# Late Aptian-Early Albian radiolaria of the Windalia radiolarite (type section), Carnarvon Basin, Western Australia

Eclogae geol. Helv. 86/3: 943-995 (1993)

0012-9402/93/030943-53 $1.50 + 0.20/0
Birkhäuser Verlag, Basel

# Late Aptian-Early Albian Radiolaria of the Windalia Radiolarite (type section), Carnarvon Basin, Western Australia

By GLYNN ELLIS[1])

## ABSTRACT

During the Late Aptian-Early Albian Australia was inundated by a widespread (global?) marine transgression that resulted in extensive sedimentation of radiolarian-rich facies. This facies is represented by the Windalia Radiolarite, and to a lesser extent the overlying Gearle Siltstone in the Carnarvon Basin of Western Australia. In this study, a detailed radiolarian biostratigraphic assessment of the type section of the Windalia Radiolarite is presented. Fifty-nine radiolarian taxa are represented, including one new genus (*Windalia* n. gen.) and three new species (*Actinomma* (?) *pleiadescensis* n. sp., *Paronaella* (?) *diastimusphere* n. sp. and *Praeconocaryomma excelsa* n. sp.). Many of these taxa have been recorded previously from Tethyan regions. However, the assemblages are dominated in abundance by a few non-Tethyan forms which are also recognized in coeval sediments elsewhere in Australia, the Indian Ocean and the Weddell Sea. These dominant taxa are considered to be endemic elements of an "Austral" faunal realm. Many of the known biostratigraphically important radiolaria are sparse or absent, but the previously recorded stratigraphic ranges of several species correspond with the Late (latest) Aptian-Early Albian age of the Windalia Radiolarite known from ammonites and belemnites, and from age constraints emplaced by the underlying and overlying formations. The published ranges of other radiolarian species from the Windalia Radiolarite, however, conflict with this age, highlighting the limited detailed knowledge of early Cretaceous radiolaria and the difficulties in applying "low latitude" radiolarian biozonations to the Austral region.

## RÉSUMÉ

Durant la période Aptien supérieur-Albien inférieur, le continent australien a été submergé par une importante transgression marine (globale?), responsable d'une vaste sedimentation de facies riches en radiolaires. Dans le bassin de Carnarvon, en Australie occidentale, ces facies sont représentés par la Formation des radiolarites de Windalia et, dans une moindre mesure, par la Fm. des siltites de Gearle, reposante sur la dernière. Ce travail présente les résultats d'une étude biostratigraphique détaillée des radiolaires de la coupe type de la Fm. des radiolarites de Windalia. Cette étude comprend une description systématique de cinquante-neuf taxa de radiolaires, dont un nouveau genre (*Windalia* n. gen.) et trois nouvelles espéces (*Actinomma* (?) *pleiadescensis* n. sp., *Paronaella* (?) *diastimusphere* n. sp. and *Praeconocaryomma excelsa* n. sp.). La plupart de ces taxa correspondent à des faunes téthysiennes. Néanmoins, les assemblages sont dominés par quelques formes non-téthysiennes, décrites en revanche dans des sédiments contemporains provenant d'autres régions de l'Australie, de l'Ocean Indien et de la Mer de Weddell sur la marge antarctique. Ces taxa dominants sont considérés comme représentants des formes endémiques d'un domaine faunique "austral". Seules quelques espèces reconnues comme étant biostratigraphique importants ont été observées dans la Fm. des radiolarites de Windalia. Leur extension biostratigraphique est en accord avec l'âge Aptien supérieur (terminal)-Albien inférieur de cette unité, établi à partir d'ammonites et de belemnites, ainsi que sur la base des contraintes stratigraphiques liées aux âges des sédiments associés. Cependant, bien d'autres espéces de radiolaires présentes dans la Fm. des radiolarites de Windalia n'ont pas été précédemment signalées de l'âge Aptien supérieur (terminal)-Albien inférieur. Ce fait souligne la connaissance encore limitée des radiolaires du Crétacé inférieur, ainsi que la difficulté d'appliquer aux régions australes les biozonations établies dans les basses latitudes.

[1]) Institut de Géologie et Paléontologie, Université de Lausanne, CH-1014 Lausanne, Switzerland.

## 1. Introduction

During the Late Aptian-Early Albian widespread deposition of radiolarian-rich facies occurred on the Australian continent. Deposition of these sediments coincides with one of the most extensive marine transgressions to have affected Australasia (Morgan 1980; Frakes et al. 1987), and as such, records a significant regional and possibly global palaeoceanographic event. Despite this, Australian Mesozoic radiolaria have been neglected by stratigraphers and palaeontologists. This is even more surprising considering that the presence of radiolaria in Lower Cretaceous rocks has been known since 1893,

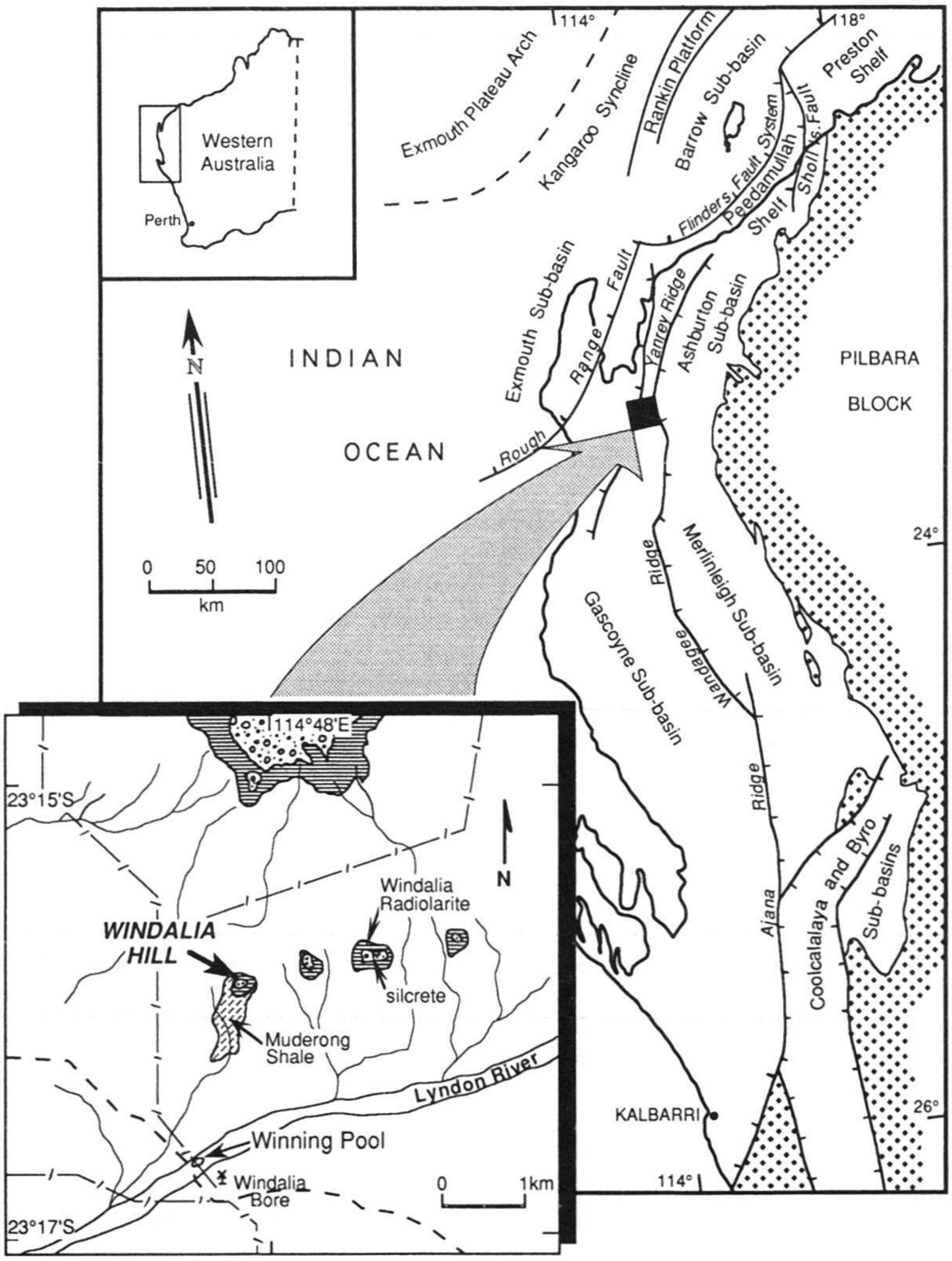



Fig. 1. The Carnarvon Basin, Western Australia – showing major tectonic elements and structural subdivisions, and location of the type section of the Windalia Radiolarite.

when G. J. Hinde described several forms from outcrops at Darwin, Northern Territory. More recently, Lloyd (1963, 1966), Haig & Barnbaum (1978), Ellis (1987) and Ellis et al. (1991) recorded early Cretaceous assemblages from the onshore Canning and Bonaparte (Western Australia and Northern Territory), Surat (Queensland) and Carnarvon (Western Australia, see Fig. 1) Basins respectively. These works (much of which is outdated by significant changes in classification in recent years) still represent the only systematic accounts of the Australian radiolarian fauna from onshore sections.

The Windalia Radiolarite in the Carnarvon Basin, Western Australia, represents one of the best exposed portions of the Australian Aptian-Albian radiolarian-depositional event. It is part of a siliciclastic third-order transgressive marine sequence (Fig. 2), the Winning Group ("Mz4b" following the sequence-based depositional framework of Hocking 1988), that was deposited following plate separation of "Greater India" from Australia in the Valanginian-Hauterivian. It is a neritic water depth hemipelagic sediment deposited within a tectonically-passive coastal epeiric basin, and contrasts with the better known Tethyan radiolarites generally assumed to be deeper water in origin. This paper presents the radiolarian fauna recovered from the type section of the Windalia Radiolarite (Figs. 1 and 3), and represents the first detailed published study of Australian Lower Cretaceous radiolaria. It is not the intention here to detail the Australian mid-Cretaceous radiolarian-depositional event, nor to outline possible depositional models in a regional context. This is the subject of ongoing research, results of which will be reported in a future publication.

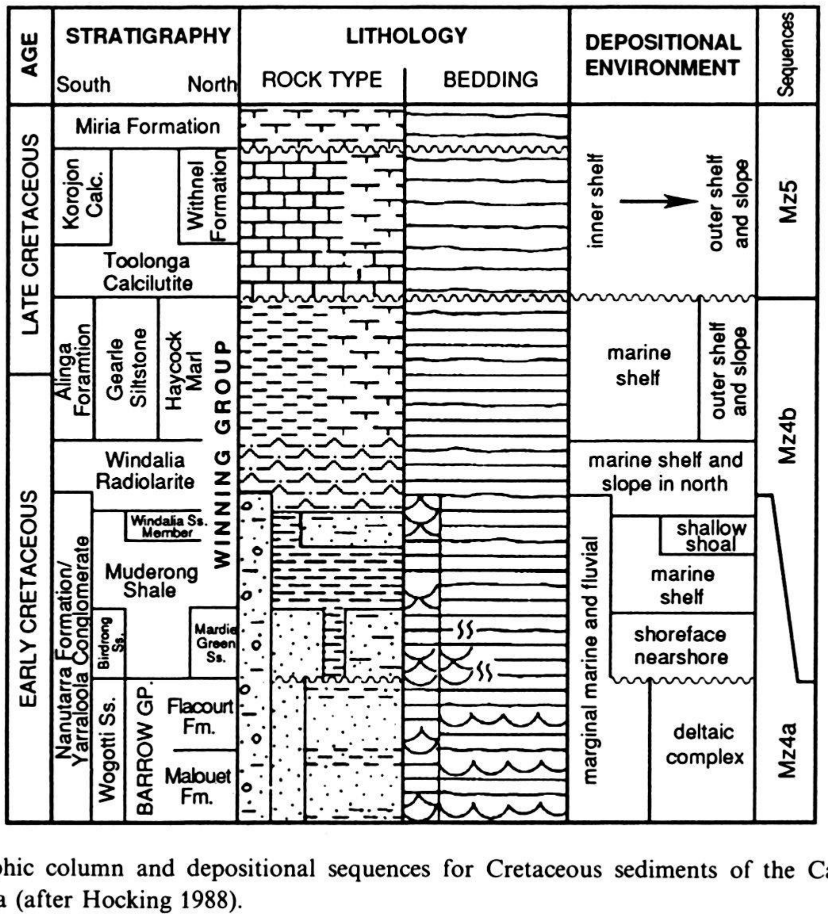



Fig. 2. Stratigraphic column and depositional sequences for Cretaceous sediments of the Carnarvon Basin, Western Australia (after Hocking 1988).

