Río Agrio (localidad aquí estudiada) ubican el límite Valanginiano/Hauteriviano dentro del Miembro Inferior de la Formación Agrio, en la base de la Zona de *Holcoptychites neuquensis*, con la asociación de *Muderongia*/*Oligosphaerdium* (no registrados en este trabajo). *Muderongia* es indicativo también de condiciones marinas abiertas, según Cornu y Monteil (en Monteil, 1990, tomado de Stover *et al*., 1996, p. 714). Posiblemente los niveles estudiados corresponden a niveles por debajo de los presentados por Aguirre-Urreta *et al*. *(op. cit*.). El género *Muderongia* corresponde a la Familia Ceratiaceae junto con *Pseudoceratium*/*Aptea*. En este trabajo dicha familia estaría representada por el género *Aptea*, pudiendo indicar la presencia de estadíos evolutivos previos dentro de dicho linaje.

COMPARACIÓN CON OTRAS CUENCAS

Patagonia Austral

Archangelsky *et al*. (1984) proponen cuatro palinozonas para el Berriasiano-Aptiano temprano de Patagonia Austral. Desde muro a techo son: 1) Zona de *Callialasporites-Contignisporites-Staplinisporites*, 2) Zona de *Interulobites-Foraminisporis*, 3) Zona de intervalo *tectifera-corrugatus* y 4) Zona de *Antulsporites-Clavatipollenites*.

La Zona de *Contignisporites-Callialasporites-Staplinisporites* está caracterizada por la abundancia de los géneros mencionados, así como por la ausencia de *Balmeiopsis* y *Cyclusphaera*, entre otros. El carácter más relevante es la frecuencia de *Callialasporites*. Se le asigna un rango de edad Berriasiano tardío-Valanginiano temprano.

Esta zona estaría representada en las secciones estudiadas (Zona 1) asignadas al Berriasiano tardío-?Valanginiano temprano por la presencia del género *Callialasporites* y ausencia de *Cyclusphera psilata*. A diferencia de la Zona de *Contignisporites-Callialasporites-Staplinisporites*, se registra aquí la presencia de *Balmeiopsis limbatus*.

Términos tithonianos-eoberriasianos no han sido detectados palinológicamente por ahora en la Cuenca Austral o en la Cuenca del NO de Santa Cruz-SO de Chubut (Archangelsky *et al*., *op. cit*.).

Para el Valanginiano tardío se registra en común con la Zona de *Interulobites-Foraminisporis* la presencia de esporas de briofitos: *Nevesisiporites* cf. *radiatus* (= *Asterisporites chlonovae*), *Interulobites* spp., *Taurocusporites* spp., *Polycingulatisporites* spp., y la presencia por primera vez de *Cyclusphaera psilata*. Otras especies comunes con esta zona son: *Celyphus rallus* y *Balmeiopsis limbatus*.

La comparación con Patagonia Austral se desdibujaría, no pudiéndose hacer comparaciones con la Zona de intervalo *tectifera-corrugatus*. No estarían representadas en las secciones estudiadas la Zona de *Antulsporites-Clavatipollenites*, en la que comienzan a desarrollarse tipos angiospermoides como *Clavatipollenites hughesii* de edad aptiana.

Según Archangelsky *et al*. (*op. cit.)*, es muy importante la aparición de taxones guías durante el Valanginiano tardío, especialmente *Cyclusphaera* y *Balmeiopsis*. Este último aparece antes en Australia y el Sahara, mientras que es también Valanginiano en Europa.

La mención en las secciones estudiadas de *Balmeiopsis*, correspondiente al Tithoniano tardío, sería su mención más antigua para el sur de Sudamérica.

Registros previos de dinoflagelados en otras cuencas

Las especies marinas (de momento) no serían de valor cronológico para calibrar el lapso correspondiente al Valanginiano, dado que en general corresponden a especies con registros previos en la cuenca, como por ejemplo: *Acanthaulax* aff. *paliuros*, *Dichadogonyaulax culmula* subsp. *curtospina*, *Sentusidinium villersense*, *Cribroperidinium reticulatum*, *Cribroperidinium orthoceras*, etc.

Entre ellos, *Cribroperidinium orthoceras* es cosmopolita, mencionado para el Caloviano (Israel), Berriasiano (Francia) y Hauteriviano-Campaniano de Argentina. C. *reticulatum* del Berriasiano (Argentina) y Valanginiano medio de Antártida. *C. delicatum* del Hauteriviano-Aptiano de Argentina, Valanginiano tardío-Hauteriviano de Australia. Es decir, no presenta registros previos al Valanginiano tardío, en este trabajo se presenta en los niveles asignados a la Formación Agrio (Hauteriviano).

AMBIENTES DEPOSICIONALES

En la Figura 3 se muestra un corte estratigráfico de la Fm. Mulichinco en el centro-oeste del Neuquén a lo largo de 192 km, entre Barranca de los Loros y Mallín Quemado (tomado de Zavala, 2000).

Considerando la relación de palinomorfos continentales *versus* marinos se reconocen ambientes marinos hasta transicionales para las formaciones Vaca Muerta y Quintuco en un transecto Norte-Sur, desde Barranca de los Loros a Mallín Quemado, para el Tithoniano tardío-Berriasiano.

Para la Formación Mulichinco, las secuencias M1a, M1b y M2 se depositaron en ambientes transicionales a marinos, desde Barranca de los Loros a Pichi Neuquén, no reconociéndose estas secuencias en el resto de las localidades que componen el transecto analizado. Zavala (2000) propone tentativamente para este intervalo un origen fluvio-lacustre. Se asignan aquí las unidades M1a y M1b al ?Valanginiano temprano.

El intervalo medio (secuencias M3 a M5), integrado por areniscas, pelitas y en menor medida conglomerados, parece depositado por sistemas fluvio-marinos (river-delta), afectado por procesos de difusión de ola y marea (Zavala, 2000); los palinomorfos indicarían el paso de condiciones transicionales a continentales en las secciones analizadas.

El intervalo superior (secuencia M6) se caracteriza mayormente por pelitas distales y en menor medida areniscas y conglomerados. Los sistemas fluvio-marinos tienen poca importancia, predominando los depósitos afectados por olas y mareas (Zavala, 2000). Las relaciones de palinomorfos continentales *versus* marinos indicarían condiciones transicionales a marinas, excepto al sur en Mallín Quemado, caracterizado por la presencia de *Botryococcus* y *Celyphus rallus* y la ausencia de microplancton marino.

Teniendo en cuenta los trabajos de estratigrafía secuencial realizados en la Cuenca Neuquina

(Legarreta y Uliana, 1999), basada en datos de subsuelo y superficie, y calibrado con fauna de ammonites, para la parte alta del Valanginiano temprano, se postulan condiciones del nivel del mar bajo, aun en el centro de cuenca (Lowstand deposits). En el Valanginiano tardío se reduce el influjo de clásticos pero la plataforma permanece bajo condiciones someras (Highstand deposits).

Zavala (2000) postula que, debido a las características marginales y parcialmente restringidas de la Cuenca Neuquina durante el Mesozoico, los descensos del nivel del mar (causados por cambios del nivel del mar, así como por cambios climáticos y tectónicos) no sólo influyeron en el registro con la generación de límites de secuencias convencionales y regresiones forzadas, sino que han llegado a desecar totalmente la cuenca con crisis de salinidad similares a la sufrida por el Mar Mediterráneo en el Mioceno tardío (Messiniano), generando un tipo particular de cortejo de mar bajo caracterizado por depósitos continentales (Mutti *et al.*, 1994). Zavala (2000) ubica este episodio en el Valanginiano tardío.

En el Berriasiano tardío-?Valanginiano temprano se registra la presencia de 31 especies marinas. Sobre la discordancia Intravalanginiana se reduce el número de especies marinas a 15. Son 45 las especies continentales en el Berriasiano tardío-?Valanginiano temprano y 30 en los depósitos posteriores a la discordancia Intravalanginiana. Esto sugeriría que se produjo un cambio en las asociaciones de las palinofloras y reducción de la diversidad con posterioridad a dicha discordancia. Los componentes microflorísticos hallados tanto en Patagonia Austral como en Cuenca Neuquina indicarían que los cambios ocurridos no sólo estarían provocados por fluctuaciones eustáticas, tectónicas y/o sedimentológicas, sino también climáticas. La menor diversidad de especies marinas indicaría crisis de salinidad en el Valanginiano tardío con respecto al Berriasiano tardío-?Valanginiano temprano (Quattrocchio *et al.*, 2002).

CONCLUSIONES

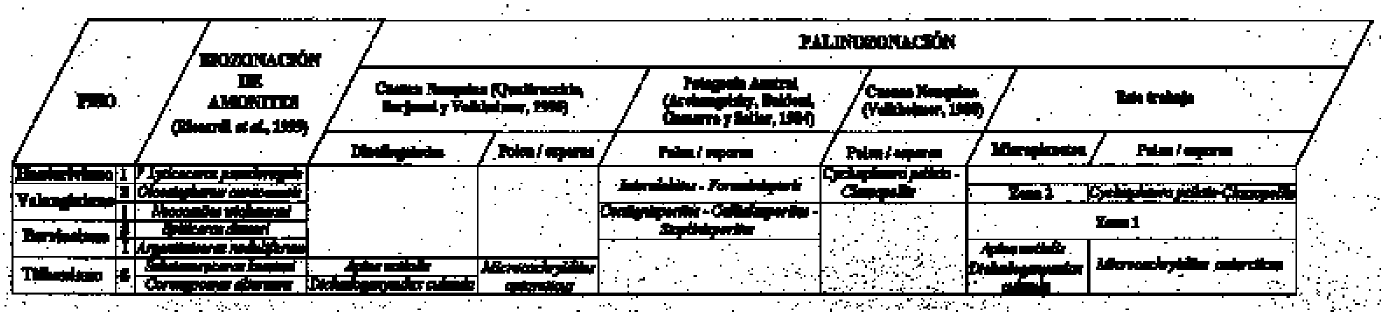
En una síntesis de la información brindada por las distintas secciones analizadas e información previa (Figura 14) se reconoce para el Tithoniano tardío-Berriasiano temprano la Zona de *Dichadogonyaulax culmula* y Zona de *Aptea notialis* (Quattrocchio y Sarjeant, 1992) y la Zona de *Microcachryidites antarcticus* (Quattrocchio *et al.*, 1996). De esta manera se extienden los rangos de estas palinozonas previamente identificadas hasta el Berriasiano temprano.

Para el Berriasiano tardío-?Valanginiano temprano (Zona 1) se registra un bioevento caracterizado por la aparición de 31 especies con respecto a la zona anterior. Al igual que la Zona de *Contignisporites-Callialasporites-Staplinisporites* (Archangelsky *et al.*, *op. cit.*) se registra la ausencia de *Cyclusphaera*. El carácter más relevante es la frecuencia del género *Callialasporites* (*C. microvelatus*, *C. trilobatus*, *C. segmentatus*, *C. turbatus*).

Otras especies características son: *Eucommidites* cf. *minor*, *Cerebropollenites macroverrucosus*, *Ischyosporites* spp., *Duplexisporites* spp., etc.

El Valanginiano temprano se incluye con dudas debido al escaso número de muestras estudiadas.

En el Valanginiano tardío se reconoce la Zona de *Cyclusphaera psilata-Classopollis* (Volkheimer, 1980) comparable con la Zona de *Interulobites-*



PISO		BIOZONACIÓN DE AMONITES (Riccardi *et al.*, 1999)	PALINOZONACIÓN					
			Cuenca Neuquina (Quattrocchio, Sarjeant y Volkheimer, 1996)		Patagonia Austral (Archangelsky, Baldoni, Gamerro y Seiler, 1984)	Cuenca Neuquina (Volkheimer, 1980)	Este trabajo	
			Dinoflagelados	Polen / esporas	Polen / esporas	Polen / esporas	Microplancton	Polen / esporas
Hauteriviano	I	? *Lyticoceras pseudoregale*			*Interulobites - Foraminisporis*	*Cyclusphaera psilata - Classopollis*		
Valanginiano	S	*Olcostephanus curacoensis*					Zona 2	*Cyclusphaera psilata-Classopollis*
	I	*Neocomites wichmanni*			*Contignisporites - Callialasporites - Staplinisporites*		Zona 1	
Berriasiano	S	*Spiticeras damesi*						
	I	*Argentiniceras noduliferum*						
Tithoniano	S	*Substeueroceras koeneni*	*Aptea notialis*	*Microcachryidites antarcticus*			*Aptea notialis* *Dichadogonyaulax culmula*	*Microcachryidites antarcticus*
		Corongoceras alternans	*Dichadogonyaulax culmula*					

FIGURA 14–Biozonación palinológica propuesta para el área de estudio.
FIGURE 14–Palynological zonation proposed to the study area.

Foraminisporis (Archangelsky *et al.*, *op. cit.*), en común con esta última palinozona se registra la presencia de especies de briofitos *Nevesisiporites* cf. *radiatus* (= *Asterisporites chlonovae*), *Interulobites* spp., *Taurocusporites* spp., *Polycingulatisporites* spp., y la presencia por primera vez de *Cyclusphaera psilata*. En el presente trabajo se utiliza para los depósitos de edad valanginiana tardía la denominación de Volkheimer (1980)-Zona de *Cyclusphaera psilata-Classopollis*, dada la gran similitud entre ambas, con especies asociadas como: *Deltoidospora australis, D. minor*, *Ruffordiaspora australiensis* (= *Cicatricosisporites australiensis*) *Cycadopites nitidus*, *Classopollis simplex, C. classoides* y *Araucariacites australis*.

Para el microplancton, además de reconocerse una notable disminución en el número de especies marinas con posterioridad a la discordancia intravalanginiana (de 31 a 15); aproximadamente el 40% de las formas microplanctónicas identificadas en el Valanginiano tardío son indicativas de condiciones de agua dulce hasta salobres. Se propone informalmente (Zona 2) una asociación de *Celyphus rallus* (probable cianobacteria Rivulariacea; Tyson, 1995), algas del género *Leiosphaeridia* (*Leiosphaeridia* sp. B, *L. menendezii*) y *Leiofusa* spp. Esta asociación sería indicativa de la crisis de salinidad mencionada para el Valanginiano tardío.

No se considera el Hauteriviano, dado el escaso número de muestras analizadas.

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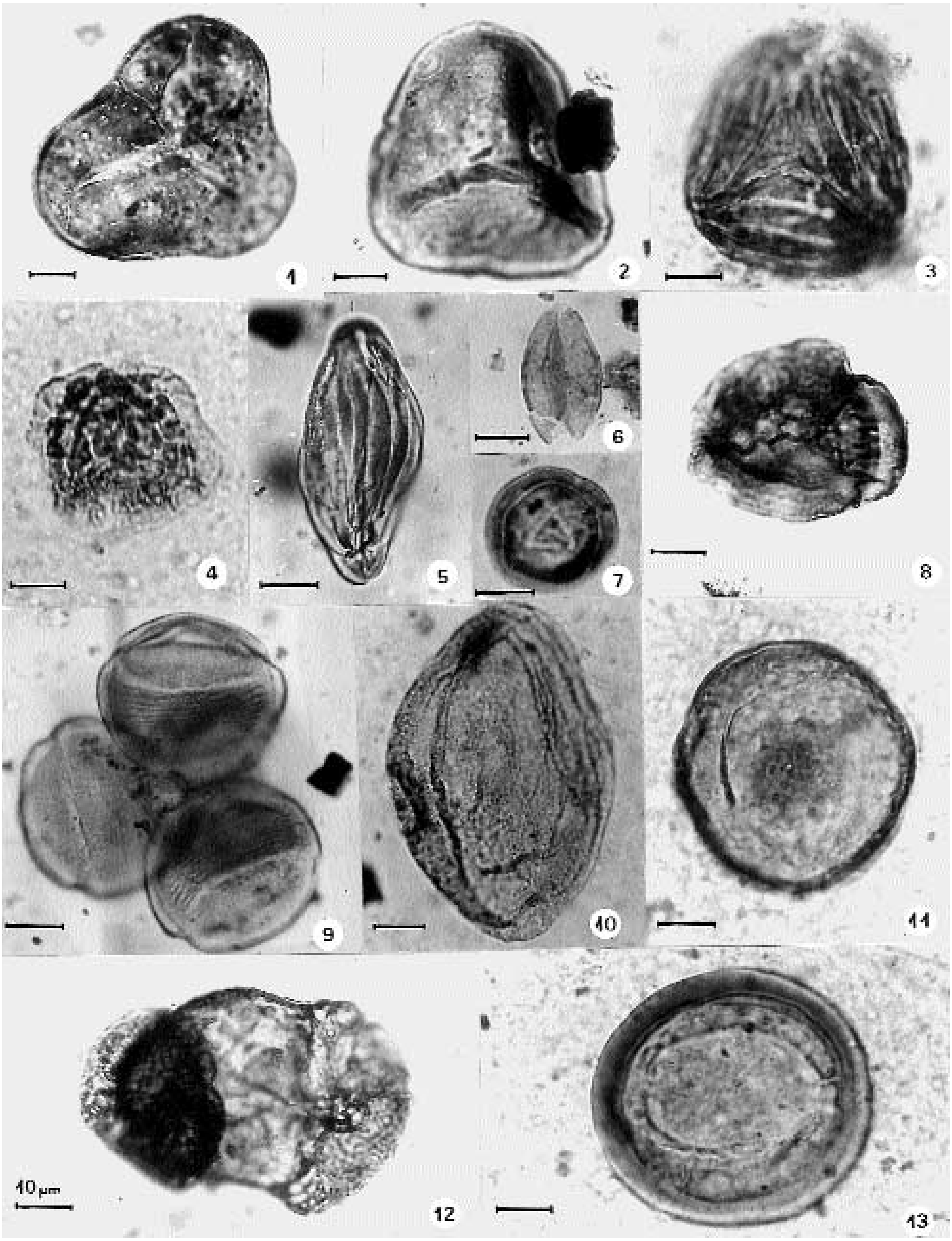
→

LÁMINA 1–*1*, *Deltoidospora australis* (Couper) Pocock, 1970. UNSP BL 3: 23,2/104,6. Cara proximal. *2*, *Biretisporites potonieai* Delcourt y Sprumont, 1955. UNSP RA 21: 14/146,6. Cara proximal. *3*, *Ruffordiaspora australiensis* (Cookson) Dettmann y Clifford, 1992. UNSP BL 3: 23/123,3. Cara proximal. *4*, *Antulsporites saevus* (Balme) Archangelsky y Gamerro, 1966. UNSP MQ 6: 19,2/142,1. Corte óptico. *5*, *Equisetosporites caichigüensis* Volkheimer y Quattrocchio, 1975. Paratipo (tomado de Volkheimer y Quattrocchio, 1975, p. 235). *6*, *Cycadopites adjectus* (De Jersey) Volkheimer y Quattrocchio, 1975. UNSP RA 20: 16,5/150. Cara distal. *7*, *Classopollis simplex* (Danzé-Corsin y Laveine) Reiser y Williams, 1969. UNSP MQ 6: 17,7/122,9. Cara proximal. *8*, *Callialasporites trilobatus* (Balme) Dev, 1961. UNSP PC 5d: 4,8/142,1. Cara proximal. *9*, *Classopollis* cf. *classoides* (Pflug) Pocock y Jansonius, 1961 (tomado de Quattrocchio, 1980). *10*, *Araucariacites australis* Cookson, 1947. UNSP MQ 6: 15,3/125,6. *11*, *Balmeiopsis limbatus* (Balme) Archangelsky, 1977. UNSP LC: 23/136,5. Vista polar. *12*, *Podocarpidites* cf. *ellipticus* Cookson, 1947. UNSP PC 5b: 19,6/116,9. Vista polar, enfoque distal. *13*, *Cyclusphaera psilata* Volkheimer y Sepúlveda, 1975. UNSP LC: 21,4/116. Vista polar. (Todas las figuras están ampliadas × 1000, escala gráfica = 10µm).

PLATE 1–(All figures × 1000, scale bar equals 10 µm). *1*, *Deltoidospora australis* (Couper) Pocock, 1970. UNSP BL 3: 23,2/104,6. Proximal surface. *2*, *Biretisporites potonieai* Delcourt and Sprumont, 1955. UNSP RA 21: 14/146,6. Proximal surface *3*, *Ruffordiaspora australiensis* (Cookson) Dettmann and Clifford, 1992. UNSP BL 3: 23/123,3. Proximal surface. *4*, *Antulsporites saevus* (Balme) Archangelsky and Gamerro, 1966. UNSP MQ 6: 19,2/142,1. Optical section. *5*, *Equisetosporites caichigüensis* Volkheimer and Quattrocchio, 1975. Paratipo (from Volkheimer and Quattrocchio, 1975, p. 235). *6*, *Cycadopites adjectus* (De Jersey) Volkheimer and Quattrocchio, 1975. UNSP RA 20: 16,5/150. Distal surface. *7*, *Classopollis simplex* (Danzé-Corsin and Laveine) Reiser and Williams, 1969. UNSP MQ 6: 17,7/122,9. Proximal surface. *8*, *Callialasporites trilobatus* (Balme) Dev, 1961. UNSP PC 5d: 4,8/142,1. Proximal surface. *9*, *Classopollis* cf. *classoides* (Pflug) Pocock and Jansonius, 1961 (from Quattrocchio, 1980). *10*, *Araucariacites australis* Cookson, 1947. UNSP MQ 6: 15,3/125,6. *11*, *Balmeiopsis limbatus* (Balme) Archangelsky, 1977. UNSP LC: 23/136,5. Polar view. *12*, *Podocarpidites* cf. *ellipticus* Cookson, 1947. UNSP PC 5b: 19,6/116,9. Polar view, distal focus. *13*, *Cyclusphaera psilata* Volkheimer and Sepúlveda, 1975. UNSP LC: 21,4/116. Polar view.

LÁMINA 1



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APÉNDICE: LISTA SISTEMÁTICA DE ESPECIES

Esporomorfos

Alisporites spp.

Alisporites cf. *similis* (Balme) Dettmann, 1963.

Anapiculatisporites sp. cf. *A. dawsonensis* Reiser y Williams, 1969.

Antulsporites saevus (Balme) Archangelsky y Gamerro, 1966 (Lám. 1, Fig. 4).

Araucariacites australis Cookson, 1947 (Lám. 1, Fig. 10).

Araucariacites cf. *fissus* Reiser y Williams, 1969.

Araucariacites spp.

Balmeiopsis limbatus (Balme) Archangelsky, 1977 (Lám. 1, Fig. 11).

Biretisporites potonieai Delcourt y Sprumont, 1955 (Lám. 1, Fig. 2).

Biretisporites spp.

Callialasporites dampieri (Balme) Dev, 1961.

Callialasporites microvelatus Schulz, 1966.

Callialasporites cf. *microvelatus* Shulz, 1966.

Callialasporites segmentatus (Balme) Srivastava, 1963.

Callialasporites trilobatus (Balme) Dev, 1961 (Lám. 1, Fig. 8).

Callialasporites turbatus (Balme) Schulz, 1967.

Callialasporites spp.

Cerebropollenites macroverrucosus (Thiergart) Schulz, 1967

Cerebropollenites spp.

Cicatricosisporites spp.

Classopollis cf. *classoides* (Pflug) Pocock y Jansonius, 1961 (en Volkheimer, 1968) (Lám. 1, Fig. 9).

Classopollis intrareticulatus Volkheimer, 1972.

Classopollis simplex (Danzé-Corsin y Laveine) Reiser y Williams, 1969 (Lám. 1, Fig. 7).

Classopollis torosus Reissinger (Burger, 1965.

Classopollis spp.

Contignisporites cooksoniae (Balme) Dettmann, 1963.

Converrucosisporites spp.

Cyclogranisporites spp.

Cycadopites adjectus (De Jersey) Volkheimer y Quattrocchio, 1975 (Lám. 1, Fig. 6).

Cycadopites deterius (Balme) Volkheimer y Quattrocchio, 1975.

Cycadopites nitidus (Balme) De Jersey, 1964.

Cycadopites spp.

Cyclusphaera psilata Volkheimer y Sepúlveda, 1975 (Lám. 1, Fig. 13).

Deltoidospora australis (Couper) Pocock, 1970 (Lám. 1, Fig. 1).

Deltoidospora minor (Couper) Pocock, 1970.

Deltoidospora neddeni Pflug, 1953.

Deltoidospora spp.

Dictyophyllidites mortoni (De Jersey) Playford y Dettmann, 1965.

Dictyophyllidites spp.

Divisisporites spp.

Duplexisporites spp.

Equisetosporites caichigüensis Volkheimer y Quattrocchio, 1975 (Lám. 1, Fig. 5).

Equisetosporites sp. cf. *E. menendezii* Volkheimer, 1972.

Equisetosporites spp.

Eucommiidites cf. *minor* Groot y Penny, 1960.

Granulatisporites spp.

Inaperturopollenites spp.

Interulobites spp.

Ischyosporites spp.

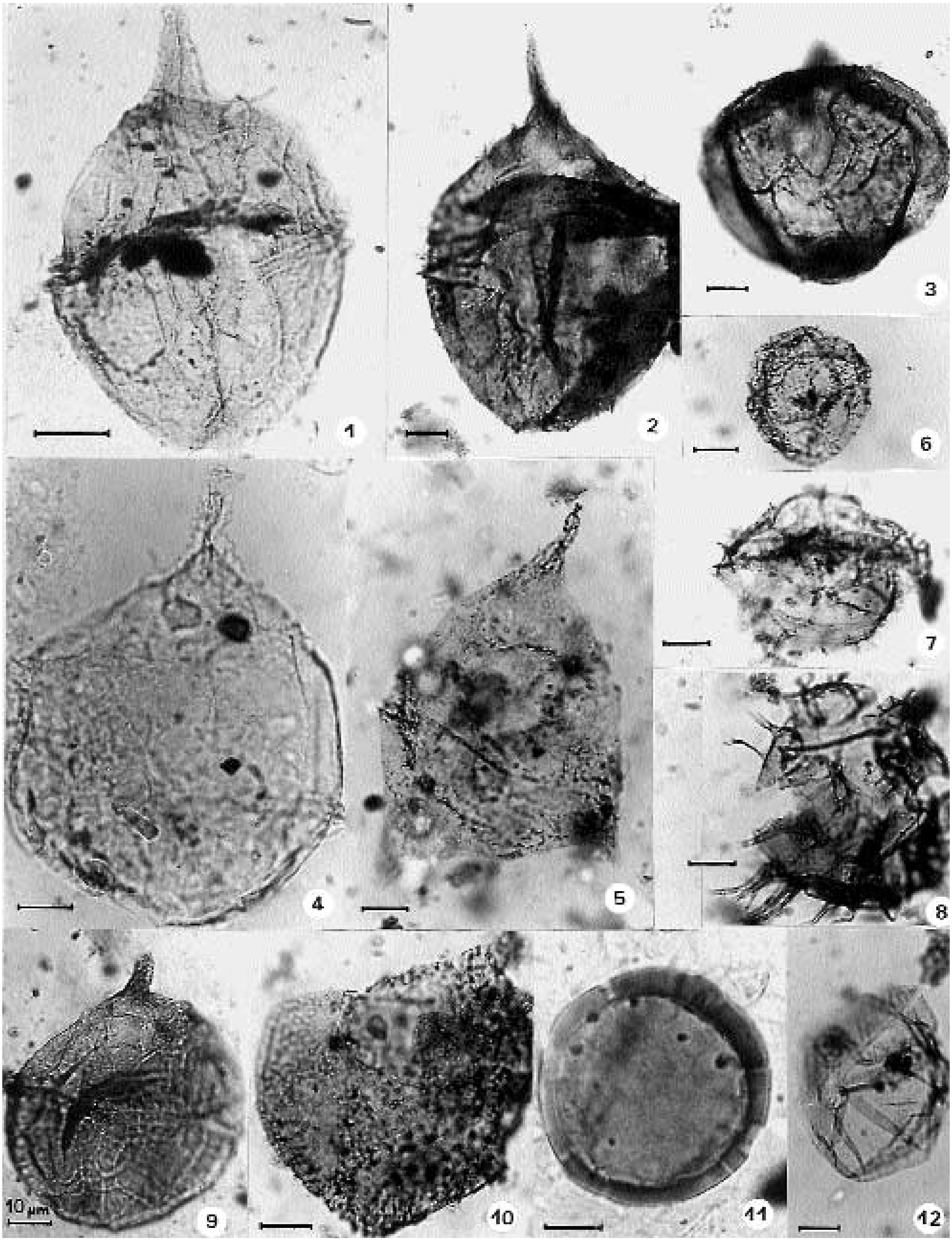
Leptolepidites major Couper, 1958.

→

LÁMINA 2–*1-4*, *Cribroperidinium orthoceras* (Eisenack) Davey, 1969; *1*, Vista ventral, superficie ventral (tomado de Quattrocchio y Volkheimer, 1990, p. 329); *2*, UNSP PC 5: 3,4/116,2. Vista dorsal, superficie ventral; *3*, UNSP PC 5b: 7,7/113,9. Vista antapical, levemente desplazada; *4*, UNSP LC: 13,5/114. Vista dorsal, corte óptico, la paratabulación es difícilmente discernible (sólo en el cíngulo), debido al mal estado de preservación del ejemplar. *5*, *Aptea* spp. UNSP PC 5b: 19,6/124,1. Vista dorsal, superficie dorsal. *6*, *Acanthaulax* aff. *paliuros* (Sarjeant) Sarjeant, 1968. UNSP PC 3: 21/160. *7*, *Dichadogonyaulax culmula* subsp. *curtospina* Quattrocchio y Sarjeant, 1992. UNSP PC 3: 8,9/140,6. *8*, *Systematophora rosenfeldii* Volkheimer y Sarjeant, 1993. UNSP PC 5: 1,5/117,7. Vista ventral, superficie ventral. *9*, *Cribroperidinium reticulatum* Quattrocchio y Volkheimer, 1985 (tomado de Quattrocchio y Volkheimer, 1985, p.190). *10*, *Sentusidinium villersense* (Sarjeant) Sarjeant y Stover, 1978. UNSP PC 5: 5,8/144,5. Vista ventral, superficie ventral. *11*, *Tasmanites* spp. UNSP LC: 13,8/134,1. *12*, *Leiosphaeridia* cf. *hyalina* (Deflandre) Downie, 1957. UNSP PC 5c: 2,4/122,7. (Todas las figuras están ampliadas × 1000, escala gráfica = 10 µm).

PLATE 2–(All figures × 1000, scale bar equals 10 µm). *1-4*, *Cribroperidinium orthoceras* (Eisenack) Davey, 1969; *1*, Ventral view, ventral surface (from Quattrocchio and Volkheimer, 1990, p. 329); *2*, UNSP PC 5: 3,4/116,2. Dorsal view, ventral surface; *3*, UNSP PC 5b: 7,7/113,9. Antapical view, slightly tilted; *4*, UNSP LC: 13,5/114. Dorsal view, optical section, the paratabulation is only identified in the cingulum due to the bad preservation state of this specimen. *5*, *Aptea* spp. UNSP PC 5b: 19,6/124,1. Dorsal view, dorsal surface. *6*, *Acanthaulax* aff. *paliuros* (Sarjeant) Sarjeant, 1968. UNSP PC 3: 21/160. *7*, *Dichadogonyaulax culmula* subsp. *curtospina* Quattrocchio and Sarjeant, 1992. UNSP PC 3: 8,9/140,6. *8*, *Systematophora rosenfeldii* Volkheimer and Sarjeant, 1993. UNSP PC 5: 1,5/117,7. Ventral view, ventral surface. *9*, *Cribroperidinium reticulatum* Quattrocchio and Volkheimer, 1985 (from Quattrocchio and Volkheimer, 1985, p.190). *10*, *Sentusidinium villersense* (Sarjeant) Sarjeant and Stover, 1978. UNSP PC 5: 5,8/144,5. Ventral view, ventral surface. *11*, *Tasmanites* spp. UNSP LC: 13,8/134,1. *12*, *Leiosphaeridia* cf. *hyalina* (Deflandre) Downie, 1957. UNSP PC 5c: 2,4/122,7.

LÁMINA 2



PERFIL	Muestra	m.b.p.
BARRANCA DE LOS LOROS	8	358,5
	7	334,5
	6	318
	5	303,5
	4	209
	3	165
	2	79,5
	1_a	6
PUERTA CURACO	11	362,5
	10	342
	9	331,5
	8	309
	7	299
	6	188,5
	5	161,5
	4	75,5
	3	48
	2	30
	1_b	3,5
PICHI NEUQUÉN	7	405,5
	6	383,5
	5	306
	4	259
	3	219,5
	2	147,5
	1	121
	0_c	6
SALADO MULA	6	197,5
	5	116,5
	4	105,5
	3	74,5
	2	56
	1_d	6,5
RAHUECO	16	603,5
	15	582,5
	14	562
	13	519,5
	12	473
	11	451,5
	10	437
	7	152,5
	6	88,5
	4	54
	3	27
	2	21
	1_e	2

PERFIL	Muestra	m.b.p.
MALLÍN QUEMADO	18	692,5
	17	669
	16	658
	15	620
	14	604,5
	13	587,5
	12	562,5
	11	545,5
	10	530
	9	518
	8	504,5
	7	486
	6	393,5
	5	365
	4	259,5
	3	200,5
	2	167,5
	1_f	45,5
RÍO AGRIO	24	443
	23	434
	22	427
	21	420,5
	20	405,5
	19	396,5
	18	391,5
	17	376
	16	355,5
	15	328,5
	14	318
	13	262
	12	259,5
	11	255,5
	10	233,5
	9	209
	8	189,5
	7	176
	6	132,5
	5	95,5
	4	49,5
	3	36,5
	2	9
	1_g	3,5
LAS COLORADAS	1_h	-

m.b.p.: metros desde la base del perfil.
a: 69 metros por debajo del límite entre las formaciones Vaca Muerta/Mulichinco.
b: 14,6 metros por debajo del límite entre las formaciones Vaca Muerta/Mulichinco.
c: 2 metros por debajo del límite entre las formaciones Vaca Muerta/Mulichinco.
d: 0,5 metros por debajo del límite entre las formaciones Vaca Muerta/Mulichinco.
e: 37,7 metros por debajo del límite entre las formaciones Vaca Muerta/Mulichinco.
f: 26 metros por encima del límite entre las formaciones Vaca Muerta/Quintuco.
g: 284,7 metros por debajo del límite entre las formaciones Quintuco/Mulichinco.
h: 10 metros por debajo del límite entre las formaciones Mulichinco/Agrio.

Leptolopidites spp.

Monosulcites spp.

Microcachryidites antarcticus Cookson,1947.

Microcachryidites spp.

Nevesisporites cf. *radiatus* (Chlonova) Srivastava, 1972 (en Martínez, Quattrocchio y Sarjeant, 2001).

Osmundacidites spp.

Phrixipollenites infrulus Haskell, 1968.

Phrixipollenites otagoensis (Couper) Haskell, 1968.

Phrixipollenites spp.

Pilasporites allenii Batten, 1968.

Pilasporites spp.

Podocarpidites ellipticus Cookson, 1947.

Podocarpidites cf. *ellipticus* Cookson, 1947 (en Volkheimer, 1968) (Lám. 1, Fig. 12).

Podocarpidites verrucosus Volkheimer, 1972.

Podocarpidites spp.

Polycingulatisporites spp.

Punctatosporites cf. *scabratus* (Couper) Norris, 1965.

Retitriletes austroclavatidites (Cookson) Döring, Krutzsch, Mai y Schulz, 1963.

Retitriletes spp.

Ruffordiaspora australiensis (Cookson) Dettmann y Clifford, 1992 (Lám. 1, Fig. 3).

Rugulatisporites spp.

Spinosisporites spp.

Taurocusporites spp.

Todisporites minor Couper, 1958.

Trichotomosulcites subgranulatus (Couper) Dettman, 1986.

Vitreisporites pallidus (Reissinger) Nilsson, 1958.

Microplancton

Acanthaulax downiei (Sarjeant) Sarjeant, 1976.

Acanthaulax aff. *paliuros* (Sarjeant) Sarjeant, 1968 (Lám. 2, Fig. 6).

Acanthaulax spp.

Aptea notialis Quattrocchio y Sarjeant, 1992.

Aptea spp. (Lám. 2, Fig. 5).

Apteodinium spp.

Athigmatocysta spp.

Batioladinium spp.

Botryococcus spp.

Celyphus rallus Batten, 1973.

Ceratiaceae Lindemann, 1928.

Chytroeisphaeridia chytroeides (Sarjeant) Downie y Sarjeant, 1965, emend. Davey, 1979.

Cribroperidinium delicatum Backhouse, 1988.

Cribroperidinium orthoceras (Eisenack) Davey, 1969 (Lám. 2, Figs. 1-4).

Cribroperidinium reticulatum Quattrocchio y Volkheimer, 1985 (Lám. 2, Fig. 9).

cf. *Comasphaeridium* spp.

Cribroperidinium spp.

Cymatiosphaera eupeplos (Valensi) Deflandre, 1954.

Cymatiosphaera spp.

Diacanthum argentinum Quattrocchio y Sarjeant, 1992.

Diacanthum cf. *hollisteri* (Habib) Habib y Drugg, 1987 (en Quattrocchio y Sarjeant, 1992).

Dichadogonyaulax culmula (Norris) Loeblich y Loeblich subsp. *culmula* Norris, 1965.

Dichadogonyaulax culmula (Norris) Loeblich y Loeblich subsp. *curtospina* Quattrocchio y Sarjeant, 1992 (Lám. 2, Fig. 7).

Dingodinium spp.

Dissiliodinium volkheimeri Quattrocchio y Sarjeant, 1992.

Escharisphaeridia pocockii (Sarjeant) Erkmen y Sarjeant, 1980.

Gonyaulacysta spp.

Hyalinsphaeridia acorpuscula Bernier y Courtinant, 1979.

Hyalinsphaeridia hyalina (Deflandre) Bernier y Courtinant, 1979.

Hystrichosphaerina neuquina (Quattrocchio y Volkheimer) emend Quattrocchio y Sarjeant, 1992.

Kalyptea spp.

Lecithodinium spp.

Leiosphaeridia menendezii Volkheimer, Caccavari y Sepúlveda, 1977.

Leiosphaeridia hyalina (Deflandre) Downie, 1957.

Leiosphaeridia cf. *hyalina* (Deflandre) Downie, 1957 (Lám. 2, Fig. 12).

Leiosphaeridia sp. B (en Volkheimer, Caccavari y Sepúlveda, 1977).

Leiosphaeridia cf. *L.* sp. B (en Quattrocchio y Volkheimer, 1983).

Leiosphaeridia spp.

Leiofusa spp.

Lithodinia sp. A (en Quattrocchio y Volkheimer, 1985).

Micrhystridium stimuliferum (Deflandre) Sarjeant y Stancliffe, 1994

Micrhystridium lymense var. *gliscum* Wall, 1965

Micrhystridium spp.

Microdinium spp.

Milloudodinium ambiguum (Deflandre) Stover y Evitt, 1978.

Paraevansia mammillata Quattrocchio y Sarjeant, 1992.

Paraevansia sp. (en Quattrocchio y Sarjeant, 1992).

Pareodinia cf. *ceratophora* (Deflandre) emend. Below, 1990.

Pareodinia sp. B (en Wiggins, 1975).

Partitomorphitae Pocock y Sarjeant (en Pocock, 1972).

Pilosidinium cactosum Quattrocchio y Sarjeant, 1992.

Pleurozonaria spp.

Prasinophyceae Parke en Parke y Dixon, 1964.

Prolixosphaeridium sp. (en Quattrocchio y Volkheimer, 1985).

Pterospermopsis hartii Sarjeant, 1960.

Pterosphaeridia volkheimerii Quattrocchio, 1980.

cf. *Rhaetogonyaulax* spp.

Rhynchodiniopsis cf. *setcheyensis* (Sarjeant) Sarjeant, 1982.

Sentusidinium villersense (Sarjeant) Sarjeant y Stover, 1978 (Lám. 2, Fig. 10).

Sentusidinium spp.

Systematophora penicillata (Ehrenberg) Sarjeant, 1980.

Systematophora rosenfeldii Volkheimer y Sarjeant, 1993 (Lám. 2, Fig. 8).

Tasmanites spp. (Lám. 2, Fig. 11).

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FRESHWATER OSTRACODA FROM THE UPPER CRETACEOUS INTERTRAPPEAN BEDS AT MAMONI (KOTA DISTRICT), SOUTHEASTERN RAJASTHAN, INDIA

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Abstract

Eight species, none of which were very abundant, were encountered at Mamoni, in the Kota District of southeastern Rajasthan State, India. The fauna was recovered from an approximately 1 m thick bed of cherty marl and chert overlying a volcanic sequence, near the village of Mamoni. This is the most northerly occurrence of intertrappean deposits. The low diversity of the fauna is probably due to low abundance. Two new species, *Mongolianella subarcuata* sp. nov. and *Eucypris cantantion* sp. nov. are described, which demonstrates the fact that even a low diversity fauna from such an isolated locality can reveal new species. The remaining six species have all been described from deposits of the same age from elsewhere to the south and west in the Deccan Volcanic Province.

Keywords: Freshwater Ostracoda, Upper Cretaceous, Intertrappeans, Deccan, India.

Resumen

Se describen ocho especies de ostrácodos procedentes del Cretácico Superior de Mamoni, distrito de Kota, región sudoriental del Estado de Rajastán, India. El número de ejemplares de cada una de ellas es bajo, y fueron recogidos en un nivel de aproximadamente 1 m de espesor de marga con chert sobre una secuencia volcánica, cerca del pueblo de Mamoni. Este hallazgo representa el registro más septentrional en depósitos intertrappeanos. Se describen dos especies nuevas: *Mongolianella subarcuata* sp. nov. y *Eucypris cantantion* sp. nov. A pesar de ser una asociación de baja diversidad resulta, sin embargo, posible el hallazgo de especies nuevas en localidades aisladas. Las otras seis especies que se describen son conocidas en localidades más meridionales y occidentales, de la Provincia volcánica del Deccan.

Palabras clave: Ostrácodos dulceacuícolas, Cretácico Superior, Intertrappeano, Deccan, India.

INTRODUCTION

The intertrappean beds near the village of Mamoni (24°13’14’’ N: 76˚6’18’’ E) in Kota District, southeastern Rajasthan, occupy a special place in the Deccan Volcanic Province, since they represent the northern limit of the province. However, these peripheral outcrops have not attracted as much attention as their counterparts in western and southern India. The only records of freshwater Ostracoda from these beds are those by Mathur & Verma (1988) and Bhatia *et al*. (1990a). Mathur & Verma’s (1988) assemblage, illustrated with outline drawings that are difficult to interpret, included a new species *Moenocypris sastryi* and the remaining 5 species were: *Cyprois* sp. (= *Cyprois* sp. of Bhatia & Rana, 1984, now named *Cypria cyrtonidion* Whatley & Bajpai, 2000a); *Moenocypris hunteri* (Jones, 1860 – ex *Cypris, non Cypris hunteri* Jones, as the present authors will demonstrate in two forthcoming papers (Whatley *et al.* in press a, b)); *Mongolianella* sp. (= *Mongolianella cylindrica* (Sowerby, 1840)); *Pseudoeucypris* sp.; and *Paracypretta* sp. Bhatia *et al.* (1990b), in an extended abstract, illustrated a few charophyte and ostracod taxa from the same locality, the latter including: *Mongolianella palmosa* [= *M. cylindrica* (Sowerby, 1840)]; *Mongolianella* sp. (= *M. cylindrica* (Sowerby, 1840)); *Altanicypris szczechurae* (Stankevitch) (neither *Altanicypris* Szczechura (1978) nor *szczechurae* Stankevitch & Sochava, 1974; it is probably *Paracypretta subglobosa* (Sowerby, 1840) but the illustration is too poor to be certain); *Frambocythere tumiensis tumiensis,* (=*F. t. anjarensis* Bhandari & Colin, 1999); *Cytheridella strangulata* (= *Gomphocythere strangulata* (Jones, 1860)); and *Candoniella altanica* [= ?*Mongolianella cylindrica* (Sowerby, 1840)].

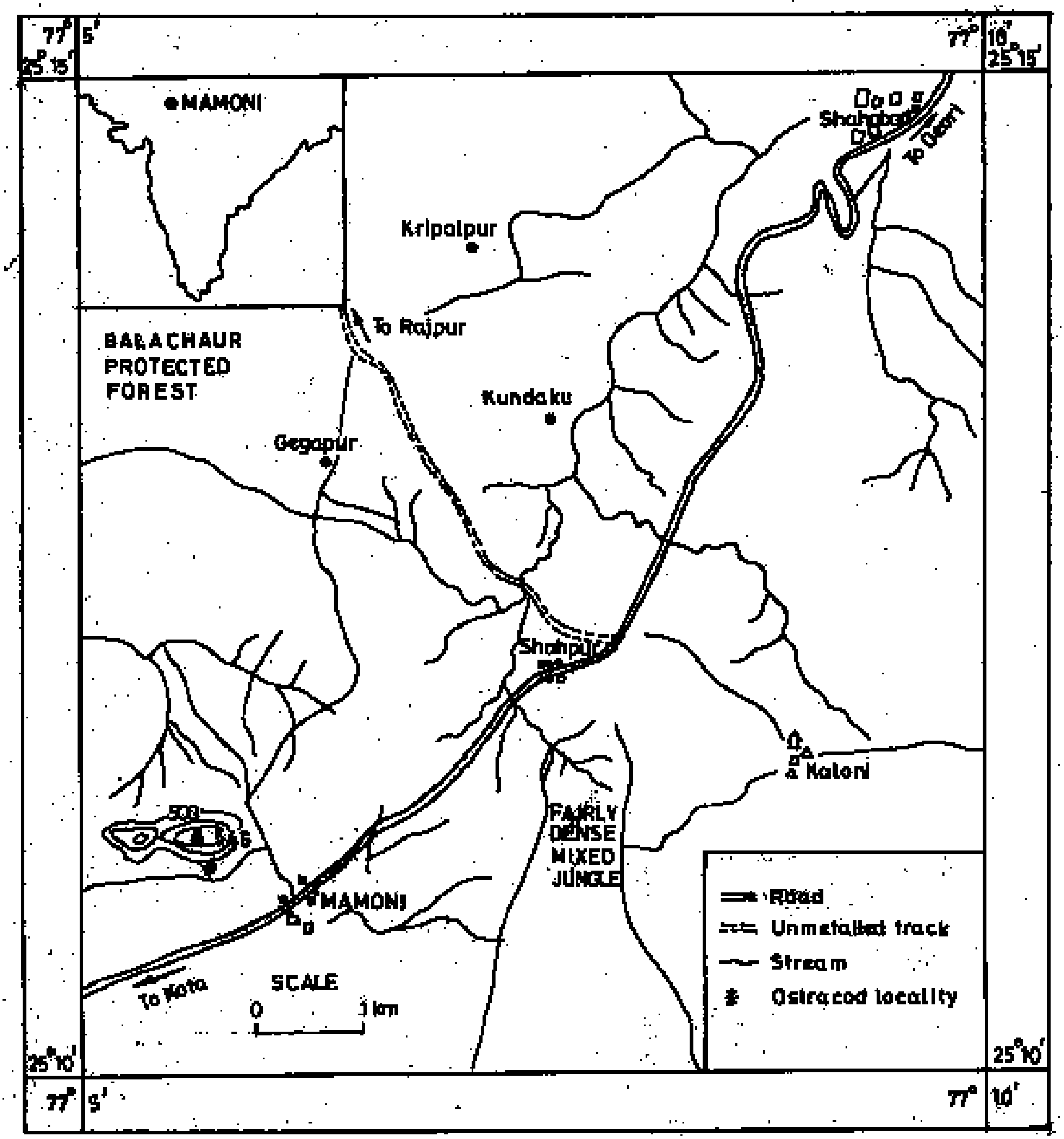


FIGURE 1–Map showing the position of Mamoni.