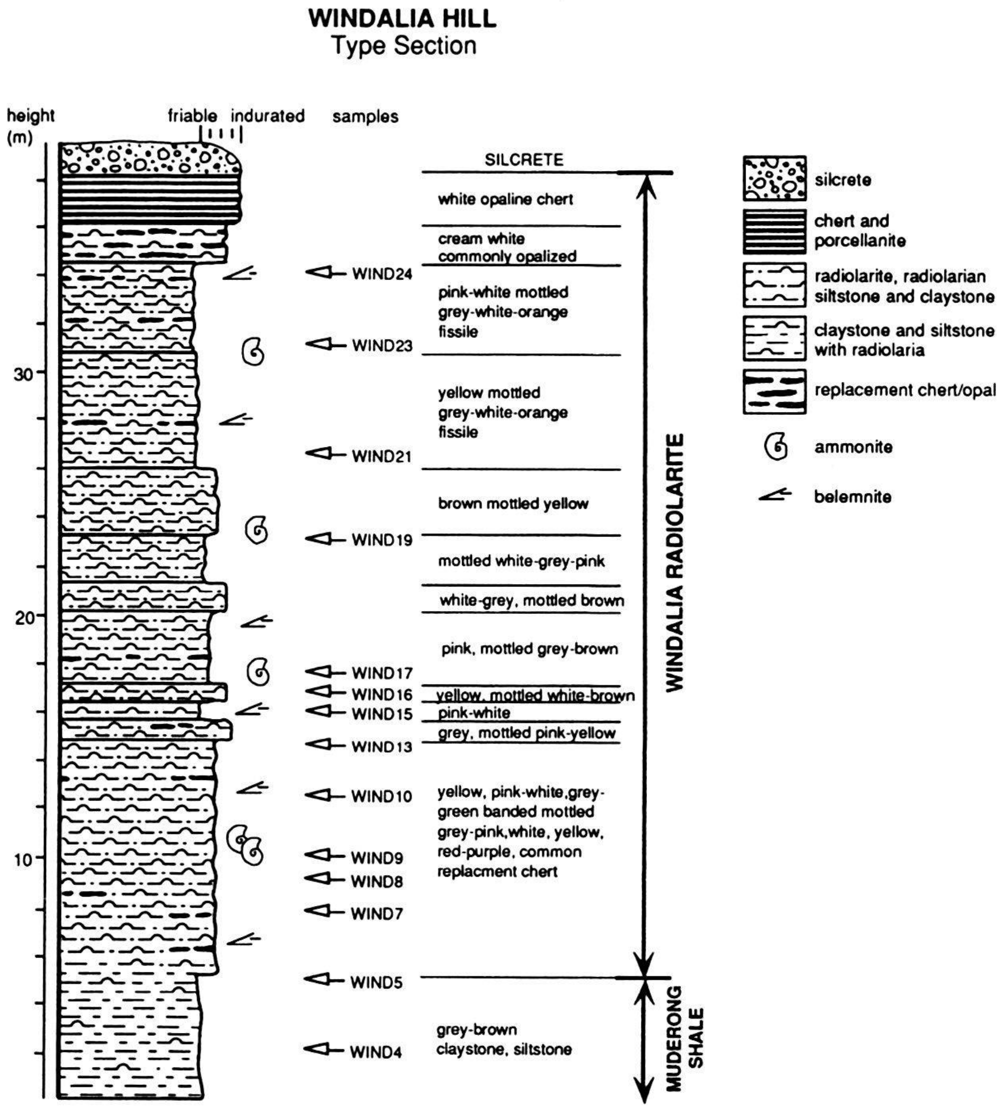



Fig. 3. Lithological column of the type section of the Windalia Radiolarite at Windalia Hill; showing distribution of collected samples used in this study.

## *Previous work*

Radiolaria are the dominant fossil group in the Windalia Radiolarite. Despite their abundance and good preservation, relatively few species have been recorded: Chapman (in: Raggatt 1936) listed 3 species from the formation on Winning Station; Crespin (1946) recorded 23 forms from the type section and numerous other localities; Edgell (1952) identified 11 species from outcrops in the Giralia Anticline about 50 km west of the type section; Glaessner (1955) identified 7 species from near Kalbarri in the southern part of the Carnarvon Basin. None of these works illustrated the fauna and their identifications mainly followed the taxonomy of Hinde (1893). The subsequent vast reorganization of radiolarian classification has made many of the previous generic and specific identifications superfluous or, at best, difficult to apply.

The age of the Windalia Radiolarite has been based previously on associated foraminifera and megafossils. Whitehouse (1926, 1927) suggested the Windalia to be equivalent in age to the Tambo Series (Albian) in Queensland based of the presence of similar belemnites. Raggatt (1936) considered the Winning Group to be Upper Albian and equivalent to the radiolarian rocks described by Hinde (1893) from the Northern Territory. Condon (1954) attributed a Late Cenomanian age for the Windalia Radiolarite based on foraminifera identified by Edgell (1952) and on the presence of large discoidal ammonites belonging to the Family Acanthoceratidae. Subsequent foraminiferal studies by Glaessner (1955) and Belford (1959; for the succeeding Gearle Siltstone), and reinterpreted ammonite identifications, which include the Family Aconoceratidae, by Brunnschweiler (1959) place the Windalia Radiolarite within the Late Aptian to Early Albian.

## 2. Material and methods

Assemblages examined for this study come from the type section of the Windalia Radiolarite at Windalia Hill (Lat. 23°16′S, Long. 114°48′E) on Winning Station (Fig. 1). Only the lower part of the formation is exposed, conformably overlying the Muderong Shale (2 samples of which are used in this study). A detailed lithostratigraphy of the type section is given below and in Fig. 3. A total of 25 samples were collected, of which 14 were analyzed for their radiolarian (and other fossil) content. Selection of samples for processing was based on observed freshness and friability. Sample preparation generally followed standard foraminiferal processing techniques. About 5 $cm^3$ of sample was broken down to mm-sized pieces and then boiled with sodium pyrophosphate (Calgon™) and a small amount of 10% hydrogen peroxide. Successive drying and retreatments were necessary to assist disaggregation of samples with high clay contents. The sediment was then washed through 150 µm and 63 µm sieves to remove the clay. Final residues were dried and stored in plastic vials.

The 63–150 µm and 150 µm-2 mm size fractions were examined and the fossil residue (radiolaria, foraminifera, sponge spicules) placed on a counting tray and collected into grided cardboard slides. The characteristics of the radiolarian thanatoconoesis for each sample were first noted on a minimum representative count of 300 specimens. The entire residue from each sample was then searched several times for rare taxa and well-preserved forms for illustration. This ensured a better perception of the true distribution of specific radiolaria that may have been unevenly dispersed on the counting tray due to size and/or shape. Qualitative estimates of species abundance are tabulated in Table 1.

Preservation of the radiolaria ranges from very poor to good. Compaction of the sediment during lithification has resulted in many broken specimens, and preservation of the finer structures of some radiolaria is rare. With many specimens superficial clay still adhered to surfaces after washing the sediment, and it was necessary to use vigorous additional cleaning (e.g. ultrasound, reboiling and sieving) to aid determinations. Unfortunately, these techniques resulted in broken specimens. The radiolaria are illustrated by scanning electron micrographs taken with a PHILLIPS SEM 505 at the University of Western Australia and with a CAMSCAN Series 4 SEM at the Université de Lausanne. Specimens were mounted onto SEM plugs using double sided tape and then coated with carbon and gold in a vacuum evaporator. The amount of coating required to prevent "charging" varied with shell type and preservation. Generally, forms with spongy tests (e.g. Spongodiscacea) required a heavier coating than forms having latticed meshwork. Transmitted light identification of some radiolaria was carried out using immersion oil or by preparing strewn slides with molten "Lakeside Cement™". Although these are quick techniques allowing viewing of internal structures, the slides are generally of poor quality and the resulting photographs are not suitable for publication.

Tab. 1. Distribution of radiolaria from the type section of the Windalia Radiolarite at Windalia Hill.

| | TAXA | Acaeniotyle diaphorogona | Acaeniotyle longispina | Acaeniotyle sp. cf. A. diaphorogona | Acaeniotyle (?) sp. A | Acaeniotyle (?) sp. B | Actinommid gen. & sp. indet | Actinomma (?) pleiadesensis | Alievium (?) sp. A | Alievium (?) sp. B | Amphipyndax stocki | Angulobracchia crassa | Arachnosphaera exilis | Archaeocenosphaera euganea | Archaeodictyomitra sliteri | Archaeodictyomitra vulgaris | Archaeospongoprunum carrierensis | Archaeospongoprunum diversispina | Archaeospongoprunum klingi | Archaeospongoprunum sp. cf. A. tehamaensis | Archaeospongoprunum sp. cf. A. praelongum | Archaeospongoprunum sp. | Artocapsa ultima | Crucella messinae | Crucella sp. | Cyrtocalpis operosa | Dicanthocapsa sp. cf. D. ancus | Gonglyothorax cephalocrypta | Haliomma sp. | Hemicryptocapsa sp. cf. H. simplex | Histastrum aster | Holocryptocanium barbui barbui | Mesosaturninus hueyi group | Mita sp. | Napora dumitricai |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WINDALIA RADIOLARITE | WIND 24 | | + | + | | | + | R | | | | + | A | | + | | | | | + | | | | + | | | | | | | + | | | | |
| WINDALIA RADIOLARITE | WIND 23 | + | + | + | + | | R | R | | | ? | + | C | | + | | | | | + | + | | | + | | | | | | | + | | | | |
| WINDALIA RADIOLARITE | WIND 21 | + | + | | | | R | R | | ? | + | + | C | | + | + | | ? | ? | + | | ? | | + | | + | | | | | + | ? | | | |
| WINDALIA RADIOLARITE | WIND 19 | + | R | R | + | + | R | C | | + | + | + | A | + | + | + | | R | | + | + | | | R | | + | + | R | | | + | + | | | |
| WINDALIA RADIOLARITE | WIND 17 | + | + | | | ? | R | F | | | + | + | A | + | + | | | | | + | + | | | R | | + | | | | | + | | | | |
| WINDALIA RADIOLARITE | WIND 16 | ? | ? | R | | | R | F | | | + | + | A | + | + | | R | | | + | | | + | R | | | | + | | | | | | | |
| WINDALIA RADIOLARITE | WIND 15 | R | R | R | + | + | R | C | | + | + | + | A | R | + | R | + | + | + | R | R | + | + | F | ? | R | + | R | + | | + | + | | + | + |
| WINDALIA RADIOLARITE | WIND 13 | + | + | + | | ? | F | F | | | + | R | A | + | + | + | | | | + | + | | | F | | + | | | | | + | | | | + |
| WINDALIA RADIOLARITE | WIND 10 | + | + | + | | + | F | F | + | | | + | A | + | + | + | + | | | R | + | | | R | | + | | + | | | | | | | |
| WINDALIA RADIOLARITE | WIND 9 | + | + | + | | | F | C | | | + | + | A | + | + | | | | | + | R | | + | R | | + | + | | | | | | | | |
| WINDALIA RADIOLARITE | WIND 8 | + | + | | + | ? | + | + | + | | + | + | C | | | | + | + | | ? | ? | + | + | + | | ? | | | | | | ? | + | | |
| WINDALIA RADIOLARITE | WIND 7 | + | R | R | | ? | F | C | | | + | R | A | | + | + | | | | R | R | + | | F | | + | | + | | | + | | | | |
| Muderong Shale | WIND 5 | + | R | R | + | | C | A | | | R | + | A | R | + | + | + | | | + | + | + | + | R | | R | + | R | | | R | | + | | |
| Muderong Shale | WIND 4 | R | R | F | + | ? | C | A | | + | R | R | A | R | + | + | ? | | | + | R | + | + | R | + | R | + | R | | + | R | + | | | |

Species abundance is defined as follows:

A = abundant – more than 30 specimens per 300
C = common – 15–29 specimens
F = few – 3–14 specimens
R = rare – 1–2 specimens
+ = very rare – fewer than 2 specimens per 1000
? = doubtful identification

| Napora sp. cf. N. durhami | Nassellarian gen et sp indet. | Orbiculiforma depressa | Orbiculiforma mclaughlini | Orbiculiforma sp. | Paronaella (?) diastimusphere n. sp. | Paronaella sp. | Paronaella (?) sp. | Paronaella spp. | Patellua sp. | Patulibracchium sp. | Patulibracchium (?) sp. | Praeconcaryomma excelsa n. sp. | Praeconocaryomma lipmanae. | Praeconocaryomma prisca | Protoxiphotractus (?) rugosa | Psuedodictyomitra lodogaensis | Spongatractus biconstrictus | Spongatractus sp. cf. S. biconstrictus | Spongodiscus renillaeformis | Spongotripus sp. cf. T. triacummata | Spongopyle ecleptos | Spongopyle galeata | Spongopyle stauromorphos | Spongopyle sp. cf. insolita | aff. Staurocyclina martini | Stichocapsa sp. | Stylosphaera pusillus | Stylosphaera sp. cf. S. hastatus | Triactomma sp. | Tricolocapsa antiqua | Tricolocapsa sp. | Windalia epiplatys | Windalia pyrgodes | Windalia sp. A | Windalia sp. B | Windalia sp. C | Windalia sp. D | Xitus sp. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | + | | | | | | | | | | ? | | | | | R | | | | | | | | | | | | | | F | | | | | |
| | | | | + | | | | + | | | | | + | + | | | | | R | | | | | | | | | | | | | | F | + | R | | | |
| | | | ? | R | | | | + | | | | | ? | + | | R | | | R | + | ? | + | | ? | | | | | + | | | | R | R | R | | + | |
| | | | | + | | | | + | + | | | | + | + | + | R | | + | C | | R | + | + | + | | + | | | | + | | F | C | + | + | + | + | + |
| | | | + | R | | | | + | + | | | | + | ? | | + | | | F | | + | + | | + | | | | | R | | | | F | + | | | + | |
| | | | | + | | | | R | + | | | | ? | + | | | | | F | + | + | + | | + | | + | | | + | | | | F | + | | | | |
| + | | | + | + | + | | | + | + | + | + | + | + | + | + | R | + | | C | + | R | + | + | R | | + | ? | | R | + | + | R | C | R | + | | R | + |
| | | | + | + | | | | R | R | ? | + | F | + | ? | | R | | | F | + | + | + | + | + | | + | | | + | | | | F | + | | | + | + |
| | | | | R | + | | | | + | ? | + | R | + | + | | | ? | | F | | + | + | ? | ? | | | | | R | | | | F | + | ? | | + | |
| | | | + | R | ? | | | + | + | | + | R | ? | + | | + | | | C | | + | ? | + | + | | | | | | + | | | C | + | + | | | |
| | | ? | + | ? | + | + | + | + | | | + | R | + | + | | | + | | + | | + | | | + | + | | + | + | | | | | F | + | ? | | + | |
| | | | | + | | | | + | + | | + | F | ? | + | | R | | | C | | + | + | | + | | + | | | | | | | F | + | + | | R | |
| | | + | + | R | + | | | + | F | | + | F | + | + | | + | | + | A | + | F | + | + | F | | + | | | R | + | | | C | R | + | + | + | |
| | + | R | + | R | + | | | R | F | | + | A | + | R | | + | + | + | C | + | R | + | + | R | | + | + | | + | + | | + | C | R | + | | R | |

## 3. Lithostratigraphy

The type section of the Windalia Radiolarite consists of a weathered pale coloured (yellow to orange) mesa capped by a thin silcrete layer (part of the lateritic profile). About 34 m of the lower part of the formation is present overlying the Muderong Shale with conformity (Fig. 3). The poorly exposed contact with the Muderong Shale is gradational over 50–100 cm, and is placed at the change from soft, dark grey, friable, bentonitic claystone and siltstone (Muderong Shale) to firmer colour-banded mottled radiolarite. The Windalia Radiolarite has a unique lithology and the term "radiolarite" in the formational name can be somewhat misleading (though correct in terms of radiolarian abundance and the dominantly biogenic nature of deposition) as the sediment is atypical of the Tethyan radiolarites (cherts and siliceous limestones). Characteristically, the Windalia Radiolarite is a radiolarian claystone and siltstone, has low specific gravity, is pale in colour, and has very high porosity and permeability. The formation is opalized in places and breaks with a conchoidal or blocky fracture.

The section is composed of continuous varicoloured banded horizons of variable unrelated induration and thickness (from millimetre "liesegang" to metre scale banding). This gives the section a bedded appearance. Close inspection, however, shows that burrow mottles (often iron stained) are ubiquitous, and obscure nearly all primary sedimentary structures. Indistinct bedding planes are sometimes visible, but most of the banded appearance results from varying degrees of iron oxidation in response to groundwater percolation through the sediment, and does not necessarily reflect original planar bedding. Colouration of the sediment is generally white when fresh, but varies from yellow through to dark red-brown depending on the intensity of iron oxidation. Decalcified casts of ammonites and belemnites and distinct bioturbate textures are common, often crowding along horizontal (bedding) planes. Their occurrence appears to be laterally extensive, but poor exposure prevents confirmation of widespread correlatability. Towards the top of the section, the radiolarite becomes fissile and paler in colour. This is probably the result of extensive downward leaching within the lateritic profile and the removal of organic silica and other mobile elements leaving the rock more permeable and paler than the underlying sediment. Iron oxide and lesser manganese oxide staining is evident throughout. The unit is capped by a thin (2 m) cream opaline chert and silcrete layer, which is the result of reprecipitation of unstable biogenic silica as opal during silcretization. Original sedimentary textures and structures are destroyed in this interval.

Petrologic examination of samples from the type section show radiolaria are the dominant rock (and fossil) constituent. Thin section observation indicates that recognizable radiolaria can occupy more than 80% by volume of the rock, but more commonly constitute 5–60 volume%, the remainder being reprecipitated silica and kaolinitic (?) clay. A few grams of sediment will often yield several thousand radiolaria when processed. The availability of such large amounts of silica from radiolarian tests indicates why the sediment is often opalized. High porosity and permeability also can be attributed to the interstitial voids between and within the radiolarian tests. Glaucony and lesser pyrite are present in varying low abundance, sometimes seen replacing radiolaria and foraminifera. Secondary gypsum is presently forming within fractures along bedding and joint planes.

## 4. Fossil distribution

### *Radiolaria*

Throughout the studied sequence radiolaria are generally common to abundant, but preservation varies considerably, confining useful assemblages to softer material (Table 1). Most recognizable radiolaria are present throughout the section, although their occurrence may be sporadic and abundance variable. Samples WIND 21, 23 and 24 contain only poorly preserved taxa. These samples are from near the top of the section where the effects of leaching are strongest. The absence of specific taxa in these samples is interpreted to be a result of post-mortem diagenesis (i.e. dissolution) and not necessarily a reflection of biostratigraphic change.

Spumellariina, and particularly forms with spongy cortical shells, dominate all the assemblages. *Arachnosphaera exilis* (Hinde) outnumbers all other taxa (often more than 50% of the assemblage); other common radiolaria characteristic for the assemblages include *Actinomma* (?) *pleiadesensis* n. sp., *Praeconocaryomma excelsa* n. sp., *Patulibracchium* (?) sp., *Spongodiscus renillaeformis* (Campbell & Clark), a variety of orbiculiformids and a profusion of unidentified actinommids (Actinommid gen. & sp. indet. being the most common). Both *P. excelsa* and *P.* (?) sp. are present only in the lower samples; *Paronaella* (?) *diastimusphere* n. sp., although rare, is large and easily recognized. Nassellarians are subordinate, comprising less than 20% of the total fauna and dominated by several species of *Windalia* n. gen. among them *Windalia pyrgodes* (Renz). With the exception of the orbiculiformids and *S. renillaeformis*, all the above radiolaria have been documented only in sediments in the southern hemisphere (see Renz 1974; Haig & Barnbaum 1978; Ling & Lazarus 1990; Baumgartner 1992) or are newly described herein. They are considered to be non-Tethyan and appear to represent endemic elements that developed in the epicontinental basins of Australia and/or the restricted juvenile Antarctic and Indian Oceans that characterized the southern fragmenting portions of Gondwanaland in the early-mid Cretaceous. A variety of early Cretaceous Tethyan taxa are present in the Windalia assemblages, including *Acaeniotyle diaphorogona* Foreman, *A. longispina* (Squinabol), *Amphipyndax stocki* (Campbell & Clark), *Angulobracchia crassa* Ozvoldova, *Crucella messinae* Pessagno, *Histastrum aster* Lipman, *Holocryptocanium barbui barbui* Dumitrica, *Tricolocapsa antiqua* (Squinabol) and species of *Archaeospongoprunum, Paranoella, Praeconocaryomma* and *Crucella* suggesting some connection with the low-latitude Tethyan seaway. However, all these forms show only moderate or rare abundance and are not dominant features of the Windalia assemblages.

### *Ammonites*

Ammonites are well represented and diverse at the type section. They occur, almost without exception, as fragmentary or crushed moulds making specific identification difficult. However, generic identification is possible. Specimens collected by the author were identified, with the assistance of Dr Ken McNamara of the Western Australian Museum, as *Tropaeum* Sowerby, *Australiceras* Whitehouse and *Toxoceratoides* Spath. Brunnschweiler (1959) reported the presence of *Tropaeum, Paracanthoplites* Stoyanow, *Aconoceras whitehousei* Brunnschweiler, and *Aconoceras astronisoides* Brunn-

SCHWEILER. *Eofalciferella condoni* BRUNNSCHWEILER was also newly identified but is considered by Kennedy & Klinger (1979) as nomen dubium; Casey (1961) suggests that *E. condoni* probably belongs in *Sanmartinoceras*. Other specimens of *Aconoceras, Toxoceratoides, Tropaeum* and *Australiceras* have been collected previously by Dr H. M. Butler, Dr McNamara and G. W. Kendrick from exposures of Windalia Radiolarite in the Carnarvon Basin (collections stored at the W. A. Museum). Ammonite and belemnite biostratigraphy is discussed separately below.

*Belemnites*

Moulds of belemnite guards occur throughout the section and similar sized morphotypes tend to be found concentrated along bedding horizons that can be tracted laterally along the outcrop. Specific identification is difficult. Typically the guards posses undeflected ventrolateral alveolar grooves identifiable with *Peratobelus* WHITEHOUSE of the Dimitobelidae (Whitehouse 1924, Stevens 1965). Latex moulds show many specimens are cylindriconical in outline with slightly depressed transverse sections, similar to *P. oxys* TENISON-WOODS. Based on the shape of other casts, species comparable with *P. australis* PHILLIPS, and others tentatively identified as *Dimitobelus stimulus* DOYLE and *D. diptychus* MCCOY also occur.

*Other fossil groups*

Foraminifera recovered from the studied samples and listed in the literature are rare and poorly preserved, and are not biostratigraphically useful. Only few siliceous agglutinated specimens of *Ammodiscus* and *Haplophragmoides* were identified. Rare species of diminutive *Hedbergella* spp. have been recorded only from coeval sediments in offshore petroleum wells (Apthorpe 1979). Rare, poorly preserved ostracods and fish teeth have also been recorded during this, and previous studies but provide little biostratigraphically useful information. Samples processed for calcareous nannoplankton and palynology proved to be barren. Evidence for benthonic dwelling calcareous organisms is rare. Only one bivalve impression was noted at a separate locality (Ellis 1987), however, Brunnschweiler (1959), Johnstone et al. (1958), Condon et al. (1956) and Condon (1968) suggest a more common presence of bivalves. Rare sponge spicules include simple (oxy-)hexactines and microscleres (Rhaxella) (Dr Benita Murchey, pers. comm. 1991). Infaunal burrowing organisms appear to have been common during deposition of the Windalia Radiolarite as is evident from a mottling of the rock color and texture. Distinct bioturbate textures include abundant *Chondrites* and lesser *Thalassinoides*. Some bedding planes are covered by a network of shallow winding and straight furrows, apparently trails of some crawling invertebrate.

## 5. Systematic palaeontology

Genera and species are listed alphabetically. A synonymy is provided for previously recorded species to clarify the taxonomic designation. Complete descriptions are given only for new species; short remarks are provided for indeterminate or atypical forms.

Information on the stratigraphic ranges and geographic distribution of previously recorded forms is provided under the headings "Range" and "Occurrence". Holotypes and paratypes of type material, and all illustrated material are deposited under the corresponding catalogue C-numbers (listed on plate explanations) with the Museum of Natural History, Basel, Switzerland. A second series of numbers provides reference to the authors photographic collections' records.

## Genus *Acaeniotyle* FOREMAN

*Acaeniotyle* FOREMAN 1973b, p. 258.

*Type species.* – Acaeniotyle diaphorogona FOREMAN 1973b.

### *Acaeniotyle diaphorogona* FOREMAN
Plate 3, Fig. 10

*Acaeniotyle diaphorogona* FOREMAN 1973b, p. 258, pl. 2, figs. 2–5; Foreman 1975, p. 607, pl. 2F, figs. 1–4 only; pl. 3, figs. 1, 2; Nakaseko et al., 1979, pl. 4, fig. 9; de Wever & Theibault 1981, p. 582, pl. 2, fig. 7; Schaaf 1981, p. 431, pl. 15, fig. 2; NAKASEKO & Nishimura 1982, p. 141, pl. 1, fig. 12 (refigured from Nakaseko et al., 1979, pl. 4, fig. 9); Ozvoldova & Sykora 1974, p. 261, pl. 1, figs. 1–3; Schaaf 1984, p. 104, pl. D, figs. H (refigured holotype), 1–5 (fig. 3 refigured from Schaaf 1981, pl. 15, fig. 2); Sanfilippo & Riedel 1985, p. 586, text-fig. 4, figs. 1a–b; de Wever et al. 1986, pl. 6, fig. 11; Aita 1987, p. 63, pl. 12, fig. 12; Thurow 1988, p. 396, pl. 9, fig. 8; Tumanda 1989, p. 33, pl. 1, fig. 2; Ozvoldova & Petercakova 1992, pl. 1, figs. 13, 16; Steiger 1992, p. 28, pl. 2, figs. 1, 2; Taketani & Kanie 1992, text-fig. 3-1.
*Acaeniotyle* sp. cf. *Acaeniotyle diaphorogona* FOREMAN 1975, p. 607, pl. 1F, fig. 1.
*Acaeniotyle* sp. aff. *A. diaphorogona* FOREMAN 1973b, p. 258, pl. 2, figs. 6, 7; pl. 16, fig. 16; Yao 1984, pl. 3, fig. 24.
cf. *Acaeniotyle diaphorogona* FOREMAN, Baumgartner 1984, p. 753, pl. 1, fig. 1 only; Tumanda 1989, p. 33, pl. 1, fig. 3; Baumgartner 1992, p. 317, pl. 3, fig. 1.
cf. *Acaeniotyle* sp. cf. *Acaeniotyle diaphorogona* FOREMAN, Thurow 1988, p. 386, pl. 6, fig. 4.
aff. *Acaeniotyle* sp. aff. *A. diaphorogona* FOREMAN, Empson-Morin 1981, p. 261, pl. 3, figs. 8a–d.
aff. *Acaeniotyle gedrangta* EMPSON-MORIN 1981, p. 261, pl. 3, figs. 6, 7.

*Range.* – Oxfordian to Middle Albian (Campanian?).
*Occurrence.* – Japan, north Pacific, Atlantic and Indian Oceans, southern Europe, Australia.