The purpose of our paper is to illustrate and describe in detail the entire ostracod assemblage recovered from an approximately 1 m thick bed of cherty marl and chert overlying the volcanics near the village of Mamoni. The fossiliferous samples come from a hill section about 1 km west of Mamoni on the Kota-Shahabad road. The section from which they were collected is the same as that published by Bhatia *et al.* (1990b, p. 118, Fig. 1). It is important to note that the Deccan Traps at this locality rest directly on the basement of Bhander Sandstone (Vindhyan Supergroup, Precambrian).

PREVIOUS RESEARCH ON INDIAN NON-MARINE UPPER CRETACEOUS OSTRACODA

Sowerby (1840), Carter (1852) and Jones (1860) first reported Ostracoda from the intertrappean beds. Following these pioneering studies, Bhatia and co-workers (Bhatia & Rana, 1984; Bhatia *et al.*,1990a & b, 1996) described ostracods from a number of localities and discussed their age and biogeographical affinities. Prasad (1986) recorded 5 species of Ostracoda from Asifabad in Andhra Pradesh, while Mathur & Verma (1988) described a fauna from the intertrappean beds of Rajasthan. Singh (1995 MS) and Singh & Sahni (1996) discussed the age and faunal affinities of the Bombay intertrappeans, based on a variety of fossil groups with special attention being given to the Ostracoda. Udhoji & Mohabey (1996) considered the Ostracoda in their study of the age and palaeozoogeographical implications of the late Cretaceous Lameta Formation of Maharashtra. Sahni & Khosla (1994) and Khosla & Sahni (2000) reported the occurrence of Ostracoda in the Lameta Formation of Jabalpur Cantonment, in Madhya Pradesh State. Bhandari & Colin (1999) described an important fauna from Anjar, Kachchh.

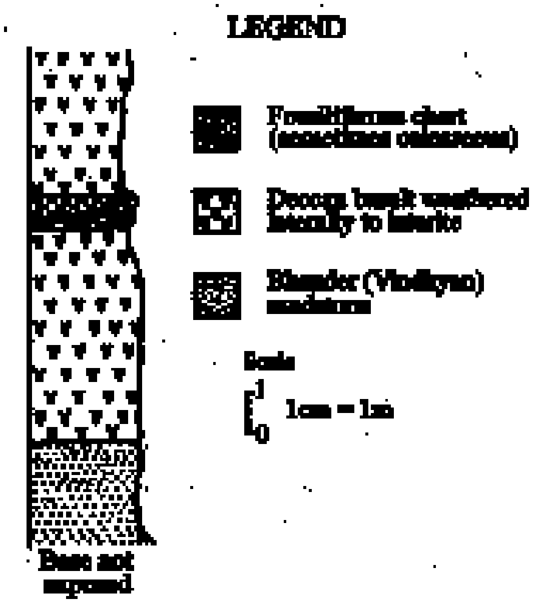


FIGURE 2–Stratigraphical section of the Upper Cretaceous at Mamoni.

This is the sixth in a series of papers that describe non-marine late Cretaceous Ostracoda from intertrappean horizons in the Deccan Traps. Previously we have described the faunas from three localities in Kachchh (Kutch), in the state of Gujarat: from Lakshmipur (Whatley & Bajpai, 2000a), Anjar (Whatley & Bajpai, 2000b), and Kora (Bajpai & Whatley, 2001). Another fauna, with several new taxa, has been described from two localities, Chandarki and Yanagundi in Gulbarga District, Karnataka State (Whatley *et al.*, 2002). A fur-ther paper by the same authors, on the Ostracoda from Mohagaonkala in the Chhindwara District of Madhya Pradesh State, is also in press (Whatley *et al.*, 2003).

Many of the ostracod species encountered in these studies had not been described previously, while others were incorrectly assigned to contemporary species described from Mongolia and China. Whatley & Bajpai (2000c) have shown that the Indian late Cretaceous intertrappean ostracods do not, as previously stated by many authors, indicate close Asian affinities. Rather, at the specific level they clearly constitute an endemic Indian fauna. In other respects, they exhibit as much affinity with African Lower and Middle Cretaceous and European late Cretaceous ostracods as they do with other Asian faunas. Chinese and Mongolian faunas, while containing representatives of most of the genera that occur in India, are dominated by *Cypridea*, its allies and descendents. *Cypridea* and allies, however, are absent from most contemporary Indian faunas and where they do occur, they are always very subordinate. Only one species, *Frambocythere tumiensis* (Helmdach), is common to both the Indian and Chinese faunas (Ye in Hou *et al.*, 1982 = *Bisulcocypris fangjiaheenensis*, Chen, 1956; Hou *et al.*, 1978; 1982, Yang *et al.*, 1989), but different, subspecies occur in each country. *Mongolocypris* cf. *M. gigantea* Ye *et al.*, 1977, an extremely large species (up to 4.12 mm in length) described by Khosla & Sahni (2000) from the Maastrichtian Lameta Formation of Jabalpur, is very close to the Chinese species from the Maastrichtian of Yunnan and to *M. distributa* Szczechura 1978, a contemporary species from the Gobi Desert. However, in all our studies of Indian intertrappean ostracods, we have never encountered this taxon, although the Lameta Formation yielded 110 specimens to Khosla & Sahni (2000). It is a rare constituent of the Indian Upper Cretaceous.

The Indian intertrappean Cypridacea are generically quite similar to African and European Cretaceous taxa, although no species seems to occur in common. However, the abundant and diverse species of the cytherid *Gomphocythere* Sars in the Indian fauna are somewhat similar to such African species as *Cytheridella* sp. of Colin *et al.* (1997) from the Upper Cretaceous of Mali, West Africa and even to such species as *Theriosynoecum camerounensis* Colin (in Colin *et al.*, 1992) from the Aptian/Albian of Cameroun and a number of species, referred to variously as *Theriosynoecum* and *Metacypris* Brady & Robertson, by Colin *&* Dépêche (1997, Pl. 5) from Chad. *Theriosynoecum silvai* (Silva, 1978) and *T. munizi* (Silva, 1978) from the contemporary and almost adjacent Aripe Basin in Brazil are also rather similar in some respects.

The age of the fauna is late Cretaceous, Maastrichtian. Apart from the two new species, the remaining 6 species are widespread at other Maastrichtian intertrappean localities whose absolute age is known from radiometric dates obtained on the basalt flows that constrain them. Many species are also shared with the Maastrichtian Lameta Formation, which is stratigraphically contiguous with the intertrappeans but is not constrained by lava flows. A feature of the Upper Cretaceous ostracod faunas of the intertrappeans, is that each new locality studied seems to contain a percentage of new species, which often subsequently prove to be to a certain degree endemic, while the remainder are more geographically widespread, perhaps more tolerant taxa. To what extent this is environmental/ecological and to what extent truly zoogeographical is a moot point. The differences in the faunas of even quite closely distant localities do not, however, seem to be due to their being of different ages, largely because of the wealth of radiometric and palaeomagnetic (Sahni & Bajpai, 1988) dates available.

Further work on the intertrappean Ostracoda is in hand. Important collections of intertrappean Ostracoda made by British natural historians in the mid to late Nineteenth Century have recently come to light in The Natural History Museum, London, and these are the subject of two taxonomic studies (Whatley *et al.*, in press a, b), while a number of new records of species from previously studied localities and new taxa from these and additional localities are the basis of another study (Whatley *et al.*, 2002b). The senior authors are completing a comprehensive review of Indian intertrappean Ostracoda, with particular reference to their age, palaeoecology, zoogeographical distribution affinities and evolution (Whatley & Bajpai, in prep.).

SYSTEMATIC DESCRIPTIONS

All type and figured specimens are deposited in the Bajpai Collection in the museum of the Department of Earth Sciences, Indian Institute of Technology, Roorkee, with catalogue numbers prefixed RUSB. The following conventions are employed: RV = right valve; LV = left valve; C = articulated carapace; A = adult; juv. = juvenile; rpc = radial pore canal; npc = normal pore canal. All dimensions are in millimetres and the size convention for adults, as used by the senior author over many years for podocopid ostracods, is as follows: <0.40 very small, 0.40-0.50 small, 0.50-0.70 medium, 0.70-1.00 large, > 1.0- very large.

Phylum CRUSTACEA Pennant, 1777
Class OSTRACODA Latreille, 1806
Order PODOCOPIDA Müller, 1894
Suborder PODOCOPINA Müller, 1894
Superfamily CYTHERACEA Baird, 1850
Family LIMNOCYTHERIDAE Klie, 1938
Subfamily TIMIRIASEVIINAE Mandelstam,
emend Colin & Danielopol,1980
Genus *Frambocythere* Colin, 1980

Frambocythere sp. cf. *F. tumiensis anjarensis*
Bhandari & Colin, 1999
(Pl. 1; Figs. 10, 11)

1999 *Frambocythere tumiensis anjarensis* Bhandari & Colin, p. 12, Pl. 1, Figs. 1-10.

Material.–4 carapaces.

Distribution.–Frambocythere tuniemnsis anjarensis was original described from Anjar, Kutch (Bhandari & Colin, 1999) and Chandari and Yanagundi in Karnataka State (Whatley *et al.* in 2002a).

Dimensions.–

	Length	Height	Width
Female C, RUSB 6180	0.33		0.27
Female C, RUSB 6181	0.33	0.19	

Remarks.–The subspecies *F. tumiensis anjarensis* differs from *F. tumiensis lakshmiae* (Whatley & Bajpai, 2000a) from Lakshmipur in Kachchh in its normal overlap, less well rounded anterior margin, the presence of large papillate tubercles on the dorsal part of the antero-median area and in the much more pronounced papillae paralleling the posterior part of the dorsal margin. The present material is smaller than the holotype of *anjarensis* from Anjar (length 0.44), although it is within the size range quoted by Bhandari & Colin (1999). However, since the present material is more elongate and lacks the two large tubercles posteriorly of the type description (males one tubercle, females two), it is merely compared to *anjarensis*.

Gomphocythere Sars, 1924

Remarks.–*Gomphocythere* Sars and *Cytheridella* Daday are somewhat similar genera in external carapace morphology. It is certainly difficult to distinguish the genera when only carapaces are available for study, although their hinges are different. The former has a reversed lophodont hinge, with the terminal bars in the LV, while the latter has normal lophodont hingement. It is, of course, arguable that hinge reversal is not necessarily a generic characteristic, since it is common in some genera and even some species. There is something of a convention that, with fossil taxa, Mesozoic species are usually referred to *Gomphocythere*, while Cainozoic species are placed in *Cytheridella*. This is to be noted in the title of such papers as Colin, *et al.*, 1997. “An early record of the genus *Cytheridella* Daday, 1905 (Ostracoda, Limnocytheridae, Timiriaseviinae) from the Upper Cretaceous of Mali, West Africa…” where “early” is the operative word. It is also the case that, generally speaking, Mesozoic species of *Gomphocythere* are more heavily ornamented than Cainozoic species of *Cytheridella*. The West African species of *Cytheridella* sp. is noted by these authors (Colin *et al.*,1997, p. 93) because …. “Besides minor details of the outline, the Malian Upper Cretaceous species differs from other known species of the genus by its strong ornamentation formed by numerous small and deep polygonal pits”. Since their specimens were all carapaces, they were also unable to see the hinge. In fact, in our opinion this African species is *Gomphocythere* and quite close to some of the species we have encountered in the Indian intertrappeans.

Gomphocythere dasyderma Whatley, Bajpai & Srinivasan, 2002a
(Pl. 1; Figs. 14, 15)

2002 a *Gomphocythere dasyderma* Whatley, Bajpai & Srinivasan, Pl. 2, Figs. 6-20.

Material.–One carapace.

Distribution.–Apart from the present record, this species was found in Chandarki and Yanagundi, Karnataka State, by Whatley *et al.* (2002a).

Dimensions.–

	Length	Height	Width
A-1 juv. C, RUSB 6182	0.41	0.22	0.21

Remarks.–This single specimen is certainly juvenile and its size accords exactly with A-1 juveniles previously recorded by Whatley *et al.* (2002a).

Superfamily CYPRIDACEA Baird, 1845
Family CYPRIDIDAE Baird, 1845
Subfamily CYPRIDINAE Baird, 1845
Genus *Paracypretta* Sars, 1924
Paracypretta subglobosa (Sowerby, 1840)
(Pl. 1; Figs. 1, 2)

1840 *Cypris subglobosa* Sowerby (in Malcolmson), description in unnumbered plate description, Pl. 47, Fig. 3.

?1990b *Altanicypris sczcechurae* (Stankevitch). Bhatia, Srinivasan, Bajpai & Jolly, p. 118, Pl. 1, Figs. 9, 10.

Non 1859 *Cypris subglobosa* Sowerby. Baird, p. 232, Pl. 63, Fig. 2.

Non 1886 *Cypris subglobosa* Sowerby. Brady, p. 300, Pl. 38, Figs. 24-27a.

Non 1976 *Cypris subglobosa* Sowerby. Neale, 125, Pl. 3, Figs. 128-132.

Material.–4 carapaces.

Distribution.–As the authors will show in a forthcoming study (Whatley *et al.*, in press a), the species occurs fairly widely in the Upper Cretaceous intertrappeans.

Dimensions.–

	Length	Height	Width
Carapace, RUSB 6182	1.27	0.82	0.82

Remarks.–The identification of this species is related to a current study, (Whatley *et al.*, in press a), which is based on syntypes of the species recently rediscovered in The Natural History Museum, London. In this study, the types of the material will be shown to be from the Upper Cretaceous and *Paracypretta subglobosa* will be compared with other species of the genus occurring in the intertrappeans. There is a previous record of *Paracypretta* from this locality. However, *Paracypretta* sp. of Mathur & Verma (1988) is very much smaller than the present species (L = 0.615). From the line drawings (Pl. 1, Figs. 7 a, b) it certainly resembles the genus. Possibly it represents a very early instar of the present species.

Subfamily CYPRIDOPSINAE Kaufmann, 1900
Genus *Cypridopsis* Brady, 1868
Cypridopsis hyperectyphos Whatley & Bajpai, 2000a
(Pl. 1; Figs. 12, 13)

2000a *Cypridopsis hyperectyphos* Whatley & Bajpai, p. 397, Pl. 4, Figs. 4-10.
2001 *Cypridopsis hyperectyphos* Whatley & Bajpai. Bajpai & Whatley, p. 96, Pl. 1, Figs. 6-8.
2002a *Cypridopsis hyperectyphos* Whatley & Bajpai. Whatley, Bajpai & Srinivasan, Pl. 3, Figs. 11-13.

Material.–5 carapaces.

Distribution.–The senior authors have recovered this species from the Upper Cretaceous intertrappeans of Lakshmipur and Anjar, Kachchh and from Yanagundi, Karnataka State.

Dimensions.–

	Length	Height	Width
C, RUSB 6184	0.53		0.50
C, RUSB 6191	0.50	0.34	

Remarks.–This most inflated of ostracods is readily identifiable. The present material is well within the size range of adults from the type material in Lakshmipur (Whatley & Bajpai, 2000a).

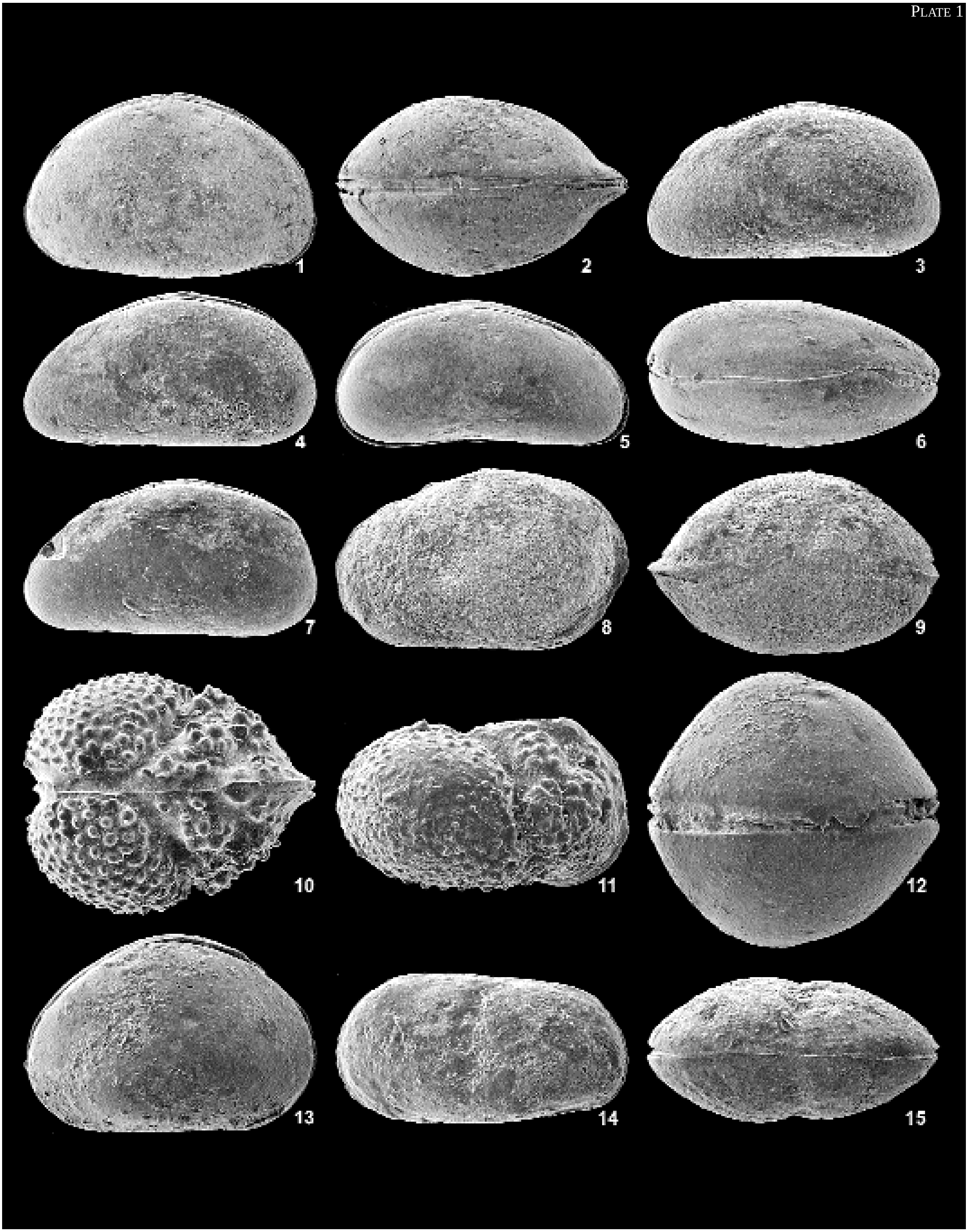
Subfamily HERPETOCYPRIDINAE Kaufmann, 1900
Genus *Mongolianella* Mandelstam in Galeeva, 1955
Mongolianella cylindrica (Sowerby, 1840)
(Text-Figure 1, 1-4)

1840 *Cypris cylindrica* Sowerby (in Malcolmson). Unnumbered page plate description, Pl. 47, Fig. 2.
1988 *Mongolianella* sp. Mathur & Verma, p. 172, Pl. 1, Fig. 5 a, b.
1990b *Mongolianella* sp. Bhatia *et al.*, p. 118, Pl. 1, Fig. 6.
?1990b *Candonianella altanica* (No author given but presumably Stankevitch, in Stankevitch & Sochava, 1974) ex = *Lycopterocypris altanicus* Stankevitch, 1974). Bhatia, Srinivasan, Bajpai & Jolly, p. 118, Fig. 11.
1994 *Mongolianella palmosa* Mandelstam. Sahni & Khosla, p. 458, Fig. 2 q, r.
1999? *Moenocypris* sp. Bhandari, p. 8, Pl. 2, Fig. 12.
2000 *Mongolianella palmosa* Mandelstam. Khosla & Sahni, p. 59, Fig. 3 k, l; 4 a-e.
2000a *Mongolianella cylindrica* (Sowerby). Whatley & Bajpai, p. 403, Pl. 6, Figs. 1-8.
2001 *Mongolianella cylindrica* (Sowerby). Bajpai & Whatley, p. 103, Pl. 3, Figs. 6, 9.

→

PLATE 1–*1, 2, Paracypretta subglobosa* (Sowerby, 1840). *1,* Carapace, right lateral view, RUSB 6183, x 43. *2,* Same specimen, dorsal view, x 43. *3-7, Eucypris catantion* sp. nov. *3,* Paratype carapace, left lateral view, RUSB 6186, x 82. *4,* Holotype carapace, left lateral view, RUSB 6187, x 76. *5,* same specimen carapace, right lateral view, RUSB 6187, x 76. *6,* Paratype carapace, dorsal view, RUSB 6188, x 87. *7,* Paratype carapace, left lateral view, RUSB 6189, x 86. *8, 9, Cyclocypris amphibolos* Whatley, Bajpai & Srinivasan (in 2002b). *8,* A-1 juvenile carapace, right lateral view, RUSB 6185, x 112. *9,* Same specimen, dorsal view, x 112. *10, 11, Frambocythere tumiensis anjarensis* Bhandari & Colin, 1999. *10,* Female carapace, dorsal view, RUSB 6180, x 167. *11,* Female carapace, right lateral view, RUSB 6181, x 167. *12, 13, Cypridopsis hyperectyphos* Whatley & Bajpai, 2000a. *12,* Carapace, dorsal view, RUSB 6184, x 104. *13,* Carapace, right lateral view, RUSB 6191, x 110. *14, 15, Gomphocythere dasyderma* Whatley, Bajpai & Srinivasan (2002a). *14,* A-1 juvenile carapace, left lateral view, RUSB 6182, x 134. *15.* Same specimen, dorsal view, x 134.

PLATE 1



2002a *Mongolianella cylindrica* (Sowerby). Whatley, Bajpai & Srinivasan, Pl. 4, Fig.10.

Non 1955 *Mongolianella palmosa* Mandelstam in Galeeva, p. 46, Pl. 11, Fig. 2

Non 1956 *Mongolianella palmosa* Mandelstam. Ljubimova, p. 86, Pl. 18, Figs. 2, 3.

Non 1978 *Mongolianella palmosa* Mandelstam. Szczechura, p. 103, Pl. 32, Figs. 3, 4.

Non 1990a *Mongolianella palmosa* (Mandelstam). Bhatia, Prasad & Rana, p. 47, Pl. 2, Fig. 8.

Non 1996 *Mongolianella palmosa* (Mandelstam). Bhatia, Prasad & Rana, p. 306, Pl. 2, Fig. 8.

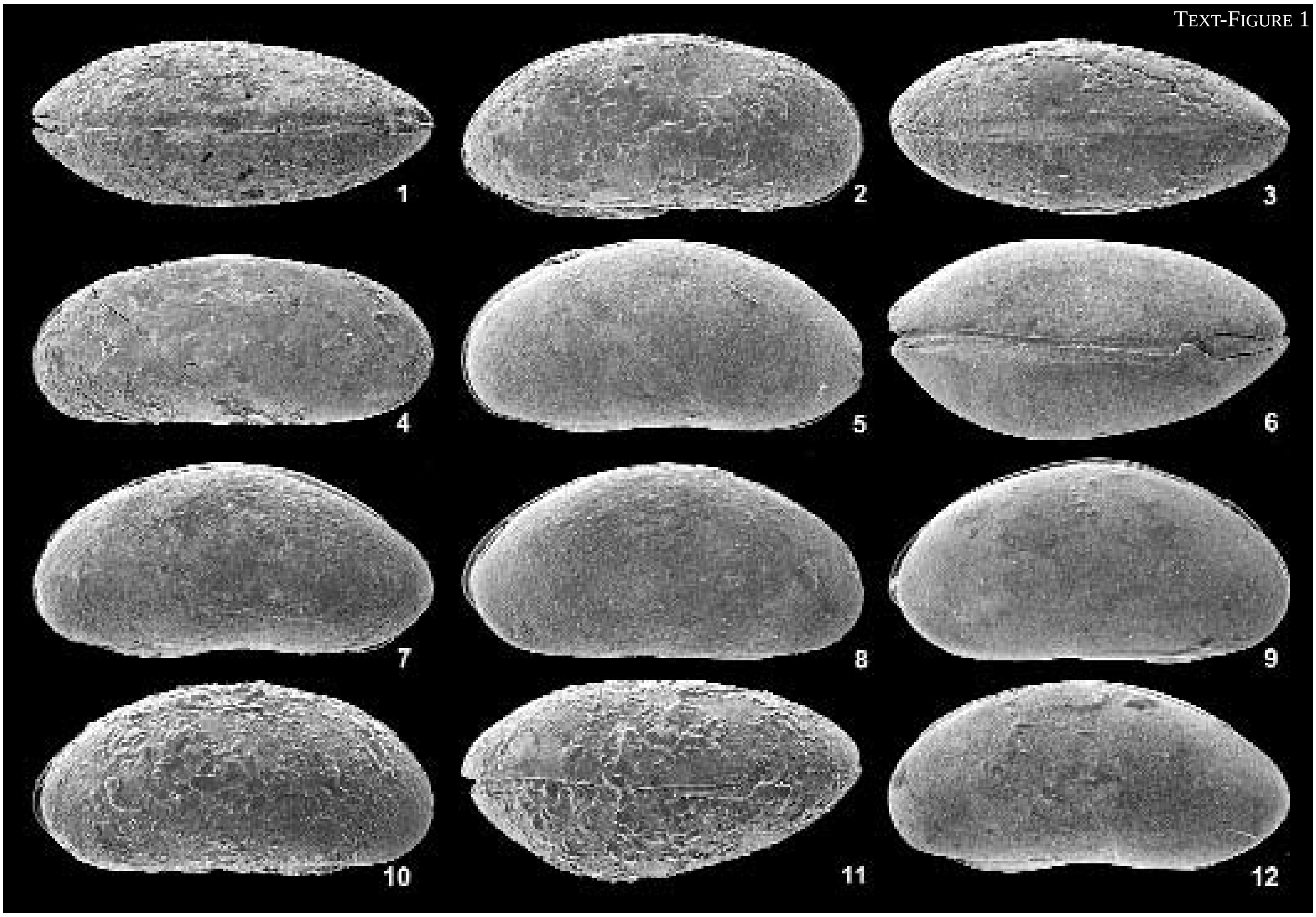
Material.–5 carapaces.

Distribution.–This species is among the most widely distributed of ostracods in Upper Cretaceous non-marine intertrappean beds in the Deccan Volcanic Province.

Dimensions.–

	Length	Height	Width
Male carapace, RUSB 6192	1.10	0.44	0.44
Female carapace, RUSB 6193	1.04	0.48	0.47
Male carapace, RUSB 6194	0.98	0.42	

TEXT-FIGURE 1



TEXT-FIGURE 1–*1-4, Mongolianella cylindrica* (Sowerby, 1840). *1*, Male carapace, dorsal view, RUSB 6192, x 50. *2*, Female carapace, right lateral view, RUSB 6193, x 53. *3,* Same specimen, dorsal view, x 53. *4,* Male carapace, left lateral view, RUSB 6194, x 56. *5-12, Mongolianella subarcuata* sp. nov. *5,* Holotype carapace, left lateral view, RUSB 6195, x 138. *6,* Same specimen, dorsal view, x 138. *7,* Paratype carapace, left lateral view, RUSB 6196, x 128. *8,* Same specimen, dorsal view, x 128. *9,* Paratype carapace, right lateral view, RUSB 6197, x 128. *10,* Paratype carapace, right lateral view, RUSB 6198, x 122. *11,* Same specimen, dorsal view, x 122. *12,* Paratype carapace, left lateral view, RUSB 6199, x 122.

Remarks.–This species differs from *Mongolianella subarcuata* sp. nov. in being more than twice as large and in its more rounded posterior margin and less concave ventral margin.

Mongolianella subarcuata sp. nov.
(Text-Figure 1; 5-12)

?2001 *Mongolianella* sp. B. Bajpai & Whatley, p. 104, Pl. 3, Fig. 11.

Derivatio nominis.–L. *sub* -somewhat + *arcuatus, a, um* – arched. With reference to the somewhat arched outline of this species, due to its convex dorsum and concave venter, especially in the left valve.

Holotype.– Carapace, RUSB 6195.

Type locality and level.–1m thick bed of cherty marl and chert overlying volcanics near the village of Mamoni, Rajasthan. Upper Cretaceous.

Material.–Twelve carapaces.

Diagnosis.–A small species of *Mongolianella* characterised, especially in the LV, by its subarcuate shape, due to the arched dorsal margin and medianly concave ventral margin. Anterior margin narrowly and asymmetrically rounded; posterior margin with rather downturned apex below mid-height.

Description.–Small. Subarcuate to elongate subovate in lateral view. Subcylindrical in dorsal and ventral views. Anterior margin rather narrowly and asymmetrically rounded, especially in LV, and with long convex antero-dorsal slope; apex in most specimens below mid-height (in paratype RUSB it is at mid-height). Dorsal margin narrow, bluntly pointed, somewhat downturned especially in LV; apex below mid-height. Dorsal margin gently and regularly arcuate; ventral margin medianly concave, especially in LV. LV larger than RV, but with some dorsal overreach of the RV. Surface minutely punctate with tiny scattered pore conuli. Internal features not seen.

Distribution–Mongolianella sp. B, which may belong to this species, was encountered by Bajpai & Whatley (2001) at Kora in Kachchh.

Dimensions.–

	Length	Height	Width
Holotype C, RUSB 6195	0.40	0.21	
Paratype C, RUSB 6196	0.43		0.22
Paratype C, RUSB 6197	0.43	0.21	0.22
Paratype C, RUSB 6198	0.45	0.21	
Paratype C, RUSB 6199	0.45	0.23	

Remarks.–This species was initially considered as possible instars of *M. cylindrica*. However, since the present species is less than half the size and no possible larger instars of *M. cylindrica* have been found, it is now confidently identified as a separate species. *Mongolianella* sp. B of Bajpai & Whatley (2001), which is represented by a single carapace from Kora, possibly belongs here but, since it is rather larger (L = 0.53), this is by no means certain.

Family CANDONIDAE Daday, 1900
Subfamily CANDONINAE Daday, 1900
Genus *Eucypris* Vávra, 1891
Eucypris catantion sp. nov.
(Pl. 1; Figs. 3-7)

2001 *Darwinula* sp. Bajpai & Whatley, p. 95, Pl. 1, Figs. 1. 3.

Derivatio nominis.–Gr. *καταντιον* facing opposite. With reference to the fact that this species is, in a sense, ‘back to front’ in that the anterior margin is much narrower than the posterior.

Holotype.–Carapace, RUSB 6187.

Type locality and level.–1m thick bed of cherty marl and chert overlying volcanics near the village of Mamoni, Rajasthan. Upper Cretaceous.

Material.–11 carapaces.

Diagnosis.–A species of *Eucypris* with a very narrowly pointed anterior margin with sub-ventral apex. LV larger than RV but with RV overhanging LV mid-dorsally.

Description.–Large. Subcuneiform in lateral view; subelliptical to subcylindrical in dorsal view, with anterior only a little more acuminate than posterior and rather flat sided laterally. Anterior margin very narrowly rounded, especially in LV; apex sub-ventral and with very long, slightly convex antero-dorsal slope. Posterior margin subtruncate in LV, rounded in RV; apex below mid-height in RV, subventral in LV. Dorsal margin with distinct break of slope just behind mid-length, behind which it is straight and sloping gently to the posterior cardinal angle. Ventral margin almost straight in LV; with slight and very shallow median concavity in LV. LV larger than RV with overlap all around the periphery, but with RV slightly overreaching LV mid-dorsally. Greatest height at about mid-length; greatest length well below mid-height; greatest width medianly. Ornament very weakly punctate. Internal features not seen, except for a double row of 5 or 6 adductor scars as external impressions.

Distribution.–Apart from the present record, the species has been recorded by Bajpai & Whatley (2001) from Kora in Kachchh.

Dimensions.–

	Length	Height	Width
Holotype C, RUSB 6187	0.72	0.36	
Paratype C, RUSB 6186	0.67	0.35	
Paratype C, RUSB 6188	0.63		0.33
Paratype C, RUSB 6189	0.64	0.34	

Remarks.–Because of the unusual shape of this species and its poor preservation, Bajpai and Whatley (2001) initially mistook it for a species of *Darwinula.* From other Upper Cretaceous intertrappean members of the genus it differs in the following ways: *Eucypris intervolcanus* Whatley & Bajpai (2000a) is considerably larger and has its posterior apex more rounded and higher. *E. pelasgicos* Whatley & Bajpai (2000a) is very much larger, with adults exceeding 1 mm in length, and is of different shape?, *Eucypris verruculosa* Whatley, Bajpai & Srinivasan, 2002a is different in shape and has a delicately reticulate ornament.

Subfamily CYCLOCYPRIDINAE Zenker, 1854
Genus *Cyclocypris* Brady & Norman, 1889
Cyclocypris amphibolos Whatley, Bajpai & Srinivasan, 2002a
(Pl. 1; Figs. 8, 9)

2002a *Cyclocypris amphibolos* Whatley, Bajpai & Srinivasan, Pl. 6, Figs. 6-18.

Material.–One carapace.

Distribution.–Apart from the present record, this species has only been recorded previously from the type locality of Yanagundi, Karnataka State (Whatley *et al*., 2002 a).

Dimensions.–

	Length	Height	Width
A-1 juv. C, RUSB 6185	0.49	0.31	0.31

Remarks.–The size of this specimen accords exactly with the upper size limit of A-1 instars in the type material.

CONCLUSIONS

The present fauna, albeit rather impoverished both in number of specimens and species is, nonetheless, an important contribution to our increasing knowledge of the Upper Cretaceous non-marine Ostracoda of the intertrappeans. It is interesting to note yet again, that the degree of endemism is high in these faunas; most localities yield, together with species which are in variable degrees widespread throughout the intertrappeans, others which seem to be endemic. This phenomenon is investigated in greater detail by Whatley & Bajpai (in prep.). Due to the excellent control provided by radiometric dates and palaeomagnetic data on the basalts at many localities, it seems from the evidence to hand so far, that these differences in the nature of faunas from various localities is not a function of their being of different ages. Rather, it seems more likely to be a reflection of the different environments and the differing palaeoautoecology of the various ostracod species. The generalists are more environmentally tolerant and are, therefore, more widely distributed.

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NEW SPECIES OF OSTRACODA FROM THE UPPER CRETACEOUS CHALK (CONIACIAN TO LOWER MAASTRICHTIAN) OF EAST ANGLIA, U.K.

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Abstract

Sixteen new species and one subspecies are described from the Coniacian to Lower Maastrichtian of East Anglia: *Argilloecia argillos, Argilloecia cretula, Asciocythere hadratos, Asciocythere prionodes, Eucythere ovoides, Eucythere sphenarion, Saida prasutegusi, Semicytherura fasciculata, Cytheropteron apeorus, C. cathetos, Sagmatocythere orthros, Paijenborchella biponticulata, Mosaeleberis dictyotos, Mosaeleberis pseudomacrophthalma, Spinoleberis ceraunos, Cythereis campanianica, Cythereis ornatissima icenica*. The ostracods, some 80,000 in total, were recovered from the Trunch Borehole and from a number of outcrop localities in Norfolk and Suffolk. Some biostratigraphical and palaeoecological comments are included.

Keywords: Ostracoda, New species, Upper Cretaceous, East Anglia, U.K.

Resumen

Se describen quince nuevas especies y una nueva subespecie de ostrácodos en depósitos de edad Coniaciense a Maastrichtiense Inferior del este de Inglaterra: *Argilloecia argillos, Argilloecia cretula, Asciocythere hadratos, Asciocythere prionodes, Eucythere ovoides, Eucythere sphenarion, Saida prasutegusi, Semicytherura fasciculata, Cythertopteron apeorus, C. cathetos, Sagmatocythere orthros, Paijenborchella biponticulata, Mosaeleberis dictyotos, Mosaeleberis pseudomacrophtalma, Spinoleberis ceraunos, Cythereis campanianica, Cythereis ornatissima icenica*. Se obtuvieron aproximadamente ochenta mil ostrácodos, procedentes tanto del sondeo de Trunch como de varias localidades en los condados de Norfolk y Suffolk en el este de Inglaterra. Se aportan comentarios bioestratigráficos y paleoecológicos.

Palabras clave: Ostracoda, Nuevas especies, Cretácico Superior, Este de Inglaterra.

INTRODUCTION

The present study, based on a doctoral project (Pyne, MS 2002), utilised a total of 205 samples. Seventy-nine of these are from the Trunch Borehole and the remainder from a series of outcrop localities collected by the British Geological Survey (BGS) from both Norfolk and Suffolk, Eastern England (Fig. 1). The samples were in the form of prepared insoluble residues, washed over a 200 BS sieve (= 75 µ). In the Trunch Borehole, samples were at approximately 5 m intervals. More than 80,000 specimens of marine ostracods were recovered, from strata ranging in age from Coniacian to Lower Maastrichtian. These belong to 145 species and 53 genera. Elsewhere, Whatley *et al.* (2003) use the Platycopina to elucidate the history of variation in oxygenation of the Upper Cretaceous seas of East Anglia, and Pyne *et al.* (in prep) detail the biostratigraphy of the total ostracod fauna.

The Trunch Borehole, drilled near Mundesley, Norfolk (Fig. 1); (Grid Reference TG 29330.345500) penetrated 469 m of Lower Maastrichtian to Cenomanian Chalk and the lithology and the nannofossil and macrofossil stratigraphy are well documented (Gallois and Morter, 1975; Burnett, MS 1988; Wood *et al.*,1994; McArthur *et al.*, 1993. The distribution of samples from the Borehole is given in Table 1.

A large number of outcrop samples were also provided by BGS, from many different localities across Norfolk (Fig. 1). These range from the Coniacian basal *coranguinum* Zone to the *Porosphaera* Beds in the *B. lanceolata* Zone of the Lower Maastrichtian. The Santonian and Coniacian stages are represented by samples from Suffolk. Using such authors as Christensen (1991), Cox *et al.* (1989), Hancock & Peake (2000), Johansen & Surlyk (1990), Peake and Hancock (1961, 1970, 2000), Whittlesea (1991) and Wood (1988), it was possible to place these samples in stratigraphical order, supplemented by information from the BGS stratigraphical logs. The outcrop sample data are presented in Table 2. The various localities are shown on the geological map of East Anglia (Fig. 1).

HISTORY OF RESEARCH ON BRITISH AND EUROPEAN UPPER CRETACEOUS OSTRACODA

Neale, writing in 1978, stated that “in Britain, the Upper Cretaceous faunas are not yet known in sufficient detail to allow the development of a zonal scheme”. In general, the lower part of the Upper Cretaceous is better served from the point of view of stratigraphy, ostracod taxonomy and the stratigraphical distribution of species, although suitable exposures are somewhat limited geographically.

Jones and Hinde’s monograph on the Cretaceous ostracods of England and Ireland (1890) is “doubtless the best single paper that has been published on Cretaceous Ostracoda” (Alexander, 1929). The work is a compilation of all the important studies in that field up to 1890 and clarifies problems of synonymy and demonstrates, by the use of various tables and diagrams, the vertical and horizontal distributions of Ostracods throughout the Cretaceous of Europe.

Little work has been carried out on the Upper Chalk ostracods of East Anglia in recent times, although Albian, Cenomanian and Turonian assemblages have been relatively well documented in the area (Wilkinson & Morter, 1981; Wilkinson, 1988a MS, 1988b; 1990). Weaver’s (1982) study of the Ostracoda of the Lower Chalk and Plenus Marls was largely concerned with southern England.

Most of the early work on Cretaceous ostracods in Britain and Europe (e.g. Triebel, 1938ab, 1940, 1941, 1949, 1950; Sylvester-Bradley, 1948) was largely taxonomic, and it was not until the 1950’s and ‘60’s that a number of more stratigraphically orientated studies began to appear (e.g. Mertens 1956; Oertli, 1958; Neale, 1960, 1962; Herrig, 1966, 1967; Gründel 1966, 1968, 1969, 1970). Kaye, 1964, published a revision of British Marine Cretaceous Ostracoda, largely based on the material of Jones (1849), Jones & Hinde (1890), Chapman & Sherborn (1893), and Chapman (1898) in The Natural History Museum, London. He re-illustrated much of the fauna and modernized the taxonomy. Of the 98 species in the original descriptions, 55 were retained as valid species. King (1968, MS) studied Upper Cretaceous British Ostracoda from Southern England. Several species listed by King appear in the Santonian to Lower Maastrichtian assemblages of East Anglia. More recent studies are by Johnson (1996a, 1996b MS 1998) and by Slipper (1996, 1998) on the Ostracoda of the Turonian and Cenomanian interval. Keen & Siddiqui (1971) studied the Cenomanian Ostracoda of Belfast, Northern Ireland.

The distribution of British Lower Cretaceous ostracods was documented by Neale in 1973, who five years later produced a stratigraphical range table for the entire British Cretaceous (Neale, 1978).

Pokorný published an extensive series of taxonomic and biostratigraphical studies on selected ostracod genera from the Upper Cretaceous of Bohemia, such as *Phacorhabdotus* (1963), *Oertliella* and *Spinoleberis* (1964), *Cythereis* (1967a,b), *Curfsina* (1967c), *Bairdia* (1975, 1976), *Bairdoppilata* (1977) and *Mosaeleberis* (1978). He also (1965) demonstrated their palaeoecological significance.

Deroo (1966) and Bless (1988) have undertaken major taxonomical and biostratigraphically based studies of Upper Campanian and Lower Maastrichtian ostracods in Holland.