### *Acaeniotyle longispina* (SQUINABOL)
Plate 3, Figs. 8, 9

*Xiphosphaera longispina* SQUINABOL 1903, p. 110, pl. 8, fig. 13.
*Xiphosphaera fossilis* SQUINABOL 1903, p. 110, pl. 8, fig. 14.
*Acaeniotyle* sp. aff. *A. umbilicata* (RÜST), Foreman 1973b, pl. 1, fig. 15; Foreman 1975, p. 609, pl. 2E, fig. 8.
*Xiphosphaera umbilicata* RENZ 1974, p. 799, pl. 2, figs. 9–12; pl. 9, fig. 21.
*Xiphosphaera* sp. cf. *A. umbilicata* (RÜST), Haig & Barnbaum 1978, figs. 3H, I.
*Acaeniotyle umbilicata* (RÜST), Baumgartner 1992, p. 317, pl. 3, fig. 2.
cf. *Acaeniotyle umbilicata* STEIGER 1992, p. 27, pl. 1, fig. 17 only.

*Remarks.* – This species differs from *A. umbilicata* (RÜST) by having more mammae which are smaller and more angular.
*Range.* – Tithonian (?) to middle Cretaceous.
*Occurrence.* – North Pacific, Atlantic and Indian Oceans, southern Europe, Australia.

*Acaeniotyle* sp. cf. *A. diaphorogona* FOREMAN
Plate 3, Fig. 25

*Remarks.* – Positive identification is hindered because the spines are broken. However, at least 3 spine bases can be seen allowing comparison with *A. diaphorogona*.

*Acaeniotyle* (?) sp. A
Plate 2, Fig. 9

*Remarks.* – Cortical shell small (about 120 μm in diameter), with irregular angular mammae each with 5–6 small circular to elliptical pores. At least 6 massive triradiate spines project from centre of respective mammae. Remaining mammae with thin circular spines projecting from tips. Internal structure is unclear.

*Acaeniotyle* (?) sp. B
Plate 2, Fig. 19

*Remarks.* – This rare form has a cortical shell similar to *Praeconocaryomma prisca*, but differs by possessing an indeterminate number (probably less than 3) of thin triradiate spines. Due to poor preservation only the spine bases can be seen.

**Actinommid** gen. and sp. indet.
Plate 4, Fig. 4

aff. Actinomid, gen. and sp. indet. FOREMAN 1973b, pl. 1, fig. 1.

*Remarks.* – Cortical shell spherical to sub-spherical, meshwork coarse, complex with irregular circular-polygonal pores set within irregular polygonal pore frames. Angular nodes at intersections of pore frames. Internal structure not known. The form illustrated by Foreman (1973b) has a similar arrangement of meshwork on the cortical shell, but is larger than the species illustrated here.

Genus ***Actinomma*** HAECKEL

*Actinomma* HAECKEL 1862, p. 440.

*Type species.* – *Haliomma trinacrium* HAECKEL 1860.

*Actinomma* (?) *pleiadesensis* n. sp.
Plate 4, Figs. 5–7

*Description.* – Thin spherical to sub-spherical test with 3 concentric shells and with about 10 massive, radially arranged, triradiate primary spines. Primary spines generally not preserved but spine bases can be easily distinguished on surface of cortical shell. Cortical shell thin, finely latticed with irregularly arranged small, polygonal pore frames and irregular circular to ovoid pores. Primary spines continuous with massive triradiate beams that connect cortical shell with first medullary shell, and first medullary shell with second medullary shell. Thin circular secondary radial beams also connect cortical shell to first medullary shell at vertices of polygonal pore frames. First medullary shell slightly smaller than cortical shell with large irregular polygonal pores. Second medullary shell subspherical with large elliptical to polygonal pores set in pentagonal and hexagonal pore frames.

*Remarks*. – *Actinomma* (?) *pleiadesensis* n. sp. differs from *A*. (?) *davisensis* PESSAGNO, *A*. (?) *douglasi* PESSAGNO from *A*. (?) *joaquinensis* PESSAGNO by having a cortical shell which is more finely latticed with irregular pores and by having spines which are more slender.

*Measurements*.

| measurement of 11 specimens (μm) | Average | Min. | Max. | Holotype: |
|---|---|---|---|---|
| diameter of cortical shell: | 230 | 200 | 270 | 255 |
| diameter of first medullary shell: (single broken specimen) | 190 | | | |
| diameter of second medullary shell: (single broken specimen) | 65 | | | |

*Etymology*. – This species is named for the Pleiades Hills on Winning Station.
*Holotype*. – Basel Museum C-37163 (paratypes registered with C-37162 and C-37164).
*Range*. – Late Aptian-Early Albian.
*Occurrence*. – Western Australia.

### Genus ***Alievium*** PESSAGNO emend. Foreman

*Alievium* PESSAGNO 1972, p. 297; emend. FOREMAN 1973, p. 262.

*Type species*. – *Theodiscus superbus* SQUINABOL 1914.

#### *Alievium* (?) sp. A
Plate 2, Fig. 17

*Remarks*. – This incomplete form is doubtfully assigned with *Alievium* because of its coarse meshwork of bars forming irregular polygons, rather than a meshwork with triangularly arranged bars typical for the Pseudoaulophacidae.

#### *Alievium* (?) sp. B
Plate 3, Fig. 15

*Alievium* sp. B THUROW 1988, p. 397, pl. 5, fig. 16.

*Remarks*. – This rare form is comparable with the Albian species of THUROW (1988). It is questionably assigned with the genus *Alievium* on the basis of its subspherical latticed shell which is evenly porous with small circular pores set in polygonal pore frames with small spines at vertices. Poor preservation prevents recognition of the characteristic meshwork for this genus.

### Genus ***Amphipyndax*** FOREMAN

*Amphipyndax* FOREMAN 1966, p. 355.

*Type species*. – *Amphipyndax enessefi* FOREMAN 1966, p. 356, text-figs. 10, 11 a–b.

#### *Amphipyndax stocki* (CAMPBELL & CLARK)
Plate 4, Fig. 19

*Stichocapsa megalocephalia* CAMPBELL & CLARK 1944, p. 44, pl. 8, figs. 26, 34.
*Stichocapsa* (?) *stocki* CAMPBELL & CLARK 1944, p. 44, pl. 8, figs. 31–33.

*Dictyomitra uralica* GORBOVETS in Kozlova & Gorbovets 1966, p. 116, pl. 6, figs. 6, 7.
*Amphipyndax stocki* (CAMPBELL & CLARK), Foreman 1968, p. 78, pl. 8, figs. 12a–c; Petrushevskaya & Kozlova 1972, p. 545, pl. 8, figs. 16, 17; Foreman 1973a, p. 78, pl. 430, pl. 13, fig. 5; Moore 1973, p. 827, pl. 11, fig. 6; Riedel & Sanfilippo 1974, p. 775, pl. 11, figs. 1–3, pl. 15, fig. 11; Pessagno 1975, p. 1016, pl. 4, figs. 4–8; Foreman 1978, p. 745, pl. 4, fig. 4; Nakaseko et al. 1979, p. 21, pl. 6, fig. 17–20; pl. 8, fig. 14, Nakaseko & Nishimura 1982, p. 145, pl. 12, fig. 5; Taketani 1982, p. 52, pl. 2, figs. 9a–b; pl. 10, figs. 13, 14; Yao 1984, pl. 5, fig. 25; Suyari 1986, pl. 3, fig. 1; pl. 5, figs. 10, 11; pl. 9, figs. 1, 2; pl. 10, fig. 5; pl. 11, fig. 10; pl. 12, fig. 6 only; pl. 14, fig. 5; pl. 16, fig. 3; pl. 18, fig. 2; pl. 19, figs. 5, 6; Teraoka & Kurimoto 1986, pl. 4, fig. 8; pl. 5, fig. 17; pl. 6, fig. 15; pl. 7, figs. 14, 15; Iwata & Tajika 1989, pl. 1, fig. 8; Tumanda 1989, p. 35, pl. 7, fig. 11; Ozvoldova 1990, p. 140, pl. 2, fig. 3.
*Amphipyndax plousios* FOREMAN 1968, p. 78, pl. 8, fig. 11; Foreman 1978, p. 745, pl. 4, fig. 5.
*Stichomitra cathara* FOREMAN, Renz 1974, p. 797, pl. 11, fig. 17.
*Amphipyndax mediocris* (TAN), Renz 1974, p. 788, pl. 5, figs. 7–9; pl. 12, fig. 3; Schaaf 1981, p. 431, pl. 3, fig. 11; pl. 22, figs. 7a–b; Nakaseko & Nishimura 1982, p. 144, pl. 12, fig. 6; Thurow 1988, p. 397, pl. 4, fig. 5.
*Protostichocapsa stocki* (CAMPBELL & CLARK), Empson-Morin 1982, p. 516, text-figs. 1A–F; text-figs. 2D–F; pl. 4, figs. 1–12 (figs. 1–3 = lectotype; figs. 5–6 = paralectotype (= pl. 8, fig. 31 of Cambell & Clark 1944)).
*Amphipyndax* sp. TAKETANI 1982, p. 52, pl. 10, fig. 16.
*Amphipyndax* sp. A TUMANDA 1989, p. 16, pl. 9, fig. 2.
cf. *Amphipyndax* sp. RIEDEL & SANFILIPPO 1970, p. 505, pl. 3, fig. 11.
cf. *Lithocampe pseudochrysalis* var. a MOORE 1973, p. 828, pl. 8, figs. 4, 5.
cf. *Amphipyndax alamedaensis* (CAMPBELL & CLARK), Nakaseko & Nishimura 1982, p. 144, pl. 17, fig. 6 only.

*Remarks.* – *Amphipyndax stocki* shows wide variation and is difficult to distinguish from *A. mediocris*. Herein, all forms with a distinct knob-like cephalis and with postabdominal segments with or without slight external strictures are identified with *A. stocki*. This contrasts with the original illustration of *A. mediocris* by Hok (1927) which shows a hemispherical cephalo-thorax that is continuous with the rest of the conical test and is not a knob-like protrusion.
*Range.* – (Aptian?) Albian to Maastrichtian.
*Occurrence.* – California, Japan, Roti, western Siberia, Europe, Pacific, Atlantic and Indian Oceans, Western Australia.

## Genus ***Angulobracchia*** BAUMGARTNER

*Angulobracchia* BAUMGARTNER 1980, p. 310.

*Type species.* – *Paronaella* (?) *purisimaensis* PESSAGNO 1971.

### *Angulobracchia crassa* OZVOLDOVA
### Plate 1, Figs. 1, 6

Hagiastrid gen. sp. indet, FOREMAN 1973b, p. 261, pl. 6, figs. 2, 5, 6 only.
*Dictyastrum crassum* OZVOLDOVA 1979, p. 10, pl. 2, figs. 1, 3.
?*Angulobracchia crassa* OZVOLDOVA, Ozvoldova & Petercakova 1992, p. 315, pl. 2, figs. 3, 4.
*Angulobracchia* spp. BAUMGARTNER 1992, p. 318, pl. 3, figs. 5, 6.
*Angulobracchia media* STEIGER 1992, p. 49, pl. 11, figs. 12, 13.
*Angulobracchia* (?) *media* STEIGER, Baumgartner 1992, p. 318, pl. 3, figs. 4.

*Remarks.* – Note the variation in interradial angles between the secondary and tertiary rays.
*Range.* – Tithonian-Albian.
*Occurrence.* – Europe, Pacific and Indian Oceans; Western Australia.

## Genus ***Arachnosphaera*** HAECKEL

*Arachnosphaera* HAECKEL 1860, p. 804.

*Type species.* – *Arachnosphaera oligacantha* HAECKEL 1860.

### *Arachnosphaera exilis* (Hinde)
### Plate 4, Figs. 1–3

*Lithocyclia exilis* HINDE 1893, p. 223, pl. 5, fig. 8; Lloyd 1963, p. 1–2, fig. 1.
*Arachnosphaera exilis* (HINDE), Lloyd 1966, p. 121, pl. 16, figs. 1, 3–10; pl. 18, figs. 1, 2; Haig & Barnbaum 1978, fig. 3W.

*Range.* – Late Aptian to Early Cenomanian (?).
*Occurrence.* – Australia.

## Genus ***Archaeocenosphaera*** PESSAGNO & YANG

*Archaeocenosphaeria* PESSAGNO & YANG in Pessagno et al. 1989, p. 203.

*Type species.* – *Archaeocenosphaera ruesti* PESSAGNO & YANG 1989 in Pessagno et al. 1989.

### *Archaeocenosphaera euganea* (SQUINABOL)
### Plate 2, Figs. 14, 16

*Cenosphaera euganea* SQUINABOL 1903, p. 109, pl. 8, fig. 1.
*Archaeo-"Cenosphaera" boria* PESSAGNO 1977b, p. 36, pl. 3, figs. 13, 19 (subsequent assignment in Pessagno et al. 1989, p. 203).

*Remarks.* – This species is assigned with *A. euganea* based on similar test diameter and number of small circular pores present, about 17 of which can be seen across the maximum diameter of the shell in side view.
*Range.* – Berriasian-middle Cretaceous (?).
*Occurrence.* – California, Italy, Western Australia.

## Genus ***Archaeodictyomitra*** PESSAGNO

*Archaeodictyomitra* PESSAGNO 1976, p. 49; emend. Pessagno 1977b, p. 41.

*Type species.* – *Archaeodictyomitra squinaboli* PESSAGNO 1976.