Babinot (1980), studying the Upper Cretaceous faunas of Provence, provides a detailed account of both marine and freshwater ostracod faunas descri-

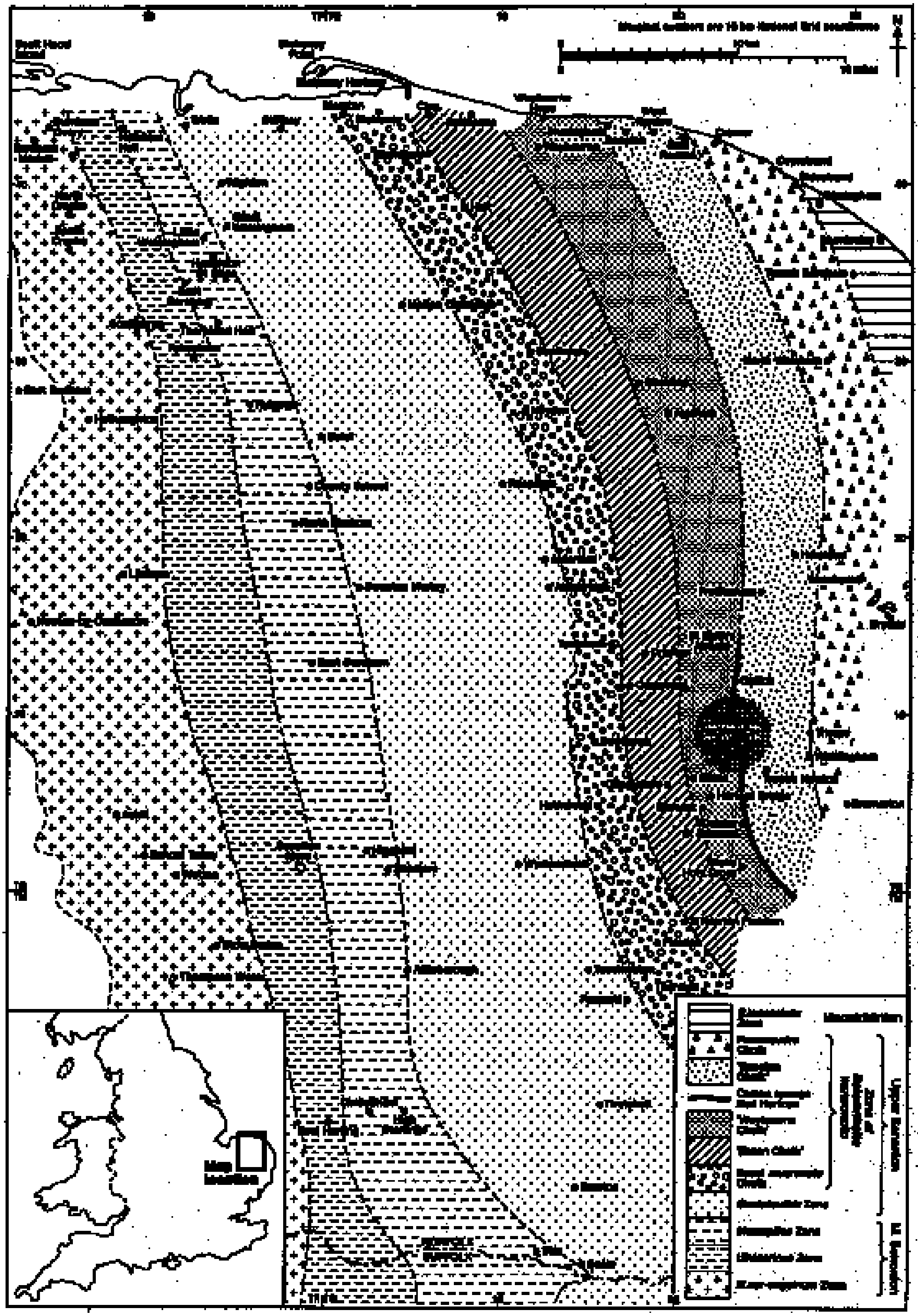


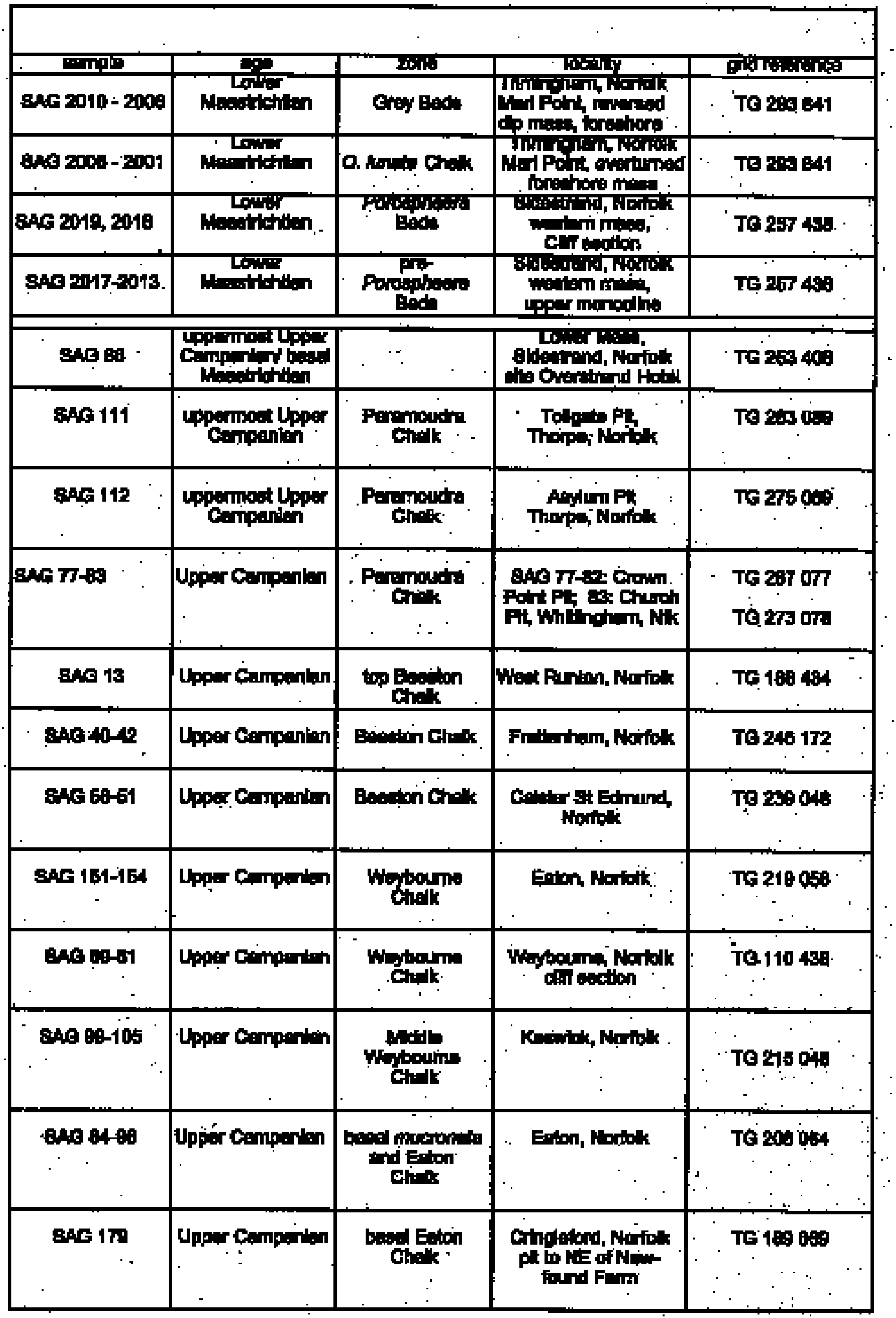
FIGURE 1–Geological map of the research area showing the position of the Trunch Borehole and major outcrop localities, East Anglia, U.K. Based on Peake & Hancock (1961).

Trunch Borehole	subdivisions	Zone	substage	outcrop samples
	Grey Beds	*Belemnella lanceolata*	Lower Maastrichtian	SAG 2010-2006
	Ostrea lunata Chalk			SAG 2001 - 2005
SAG 213, 216	*Porosphaera* Beds			SAG 2018 - 2019
SAG 217, 221, 231	pre-*Porosphaera* Beds			SAG 2013 - 2017
SAG 241 - 306	Paramoudra Chalk	*Belemnitella mucronata*	Upper Campanian	SAG 66, 111, 112 63 - 77
SAG 308 - 357	Beeston Chalk			SAG 13, 51 - 58
↑ SAG 361-433 ↓	Weybourne Chalk			SAG 99 - 105, 59 - 61, 151-154, 20-24, 9-12
	Eaton Chalk			SAG 92 - 98
	basal *mucronata* Chalk			SAG 67, 68, 106-110 179, 84-91
SAG 434 - 560		*Gonioteuthis quadrata*	Lower Campanian	SAG 202, 201, 35-34 SAG 186-189, 44, 45, 25, 26, 27, 28, 29
SAG 566 - 629		*Offaster pilula*		SAG 30, 31, 32, 33
SAG 630 - 648		*Marsupites testudinarius*	Santonian	SAG 43, 190
		Uintacrinus		SAG 73
		high *coranguinum*		SAG 14, 15, 47 - 50
		coranguinum	Coniacian	SAG 113-115, 183, 184,
		low *coranguinum*		SAG 16, 17, 18, 19
		basal *coranguinum*		SAG 130, 131, 132, 133, 134, 135

TABLE 1–Stratigraphical distribution of the samples studies in both the Trunch Borehole and outcrop samples, East Anglia, U.K.

bing and illustrating 174 species (53 Cenomanian, 18 Lower to Middle Turonian, 25 Upper Turonian and Coniacian, 57 Santonian and 21 from Campanian–Maastrichtian freshwater deposits). He also includes a useful discussion on the classification, illustrating the difficulties faced in working with the multiplicity of Upper Cretaceous generic taxa, and on their biostratigraphical and palaeoecological significance.

Many studies of Cenomanian ostracods have been carried out by French workers. Babinot (1970, 1971), Colin (1973a,b; 1974a,b), Damotte (1971, 1977), Damotte & Grosdidier (1963) and Donze & Porthault (1972). Many of these demonstrate their biostratigraphical and palaeoenvironmental significance. Babinot *et al*. (1978) summarise the results of this work, revealing provincialism in ostracod faunas during the Cenomanian. German Cenomanian ostracods have been studied by such authors as Gründel (1966) and Mertens (1956). Gründel produced a range chart showing the distribution of 87 species through the German Albian. Mertens (1956), recognising the usefulness of ostracods in stratigraphical determination, produced a range chart for the Upper Albian and late Cenomanian. Weaver (1982) produced a monograph of Ostracoda from the British Lower Chalk and Cenomanian Plenus Marls of Southern England, describing 117 species and subspecies (58 of which are new) in a taxonomical and biostratigraphical context.



sample	age	zone	locality	grid reference
SAG 2010 - 2009	Lower Maastrichtian	Grey Beds	Trimingham, Norfolk Marl Point, reversed dip mass, foreshore	TG 293 841
SAG 2008 - 2001	Lower Maastrichtian	*O. lunata* Chalk	Trimingham, Norfolk Marl Point, overturned foreshore mass	TG 293 841
SAG 2019, 2018	Lower Maastrichtian	*Porosphaera* Beds	Sidestrand, Norfolk western mass, Cliff section	TG 257 435
SAG 2017-2013	Lower Maastrichtian	pre-*Porosphaera* Beds	Sidestrand, Norfolk western mass, upper monocline	TG 257 436
SAG 88	uppermost Upper Campanian/ basal Maastrichtian		Lower Mass, Sidestrand, Norfolk site Overstrand Hotel	TG 253 406
SAG 111	uppermost Upper Campanian	Paramoudra Chalk	Tollgate Pit, Thorpe, Norfolk	TG 263 089
SAG 112	uppermost Upper Campanian	Paramoudra Chalk	Asylum Pit Thorpe, Norfolk	TG 275 089
SAG 77-83	Upper Campanian	Paramoudra Chalk	SAG 77-82: Crown Point Pit; 83: Church Pit, Whitlingham, Nfk	TG 267 077 TG 273 078
SAG 13	Upper Campanian	top Beeston Chalk	West Runton, Norfolk	TG 188 434
SAG 40-42	Upper Campanian	Beeston Chalk	Frettenham, Norfolk	TG 246 172
SAG 58-61	Upper Campanian	Beeston Chalk	Caistor St Edmund, Norfolk	TG 239 046
SAG 151-154	Upper Campanian	Weybourne Chalk	Eaton, Norfolk	TG 219 058
SAG 59-61	Upper Campanian	Weybourne Chalk	Weybourne, Norfolk cliff section	TG 110 438
SAG 99-105	Upper Campanian	Middle Weybourne Chalk	Keswick, Norfolk	TG 215 046
SAG 84-98	Upper Campanian	basal *mucronata* and Eaton Chalk	Eaton, Norfolk	TG 208 064
SAG 179	Upper Campanian	basal Eaton Chalk	Cringleford, Norfolk pit to NE of Newfound Farm	TG 189 069

TABLE 2–Geographical location and stratigraphical position of the outcrop samples. East Anglia, U.K.

sample	age	zone	locality	grid reference
SAG 8-12	Upper Campanian	Weybourne Chalk	Catton Grove, Norfolk	TG 229 109
SAG 24-20	Upper Campanian	Weybourne Chalk	Stoke Holy Cross, Nfk	TG 233 028
SAG 110-106	Upper Campanian	basal *mucronata* Chalk	Cringleford, Norfolk	TG 197 059
SAG 25-27	Lower Campanian	restricted *quadrata* Zone	Stiffkey, Norfolk locality 1	TF 975 428
SAG 28-29	Lower Campanian	restricted *quadrata* Zone	Stiffkey, Norfolk locality 2	TF 971 429
SAG 30-32	Lower Campanian	*pilula* Zone	Wells, Norfolk	TF 428 429
SAG 33	Lower Campanian	*pilula/quadrata* Zone	Wells, Norfolk	TF 428 429
SAG 34-38	Lower Campanian	restricted *quadrata* Zone	Wells, Norfolk	TF 428 429
SAG 44-45	Lower Campanian	restricted *quadrata* Zone	Alderford Common, Norfolk	TG 129 183
SAG 161 SAG 162	Lower Campanian	topmost restricted *quadrata* Zone	Bawburgh, Norfolk	TG 149 088 TG 148 098
SAG 186-189	Lower Campanian	restricted *quadrata* Zone	Warham, Norfolk, disused pit nr. Chalk Hill Farm	TF 950 413
SAG 201	Lower Campanian	restricted *quadrata* Zone	Stiffkey Hall Farm Pit, Stiffkey, Norfolk	TF 975 428
SAG 202	Lower Campanian	restricted *quadrata* Zone	Stiffkey, Norfolk pit by new road beyond Hall Farm	TF 978 435
SAG 199	Upper Santonian	*Marsupites testudinarius*	Houghton St Giles, nr. Walsingham, Norfolk	TF 928 354
SAG 43	Santonian	*Marsupites* Zone	Quidenham, Norfolk	TM028 354

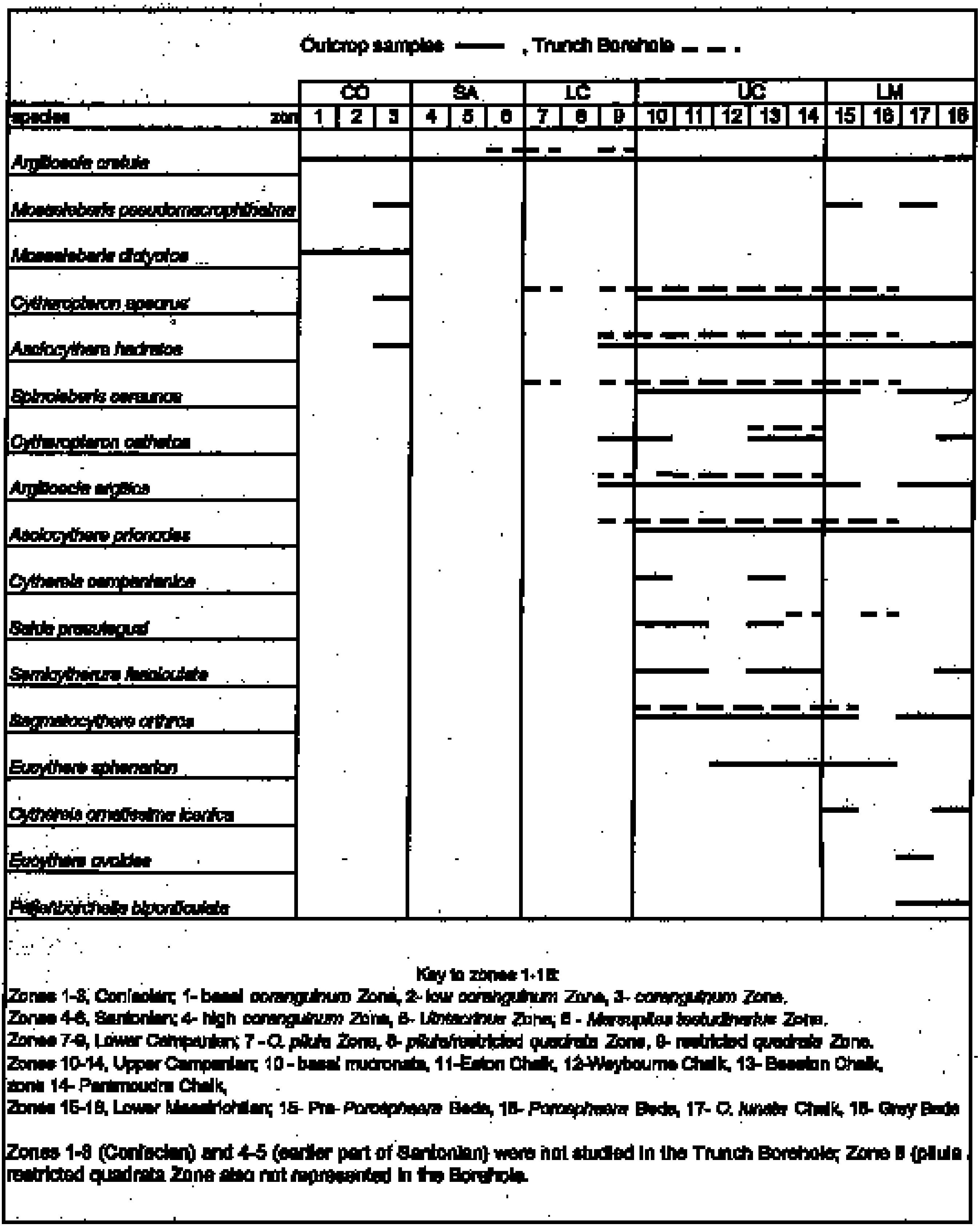
TABLE 2–Geographical location and stratigraphical position of the outcrop samples. East Anglia, U.K.

sample	age	zone	locality	grid reference
SAG 73	Santonian	*Uintacrinus* Zone	Stanton, Suffolk	TL 964 741
SAG 148-150	Santonian	*coranguinum* Zone	Burnham Overy, Nfk Rowe's locality 65	TF 843 432
SAG 14-15	Santonian	*coranguinum* Zone	Stowlangtoft, Suffolk	TL 938 689
SAG 47-50	Santonian	*coranguinum* Zone	Helhoughton, Norfolk	TF 851 273
SAG 113-115	Coniacian	coranguinum Zone	South Pickenham, Norfolk	TF 864 042
SAG 153 SAG 154	Coniacian	*coranguinum* Zone	Litcham, Norfolk	TF 889 161 TF 188 178
SAG 16-17	Coniacian	low coranguinum Zone	Euston, Suffolk	TL 896 776
SAG 130-133	Coniacian	basal coranguinum Zone	Newton By Castle Acre, Norfolk working quarry NE face	TG 837 150
SAG 134-135			quarry, SE face	TF 837 149

TABLE 2–Geographical location and stratigraphical position of the outcrop samples. East Anglia, U.K.

SYSTEMATIC DESCRIPTIONS

All the type specimens illustrated herein are prefixed by the catalogue letter MPK, which refers to the collections of the British Geological Survey, Keyworth, Nottingham, where the material is housed. The following conventions are employed: RV = right valve; LV = left valve; C = articulated carapace; A = adult; juv. = juvenile, rpc = radial pore canal; npc = normal pore canal. All dimensions are in millimetres and the size convention for adult podocopid ostracods is as follows: <0.40 very small, 0.40-0.50 small, 0.50-0.70 medium, 0.70-1.00 large, > 1.0- very large. Zone and division numbers mentioned to in the distribution of the various species refer to the numbers in Fig. 2.



Key to zones 1-18:

Zones 1-3, Coniacian; 1- basal *coranguinum* Zone, 2- low *coranguinum* Zone, 3- *coranguinum* Zone.
Zones 4-6, Santonian; 4- high *coranguinum* Zone, 5- *Uintacrinus* Zone; 6 - *Marsupites testudinarius* Zone.
Zones 7-9, Lower Campanian; 7 - *O. pilula* Zone, 8- *pilula*/restricted *quadrata* Zone, 9- restricted *quadrata* Zone.
Zones 10-14, Upper Campanian; 10 - basal *mucronata*, 11-Eaton Chalk, 12-Weybourne Chalk, 13- Beeston Chalk,
zone 14- Paramoudra Chalk,
Zones 15-18, Lower Maastrichtian; 15- Pre-*Porosphaera* Beds, 16- *Porosphaera* Beds, 17- *O. lunata* Chalk, 18- Grey Beds

Zones 1-3 (Coniacian) and 4-5 (earlier part of Santonian) were not studied in the Trunch Borehole; Zone 8 (*pilula* / restricted *quadrata* Zone also not represented in the Borehole.

FIGURE 2–Biostratigraphical distribution by zone of the Ostracoda described in the paper in both the Trunch Borehole and outcrop samples, East Anglia, U.K.

Phylum Crustacea Pennant, 1777
Class OSTRACODA Latreille, 1806
Order PODOCOPIDA G. W. Müller, 1894
Suborder PODOCOPINA G. W. Müller, 1894
Superfamily CYPRIDACEA Baird, 1845
Family PONTOCYPRIDIDAE G. W. Müller, 1894
Genus *Argilloecia* Sars, 1866

Argilloecia argillos sp. nov.

(Pl. 1; Figs. 1-6)

Derivatio nominis.–Gr. *αργIλλos* white clay, with reference to the occurrence of this species in the White Upper Chalk.

Holotype.–Carapace, MPK 11345.

Type locality and level.–Upper Campanian, basal *mucronata* Chalk, Cringleford, Norfolk.

Material.–At least 500 specimens.

Diagnosis.–A medium to large species of *Argilloecia*, distinguishable from most other Cretaceous representatives of the genus by its elongate valves, arched dorsal margin and acutely, pointed posterior.

Description.–Medium to large. Elongate subovate to sublunate. Valves of different shape. Anterior margin obliquely-rounded in RV, more angular in LV with very marked angle antero-dorsally; apex at mid-height in RV, above mid-height in LV. Posteriorly margin acutely pointed in LV, less so in RV, apex sub-ventral in both valves. Dorsal margin regularly arched with apex at mid-length. Ventral margin with pronounced median concavity. RV considerably larger than LV, with strong dorsal; overlap. Smooth. Internal features as for genus. Sexual dimorphism not observed.

Distribution.–In outcrop samples, first appears in the Lower Campanian *Gonioteuthis quadrata* Zone (9) and is present throughout the Upper Campanian (basal *mucronata* Zone–Paramoudra Chalk: zones 10-14). The species crosses the Campanian–Maastrichtian boundary and occurs in all samples from the pre-*Porosphaera* Beds of Sidestrand (15) and the *Ostrea lunata* Chalk of Trimingham (17) and in all but one sample of the Grey Chalk (18).

In the Trunch Borehole, it does not appear until later in Zone 9 (First Appearance SAG 488) and is present throughout the Upper Campanian (zones 10-14) but does not extend into the Lower Maastrichtian.

Dimensions.–

	Length	Height
Holotype. C. MPK 11345	0.69	0.27
Paratype C. MPK 11344	0.66	0.27
Paratype RV MPK 11346	0.72	0.28
Paratype RV MPK 11347	0.66	0.27
Paratype LV MPK 11348	0.62	0.25
Paratype LV MPK 11349	0.62	0.25
Paratype LV MPK 11350	0.61	0.26
Paratype LV MPK 11351	0.61	0.26
Paratype LV MPK 11352	0.61	0.26

Remarks.–This species differs from *A. cretula* sp. nov. in being slightly smaller and more elongate. It differs in being, narrower and in its acutely pointed posterior margin, medianly concave ventral and strongly arched dorsal margins and in its two valves being of different shape. *Argilloecia gracilis* Bonnema, 1940 (Pl. 2, Figs. 24-26) from the Upper Cretaceous “Schreibkreide” of the Netherlands is smaller, similar in shape but less elongate, with posterior margins less acute; dorsal margin less arched. *A. constricta* Holden (1964, p. 403, Tf. 9a-c), from the Upper Cretaceous Rosario Formation of California, is similar in size but differs in its less elongate and truncated posterior. The material of the present study lacks the “small anterodorsal flange and conspicuously laterally flattened carapace” of Holden’s species. *Argilloecia taylorensis* Alexander (1935, p. 356, Text-Fig. 1a, 1b) from the Upper Taylor (Upper Campanian) Formation of Onion Creek, Texas, differs from *A. argillos* in its smaller size, in being broader and less elongate and in its more evenly rounded anterior margin, obtuse posterior and almost straight ventral margin.

Argilloecia cretula sp. nov.

(Pl. 1; Figs. 7-12)

Derivatio nominis.–L. *creta* chalk, white earth or clay, with reference to the occurrence of this species in the White Upper Chalk.

Holotype.–RV MPK 11354.

Type locality and level.–Upper Campanian, Eaton Chalk, Eaton, Norfolk.

Material.–More than 1000 specimens.

Diagnosis.–A medium species of *Argilloecia* characterized by its broad valves, rounded anterior and posterior margins, dorsal margin only weakly arched; ventral margin nearly straight.

Description.–Medium. Elongate subovate. Valves of similar shape. Anterior margin rather narrowly rounded about a blunt apex at mid-height. Posterior margin with long convex postero-dorsal slope and subventral pointed apex (sharpest in female). Dorsal margin gently convex but straight medianly in male. Ventral margin with very subdued median concavity. Greatest length below mid-height; greatest height at about mid-length. Smooth. Internal features as for genus.

Distribution.–In the outcrop samples, the species ranges from the Coniacian to Lower Maastrichtian. It first appears in the middle basal *coranguinum* Zone (Coniacian, zone 1) but is absent in much of the low *coranguinum* Zone (2) and is more common in the upper Coniacian (3). It is present in the Santonian only in upper samples of the high *coranguinum* Zone (4), but is better represented in the *Uintacrinus* and *Marsupites* zones (5, 6). It is more abundant in the Lower Campanian *G. quadrata* Zone (9) and occurs throughout the Upper Campanian and Lower Maastrichtian (zones 10-18). In the Trunch Borehole, it first appears in the top sample of the Santonian *Marsupites testudinarius* Zone (FAD SAG 630) and ranges into the Lower Maastrichtian.

Dimensions.–

	Length	Height
Holotype MPK 11354	0.69	0.25
Paratype RV MPK 11353	0.72	0.27
Paratype RV MPK 11355	0.73	0.27
Paratype RV MPK 11356	0.73	0.27
Paratype RV MPK 11357	0.73	0.27
Paratype RV MPK 11358	0.73	0.26
Paratype LV MPK 11359	0.69	0.25

Remarks.–This species differs from *A. argillos* sp. nov. and *Argilloecia gracilis* Bonnema, 1940, in size (slightly larger), shape (less elongate, broader; posterior margin rounded, ventral margin nearly straight; dorsal margin less strongly arched). The latter species is smaller, narrower, more elongate, with a rounded anterior and pointed posterior; dorsal margins strongly arched; ventral margin concave. The present species strongly resembles *Argilloecia communis* Bonnema, 1940 (Pl. 2, Figs. 18-20) in shape but is larger with a less arched dorsal margin and also less elongate. *A. taylorensis* Alexander (1935, Text-Fig. 1a, 1b) from the Upper Taylor (Upper Campanian) Formation of Onion Creek, Texas differs is smaller, broader, less elongate and with and more evenly rounded anterior margin and obtuse, less rounded posterior.

Superfamily CYTHERACEABaird, 1850
Family CYTHERIDEIDAE Sars, 1925
Subfamily CYTHERIDEINAE Sars, 1925
Genus *Asciocythere* Swain, 1952
Asciocythere hadratos sp. nov.
(Pl. 1; figs 13-21)

Derivatio nominis.–Gr. *ἁδροζ* hadros – with reference to the thick-shelled carapace of this species.

Holotype.–LV MPK 11442.

Type locality and level.–Upper Campanian, Paramoudra Chalk, Crown Point Pit, Whitlingham, Norfolk.

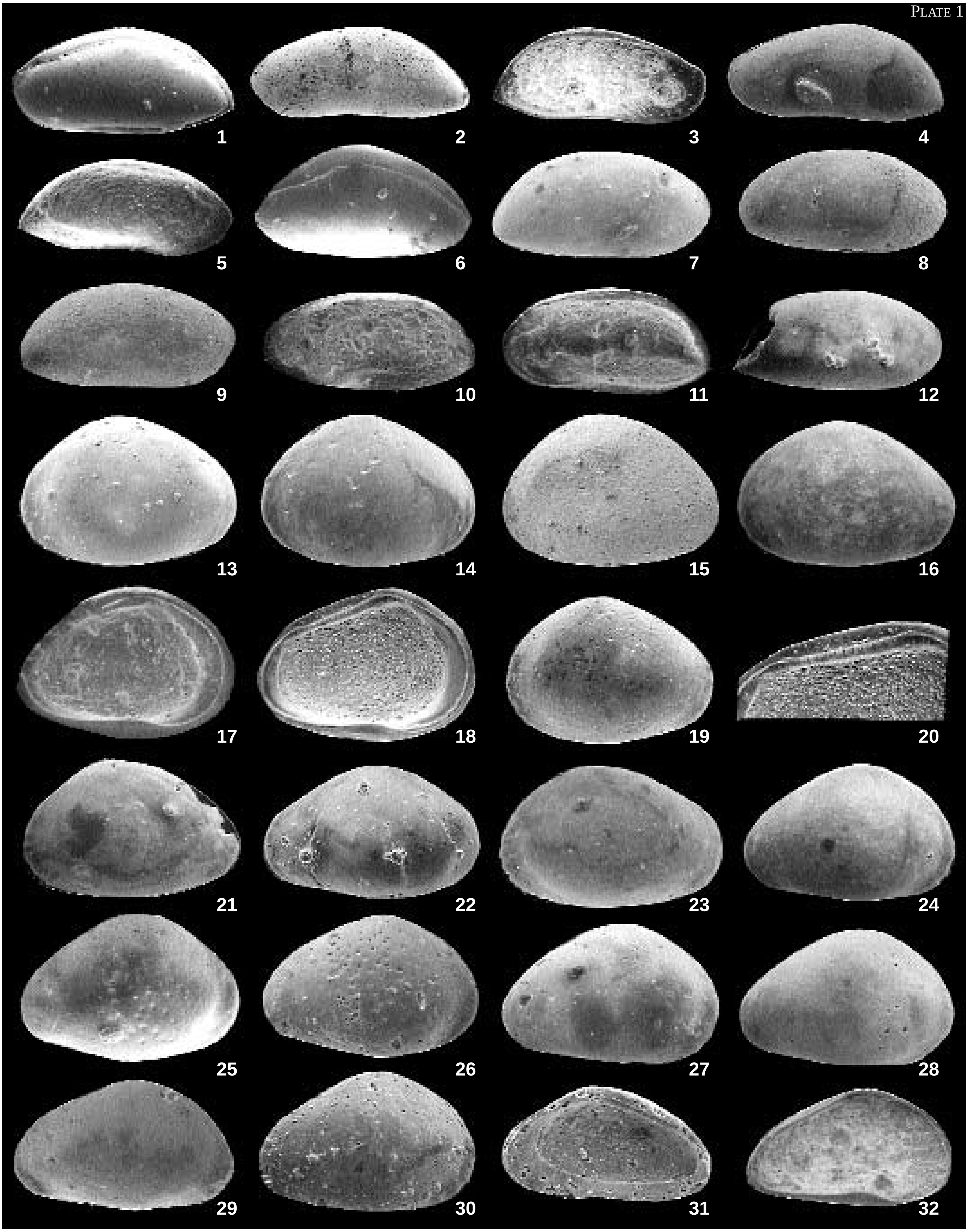
Material.–More than 100 specimens.

Diagnosis.–A medium, thick-shelled, sub-ovate species of *Asciocythere*, characterized by a broadly rounded, feebly dentate anterior and smooth posterior margins. Dorsal margin highly arched.

→

PLATE 1–*1-6*, *Argilloecia argillos* sp. nov. *1*, holotype, carapace, left lateral view, MPK 11345, X 100. *2*, paratype, left valve, external lateral view, MPK 11352, x 100. *3*, paratype left valve, internal view, MPK 11348, x 100. *4*, paratype, left valve, external lateral view, MPK11350, x 100. *5*, paratype, left valve, internal view, MPK 11350, x 100. *6*, paratype, carapace, oblique dorsal view, MPK 11344, x 100. *7-12*, *Argilloecia cretula* sp. nov. *7*, holotype, right valve, external lateral view, MPK 11354, x 100. *8*, paratype, right valve, external lateral view, MPK 11355, x 100. *9*, paratype, right valve, external lateral view, MPK 11833, x 100. *10*, paratype, right valve, internal view, MPK 11834, x 100. *11*, paratype, right valve, internal view, x 100. *12*, right valve, external lateral view, MPK 11836, x 100. *13-21*, *Asciocythere hadratos* sp. nov. *13*, paratype, left valve, external lateral view, MPK 11447, x 82. *14*, holotype, left valve, external lateral view, MPK 11442, x 83. *15*, paratype, left valve, external lateral view, MPK 11837, x 83. *16*, paratype, left valve, external lateral view, MPK 11439, x 80. *17*, paratype, left valve, internal view, MPK 11440, x 80. *18*, holotype, left valve, internal view, MPK 11442, x 83. *19*, paratype, left valve, external view, MPK 11441, 83. *20*, holotype, detail of hinge, x 160. *21*, paratype, left valve, external lateral view, MPK 11838, x 80. *22-32*, *Asciocthere prionodes* sp. nov. *22*, paratype, male right valve, external lateral view, MPK 11454, x 85. *23*, holotype, female left valve, external lateral view, MPK 11459, x 85. *24*, paratype, female right valve, external lateral view, MPK 11453, x 85. *25*, paratype, female right valve, external lateral view, MPK 11839, x 85. *26*, paratype, female right valve, external lateral view, MPK 11449, x 85. *27*, paratype, female right valve, MPK 11451, x 86. *28*, paratype, female right valve, external lateral view, MPK 11450, x 86. *29*, paratype, male right valve, external laterl view, MPK 11455, x 85. *30*, paratype, female right valve, external lateral view, MPK 11452, x 85. *31*, paratype, female right valve, internal view, MPK 1180, x 85. *32*, paratype, A-1 juvenile left valve, internal view, MPK 11841, x 85.

PLATE 1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Description.–Medium. Subovate. Thick-shelled. Anterior margin very broadly rounded and bearing 5, minute marginal denticles. Posterior margin more narrowly rounded. Both margins with apex below mid-height. Dorsal margin sub-umbonate, with apex at mid-length. Ventral margin gently convex in lateral view, with oral incurvature in internal view. LV strongly overlapping RV. Smooth. Inner lamella strongly calcified; rather narrow for genus. Radial pore canals poorly seen but relatively numerous and in fan-shaped arrangement. Hinge antimerodont with, in the LV, loculate terminal sockets, with 6 loculi anteriorly and 5 posteriorly, separated by a denticulate bar. A gutter-like accommodation groove occurs above the median element in the LV. Muscle scars not seen.

Distribution.–In the Trunch Borehole, the species ranges from mid Lower Campanian *Gonioteuthis quadrata* Zone (FAD = SAG 540) to Lower Maastrichtian. In the outcrop samples, it first appears in the Coniacian *coranguinum* Zone (3), but is a Lazarus taxon across the Santonian and early-middle Lower Campanian, reappearing in the *G. quadrata* Zone (9). It is then present in zones 10-14 (Upper Campanian basal *mucronata*, Eaton, Weybourne, Beeston and Paramoudra chalks) and in the Lower Maastrichtian pre-*Porosphaera*, *Porosphaera*, *O. lunata* and Grey Beds of Sidestrand and Trimingham (zones/subdivisions 15, 16, 17, 18).

Dimensions.–

	Length	Height
Holotype LV MPK 11440	0.63	0.41
Paratype RV MPK 11439	0.63	0.40
Paratype LV MPK 11441	0.66	0.44
Paratype LV MPK 11442	0.66	0.42
Paratype LV MPK 11446	0.66	0.43
Paratype LV MPK 11447	0.65	0.43
Paratype LV MPK 11449	0.67	0.43

Remarks.–*Clithrocytheridea* aff. *C. brevis* (Cornuel, 1846) of Oertli (1958), from the French Lower Albian to Aptian (Pl. 4, Fig. 87-89) is a somewhat variable species with the female RV resembling the present species, although smaller and less posteriorly elongate. *C.* aff. *C. brevis* is more strongly dimorphic (Oertli, 1958, Pl. 4, Figs. 89, 94-99) and more elongate than the females (1958, Pl. 4, Figs. 87, 88, 90-93). *Asciocythere rotunda* (Vanderpool) as illustrated by Swain & Chuanli (1991), is similar in shape but is less heavily calcified and smaller. This species is rather similar to *A. prionodes* sp. nov. and, although its mean length (0.65) and height (0.42) is grater than that of *A. prionodes* (0.60, 0.38), the two species are of similar size. The two species differ in that A. *hadratos* is more subovate and less subtriangular, is smooth rather than with deep somewhat isolate puncta as in *A. prionodes*. The latter is also notable for its more strongly developed anterior marginal denticles, its more narrowly rounded posterior and its thinner shell.

Asciocythere prionodes sp. nov.
(Pl. 1, Figs. 22-32)

Derivatio nominis.–Gr. *πριονωδης* prionodes saw-like, with reference to the very small antero-ventral marginal denticles of the species, causing that margin to resemble a saw blade.

Holotype.–LV MPK 11459.

Type locality and type level.–Upper Campanian, basal mucronata Chalk, Cringleford, Norfolk.

Material.–More than 80 specimens

Diagnosis.–A subovate (LV) to subtriangular (RV) species of *Asciocythere*, with denticles on the antero-ventral margin, especially of the LV, which resemble a saw blade.

Description.–Medium. Rather thin-shelled for the genus. Elongate subovate in LV to rounded subtriangular in RV. Anterior margin asymmetrically rounded with apex below mid-height and bearing antero-ventrally, especially in LV, a number of small marginal denticles, which impart a serrated, saw-like aspect to the margin. Dorsal margin strongly convex about the apex which is just anterior of mid-length. Ventral margin straight to gently convex in lateral view. LV larger than right with overlap around entire periphery. Smooth but with deep, rather isolate puncta. Inner lamella relatively wide. Hinge antimerodont, with gutter-like accommodation groove above the median element in the LV. Muscle scars a vertical row of four adjacent oval scars, with a heart-shaped frontal scar.

Distribution.–In the Trunch Borehole, the species ranges from Lower Campanian (SAG 520 = FAD) to Lower Maastrichtian (LAD = SAG 216); in the outcrop samples, the range is similar i. e. Lower Campanian to Lower Maastrichtian.

Dimensions.–

	Length	Height
Holotype LV MPK 11459	0.64	0.41
Paratype RV MPK 11451	0.57	0.37
Paratype RV MPK 11452	0.58	0.37

	Length	Height
Paratype RV MPK 11453	0.60	0.39
Paratype RV MPK 11454	0.60	0.39
Paratype RV MKP 11455	0.57	0.36
Paratype RV MPK 11456	0.61	0.39
Paratype A-1 juv. MPK 11457	0.54	0.35
Paratype RV MPK 11458	0.61	0.39
Paratype LV MPK 11460	0.64	0.41

Remarks.–*Clithrocytheridea parva* Weaver, 1982 (p. 32, Pl. 5, Figs. 14-17), from the British Lower Cenomanian, is similar in shape, is significantly smaller and its posterior is also more broadly rounded and the dorsal margin is more strongly arched.

Family EUCYTHERIDAE Puri, 1954

Genus *Eucythere* Brady, 1868

Eucythere ovoides sp. nov.

(Pl. 2; Figs. 1-8)

Derivatio nominis.–L. with reference to the imperfectly ovoid shape of this species.

Holotype.–Female RV MPK 11469.

Type locality and level.–Paramoudra Chalk, uppermost Upper Campanian, Thorpe, Norfolk.

Material.–11 specimens.

Diagnosis.–Typically eucytherine in shape but differentiated from other Cretaceous species, by its greater size, broadly rounded anterior margin, narrowly rounded posterior, arched dorsal margin, straight to weakly convex ventral margin and strong sexual dimorphism. It is more inflated than many other representatives of the genus.

Description.–Medium. Rather heavily calcified. Triangular in lateral view. Anterior margin smooth and broadly rounded, apex at mid-height; dorsal margin broadly rounded, apex at approximately two-thirds length, sloping to a rounded posterior, apex at mid-height. Ventral margin smooth and relatively short, straight to slightly convex. Lateral surface smooth. Sexual dimorphism very pronounced, males more elongate and narrower than females; females more inflated with more broadly rounded anterior and posterior margins. LV larger than RV. Juveniles distinguishable from adults by their lesser size, narrower marginal Zone and simple hinge structure. Inner lamella wide anteriorly, narrow in ventral and posterior regions; avestibulate; marginal pore canals few, straight, simple, widely spaced and often indistinct. A few large marginal pores were seen in a single RV specimen. Muscle scars indistinct or partially obscured. Hinge modified lophodont, not clearly seen. However, in RV, the terminal elements are positive structures separated by a smooth groove that is retained internally by what seems to be a dentate anti-slip bar.

Distribution.- Absent from the Trunch Borehole. Restricted to the uppermost Upper Campanian–Paramoudra Chalk to the Lower Maastrichtian *O. lunata* Chalk and Grey Beds of Trimingham, Norfolk.

Dimensions.–

	Length	Height
Holotype female LV MPK 11469	0.65	0.40
Paratype male LV MPK 11467	0.69	0.36
Paratype female RV MPK 11470	0.61	0.40
Paratype male MPK 11472	0.68	0.35

Remarks.–While this species and *Eucythere sphenarion* sp. nov. are very similar, they can be consistently distinguished by the slightly larger size, more pronounced sexual dimorphism and less elongate, more rounded posterior of the former The anterior margin is also more broadly rounded and the carapace more heavily calcified.

Eucythere sphenarion sp. nov.

(Pl. 2; Figs. 9-14)

Derivatio nominis.–Gr. *σϕηναριον* sphenarion a wedge, with reference to the shape of this species in lateral view.

Holotype.–Female RV MPK 11464.

Type locality and level.–Caistor St-Edmund, Norfolk. Upper Campanian, Beeston Chalk.

Material.–Some 20 specimens.

Diagnosis.–Typically eucytherine in shape and closely resembling several other published Cretaceous species from which it is differentiated by its size, broadly rounded anterior margin, nearly straight ventral margin and the angle by which the dorsal margin, broadly rounded until about mid-length, slopes down to the narrowly rounded posterior.

Description.–Medium. Rather thin-shelled. Triangular in lateral view. Anterior margin smooth and broadly rounded, apex at mid-height; dorsal margin broadly rounded, apex at approximately two-thirds length, sloping to a narrowly rounded posterior, apex at mid-height. Ventral margin smooth and relatively short, with a slight concavity at about mid-length in RV, ventral margin in LV straight. Lateral surface smooth; ocular tubercle and internal ocular sinus absent. Sexually dimorphic, males more elongate and narrower than females. LV larger than RV. Juveniles distinguishable from adults by their narrow marginal zone and simple hinge structure; partial ontogeny seen with the smallest instars averaging 0.46 mm in length and the largest ranging from 0.55 to 0.58 mm. Inner lamella wide anteriorly, narrow ventrally and posteriorly; avestibulate; marginal pore canals few, straight, simple, widely spaced and often indistinct. Muscle scars indistinct or partially obscured, consisting of an arcuate row of four adductor scars, frontal scar not seen. Hinge modified lophodont as in *E. ovoides* sp. nov.

Distribution.–In the Trunch Borehole, the species has a relatively short range and is a rare component in all the samples in which it occurs; First Appearance Datum = SAG 417, Last Appearance = SAG 336. It is restricted to the Upper Campanian (*B. mucronata* Zone) Beeston and Weybourne Chalk. In the outcrop samples, the range is Upper Campanian to Lower Maastrichtian, but the species is more abundant in the Upper Campanian.

Dimensions.–

	Length	Height
Holotype female RV MPK 11464	0.62	0.33
Paratype female LV MPK 11462	0.64	0.35
Paratype female RV MPK 11463	0.61	0.33
Paratype male LV MPK 11465	0.62	0.33
Paratype ? juv. MPK 11466	0.57	0.29

Remarks–The species is similar in shape and outline to *Eucythere solitaria* Triebel, 1940 (see also Neale 1978, Pl. 1, Fig. 11, from the Middle Albian of the Speeton Clay), but is much larger, with only juveniles being the same size as Triebel's material. *Eucythere trigonalis* Jones & Hinde, 1890 (illustrated by Neale, 1978, Pl. 1, Fig. 10, and Wilkinson, 1988b, Pl. 3, Fig. 7) differs in its more rounded anterior and dorsal margins; the dorsal margin is nearly convex, sloping down to a very narrow posterior. It differs from *Eucythere ovoides* sp. nov. in its smaller size, less pronounced sexual dimorphism and more elongate posterior. In *E. ovoides,* the anterior margin is also more broadly rounded, the posterior is broader and elongate and the shell more heavily calcified. Brouwers & Hazel (1978) describe *E. alexanderi* (Pl. 1, Figs. 3, 5, p. 15) from the Upper Cretaceous of Alabama and Arkansas. The holotype is Maastrichtian and differs from the present species in its smaller size; it is also more elongate and less arched dorsally. Weaver (1982, Pl. 6, Figs. 3, 4, 5) assigned a new species to the genus *Phodeucythere* Gründel, 1978 which, in Weaver's opinion is conspecific with *Eucythere* sp. 1 Colin, 1974. This species is very similar to the present species but is less posteriorly elongated and narrower in the anterior marginal area. Weaver compares *P. cuneiformis to P. solitaria (*Triebel, 1940) and *P. trigonalis (*Jones & Hinde, 1890, Pl. 3, Figs. 25, 26; Pl. 4, Figs. 1-2. The present authors regard *Phodeucythere* Gründel as a junior synonym of *Eucythere* Brady.

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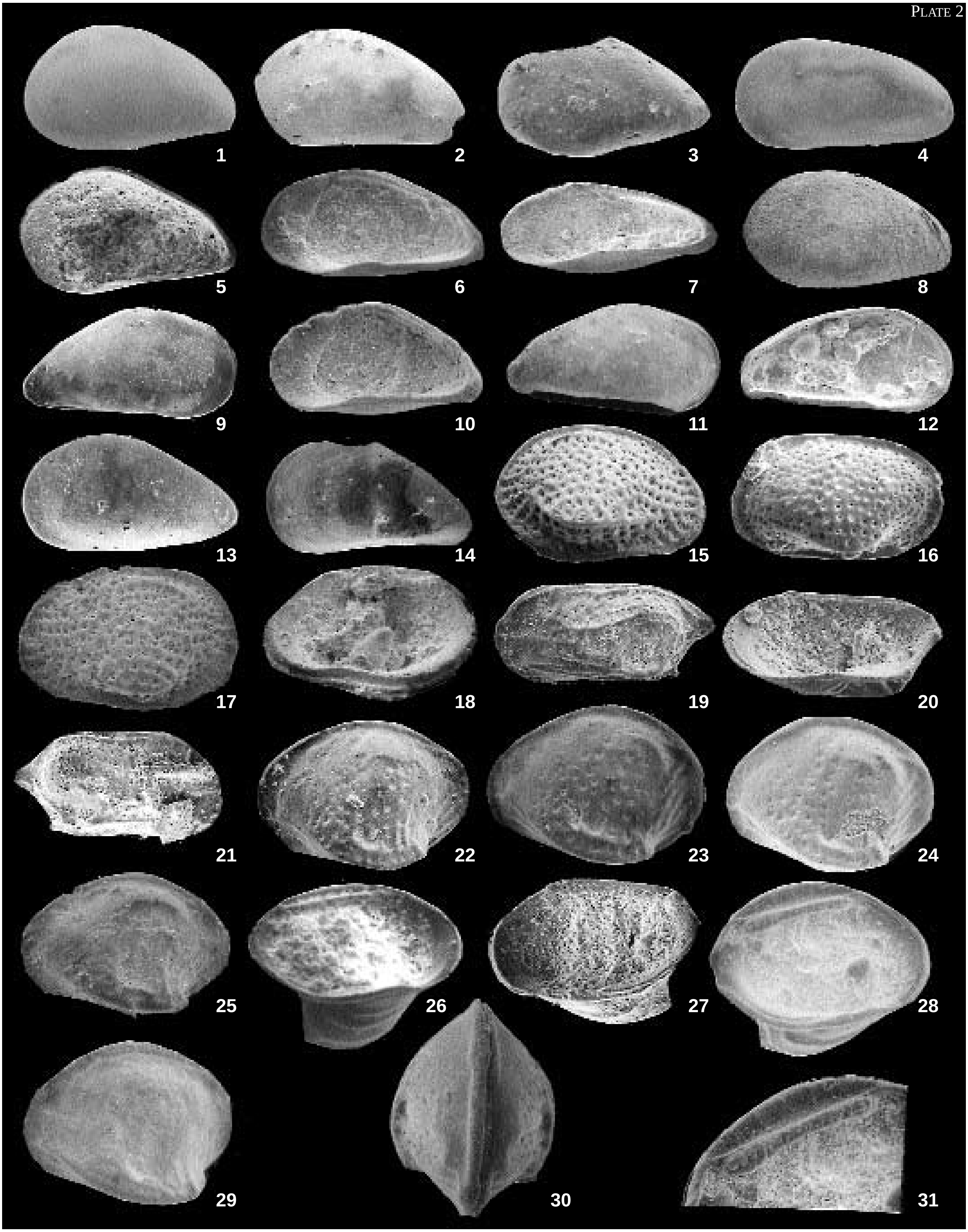
PLATE 2–*1-8, Eucythere ovoides* sp. nov. *1*, holotype, female left valve, external lateral view, MPK 11469, x 80. *2*, paratype, female, left valve, external lateral view, MPK 12642, x 80. *3*, paratype, female left valve, external lateral view, MPK 12643, x 80. *4*, paratype male left valve, external lateral view, MPK 11467, x 78. *5*, paratype, female right valve, internal view, MPK 11471, x 80. *6*, paratype, female right valve, internal view, MPK 11470, x 80. *7*, paratype, male right valve, internal view, MPK 11472, x 77. *8*, paratype, female left valve, external lateral view, MPK 11468, x 80. *9-14*, *Eucythere sphenarion* sp. nov. *9*, paratype, female right valve, external view, MPK 11465, x 80. *10*, paratype, female right valve, internal view, MPK 11463, x 80. *11*, paratype, male right valve, external lateral view, MPK 12644, x 78. *12*, paratype A-1 juvenile right valve, internal view, MPK 11466, x 90. *13*, paratype, female left valve, external lateral view, MPK 11462, x 80. *14*, holotype, female right valve, external lateral view, MPK 11464, x 80. *15-18*, *Saida prasutegusi* sp. nov. *15*, holotype, female right valve, external lateral view, MPK 11428, x 123. *16*, paratype, male left valve, external lateral view, MPK 11430, x 114. *17*, paratype, female left valve, external lateral view, MPK 11429, x 129. *18*. paratype, female left valve, internal, view, MPK 11431, x 129. *19-21*, *Semicytherura fasciculata* sp. nov. *19*, holotype, male left valve, external lateral view, MPK 11504, x 93. *20*, paratype, male right valve, internal view, MPK 11505, x 91. *21*, paratype, female right valve, external lateral view, MPK 11508, x 111. *22-31*, *Cytheropteron apeorus* sp, nov. *22*, holotype, left valve, external lateral view, MPK 11519, x 80. *23*, paratype, left valve, external lateral view, MPK 11518, x 80. *24*, paratype, left valve, external lateral view, MPK 11517, x 80. *25*, paratype, left valve, external lateral view, MPK 11522, x 80. *26*, paratype, left valve, internal view, MPK 11521, x 80. *27*, paratype, right valve, internal view, MPK 11526, x 80. *28*, paratype, left valve, internal view, MPK 11525, x 80. *29*, paratype, left valve, external lateral view, MPK 1523, x 80. *30*, paratype, carapace, dorsal view, MPK 11516, x 80. *31*, paratype, left valve, detail of hinge, MPK 11525, x 160.

PLATE 2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Family CYTHERIDAE Baird, 1850
Genus *Saida* Hornibrook, 1952
Saida prasutegusi sp. nov.
(Pl. 2; Figs. 15-18)

Derivatio nominis.–Named for Prasutegus, the king of the Iceni; the British Iron Age Celtic tribe in Norfolk at the time of the Roman Invasion.

Holotype.–Female LV MPK 11428.

Type locality and level.–Sidestrand, Norfolk. Lower Maastrichtian pre-*Porosphaera* Beds.

Material.–12 specimens.

Diagnosis.–A small sub-rhomboidal to sub-ovate species of *Saida*, with an arched dorsal margin; rounded anterior and posterior margins; narrow, smooth marginal rim; ventro-lateral subalar process.

Description.–Small. Relatively thin-shelled. Sub-rhomboidal to sub-ovate, with an arched dorsal margin in LV, almost straight in RV, LV slightly larger than RV; apex at mid-length rounded anterior (more so in LV) and posterior margins; greatest height at mid-point, posterior slightly flattened in lateral view; ventro-lateral margin expanded to form a blunt, alar process which does not obscure the ventral margin in lateral view. No ocular tubercle or internal ocular sinus. Sexually dimorphic with males more elongate and less high than females. No juveniles known. Ornament covers all of lateral surface, including the alar process, except for the smooth, narrow rim which extends along the anterior, ventral and posterior margins, especially prominent anteriorly; ornament consists of small, round regularly spaced puncta. Hinge antimerodont, feebly developed, in RV consists of dentate terminal bars, separated by a straight, locellate groove. Marginal zone moderately wide; avestibulate; muscle scars not seen; radial canals not numerous, simple.

Distribution.–The species is absent from the Trunch Borehole, rare in the outcrop samples and restricted to the Upper Campanian Paramoudra Chalk and Lower Maastrichtian *Porosphaera*, pre-*Porosphaera* and *O. lunata* Chalks of Sidestrand and Trimingham, Norfolk.

Dimensions.–

	Length	Height
Holotype female RV MPK 11428	0.35	0.24
Paratype female RV MPK 11429	0.33	0.24
Paratype male LV MPK 11430	0.41	0.22
Paratype female LV MPK 11431	0.35	0.35
Paratype female LV MPK 11432	0.33	0.26

Remarks.–*Saida elliptica* (Bonnema, 1941), from the Chalk of the Netherlands, is similar in ornament but the present species is larger and more ovate, with a more rounded dorsal margin in the LV, and the ventro-lateral process is more pronounced. *Saida nettgauensis* Gründel, 1966, from the Lower Albian of Germany (p. 49, Pl. 8, Figs. 36, 37) is larger, with a longer, more ventrally positioned lateral rib. *S.* cf. *nettgauensis* Gründel, of Weaver (1982, p. 98, Pl. 20, Figs. 4, 5, 6) from the British Middle and Upper Cenomanian can be distinguished by its coarser reticulation, more angular ventro-lateral rib and ventro-lateral spine. *Saida* species have only been rarely recorded from the Cretaceous (Herrig, 1968), possibly due to their small size.

Family CYTHERURIDAE Müller, 1894
Subfamily CYTHERURINAE Müller, 1894
Genus *Semicytherura* Wagner, 1957
Semicytherura fasciculata sp. nov.
(Pl. 2; Figs. 19-21)

Derivatio nominis.–L. *fascis* (diminutive – *fasciculus*) a bundle or sheaf of rods, with reference to the parallel, numerous longitudinal ribs of this species with their fanciful resemblance to the bundle of rods carried by the Roman lictors.

Holotype.–Male LV MPK 11504.

Type locality and level.–Eaton, Norfolk. Early Upper Campanian, Eaton Chalk

Material.–25 specimens.

Diagnosis.–A medium, elongate, subovate to subrectangular species of *Semicytherura* with a prominent caudal process. Ornament a series of narrow longitudinal, ribs and intercostal punctation; eye tubercle small but clear.

Description.–Medium. Elongate, sub-ovate to subrectangular with a caudal process at mid-height. Anterior margin rounded, apex at approximately mid-height; dorsal margin straight; eye tubercle small but distinct, hemispherical. Posterior margin with caudal process. Greatest height at approximately two-thirds length, posterior in males slightly inflated; ventral margin straight, parallel to dorsal margin. Lateral surface ornate consisting of 8-9 narrow, longitudinal ribs extending across the length of the valve, separated by intercostal puncta, which impart an overall reticulate appearance. Sexual dimorphism pronounced, male carapace wider posteriorly and more posteriorly inflated than females. Articulated carapaces not seen; LV slightly larger than RV, but RV predominate. Inner lamella wide anteriorly; avestibulate; marginal pore canals not seen; muscle scars obscured and indistinct. Hinge modified antimerodont, weakly developed LV with weakly loculate terminal sockets separated by a denticulate bar.

Distribution.–In the Trunch Borehole, the species ranges from the basal *mucronata* Chalk (Upper Campanian zone/subdivision 10) to the Lower Maastrichtian. In the outcrop samples, it ranges from Lower Campanian to Lower Maastrichtian, but in the Maastrichtian is restricted to the Grey Beds of Trimingham, Norfolk. It is most abundant in the Upper Campanian.

Dimensions.–

	Length	Height
Holotype male LV MPK 11504	0.49	0.36
Paratype male RV MPK 11505	0.48	0.36
Paratype female RV MPK 11506	0.45	0.32
Paratype female LV MPK 11507	0.46	0.33
Paratype female RV MPK 11508	0.45	0.32

Remarks.–*S. fasciculus* sp. nov. does not closely resemble any of the many other species of the genus known to the authors.

Family CYTHERURIDAE Müller, 1894
Subfamily CYTHEROPTERINAE Hanai, 1957
Genus *Cytheropteron* Sars, 1866
Cytheropteron apeorus sp. nov.
(Pl. 2; Figs. 22-31)

Derivatio nominis.–*Gr*. *απεορος* apeorus soaring, hanging in the air, with reference to a fanciful flight performed by a species with such large alae.

Holotype.–LV MPK 11519.

Type locality and level.–Caistor-St-Edmund, Norfolk. Upper Campanian, Beeston Chalk.

Material.–Some 65 specimens.

Diagnosis.–A small to medium species of *Aversovalva* characterized by a strongly arched dorsal margin, rounded anterior and posterior margins. Four or five, fine parallel ribs cross the ventral margin and extend onto the antero- and postero-ventral surfaces. Ventral margin completely obscured by large, strongly developed ventro-lateral ala which is reticulate; ornament in the form of rounded, regularly spaced puncta

Description.–Small-medium. Rather inflated with a strongly arched, smooth dorsal margin, apex at about mid-height. Anterior and posterior margins smoothly rounded, apices at mid-height. There are two variants, an ornate and a rarer smooth form. In the former, four or five, fine parallel ribs cross the ventral margin and extend onto the antero and postero-ventral surface, these are absent in the inornate form. Ventral margin completely obscured by ventro-lateral ala, well developed with about 6 reticulate fossae, anterior part of ala with a small triangle of finer, regularly spaced puncta in the smoother form, less evident in the ornate form. Ornament usually a series of deep, circular, regularly spaced puncta, rarely smooth or finely punctate. RV slightly larger than LV, overlapping it distinctly along the line of the hinge, especially clear when complete carapaces seen in dorsal view. Hinge modified antimerodont and well developed. In the LV, the circular terminal sockets are separated by a denticulate bar. Avestibulate. Marginal Zone of medium width, narrower at posterior. Other internal features not seen.

Distribution.–This species has a wide stratigraphical range. In the Trunch Borehole, it ranges from the Lower Campanian *Gonioteuthis quadrata* Zone to the Lower Maastrichtian *B. lanceolata* Zone; it is also a moderate component in some of the outcrop samples, ranging from the Coniacian low-*coranguinum* Zone in South Pickenham, Norfolk and the *coranguinum* (assigned to Co. 3 of the German scheme) Zone at Litcham, Norfolk, to the Lower Maastrichtian *Porosphaera* and pre- *Porosphaera* Beds of Sidestrand, the *O. lunata* Chalk and Grey Beds of Trimingham, Norfolk. It is absent in Santonian assemblages.

Dimensions.–

	Length	Height
Holotype LV MPK 11519	0.49	0.32
Paratype C MPK 11516	0.50	0.34
Paratype LV MPK 11517	0.48	0.33
Paratype LV MPK 11518	0.49	0.33
Paratype LV MPK 11520	0.47	0.34
Paratype LV MPK 11521	0.47	0.34
Paratype LV MPK 11522	0.48	0.33
Paratype LV MPK 11523	0.49	0.34
Paratype RV MPK 11524	0.51	0.35
Paratype LV MPK 11525	0.47	0.33
Paratype RV MPK 11526	0.53	0.35

Remarks.–The majority of specimens are ornamented but some specimens from the Santonian and Lower Campanian (e.g. Trunch Borehole sample SAG 484, *Gonioteuthis quadrata* Zone, Lower Campanian; Santonian *coranguinum* Zone, SAG 47, Helhoughton, Norfolk) lack the characteristic vertical rows of puncta. *Aversovalva arrectihypa* Crane, 1965 (p. 204, Pl. 3, Fig. 4) from the Upper Cretaceous of Georgia, Texas, Arkansas and Alabama is similar to the present material in shape and size but differs in the "closely spaced vertical rows of reticulations in the median area of the valve." *A. puncta* Crane, 1965 (p. 205, Pl. 3, Fig. 5) differs from the previously mentioned species in having vertically orientated rows of reticulations on the mid-portion of the lateral surface, rather than a punctate surface with puncta arranged in vertical rows. It differs from the present species in its smaller size, its ventro-lateral alae (less pronounced) and punctate ornament which, although like *A. apeorus* are arranged in vertical rows, are much less pronounced. *Cytheropteron nanissum* Damotte & Grosdidier, 1963 (Pl. 1, Fig. 2a-f) from the Upper Albian of France is also figured by Gründel (1966, Pl. 8, Figs. 27, 28; German Middle and Upper Albian) and Weaver (1982, Pl. 17, Figs. 11-14; British Cenomanian). It is similar in size but slightly more elongate with a rounded anterior and a slightly pointed posterior. It also has a short rib just beneath the dorsal margin from which a vertical rib extends down to the alar process. The ornament is also smoother, with little evidence of the punctate ornament seen in the present species, which also has a less pointed, broader ventro-lateral ala and the structure of the hinge also differs. The present species is very similar to *Aversovalva vscriptum* (Van Veen, 1936), illustrated by Damotte (1971, Pl. 8, Fig. 15) and Babinot *et al.* (1985, Pl. 64, Fig. 18). However, the alae are less pronounced and non-reticulate in Van Veen's species it is smaller (0.36 –0.38mm in length, whereas *A. apeorus* sp. nov. ranges from 0.46-0.53 mm). The puncta are also larger and less regularly spaced. In the present species, they are arranged in clear vertical rows. In *v-scriptum*, the v-shaped median furrow is more prominent. The present species differs from *Aversovalva tenuiculum* Damotte, 1965 (Pl. 1, Figs. 4a-c) from the French Lower Campanian in being larger and in the more convex dorsal margin, the larger, more backwardly curved and reticulae alae and Damotte's species is smooth. *Cytheropteron* sp. Bertels, 1975 (Pl. 6, Figs. 10a-b), from the Middle Maastrichtian of Argentina, differs from the present species in its smooth lateral surface and ventro-lateral alae, both upper and lower margins of which are straight; anterior and posterior margins less broadly rounded. The two species are similar in size and in dorsal view, differing only in the position of the alae.

Cytheropteron cathetos sp. nov.
(Pl. 3; Figs. 1-5)

Derivatio nominis.–καθετος perpendicular, upright, with reference to the strong alae which would maintain this species in a vertical position.

Holotype.–LV MPK 11527.

Type locality and level.–Crown Point Pit, Whitlingham, Norfolk. Topmost Campanian, *Paramouda* Chalk.

Material.–24 specimens.

Diagnosis.–A small to medium, very strongly alate species of *Cytheropteron* with pronounced punctate ornament.

Description.–Small to medium (Maastrichtian representatives slightly larger than older specimens). Rather thin-shelled. Posterior margin with small, tube-like caudal process with apex above mid-height (see holotype). less acute, not heavily calcified. Anterior margin somewhat truncated medianly. Dorsal margin strongly arched, especially in RV, apex at about mid-length. Alae strong, well developed, backward curving and ending in a sharp hollow point; leading edge with strong rib and with depression at base of process. Ornament of numerous, small, well-spaced rounded puncta, not visible in poorly preserved specimens. Internal features as for genus.

Distribution.–The species occurs in the Upper Campanian of the Trunch Borehole, the type locality, and other outcrop localities and in the Lower Maastrichtian Grey Beds of Trimingham (see Fig. 2).

Dimensions.–

	Length	Height
Holotype LV MPK 11527	0.44	0.26
Paratype LV MPK 11528	0.44	0.27
Paratype RV MPK 11529	0.49	0.29
Paratype LV MPK 11530	0.46	0.27
Paratype LV MPK 11531	0.45	0.26
Paratype RV MPK 11532	0.45	0.26

Remarks.–*Cytheropteron nanissum* Damotte & Grosdider, 1963 (Pl. 1, Fig. 2a-f) is smaller than the present species. Both have rounded anterior margins and are acutely pointed caudally but, in the former, the anterior margin is higher and more convex; also in *C. nanissum* the alae are longer, more antero-ventral in position and backward curved. *C. pitstonensis* Weaver, 1982 (Pl. 17, Figs. 15-18) differs in its size (smaller); dorsal margin (nearly straight); less pointed posterior and smaller, less pointed alae. *Cytheropteron* *harrisi* Skinner, 1956 (of Benson & Tatro, 1964, Pl. 3, Figs. 5-6) from the Campanian Marlbrook Marl of Arkansas, USA, is of similar size but has a pointed posterior and a bluntly rounded anterior, and lacks the puncta that cover the entire lateral surface of the present species, dorsal margin is also less arched, the alae are smaller with a nearly straight upper surface. In the present species, the upper surface of the ala is curved backwards and ends in a point. *C. pantaleonensis* Stchepinsky, 1954, recorded by Damotte, 1971, from the Lower Aptian of the Paris Basin, is smaller, with a straight dorsal margin, a less pronounced alar process and smooth ornament. *C. arguta* Kaye, 1965 (as figured by Wilkinson, 1988a MS, Pl. 13, Figs. 14, 15) from the Albian of eastern England differs in size, and in the distinct caudal process, the inflated, broad ventrolateral alae and the coarsely punctate-reticulate ornament; the dorsal and ventral margins are straight and parallel. Wilkinson (1988a, MS) describes and illustrates another eight early and mid-Cretaceous species of *Cytheropteron* (Pl. 13, Figs. 16, 17, 20, 21; Pl. 14, Figs. 1-6), all of which differ from the present species in size, shape and ornament.

Family Loxoconchidae Sars, 1925
Subfamily Loxoconchinae Sars, 1925
Genus *Sagmatocythere* Athersuch, 1976
Sagmatocythere orthros sp. nov.
(Pl. 3; Figs. 6-14)

Derivatio nominis.–Gr. *ορθρος* orthros early, with reference to the stratigraphical occurrence of the species, possibly the first record from the Mesozoic.

Holotype.–Female LV MPK 11564.

Type locality and level.–Crown Point Pit, Whitlingham, Norfolk. Topmost Upper Campanian, Paramouda Chalk.

Material.–More than 50 specimens.

Diagnosis.–A small, strongly dimorphic, species of *Sagmatocythere*, with a pronounced eye tubercle, median sulcus, reticulo-punctate ornament in which the horizontal muri dominate and pronounced alar projection.

Description.–Small. Rather thin-shelled. Sexually dimorphic; males subrectangular, females subquadrate. Anterior margin rounded with apex at or near mid-height. Posterior margin more truncated in female than male; apex above mid-height. Dorsal margin straight; overhung by short dorsal rib posteriorly. Ventral margin appears straight in lateral view. Ornament reticulo-punctate. Longitudinal muri dominate but become irregular associated with the median sulcus and the base of the conspicuous alar process which terminates in a short, perforated spine and below which the longitudinal muri of the ornament curve to parallel the ventral margin. Ornament most regular towards the end margins and generally much more regular in juveniles. Eye tubercle prominent. Marginal areas broad at anterior and posterior. Hinge gongylodont, with long, straight median element.

Distribution.–In the Trunch Borehole, the species ranges from the Upper Campanian *B. mucronata* Zone, Weybourne and Beeston Chalk (first appearance in SAG 417) to the Lower Maastrichtian (last appearance SAG 231). In the outcrop localities, the range is also Upper Campanian to Lower Maastrichtian. It occurs in the *O. lunata* Chalk and Grey Beds of Trimingham, Norfolk, and the pre-*Porosphaera* Beds of Sidestrand. It was also present in the topmost Upper Campanian (Paramoudra Chalk) of Crown Point Pit, Whitlingham, Norfolk, the Beeston Chalk at Caistor St. Edmund and the early Upper Campanian Weybourne Chalk at Eaton, Norfolk.

Dimensions.–

	Length	Height
Holotype female LV MPK 11546	0.45	0.27
Paratype female LV MPK 11547	0.45	0.27
Paratype female LV MPK 11548	0.44	0.26
Paratype male LV MPK 11549	0.50	0.24
Paratype male LV MPK 11550	0.50	0.24
Paratype female LV MPK 11551	0.45	0.27
Paratype A-1 juv. LV MPK 11552	0.37	0.20
Paratype A-1 juv. RV MPK 11553	0.35	0.21
Paratype female RV MPK 11554	0.43	0.26
Paratype female RV MPK 11555	0.43	0.25
Paratype female RV MPK 11556	0.43	0.26
Paratype male LV MPK 11557	0.49	0.23
Paratype female RV MPK 11558	0.43	0.26

Remarks.–*Sagmatocythere orthros* sp. nov. is similar to *Eucytherura (Eucytherura) longisculpta* Weaver, 1982, from the English Cenomanian, but differs in size, ornament, and most importantly in hingement. Among the very diverse fauna of this genus described by Maybury (MS, 1985) from the late Pliocene of Cornwall and NW France are several which resemble the present taxon. The closest species in the Pliocene assemblage, however, is *S. variolata* (Brady, 1878), which, although smaller, is very similar in shape and ornament. This is probably the first formal description if the genus from the Mesozoic.

Family SCHIZOCYTHERIDAE Howe, 1961
Genus *Paijenborchella* Kingma, 1948
Paijenborchella biponticulata sp. nov.
(Pl. 3; Figs. 15-24)

Derivatio nominis.–L. *biponticula* two bridges. With reference to the two bridge-like structures on the lateral surface.

Holotype.–Female LV MPK 11586.

Type locality and level.–Marl Point, Trimingham, Norfolk. Lower Maastrichtian *O. lunata* Chalk.

Material.–59 specimens.

Diagnosis.–A medium, biponticulate and smooth species of *Schizocythere.*

Description.–Medium. Thick shelled. Sub-ovate to sub-trapezoidal in lateral view; strongly inflated ventro-laterally in dorsal view and flattened ventrally. Sexually dimorphic; males more elongate and less strongly inflated than females. Anterior margin asymmetrically rounded with long, slightly convex antero-dorsal slope and much shorter, strongly convex antero-ventral slope; apex well below mid-height; posterior margin caudate, more pointedly so in male specimens. Apex at or near mid-height; posterodorsal slope concave, particularly in males; posteroventral slope straight and almost keel like in males. Dorsal margin with greatest height anterior of mid- length , sloping towards posterior; ventral margin entirely obscured in lateral view by valve tumidity. Greatest length below mid-height; greatest height through dorsal umbo. Eye tubercle and ocular sinus absent. A deep vertical median sulcus occurs just anterior of mid-length, bridged by a short, median ponticulate rib and a longer, concave upward sub-ponticulate ventrolateral rib which is strongly thickened medianly. A third rib borders the dorsal margin; intercostal areas smooth. Inner lamella rather narrow, avestibulate; muscle scars not seen. Hinge schizodont with, in RV, a stepped anterior tooth increasing in height proximally anteriorly and a strongly bilobate posterior tooth; median element very strongly locellate posteromedianly and with a strongly bi-loculate anteromedian socket; complementary structures occur in LV, above median element of which is a long and gutter-like accommodation groove.

Distribution.–Restricted to the Lower Maastrichtian *O. lunata* Chalk and Grey Beds of Trimingham, Norfolk. In the assemblages in which it occurs, the species makes up between 0.7 to 7.6% of the total assemblage, with a maximum abundance in SAG 2004 (*O. lunata* Chalk - 23 specimens).

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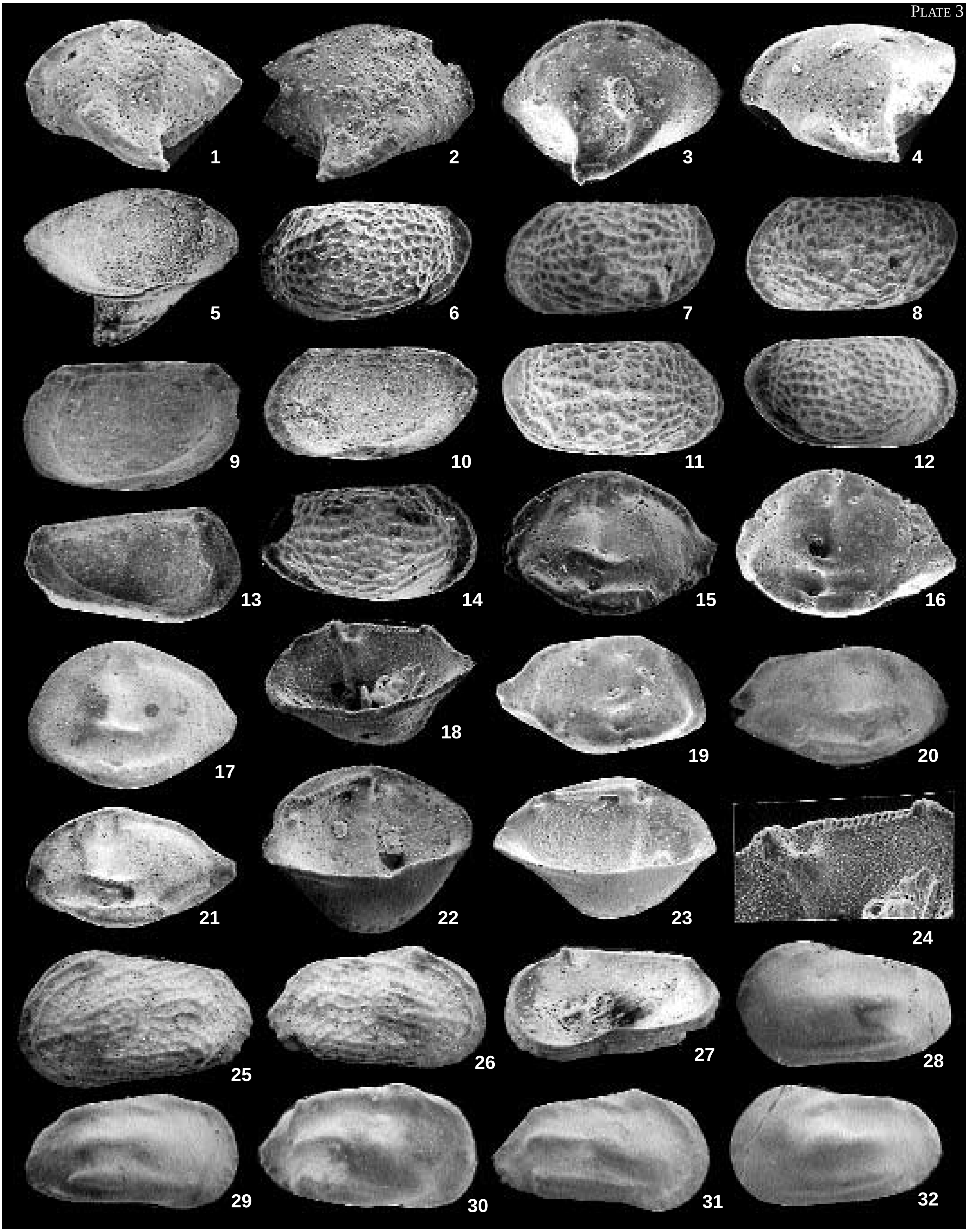
PLATE 3–*1-5*, *Cytheropteron cathetos* sp. nov. *1*, paratype, left valve, external lateral view, MPK 11528, x 100. *2*, paratype, right valve, external lateral view, MPK 11529, x 100. *3*, paratype, right valve, external lateral view, MPK 11532, x 100. *4* holotype, left valve, external lateral view, MPK 11527, x 100. *5*, paratype, left valve, internal view, MPK 11530, x 100. *6-14*, *Sagmatocythere orthros* sp. nov. *6*, holotype, female left valve, external lateral view, MPK 11546, x 100. *7*, paratype, male left valve, external lateral view, MPK 11549, x 100. *8*, paratype, female left valve, external lateral view, MPK 11547, x 100. *9*, paratype, female right valve, internal view, MPK 11554, x 100. *10*, paratype, male right valve, internal view, MPK 11549, x 100. *11*, paratype, female right valve, external lateral view, MPK 11555, x 100. *12*, paratype, female right valve, external view, MPK 11556, x 100. *13*, paratype, male left valve, internal view, MPK 11550, x 100. *14*, paratype, female right valve, external lateral view, MPK 11558, x 100. *15-24*, *Paijenborchella biponticulata* sp. nov. *15*, holotype, female left valve, external lateral view, MPK 11586, x 85. *16*, paratype, female left valve, external lateral view, MPK 11585, x 80. *17*, paratype, female left valve, external lateral view, MPK 11585, x 85. *18*, paratype, female right valve, internal view, MPK 11591, x 85. *19*, paratype, female right valve, external lateral view, MPK 11588, x 76. *20*, paratype, male right valve, external lateral view, MPK 11589, x 78. *21*, paratype, male left valve, external lateral view, MPK 11587, x 77. *22*, paratype, female left valve, internal view, MPK 11590, x 83. *23*, paratype, female left valve, internal view, MPK 11593, x 83. *24*, paratype, female right valve, hinge detail, MPK 11591, x 170. *25-27*, *Mosaleberis dictyotos* sp. nov. *25*, holotype, left valve, external lateral view, MPK 11748, x 80. *26*, paratype, right valve, external lateral view, MPK 11745, x 80. *27*, paratype, right valve, internal view, MPK 11747, x 80. *28-32*, *Mosaeleberis pseudomacrophthalma* sp. nov. *28*, holotype, female left valve, external lateral view, MPK 11758, x 80. *29*, paratype, A-1 juvenile right valve, external lateral view, MPK 11762, x 86. *30*, paratype, female right valve, external lateral view, MPK 11759, x 80. *31*, paratype, male right valve, external lateral view, MPK 11763. *32*, paratype, female carapace, left lateral view, MPK 11760, x 80.

PLATE 3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Dimensions.–

	Length	Height
Holotype female LV MPK 11586	0.64	0.40
Paratype female LV MPK 11585	0.64	0.39
Paratype male LV MPK 11587	0.67	0.37
Paratype female RV MPK 11588	0.65	0.39
Paratype male RV MPK 11589	0.68	0.37
Paratype female LV MPK 11590	0.63	0.39
Paratype female RV MPK 11591	0.65	0.39
Paratype male LV MPK 11592	0.68	0.36
Paratype female LV MPK 11593	0.64	0.39
RV juvenile from SAG 2004	0.60	0.34
LV juvenile from SAG 2001	0.58	0.32

Remarks.–The species resembles *Paijenborchella marssoni* (Triebel, 1949, p. 199, Pl. 2, Fig. 13; Pl. 3, Fig. 14; see also Howe & Laurencich, 1958, p. 441; Herrig, 1967, Pl. 1, Text-Fig. 4) but there are several differences. In *P. marssoni* the caudal process is narrow and elongate; in the present species, this structure is short and square (less than half the length), the median sulcus is less pronounced and the well-developed hinge is schizodont. *S. biponticulata* has a size range of 0.63-0.67 mm in length; *P. marssoni* is a smaller species (recorded length c. 0.52 mm).

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948
Genus *Mosaeleberis* Deroo, 1966
Mosaeleberis dictyotos sp. nov
(Pl. 3; Figs. 25-27)

1970 *Mosaeleberis* sp. Gründel, p. 48, Pl. 1, Figs. 6-8.

Derivatio nominis.–Gr. *δΙκτυοτος dictyotos* a net. With reference to the regular reticulate ornament covering the lateral surface of this species.

Holotype.–LV MPK 11748.

Type locality and level.–Euston, Suffolk, low *coranguinum* Zone, Coniacian.

Material.–6 specimens (see Remarks).

Diagnosis.–A medium species of *Mosaeleberis*, distinguished by its net-like reticulate ornament, inflated valves and double anterior rib. Eye tubercle small but distinct; small papillae within reticulae.

Description.–Medium. Sub-quadrate in lateral view and inflated. Anterior margin in LV broadly rounded, apex at approximately mid-height; in RV anterior margin less broadly rounded with apex below mid-height. Dorsal and ventral margins straight and inclined to narrow posterior margin which is rounded in LV, slightly more acute in RV. Primary ornament covers entire lateral surface, consisting of a fine, net-like regular reticulation with secondary ornament of fine papillae within each fossa. Two narrow parallel anterior marginal ribs Three very small postero-ventral tubercles and small ventral rib that partially obscures ventral margin. Sub-central tubercle absent in LV or obscured by ornament, very indistinct in RV. Eye tubercle small, spherical and prominent. Inner lamella rather narrow, widest anteriorly; avestibulate. Central muscle scars indistinct and partially obscured but conform to the typical *Mosaeleberis* pattern as described by Pokorný (1978, p. 146). Hinge hemiam-phidont. Posterior tooth small and feebly lobed, median element smooth; anterior tooth smooth.

Distribution.–The species was absent from the Trunch Borehole, and is restricted to the Coniacian in the outcrop samples. It is, however, a rare species present in only four samples; the basal *coranguinum* Zone of Newton by-Castle-Acre, Norfolk, the low *coranguinum* Zone at Euston, Suffolk and the Upper *coranguinum* Zone of South Pickenham, Norfolk.

Dimensions.–

	Length	Height
Holotype LV MPK 11748	0.69	0.45
Paratype LV MPK 11745	0.66	0.43
Paratype RV MPK 11746	0.68	0.45
Paratype RV MPK 11747	0.66	0.44

Remarks.–Gründel, 1970, recorded *Mosaeleberis* sp. from the Middle Turonian of Saxony, which is believed to be conspecific with the present species. Although Pokorný included Gründel's specimens in synonomy with *M. interruptoidea,* the present authors do not agree. Gründel's material is larger and the ornament is finer, with a double anterior rib extending parallel to the broadly rounded anterior margin; because of this Gründel's specimens are included in synonomy with *M. dictyotos* sp. nov. Pokorný (1978, p. 147) describes *M. interruptoidea* and *M.* ex. gr. *interruptoidea* (Van Veen, 1936) from the Lower and early Middle Turonian of Bohemia. The nominative species was originally recorded from the Maastrichtian of the Netherlands and is, in its shape and general ornament, very similar to the material of the present study, but differs in its smaller size (0.45-0.52 mm in length, compared to 0.66 to 0.68 for *M. dictyotos*). The ornament in the former species has larger reticulae and there is no double anterior rib. Pokorný notes that on examining several specimens from the Upper Maastrichtian, there are no important differences between these and those specimens occurring in the Lower and early Middle Turonian in Bohemia. In view of the considerable time difference, future statistical investigations "may reveal differences of sub-specific rank". The present authors believes it unlikely that the Turonian forms will prove conspecific with those from the Maastrichtian and the Maastrichtian specimens of Veen (p. 140, Pl. 3, Figs. 31-36), Howe & Laurencich (1958, p. 206) and Deroo (1966, p. 131, Pl. 18, Figs. 504-510) should be retained as *M. interruptoidea* and the Turonian forms revised as a new subspecies. The type species, *Mosaeleberis interrupta (*Bosquet, 1847) differs from the present material in the pattern of reticulation and the presence of a distinct median rib. Pokorný (1978, p. 153) discusses this species and describes the ornament in the following terms "in the ventral intercostal field of *M. interrupta*, the longitudinal riblets are strong and dominating, being weakly developed only in the narrow stripe ventral to the median ridge". In *M. dictyotos*, the reticulate ornament covers the entire lateral surface and is equally developed throughout. The longitudinal riblets are well formed and distinct, but less strongly developed than in the type species or either of Pokorný's species from the Coniacian of Bohemia. *M. crassa* (Pokorný, 1978, pp. 153-154, Pl. 5) differs in the presence of a large hinge ear in the left valve, with prominent median and dorsal ribs, it is also larger than the present material. *Mosaeleberis bohemica* (Pokorný, 1978, pp. 149-153, Pl. 2, Figs. 1-2; Pl. 3, Figs. 1-4; Pl. 4, Figs. 1-4, Text-Figs. 5, 6) is also much larger (L = (males 0.88-0.92, females 0.76-0.83) and differs in outline and in the presence of a large hinge ear in the LV and a straight to slightly curved median rib extending from the sub-central tubercle. *M. propinqua* (Bosquet, 1854) as illustrated by Babinot *et al.* (1985, Pl. 64, Fig. 8) is of similar shape to the present species, with a double anterior rib but intercostal areas between the longitudinal ribs are finely punctate and the eye tubercle is also smaller. The posterior margin is more elongate with 4 postero-ventral spines; the first two being twice as long as the last two. Bless (1988, p. 64, Pl. 1, Figs. D, E; p. 66, Pl. 2, Fig. F) illustrates *M. ex gr. rutoti* Deroo, 1966, from the Upper Campanian of South Limburg, which is identical in shape and valve tumidity to the present species but has a smooth, featureless surface.

Mosaeleberis pseudomacrophthalma sp. nov.
(Pl. 3; Figs. 28-32; Pl. 4, Figs. 1-3)

Derivatio nominis.–Referring to its similarity to *M. macrophthalma* (Bosquet, 1847).

Holotype.–Female LV MPK 11758.

Type locality and level.–South Pickenham, Norfolk. Coniacian *coranguinum* Zone.

Material.–12 specimens.

Diagnosis.–A medium species of *Mosaeleberis*, with large hinge ear in the LV, four or five short postero-ventral spines or denticles, prominent sub-central tubercle separate from short, thick median rib; intercostal areas smooth.

Description.–Medium. Subquadrate in lateral view, carapace fusiform in dorsal view. Anterior margin broadly rounded with a delicate marginal rib which is faintly plicated; apex at approximately mid-point. Posterior margin pointed with apex at about mid height and with concave postero-dorsal and convex postero-ventral slopes, the latter bearing strong denticles. LV larger than RV with distinct overlap. LV with large hinge ear, dorsal margin behind hinge ear straight. Hinge ear absent in RV, dorsal margin entirely straight. Eye tubercle hemispherical and distinct, less so in RV. Ventral margin in both valves partially obscured by a ventro-lateral rib. Sexual dimorphism distinct, males more elongate and less inflated, females slightly higher and less elongate, posteriorly broader and less acute. Sub-central tubercle small but distinct, hemispherical. A short, thick median rib separate from sub-central tubercle extending almost to the posterior; intercostal areas smooth. Inner lamella relatively narrow anteriorly, widest posteriorly. Hinge holamphidont, strongly developed. Other internal features as for genus.

Distribution.–The species was absent from the Trunch Borehole and ranges in the outcrop samples from Coniacian to topmost Lower Campanian/basal Upper Campanian in Norfolk but is absent in the Santonian. It was recorded in the Coniacian *coranguinum* Zone of South Pickenham, in the Lower Campanian restricted *quadrata* Zone of Stiffkey (locality 1, absent at locality 2), the ?*pilula* Zone of Wells and in the topmost restricted *quadrata* Zone (upper Lower Campanian) or basal mucronata Zone (basal Upper Campanian) of Bawburgh, Norfolk.

Dimensions.–

	Length	Height
Holotype female LV MPK 11758	0.65	0.45
Paratype female RV MPK 11759	0.63	0.42

	Length	Height
Paratype female C MPK 11760	0.65	0.43
Paratype female RV MPK 11761	0.63	0.42
Paratype A-1 juvenile MPK 11762	0.60	0.39
Paratype male RV MPK 11763	0.68	0.44

Remarks.–This species is similar to *M. macrophthalma* (Bosquet, 1847) but has a much larger hinge ear in the LV and a stronger median rib; it is significantly smaller with a more restricted range (Coniacian to uppermost Lower Campanian/basal Upper Campanian; the latter species occurring in the Santonian to Campanian in British records (Neale, 1978, p. 366) and in the Lower Maastrichtian of the Netherlands. *M. macrophthalma* occurs in the Upper Coniacian to Lower Maastrichtian in the present study, which may represent an extension of its known stratigraphical range. Adults of *M. pseudomacrophthalma* sp. nov. (L = 0.63-0.68 mm), are the same size as juvenile specimens of Bosquet's species (adult length range from 0.73 to 0.76 mm). If *M. pseudomacrophthalma* did not exhibit a typically adult hingement, it might be considered as the juvenile of *M. macrophthalma*; differences in ornament and size make this unlikely. The present authors are satisfied that the two are not conspecific.

Genus *Spinoleberis* Deroo, 1966
Spinoleberis ceraunos sp. nov.
(Pl. 4; Figs 4-15)

Derivatio nominis.–Gr. *κεραυνος* - keraunos, a thunderbolt or stone supposed to have fallen from the sky, from the fanciful resemblance of the surface ornament of this species to that of a stony meteorite.

Holotype.- Female LV MPK 1638.

Type locality and level.–Trunch Borehole, Upper Campanian, Weybourne Chalk.

Material.–More than 150 specimens.

Diagnosis.–A medium species of *Curfsina* characterised by its distinct ornament; anterior part of lateral surface covered with small, regularly distributed puncta; area behind large, smooth sub-central tubercle comprising several deep, rectangular pits.

Description.–Medium. Thick shelled. Subquadrate in lateral view; Strongly bilobate and with wide, dentate anterior rim when carapace seen in dorsal view. Anterior margin broadly rounded with 4-5 denticles in LV, 3 in RV, apex at about mid-height. Strong marginal rim. Posterior margin narrow, caudate, elongate, pointed, apex at mid-height and with thick marginal rib. Dorsal margin straight, broken by three short spines which extend beyond the margin. Ventral margin straight, spinose with a larger postero-ventral spine,

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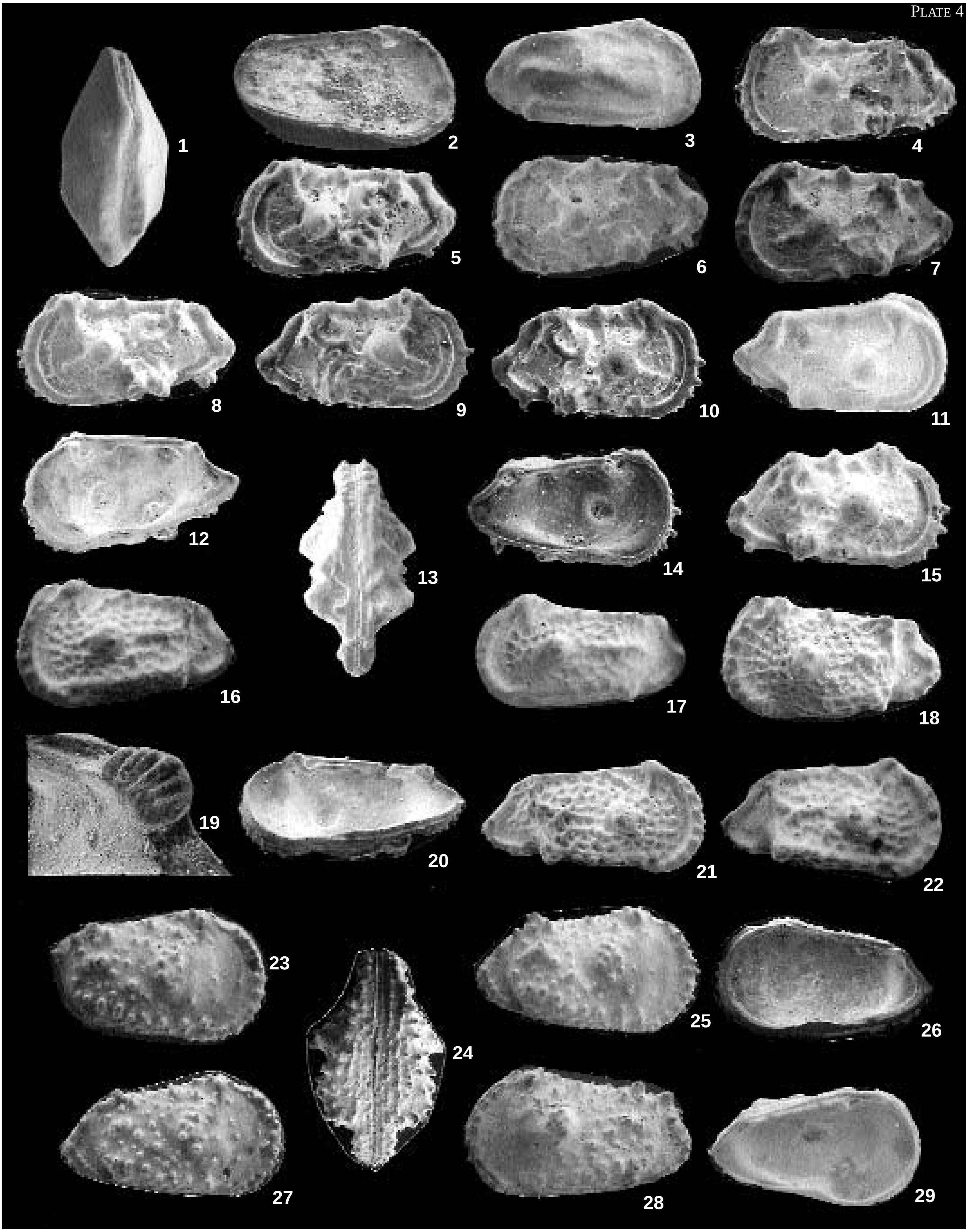
Plate 4–*1-3*, *Mosaeleberis pseudomacrophthalma* sp. nov. *1*, paratype, female carapace, dorsal view, MPK 11760, x 80. *2*, paratype, female left valve, internal view, MPK 11759, x 80. *3*, paratype, male right valve, external lateral view, MPK 12645, x 80. *4-15*, *Spinoleberis ceraunos* sp. nov. *4*, paratype, male left valve, external lateral view, MPK 11640, x 76. *5*, holotype, female left valve, external lateral view, MPK 11638, x 85. *6*, paratype, male left valve, external lateral view, MPK 11641, x 80. *7*, paratype, female left valve, external lateral view, MPK 11642, x 85. *8*, paratype, male left valve, external lateral view, MPK 11639, x 85. *9*, paratype, female right valve, external lateral view. MPK 11645. x 82. *10*, paratype, female right valve, external lateral view, MPK 11647, x 85. *11*, paratype, A-1 juvenile right valve, external lateral view, MPK 11650, x 100. *12*, paratype, female right valve, internal view, MPK 11643, x 85. *13*, paratype, female carapace, dorsal view, MPK 11649, x 82. *14*, paratype, female left valve, internal view, MPK 11644, x 85. *15*, paratype, female right valve, external lateral view, MPK 11646, x 85. *16-22*, *Cythereis campanianica* sp. nov. 16, paratype, female left valve, external view, MPK 11666, x 50. *17*, paratype, male left valve, external lateral view, MPK 11667, x 45. *18*, holotype, female left valve. external lateral view, MPK 11668, x 50. *19*, same specimen, detail of posterior hinge element, x 746. *20*, paratype, male right valve, internal view, MPK 11670, x 50. *21*, paratype, male right valve, external lateral view, MPK 11669, x 50. *22*, paratype, female right valve, external view, MPK 11671, x 50. *23-29*, *Cythereis ornatissima* (Reuss) *icenica* subsp. nov. *23*, paratype, left valve, external lateral view, MPK 116783, x 50. *24*, paratype, carapace, ventral view, MPK 11684, x 50. *25*, holotype, female right valve, external lateral view, MPK 11681, x 50. *26*, paratype, A-1 juvenile right valve, internal view, MPK 11685, x 54. *27*, paratype right valve, external lateral view, MPK 11680, x 50. *28*, paratype, left valve, external lateral view, MPK 11682, x 50. *29*, paratype, A-1 juvenile left valve, internal view, MPK 12646, x 54.