### *Archaeodictyomitra vulgaris* PESSAGNO
### Plate 5, Figs. 7, 14

*Lithocampe lipmanae* ALIEV 1965, p. 64, pl. 12, figs. 1–3 only.
*Archaeodictyomitra vulgaris* PESSAGNO 1977b, p. 44, pl. 6, fig. 15; Schaaf 1981, p. 432, pl. 4, fig. 2; Suyari 1986, pl. 2, fig. 5; pl. 11, fig. 5; pl. 19, fig. 10; Teraoka & Kurimoto 1986, pl. 2, fig. 12; pl. 3, fig. 12; Thurow 1988, p. 398, pl. 6, fig. 19; Tumanda 1989, p. 36, pl. 7, fig. 4 only.
*Archaeodictyomitra* sp. cf. *A. vulgaris* PESSAGNO, Yao 1984, pl. 4, fig. 6.
cf. *Dictyomitra ordinaria* ALIEV 1965, p. 51, pl. 9, fig. 4.
cf. *Dictyomitra ordinaria* var. *elongata* ALIEV 1965, p. 52, pl. 9, fig. 5.
cf. *Dictyomitra mutabila* ALIEV 1965, p. 53, pl. 9, fig. 6 only.
cf. *Dictyomitra* sp. FOREMAN 1973b, pl. 10, fig. 8.

cf. *Archaeodictyomitra vulgaris* PESSAGNO, Steiger 1992, p. 88, pl. 26, fig. 1.
aff. *Lithocampe lipmanae* var. n. ALIEV 1965, p. 65, pl. 12, fig. 8.
aff. *Archaeodictyomitra* sp. cf. *A. vulgaris* PESSAGNO, Thurow 1988, p. 398, pl. 7, fig. 13.

*Remarks.* – Included here are all forms with a uniform broad conical outline lacking pronounced constrictions between segments, and with about 20 widely spaced continuous costae per segment.
*Range.* – Albian; Late Aptian herein.
*Occurrence.* – California, Europe, central Pacific and North Atlantic Oceans, Western Australia.

*Archaeodictyomitra sliteri* PESSAGNO
Plate 5, Fig. 15

*Dictyomitra costata* (SQUINABOL), Petrushevskaya & Kozlova 1972, p. 550, pl. 2, fig. 3.
*Dictyomitra* sp. A FOREMAN 1975, p. 615, pl. 2G, fig. 18; not pl. 1G, fig. 7; not pl. 2G, figs. 19, 20.
*Dictyomitra* sp. cf. *Dictyomitra* sp. A FOREMAN (1975), Haig & Barnbaum 1978, fig. 40.
*Archaeodictyomitra sliteri* PESSAGNO 1977b, p. 43, pl. 6, figs. 3, 4, 22, 23, 27; de Wever & Thiébault 1981, p. 585, pl. 1, fig. 19; Suyari 1986, pl. 2, fig. 7; pl. 13; Teraoka & Kurimoto 1986, pl. 3, fig. 13 only; Tumanda 1989, p. 36, pl. 7, fig. 2; Marcucci et al. 1991, text-figs. 3n–o; (not Steiger 1992, p. 88, pl. 26, fig. 2).
*Dictyomitra* sp. A TAKETANI 1982, p. 59, pl. 4, figs. 5a–b.
*Archaeodictyomitra* aff. *A. sliteri* PESSAGNO, Suyari 1986, pl. 2, fig. 8.

*Remarks.* – Included here are all forms with a slender outline, conical proximally becoming cylindrical distally; with about 20 moderately massive closely spaced continuous costae on postabdominal chambers; with or without slight constrictions.
*Range.* – Albian to Cenomanian; Late Aptian herein.
*Occurrence.* – California, Europe, Pacific and North Atlantic Oceans, Australia.

## Genus ***Archaeospongoprunum*** PESSAGNO

*Archaeospongoprunum* PESSAGNO 1973, p. 57.

*Type species.* – *Archaeospongoprunum venadoensis* PESSAGNO 1973.

*Archaeospongoprunum carrierensis* PESSAGNO
Plate 3, Figs. 3, 4

*Archaeospongoprunum carrierensis* PESSAGNO 1977b, p. 29, pl. 1, figs. 6, 7, 9.

*Range.* – Albian; Late Aptian in this study.
*Occurrence.* – California, Western Australia.

*Archaeospongoprunum diversispina* (SQUINABOL)
Plate 3, Fig. 11

*Spongoprunum diversispina* SQUINABOL 1904, p. 199, pl. 4, fig. 2; Renz 1974, p. 796, pl. 10, fig. 18.
*Archaeospongoprunum* sp. cf. *A. tehamaensis* PESSAGNO, Thurow 1988, p. 398, pl. 6, fig. 1.

*Range.* – Middle Cretaceous; Late Aptian in this study.
*Occurrence.* – Southern Europe, Indian Ocean, Western Australia.

*Archaeospongoprunum klingi* PESSAGNO
Plate 3, Fig. 7

*Archaeospongoprunum klingi* PESSAGNO 1977b, p. 29, pl. 2, figs. 21, 23, 24.

*Range.* – Albian; Late Aptian in this study.
*Occurrence.* – California, Western Australia.

*Archaeospongoprunum* sp. cf. *A. praelongum* PESSAGNO
Plate 3, Fig. 6

cf. *Archaeospongoprunum praelongum* PESSAGNO 1977b, p. 30, pl. 2, figs. 4, 13, 18, 19.

*Remarks.* – Only poorly preserved specimens were observed restricting accurate identification.

*Archaeospongoprunum* sp. cf. *A. tehamaensis* PESSAGNO
Plate 3, Fig. 5

*Spongoprunum* sp. aff. *Cyphantus probus* (RÜST), Renz 1974, p. 796, pl. 2, figs. 19–22; pl. 10, fig. 19.
*Archaeospongoprunum tehamaensis* PESSAGNO, Schaaf 1981, p. 432, pl. 7, fig. 3 only; pl. 10, figs. 7a–b; Schaaf 1984, pl. Hauterivian, fig. 11 only (refigured from Schaaf 1981, pl. 7, fig. 3); (not Pessagno 1973, p. 65, pl. 9, figs. 2, 3; not Pessagno 1976, p. 33, pl. 1, fig. 1; not Pessagno 1977b, p. 30, pl. 2, figs. 3, 9).
*Archaeospongoprunum* sp. A PESSAGNO 1977b, p. 30, pl. 2, fig. 2.
cf. *Spongoprunum minimum* SQUINABOL 1903, p. 118, pl. 10, fig. 26.

*Remarks.* – This form is similar to *A. tehamaensis* in that they both possess tetraradiate polar spines which are straight and without torsion. It differs from *A. tehamaensis sensu stricto* by having polar spines which are more slender. *Archaeospongoprunum* sp. cf. *A. tehamaensis* appears to be restricted to the Hauterivian to Albian and may be ancestral to *A. tehamaensis.*

*Archaeospongoprunum* sp.
Plate 3, Fig. 2

aff. *Archaeospongoprunum* sp. A HAIG & BARNBAUM 1978, fig. 3D.

*Remarks.* – Test as with genus, elongate, cylindrical with two distinct lobes at each end. Polar spines both triradiate in axial section; torsion of spines not evident due to specimens being incomplete.

Genus ***Artocapsa*** HAECKEL

*Artocapsa* HAECKEL 1887, p. 438.

*Type species.* – *Artocapsa fusiformis* HAECKEL 1887.

*Artocapsa ultima* TAN
Plate 4, Figs. 14, 15

*Artocapsa ultima* TAN, Hok 1927, p. 74, pl. 16, fig. 143; Renz 1974, p. 788, pl. 6, fig. 24; pl. 11, fig. 13.
*Artocapsa livermorensis* CAMPBELL & CLARK 1944, p. 45, pl. 8, figs. 19, 21, 27.
?*Stichomitra livermorensis* (CAMPBELL & CLARK), Foreman 1968, p. 76, pl. 8, fig. 2b only.
aff. *Stichomitra* (?) sp. B THUROW 1988, p. 406, pl. 4, fig. 22.

*Remarks.* – The species illustrated here generally agree with the description for *A. ultima* (and for ?*S. livermorensis* FOREMAN 1968, p. 76). They differ by being more slender with distinct strictures separating post-thoracic segments and by having lateral spines on the final postabdominal chambers.
*Range.* – Middle Cretaceous to Campanian; Late Aptian in this study.
*Occurrence.* – Roti, California, Indian and Atlantic Oceans, Western Australia.

### Genus ***Crucella*** PESSAGNO

*Crucella* PESSAGNO 1971, p. 52.

*Type species.* – *Crucella messinae* PESSAGNO 1971.

### *Crucella messinae* PESSAGNO
### Plate 2, Figs. 1–4

*Crucella messinae* PESSAGNO 1971, p. 56, pl. 6, figs. 1–3; Foreman 1975, p. 612, pl. 1 D, figs. 8, 9; pl. 5, fig. 2; Pessagno 1976, p. 32, pl. 1, fig. 4 (refigured holotype of Pessagno 1971, pl. 6, fig. 1); Pessagno 1977b, p. 27, pl. 1, figs. 3, 4, 13; Taketani 1982, p. 50, pl. 9, fig. 17; Thurow 1988, p. 399, pl. 5, fig. 22; Koutsoukos & Hart 1990, p. 54, pl. 2, figs. 7, 8.
cf. *Crucella espartonensis* PESSAGNO, Renz 1974, pl. 1, fig. 12 only.
cf. *Crucella* sp. B. THUROW 1988, p. 399, pl. 2, fig. 15.

*Remarks.* – Note increased development of patagium with progressively larger specimens. The transmitted light form illustrated by Renz (1974) appears to lack a lacuna characteristic for *C. espartonensis*, it is tentatively assigned to *C. messinae* herein.
*Range.* – Approximately Aptian to Late Cenomanian.
*Occurrence.* – Southern Europe, North Atlantic, Pacific and Indian Oceans, Western Australia.

### *Crucella* sp.
### Plate 2, Fig. 8

*Remarks.* – This rare form possess a central lacuna somewhat similar to *C. espartoensis*.

### Genus ***Cyrtocalpis*** HAECKEL

*Cyrtocalpis* HAECKEL 1860, p. 835.

*Type species.* – *Cyrtocalpis amphora* HAECKEL 1862.

### *Cyrtocalpis operosa* TAN
### Plate 5, Figs. 19, 25

*Cyrtocalpis operosa* TAN 1927, p. 40, pl. 7, fig. 27; Riedel & Sanfilippo 1974, p. 778, pl. 4, figs. 1–3; pl. 14, fig. 10.
?*Cyrtocalpis operosa* TAN, Renz 1974, p. 778, pl. 4, figs. 15, 16; pl. 12, fig. 8.
*Cyrtocalpis* sp. aff. *C. operosa* TAN, Foreman 1978, p. 746, pl. 5, fig. 6.
cf. *Cyrtocalpis operosa* TAN, Yao 1979, p. 25, pl. 1, figs. 1–9.

*Range.* – Valanginian to middle Cretaceous.
*Occurrence.* – Roti, Atlantic and Indian Oceans, Western Australia.

## Genus *Dicanthocapsa* SQUINABOL

*Dicanthocapsa* SQUINABOL 1903, p. 133; emend. Dumitrica 1970, p. 61.

*Type species.* – *Dicanthocapsa euganea* SQUINABOL 1903.

### *Dicanthocapsa* sp. cf. *D. ancus* (FOREMAN)
Plate 5, Fig. 20

*Dicanthocapsa* cf. *ancus* (FOREMAN), Dumitrica 1970, p. 64, pl. 6, figs. 35a–b; pl. 7, fig. 40; pl. 20, fig. 125; Nakaseko & Nishimura 1982, p. 149, pl. 5, fig. 5.
*Theocapsomma* sp. FOREMAN 1971, p. 1681, pl. 5, figs. 8, 9 only.
*Dicanthocapsa* sp. B RENZ 1974, p. 790, pl. 11, fig. 18.
cf. *Theocapsomma* sp. RIEDEL & SANFILIPPO 1970, p. 505, pl. 3, fig. 1.
cf. *Dicanthocapsa* sp. PETRUSHEVSKAYA & KOZLOVA 1972, p. 790, pl. 7, fig. 4 only.
cf. *Dicanthocapsa* sp. TERAOKA & KURIMOTO 1986, pl. 5, figs. 6–7.

*Remarks.* – This species differs from those illustrated by Foreman (1971) and Renz (1974) by having a more inflated abdomen. Its poor preservation and scarcity prevents accurate identification.

## Genus *Gongylothorax* FOREMAN emend. Dumitrica

*Gongylothorax* FOREMAN 1968, p. 19; emend. DUMITRICA 1970, p. 56.

*Type species.* – *Gongylothorax verbeeki* (TAN), Foreman 1968.

### *Gongylothorax cephalocrypta* (TAN)
Plate 4, Fig. 16

*Dicolocapsa cephalocrypta* TAN 1927, p. 44, pl. 8, fig. 42.
*Dicolocapsa exquisita* TAN 1927, p. 44, pl. 8, fig. 43.
*Gongylothorax verbeeki* (TAN), Haig & Barnbaum 1978, text-fig. 4V; Schaaf 1981, p. 434, pl. 1, figs. 1a, b; pl. 9, figs. 9a, b; Tumanda 1989, p. 37, pl. 8, fig. 18; (not Foreman 1968, p. 20, pl. 2, figs. 8a–c; not Dumitrica 1970, p. 57, pl. 1, figs. 6a–b; pl. 2, figs. 7–10; not Foreman 1973a, p. 429, pl. 13, fig. 4; not Wu & Li 1982, p. 66, pl. 1, fig. 10).
cf. *Dicolocapsa verbeeki* TAN 1927, p. 44, pl. 8, figs. 40, 41.
cf. *Gongylothorax favosus* DUMITRICA 1970, p. 56, pl. 1, figs. 1a–c, 2; Matsuoka 1986, pl. 2, fig. 5; (not Wu & Li 1982, pl. 1, figs. 8, 9).
aff. *Dicolocapsa* aff. *abbreviata* NEVIANI, Heitzer 1930, p. 394, pl. 28, fig. 40.

*Remarks:* This rare form compares well with the original description and illustration for *G.* (= *Dicolocapsa*) *cephalocrypta*. It is placed with *Gongylothorax sensu* DUMITRICA on the basis of its poreless cephalis being partly encased in an inflated thorax and in possessing a restricted aperture. A relatively large, simple sutural pore is located on the upper surface near the cephalis. Foreman (1968, p. 20) remarked that *G. cephalocrypta* lacked angular pore frames. However, Tan (1927, p. 44) clearly describes the thorax having a "... rugged upper surface ...". This is evident in his illustration and is interpreted here as the polygonal nature of the pore frames surrounding depressed pores. *Gongylothorax cephalocrypta* differs from both *G. verbeeki* and to *G. favosus sensu stricto* (1) in the elongate ovoid shape of the thoracic segment; (2) the size of the poreframes on the thorax, and (3) in the characteristics of the sutural pore. Species with spherical thoracic segments and assignable with *G. verbeeki* or with *G. favosus* have not been observed in

our samples. *G. favosus* possesses a narrow circular sutural pore; and in *G. verbeeki* a large simple sutural pore develops only in younger (Campanian-Maastrichtian) species. Future work will clarify whether the specific criteria used here are valid. However, it is probable that *G. favosus* is ancestral to *G. cephalocrypta* (with the development of an elongate thoracic segment and large simple sutural pore in the Aptian-Albian), and separately (?) to *G. verbeeki* (with the development of smaller poreframes (?) and modification of the sutural pore).
*Range.* – (Upper Calovian-Oxfordian?) Late Barremian-middle Cretaceous.
*Occurrence.* – Japan, Tibet, Roti, southern Europe, central Pacific Ocean, Australia.

### Genus ***Haliomma*** PESSAGNO

*Haliomma* EHRENBERG 1838, p. 128.

*Type species.* – *Haliomma aequoreum* EHRENBERG 1844.

#### *Haliomma* sp.
#### Plate 2, Figs. 10, 13

aff. *Haliomma minor* CAMPBELL & CLARK, Renz 1974, p. 793, pl. 9, fig. 8.
*Actinomma* sp. LING & LAZARUS 1990, p. 355, pl. 1, fig. 3; pl. 4, fig. 7.

*Remarks.* – Spherical to sub-spherical with 2 concentrically arranged lattice shells. Cortical shell latticed with large circular to elliptical pores set in thick irregular polygonal pore frames. About 6 thin triradiate spines radially arranged, and continuous with massive triradiate radial beams connecting cortical shell with medullary shell. First medullary shell with large polygonal pore frames and pores.

### Genus ***Hemicryptocapsa*** TAN

*Hemicryptocapsa* TAN 1927, p. 50.

*Type species.* – *Hemicryptocapsa capita* TAN 1927.

#### *Hemicryptocapsa* sp. cf. *H. simplex* DUMITRICA
#### Plate 4, Figs. 21, 23

cf. *Hemicryptocapsa simplex* DUMITRICA 1970, p. 74, pl. 16, figs. 104a–b; pl. 21, figs. 142–148 (?).

*Remarks.* – *Hemicryptocapsa* sp. cf. *H. simplex* differs from *H. simplex* by having a less encased thorax. It shows similarities with the late Jurassic *Williriedellum caparthicum* DUMITRICA; it is possible that these three forms are closely related.

### Genus ***Histiastrum*** EHRENBERG

*Histiastrum* EHRENBERG 1847a, p. 386.

*Type series.* – *Histiastrum quaternarium* Ehrenberg 1875, subsequent designation Haeckel 1887.

### *Histiastrum aster* LIPMAN
### Plate 3, Fig. 21

*Histiastrum aster* LIPMAN 1952, p. 35, pl. 2, figs. 6, 7; Lipman 1962, p. 300, pl. 2, fig. 5; Kozlova & Gorbovets 1966, p. 84, pl. 3, fig. 9; Schaaf 1981, p. 435, pl. 8, fig. 1; pl. 11, fig. 5; Schaaf 1984, pl. Albien, fig. 2 (refigured from Schaaf 1981, pl. 8, fig. 1).

*Range*. – Hauterivian-Campanian.
*Occurrence*. – Siberia, Pacific and Indian Oceans, Western Australia.

## Genus ***Holocryptocanium*** DUMITRICA

*Holocryptocanium* DUMITRICA 1970, p. 75.

*Type species*. – *Holocryptocanium tuberculatum* DUMITRICA 1970.

### *Holocryptocanium barbui barbui* DUMITRICA
### Plate 4, Fig. 24

*Holocryptocanium barbui* DUMITRICA 1970, p. 76, pl. 17, figs. 105a–108a; pl. 21, fig. 136; Petrushevskaya & Kozlova 1972, pl. 1, fig. 3; Foreman 1975, p. 618, pl. 1 F, fig. 9; pl. 6, fig. 13; Schaaf 1981, p. 435, pl. 2, figs. 1a, b; pl. 10, figs. 6a, b; Taketani 1982, p. 67, pl. 7, figs. 1a–b; [?]pl. 13, figs. 18, 19, 21; Baumgartner 1984, p. 768, pl. 4, fig. 14; Yao 1984, pl. 5, fig. 1; Sanfilippo & Riedel 1985, p. 614, text-fig. 12, figs. 2a–c; Teraoka & Kurimoto 1986, pl. 2, fig. 1; pl. 4, fig. 1.
*Holocryptocanium japonicum* NAKASEKO & NISHIMURA in Nakaseko et al. 1979, p. 23, pl. 5, figs. 8, 10; Taketani 1982, p. 67, pl. 7, figs. 2a, b, 3; pl. 13, fig. 21.
*Holocryptocanium barbui japonicum* NAKASEKO & NISHIMURA, Nakaseko & Nishimura 1982, p. 154, pl. 3, figs. 5–7; pl. 14, fig. 10; Suyari 1986, pl. 9, fig. 9; Suyari & Kuwano 1986, pl. 3, fig. 4.
*Holocryptocanium* sp. SCHAAF 1981, pl. 2, fig. 8; Suyari 1986, pl. 4, fig. 9.
*Holocryptocanium barbui barbui* DUMITRICA, Baumgartner 1992, p. 321, pl. 7, fig. 4.

*Range*. – (Tithonian?) Late Berriasian-Cenomanian.
*Occurrence*. – Southern Europe, North Atlantic, Pacific and Indian Oceans, Western Australia.

## Genus ***Mesosaturnalis*** KOZUR & MOSTLER emend. de Wever

*Mesosaturnalis* KOZUR & MOSTLER 1981, p. 57; emend. DE WEVER 1984, p. 17.

*Type species*. – *Palaeosaturnalis levis* DONOFRIO & MOSTLER 1978.

### *Mesosaturnalis* sp.
### Plate 3, Fig. 12

aff. *Spongosaturnalis* sp. aff. *Saturnalis polymorphus* (SQUINABOL), Renz 1974, p. 797, pl. 2, fig. 5; pl. 9, fig. 22 (refigured pl. 2, fig. 5).

*Remarks*. – Saturnalids are rarely recovered from the Windalia Radiolarite, mainly as a result of their fragile nature and breakage during sediment lithification. Tentative comparison with Renz's (1974) specimens is based on similar shape of the ring structure and because her material was recovered from a relatively nearby locality in the eastern Indian Ocean. However, without more complete specimens specific assignment is not possible.

## Genus *Mita* PESSAGNO

*Mita* PESSAGNO 1977b, p. 44.

*Type species*. – *Mita magnifica* PESSAGNO 1977.

### *Mita* sp.
### Plate 5, Fig. 13

*Mita* sp. B PESSAGNO 1977b, p. 45, pl. 7, fig. 6.
*Mita* sp. A THUROW 1988, p. 402, pl. 3, fig. 1.
aff. *Archaeodictyomitra squinaboli* PESSAGNO, Suyari 1986, pl. 2, fig. 3 only.

*Remarks*. – This species shows some similarities with *Archaeodictyomitra squinaboli*. Further comparison is not made here due to the scarcity of *Mita* sp., its smaller size and poor state of preservation.

## Genus *Napora* PESSAGNO

*Napora* PESSAGNO 1977a, p. 94.

*Type species*. – *Napora bukryi* PESSAGNO 1977a.

### *Napora dumitricai* PESSAGNO
### Plate 2, Figs. 5, 6

*Tripilidium* (?) sp. A FOREMAN 1973b, p. 265, pl. 10, figs. 13–15.
*Tripilidium* (?) sp. C FOREMAN 1973b, p. 265, pl. 10, fig. 19.
*Napora* (= *Ultranapora*) *dumitricai* PESSAGNO 1977b, p. 38, pl. 5, figs. 7, 16, 17, 21.
cf. *Tripilidium obliquum* HINDE 1900, p. 26, pl. 2, fig. 9.
cf. *Dictyophimus obliquum* (HINDE), Renz 1974, p. 791, pl. 5, fig. 17; pl. 11, fig. 1.

*Remarks*. – Note flanging at the top of the (broken) polar spine indicating the base of subsidiary spines in figure 6. Foreman (1973) records this species from the Valanginian-Early Hauterivian. Pessagno (1977b) regarded the range of this species from his Californian assemblages to be Middle-Late Albian and explained the conclusions of Foreman (1973) to result from reworking or downhole contamination. The presence of *N. dumitricai* in the Windalia assemblage indicates the range of this form must extend into at least the Late Aptian.
*Range*. – (Valanginian?) Middle-Late Albian; Late Aptian herein.
*Occurrence*. – Borneo, Pacific and eastern Indian Oceans, Western Australia.

### *Napora* sp. cf. *N. durhami* PESSAGNO
### Plate 2, Fig. 7

*Tripilidium* (?) sp. B FOREMAN 1973b, p. 265, pl. 10, figs. 16–18.
cf. ?*Tricalpis ellyae* TAN, Renz 1974, p. 798, pl. 5, figs. 18, 19; pl. 11, fig. 10 (refigured pl. 5, fig. 18).
cf. *Dictyophimus* sp. A HAIG & BARNBAUM 1978, fig. 4d only.
cf. *Napora* (= *Ultranapora*) *durhami* PESSAGNO 1977b, p. 38, pl. 5, figs. 7, 16, 17, 21; de Wever & Thiébault 1981, p. 594; pl. 2, fig. 5; Thurow 1988, p. 402, pl. 5, fig. 3; Ling & Lazarus 1990, p. 356, pl. 3, fig. 15; pl. 5, fig. 1.

**Nassellariina** gen. and sp. indet.
Plate 4, Fig. 20

*Remarks.* – Test with 5–6 segments, conical becoming ovoid distally, without aperture. Cephalis spherical, imperforate. The cephalis is questionably slightly encased by the thorax. Thorax trapezoidal, partly porous with simple circular thoracic opening. Abdomen trapezoidal with large simple sutural pore. First and second postabdominal chambers trapezoidal, increasing gradually in width; final postabdominal chamber truncate spherical, decreasing in width rapidly. Abdomen and postabdominal chambers with coarse circular-elliptical pores set in polygonal (dominantly hexagonal) pore frames. This rare species could not be assigned to any meaningful generic classification due to the number of segments or to the presence of the large sutural pore or both.

Genus ***Orbiculiforma*** PESSAGNO

*Orbiculiforma* PESSAGNO 1973, p. 71.

*Type species.* – *Orbiculiforma quadrata* PESSAGNO 1973.

*Orbiculiforma depressa* WU
Plate 1, Fig. 21

*Orbiculiforma depressa* WU 1986, p. 355, pl. 1, figs. 3, 6, 9, 22.

*Range.* – Early Cenomanian; Late Aptian-Early Albian herein.
*Occurrence.* – Tibet, Western Australia.

*Orbiculiforma mclaughlini* PESSAGNO
Plate 1, Fig. 20

*Orbiculiforma mclaughlini* PESSSAGNO 1977a, p. 74, pl. 4, figs. 4–7.
cf. *Spongodiscus* sp. cf. *S. americanus* KOZLOVA, Renz 1974, p. 796, pl. 3, fig. 12; pl. 10, fig. 6.
cf. *Orbiculiforma* sp. A PESSAGNO 1977b, p. 28, pl. 1, fig. 19.

*Range.* – Late Kimmeridgian-Early Tithonian; Late Aptian – Early Albian herein.
*Occurrence.* – California, Western Australia.

*Orbiculiforma* sp.
Plate 1, Fig. 19

*Orbiculiforma* spp. BAUMGARTNER 1992, pl. 7, fig. 11 only.
cf. Spongodiscid, gen. & sp. indet. FOREMAN 1971, pl. 5, fig. 2 only.
cf. *Orbiculiforma railensis* PESSAGNO, Baumgartner 1992, pl. 7, figs. 9, 10.

*Remarks.* – This species is characterized by a polygonal test with a thin periphery and coarser meshwork. Central cavity moderately deep with a raised central area, and having 9–10 (possibly more?) spines. It is similar to the forms illustrated by Baumgartner (1992) which differ only by having more numerous spines which are bladed and not spongy.

## Genus *Paronaella* PESSAGNO sensu BAUMGARTNER

*Paronaella* PESSAGNO 1971, p. 46; emend. BAUMGARTNER 1980, p. 300.

*Type species.* – *Paronaella solanoensis* PESSAGNO 1971.