PLATE 4



and a shorter spine behind. Eye tubercle connected to anterior marginal rib and joined to the large, boss-like sub-central tubercle by a short, straight rib; a second rib of equal size and thickness connects the tubercle with the antero-ventral part of the valve but this does not join the anterior marginal rib. Sub-central tubercle is slightly larger in LV, more so in females. Sexual dimorphism pronounced; males longer, anterior margins more spinose, females less elongate, broader, more inflated, dorsal margins slightly shorter, less spinose. Earlier stage juveniles are entirely punctate, later stage juveniles more like the ornament of the adult; subcentral tubercles and marginal and posterior ribs, eye tubercle and posterodorsal and postero-ventral processes evident at an early stage of development. Anterior part of lateral surface covered with very small, regularly spaced puncta grouped into sub-rectangular arrangements, 9-12 in each group; area behind large, smooth sub-central tubercle comprising several deep, rectangular pits which are especially clear in LV, more irregular in RV; anterior and posterior marginal ribs smooth with a narrow area behind this rib which is also smooth. Posterior area behind the rectangular pits and in front of the posterior marginal rib with small, circular puncta similar to those of the anterior area. Sub-central tubercle clear in internal view of adult; marginal zones moderately broad, widest at anterior, avestibulate; marginal pore canals indistinct, few, widely spaced, straight and simple. Hinge holamphidont, strongly developed. Other internal features not seen.

Distribution.–In the Trunch Borehole, the species ranges from the Lower Campanian *O. pilula* Zone (7; FAD SAG 602) to the Lower Maastrichtian pre-*Porosphaera* Beds (15; LAD SAG 217). In the outcrop samples, it is present in the Upper Campanian basal *mucronata*, Eaton, Weybourne, Beeston and Paramoudra chalks (10-14) and in the Lower Maastrichtian pre-*Porosphaera* Beds of Sidestrand and the *O. lunata* and Grey Beds at Trimingham.

Dimensions.–

	Length	Height
Holotype female LV MPK 11638	0.66	0.40
Paratype male LV MPK 11639	0.70	0.38
Paratype male LV MPK 11640	0.70	0.37
Paratype male LV MPK 11641	0.72	0.37
Paratype female LV MPK 11642	0.66	0.41
Paratype female RV MPK 11643	0.62	0.38
Paratype female LV MPK 11644	0.66	0.41
Paratype male RV MPK 11645	0.69	0.38
Paratype female RV MPK 11646	0.64	0.40
Paratype female RV MPK 11647	0.66	0.40
Paratype male C MPK 11648	0.69	0.38
Paratype female C MPK 11680	0.66	0.40
Paratype A-1 juv. C MPK 1650	0.57	0.28

Remarks.–Two distinct forms can be identified based on differences in size, ornament and stratigraphical range. One is slightly larger (average adult lengths 0. 66 to 0.72), more elongate and conforms to the species diagnosis and description; the ornament is distinctive; tiny regular puncta on the anterior lateral surface, a large sub-circular sub-central tubercle and numerous deep and irregular to rectangular pits on the posterior lateral surface. Juveniles have a more spinose ornament but, even in the early instars, the anterior and posterior marginal rims and the large sub-central tubercle are evident. The other form is smaller (length = 0.63 mm) and characterized by a broader, less spinose anterior margin and, in the LV, has 7-8 small, round tubercles. This species seems closest to *S. ectypus* Babinot, 1973, from the Turonian of southern France, but the latter species is smaller, much more irregularly tuberculate and lacks the rather regular reticulum of the present species.

Genus *Cythereis* Jones, 1849
Cythereis campanianica sp. nov.
(Pl. 4; Figs. 16-22)

Derivatio nominis.–Named for its apparent restriction to the Upper Campanian.

Holotype.–Female LV MPK 11668.

Type locality and level.–Upper Campanian, Beeston Chalk, Caistor St Edmund, Norfolk.

Material.–12 specimens.

Diagnosis.–A large, elongate species of *Cythereis* with strong paramphidont hinge, broad anterior denticulate rib, large subcentral tubercle bearing 3 small rounded tubercles. Median rib in LV short, straight, absent or reduced in RV.

Description.–Large. Elongate subrectangular. Anterior margin broadly rounded with apex at mid-height. Posterior margin caudate with apex below mid-height. Dorsal margin straight, slightly spinose and inclined towards the posterior and with strong antero-dorsal hinge ear in LV. Ventral margin largely obscured by ventro-lateral rib. A strong, broad denticulate rib borders the anterior margin, paralleled by a weaker, more proximal rib; area between the two ribs smooth. A short curved rib extends downward from the large hemispherical eye tubercle towards the large, boss-like, tuberculate subcentral tubercle, which it fails to reach. Dorsal rib feebly developed. Median rib short, straight, not connected to subcentral tubercle. Intercostal areas regularly reticulate. Strong sexual dimorphism; males more elongate than females. Hinge strongly paramphidont with, in the RV, curved terminal elements bearing 4 strong teeth anteriorly and 6 posteriorly. Other internal features as for genus.

Distribution.–Absent in the Trunch Borehole and rare in the outcrop samples. Restricted to the Upper Campanian Beeston and Paramouda chalks at several localities.

Dimensions.–

	Length	Height
Holotype female LV MPK 11668	0.80	0.43
Paratype female LV MPK 11666	0.80	0.43
Paratype male LV MPK 11667	0.85	0.40
Paratype male RV MPK 11670	0.84	0.41
Paratype female RV MPK 11671	0.81	0.42
Paratype female RV MPK 11673	0.81	0.42

Remarks.- Similar in shape and disposition of ribs to *Cythereis agedincumensis* Damotte (1964, p. 320, Pl. 1, Fig. 4 a-d) from the Upper Campanian of the Paris Basin, also recorded by Damotte (1965, 1971, p. 75), from the Upper Santonian sporadically into the basal Upper Campanian. This is smaller than the present species (L = males 0.71-0.73), although Babinot *et al*. (1985) figured specimens of *C. agedincuminensis* which are closer to the present material, but differ in having a smaller, less tuberculate subcentral tubercle and a narrower anterior rib with less prominent denticles. The ornament of the present species is more delicate than that of *Cythereis hirsuta* Damotte & Grosdidier or *C. reticulata* Jones & Hinde, as illustrated by Witte *et al*. (1992, Pl. 6, 1-3, 7). Both are broader and less elongate. Kaye (1964), in revising Jones & Hinde, illustrated the latter species (Pl. 8, Figs. 16-19) showing its heavily calcified valves and the strongly inflated carapace as seen in dorsal view, with a double row of anterior tubercles and 6, short posterior spines. The ventral rib is also more spinose than that of the present species and the eye tubercle larger. *C. neumannae* Colin, 1974 (Pl. 2, Fig. 1, 2) is similar but is smooth anteriorly, has a narrower anterior rib and is larger (L = 0.93-1.10).

Cythereis ornatissima (Reuss) *icenica* subsp. nov.
(Pl. 4; Figs. 23-29)

Derivatio nominis.–icenica refers to the occurrence of the subspecies in Norfolk, after the Iceni, the Celtic tribe in this area during the Iron Age.

Holotype.–RV MPK 11681.

Type locality and level.–Lower Maastrichtian, Grey Beds of Trimingham, SAG 2007.

Material.–20 specimens.

Diagnosis.–A large subspecies of *C. ornatissima*, characterized by its smooth anterior marginal area in front of the subcentral tubercle with only a double row of indistinct tubercles; the subcentral tubercle spinose, with a ring of five nodes; ventral rib reduced to a series of tubercles; a second row of four postero-ventral tubercles below the first.

Description.–Large. Rather inflated. Thick shelled. Sub-rectangular in lateral view. Sub-quadrate in dorsal view of the complete carapace, with double row of short, regularly spaced spines along the dorsal margin. Anterior margin broadly rounded, spinose with a tuberculate anterior rib. Posterior margin with strong marginal rim; pointed at mid-height, especially in RV. Dorsal and ventral margins straight, convergent posteriorly. Eye tubercle small but distinct. Some specimens with a short rib extending down from the eye tubercle in LV, this is absent in the RV. Anterior area in front of sub-central tubercle smooth apart from a ventral double row of very faint tubercles, five in each row. Subcentral tubercle prominent, spinose with a ring of 5-6 very small nodes. Dorsal margin spinose, 6 short spines and a larger postero-dorsal spine. In the RV, there are a further 2 spines, in the LV, and a second spine behind the posterodorsal one. Dorsal rib absent or reduced; posterior margin narrow and acute, postero-dorsal slope with 2 short spines; postero-ventral slope more spinose with a clear rib with a further 4 spines. Ventro-lateral rib reduced to 7-8 spines; in posterior of valve, a second row of four spines almost extends to the upper row. Below the postero-dorsal spine, is a postero-ventral spine of equal size. Ornament largely restricted to posterior, consisting of rounded tubercles or short spines; median rib reduced to two larger tubercles at mid-point between postero-dorsal and postero-ventral spines. Sexual dimorphism not observed. Internal features as for genus and species.

Distribution.–In the outcrop samples, this subspecies is restricted to the Lower Maastrichtian pre-*Porosphaera* Beds of Sidestrand and the Grey Beds of Trimingham, Norfolk.

Dimensions.–

	Length	Height
Holotype. RV MPK 11681	0.90	0.49
Paratype RV MPK 11680	0.85	0.43

	Length	Height
Paratype LV MPK 11682	0.88	0.48
Paratype RV MPK 11683	0.85	0.44
Paratype C MPK 11684	0.86	0.47
Paratype A-1 juv. RV MPK 11685	0.78	0.35

Remarks.–Differs sufficiently from *Cythereis ornatissima ornatissima* Reuss, 1846, to be considered a new subspecies. *C. ornatissima* as figured by Neale, (1978, p. 366, pl. 17, figs 10-12), ranges from the Campanian to Lower Maastrichtian in British records but is significantly larger than the present material (L = 0.99-1.08 mm), with a more spinose anterior margin. The anterior marginal area in front of the subcentral tubercle in the present material is smooth with a double row of faint tubercles, while in the RV in the nominative subspecies, these tubercles are larger and more distinct. The subspecies of Pokorný (1963) are all larger and more ornate. Kaye (1964) extensively revised *C. ornatissima* but neither described nor illustrated anything similar to the present subspecies (see Kaye, pp. 64-66; Pl. 8, Figs. 1, 2, 4, 6). *Cythereis coronata* Weaver, 1982, is similar to the present subspecies but the double row of small tubercles is more distinct. The present material differs in its more inflated valves, lack of a distinct anterior marginal rim and different marginal rib composition. *C. ornatissima icenica* subsp. nov. is slightly larger; its dorsal margin is straight and slopes less towards the posterior than in *C. coronata*. The former species also differs in its ornament; a series of circular tubercles and smooth intercostal areas compared to a reticulate network behind the sub-central tubercle. The material present subspecies is smaller and more spinose than *C. folkstonensis* Kaye, 1964 (p. 63, Pl. 7, Figs. 1-5). Both show reduction of the ventral ribs (6-7 in the former species, 9 in the latter species), but the latter lacks the median row of 6 tubercles behind the subcentral tubercle. Kaye (p. 63) notes that this is "the most diagnostic feature of *C. folkstonensis*". The subcentral tubercle is more spinose in the present material, consisting of a ring of 5-6 rounded nodes; Kaye's specimens have a smooth to weakly spinose rounded tubercle, with a clear longitudinal row of tubercles along the reduced dorsal rib, a distinct anterior marginal rib and larger eye tubercle. The present material is similar in shape in lateral view and in dorsal and ven-

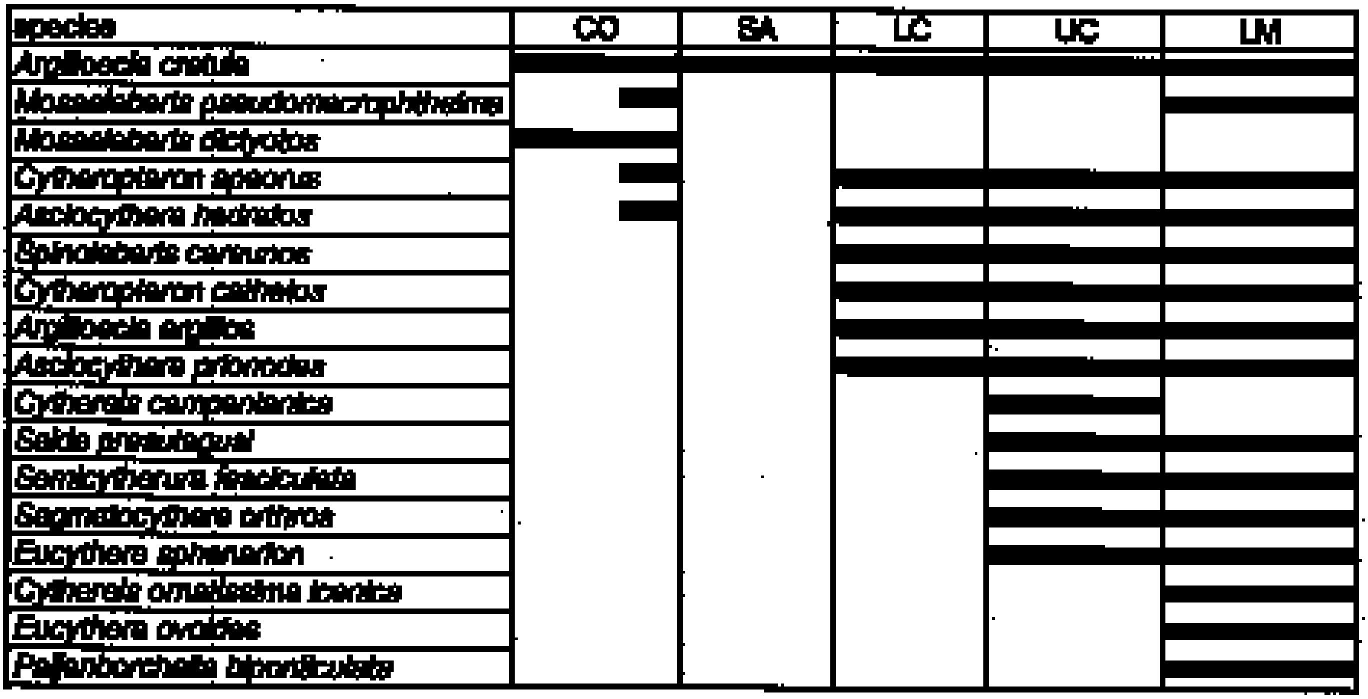


FIGURE 3–Biostratigraphical distribution by zone of the Ostracoda described in the paper in both the Trunch Borehole and outcrop samples by stage/substage.

tral carapace views to *Cythereis peturbatrix* Pokorný, 1965, illustrated by Gründel (1970, Pl. 2, Figs. 2-4) but this species differs in its smaller size and in the presence of a distinct anterior rib. Gründel reported a size range of 0.64-0.66 mm (females), 0.68-0.76mm (males). In the present material, the posterior apex is at or just below mid-height, while in *C. peturbatrix* it is well below mid-height.

CONCLUSIONS

The biostratigraphical distribution of the 17 new species/subspecies described in the present study at stage/substage level is given in Figures 2 and 3. The biostratigraphy of the total ostracod fauna of 145 species from the Coniacian to Lower Maastrichtian of East Anglia, from both the Trunch Borehole and the outcrop samples, forms the basis of a separate study (Pyne *et al.*, in prep.).

Whatley *et al.* (2003) demonstrate, on the basis of the percentage of filter feeding (Platycopina) ostracod specimens per sample that (in general terms) the Coniacian and particularly the Santonian, were episodes of low to very low oxygenation. This is not only reflected in the high levels of platycopid ostracods, but also in the overall ostracod low simple species diversity. The Lower Campanian was somewhat better (but still poorly) oxygenated, while dissolved oxygen levels in the Upper Campanian and Lower Maastrichtian were notably higher, with a much lower percentage of platycopids and a much higher overall ostracod species diversity. These generalized variations in the oxygen levels of East Anglian late Cretaceous seas are reflected in Fig. 2, with much higher diversity of new species occurring in the Upper Campanian and Lower Maastrichtian.

Five of the new species occur in the Coniacian but only one, *Mosaeleberis dictyos* is confined to the stage. All of the other four species are also present in the Lower Maastrichtian. *Argilloecia cretula* occurs in all the substages, *Asciocythere hadratos* and *Cytheopteron apeorus* occur in all but the Santonian, while *Mosaeleberis pseudomacrophthalma* only in the Coniacian and the Lower Maastrichtian, being absent from the three intervening substages.

The very low oxygen levels of the Santonian are reflected in the low ostracod diversity, with only the single new species, *Argilloecia cretula* occurring in this stage. The Lower Campanian, with 7 species is rather more diverse, but all seven of its species, the three inherited taxa and the newly appearing *Cytheropteron cathetos*, *Argilloecia argillos*, *Spinoleberis ceraunos* and *Asciocythere prionodes*, all persist into the Lower Maastrichtian. Very notable is the sudden increase in diversity at zones 8 and 9, demonstrating the recovery of the ecosystem after the major oxygen crisis.

The diversity of new ostracod species in the Upper Campanian, with 12 species, is significantly improved. One species, *Cythereis campanianica*, is confined to the substage but the remainder, including the other 4 incoming taxa, *Saida prasategusi*, *Eucythere sphenarion*, *Semicytherura fasciculata* and *Sagmatocythere orthros* all also occur in the Lower Maastrichtian. The highest diversity, of 15 of the new species, occurs in the Lower Maastrichtian, where the three newly appearing species are *Cythereis ornatissima icenica*, *Eucythere ovoides* and *Paijenborchella biponticulata.*

A more detailed distribution of the 17 new species, by zone and subdivision of the stages is given in Figure 3.

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RECENT SUBANTARCTIC BENTHIC OSTRACOD FAUNAS FROM THE MARION AND PRINCE EDWARD ISLANDS ARCHIPELAGO, SOUTHERN OCEAN

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Abstract

Twenty-seven sea-floor samples from a depth range of 32-474 m around Marion Island in the Southern Ocean, mid-way between southern Africa and Antarctica, yielded fifty-nine species of benthic ostracods in at least thirty-six genera. This compares with twelve species which were collected from the Prince Edward Islands archipelago during the HMS *Challenger* expedition in 1874 (Brady, 1880). Zonation in the ostracod faunas can be related to changes with depth in the type and distribution of sea-floor benthos. The endemic nature of the fauna is reflected in the probability that thirty-four of the species are new. Five of these are formally described: *Dutoitella lesleyae, Hemicytherura branchae, Munseyella bissetae, Poseidonamicus whatleyi,* and *Rabilimis*? *marionensis.*

Keywords: Benthic Ostracoda, Marion Island, Southern Ocean, Recent, Taxonomy, Ecology.

Resumen

Se estudiaron los ostrácodos bentónicos procedentes de setenta y siete muestras de suelo recogidas en profundidades entre 32 y 474 m alrededor de Marion Island en el Océano Meridional, entre África del Sur y la Antártida. La asociación se encuentra compuesta por cincuenta y nueve especies pertenecientes a treinta y seis géneros, frente a las doce especies recogidas en el archipiélago de las Prince Edward Islands durante la expedición del HMS *Challenger* en 1874 (Brady, 1880). La zonación de las asociaciones de ostrácodos puede relacionarse con los cambios de profundidad en cuanto al tipo y distribución del bentos marino. La presencia de treinta y cuatro especies nuevas confirma la naturaleza endémica de esta fauna de ostrácodos. Cinco de ellas se describen formalmente en el presente trabajo: *Dutoitella lesleyae*, *Hemicytherura branchae*, *Munseyella bissetae*, *Poseidonamicus whatleyi* y *Rabilimis*? *marionensis.*

Palabras clave: Ostrácodos bentónicos, Marion Island, Océano Meridional, Reciente, Taxonomía, Ecología.

INTRODUCTION

Marion Island (46.8333°S, 37.833°E), and nearby Prince Edward Island (collectively: the Prince Edward Islands), form a small, isolated volcanic archipelago in the Southern Ocean, midway between southern Africa and Antarctica, and South America and Australia (Fig. 1). This report describes the benthic Ostracoda from 27 sea-floor samples collected in 1984 to 1989 during the annual relief of the SA government weather station on Marion Island by the South African Department of Transport vessel *SA Agulhas* (Fig. 2, Table 1). Sample sites range in depth from 32 m to 474 m, and originally constituted dredged rocks, algae and sediments and associated benthos, although the author had access to dried sediment residues only. A general account of the benthos and substrates has been given by Branch *et al.* (1993).

The only previous account of Ostracoda from the vicinity of Marion Island was by Brady (1880) who recorded twelve species from HMS *Challenger* station 145 in 50-150 fm near Prince Edward Island (46.800°S, 37.825°E) (Fig. 2), of which three were new (Table 2). A further important fauna, consisting of thirty species (15 new), of which seven species were common with station 145, was described from the three *Challenger* stations at the Kerguelen Island archipelago (Brady, 1880) (Table 2). For comparison, use can be made of the extensive documentation of Recent faunas from the SW Atlantic subantarctic and southern Argentinean areas: Skogsberg (1928, 1939), Hartmann-Schröder & Hartmann (1962) and the numerous works of Whatley and collaborators (Whatley *et al.*, 1987, 1988, 1995, 1996, 1997a, 1997b, 1998a). Syntheses of palaeozoogeo-

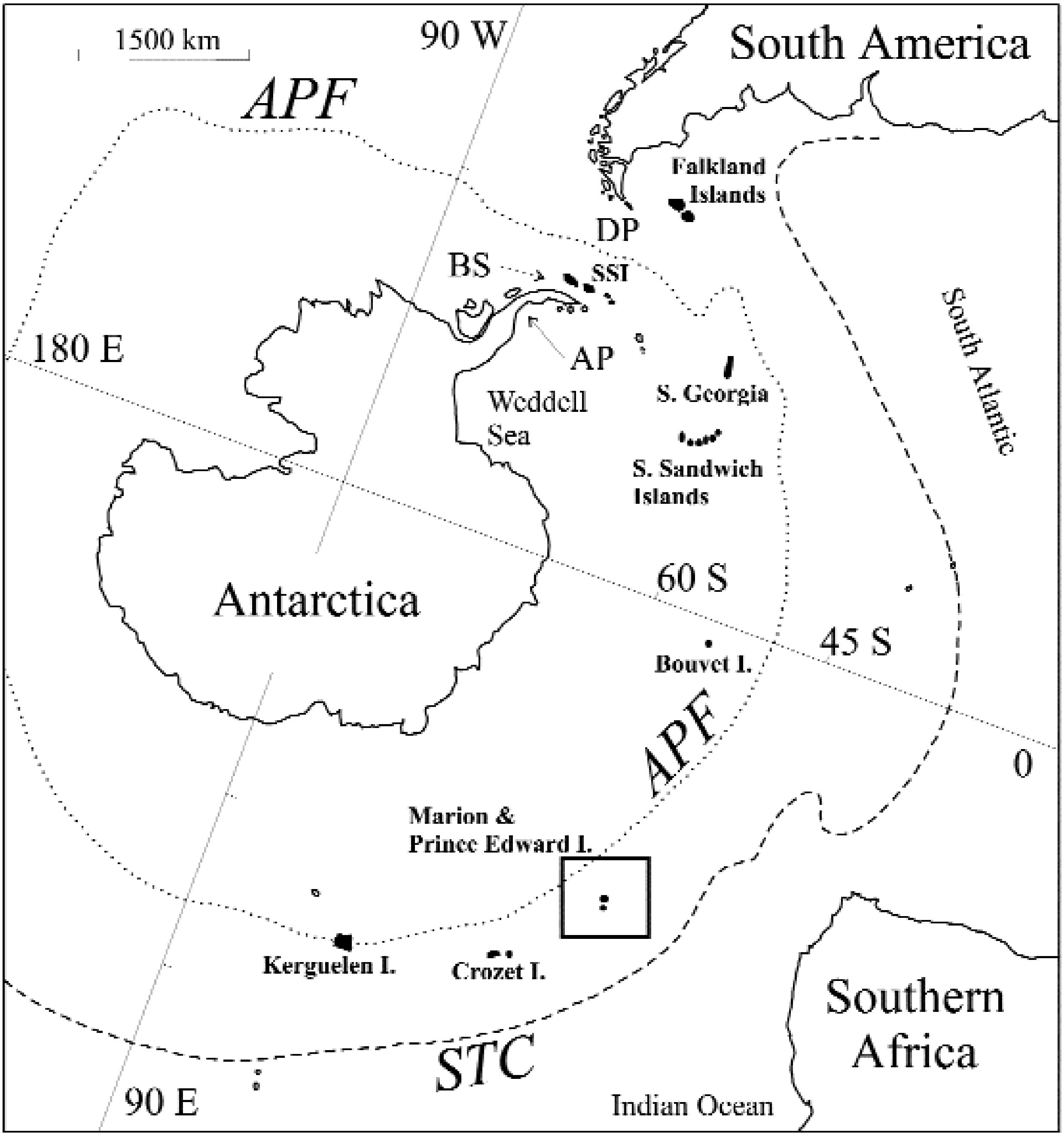

FIGURE 1–Location of Marion and Prince Edward islands in the Southern Ocean. APF= Antarctic Polar Front, STC= Sub-Tropical Convergence, DP= Drake Passage, AP = Antarctic Peninsula, BS= Bransfield Strait, SSI = South Shetland Islands. After Knox (1960). Distance scale is approximate for regions between 60 and 45°S.

graphy and provincial distribution from these works have been produced by Whatley *et al.* (1998c) and Wood *et al.* (1999). Further comparison can be made with the Antarctic faunas that have been described by Müller (1908), Benson (1964), Neale (1967), Hartmann (1988, 1989a, 1989b, 1990, 1992, 1993, 1997), Whatley *et al.* (1998b) and Whatley & Roberts (1999). In a related publication, Dingle (2002) has discussed endemism, insularity and the Quaternary colonisation of Marion Island by ostracods in relation to regional zoogeography and putative oceanographic changes during the southern high latitude Quaternary glaciations, while particular evolutionary problems posed by some species found at Marion Island were also considered.

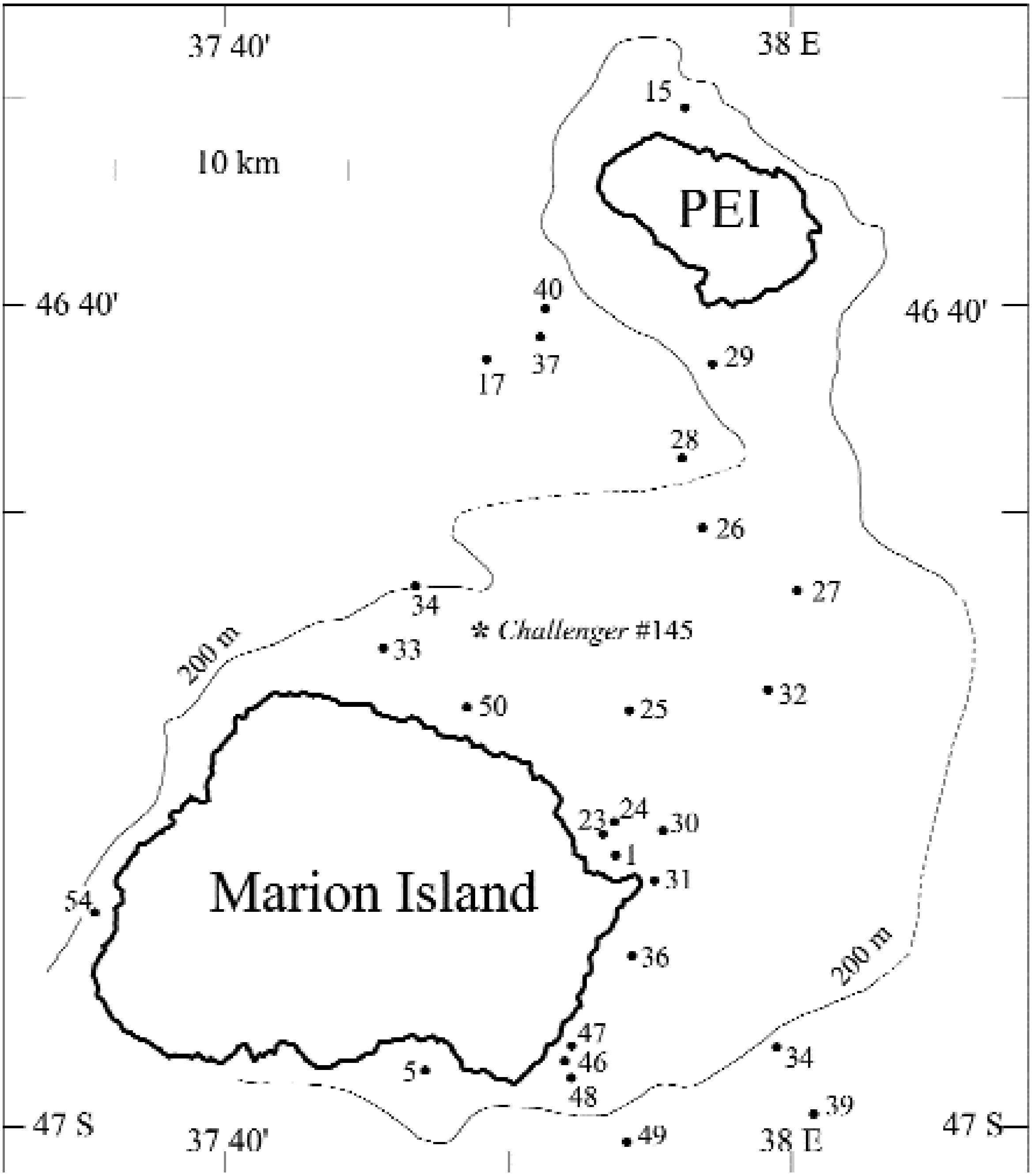

FIGURE 2–Ostracod sample sites around Marion Island and *HMS Challenger* station 145. After Branch *et al.* (1993), Dingle (2002).

OCEANOGRAPHICAL SETTING OF MARION ISLAND

Marion Island lies ~6 degrees of latitude south of the Sub-Tropical Convergence, south of southern Africa (Lutjeharms, 1985), while the Antarctic Polar Front lies to the south of the islands at ~49°S (Fig. 1). The Subantarctic Water surrounding the archipelago typically has surface temperatures of 6-7°C. Generally, the difference between mid-summer and mid-winter mean sea-surface temperatures is only 1.5°C, although it can be as much as 4°C (from 9.0° to 5.1°C) and salinity can vary by 0.22‰ (from 33.89 to 34.11‰), when the weak Subantarctic Front (which normally lies at ~45°S) migrates across the islands (Lutjeharms, 1985; Branch *et al.*, 1993). Temperatures at 50 m are usually the same as at the surface, whereas at 200 m and 500 m they are 3-5°C and 2.5-3.5°C, respectively (Duncombe-Rae, 1989; Branch *et al.*, 1993). Marion Island lies within the “Roaring Forties” and experiences year round strong westerly winds and relatively rough sea conditions. It is swept by the Antarctic Circumpolar Current system (West Wind Drift), and mean sea surface velocities adjacent to the islands are ~20cm/sec from the west (Webb *et al.*, 1991), although the Prince Edward Islands themselves may lie in a stationary eddy (Perissinotto & Duncombe-Rae, 1990).

OSTRACOD FAUNAS OF MARION ISLAND

Fifty-nine species of Ostracoda belonging to at least thirty-six genera have been recorded from the 27 samples (Tab. 1). A total of ~13,900 specimens were extracted, and in terms of the total population available, which occupies depths from 32 to 474m, 95% belong to only 18 species (Tab. 1). In the following discussions of distribution and population composition, samples with fewer than 50 specimens (4 samples) have been disregarded.

Distribution with depth

Figure 3 shows variations with depth of the number of valves available for study, and an index of species diversity. The latter is the Fisher alpha index of species richness (Fisher *et al.*, 1943), which Murray (1991) successfully applied to studies of benthic foraminifera. Correlation between the richness index and number of valves in each sample is low ($R^2 = 0.0356$), so variations in population size do not seriously distort the diversity values. In depths shallower than 170 m, diversity generally increases offshore, but is very variable (<3 to 6), whereas between 200-300 m there is a plateau in values of 4-5. Particularly low values (<3) are encountered at two sites in ~360 m, while at the deepest site (474 m) species richness is again relatively high. Distribution with depth of the ostracod species comprising >95% of the total population is shown in Figure 4. Five depth-related ostracod assemblages can be characterised by a dominant taxon which constitutes a mean of ~20-50% of the population, plus various abundant and common species (Table 3).

Relationship of ostracod assemblages 1-5 to macrobenthos

At the Prince Edward Island archipelago, Branch *et al.* (1993 p. 32) reported relationships between depth and substrate to degree of sea-floor cover by, and relative numbers, and types of macrobenthos. Inshore areas (38-98 m: Group G) are dominated by dense algae growing on sand, rock and gravel; intermediate areas (45-368 m: Groups A & B) are dominated by Polychaeta, Porifera, Brachiopoda, Ophiuroidea, Bivalvia, Echinoidea, and especially, Bryozoa, living on sand and mud, with accompanying algal cover to ~150-180 m; while deep areas (289-690 m: Groups C, & D) are dominated by large luxuriant upright branching Octocorallia, with Porifera, Bryozoa, Isopoda and Crinoidea living on rock and sand. The relationship of these macrobenthos groups (all citations are from Branch *et al.*, 1993) to the ostracod assemblages is discussed below and shown in Figure 3 and Table 3.

Assemblage 1. These faunas occur in shallow (<~50m) isolated sites close to Marion Island, where sediments consist of sand and gravel, with dominant red algal cover and a preponderance of the decapod *Nauticaris marionis*. In these areas, many of the sites have a “unique” macrobenthos with <40% similarity with neighbouring sites. Sea-floor cover is ~32%, with animals contributing only ~2%. The ostracod faunas are dominated by *Meridionalicythere taeniata* with *Loxoreticulatum securifer* and abundant *Aurila* cf. *A. kerguelenensis* and common *Xestoleberis setigera*. This assemblage is characterised by variable species diversity (2.6-4.2), and is restricted to the relatively “warm” surface waters (mean temperatures in the range 9-5.1 ºC). No species are known to occur solely in this assemblage.

Assemblage 2. These faunas occur at shallow (~50-110 m) sites around Marion Island and on the plateau between it and Prince Edward Island, where sediments consist of soft sand/mud. Overall, they are

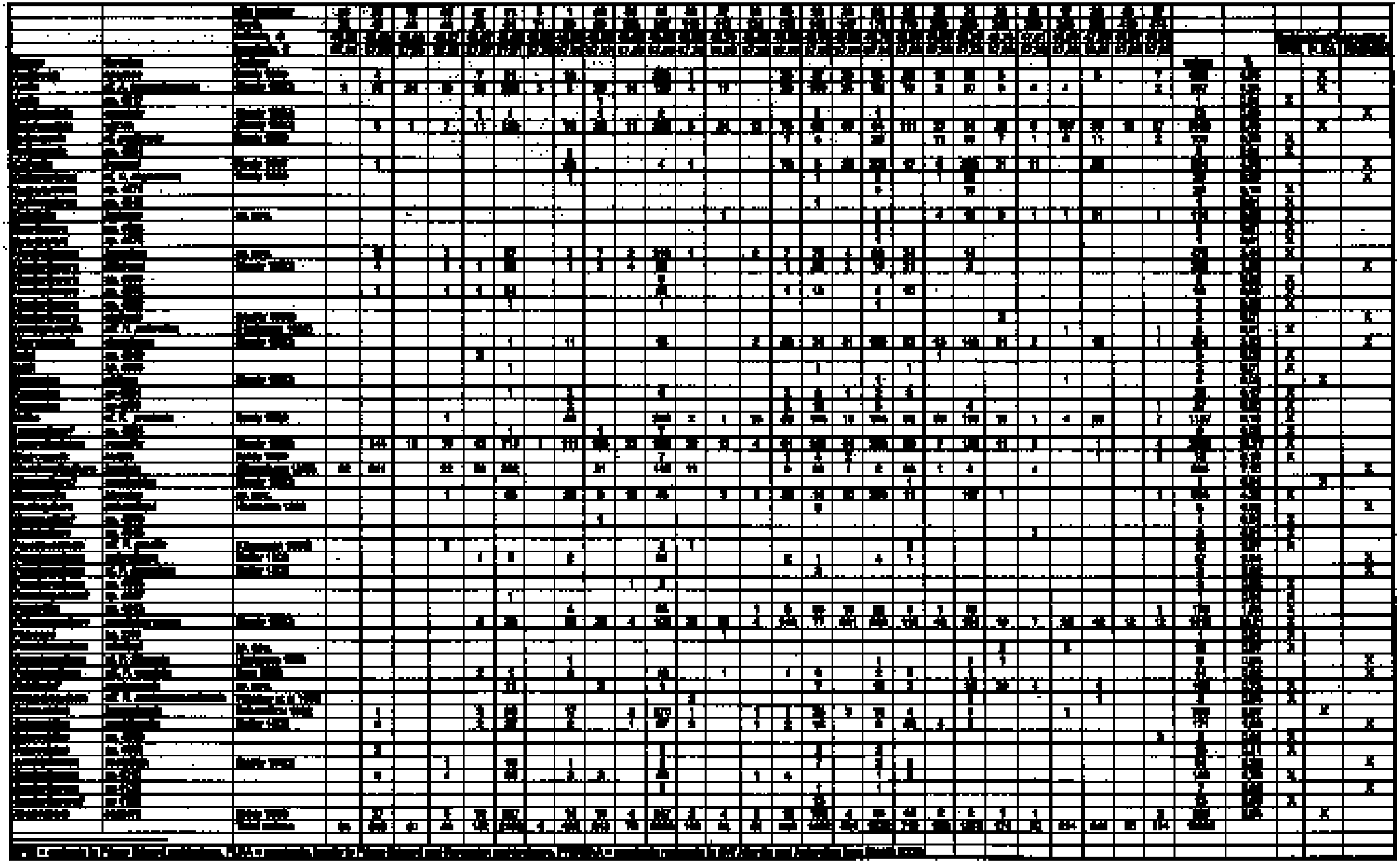

TABLE 1–Recent Ostracoda from Marion Island.

dominated by *Loxoreticulatum securifer* with abundant *Aurila cf. A. kerguelenensis* and *Bairdoppilata villosa* and common *Meridionalicythere taeniata*. Assemblage 2 occupies a zone of overlap between inshore and intermediate macrobenthos zones and the sea-floor is characterised by cover of ~ 42% dominated by Bryozoa (19%), tubicolous polychaetes (19%) and algae (8%), with abundant brachiopods, bivalves and ophiuroids. Two sites (47 & 48) have ostracod faunas that are subtly different to the others, with a lower percentage of *Hemicytherura branchae* sp. nov., an absence of both *Semicytherura costellata* and *Krithe* cf. *K. producta*, and a relatively large percentage of the rare species *Bairdoppilata angulata*. Branch *et al.* (1993) found that these samples had a sufficiently different dominant macrobenthos (various Tanaidacea, Decapoda, Bryozoa and Polychaeta) to place them in a separate grouping (G). The mean species diversity value is intermediate (3.6), but variable (range 3-5.1). Apart from singletons (6), two species are restricted to this assemblage: *Loxocythere*? sp. 4904 and *Paradoxostoma* sp. 4093. Sixteen species have their lower depth limits in this assemblage, while none have their upper depth limits therein.

					PEI	Kerguelen		
Genus	**species**		**Revised taxonomy**			**Balfour Bay**	**Christmas Harbour**	**Royal Bay**
Aglaia	*obtusata*	sp. nov.				X		
Argilloecia	*eburnea*	sp. nov.	*Argilloecia eburnea*	#		X	x	
Bairdia	*villosa*	sp. nov.	*Bairdoppilata villosa*	#	x	X	x	
Bairdia	*victrix*	Brady 1866					x	
Bythocypris	*reniformis*	Brady 1880	*Bythocypris* cf. *B. reniformis*	#	x			
Bythocythere	*pumilio*	sp. nov.	*Hemingwayella pumilio*			X		
Cypridina	*danae*	Brady 1880					x	
Cythere	*audei*	Brady 1868				x		
Cythere	*foveolata*	sp. nov.	*Loxoreticulatum foveolata*				X	
Cythere	*kerguelenensis*	sp. nov.	*Aurila* cf. *A. kerguelenensis*	#	x	x		x
Cythere	*parallelogramma*	sp. nov.	*Patagonacythere parallelogramma*	#	X			
Cythere	*polytrema*	Brady 1878	*Cativella bensoni* Neale 1967	#	x			
Cythere	*securifer*	sp. nov.	*Loxoreticulatum securifer*	#	X			
Cythere	*subrufa*	sp. nov.			x	X		
Cythere	[illegible]	sp. nov.	[illegible] [illegible] sp. nov.	#	x			
Cythere	*wyvillethompsoni*	sp. nov.				x	X	
Cytheropteron	*angulatum*	sp. nov.				X		
Cytheropteron	*australe*	sp. nov.					x	
Cytheropteron	*fenestratum*	sp. nov.					X	
Cytheropteron	*scaphoides*	sp. nov.	[illegible] *scaphoides*	#		X		
Cytherura	*costellata*	sp. nov.	*Semicytherura costellata*	#		X		
Cytherura	*lilljeborgi*	sp. nov.	*Hemicytherura lilljeborgi*	#		X		
Cytherura	*obliqua*	sp. nov.	*Kangarina obliqua*	#		X		
Krithe	*bartonensis*	(Jones) 1857					x	
Krithe	*producta*	sp. nov.	*Krithe* cf. *K. producta*	#	x			
Macrocypris	*decora*	(Brady) 1866					x	
Macrocypris	*maculata*	(Brady) 1866			x	x		x
Macrocypris	*tumida*	sp. nov.				x		X
Paradoxostoma	*abbreviatum*	Sars 1866	*Sclerochilus* [illegible] Müller 1908	#		x		
Polycope	*orbicularis*	Sars 1866					x	
Pseudocythere	*caudata*	Sars 1866	*Pseudocythere* aff. *P. caudata*	#	x	x	x	
Sclerochilus	*contortus*	(Norman) 1862	*Sclerochilus kerguelensis* Schornikov 1982	#		x		
Xestoleberis	*curta*	(Brady) 1866						x
Xestoleberis	*depressa*	Sars 1866				x		
Xestoleberis	*setigera*	sp. nov.	*Xestoleberis setigera*	#	X		x	
Xiphichilus	*complanatus*	sp. nov.					X	

x = presence, X = lectotype
\# = recorded from PEI in present study

TABLE 2–Ostracod species recorded by Brady (1880) from Prince Edward Islands and Kerguelen archipelago.