### *Paronaella* (?) *diastimusphere* n. sp.
Plate 1, Figs. 9, 11, 15

*Description.* – Test with three rays, primary ray often slightly longer, with two prominent lateral spines and one central spine at ray tips. Distinctive large disc-shaped central area (not patagium) with irregular tetragonal, pentagonal and hexagonal pore frames. Rays elliptical in axial section; pore frames rectangular or slightly polygonal with linear arrangement. Inter-radial angles generally equal (not considered to be diagnostic). This form is tentatively assigned as *Paronaella* until further internal examination is undertaken positively identifying the lack of a bracchiopyle.
*Remarks.* – *Paronaella* (?) *diastimusphere* n. sp. differs from all other species of *Paronaella* by its large disc-shaped central area.
*Measurements.*

| measurement of 15 specimens (μm) | Average | Min. | Max. | Holotype: |
|---|---|---|---|---|
| length of rays: | 225 | 190 | 255 | AX: 230<br>BX: 195<br>CX: 215 |
| width of rays: | 100 | 75 | 125 | 105 |
| diameter of central area: | 240 | 190 | 365 | 255 |

*Etymology.* – Greek. *diastam*, space + *sphaira*, sphere – with reference to the saucer shape of the central area.
*Holotype.* – Basel Museum C-37099 (paratypes registered with C-37100 and C-37101).
*Range.* – Late Aptian-Early Albian.
*Occurrence.* – Western Australia.

### *Paronaella* sp.
Plate 1, Fig. 2

*Remarks.* – Distinctive but rare form with inflated ray tips and with open inter-radial angle between second and tertiary rays. Ray structure of *Paronaella* sp. resembles that of *P. petroleumensis* PESSAGNO, however, the scarcity and poor preservation does not permit accurate comparison.

### *Paronaella* (?) sp.
Plate 1, Fig. 3

*Remarks.* – Only a few specimens observed; poor preservation restricts accurate identification.

### *Paronaella* spp.
Plate 1, Figs. 5, 10, 13

*Remarks.* – Includes all forms with ray tips moderately to greatly inflated and with a central spine flanked by 2 or more lateral spines.

## Genus ***Patellula*** KOZLOVA emend. Empson-Morin

*Patellula* Kozlova in Petrushevskaya & Kozlova 1972, p. 527; emend. Empson-Morin 1981, p. 257.

*Type species.* – *Stylospongia planoconvexa* PESSAGNO 1963.

### *Patellula* sp.
### Plate 3, Fig. 20

*Patellula planoconvexa* (PESSAGNO), Schaaf 1981, p. 436, pl. 8, fig. 9.

*Remarks.* – This species compares well with the Albian form illustrated by Schaaf (1981). It differs, however, from the type species of *P. planoconvexa* (PESSAGNO) by being biconvex with a tholus-type structure on both sides of the test.

## Genus ***Patulibracchium*** PESSAGNO

*Patulibracchium* PESSAGNO 1971, p. 26.

*Type species.* – *Patulibracchium davisi* PESSAGNO 1971.

### *Patulibracchium* sp.
### Plate 1, Figs. 4, 8

?Spongodiscid, gen. & sp. indet. FOREMAN 1971, p. 1681, pl. 5, fig. 4 only.

*Remarks.* – Distinctive three-ray test with bracchiopyle; pore frames irregular and spongy in central area, becoming more aligned and polygonal on distal half of each arm. Ray tips with large cylindrical central spine, flanked by two stout triangular spines. With or without patagium.

### *Patulibracchium* (?) sp.
### Plate 1, Figs. 7, 12, 16, 17

*Rhopalodictyum* sp. RENZ 1974, pl. 3, figs. 10, 11; pl. 10, fig. 2.
cf. *Euchitonia novalensis* SQUINABOL 1914, p. 277, pl. 21, fig. 7.

*Remarks.* – This form has a characteristic raised triangular-shaped central area. A bracchiopyle could not be positively identified and it is questionably assigned as *Patulibracchium*.
*Range.* – Aptian-Senonian (?).
*Occurrence.* – Southern Europe (?), Indian Ocean, Western Australia.

## Genus ***Praeconocaryomma*** PESSAGNO

*Praeconocaryomma* PESSAGNO 1976, p. 40.

*Type species.* – *Praeconocaryomma universa* PESSAGNO 1976.

### *Praeconocaryomma excelsa* n. sp.
### Plate 3, Figs. 22–24

aff. *Cenosphaera disseminata* RÜST 1885, p. 16, pl. 27, fig. 4.
aff. *Astrophacus* sp. A HINDE 1893, p. 223, pl. 5, figs. 4 (?), 5.

*Description.* – Test spherical to ellipsoidal. Cortical shell with numerous large prominent mammae, radially arranged, and rising perpendicularly. Tops and distal third of mammae imperforate; tops flattened, rectangular to hexagonal in outline. Base of mammae with large elongate pores, separated by vertical circular bars that project into intermammary areas and irregularly bifurcate and trifircate linking up with rays of neighbouring mammae. With broken specimens, bars thicker and flattened under mammae and continuous. Small nodes present at ray bi-, trifurcations. Intermammary areas with irregular small polygonal pores. First medullary shell approximately one third the diameter of the cortical shell, with small polygonal pore frames with subcircular to polygonal pores; connected to cortical shell by 6–10 (?) thick, bladed radial beams. Structure of second and third medullary shell unknown.

*Remarks.* – *Praeconocaryomma excelsa* n. sp. is grossly similar with *P. immodica* PESSAGNO & POISSON (1979) from the Jurassic. It differs form *P. immodica*, (1) by possessing considerably more mammae (approximately 60 mammae can be seen in lateral view on well preserved specimens compared with about 35 mammae for *P. immodica*); (2) by possessing mammae that are, on average, thinner (avg. 20 µm, range 17–29 µm for *P. excelsa*, compared with avg. 35 µm, range 25–40 µm, for *P. immodica*); (3) by having mammae that are more closely spaced and with rays that rise more vertically; (4) by having a first medullary shell with coarse polygonal pore frames rather than a triangular meshwork; and (5) by having a first medullary shell connected to the cortical shell by only 6–10 massive radial beams.

The increase in the number of prominent mammae and complexitity of the intermammary areas suggest that *P. excelsa* is a continuation of the Jurassic *P. parvimamma* lineage group discussed by Pessagno & Poisson (1979, p. 57–59). However, the first medullary shell of species in the *P. parvimamma* lineage group is distinctly different from that of *P. excelsa* making any direct relationship unlikely.

*Measurements.*

| measurement of 22 specimens (µm) | Average | Min. | Max. | Holotype: |
|---|---|---|---|---|
| diameter of cortical shell | 250 | 210 | 270 | 235 |
| height of mammae | 20 | 15 | 30 | 20 |
| diameter of first medullary: (2 specimens) | 60 | | | |

*Etymology.* – Latin excellsus-a-um, rise, with reference to the raised mammae.
*Holotype.* – Basel Museum C-37154 (paratypes registered with C-37155 and C-37156).
*Range.* – Late Aptian-Early Albian.
*Occurrence.* – Western Australia.

### *Praeconocaryomma lipmanae* PESSAGNO
Plate 2, Fig. 18

*Praeconocaryomma lipmanae* PESSAGNO 1976, p. 41, pl. 4, figs. 12, 13; Taketani 1982, p. 47, pl. 9, fig. 3.
*Conocaryomma lipmanae* (PESSAGNO), Thurow 1988, p. 590, pl. 5, fig. 9.

*Range.* – Late Albian to Turonian; late Aptian in this study.
*Occurrence.* – Japan, California, north Atlantic Ocean, Western Australia.

*Praeconocaryomma prisca* PESSAGNO
Plate 3, Figs. 16, 17

*Praeconocaryomma prisca* PESSAGNO 1977b, p. 33–34, pl. 3, fig. 20.

*Range.* – Valanginian; Late Aptian – Early Albian in this study.
*Occurrence.* – California, Western Australia.

## Genus *Protoxiphotractus* PESSAGNO

*Protoxiphotractus* PESSAGNO 1973, p. 81.

*Type species.* – *Protoxiphotractus perplexus* PESSAGNO 1973.

*Protoxiphotractus* (?) *rugosa* TAN
Plate 3, Fig. 1

*Ellipsoxiphus rugosa* TAN 1927, p. 37, pl. 6, fig. 12.

*Remarks.* – This rare form is tentatively assigned with *Protoxiphotractus* on the basis of its subspherical latticed cortical shell with coarse polygonal meshwork and two short polar spines which tend to be elliptical in axial section towards their tips. It displays similarities with *Acaeniotyle starka* Empson-Morin but lacks a strongly nodose surface and spine bases. Internal structure of test unknown.
*Range.* – Middle Cretaceous; Late Aptian in this study.
*Occurrence.* – Roti, Western Australia.

## Genus *Pseudodictyomitra* PESSAGNO

*Pseudodictyomitra* PESSAGNO 1977b, p. 50.

*Type species.* – *Pseudodictyomitra pentacolaensis* PESSAGNO 1977b.

*Pseudodictyomitra lodogaensis* PESSAGNO
Plate 4, Figs. 18, 19

*Pseudodictyomitra lodogaensis* PESSAGNO 1977b, p. 50, pl. 8, figs. 4, 21, 28; Nakaseko & Nishimura 1982, p. 159, pl. 9, fig. 5; Taketani & Kanie 1992, text-fig. 5.1; (not Schaaf 1981, p. 437, pl. 3, fig. 5; not Yao 1984, pl. 5, fig. 14; not Thurow 1988, p. 405, pl. 3, fig. 12).
*Dictyomitra* sp. C HAIG & BARNBAUM 1978, fig. 4I.
*Pseudodictyomitra vestalensis* PESSAGNO, Thurow 1988, p. 405, pl. 8, fig. 15.
*Dictyomitra* ex. gr. *multicostata* ZITTEL, Koutsoukos & Hart 1990, p. 53, pl. 1, figs. 4, 5 (6, 7?).
*Pseudodictyomitra pentacolaensis* PESSAGNO, Ling & Lazarus 1990, P. 405, pl. 2, figs. 11, 12; pl. 4, figs. 5–7.
cf. *Zifondium* (?) sp. YAO 1984, pl. 4, fig. 5.

*Range.* – Aptian to Cenomanian.
*Occurrence.* – California, Japan, Brazil, central Pacific and North Atlantic Oceans, Weddell Sea, Australia.

## Genus ***Spongatractus*** HAECKEL

*Spongatractus* HAECKEL 1887, p. 350.

*Type species.* – *Spongosphaera pachystyla* EHRENBERG 1873.
*Remarks.* – Included with *Spongatractus* are all forms with a thick ellipsoidal spongy cortical shell and a single medullary shell, and with a single spine at each of the 2 poles. The synonymy of *Spongotractus* HAECKEL with *Spongosphaera* EHRENBERG as suggested by Cambell (1954, D74) is not followed here.

### *Spongatractus biconstrictus* RÜST
Plate 4, Fig. 9

*Ellipsoxiphus biconstrictus* RÜST 1898, p. 16, pl. 5, fig. 8.
cf. *Spongodruppa cocos* RÜST, Tumanda 1989, p. 35, pl. 7, fig. 9.

*Remarks.* – Rüst (1898) described *S. biconstrictus* having a smooth surface of irregularly dispersed middle-sized pores. We interpret this as suggesting a spongy cortical shell, analogous with the specimens illustrated herein, despite his illustration presenting a cortical shell with coarse pores. *Spongatractus biconstrictus* differs from Tumanda's (1989) *S. cocos* by possessing spines at each of the poles.
*Range.* – Late Jurassic-Early Cretaceous; late Aptian-Early Albian in this study.
*Occurrence.* – Southern Europe, Japan (?), Western Australia.

### *Spongatractus* sp. cf. *S. biconstrictus* RÜST
Plate 4, Fig. 10

cf. ?*Spongodruppa cocos* RÜST, Schaaf 1981, p. 439, pl. 6, fig. 13; pl. 15, figs. 4a, b.
cf. *Spongodruppa cocos* RÜST, Schaaf 1984, pl. Albien, fig. 3 (refigured from Schaaf 1981, pl. 6, fig. 13).

*Remarks.* – *Spongotractus* sp. A is more inflated than *S. biconstrictus*. Internal structure is identicle to Schaafs (1981, 1984) *S. cocos* but it differs by possessing polar spines.

## Genus ***Spongodiscus*** EHRENBERG

*Spongodiscus* EHRENBERG 1854, p. 246.

*Type species.* – *Spongodiscus resurgens* EHRENBERG 1854.

### *Spongodiscus renillaeformis* CAMPBELL & CLARK
Plate 1, Figs. 14, 18

*Spongodiscus renillaeformis* CAMPBELL & CLARK 1944, p. 18, pl. 6, figs. 5, 6, 8, 10; Schaaf 1981, p. 438, pl. 8, fig. 4 only; pl. 13, fig. 9; pl. 15, fig. 1; Schaaf 1984, p. 160, pl. Albien, fig. 1 (refigured Schaaf 1981, p. 438, pl. 8, fig. 4).
*Spongodiscus impressus* LIPMAN in Kozlova & Gorbovets 1966, p. 87, pl. 4, figs. 8, 9.
aff. *Orbiculiforma* spp. BAUMGARTNER 1992, pl. 7, fig. 12 only.

*Remarks.* – Note the large variation in size between specimens.
*Range.* – Albian-Lower Cenomanian (Campanian?); Late Aptian-Early Albian herein.
*Occurrence.* – Southern Europe, eastern Indian Ocean, Western Australia.

## Genus *Spongopyle* DREYER

*Spongopyle* DREYER 1889, p. 42.