Assemblage 3. Samples containing these faunas were from soft mud or sand sea-floors in moderately deep water ~110-200 m. The dominant taxon is *Patagonacythere parallelogramma* with abundant *Loxoreticulatum securifer*, *Bairdoppilata villosa* and *Krithe* cf. *K producta*. This assemblage inhabits the zone which includes the boundary between algal and non-algal sea-floor cover (i.e. deeper sites with Group A and shallower sites with Group B macrobenthos) (Branch *et al.*, 1993). Overall sea-floor cover drops from 42% in Group A, to 18% (Bryozoa 13%, Polychaeta 3% dominant) in Group B, with brachiopods and echinoids becoming more, and less important, respectively. Although the composition of ostracod assemblage 3 remains relatively stable across the transition between macrobenthos Groups A and B, there is a reduction in the importance of *Xestoleberis setigera* (presumably coinciding with the disappearance of plant cover), and small increases in frequency and percentages of *Bairdoppilata angulata*, *Bythocypris* cf. *B. reniformis* and *Cativella bensoni*. Overall ostracod species diversity in this assemblage is relatively high (mean 4.4) and very variable (range 2.9-5.9), and is slightly higher in samples from

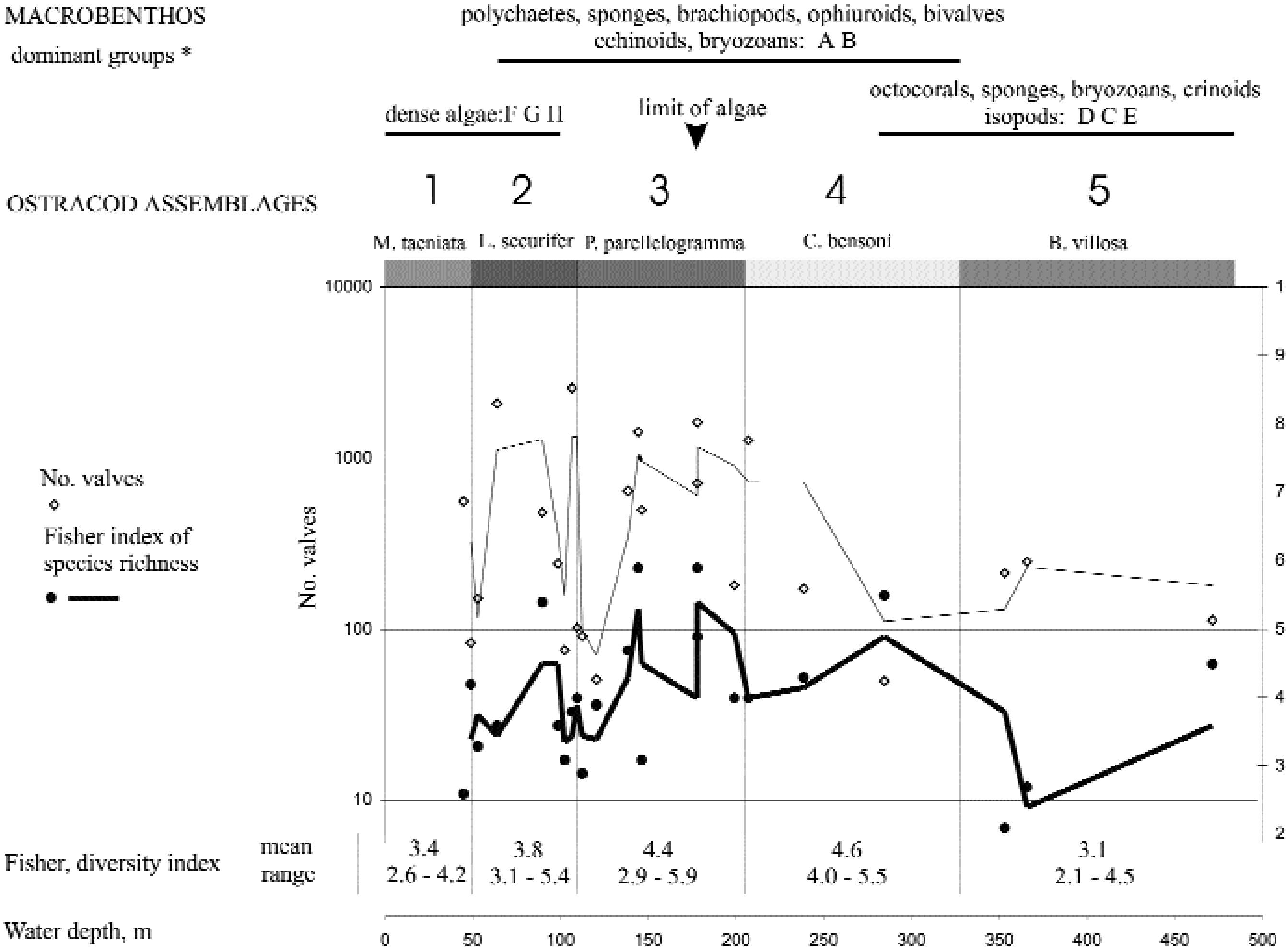

FIGURE 3–Variation in ostracod species diversity with depth at Marion Island expressed as Fisher alpha index of species richness (Fisher *et al.*, 1943; Murray, 1991). Number of valves available is also shown. Correlations are shown with dominant macrobenthos groups (based on Branch *et al*., 1993) and ostracod assemblages 1-5 (see Figure 4). Data are raw and smoothed 2 point means.

Branch *et al.'s* (1993) upper Group B compared to lower Group A (means 4.7 *vs* 4.1, respectively). Apart from singletons, no species are restricted to this assemblage, while eleven have their lower, and two their upper depth limits therein.

Assemblage 4. Samples with these faunas came from mixed sand/mud/ and rock bottoms in moderately deep water (208-286 m). The dominant ostracod taxon is *Cativella bensoni*, with abundant *Bairdoppilata villosa* and *Patagonacythere parallelogramma*, *Krithe* cf. *K producta*, and common *Rabilimis? marionensis* sp. nov. and *Henryhowella dasyderma*. *Bythocypris* cf *B. reniformis* is a characteristic component. Several rare species are also relatively more abundant in this assemblage: *Cytheropteron abyssorum*, *Cytheropteron* sp. 4873, and *Pseudeucythere* cf. *P. filiornata*, while *Dutoitella lesleyae* sp. nov. and *Poseidonamicus whatleyi* sp. nov. are both present. The macrobenthos falls into two categories: the deeper sites of Group B, and Group D which are characterised by dominant bryozoans, with ophiuroids and octocorals. The mean species diversity value for this assemblage is the highest (4.6) and the species richness progressively increases over the depth range from 4.0 to 5.5. Apart from singletons, no species are restricted to this assemblage, while eight have their lower, and one their upper depth limits therein.

Assemblage 5. Samples in this category come from deep (355-474 m), rocky environments. *Bairdoppilata*

Assemblage	Mean spp/sample	Depth	*Main substrate	*Benthos Groups & dominant macrobenthos	OSTRACODS Dominant	Abundant	Common
1	14	<50m	sand/gravel	LS - Algae	*Meridionalicythere laciniata* (Skogsberg) - 41% *Loxoreticulatum securifer* (Brady) - 23%	*Aurila* cf. *A. kerguelenensis* (Brady) - 13%	*Xestoleberis setigera* Brady - 8%
2	20	50-110m	sand/mud	A&G - Algae/bryozoa/polychaetes	*Loxoreticulatum securifer* (Brady) - 20%	*Aurila* cf. *A. kerguelenensis* (Brady) - 12% *Bairdoppilata villosa* (Brady) - 10%	*Meridionalicythere laciniata* (Skogsberg) - 8%
3	24	110->200m	sand/mud	A&B - Bryozoa/polychaetes	*Patagonacythere parallelogramma* (Brady) - 22%	*Loxoreticulatum securifer* (Brady) - 16% *Bairdoppilata villosa* (Brady) - 13% *Krithe* cf. *K. producta* Brady - 13%	
4	21	208-350m	sand/mud/rock	B&D - Bryozoa	*Cativella bensoni* Neale - 27%	*Bairdoppilata villosa* (Brady) - 10% *Krithe* cf. *K. producta* Brady - 12% *Patagonacythere parallelogramma* (Brady) - 12%	*Henryhowella dasyderma* (Brady) - 9% *Rabilimis? marionensis* sp. nov. - 8%
5	13	>350m	rock/gravel	B,C & LS - Octocorals	*Bairdoppilata villosa* (Brady) - 60%	*Patagonacythere parallelogramma* (Brady) - 13% *Dutoitella lesleyae* sp. nov. - 12%	*Krithe* cf. *K. producta* Brady - 6% *Cativella bensoni* Neale - 3%

* - based on Branch et al. 1993a
LS = low similarity

TABLE 3–Ostracod assemblages related to depths/substrate/macrobenthos.

villosa dominates this assemblage with a mean value of ~50%, accompanied by abundant *Dutoitella lesleyae* sp. nov. and *Patagonacythere parallelogramma* and common *Cativella bensoni* and *Krithe* cf. *K. producta*. *Henryhowella dasyderma* and *Poseidonamicus whatleyi* sp. nov. both occur locally in moderate numbers. *Bythocypris* cf. *reniformis* is a consistent, but minor component (mean 2.8%). The change from ostracod assemblage 4 (*Cativella bensoni*) to assemblage 5 (*Bairdoppilata villosa*) coincides approximately with a decrease in sea-floor animal cover from 18% in B (with dominant bryozoa) to 15% in C (with dominant octocorals), accompanied by a decrease in abundance of brachiopods, ophiuroids and bivalves. The depth of the change in the ostracod faunas cannot be located more precisely than 250-350 m, but Branch *et al.* (1993) indicate that the major macrobenthos change (which includes an increase in sponges, and the appearance of particular species of crinoids, isopods and bryozoans) coincides with an increase in incidence of rocky substrates (with interspersed patches of sand and gravel). This suggests that it may be unrelated to depth *per se*, although there is a strong thermal gradient at these depths from means of 3-5 °C at 200 m (upper limit of assemblage 4) to 2.5-3.5 °C at 500 m (assemblage 5) (Duncombe-Rae, 1989). Apart from one singleton, only *Hemingwayella* aff. *H. antarctica* Hartmann is restricted to assemblage 5, while six species have their lower, and one their upper depth limits therein.

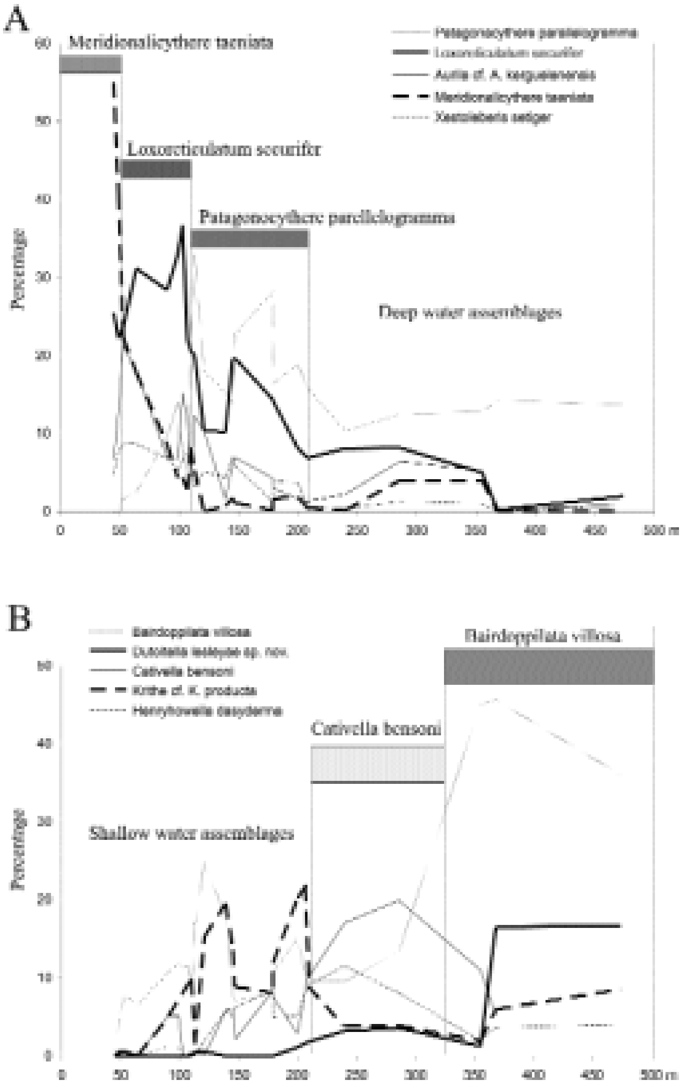

FIGURE 4–Distribution with depth of species comprising ~95% of total fauna. A. Shallow water assemblages. B. Deep water assemblages. Curves are 2 point means.

Of relevance to assessing the relationships between macrobenthos and ostracod faunas was the demonstration by Whatley & Wall (1975) that the distribution of phytal-living ostracods is more likely to be influenced by plant morphology and entrapped sediment types than changes in algal species. Hartmann-Schröder & Hartmann (1977) have discussed the general distribution of large brown macrophytes and ostracods in the southern oceans, and both works suggest that changes in algal cover around Marion Island would be accompanied by differences in the species of inhabiting ostracods. Of further interest are the observations by Whatley (1976) that high abundances of ostracods are found associated with bryozoa and hydroid colonies. Bryozoa are a very important and varied component of the macrobenthos in the aphotic zone around the Prince Edward Islands, and variations in abundance and species of ostracods with bryozoan types might be anticipated.

TAXONOMY

All types and figured specimens are located in the Natural History Museum (London) (NHM 2002.996-1071 or BMNH 80.38.119, 151; 1961.12.4.24), while additional specimens are lodged at the South African Museum, Cape Town (SAM MF1088-1157). Species in open nomenclature, figured and additional material (SA Museum specimens) are related to the author's SEM image data base (disc and photographic negatives) by cross referencing with a unique sequential number (RVD3967-4948). All specimen dimensions are in microns (1 = 0.001 mm).

Sub-Phylum CRUSTACEA Pennant, 1777
Class OSTRACODA Lattreille, 1806
Order PODOCOPIDA Müller, 1894
Suborder PODOCOPINA Müller, 1894
Superfamily BAIRDIACEA Sars, 1888
Family BAIRDIIDAE Sars, 1888
Subfamily BAIRDIINAE Sars, 1888
Genus *Bairdoppilata* Coryell, Sample & Jennings, 1935

Bairdoppilata villosa (Brady,1880)
(Plate 1, Fig.1)

1880 *Bairdia villosa* Brady: 50, Pl. 3, Figs. 3a-b, Pl. 5, Figs. 2a-g, Pl. 8, Figs. 4a-f.
1908 *Nesidea villosa* (Brady), Müller: 100.
1969 *Bairdoppilata (B.?) villosa* (Brady), Maddocks: 75, Figs. 40, 41a-c.
1976 *Bairdia villosa* Brady, Puri & Hulings: 266, Pl. Figs. 1-4.
1988 *Bairdoppilata villosa* (Brady), Neale: 717, Pl. 2, Fig. 3.
1997 *Bairdoppilata villosa* (Brady), Hartmann: 47, Text-Fig. 12.
2002 *Bairdoppilata villosa* (Brady), Dingle: Tab. 1.

Material.–1310 valves.

Additional specimens.–SAMMF1088 (RVD4085), 1089 (4086).

Remarks.–Brady (1880) recorded this species from Prince Edward Island (50-150 fm) and Kerguelen, where it was very abundant in Balfour Bay (20-50 fm, type locality). He also commented on the particularly hirsute nature of this species. It has been reported only from some of the subantarctic islands (including Macquarie), and Tristan d'Acunha, as well as Brady's own record from Australia (1880, Bass Strait) (queried by Hartmann, 1997). At Marion Island, *B. villosa* ranges in depth from 45-474 m, being common/abundant >90 m and particularly so deeper than 355 m.

Bairdoppilata angulata (Brady, 1870)
(Plate 1, Fig. 2)

1870 *Bairdia angulata* Brady: 199, Pl. 27, Figs. 11-12.
1880 *Bairdia angulata* Brady, Brady: 59, Pl. 11, Fig. 5a-d.
1915 *Bairdia angulata* Brady, Chapman: 38, Pl. 2, Fig. 3.
1969 *Anchistrocheles? angulata* (Brady), Maddocks: 113, Fig. 60h.
1976 *Anchistrocheles? angulata* (Brady), Maddocks: Pl. 2, Figs. 8-9, Pl. 7, Figs. 1-11.
1993 *Paranesidea* sp. Hartmann: 231, Pl. 2, Figs. 2-4.
1996 *Bairdoppilata angulata* (Brady), Whatley *et al.*: 55, Pl. 1, Figs. 1-2.
1997 *Anchistrocheles? angulata* (Brady), Hartmann: 53, Text-Fig. 15.
1998b *Bairdoppilata angulata* (Brady), Whatley *et al.*: 115, Pl. 1, Figs. 1-2.
2002 *Bairdoppilata angulata* (Brady), Dingle: Tab. 1.

Material.–12 valves.

Additional specimens.–SAMMF1151 (RVD4006), 1152 (4006).

Remarks.–This appears to be a subantarctic species. Whatley *et al.* (1996) recorded it from 990m in the Scotia Sea, while Brady (1880), Hartmann (1997) and Whatley *et al.* (1998b) recorded it from Magellan Strait (18-527m). Hartmann (1993) found it off eastern Tierra del Fuego in 190 m, and according to Hartmann (1997), it has also been found in southernmost New Zealand (by McKenzie, 1977). At Marion Island *B. angulata* has been found at six sites over a depth range 53-179 m.

Subfamily BYTHOCYPRININAE Maddocks, 1969
Genus *Bythocypris* Brady, 1880

Bythocypris cf. *B. reniformis* Brady, 1880
(Plate 1, Figs. 3-4)

1880 *Bythocypris reniformis* Brady: 46, Pl. 5, Figs. 1a-l.
1976 *Bythocypris reniformis* Brady, Puri & Hulings: 262, Pl. 2, Figs. 7-10, Text-Fig. 1.
?1978 *Bythocypris reniformis* Brady, Briggs: 29.
2002 *Bythocypris* cf. *B. reniformis* Brady, Dingle: Tab. 1.

Material.–104 valves.

Additional specimens.–SAMMF1134 (RVD3970), 1135 (3972).

Remarks.–The new material is identical to the topotypic specimen illustrated by Puri & Hulings (1976) from *Challenger* station 145 off Marion Island and has large vestibules that extend antero-ventrally, and canals that occur in relatively simple clusters of two or three with scalloped outlines along the distal margins of the vestibule. However, it differs from the lectotype from the West Indies (Puri & Hulings, 1976) which has smaller vestibules and complex, fan-like radial pore canals. It is suspected that the Prince Edward archipelago populations are a subspecies, which are also smaller and less elongate than the deep-water species (*B. kyamos*) described by Whatley *et al.* (1998b) from the Scotia Sea. At Marion Island, *B.* cf. *B. reniformis* has been found at ten sites over a depth range of 139 - 474 m. It is most common (maximum, 6%) at the deeper sites (200-474 m).

Bythocypris sp. 4894
(Plate 1, Fig. 5)

2002 *Bythocypris* sp. 1/6 Dingle: Tab. 1.

Material.–2 valves

Remarks.–These are probably juvenile valves (~430 microns), but are significantly less elongate than the adults of *B.* cf. *B. reniformis* (l/h: 1.59 *vs* 1.88). This very rare species occurs at site 1 only (9 m).

Superfamily CYPRIDACEA Baird, 1845
Family MACROCYPRIDIDAE Müller, 1912
Genus *Macrocypris* Brady, 1868
Macrocypris similis Brady, 1880
(Plate 1, Fig. 6)

1880 *Macrocypris similis* Brady: 42, Pl. 2, Figs. 2a-d.
1967 *Macrocypris* cf. *M. similis* Brady 1880, Neale: 7, Pl. I, Figs. s, s', t.
1976 *Macrocypris similis* Brady, Puri & Hulings: 260, Pl. 1, Figs. 13-14.
1998b *Macrocypris similis* Brady, Whatley *et al.*: 118, Pl. 1, Figs. 21-23.
2002 *Macrocypris similis* Brady, Dingle: Tab. 1.

Material.–18 valves.

Additional specimen.–SAMMF1099 (RVD4018).

Remarks.–All the specimens are probably juveniles, and most are fragmented and poorly preserved. Brady's (1880) type material is from deep water (650 fathoms) off Brazil, but he also recorded it from Patagonia and Ascension Island. In Antarctica and the subantarctic, it has been found at Halley Bay (~200 m), the western Antarctic Peninsula (2 m) and Scotia Sea (1340 m). At Marion Island the species was recovered from six sites ranging in depth from 107-474 m.

Family PONTOCYPRIDIDAE Müller, 1894
Genus *Argilloecia* Sars, 1866
Argilloecia eburnia Brady, 1880
(Plate 1, Figs. 7-8)

1880 *Argilloecia eburnia* Brady: 40, Pl. 4, Figs. 1-15.
1910 *Argilloecia eburnia* Brady, Chapman: 428.
1912 *Argilloecia eburnia* Brady, Müller: 395.
1919 *Argilloecia eburnia* Brady, Chapman: 20.
1969 *Argilloecia eburnia* Brady, Maddocks: 45, Figs. 8c, 33i.
1976 *Argilloecia eburnia* Brady, Puri & Hulings: 259, Pl. 2, Figs. 5-6.
1997 *Argilloecia eburnia* Brady, Hartmann: 266.
2002 *Argilloecia eburnia* Brady, Dingle: Tab. 1.
2002 *Australoecia* sp. 39/7 Dingle: Tab. 1.

Material.–688 valves.

Additional specimens.–SAMMF1104 (RVD4028), 1105 (4030), 1136 (3975), 1137 (3976).

Remarks.–This material is identical to the lectotype from Kerguelen (Puri & Hullings, 1976). Brady (1880) recorded this species as "plentiful" at two sites at Kerguelen (20-25 and 120 fathoms). At Marion Island it occurs at 15 sites over a depth range 45-474 m. It is most abundant (~9%) at site 24 in 107 m.

Superfamily CYTHERACEA Müller, 1894
Family BYTHOCYTHERIDAE Sars, 1926
Genus *Nodobythere* Schornikov, 1981
Nodobythere sp. 4916
(Plate 1, Fig. 9)

2002 *Bythocythere* sp. 49/5 Dingle: Tab. 1.

Material.–2 valves.

Remarks.–*Nodobythere* is a cold water genus first recorded by Schornikov (1981) from the subarctic Kurile Islands. Hartmann (1989) has found two species in Antarctica: *N. reticulata* and *N. insulelephantensis*. The Marion Island species is finely ornamented with delicate reticulation and ribs, and is closest to *N. insulelephantensis*, but differs in lacking a vertical median sulcus and possessing a more acuminate caudal process. Hartmann (1997) recorded *N. insulelephantensis* from 27-358 m in the South Shetland Islands. At Marion Island, *N.* sp. 4916 occurs at site 49 (286 m) only.

Genus *Nealocythere* Schornikov, 1982
Nealocythere schornikovi Hartmann, 1986
(Plate 1, Fig. 10)

1986 *Nealocythere schornikovi* Hartmann: 169, Text-Figs. 55-56.
1986 *Nealocythere* cf. *schornikovi* Hartmann: 170, Text-Fig. 66.
1987 *Nealocythere* cf. *schornikovi* Hartmann, Hartmann: 130.

1989a *Nealocythere* cf. *schornikovi* Hartmann, Hartmann: 215, Pl. II, Figs. 4-9, Text-Figs. 14-21.
1989b *Nealocythere schornikovi* Hartmann, Hartmann: 247, Pl. III, Fig. 9.
1997 *Nealocythere schornikovi* Hartmann, Hartmann: 177, Pl. 16, Figs. 6-9, Pl. 17, Fig. 4, Text-Fig. 66.
2002 *Pellucistoma* sp. 29/25, Dingle: Tab. 1.

Material.–3 valves.

Remarks.–Hartmann (1997) included two morphotypes in his species: elongate, with fine longitudinal plications over the whole valve surface, and a squatter variety with plications only in the posterior third. These are considered males and females, respectively. The latter is the morphotype found at Marion Island. The species has been recorded from South Georgia and the northern Antarctic Peninsula over a depth range 137-458 m (Hartmann, 1997). At Marion Island, this very rare species was encountered at site 29 (145 m) only.

Genus *Pseudocythere* Sars, 1866
Pseudocythere aff. *P. caudata* Sars, 1866
(Plate 1, Fig. 11)

1866 *Pseudocythere caudata* Sars: 88.
1908 *Pseudocythere similis* Müller: 106, Pl. X, Figs. 13-16.
1926 *Pseudocythere caudata* Sars, Sars: 239, Pl. 109, Fig. 2.
1964 *Pseudocythere* aff. *P. caudata* Sars, Benson: 13, Pl.1, Fig. 8, Text-Fig. 7.
1967 *Pseudocythere* cf. *P. caudata* Sars, Neale: 14, Pl. 1, Figs. Ia, b, e, f, Text-Fig. 5.
1978 *Pseudocythere caudata* Sars, Briggs: 29, Fig. 2.
1982 *Pseudocythere similis* Müller, Schornikov: 14, Pl. 5 Figs. 1-3, 8, 10, 12, Pl. 6, Figs. 1-10, Pl. 7, Figs. 1-3.
1988 *Pseudocythere similis* Müller, Hartmann: 148, Text-Fig. 9.
1989a *Pseudocythere similis* Müller, Hartmann: 218, Pl. II, Figs. 10-12.
1989b *Pseudocythere similis* Müller, Hartmann: 249, Pl. XIV, Figs. 4-7.
1990 *Pseudocythere similis* Müller, Hartmann: 209.
1992 *Pseudocythere similis* Müller, Hartmann: 411.
1997 *Pseudocythere similis* Müller, Hartmann: 187, Pl. 17, Figs. 6-9, Text-Fig. 70.
1998b *Pseudocythere* cf. *P. caudata* Sars, Whatley *et al.*: 119, Pl. 2, Figs. 6-7.
2000 *Pseudocythere* cf. *P. caudata* Sars, Dingle: 484.
2002 *Pseudocythere* cf. *P. caudata* Sars, Dingle: Tab. 1.

Material.–44 valves.

Additional specimens.–SAMMF1149 (RVD4000), 1150 (4003).

Remarks.–This is a cosmopolitan species which nei-ther Benson (1964) nor Neale (1967) could differentiate from Müller's species *P. similis*. It occurs at Halley Bay, in the Ross Sea, at Gauss Station,

→

PLATE 1–All specimens are from Marion Island. *1, Bairdoppilata villosa* (Brady, 1880), LV, site 24, NHM 2002.996, RVD4821. *2, Bairdoppilata angulata* (Brady, 1870), LV, site 29, NHM 2002.997, RVD4945. *3, Bythocypris* cf. *B. reniformis* Brady, 1880, LV, site 34, NHM 2002.998, RVD4917. *4, Bythocypris* cf. *B. reniformis* Brady, 1880, RV, internal view, site 34, NHM 2002.999, RVD4920. *5, Bythocypris* sp. 4894, LV, site 1, NHM 2002.1000, RVD4894. *6, Macrocypris similis* Brady, 1880, LV, site 24, NHM 2002.1001, RVD4893. *7, Argilloecia eburnia* Brady, 1880, RV, site 34, NHM 2002.1002, RVD4895. *8, Argilloecia eburnia* Brady, 1880, LV internal view, site 34, NHM 2002.1003, RVD4897. *9, Nodobythere* sp. 4916, carapace, left view, site 49, NHM 2002.1004, RVD4916. *10, Nealocythere schornikovi* Hartmann, 1986, RV, site 29, NHM 2002.1005, RVD4889. *11, Pseudocythere* aff. *P. caudata* Sars, 1866, RV, site 24, NHM 2002.1006, RVD4892. *12, Sclerochilus kerguelensis* Schornikov, 1982, RV, site 24, NHM 2002.1007, RVD4900. *13, Sclerochilus meridionalis* Müller, 1908, RV, site 24, NHM 2002.1008, RVD4901. *14, Sclerochilus* sp. 4886, RV, site 37, NHM 2002.1009, RVD4886. *15, Sclerochilus* sp. 4891, RV, site 39, NHM 2002.1010, RVD4891. *16, Loxocythere?* sp. 4904, LV, site 24, NHM 2002.1011, RVD4904. *17, Rotundracythere* aff. *R. austromarscotiaensis* Whatley *et al.*,1998b, carapace, right view, site 33, NHM 2002.1012, RVD4876. *18, Rotundracythere* aff. *R. austromarscotiaensis* Whatley *et al.*, 1998b, carapace, right view, detail of central, antero-dorsal region, site 33, NHM 2002.1012, RVD4877. Scale bars, microns: *500* - 1, 3, 4, 6; *200* - 2, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17; *50* - 18.

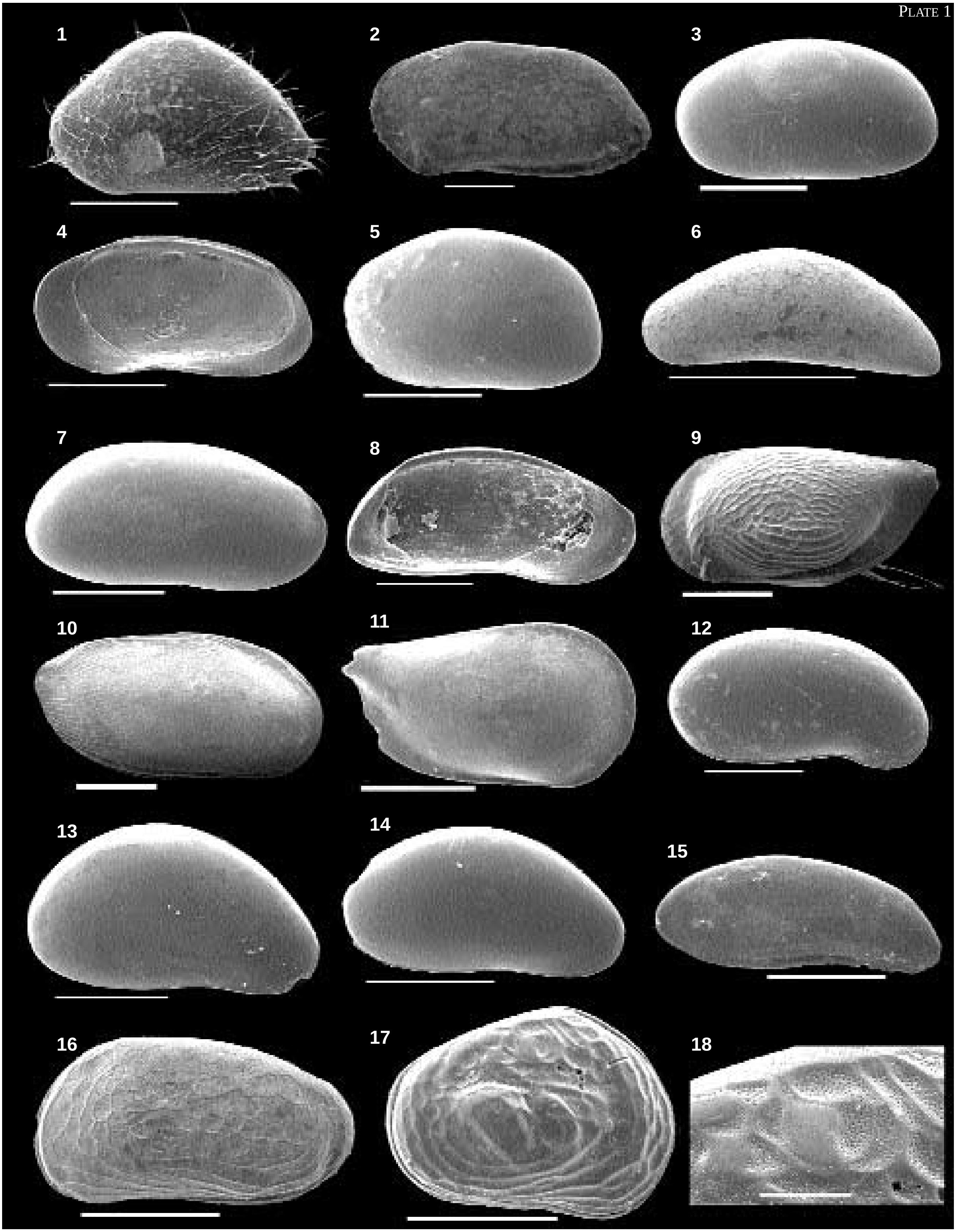
PLATE 1

various points in the Antarctic Peninsula and, according to Whatley *et al.* (1998b), at 2370 m in the Scotia Sea. The non-Scotia Sea sites give the species a depth range in the Antarctic of 125-427 m. At Marion Island it was found at ten sites within a depth range 53-208 m.

Genus *Sclerochilus* Sars, 1866
Sclerochilus kerguelensis Schornikov, 1982
(Plate 1, Fig. 12)

1880 *Sclerochilus contortus* (Norman, 1861) Brady: 147
1982 *Sclerochilus (Praesclerochilus) kerguelensis* Schornikov: 28, Pl. 18-19.
1997 *Sclerochilus (Praesclerochilus) kerguelensis* Schornikov, Hartmann: 206, Text-Fig. 77.
2002 *Sclerochilus kerguelensis* Schornikov, Dingle: Tab. 1.

Material.–369 valves.

Additional specimens.–SAMMF1102, 1103.

Remarks.–This species has a length/height ratio (~1.9) that is intermediate between those of *S. antarcticus* Müller 1908 and *S. reniformis* Müller 1908 (~2.2) and the relatively less elongate *S. meridionalis* Müller 1908 (1.8). It is also distinguished by its broadly rounded posterior outline. *S. kerguelensis* is confined to the Prince Edward-Kerguelen archipelagos, and at Marion Island it occurs at depths between 45-355 m. It is most abundant between 90-179 m.

Sclerochilus meridionalis Müller, 1908
(Plate 1, Fig. 13)

1880 *Paradoxostoma abbreviatum* Sars, Brady: 150, Pl. XXXV, Figs. 1a-d.
1908 *Sclerochilus meridionalis* Müller: 104, Pl. XIX, Figs. 8, 11, 14, Text-Fig. p. 104.
1967 *Sclerochilus meridionalis* Müller, Neale: 10, Pl. IV, Fig. d.
1982 *Convexochilus meridionalis* Müller, Schornikov: 16, Figs. 8-13.
1989b *Convexochilus meridionalis* Müller, Hartmann: 249, Text-Figs. 51-52.
1990 *Convexochilus meridionalis* Müller, Hartmann: 210.
1997 *Sclerochilus (Convexochilus) meridionalis* Müller, Hartmann: 201, Text-Fig. 76.
1998b *Sclerochilus meridionalis* Müller, Whatley *et al.*: 119, Pl. 2, Figs. 10-11.

*Materia*l.–171 valves.

Remarks.–This species has been widely recorded from Antarctic (Halley Bay, Antarctic Peninsula, Gauss station) and subantarctic (Kerguelen) sites in water depths ranging from ~200-400 m. It was recovered at Marion Island from 14 sites over a depth range of 45-208 m, and is most abundant (8%) at site 36 (179 m).

Sclerochilus sp. 4886
(Plate 1, Fig. 14)

2002 *Paradoxostoma* sp. 2 Dingle: Tab. 1.

Material.–2 valves.

Remarks.–This species is more elongate than *S. meridionalis* Müller, and is probably closer to *S. compressus* Müller 1908, which has been recorded from various Antarctic and subantarctic localities: Gauss station (Müller, 1908) and the southern Indian Ocean (Schornikov, 1982). At Marion Island, this very rare species was encountered at site 47 (474 m) only.

Sclerochilus sp. 4891
(Plate 1, Fig. 15)

2002 *Sclerochilus*? sp. 29/25a Dingle:

Material.–16 valves.

Remarks.–This species appears closest to *S. antarcticus* Müller, but is longer, narrower, has a more acuminate anterior margin outline, and possesses a distinct ventral margin "keel". At Marion Island it was recovered from four sites over a depth range 45-179 m.

Family CYTHERIDAE Baird, 1850
Genus *Loxocythere* Hornibrook, 1952
Loxocythere? sp. 4904
(Plate 1, Fig. 16)

2002 Indet. sp. 24/5, Dingle: Tab. 1.

Material.–9 valves.

Remarks.–This species is closest to *L. variasculpta* Whatley *et al.*, 1997a, which has a wide range of surface ornamentation. The Marion Island species is most similar to the finely punctate variety, but differs in the disposition of ribs, and in possessing a short posterior marginal rim and a more broadly rounded posterior outline. The muscle scars are very similar to those of *L. variasculpta*, and similarly, are externally celated. Whatley *et al.* (1997a) recorded *L. varias-*

culpta abundantly from littoral sites between ~ 40.5-49°S in Argentina, and in the Falkland Islands. At Marion Island, *Loxocythere*? sp. 4904 was recovered from three sites over a depth range 64-107 m.

Family EUCYTHERIDAE Puri, 1954
Genus *Rotundracythere* Mandelstam, 1958
Rotundracythere aff. *R. austromarscotiaensis* Whatley *et al.*, 1998b
(Plate 1, Figs. 17-18)

?1978 "*Rotundracythere*" sp. B Briggs: Fig. 2.37.
1998b *Rotundracythere austromarscotiaensis* Whatley *et al.*: 120, Pl. 2, Figs. 19-22.
2002 *Rotundracythere austromarscotiaensis* Whatley *et al.*, Dingle: Tab. 1.

Material.–5 valves.

Remarks.–This species was reported from deep water (990m) in the Scotia Sea by Whatley *et al.* (1998b). Specimens from Marion Island lack the large central circular pits of Whatley *et al.*'s species, and centrally have two rounded nodes. Overall, the irregularly reticulate ornamentation has a secondary, very fine punctation of round and comma-shaped pits. *R. polonezensis* Blaszyk, 1987 (Oligocene, South Shetland Islands) also lacks the central pits, but has different dorsal and anterior outlines. The Marion Island material is probably a new species, though it may be conspecific with "*Rotundracythere*" sp. B from the Pleistocene Taylor Formation of the Ross Sea (Briggs, 1978). At Marion Island it has been recovered at three sites with a depth range 110-368 m.

Genus *Pseudeucythere* Hartmann, 1989
Pseudeucythere filiornata Hartmann, 1989
(Plate 2, Fig. 1)

1978 "*Rotundracythere*" sp. A Briggs: Fig. 2.30.
1989b *Pseudeucythere filiornata* Hartmann: 251, Pl. XIV, Figs. 8-11, Pl. XV, Figs. 1-9, Text-Figs. 71-82.
1992 *Pseudeucythere filiornata* Hartmann, Hartmann: 418.
1997 *Pseudeucythere filiornata* Hartmann, Hartmann: 238, Pl. 19, Figs. 7-11, Text-Fig. 100.
2002 *Pseudeucythere* cf. *P. filiornata* Hartmann, Dingle: Tab. 1.

Material.–6 valves.

Remarks.–Hartmann (1997) found this species only in the northern Antarctic Peninsula (60.84-65.7°S) in relatively deep water (135-532 m), while Briggs (1978) recorded it from the Pleistocene Taylor Formation of the Ross Sea area. At Marion Island, *P. filiornata* was encountered at four sites over a depth range 90-240 m.

Family KRITHIDAE Mandelstam, 1958
Genus *Krithe* Brady, Crosskey & Robertson, 1874
Krithe cf. *K. producta* Brady, 1880
(Plate 2, Figs. 2-3)

1880 *Krithe producta* Brady: 114, Pl. 27, Figs. 1a-j.
1976 *Krithe producta* Brady, Puri & Hulings: 295, Pl. 17, Figs. 16-18.
2002 *Krithe* cf. *K. producta* Brady, Dingle: Tab. 1 (pars).

Material.–1137 valves.

Additional specimens.–SAMMF1132 (RVD3967).

Remarks.–The lectotype for Brady's (1880) species was selected from *Challenger* station 146, ~500 km NE of the Prince Edward Islands on the Crozet Plateau in 1375 fathoms (Puri & Hulings, 1976). Brady (1880) also recorded the species from the Prince Edward archipelago (but not Kerguelen), and considered it to be cosmopolitan (he recorded it from 17 sites on the *Challenger* expedition). Present specimens from Marion Island differ from the lectotype (which is probably a juvenile) in having much wider anterior marginal areas, relatively narrow, funnel-shaped vestibules and ~13 radial pore canals. Otherwise, muscle scar patterns and overall shell outline are very similar. It is possible that the Marion Island and Crozet species are separate.

In extensive surveys in the SW Atlantic,Whatley and colleagues have reported five extant species of *Krithe*, none of which are identical to the Marion Island material: *K.* sp. 1 Whatley *et al.* (1998a) has a differently shaped anterior vestibule, *K.* sp. 2 (Whatley *et al.*, 1998a) and *K.* sp. (Whatley *et al.*, 1996) have different valve outlines, while *K. magna* (Hartmann, 1986) has differently shaped muscle scars and anterior vestibules. At Marion Island, *K.* cf. *K. producta* occurs at 18 sites over a depth range of 49-474m, where it is most abundant (mean 14.7%) between ~120-208 m.

Genus *Parakrithe* Bold, 1958
Parakrithe sp. 4913
(Plate 2, Fig. 4)

2002 *Krithe* cf. *K. producta* Brady, Dingle: Tab. 1 (pars).

*Materia*l.–173 valves.

Additional material.–SAMMF1133 (RVD4116)

Remarks.–This species bears a close resemblance to Bold's genotype [*Cytheridea (Dolocytheridea) vermunti* Bold, 1946], but is somewhat more elongate, with a longer hinge structure and a wide, broadly rounded postero-ventral marginal area. It also has wider anterior marginal areas, with 8 long and 7 short (false) radial pore canals, and a very small, medianly located vestibule. The genus has not been noted previously in SW Atlantic-Antarctic Peninsula areas, but Hartmann (1997) and Whatley *et al*. (1998c) both recorded the similar *Parakrithella hanaii* Hartmann, 1962 from littoral regions of southern South America. *Parakrithe* sp. 4913 differs from the latter by having a less broadly rounded dorsal margin (see Whatley *et al*., 1997a, Pl. 3 Figs.13-15). At Marion Island, *P*. sp. 4913 occurs at 11 sites over a depth range of 90-474 m. It is most abundant (6%) at site 29 (145 m), with one record only in depths greater than 208 m.

Family CYTHERURIDAE Müller, 1894
Genus *Cytheropteron* Sars, 1866
Cytheropteron cf. *C. abyssorum* Brady, 1880
(Plate 2, Fig. 5)

1880 *Cytheropteron abyssorum* Brady: 138, Pl. 34, Figs. 3a-d.
1910 *Cytheropteron abyssorum* Brady, Chapman: 437.
1915 *Cytheropteron abyssorum* Brady, Chapman: 47.
1919 *Cytheropteron abyssorum* Brady, Chapman: 35.
1967 *Cytheropteron abyssorum* Brady, Neale: 24, Figs. 8a-d, I-l.
1976 *Cytheropteron abyssorum* Brady, Puri & Hulings: 305, Pl. 23, Fig. 8.
1988 *Cytheropteron abyssorum* Brady, Whatley *et al.*: 181, Pl. 3, Figs. 5-7.
1989b *Cytheropteron gaussi* Müller, Hartmann: Pl. X, Fig. 9, Pl. XI, Fig. 1.
non 1996 *Cytheropteron abyssorum* Brady, Whatley *et al.*: 57, Pl. 1, Fig. 10.
1997 *Cytheropteron gaussi* Müller, Hartmann: Pl. 14, Fig. 2.
2002 *Cytheropteron* cf. *C. fenestratum* Brady, Dingle: Tab. 1.

Material.–28 valves.

Remarks.–Brady (1880) originally recorded this species from 2600 fathoms in the Southern Ocean off Australia. Neale (1967) and Whatley *et al.* (1988) found it at ~200 m at Halley Bay in Antarctica, while Hartmann (1989b, 1997) also recorded it (as purported instar of *C. gaussi* Müller, 1908) from the Antarctic Peninsula. At Marion Island it was encountered at five sites over a depth range 90-208 m.

Cytheropteron sp. 4873
(Plate 2, Fig. 6)

2002 *Cytheropteron* sp. 26/26, Dingle: Tab. 1.

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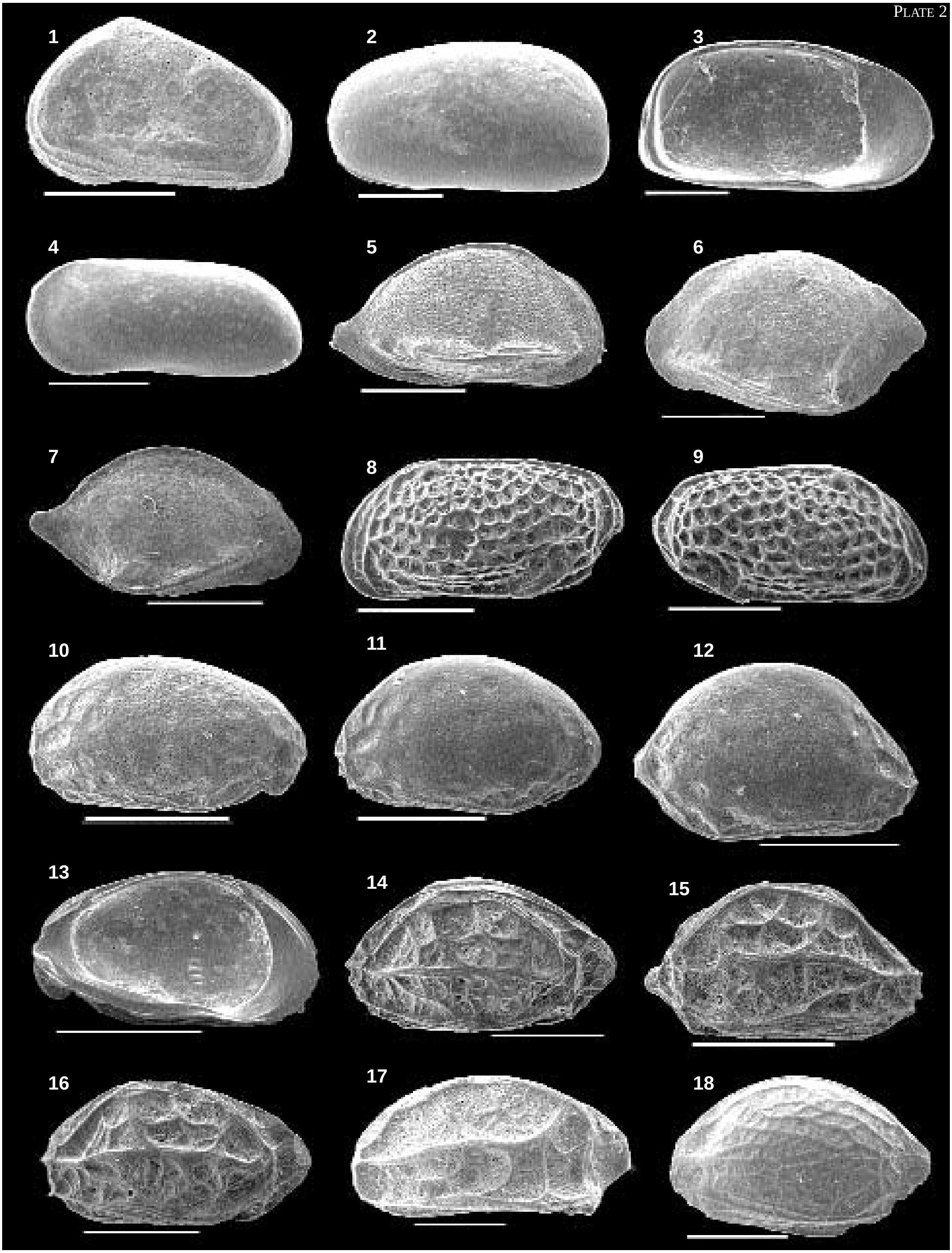
PLATE 2–All specimens are from Marion Island, except figure 14 (Kerguelen Islands). *1, Pseudeucythere filiornata* Hartmann, 1989, LV, site 28, NHM 2002.1013, RVD4878. *2, Krithe* cf. *K. producta* Brady, 1880, LV, site 24, NHM 2002.1014, RVD4909. *3, Krithe* cf. *K. producta* Brady, 1880, LV, internal view, site 24, NHM 2002.1015, RVD4911. *4, Parakrithe* sp. 4913, LV, site 24, NHM 2002.1016, RVD4913. *5, Cytheropteron* cf. *C. abyssorum* Brady, 1880, RV, site 34, NHM 2002.1017, RVD4870. *6*, *Cytheropteron* sp. 4873, LV, site 26, NHM 2002.1018, RVD4873. *7, Cytheropteron* sp. 4946, RV, site 29, NHM 2002.1019, RVD4946. *8, Loxoreticulatum securifer* (Brady, 1880), LV, site 26, NHM 2002.1020, RVD4814. *9, Loxoreticulatum securifer* (Brady, 1880), RV, site 26, NHM 2002.1021, 4815. *10, Hemicytherura branchae* sp. nov. Holotype, LV, male, site 24, NHM 2002.1022, RVD4843. *11, Hemicytherura branchae* sp. nov. Paratype, LV, female, site 24, NHM 2002.1023, RVD4845. *12, Hemicytherura branchae* sp. nov. Paratype, RV, female, site 24, NHM 2002.1024, RVD4846. *13, Hemicytherura branchae* sp. nov. Paratype, LV, internal view, site 31, NHM 2002.1025, RVD4847. *14, Hemicytherura lilljeborgi* (Brady, 1880), LV, Lectotype, *Challenger* station 149, Balfour Bay Kerguelen Islands, BMNH 80.38.151. (NHM negative number P068166). *15, Hemicytherura lilljeborgi* (Brady, 1880), RV, site 31, NHM 2002.1026, RVD4943. *16, Hemicytherura lilljeborgi* (Brady, 1880), LV, site 31, NHM 2002.1027, RVD4944. *17, Hemicytherura* sp. 4869, LV, site 26, NHM 2002.1028, RVD4869. *18, Hemicytherura stationis* (Müller, 1908), LV, site 28, NHM 2002.1029, RVD4864. Scale bars, microns: *100* - 17; *176* - 14; all others = *200.*

PLATE 2



Material.–20 valves.

Remarks.–This species is closest to *C. gaussi* Müller, 1908, but it has a somewhat less highly arched dorsal outline, and a distinctly mamillate alar tip. *C*. sp. 4873 occurs at three sites at Marion Island, over a depth range 145-208 m.

Cytheropteron sp. 4946
(Plate 2, Fig. 7)

Material.–1 valve.

Remarks.–This species has a long, broad, blade-like alar that terminates in a rounded tip (in contrast to a point in *C*. sp. 4873). There is a small spine on the posterior, trailing edge of the alar. At Marion Island, *C*. sp. 4946 was encountered at site 29 (145 m) only.

Genus *Loxoreticulatum* Benson, 1964
Loxoreticulatum securifer (Brady, 1880)
(Plate 2, Figs. 8-9)

1880 *Cythere securifer* Brady: 76, Pl. 13, Figs. 4a-h.
1976 *Cythere securifer* Brady, Puri & Hulings: 288, Pl. 7, Figs. 8-15.
2002 *Loxoreticulatum securifer* (Brady), Dingle: Tab. 1.

Material.–2608 valves.

Additional specimens.–SAMMF1139 (RVD3988), 1140 (3982), 1141 (3985), 1142 (3987).

Remarks.–*Loxoreticulatum securifer* is the most abundant taxon at Marion Island, and appears endemic to the Prince Edward Islands. It is strongly sexually dimorphic, with the elongate morphs (?males) possessing a distinctive posteroventral velate structure (“triangular or hatchet-shaped protuberance” of Brady, 1880), while the ?females have a similar, reduced feature. These structures serve to distinguish *L. securifer* from two similar species: *L. foveolata* (Brady, 1880) and *L. fallax* (Müller, 1908), between which taxonomical relationships remain uncertain (see Benson 1964). Three further species of the genus have been recorded from the SW Atlantic area: *L. bucellatum* Whatley *et al.*, 1987; *L. dichtyotos* Whatley *et al.*, 1988, and *L. cacothemon* Whatley *et al.*,1988. At Marion Island, *L. securifer* has been recovered from twenty-four sites. It occurs across the full depth range of the survey (45-474 m), but is most abundant shallower than 113 m (mean 27%), and relatively uncommon deeper than 240 m (3.5%).

Genus *Hemicytherura* Elofson, 1941
Hemicytherura branchae sp. nov.
(Plate 2, Figs. 10-13)

2002 *Hemicytherura* sp. 4034 Dingle: Tab. 1.

Derivation of name.–Named for Margo Branch, University of Cape Town, for her work on the macrobenthos of the Prince Edward Islands.

Holotype.–NHM 2002.1022 (RVD4843), LV, site 24.

Paratypes.–NHM 2002.1023 (RVD4845), LV, site 24; NHM 2002.1024 (RVD4846), RV, site 24; NHM 2002.1025 (RVD4847), LV, site 31.

Type locality.–Site 24, Marion Island, 107 m.

Material.–478 valves.

Additional specimens.–SAMMF1106 (RVD4033), 1107 (4035).

Diagnosis.–Ovate species with marked sexual dimorphism. Ornamented overall with very fine punctae. Shallow circular depressions occur in the anterior and posterior areas. Left valves of presumed males have prominent, small, postero-ventral rudder-shaped shell extensions.

Description.–Relatively thin shelled. Anterior margin asymmetrically rounded with weak postero-ventral dentation. Posterior margin somewhat extended, with slight convexity postero-ventrally. In presumed males, the latter feature is more marked and there is a small rudder-shaped extension to the shell margin. Ventral margins relatively straight, dorsal margins convex, strongly so in right valves. Ornamentation is weak: at low magnification valves appear smooth, but overall they are finely punctate and the valve is “cratered” by numerous shallow, circular, rimmed pits that contain a central pore. These pits are most numerous in the anterior margin and posterior areas. Internally, anterior marginal areas are relatively narrow, with small vestibules that have three nodes from which radiate three radial canals. There are approximately 13 radial canals anteriorly in total. The merodont hinge and muscle scars (four adductors, divided antennal) appear typical for the genus.

Dimensions.–

	Length	Height
Holotype NHM 2002.1022, LV	380	220
Paratype NHM 2002.1023, LV	405	240
Paratype NHM 2002.1024, RV	400	245
Paratype NHM 2002.1025, LV	380	200
SAMMF1107, LV	420	240
SAMMF1106, RV	400	230

Remarks.–This species of *Hemicytherura* is unusual in lacking any surface ribs, and in this regard it most resembles *H. reticulata* Hartmann, 1962. The latter does, however, have short ribs in the anterior quarter of the valve, and lacks the shallow surface pits and the small rudder-like extensions in male left valves of the new species. *H. branchae* sp. nov. appears endemic to the Prince Edward Islands archipelago, and at Marion Island it occurs at fifteen sites in depths ranging from 45-208 m. It is most abundant at site 24 (8.7%) in 107 m.

Hemicytherura lilljeborgi (Brady, 1880)
(Plate 2, Figs. 14-16)

1880 *Cytherura lilljeborgi* Brady: 132, Pl. 32, Figs. 6a-d.
non 1975 *Hemicytherura* aff. *Cytherura lilljeborgi* Brady, Bertels: 335, Pl. 5, Fig. 16.
1976 *Cytherura lilljeborgi* Brady, Puri & Hulings: 304, Pl. 21, Figs. 3-6.
1979 *Hemicytherura* sp. cf. *H. reticulata* Hartmann, Kaesler *et al.*: 239, Pl. FF.
1987 *Hemicytherura arctowskii* Blaszyk: 73, Pl. 16, Figs. 1a-d, 2a-c, 3a-d, 4a-d.
1988 *Hemicytherura splendifera* Whatley *et al.*: 175, Pl. 1, Figs. 14-16.
1993 *Hemicytherura anomala* (Müller), Hartmann: Pl. 1, Fig. 7.
1997 *Hemicytherura splendifera* Whatley *et al.*, Hartmann: 36.
1997a *Hemicytherura splendifera* Whatley *et al.*, Whatley *et al.*: 29, Pl. 4, Figs. 2, 5.
1998a *Hemicytherura splendifera* Whatley *et al.*, Whatley *et al.*: 99, Pl. 2, Fig. 26.
2000 *Hemicytherura splendifera* Whatley *et al.*, Cusminsky & Whatley, 207.
2002 *Hemicytherura lilljeborgi* (Brady), Dingle: Tab. 1.
2002 *Hemicytherura* sp. 25/21-1 Dingle: Tab. 1.
2002 *Hemicytherura* sp. 2 26/32 Dingle: Tab. 1.

Material.–208 valves.

Additional specimens.–SAMMF1112 (RVD4045), 1113 (4047), 1114 (4128), 1117 (4139), 1118 (4140), 1128 (4077).

Remarks.–Brady (1880) originally recorded this species from the Kerguelen archipelago. It occurs widely in the South American littoral from 40.67°S (Whatley *et al.*, 1997) to 63°S in 97 m on the southern side of the Bransfield Strait (Hartmann, 1993). Blaszyk (1987) also recovered it from Early Oligocene strata in the South Shetland Islands. At Marion Island, *H. lilljeborgi* occurs at 13 sites over a depth range of 45-208 m. It is most abundant (5.3%) at site 54 in 103 m.

Hemicytherura stationis (Müller, 1908)
(Plate 2, Fig. 18)

1908 *Cytheropteron stationis* Müller: 112, Pl. XVI, Figs. 4, 7, Text-Fig. 112.
1986 *Cytheropteron stationis* Müller, Hartmann: 165.
1987 *Cytheropteron stationis* Müller, Hartmann: 128.
1988 *Hemicytherura stationis* (Müller), Whatley *et al.*: 176, Pl. 1, Figs. 17-20.
1990 *Cytheropteron* cf. *stationis* Müller, Hartmann: 207, Text-Fig. 35.
1996 *Hemicytherura stationis* (Müller), Whatley *et al.*: 58, Pl. 1, Fig. 12.
1998b *Hemicytherura stationis* (Müller), Whatley *et al.*: 123, Pl. 3, Figs. 19-20.
2002 *Hemicytherura* sp. 28/15 Dingle: Tab. 1.

Material: 2 valves.

Remarks: The lateral surface ribbing is weaker in specimens from Marion Island than in those illustrated by Whatley *et al.* (1988), but otherwise it has an identical ornamentation. *H. stationis* is widely distributed in southern South America, Scotia Sea, Gauss station and the northern Antarctic Peninsula over a considerable depth range (16-2370 m). At Marion Island it was recovered at site 28 (240 m) only.

Hemicytherura sp. 4869
(Plate 2, Fig. 17)

Material.–3 valves.

Additional specimen.–SAMMF1125 (RVD4070).

Remarks.–This species resembles *H. lilljeborgi* (Brady), but is more elongate, and the main central rib sweeps up in a broad curve to the postero-dorsal margin and does not extend farther posteriorly. At Marion Island, this very rare species was encountered at three sites only: 24 (107 m), 26 (179 m) and 31 (64 m).

Hemicytherura sp. 4038
(Plate 3, Fig. 1)

2002 *Hemicytherura sp* 4038 Dingle: Tab. 1.

Material.–3 valves.

Additional specimen.–SAMMF1109 (RVD4038).

Remarks.–This species has five longitudinal blade-like ridges on its lateral surface, and is similar to *H. anomala* (Müller, 1908). However, rib disposition in the Marion Island species is different, and the caudal process lies dorsal of the mid-line. It was recorded at site 24 (107 m) only.

Hemicytherura sp. 4073
(Plate 3, Figs. 2-3)

1988 *Semicytherura* sp. 3. Whatley *et al.*: 180, Pl. 3, Figs. 2-4.
2002 *Semicytherura* sp. 3 Whatley *et al.*, Dingle: Tab. 1.
2002 *Semicytherura* sp. 36/17 Dingle: Tab. 1.

Material.–93 valves.

Additional specimens.–SAMMF1126 (RVD4073), 1129 (4078), 1153 (4008).

Remarks.–This species is similar to *H. reticulata* Hartmann, 1962 in having a celate/reticulate central area, but differs in details of ornamentation. Surface reticulation in the new material is coarser, and there is a thin, but conspicuous, marginal ridge which encompasses almost the whole valve surface in lateral view. This ridge is particularly prominent posteriorly, where it is straight and vertical. *H.* sp. 4073 is most similar to *Semicytherura* sp. 3 Whatley *et al.* (1988) and the two species are provisionally considered conspecific. The latter has been recorded from eulittoral algae at a relatively low latitudes (38ºS) on the Argentinean coast, and from the Magellan Strait (53.27ºS) (Whatley *et al.*,1988). At Marion Island, *H.* sp. 4073 was recovered at nine sites over a depth range of 45-179 m.

Genus *Semicytherura* Wagner, 1957
Semicytherura costellata (Brady), 1880
(Plate 3, Fig. 4)

1880 *Cytherura costellata* Brady: p. 134, Pl. 32, Figs. a-d.
1912 *Cytherura costellata* Brady, Müller: 267.
1916 *Cytherura costellata* Brady, Chapman: 51.
1964 *Semicytherura* sp. aff. *S. costellata* (Brady), Benson: 17, Pl. 2, Figs. 3, 5, 6, Text-Fig. 10.
1976 *Cytherura costellata* Brady, Puri & Hulings: 304, Pl. 21, Figs. 7-8.
1978 *Semicytherura costellata* (Brady), Briggs: 29, Fig. 2-21.
1985 *Semicytherura costellata* (Brady), Gou & Li: 83, Pl. IV, Figs. 9-10.
1989b *Semicytherura* cf. *costellata* (Brady) *sensu* Benson, Hartmann: 242, Pl. IX, Fig. 5, Text-Fig. 15-18.
1990 *Semicytherura* cf. *costellata* (Brady) *sensu* Benson, Hartmann: 206, Pl. IV, Figs. 36-37.
1992 *Semicytherura costellata* (Brady), Hartmann: 418 (table).
1993 *Semicytherura* cf. *costellata* (Brady), Hartmann: 230 (table).
1997 *Semicytherura costellata* (Brady), Hartmann: 128, Pl. 11, Figs. 5-6, Text-Figs. 45-46.
2000 *Semicytherura* cf. *S. costellata* (Brady), Dingle: 491, Fig. 5G.
2002 *Semicytherura costellata* (Brady), Dingle: Tab. 1.

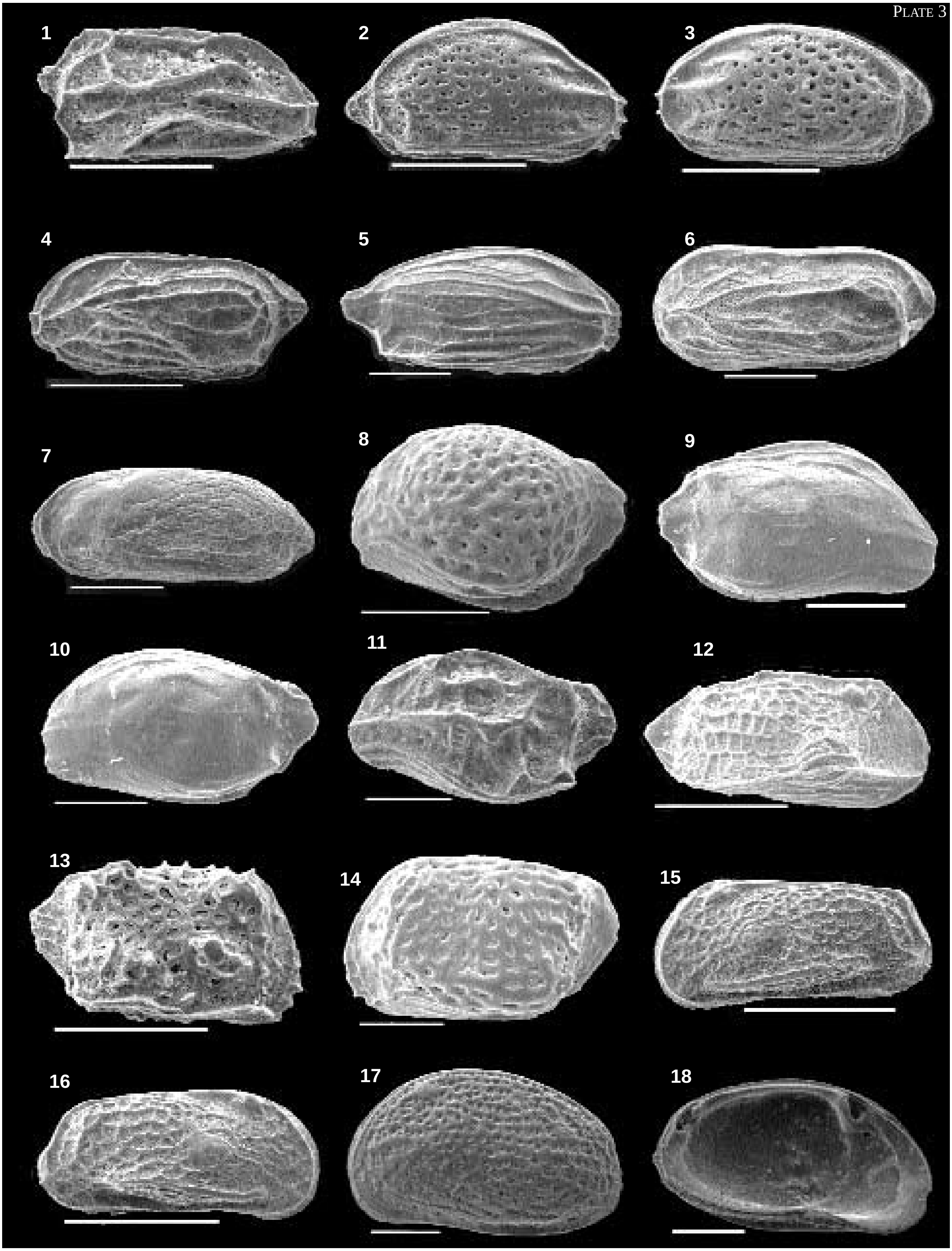
Material.–31 valves.

Additional specimens.–SAMMF1110 (RVD4040), 1111 (4042), 1123 (4067).

→

PLATE 3–All specimens are from Marion Island. *1, Hemicytherura* sp. 4038, RV, site 24, NHM 2002.1030, RVD4935. *2, Hemicytherura* sp. 4073, RV, site 24, NHM 2002.1031, RVD4937. *3, Hemicytherura* sp. 4073, LV, site 24, NHM 2002.1032, RVD4936. *4, Semicytherura costellata* (Brady, 1880), LV, site 31, NHM 2002.1033, RVD4942. *5, Semicytherura* sp, 4136, RV, site 24, NHM 2002.1034, RVD4938. *6, Semicytherura* sp. 4010, LV, site 24, NHM 2002.1035, RVD4826. *7, Semicytherura?* sp. 4122, LV, site 24, NHM 2002.1036, RVD4939. *8, Kangarina obliqua* (Brady, 1880), LV, site 26, NHM 2002.1037, RVD4865. *9, Kangarina* sp. 4064, RV, site 24, NHM 2002.1038, RVD4863. *10, Kangarina* sp. 4064, LV, site 25, NHM 2002.1039, RVD4862. *11, Kangarina* sp. 4069, LV, site 25, NHM 2002.1040, RVD4922. *12, Hemingwayella* aff. *H. antarctica* (Hartmann, 1992), RV, site 17, NHM 2002.1041, RVD4855. *13, Eucytherura* sp. 4822, RV, site 26, NHM 2002.1042, RVD4822. *14, Eucytherura* sp. 4875, LV, site 26, NHM 2002.1043, RVD4875. *15, Patagonacythere parallelogramma* (Brady, 1880), LV, site 25, NHM 2002.1044, RVD4812. *16, Patagonacythere parallelogramma* (Brady, 1880), RV, site 25, NHM 2002.1045, RVD4813. *17, Aurila* cf. *A. kerguelenensis* (Brady, 1880), LV, site 29, NHM 2002.1046, RVD4947. *18, Aurila* cf. *A. kerguelenensis* (Brady, 1880), LV, internal view, site 29, NHM 2002.1047, RVD4948. Scale bars, microns: *500* - 15, 16; *200* - 1, 2, 3, 4, 8, 12, 13, 17, 18; *100* - 5, 6, 7, 9, 10, 11, 14.

PLATE 3



Remarks.–Brady (1880) originally described this species from the Kerguelen archipelago (20-50 fm), but did not record it from the Prince Edward Islands. In Recent sediments it is known from the Antarctic Peninsula (61-63ºS), where it has a depth range of 112-358 m (Hartmann, 1997). It is also known from higher latitudes (Ross Sea) both fossil (Quaternary: Briggs, 1978; Dingle, 2000), and Recent (Benson, 1964), but it has not been recovered from South America. *S. costellata* was recorded from seven sites at Marion Island over a depth range of 49-179 m.

Semicytherura sp. 4136
(Plate 3, Fig. 5)

1996 *Semicytherura* sp. 3 Whatley *et al.*: 59, Pl.1, Fig. 18.
non 1988 *Semicytherura* sp. 3 Whatley *et al.*: 180, Pl. 3, Figs. 2-4.
2002 *Semicytherura* sp. 3 Whatley *et al.*, Dingle: Tab. 1.

Material.–7 valves.

Additional specimens.–SAMMF 1115 (RVD4135), 1116 (4136).

Remarks.–This small (~350 microns), fragile species is ornamented with numerous, weak, longitudinal ribs and fine puncta. It was erroneously allocated to *S*. sp. 3 Whatley *et al.*, 1988 by Whatley *et al.* (1996), when a single specimen was collected at a depth of between 386-456 m in the Magellan Straits. At Marion Island, *S*. sp. 4136 occurs at three sites over a depth range of 107-179 m.

Semicytherura sp. 4010
(Plate 3, Fig. 6)

?1978 *Semicytherura notalis* (Müller), Briggs: Fig. 2.22.
2002 *Semicytherura* sp. 4010 Dingle: Tab. 1.
2002 *Semicytherura* sp. 1/5 Dingle: Tab. 1.
2002 *Semicytherura* sp. 25/6 Dingle: Tab. 1.
2002 *Semicytherura* sp. 1/4 Dingle: Tab. 1.

Material.–109 valves.

Additional specimens.–SAMMF 1154 (RVD4010), 1119 (4058), 1120 (4061), 1155 (4012).

Remarks.–This small species (~300 microns) has a rounded caudal process in the left valve, and is delicately ornamented with fine longitudinal ribs and puncta. It is characterised by a rib which follows a loop-shaped trajectory: commencing as two closely parallel ribs near the anterior border, the loop expands posteriorly and outlines a postero-ventral swelling. The lateral surfaces have scattered, pustulate, normal pore openings. *S*. sp. 4010 was recovered from ten sites at Marion Island over a depth range of 45-179 m.

Semicytherura? sp. 4122
(Plate 3, Fig. 7)

2002 *Semicytherura*? sp. 4122 Dingle: Tab. 1.

Material.–13 valves.

Additional specimens.–SAMMF 1156 (RVD4122), 1157 (4017).

Remarks.–The affinities of this species are unclear. It has an inflated aspect, particularly postero-ventrally, and is ornamented with feint reticulation and fine puncta. No comparable species were recorded by Whatley and colleagues or Hartmann in their extensive SW Atlantic and Antarctic surveys. At Marion Island, it was recovered at site 29 (145 m) only.

Genus *Kangarina* Coryell & Fields, 1937

Kangarina obliqua (Brady, 1880)
(Plate 3, Fig. 8)

1880 *Cytherura obliqua* Brady: 131, Pl. 32, Figs. 1a-d.
non 1916 *Cytherura obliqua* Brady, Chapman: pp. 73, 77.
non 1975 *Hemicytherura* sp. aff. *Cytherura obliqua* Brady, Bertels: Pl. 5, Fig. 15.
2002 *Kangarina obliqua* (Brady), Dingle: Tab. 1.
2002 *Kangarina* sp. 17/14, Dingle: Tab. 1.

Material: 2 valves.

Remarks: Brady (1880) recorded this species only from Balfour Bay in the Kerguelen archipelago, and no subsequent records appear valid. At Marion Island, *K. obliqua* was encountered at sites 26 (179 m) and 17 (355 m) only.

Kangarina sp. 4064
(Plate 3, Figs. 9-10)

2002 *Kangarina* sp. 4064 Dingle: Tab. 1.
2002 *Kangarina* sp. 26/31 Dingle: Tab. 1.
2002 *Hemicytherura* sp. 25/21-3 Dingle: Tab. 1.
2002 *Hemicytherura* sp. 1 26/32 Dingle: Tab. 1.

Material.–23 valves.

Additional specimens.–SAMMF 1121 (RVD4063), 1122 (4064).

Remarks.–This small (~300 microns), S-shaped species is generally celate, with ill-defined longitudinal ribs, small pits and weak reticulation. One specimen from deeper water (site 26, 176 m), is larger (380 microns) and has a more reticulated ornamentation. Shells of this species seem particularly prone to post-mortem bacterial bio-erosion. The closest known relative is *Kangarina* sp. from the Pleistocene Taylor Formation of the Ross Sea area (Briggs, 1978), which has a similar outline, but coarser reticulation and fewer ribs on the lateral surface. At Marion Island, *Kangarina* sp. 4064 was recovered at eight sites, in depths ranging from 64-179 m.

Kangarina sp. 4069
(Plate 3, Fig. 11)

2002 *Kangarina* sp. 4069 Dingle: Tab. 1.
2002 *Hemicytherura* sp. 25/21-2 Dingle: Tab. 1.

Material.–27 valves.

Additional specimen.–SAMMF 1124 (RVD4069).

Remarks.–A small (~315 microns), strongly S-shaped species with bold, curved dorsal, ventral and median longitudinal ribs. The anterior portion of the shorter, thick median rib is seen at high magnification to consist of two closely adjacent ribs. At Marion Island, *K*. sp. 4069 was recovered from six sites ranging from 90-474 m.

Genus *Hemingwayella* Neale, 1975
Hemingwayella aff. *H. antarctica* (Hartmann, 1992)
(Plate 3, Fig. 12)

?1978 *Bythocytheromorpha*? sp. Briggs: Fig. 2.32.
1992 *Paracytheridea antarctica* Hartmann: 410, Pl. I, Figs. 6-7, Text-Fig. 7.
1997 *Paracytheridea antarctica* Hartmann, Hartmann: 124, Pl. 11, Figs. 3-4, Text-Fig. 44.
2002 *Hemingwayella* cf. *H. antarctica* (Hartmann), Dingle: Tab. 1.

Material.–2 valves.

Remarks.–This species has the characteristic triangular-shaped ventro-median feature of the genus (Neale, 1975). It is similar overall to *H. pumilio* (Brady), as illustrated by Whatley & Maybury (1991), but has a more asymmetrical anterior outline, a more acuminate posterior outline, and its reticulate ornamentation is less incised and superimposed on a finely punctate surface. In ornamentation and shell outline it is closer to *H. antarctica* (Hartmann), but is larger (400 *vs* 260 microns in length), and does not have a dorsal upturn to the caudal process. Hartmann (1997) has recorded the latter species only from relatively deep water (392 m) at Elephant Island (South Shetland archipelago). The Marion Island taxon is probably a new species that may be endemic to the Prince Edward archipelago, although a similar, if not identical, species occurs in the Pleistocene Taylor Formation of the Ross Sea (as *Bythocytheromorpha*? sp. Briggs 1978). At Marion Island, *H.* aff. *H. antarctica* was recovered at the two deepest sites only: 17 (355 m) and 37 (474 m).

Genus *Eucytherura* Müller, 1894
Eucytherura sp. 4822
(Plate 3, Fig. 13)

2002 *Eucytherura*? sp. 26/24 Dingle: Tab. 1.

Material.–2 valves.

Remarks.–A small (330 microns), rectangular species with six small spines along the dorsal margin and a coarsely reticulate ornamentation. At Marion Island, it occurs at site 26 (179 m) only.

Eucytherura sp. 4875
(Plate 3, Fig. 14)

2002 *Cytheropteron* sp. 26/24, Dingle: Tab. 1.

Material.–1 valve.

Remarks.–A small (320 micron) sub-quadrate species characterised by strongly reticulate ornamentation, an asymmetrically rounded anterior margin and a somewhat rounded caudal process. At Marion Island, it occurs at site 26 (179 m) only.

Family HEMICYTHERIDAE Puri, 1953
Genus *Patagonacythere* Hartmann, 1962
Patagonacythere parallelogramma (Brady, 1880)
(Plate 3, Figs. 15-16)

1880 *Cythere parallelogramma* Brady: 82, Pl. 15, Figs. 1a-e.
non 1916a *Cythere parallelogramma* Brady, Chapman: 38, Pl. IV, Fig. 3
non 1916b *Cythere parallelogramma* Brady, Chapman: 49.
1976 *Cythere parallelogramma* Brady, Puri & Hulings: Pl. 8, Figs. 15-18.
2002 *Patagonacythere parallelogramma* (Brady), Dingle: Tab. 1.

Material.–1419 valves.

Additional specimens.–SAMMF 1093 (RVD4094), 1094 (4197).

Remarks.–*Patagonacythere parallelogramma* is very close to *P. devexa* (Müller), but they can be distinguished on differences in lateral outline, details of reticulation, the lengths of their ventrolateral ridges, and muscle scars. *P. parallelogramma* appears to be endemic to the Prince Edward Islands, as the record of it by Chapman (1916) from Antarctica was a mis-identification of *P. devexa* (Benson, 1964; Whatley *et al.*, 1998b). At Marion Island, *P. parallelogramma* occurs at 22 sites over a depth range 53-474 m, and is most abundant (40%) at site 32 (147 m).

Genus *Aurila* Pokorny, 1955

Aurila cf. *A. kerguelenensis* (Brady, 1880)

(Plate 3, Figs. 17-18)

1880 *Cythere kerguelenensis* Brady: 78, Pl. 4, Figs. 16-18, Pl. 20, Fig. 1a-f.

non 1908 *Cythereis kergeulensis* (sic) Müller: 138, Pl. 18, Fig. 7, Text-Fig. p. 139.

non 1964 *Hemicythere* sp. aff. *H. kerguelenensis* (Brady), Benson: 21, Pl. 2, Figs. 1, 2, 4, Text-Fig. 13, 14.

1976 *Cythere kerguelenensis* Brady, Puri & Hulings: 279, Pl. 12, Figs. 14-18.

non 1985 *Hemicythere kerguelenensis* (Brady), Gou & Li, 86, Pl. 4, Figs. 1-4.

2002 *Aurila* cf. *A. kerguelenensis* (Brady), Dingle: Tab. 1.

Material.–867 specimens.

Additional specimens.–SAMMF 1100 (RVD4020), 1101 (4022), 1130 (4080), 1131 (4082).

Remarks.–As discussed by Whatley *et al.* (1998b), there has been confusion between *Cythere kerguelenensis* Brady and *Cythereis (Procythereis) robusta* Skogsberg 1928 (Müller, 1908; Benson, 1964). However, the two can be distinguished on the grounds of the more compressed anterior marginal areas of *robusta*, and the significantly more rounded left valve dorsal margin outline, greater concavity of the anteroventral outline, and strong posteroventral marginal compression of specimens of *kerguelenensis*. In addition, the muscle scars differ slightly, with the antennal “exclamation mark” (Benson, 1964) arrangement of *robusta* being reversed in the Marion Island specimens (i.e. the lower scar being the larger). A problem of conspecificy remains with the type material, however. When they selected a lectotype for *Cythere kerguelenensis* from Brady’s *Challenger* material, Puri & Hulings (1976) designated a carapace from the Bass Strait, Australia. This is very close in all important aspects to the Marion Island material, but the latter is more coarsely reticulate and conspecificy is equivocal. At Marion Island, *Aurila* cf. *A. kerguelenensis* was recovered from twenty four sites over a range 32-474 m. It is most abundant between 49-71 m (maximum ~24%).

Aurila sp. 4817

(Plate 4, Fig. 1)

2002 *Aurila* sp. 48/11 Dingle: Tab. 1.

Material.–1 valve.

Remarks.–One valve, which is otherwise identical to *Aurila* cf. *A. kerguelenensis* (Brady), has a fine punctation superimposed on the reticulate ornamentation, and exhibits small prominent pustules around normal pore openings. This morph was encountered at site 48 (99 m) only.

Genus *Meridionalicythere* Whatley, Chadwick, Coxill & Toy, 1987

Meridionalicythere taeniata (Skogsberg, 1928)

(Plate 4, Fig. 2)

1928 *Cythereis (Cythereis) taeniata* Skogsberg: 72, Pl. 1, Fig. 6, Pl. 4, Fig. 5, Text-Fig. 11.

1962 *Aurila? taeniata* (Skogsberg), Hartmann: 236.

non 1978 *Hemicythere taeniata taeniata* (Skogsberg), Briggs: Fig. 2.7.

1979 “*Aurila*” *taeniata* (Skogsberg), Kaesler *et al.*: 239.

1987 *Meridionalicythere taeniata* (Skogsberg), Whatley *et al.*: 9, Pl. 3, Figs. 10-14.

1995 *Meridionalicythere taeniata* (Skogsberg). Whatley *et al.*: 24, Pl. 2, Figs. 13 & 16.

1997a *Meridionalicythere taeniata* (Skogsberg), Whatley *et al.*: 42, Pl. 6, Fig. 10.

2002 *Meridionalicythere taeniata* (Skogsberg), Dingle: Tab. 1.

Material.–994 specimens.

Additional specimens.–SAMMF 1143 (RVD3988), 1144 (3990).

Remarks.–Specimens from Marion island are very similar to those described by Skogsberg (1928) and

Whatley *et al.* (1987, 1995, 1997a) from the littoral of the Falkland Islands (type locality) and Argentina. However, while the ornamentation is essentially the same, reticulation is consistently coarser and longitudinal ribs are more strongly developed in the Marion Island material. In particular, the dorsal rib, which slopes downwards anteriorly, is much more strongly developed. There is currently no valid record of the species from Antarctica. At Marion Island, *M. taeniata* was encountered at sixteen sites over a depth range 32-286 m, and is most abundant shallower than 50 m (site 46, 26%).

Genus *Neocaudites* Puri, 1960
Neocaudites? sp. 4879

2002 *Neocaudites* sp. 48/7 Dingle: Tab. 1.

Material.–1 valve.

Remarks.–The poorly preserved valve available resembles *N. planeforma* Whatley *et al.* (1997), but differs in its postero-ventral outline and appearing to be reticulate. At Marion Island this species was encountered at site 48 (99 m) only.

Family PARADOXOSTOMATIDAE Brady & Norman, 1889
Genus *Paradoxostoma* Fischer, 1855
Paradoxostoma aff. *P. gracilis* (Chapman, 1915)
(Plate 4, Fig. 4)

1915 *Macrocypris gracilis* Chapman: 37, Pl. 11, Figs. 2a-c.
1919 *Xiphichilus gracilis* (Chapman), Chapman: 40.
1967 *Xiphichilus gracilis* (Chapman), Neale: 8, Figs. 3a-c.
1997 *Paradoxostoma gracilis* (Chapman) *sensu* Neale, Hartmann: 223, Text-Fig. 92.
1998b *Paradoxostoma gracilis* (Chapman), Whatley *et al.*: 128, Pl. 4, Fig. 13.
2002 *Paradoxostoma* aff. *P. gracilis* (Chapman), Dingle: Tab. 1.
2002 *Sclerochilus* sp. 46/5 Dingle: Tab. 1.

Material.–10 valves.

Remarks.–Specimens from Marion Island are close to those illustrated by Whatley *et al.* (1998b), but have a less drawn out posterior outline. All previous records of this taxon have been from the high Antarctic. At Marion Island, the species occurs at four sites ranging from 49-179 m.

Paradoxostoma antarcticum Müller, 1908
(Plate 4, Fig. 5)

1908 *Paradoxostoma antarcticum* Müller: 121, Figs. 1-4.
1912 *Paradoxostoma antarcticum* Müller, Scott: 287.
1916 *Paradoxostoma antarcticum* Müller, Chapman: 40.
1964 *Paradoxostoma antarcticum* Müller, Benson: 11, Pl. 1, Figs. 1, 2, 4, 5, 9, Text-Figs. 3-4.
1984 *Paradoxostoma antarcticum* Müller, Setty: 377, Fig. 3.
1985 *Paradoxostoma antarcticum* Müller, Gou & Li: 78, Pl. 2, Figs. 5-6.
1986 *Paradoxostoma antarcticum* Müller, Hartmann: 171, Text-Fig. 69-71.
1987 *Paradoxostoma antarcticum* Müller, Hartmann: 131.
1988 *Paradoxostoma antarcticum* Müller, Hartmann: 149.
1989b *Paradoxostoma antarcticum* Müller, Hartmann: 250.
1993 *Paradoxostoma antarcticum* Müller, Hartmann: 231.
1997 *Paradoxostoma antarcticum* Müller, Hartmann: 221, Text-Fig. 91.
1998b *Paradoxostoma antarcticum* Müller, Whatley *et al.*: 128, Pl. 4, Fig. 10.
2002 *Paradoxostoma* sp. 1 Dingle: Tab. 1.

Material.–47 valves.

Remarks.–This species is distributed widely in Antarctica south of ~61°S over a depth range of 2-385 m. At Marion Island it was recovered from eight sites over a depth range 53-179 m.

Paradoxostoma cf. *P. hypselum* Müller, 1908
(Plate 4, Fig. 6)

1908 *Paradoxostoma hypselum* Müller: 118, Pl. 19, Fig. 7, Text-Figs. 1-3.
1964 *Paradoxostoma hypselum* Müller, Benson: 12, Pl.1, Fig. 2, Text-Figs. 4-5.
1967 *Paradoxostoma hypselum* Müller, Neale: 9, Pl. 1, Figs. g, k.
1985 *Paradoxostoma hypselum* Müller, Gou & Li: 78, Pl. 2, Figs. 3-4.
1986 *Paradoxostoma hypselum* Müller, Hartmann: 172, Text-Fig. 68.
1987 *Paradoxostoma hypselum* Müller, Hartmann: 131.

1989b *Paradoxostoma hypselum* Müller, Hartmann: 250, Text-Figs. 61-62.
1990 *Paradoxostoma hypselum* Müller, Hartmann: 210.
1997 *Paradoxostoma hypselum* Müller, Hartmann: 224, Text-Fig. 93.
1998b *Paradoxostoma hypselum* Müller, Whatley *et al.*: 128, Pl. 4, Figs. 11-12.

Material.–3 valves

Remarks.–This species is distributed widely in Antarctica over a depth range 2-385 m. At Marion Island it occurs at site 29 (145 m) only.

Paradoxostoma sp. 4903
(Plate 4, Fig. 7)

Material.–3 valves.

Remarks.–This slender species is reminiscent of *P. dolichoforma* Whatley *et al.*, 1997a, but has less strongly arched dorsal, and slightly more broadly rounded anterior outlines. At Marion Island, it occurs at sites 24 (107 m) and 54 (103 m) only.

Paradoxostoma? sp. 4887
(Plate 4, Fig. 8)

2002 *Paradoxostoma* sp. 31/20/1 Dingle: Tab. 1.

Material.–1 valve.

Remarks.–The generic placement of this species is uncertain, although it has the characteristic, upturned caudal process. At Marion Island, it was encountered at site 31 (64 m) only.

Family MICROCYTHERIDAE Klie, 1938
Genus *Microcythere* Müller, 1894
Microcythere? *scaphoides* (Brady, 1880)
(Plate 4, Fig. 9)

1880 *Cytheropteron scaphoides* Brady: 136, Pl. 33, Figs. 1a-d.
1976 *Cytheropteron scaphoides* Brady, Puri & Hulings: 307, Pl. 21, Figs. 14-18.
1978 *Microcythere scaphoides* (Brady), Briggs: Fig. 29.
2002 *Microcythere*? sp. 36/22 Dingle: Tab. 1.

Material.–1 valve.

Remarks.–Brady (1880) described *Cytheropteron scaphoides* from Balfour Bay (Kerguelen), but did not record it at the Prince Edward archipelago. Briggs (1978) found it in the Pleistocene (Taylor Formation) of the Ross Sea. At Marion Island, it occurs at site 36 (179 m) only.

Family PECTOCYTHERIDAE Hanai, 1957
Genus *Munseyella* Bold, 1957
Munseyella bissetae sp. nov.
(Plate 4, Figs. 10-13)

2002 *Munseyella* sp. 3997 Dingle: Tab. 1.

Derivation of name.–Named for Linda Bisset, ex South African Museum Cape Town, for her assistance with preparing and photographing the Marion Island fauna.

Holotype.–NHM 2002.1056 (RVD4881), LV, site 34.

→

PLATE 4–All specimens are from Marion Island. *1, Aurila* sp. 4817, LV, site 48, NHM 2002.1048, RVD4817. *2, Meridionalicythere taeniata* (Skogsberg, 1928), RV, site 31, NHM 2002.1049, RVD4850. *3, Neocaudites?* sp. 4879, LV, site 48, NHM 2002.1050, RVD4879. *4, Paradoxostoma* aff. *P. gracilis* (Chapman, 1915), LV, site 36, NHM 2002.1051, RVD4885. *5, Paradoxostoma antarcticum* Müller, 1908, LV, site 24, NHM 2002.1052, RVD4902. *6, Paradoxostoma* cf. *P. hypselum* Müller, 1908, LV, site 29, NHM 2002.1053, RVD4888. *7, Paradoxostoma* sp. 4903, RV, site 24, NHM 2002.1054, RVD4903. *8, Paradoxostoma?* sp. 4887, LV, site 31, specimen lost, RVD4887. *9, Microcythere? scaphoides* (Brady, 1880), RV, site 36, NHM 2002.1055, RVD4899. *10, Munseyella bissetae* sp. nov., Holotype, LV, site 34, NHM 2002.1056, RVD4881. *11, Munseyella bissetae* sp. nov., Paratype, RV, site 34, NHM 2002.1057, RVD4880. *12, Munseyella bissetae* sp. nov., Paratype, RV, internal view, site 34, NHM 2002.1058, RVD4882. *13, Munseyella bissetae* sp. nov., Paratype, carapace, dorsal view, site 34, NHM 2002.1059, RVD4884. *14, Dutoitella lesleyae* sp. nov. Holotype, LV, site 39, NHM 2002.1060, RVD4833. *15, Dutoitella lesleyae* sp. nov. Paratype, RV, site 39, NHM 2002.1061, RVD4834. *16, Dutoitella lesleyae* sp. nov. Paratype, LV, internal view, site 39, NHM 2002.1062, RVD4838. *17, Dutoitella lesleyae* sp. nov. Topotype, LV, instar, *Challenger* station 145, Prince Edward Islands, ex BMNH slide no.1961.12.4.24 (negative No. P 068172). *18, Dutoitella lesleyae* sp. nov. Topotype, RV, instar, *Challenger* station 145, Prince Edward Islands, ex BMNH slide no.1961.12.4.24 (negative No. P 068167). Scale bars, microns: *500* - 1, 14, 15, 16; *380* - 17, 18; *200* - 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13; *100* - 9.

PLATE 4

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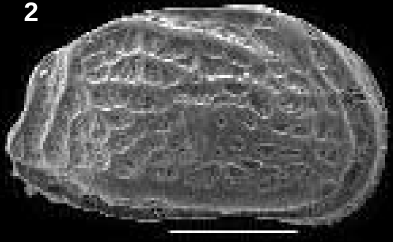

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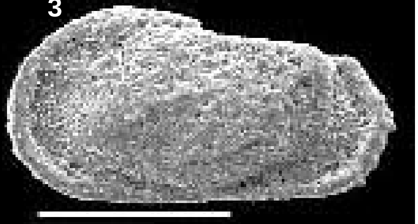

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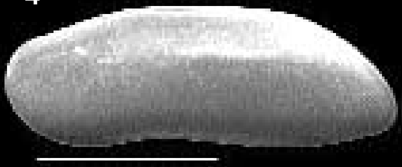

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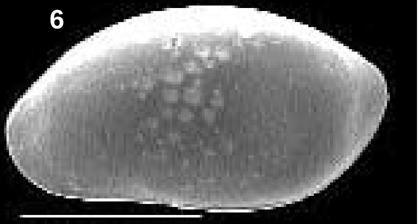

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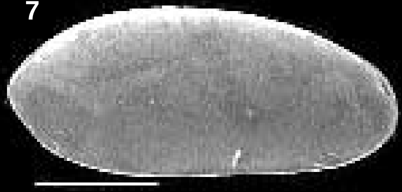

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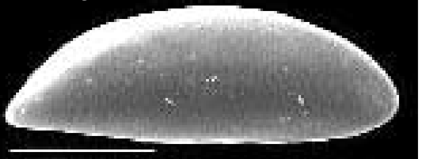

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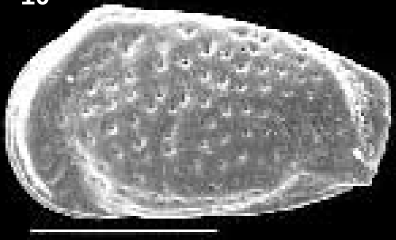

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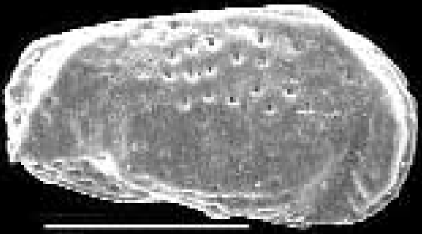

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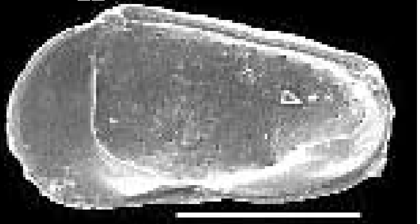

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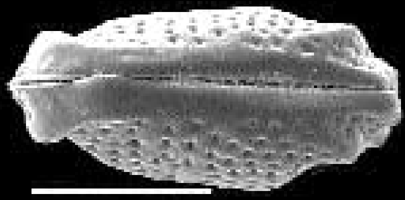

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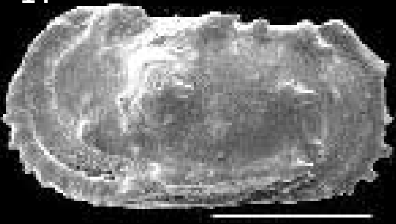

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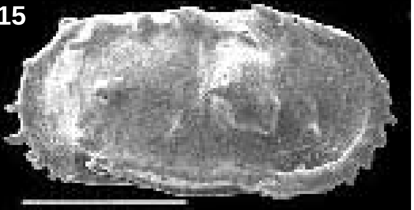

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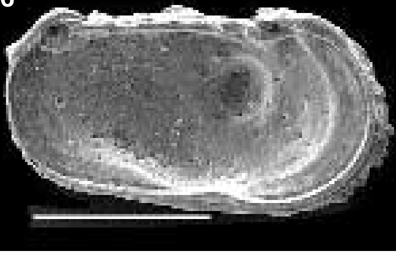

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18


Paratypes.–NHM 2002.1057 (RVD4880), RV, site 24; NHM 2002.1058 (RVD4882), RV, site 24; NHM 2002.1059 (RVD4884), carapace, site 34.

Type locality.–Site 34, Marion Island, 208 m.

Material.–604 specimens.

Additional specimens.–SAMMF1147 (RVD3997), 1148 (4119).

Diagnosis.–Subrectangular in lateral view, laterally compressed in dorsal view. Lateral surface planar, ornamented with small rounded pits arranged in seven vertical columns in posterior half. An angular ridge runs from the postero-dorsal area to a small postero-ventral protuberance.

Description.–Small, subrectangular species, laterally compressed in dorsal view with prominent anterior marginal and posterior cardinal elevations. In lateral view, anterior margin is broadly rounded, with a wide anterior marginal rim. Anterior cardinal angle is prominent. Posterior margin is short, truncated. There is a small, but prominent postero-ventral protuberance at the termination of an obliquely sloping angular ridge which extends from the posterior end of the straight dorsal margin. Ventral margin straight. There is a short, convex ventro-lateral keel which ends at a small embayment immediately anterior of the postero-ventral protuberance. Lateral surface is planar, and ornamented with widely space pores. These are arranged in seven vertical columns in posterior half of valve. Interiorly, anterior and posterior marginal areas are wide, and there is a large anvil-shaped anterior vestibule. Anterior radial pore canals relatively sparse (10-11). Muscle scars relatively large, with four adductors, and an inclined, elongate antennal scar. Hinge, modified pentodont, with right valve loccelate median groove and distinctly bilobed posterior terminal tooth. Sexual dimorphism is weak.

Dimensions.–

	Length	Height	Width
Holotype, NHM 2002.1056, LV	420	220	
Paratype, NHM 2002.1057, RV	400	210	
Paratype, NHM 2002.1058, RV	420	220	
Paratype, NHM 2002.1059, C	415		200
SAM1147, RV	470	270	
SAM1148, LV	460	250	

Remarks.–There are many similarities between *M. bissetae* sp. nov. and *M. undulata* Whatley *et al.* 1997a, and it seems likely that the two species are closely related. The new species differs primarily in lacking the surface ribs that give Whatley *et al.*'s species its name, and in possessing the prominent, oblique posterior ridge that terminates in a postero-ventral protuberance. *M. undulata* has been recorded from littoral depths off southern Argentina between 36.2 - 53.9ºS, from the Falkland Islands and the Magellan Strait (Whatley *et al.*, 1995, 1996, 1997a), while Cusminsky & Whatley (2000) recorded it from the Pliocene of Burdwood Bank (54.77ºS). At Marion Island, *M. bissetae* sp. nov. was encountered at sixteen sites over a depth range 49-474 m. It is most abundant (13.1%) at site 34 (208 m).

Family Trachyleberididae Sylvester-Bradley, 1948
Subfamily Unicapellinae Dingle, 1981
Genus *Dutoitella* Dingle, 1981
Dutoitella lesleyae sp. nov.
(Plate 4, Figs. 14-18)

1880 *Cythere suhmi* Brady: 106, Pl. 26 Figs. 3e-h, *non* Figs. 3a-d.
2002 *Dutoitella* sp. 4194 Dingle: Tab. 1.

Derivation of name.–Named for my wife for her support and inspiration.

Holotype.–NHM 2002.1060 (RVD4833), LV, site 39.

Paratypes.–NHM 2002.1061 (RVD4834), RV, site 39; NHM 2002.1062 (RVD4838), LV, site 39; BMNH 1961.12.4.24, P068172, LV, instar, *Challenger* station 145, Prince Edward Islands; BMNH 1961.12.4.24, P068167, RV, instar, *Challenger* station 145, Prince Edward Islands.

Type locality.–Sample 39, Marion Island, 368 m.

Material.–114 specimens.

Additional specimens.–SAMMF 1090 (RVD4089), 1091 (4194), 1092 (4195).

Diagnosis.–Large, robust, subrectangular species with eye tubercles. Surface smooth, with scattered tubercles and stout spines that, typically, have posteriorly deflected tips. There is a large domed sub-central tubercle. The ventro-lateral ridge connects to the anterior marginal rim via a narrow neck.

Description.–A large, robust subrectangular species. Broadly rounded anterior margin with a broad marginal rim ornamented with short stout spines. In right valves, the antero-dorsal outline is straight and angled obliquely. Posterior outline is broadly rounded with prominent stout spines ventrally, and with a prominent postero-dorsal process in the left valve. Dorsal and ventral margins are straight and parallel. There is a prominent eye-spot with an attached posteriorly deflected post-adjacent spine. A prominent ventro-lateral ridge which ends posteriorly in a double, prong-like spine, is connected by a narrow neck to the antero-marginal ridge. The dorsal margin carries three tubercles, the posterior of which forms a prominent postero-dorsal feature. The sub-central tubercle (SCT) is large, dome-shaped, and there is a small, post-adjacent tubercle in line with the posterior end of the ventro-lateral ridge. Most of the tubercles, particularly those associated with the SCT, the eye-spot and the dorsal marginal, bear short, posteriorly directed spinous tips. Overall the lateral surface is smooth, with scattered pustules and pustulate normal pore canal openings. Marginal areas are relatively narrow, with ~18 short straight anterior marginal pore canals. Muscle-scars with four elongate adductors, the second dorsal-most being split, and two small rounded frontal scars. The hinge is holamphidont.

Dimensions.–

	Length	Height	Width
Holotype, NHM 2002.1060, LV	1200	630	
Paratype, NHM 2002.1061, RV	1150	580	
Paratype, NHM 2002.1062, LV	1100	580	
SAM1090, C	1200		500
SAM1091, RV	1100	550	
SAM1092, LV	1099	590	

Remarks.–*Dutoitella lesleyae* sp. nov. is very similar to *D. dutoiti* (Maastrichtian of South Africa, Dingle 1981), but is much larger, has a more quadrate outline, lacks a large rounded postero-median node (it is small and spinous in *lesleyae*), has posteriorly deflected tips on tubercles, and has eye tubercles. This suggests the maintenance of a genetic link over ~60Ma along with other similar species in the SW Indian Ocean area (*D. dinglei*, Danian of Madagascar, Guernet *et al.*, 2001, and *D. mimica*, Maastrichtian of South Africa and Palaeocene-Eocene of Maud Rise, Dingle, 1981; Majoran & Dingle, 2002) that manifests itself in a sighted, relatively shallow-living descendent in high latitude, cold water environments.

Brady (1880) illustrated two specimens in his original description of *Cythere suhmi*. One (a female carapace) from deep water in the NW Pacific (Pl. 26 Figs. 3a-d), which was taken by Puri & Hulings (1976) as the Lectotype (BM 80.38.119) (Pl. 5 Fig. 1), and a male carapace (Pl. 26 Figs. 3e-h) from shallow water (50-150 fathoms) from Prince Edward Island. These two specimens are not conspecific, and the male carapace is our new species *D. lesleyae*. Puri & Hulings (1976) designated a topotype (BM 1974.289) (= *D. lesleyae* sp. nov.) for *C. suhmi* from Prince Edward Island, but according to records, it is no longer in the Natural History Museum collections. The two species differ in surface ornamentation (*D. suhmi* is reticulate), shape and the strength and disposition of surface tubercles. In addition, *D. suhmi* is eyeless. This distinction has resolved the incongruity, wherein *Dutoitella suhmi* (Brady), which has been widely reported from deep-water sites in all the major oceans (Benson, 1977; Guernet, 1985; Coles & Whatley, 1989; Dingle *et al.*, 1990; Whatley & Roberts, 1999) had a single reported occurrence in shallow water (50-150 fms) off the Prince Edward Islands (Brady 1880).

The recognition of *D. lesleyae* raises a further incongruity, however. All previous records of *Dutoitella* have been of blind species, whereas *D. lesleyae* has eye tubercles and lives in relatively shallow water (at least to 113 m). To resolve this, its presence on a small, isolated, mid-oceanic plateau that is known to be no older than 450ka (McDougall *et al.*, 2001), led Dingle (2002) to propose that *D. lesleyae* (along with *Poseidonamicus whatleyi* sp. nov.) illustrates an example of ocular-rejuvenation by selection for dormant genes in ostracods.

At Marion Island, *D. lesleyae* was recovered from nine sites over a depth range 113-474 m. The species appears to be endemic to the Prince Edward Islands.

Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948

Genus *Cativella* Coryell & Fields, 1937

Cativella bensoni Neale, 1967

(Plate 5, Fig. 2)

non 1878 *Cythere polytrema* Brady: 393, Pl. 66, Figs. 1a-d.
1880 *Cythere polytrema* Brady. Brady: 87, Pl. 21, Figs. 5a-h.
1916 *Cythere polytrema* Brady. Chapman: 50, Pl. 6, Fig. 3.
1964 *Cativella* sp. Benson: 32, Text-Fig. 23.
1967 *Cativella bensoni* Neale: 30, Pl. 3 Figs. a, b, d, f, f’, f”, Pl. 4, g, h, h’, Text-Fig. 10.

1972 *Cativella bensoni* Neale, Dell: 72
1978 *Cativella bensoni* Neale, Briggs: 29, Figs. 2-5.
1987 *Cativella bensoni* Neale, Hartmann: 124, Pl. 1, Figs. 5-14, Pl. 2, Fig. 15, Text-Fig. 25-27.
1989a *Cativella bensoni* Neale, Hartmann: 214.
1989b *Cativella bensoni* Neale, Hartmann: 239, Pl. 6, Figs. 3-7.
1990 *Cativella bensoni* Neale, Hartmann: 204.
1992 *Cativella bensoni* Neale, Hartmann: 418.
1996 *Cativella bensoni* Neale, Whatley *et al.*: 367, Pl. 3, Fig. 7.
1997 *Cativella bensoni* Neale, Hartmann: 88, Pl. 5, Figs. 1-12, Pl. 6, Fig. 1, Text-Fig. 30
1998a *Cativella bensoni* Neale, Whatley *et al.*: 110, Pl. 5, Figs. 14-15.
1998b *Cativella bensoni* Neale, Whatley *et al.*: 128, Pl. 4, Figs. 17-18
2000 *Cativella bensoni* Neale, Cusminsky & Whatley: 207.
2000 *Cativella bensoni* Neale, Dingle: 488, Fig. 5E.
2002 *Cativella bensoni* Neale, Dingle: Tab. 1.

Material.–664 valves.

Additional specimens.–SAMMF1095 (RVD4098), 1096 (4101), 1097 (4102).

Remarks.–This is a widely distributed species in both Antarctic and subantarctic areas, as well as along the coast of southern Argentina. It has a latitudinal range of ~77.5°S (Ross Sea, Benson 1964) to 39.283°S (Rio Negro Province, Whatley *et al.*, 1998a), and a depth range of 448 m (Ross Sea), through 404 m (Antarctic Peninsula) (Hartmann, 1990), to 37 m at its northern latitudinal limit. It has not been recorded from the Falkland Islands (Whatley *et al.*, 1995), but specimens from the Prince Edward Islands (present collection, and Brady 1880) are identical to previously described material. At Marion Island, *C. bensoni* occurs at fourteen sites over a depth range of 45-368 m. It is most abundant between 208-286 m (maximum, 22%, site 49, 286 m).

Genus *Henryhowella* Puri, 1957

Henryhowella dasyderma (Brady), 1880 *sensu* Whatley *et al.*, 1998b

(Plate 5, Fig. 3)

1880 *Cythere dasyderma* Brady: 105, Pl. 17, Figs. 4a-d, *non* Pl. 17, Figs. 4e-ff, Pl. 18, Figs. 4a-f.
non 1964 *Echinocythereis dasyderma* (Brady)?, Benson: 34, Text-Fig. 25.
1976 ?*Cythere dasyderma* Brady, Puri & Hulings: 273, Pl. 11, Figs. 10-11.
non 1987 *Henryhowella* sp. cf. *H. dasyderma* (Brady), Whatley & Coles, Pl. 5, Fig. 12.
1996 *Henryhowella dasyderma* Brady, Whatley *et al.*: 367, Pl. 3, Fig. 9.
non 1997 *Echinocythereis dasyderma* (Brady), Hartmann: 91, Text-Fig. 31.
1998b *Henryhowella dasyderma* Brady, Whatley *et al.*: 129, Pl. 4, Figs. 24-27.
2002 *Henryhowella dasyderma* Brady, Dingle: Tab. 1.

Material.–491 specimens.

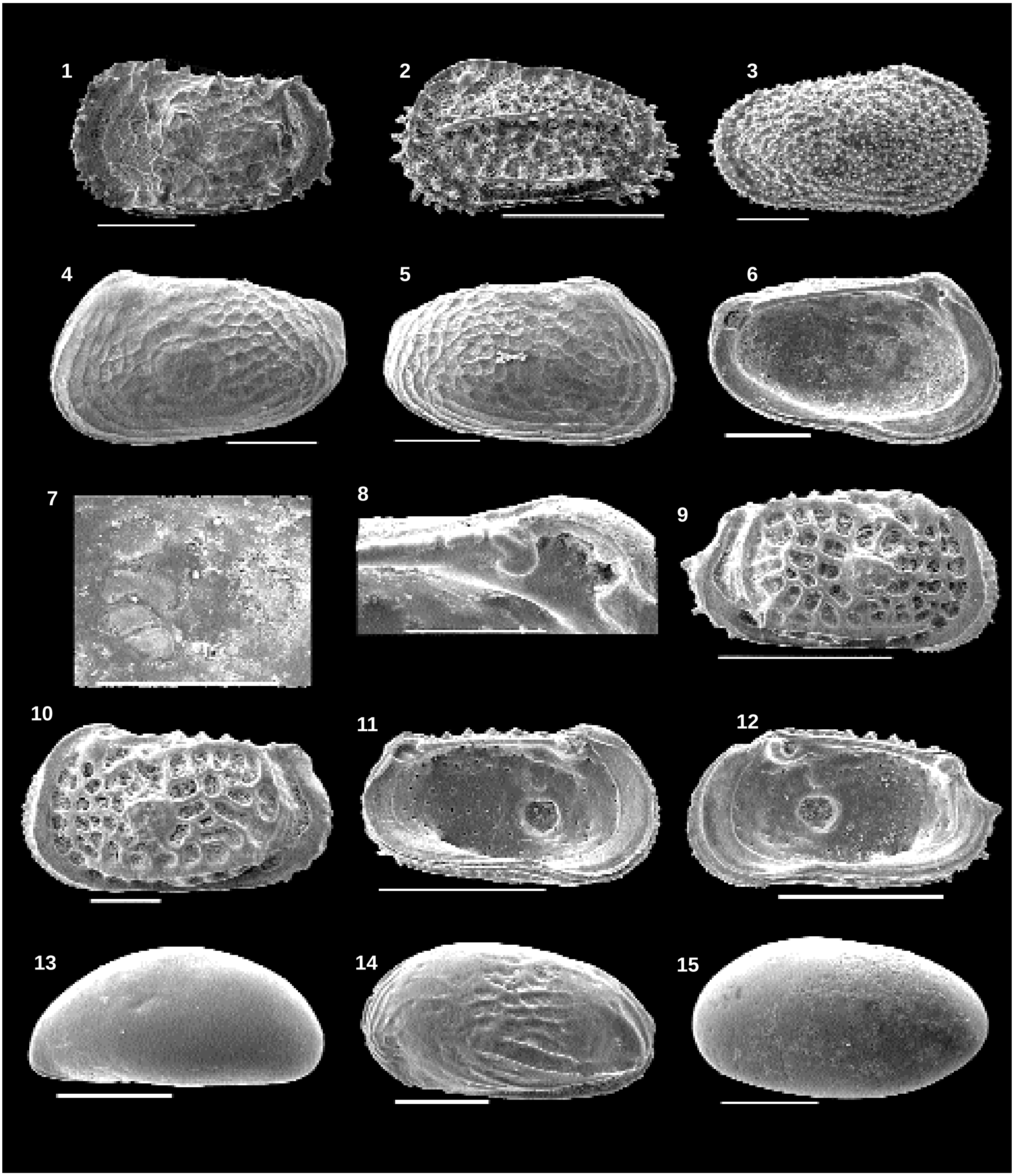
Additional specimen.–SAMMF1098 (RVD4105).

Remarks.–Brady's (1880) original description probably included several related taxa, and while the lectotype selected by Puri & Hulings (1976) from the SE

→

Plate 5–All specimens are from Marion Island, except figure 1 (Pacific Ocean). *1, Dutoitella suhmi* (Brady, 1880), Lectotype, LV, *Challenger* station 241 (NW Pacific), BMNH 80.38.119 (negative No. 068263). *2, Cativella bensoni* Neale, 1967, LV, site 25, NHM 2002.1063, RVD4816. *3, Henryhowella dasyderma* (Brady, 1880), RV, site 34, NHM 2002.1064, RVD4811. *4, Rabilimis? marionensis* sp. nov., Holotype, LV, site 28, NHM 2002.1065, RVD4849. *5, Rabilimis? marionensis* sp. nov., Paratype, RV, site 28, NHM 2002.1066, RVD4850. *6, Rabilimis? marionensis* sp. nov., Paratype, LV, internal view, site 28, NHM 2002.1067, RVD4851. *7, Rabilimis? marionensis* sp. nov., Paratype, LV, internal view, muscle scars, site 28, NHM 2002.1067, RVD4852. *8, Rabilimis? marionensis* sp. nov., Paratype, LV, internal view, anterior part of hinge, site 28, NHM 2002.1067, RVD4853. *9, Poseidonamicus whatleyi* sp. nov., Holotype, RV, site 17, NHM 2002.1068, RVD4830. *10, Poseidonamicus whatleyi* sp. nov. Paratype, LV, site 17, NHM 2002.1069, RVD4832. *11, Poseidonamicus whatleyi* sp. nov. Paratype, LV, internal view, site 17, NHM 2002.1069, RVD4925. *12, Poseidonamicus whatleyi* sp. nov. Holotype, RV, internal view, site 17, NHM 2002.1068, RVD4930. *13, Xestoleberis setigera* Brady 1880, LV, site 31, NHM 2002.1070, RVD4908. *14,* Indeterminate sp. 4906, LV, site 29, NHM 2002.1071, RVD4906. *15,* Indeterminate sp. 4819, LV, site 38, specimen lost, RVD4819. Scale bars, microns: *500* - 2, 9, 11, 12; *430* - 1; *200* - 3, 4, 5, 6, 10, 13, 15; *100* - 7, 8, 14.

PLATE 5



Pacific (Challenger station 296) is similar to the specimens from Marion Island, there is a difference in ornamentation in the postero-ventral area. The Marion Island species appears to be that recorded by Whatley *et al.* (1996, 1998b) from sites in the Magellan Strait (1-527 m) and the South Scotia Sea (1155-2370 m), and these are probably the same as those illustrated by Brady (1880, Pl. 17, Figs. 4a-d) from a site north of the Falkland Islands (1035 fm). The essential features, as pointed out by Whatley *et al.* (1998b), are the dense, finely spinose/papillose ornament, and lack of median plication. The population of *H. dasyderma* at Marion Island is characterised by a particularly large hook-shaped frontal muscle scar and a looped (both open and infilled) posterior end to the dorsal-most adductor scar. Hartmann (1989b, 1997) has illustrated a superficially similar species from the Antarctic Peninsula (as *Echinocythereis* sp. Ant 68/7), but this species has a finely denticulate median element to its hinge (the Marion Island specimens have a narrow, smooth median bar, left valve), and the dorsal and ventral margins are not parallel. Brady (1880) did not record this, or any similar species from Prince Edward or the Kerguelen Islands. At Marion Island, *Henryhowella dasyderma* occurs at fifteen sites over a depth range of 64-474 m, and is most abundant (12%) at site 28 (240 m).

Genus *Rabilimis* Hazel, 1967
Rabilimis? *marionensis* sp. nov.
(Plate 5, Figs. 4-8)

?1996 *Rabilimis*? sp. Szczechura & Blaszyk: 181, Pl. 42, Figs. 1-7.
2002 *Rabilimis*? sp. 28/2 Dingle: Tab. 1.

Derivation of name.–Marion Island, type locality.

Holotype.–NHM 2002.1065 (RVD4849), LV, site 28.

Paratypes.–NHM 2002.1066 (RVD4850), RV, site 28; NHM 2002.1067 (RVD4851), LV, site 28.

Type locality.–Site 28, Marion Island, 240 m.

Material.–102 valves.

Diagnosis.–Reticulate species with a prominent postero-dorsal marginal swelling in left valve.

Description.–Plump, trapezoidal outline with straight dorsal margin and almost straight ventral margin that rises and curves slightly posteriorly, particularly in left valves. Highest point of valves lies at anterior cardinal angle where there is a broad ocular bulge in both valves. Anterior outline broadly and asymmetrically rounded, posterior margin narrow, truncated, with a distinct postero-dorsal angle, accompanied by a small, but prominent swelling in left valves. There is a low, ill-defined sub-central tubercle. Valve surface is weakly reticulate overall, with fine, concentric, marginal parallel ribs adjacent to the anterior and ventral margins. The area in the vicinity of the low eye spot is typically celate. Prominent, weakly pustulate normal pore canal openings are randomly scattered over the lateral surface. Hinge is amphidont, with a denticulate median element that has a left valve composite stepped anterior tooth. Left valve terminal element sockets are open ventrally. Marginal areas of moderate width, ~ 15 straight anterior marginal pore canals, with very narrow vestibule. Muscle scars consist of a curved row of four adductors, the second dorsal-most of which is the largest and has a median constriction. The frontal scar is V-shaped, with a foreshortened anterior limb.

Dimensions.–

	Length	Height
Holotype, NHM 2002.1065, LV	640	360
Paratype, NHM 2002.1066, RV	680	400
Paratype, NHM 2002.1067, LV	680	400

Remarks.–This species compares well with the genotype from NW Europe [*Cythere mirabilis* (Brady)], although the slightly unusual structure of the anterior end of the median hinge element leaves some doubt for the generic placement. It is possibly conspecific with *Rabilimis*? sp. from the Pliocene of Cockburn Island (northern Antarctic Peninsula) (Szczechura & Blaszyk, 1996), but neither the hinge nor the muscle scars are well enough preserved in the latter, to be confident. Also, the concentric rib pattern on *R.*? *marionensis* is better developed, and the postero-dorsal left valve swelling is more prominent than in the Pliocene material. At Marion Island, *R*? *marionensis* was recovered from ten sites over a depth range of 64-368 m, and is most abundant (11.5%) at site 28 (240 m).

Family THAEROCYTHERIDAE Hazel, 1967
Genus *Poseidonamicus* Benson, 1972
Poseidonamicus whatleyi sp. nov.
(Plate 5, Figs. 9-12)

2002 *Poseidonamicus* 5000 Dingle: Tab. 1.

Derivation of name.–For Professor R C Whatley, for his extensive works on this genus.

Holotype.–NHM 2002.1068 (RVD4830), RV, site 17.

Paratype.–NHM 2002.1069 (RVD4832), LV, site 17.

Type locality.–Site 17, Marion Island, 355 m.

Material.–10 specimens

Diagnosis.–A large, sighted, coarsely reticulate species with a sub-vertical, posteriorly placed rib that joins the prominent ventro-lateral rib to the dorsal rib in a quadrate loop.

Description.–Large, robust, subrectangular in lateral view. Anterior margin broadly and symmetrically rounded, posterior margins are truncated, angular in left valve and more acuminate in right valve, with convex outline above mid-height. Dorsal and ventral margins relatively straight, with five small protuberances along the former. Cardinal angles prominent in left valve, obscured by dorsal margin in right valve. There is a large glassy eyespot, and the sub-central tubercle is prominent. Surface is ornamented with coarse reticulae and ribs. Prominent ribs lie along the ventral and dorsal margins, and are joined by a sub-vertical rib in the posterior part of the valve. These three ribs form a prominent, sub-quadrate loop. The dorsal rib descends obliquely anteriorly, ending just below the eyespot, and in the left valve is connected to the posterior cardinal angle by a further short rib. The hinge is holamphidont. Muscle scars consist of a vertical row of four adductors, the second dorsal-most being subdivided, while the antennal scar consists of upper rounded, and lower J-shaped impressions. The species is avestibulate, with relatively narrow anterior marginal areas, while the ocular sinus is large and distinct.

Dimensions.–

	Length	Height
Holotype, NHM 2002.1068, RV	900	460
Paratype, NHM 2002.1069, LV	890	480

Remarks.–This is the second Recent record of a sighted species of *Poseidonamicus* from relatively shallow water, the previous being *P. panopsus* Whatley & Dingle (1989) from the continental margin off southwestern Africa. The two species are morphologically very similar, but can be distingui-shed easily by details of shape and ornamentation, while *P. panopsus* does not have subdivision of any adductor muscle scars. Whatley *et al.* (1998b) have recently described a new species from subantarctic waters (*P. ansoni*), but in addition to lacking an eye tubercle, the latter is considerably larger, has higher caudal shoulders, no vertical posterior rib, possesses delicate secondary reticulation and has a prominent RV postero-ventral spine. A rare, un-named blind species has also been recorded from unusually shallow water in the Strait of Magellan (Whatley *et al.* 1996, 1997b), but this has a different rib pattern to *P. whatleyi*.

The presence of this sighted species of *Poseidonamicus* at Marion Island poses similar problems in connection with the colonisation and evolution of the Marion Island ostracod fauna to those of *Dutoitella lesleyae* sp. nov. The genus is cosmopolitan and typically indicative of psychrospheric faunas (>1000 m) (Benson 1990). Although two potentially ancestral sighted species of the genus are known (*P. panopsus* Whatley & Dingle and *P. ocularis* Whatley *et al.* 1986), the latter has ocular structures only in instar stages, and has no known living descendants. Whatley & Dingle (1989) followed Whatley *et al.* (1986) in suggesting putative, sighted, but undiscovered progenitors, but a further possibility is the genetic rejuvenation of an ocular apparatus, as discussed by Dingle (2002).

Poseidonamicus whatleyi appears to be endemic to Marion Island, where it was encountered at two sites only: 17 (355 m) and 28 (240 m).

Family XESTOLEBERIDIDAE Sars, 1928

Genus *Xestoleberis* Sars, 1866

Xestoleberis setigera Brady, 1880

(Plate 5, Fig. 13)

1880	*Xestoleberis setigera* Brady: 125, Pl. 31, Figs. 2a-d, 3a-c.
?1967	*Xestoleberis setigera* Brady, Neale: 18, Pl. I, Fig. c.
1976	*Xestoleberis setigera* Brady, Puri & Hulings: 301, Pl. 20, Figs. 9-11.
?1995	*Xestoleberis setigera* Brady, Whatley *et al.*: 28, Pl. 3, Fig. 14.
?1997a	*Xestoleberis setigera* Brady, Whatley *et al.*: 72, Pl. 13, Figs. 5-7.
2002	*Xestoleberis setigera* Brady, Dingle: Tab. 1.

Material.–826 valves.

Additional specimens.–SAMMF1145 (RVD3992), 1146 (3994).

Remarks.–*Xestoleberis setigera* has been recorded from Antarctica (Chapman,1915; Neale, 1967), the Falkland Islands (Whatley *et al.*, 1995) and southern Argentina (Whatley *et al.*, 1997), but none of the illustrated specimens appear conspecific with the lectotype selected by Puri & Hulings (1976) from *Challenger* station 145, Prince Edward Islands. In particular, they do not have the acute antero-ventral outlines, and are too roundly truncated posteriorly.

This suggests that *X. setigera* maybe pandemic to the Prince Edward-Kerguelen archipelagos.

At Marion Island, this species occurs at twenty-one sites over a depth range 45-474 m, and is most common between 49-64 m.

Indeterminate species
Indet sp. 4906
(Plate 5, Fig. 14)

2002 Indet. sp. 29/33a Dingle: Tab. 1.
2002 Indet. sp. 31/23/1 Dingle: Tab. 1.

Material.–2 valves.

Remarks.–A small species (~300 microns) which tapers in height posteriorly, has a weakly reticulate and ribbed central portion to its valve and a prominent looped rib in its postero-ventral region. The anterior of the valve is variously celate. Found only at sites 29 (145 m) and 31 (64 m).

Indet. sp. 4819
(Plate 5, Fig. 15)

2002 *Austrocytheridea?* 38/13 Dingle: Tab. 1.

Material.–3 valves.

Remarks.–As none of the specimens have well-preserved hinges or muscle scars, a generic assignment is not possible. The species occurs at two sites only: 38 (200 m) and 47 (53 m).

Order CLADOCOPIDA Sars, 1866
Family POLYCOPIDAE Sars, 1866
Genus *Polycope* Sars, 1866
Polycope sp. 27/6

2002 *Polycope* 27/6 Dingle: Tab.1.

Material.–1 valve.

Remarks.–One fragmented, smooth, ?juvenile specimen was found at site 27 (113 m). Brady (1880) recorded *P. orbicularis* Sars from Kerguelen, but the species found at Marion Island differs in outline and convexity of valve surface in dorsal view. The specimen was too fragile to prepare for SEM examination.

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Nuevo libro/*New book*: M.A.A. BASSIOUNI (2002). Mid-Cretaceous (Aptian – Early Turonian) Ostracoda from Sinai, Egypt. *Neue Paläontologische Abhandlungen*, Dresden, Band 5, 123 pp., 23 pl., 8 fig., 2 tabl. Price: 36 €.

In this significant work the author listed 117 species of ostracodes belonging to 61 genera, in the interval ranging between the Aptian and the lower Turonien of Sinai (Egypt). Thirty-nine new species, 4 genera and 3 new sub-genera are created. All the species are beautifuly illustrated on 23 plates with more than 400 excellent SEM photographs

With regard to the geological introduction, one would have liked to have information on the justification of the datings of the various sampled section.

The systematic part, which represents the major part of work (80 p) is very complete and is well structured. The diagnosis and descriptions are very detailed. It is however regrettable that the taxonomy is based on the Treatise on Invertebrate Paleontology going back to 1961. If the creation of certain new genera seems justified (*Sabekacythere*, *Paraclithocytheridea),* we do not see on the other hand the need for having encumbered the list of genera and sub-genera with *Hartmannia*, *Paracytherura, Hiltermannia*, *Bremeniana* and *Kemperiana*. It is as strongly regrettable that the author judged necessary to create subspecies of typical European species such as *Schuleridea jonesiana, Curfsina nuda* and *Cythererella ovata;* this being able only to create confusions for the paleobiogeographic reconstitutions. The same is true for the use of the typical Austral genera *Majungaella* and *Rostrocytheridea*.

A synthetic table of stratigraphic distribution would have been welcome.

Although relatively well documented, the chapter concerning the paleobiogeography remains too brief, often very approximate, sometimes erroneous (relationships to the north-Tethyan), and does not take account of the recent syntheses on this topic.

The chapter on paleoecology is reduced to its simplest expression (10 lines).

In conclusion it is an excellent and essential stratigraphic Atlas for all the specialists working on the ostracodes of south-Tethyan margin, from Morocco to the Middle East (Afro-Arabian bioprovince).

J.-P. COLIN

Nuevo libro/*New book*: E. MOLINA (Editor) (2002), *Micropaleontología*. Prensas Universitarias de Zaragoza, Colección Textos Docentes, nº 93, 634 pp. ISBN: 84-7733-619-9. Precio: 25 €.

Se trata de un manual de Micropaleontología que va dirigido inicialmente a los alumnos de esta asignatura de la Universidad de Zaragoza (España). Se adapta al programa impartido en el Departamento de Ciencias de la Tierra y ha sido realizado por todos aquellos profesores e investigadores implicados en la docencia de dicha asignatura y en la investigación en Micropaleontología. Sin embargo, se ha procurado huir de localismos para hacer también útil el libro a los alumnos de otras universidades. Así, se ha evitado dar mucha más extensión a los grupos más frecuentes en Aragón y España, procurando aportar datos e ilustraciones de microfósiles de cualquier parte del mundo.

La gran dificultad de tratar todos los grupos micropaleontológicos con la misma extensión ha llevado a elegir el de los foraminíferos como grupo piloto por ser el más clásico y útil. A él se dedican varios capítulos donde se describen a nivel genérico, mientras que los demás grupos de microfósiles han sido tratados en un solo capítulo, ya que, en caso contrario, hubiera dado lugar a un libro mucho más voluminoso y con demasiada sistemática. El capítulo de los foraminíferos planctónicos es el que se ha desarrollado más ampliamente, ya que son los que tienen mayores aplicaciones y en prácticas se enseña a determinarlos a nivel específico. De esta forma, el alumno aprende la metodología para determinar los foraminíferos y puede aplicarla a otros grupos si lo necesita en el futuro. El orden de los capítulos no ha sido el usual de más primitivos a más modernos, sino el orden con que se imparten en clase. Por razones de tipo pedagógico, los foraminíferos se tratan antes que el resto de los grupos y los foraminíferos planctónicos antes que los bentónicos. El índice de capítulos y autores es el siguiente:

I PARTE: FUNDAMENTOS

1. Micropaleontología. Concepto, historia y estado actual. *Eustoquio Molina.*
2. Metodología: muestreos, técnicas de preparación y métodos de estudio. *Concepción Gonzalvo.*
3. Tafonomía: particularidades de la fosilización de los microfósiles. *Eustoquio Molina.*
4. Los microfósiles y la Clasificación biológica. *Beatriz Azanza.*

II PARTE: SISTEMÁTICA

5. Foraminíferos: biología, organización de la concha y clasificación. *Ignacio Arenillas.*
6. Foraminíferos planctónicos: Globigerinina. *Eustoquio Molina.*
7. Foraminíferos bentónicos: Lagenina, Involutinina, Robertinina. *Laia Alegret.*
8. Foraminíferos bentónicos: Rotaliina. *Ignacio Arenillas.*
9. Foraminíferos bentónicos: Miliolina. *Ignacio Arenillas.*
10. Foraminíferos bentónicos: Fusulinina. *José Antonio Arz.*
11. Foraminíferos bentónicos: Allogromiina y Textulariina. *Silvia Ortiz.*
12. Radiolarios. *José Antonio Arz.*
13. Tintínidos. *José Ignacio Canudo.*
14. Bacterias. *José Antonio Arz.*
15. Cocolitofóridos y otros nanofósiles calcáreos. *Eustoquio Molina.*
16. Diatomeas y silicoflagelados. *José Antonio Arz.*
17. Dinoflagelados y quitinozoos. *Laia Alegret.*
18. Polen y esporas. *José Ignacio Canudo.*
19. Algas calcáreas. *José Ignacio Canudo.*
20. Briozoos. *Laia Alegret.*
21. Ostrácodos. *José Ignacio Canudo.*
22. Otros microfósiles de invertebrados y afinidades inciertas. *Eustoquio Molina*.
23. Conodontos. *José Ignacio Canudo.*
24. Otros microfósiles de vertebrados. *Beatriz Azanza.*

III PARTE: APLICACIONES

25. Paleoecología y reconstrucción paleoambiental con microfósiles. *Laia Alegret.*
26. Paleobiogeografía y paleogeografía global con microfósiles. *Ignacio Arenillas.*
27. Bioestratigrafía: limitaciones y ventajas de los microfósiles. *Ignacio Arenillas*.
28. Bioestratigrafía integrada y sus aplicaciones. *Ignacio Arenillas*.
29. Evolución. Modalidades y causas de evolución y extinción. *Eustoquio Molina*.
30. Origen de la vida y evolución de la microbiota en el Precámbrico. *José Antonio Arz.*
31. Historia general de la microbiota fanerozoica. Microfacies. *José Antonio Arz.*
32. Diccionario de términos micropaleontológicos. *Eustoquio Molina*.

Una de las principales recomendaciones del editor para la elaboración de los distintos capítulos ha sido ir a las fuentes originales y citar la procedencia de los datos e ilustraciones. Además, se ha tratado de aportar datos propios, para lo cual se han distribuido los capítulos según la especialidad y conocimientos de cada autor. Se ha procurado ilustrar cada capítulo, con fotos de microscopio electrónico de barrido y reducir la sistemática en la medida de lo posible. Se han desarrollado unos temas de fundamentos donde se tratan las particularidades de los microfósiles, y otros de aplicaciones donde se resumen ejemplos de la gran utilidad de la Micropaleontología en Ciencias de la Tierra y en Ciencias Biológicas.

El breve diccionario trata de contener los términos más utilizados en Micropaleontología, aunque muchos de ellos no sean propios de esta disciplina. Se indican los términos en español, inglés, alemán, francés e italiano para facilitar a los alumnos la consulta de la abundante bibliografía en estos idiomas, recomendada al final de cada capítulo. Además, a modo de índice se indica el capítulo donde se puede encontrar mejor definido o ilustrado cada término.

Cada capítulo ha sido realizado por un solo autor a fin de agilizar al máximo la redacción y no diluir la responsabilidad. Los aspectos de forma han sido corregidos por el editor, con la ayuda técnica prestada por algunos de los autores y del personal técnico del Departamento de Publicaciones de la Universidad de Zaragoza. La mayoría de los capítulos han sido revisados por prestigiosos especialistas ajenos al grupo de Micropaleontología de la Universidad de Zaragoza. Sin ellos este libro tendría menos rigor científico, pero todos están exonerados de los errores y omisiones que los autores y el editor podamos haber cometido. La primera edición ha tenido una buena acogida, se está vendiendo muy rápidamente y estamos preparando otra corregida y ampliada que será publicada hacia septiembre de 2003.

EUSTOQUIO MOLINA (Editor)

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C/ Pedro Cerbuna, 12
E-50009 Zaragoza.

ANUNCIO / ANNOUNCEMENT

2nd Circular

BIOEVENTS: THEIR STRATIGRAPHIC RECORDS, PATTERNS AND CAUSES

Caravaca de la Cruz, June 3rd - 8th, 2003

We are pleased to invite you to participate in the international conference on Bioevents: their stratigraphic records, patterns and causes to be held in Caravaca de la Cruz, Spain, from Tuesday June 3rd, to Sunday June 8th, 2003.

The Barranco del Gredero have became a main reference in the worldwide literature, even more important after publication of the meteorite impact hypothesis which presents a unifying theory to explain the cause of the mass extinction event at the close of the Cretaceous. The international meeting in Caravaca de la Cruz will discuss our current state of knowledge on bioevents:

- Fossil record, stable isotopes, biomarkers, other geochemical and mineralogical markers.
- Extinction-radiation, innovation and dispersal events, catastrophic events, periodicity of events, selectivity of events (geographical or environmental).
- Cosmic, telluric, or biotic causes. Multicausal events.

Scientific activities will take place over four days, and will include: invited talks (English or Spanish, with simultaneous translation), visit to Barranco del Gredero for both K/T and P/E boundary sections, poster sessions, and other activities.

Organizer: Caravaca de la Cruz Council

Scientific Committee

Marcos A. Lamolda, Universidad del País Vasco; Rafael Arana, Universidad de Murcia; Jenaro L. García Alcalde, Universidad de Oviedo; José M.ª González Donoso, Universidad de Málaga; Kunio Kaiho, Tohoku University; Florentin Maurrasse, Florida International University; Christopher R. C. Paul, University of Liverpool; Jan Smit, Vrije Universiteit Amsterdam.

Secretariat

Diego Marín Ruiz de Assín; Pedro García Esteller; Carlos Díaz Bermejo; Luis Arrufat Milán.

Sponsors

- Consejería de Educación y Cultura. Regional Government of Murcia

This international conferences is organized under the auspices of:

International Paleontological Association, Sociedad Española de Paleontología, Spanish National Committee, IGCP, and Universidad de Murcia.

Registration fees

* Conference participants: 120 euros (member of collaborating organizations 75 euros)
* Students and scholarship recipients: 80 euros (member of collaborating organizations 50 euros)
** Accompanying guest: 50 euros
Pre-conference field-trip, June 3rd: 21 euros (lunch included)
Post-conference field-trip, June 8th: 18 euros (lunch included)

(*) These fees include costs of attendance at all scientific sessions, the Barranco del Gredero field-trip, social events, and meeting documents.

(**) These fees include the cost of attendance at the social events only.

Student Grant Awards

- A number of accommodation grants will be available for Graduate students, and young PhD’s (no more than 35 years old) who have contribution(s) accepted for presentation at the meeting. These grants will be offered on a first come first serve basis.
- A number of free registration awards will also be available for Undergraduate students majoring in a field of the Earth sciences, and who are in their last year of study. These awards will be offered on a first come first serve basis.

This grant programme is sponsored by the Dirección General de Cultura, of the Consejería de Educación y Cultura, Regional Government of Murcia.

Important dates

- Deadline for registration and submission of abstract: March 10th, 2003
- Payment of fees: April 10th, 2003
- 3rd and last Circular: May, 2003

Conference Secretariat
Secretaría de Bioeventos 2003
Plz. Templete, 1
30400 Caravaca de la Cruz; SPAIN

E-mail: Bioeventos Caravaca 2003 <BIOEVENTOS@telefonica.net>
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La *Revista Española de Micropaleontología* publica manuscritos originales, relacionados con cualquier aspecto micropaleontológico. Solamente aquellos remitidos de acuerdo con las normas editoriales, serán enviados para su revisión a un mínimo de dos revisores.

Texto

La revista acogerá para su publicación trabajos en español o inglés. Excepcionalmente se aceptarán en otro idioma (en este caso con resúmenes también en español e inglés).

En la primera página debe consignarse el/los nombre/s de el/los autor/es, dirección/es postal/es y de e-mail. En el caso de más de un autor, se debe indicar el autor con quien el editor mantendrá la correspondencia. El *título* debe ser breve pero informativo, con referencia al grupo fósil, la edad y el área geográfica. No debe incluir nuevos nombres de taxones.

El *resumen* no deberá superar las 300 palabras y debe dar una idea clara del contenido del trabajo; deberá mencionar en su caso las nuevas determinaciones sistemáticas. También, se incluirá un resumen en inglés, junto con 4 a 6 palabras clave en ambos idiomas.

En el *apartado sistemático,* el nivel del taxón más elevado queda a discreción del autor, pero deben estar acompañados de autor y año, de acuerdo con los siguientes ejemplos:

Orden FORAMINIFERIDA Eichwald, 1830
Familia THOMASINELLIDAE Loeblich y Tappan, 1984
Género *Thomasinella* Schlumberger, 1893
Thomasinella punica Schlumberger, 1893

Las *tablas* irán en páginas independientes, aunque se intercalarán en el lugar que les corresponda en el texto. Se proyectarán teniendo en cuenta el formato de la página (180 mm) y de la columna (85 mm), y sus explicaciones deberán in en hoja aparte.

Las *referencias bibliográficas* se citarán en el texto en minúsculas, seguidas por el año de publicación. Se deberá utilizar *et al.* para más de dos autores. Las citas bibliográficas se dispondrán en forma de lista al final del trabajo por orden alfabético de autores, y únicamente se incluirán las publicaciones a las que se haya hecho referencia en el manuscrito. No deben abreviarse los nombres de las revistas. Los siguientes ejemplos pueden servir de modelo:

Bengston, P. 1988. Open Nomenclature. *Palaeontology,* 31, 223-227.

Bolli, H., Beckmann, J. P. and Sanders, J. 1994. *Benthonic foraminiferal biostratigraphy of the South Caribbean Region.* Cambridge University Press, Cambridge, 408 pp.

Müller, A. H. 1979. Fossilization (Taphonomy). In: *Treatise on Invertebrate Paleontology* (Eds. R. A. Robison and C. Teichert). The University of Kansas Press & The Geological Society of America, Boulder, 2-78.

Ilustraciones

Las figuras de línea, láminas fotográficas y fotografías en el texto serán de buena calidad y se entregarán aisladas y numeradas de acuerdo con su orden de citación en el texto. Su tamaño no deberá sobrepasar el doble del tamaño final. Las láminas fotográficas deberán tener exactamente las dimensiones de la página impresa de la revista. Todas las ilustraciones deben estar referidas en el texto, y en los márgenes del manuscrito se indicará su lugar correspondiente dentro del trabajo.

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Articles should be written in Spanish or English. Other languages may occasionally be accepted (with abstracts also provided in Spanish and English). Typescripts should be submitted on a good-quality paper of International A4 size and prepared on a word processor.

Title page should include the name(s) of the author(s), affiliation(s) and e-mail address(es). In case of more than one author, please indicate to whom the correspondence should be addressed. The *title* should be short but informative, with indications about the fossil group, the age and the geographic area. It should not include the names of new taxa.

A concise *abstract* of no more than 300 words should summarize results of the paper and must mention all new systematic names. Abstract should be written in English and Spanish. Also provide 4 to 6 *keywords* placed beneath the abstract.

In the *systematic work,* the level of the highest taxon is at the discretion of the author, but must always be accompanied by authority and date. Example:

Order FORAMINIFERIDA Eichwald, 1830
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Genus *Thomasinella* Schlumberger, 1893
Thomasinella punica Schlumberger, 1893

Use italics rather than underlining for genus/species names.

Keep *tables* few and simple. Plan them so that take up the entire width of the printed page (180 mm) or the width of one column (85 mm). Captions are to be typed separately.

References in the text should be cited with the name of the author (in lowercases), followed by the year of publication. Use ampersand ('&') for two authors and '*et al.*' for more than two. References should be listed at the end of the text in alphabetical order of authors' names; journal and book titles are written out, not abbreviated. Examples:

Bengston, P. 1988. Open Nomenclature. *Palaeontology,* 31, 223-227.

Bolli, H., Beckmann, J. P. and Sanders, J. 1994. *Benthonic foraminiferal biostratigraphy of the South Caribbean Region.* Cambridge University Press, Cambridge, 408 pp.

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