*Type species.* – *Spongopyle setosa* DREYER 1889, subsequent designation Campbell 1954.
*Remarks.* – There are several species of *Cyrtocalpis* described by Rüst (1885) which conform with *Spongopyle* as used here, however, no reference is made to their internal structure making any accurate comparison impossible.

### *Spongopyle ecleptos* RENZ
Plate 2, Fig. 21

*Spongopyle ecleptos* RENZ 1974, p. 796, pl. 3, figs. 2–6; pl. 10, fig. 14; Schaaf 1981, p. 439, pl. 17, figs. 2a–b, 9.
*Spongopyle insolita* KOZLOVA group, Riedel & Sanfilippo 1974, p. 780, pl. 2, fig. 10 only.
aff. *Cyrtocalpis minima* RÜST 1885, p. 302, pl. 25, fig. 6.

*Remarks.* – This species shows no internal structure. In reflected light it can be distinguished from *S. stauromorphos* by its flattened central area and flared pylome, the latter species has a more inflated central region.
*Range.* – Late Jurassic to Campanian.
*Occurrence.* – Eastern Indian Ocean, Western Australia.

### *Spongopyle galeata* RENZ
Plate 4, Fig. 8

*Spongopyle galeata* RENZ 1974, p. 796, pl. 10, fig. 8.

*Remarks.* – *Spongopyle galeata* is easily identified by its large size and no internal structure (compare with *S. ecleptos* and *S.* sp. cf. *S.* sp. cf. *S. insolita*).
*Range.* – Middle Cretaceous; Late Aptian in this study.
*Occurrence.* – Eastern Indian Ocean, Western Australia.

### *Spongopyle stauromorphos* RENZ
Plate 2, Fig. 11

*Spongopyle stauromorphos* RENZ 1974, p. 796, pl. 3, figs. 1a–b; pl. 10, fig. 9.
*Spongopyle* sp. SCHAAF 1981, pl. 17, figs. 1a–b.

*Remarks.* – Internal examination shows a central area with about 6 narrow concentric rings conforming with the original description.
*Range.* – Barremian (?) to middle Cretaceous.
*Occurrence.* – Central Pacific and eastern Indian Ocean, Western Australia.

### *Spongopyle* sp. cf. *S. insolita* KOZLOVA
Plate 2, Fig. 20

cf. *Spongopyle insolita* KOZLOVA in Kozlova & Gorbovets 1966, p. 91, pl. 4, figs. 11a–b; Riedel & Sanfilippo 1970, p. 505, pl. 2, fig. 2; Petrushevskaya & Kozlova 1972, pl. 5, fig. 10; Renz 1974, p. 796, pl. 3, figs. 7–8; pl. 10, fig. 10.
cf. *Spongopyle insolita* KOZLOVA group, Riedel & Sanfilippo 1974, p. 780, pl. 2, fig. 7–9, 11 only; pl. 14, fig. 4.

*Remarks.* – This species is only tentatively compared with *S. insolita* as internal examination shows a central area with about 6–7 narrow concentric rings rather than about

4–5 rings which are wide apart. It differs from *S. stauromorphos* by being considerably smaller and by lacking spines.

### Genus ***Spongotripus*** HAECKEL

*Spongotripus* HAECKEL 1881, p. 461.

*Type species.* – *Spongotripus regularis* HAECKEL 1887.

#### *Spongotripus* sp. cf. *Tripodictya triacummata* LIPMAN
Plate 3, Fig. 19

*Spongotripus* sp. cf. *Tripodictya triacummata* LIPMAN, Renz 1974, p. 797, pl. 10, fig. 3.
cf. *Tripodictya triacummata* LIPMAN 1952, p. 33, pl. 2, fig. 2.
cf. *Spongotripus* sp. PETRUSHEVSKAYA & KOZLOVA 1972, p. 528, pl. 21, fig. 2.

*Remarks.* – This rare form compares well with the early Cretaceous specimens from Renz (1974), but lacks triradiate spines allowing only tentative comparison. *Spongotripus* sp., although similar, is Eocene in age.

### Genus ***Staurocyclia*** HAECKEL

*Staurocyclia* (= *Coccostaurus*) HAECKEL 1881, p. 458.

*Type species.* – *Staurocyclia* (= *Coccostaurus*) *cruciata* HAECKEL 1881.

#### aff. *Staurocyclia martini* RÜST
Plate 3, Fig. 18

Spongodiscid 1 gen. and sp. indet. RENZ 1974, p. 796, pl. 3, fig. 9; pl. 10, fig. 4.
aff. *Staurocyclia martini* RÜST 1898, p. 21, pl. 6, fig. 11; Schaaf 1981, p. 439, pl. 11, figs. 2a, b; Thurow 1988, p. 406, pl. 10, fig. 8.

*Remarks.* – This form is questionably assigned to *S. martini* as it lacks the circular arrangement of nodes (tholus?) in the central area.
*Range.* – Barremian-Early Aptian; Late Aptian this study.
*Occurrence.* – Southern Europe, north Atlantic and central Pacific Ocean, Western Australia.

### Genus ***Stichocapsa*** HAECKEL

*Stichocapsa* HAECKEL 1881, p. 439.

*Type species.* – *Stichocapsa jaspidea* RÜST 1885.
*Remarks.* – Many species belonging with *Stichocapsa* have previously been included with *Stichomitra* Cayeux. However, the designation of *S. costata* as a type species for *Stichomitra* by Chediya 1959 (reference not available to the author) made this genus synonymous with *Dictyomitra* (as indicated by Campbell 1954, D 140; Petrushevskaya & Kozlova 1972, p. 545 and later by Sanfilippo & Riedel 1985, p. 622). Pessagno (1976, p. 54) improperly indicated *S. jaspidea* as a type species for *Stichomitra* in the sense of

the description for the genus made by Foreman (1968, p. 71). *Stichomitra sensu* FOREMAN (1968) is regarded as a junior synonym for *Stichocapsa*.

*Stichocapsa* sp.
Plate 4, Fig. 12

cf. *Stichocapsa* sp. PETRUSHEVSKAYA & KOZLOVA 1972, pl. 8, figs. 6, 7 (?).
cf. *Lithostrobus litus* FOREMAN 1978, p. 747, pl. 4, fig. 12.
cf. *Amphipyndax conicus* NAKASEKO & NISHIMURA, Suyari 1986, pl. 3, fig. 2 only.
cf. *Stichomitra* (?) sp. A THUROW 1988, p. 406, pl. 1, fig. 17.
cf. *Amphipyndax* sp. B TUMANDA 1989, p. 16, pl. 9, fig. 6.

Genus ***Stylosphaera*** EHRENBERG

*Stylosphaera* EHRENBERG 1847b, p. 54.

*Type species*. – *Stylosphaera hispida* EHRENBERG 1854, subsequent designation Frizzell in Frizzell & Middour 1951.

*Stylosphaera pusillus* CAMPBELL & CLARK emend. Foreman
Plate 3, Fig. 13

*Stylosphaera* (*Stylospharella*) *pusilla* CAMPBELL & CLARK 1944, p. 5, pl. 1, figs. 2, 4, 5.
*Stylosphaera pusilla* CAMPBELL & CLARK, Renz 1974, p. 798, pl. 9, fig. 20 only.
*Druppatractus* sp. A FOREMAN 1977, pl. 1, fig. 3.
*Ellipsoxiphus pusilla* (CAMPBELL & CLARK), Foreman 1978, p. 743, pl. 2, figs. 9, 10, 17.
*Praestylosphaera* sp. aff. *P. pusillus* (CAMPBELL & CLARK), Empson-Morin 1981, p. 262, pl. 4, fig. 6.
*Lithatractus pusillus* (CAMPBELL & CLARK), Taketani 1982, p. 48, pl. 1, figs. 8a, b; pl. 9, figs. 5, 6; Iwata & Tajika 1989, pl. 3, fig. 3; Baumgartner 1992, p. 321, not illustrated.

*Remarks*. – Foreman (1978) emended the original description to include forms with smooth or bladed spines. Internal observation indicates the presence of a single medullary shell indicating that assingment with *Stylosphaera* is appropriate.
*Range*. – Early Barremian-Early Campanian.
*Occurrence*. – California, southern Europe, Japan, Pacific, Atlantic and Indian Oceans, Western Australia.

*Stylosphaera* sp. cf. *S. hastatus* (CAMPBELL & CLARK)
Plate 3, Fig. 14

*Sphaerostylus* (*Sphaerostylantha*) *hastatus* CAMPBELL & CLARK 1944, p. 5, pl. 1, figs. 1, 6.
*Ellipsoxiphus hastatus* (CAMPBELL & CLARK), Foreman 1978, p. 742, pl. 2, fig. 13.
*Praestylosphaera hastata* (CAMPBELL & CLARK), Empson-Morin 1981, p. 262, pl. 4, figs. 4, 5a–c.

*Remarks*. – This species is tentatively compared with *Stylosphaera hastata* CAMPBELL & CLARK based on its relatively large spherical cortical shell composed of uniform circular pores set in polygonal pore frames.

## Genus *Triactoma* RÜST emend. Pessagno et al.

*Triactoma* RÜST 1885, p. 289; emend. Pessagno et al. 1989, p. 205.

*Type species.* – *Triactoma tithonianum* RÜST 1885 (subsequent designation by Campbell 1954).

### *Triactoma* sp.
### Plate 2, Figs. 12, 15

*Remarks.* – Sub-spherical to spherical cortical shell with large hexagonal pore frames and circular pores. Although the spines are not preserved in our specimens, three radially arranged massive triradiate spine bases symmetrically arranged on test are present. This rare form is present in most of the samples examined from the Windalia Radiolarite type section.

## Genus *Tricolocapsa* HAECKEL

*Tricolocapsa* HAECKEL 1887, p. 436.

*Type species.* – *Tricolocapsa theophrasti* HAECKEL 1887, subsequent designation Cambell 1954.

### *Tricolocapsa antiqua* (SQUINABOL)
### Plate 4, Figs. 17, 22

*Theocorys antiqua* SQUINABOL 1903, p. 135, pl. 8, fig. 25; Riedel & Sanfilippo 1974, p. 781, pl. 10, fig. 9 only; Haig & Barnbaum 1978, fig. 4F; Kozlova in Basov et al. 1979, fig. 4; Schaaf 1981, p. 440, pl. 24, figs. 10a, b; Sanfilippo & Riedel 1985, p. 623–624, text-fig. 14, figs. 6a–b, d only.
*Theocorys oblonga* SQUINABOL 1904, p. 226, pl. 9, fig. 3.
*Theocorys* sp. aff. *T. antiqua* SQUINABOL, Renz 1974, p. 798, pl. 6, figs. 4–7; pl. 11, fig. 4.
*Theocorys* sp. 1 LING & LAZARUS 1990, p. 357, pl. 3, fig. 8; pl. 4, fig. 9.
*Tricolocapsa* sp. LING & LAZARUS 1990, p. 357, pl. 4, fig. 10.
cf. *Tricolocapsa parvipora* TAN 1927, p. 48, pl. 9, fig. 59.
cf. *Tricolocapsa parvipora* var. a TAN 1927, p. 49, pl. 9, fig. 60.

*Remarks.* – Only forms with 3 segments, a conical to spindle shaped test with a constricted aperture, and generally with a longitudinal arrangement of small, closely spaced pores (often between plicae) are included with *T. antiqua* here. This species was initially assigned with *Theocorys*, however, it bears little resemblance to this genus which is characterized by having large pores and with a third segment being wide open terminally. Reassignement of this species to *Tricolocapsa* is more appropriate, although a basal cover plate over the aperture is generally not preserved (see, however, *Tricolocapsa* sp. Ling & Lazarus 1990, p. 357, pl. 4, fig. 10). It is not clear whether Tan's (1927) species of *T. parvipora* possesses a constricted aperture. Forms with 4 segments initially included with *T. antiqua* (e.g. Riedel & Sanfilippo 1974, pl. 10, figs. 10, 11 and Sanfilippo & Riedel 1985, p. 623–624, text-fig. 14, fig. 6c) appear to conform with *Stichocapsa naradaniensis* YAO (1979).
*Range.* – Aptian to Santonian.
*Occurrence.* – Southern Europe, Atlantic, Indian and Pacific Oceans, Weddell Sea, Roti (?), Australia.

## *Tricolocapsa* sp.
Plate 4, Fig. 11

*Theocorys antiqua* (SQUINABOL), Sanfilippo & Riedel 1985, p. 623–624, text-fig. 14, fig. 6d only.
cf. *Dicolocapsa radiata* HEITZER 1930, p. 395, pl. 28, figs. 44a–b.
cf. *Tricolocapsa plicarum* YAO 1979, p. 32, pl. 4, figs. 1–11.
aff. *Heliocapsa gutta* HEITZER 1930, p. 392, pl. 28, fig. 30.

*Remarks.* – This rare form differs from *T. antiqua* by the more spherical shape of its abdomen. It compares well with *T. plicarum*, but differs by lacking a characteristic robust basal cover plate.

## Genus ***Windalia*** ELLIS n. gen.

*Type species.* – *Amphipyndax* (?) *pyrgodes* RENZ 1974, p. 788, pl. 12, fig. 1.

*Description.* – Test conical, elongate, lobate outline, multicyrtoid. Cephalis small, conical, imperforate, separated from thorax by single row of elliptical pores set between poorly developed ridges. Small apical horn may or may not be present. Thorax trapezoidal to campanulate in outline, small, sparsely perforate with weakly developed ridges. Cephalothorax conical, sometimes cylindrical. Abdomen trapezoidal, separated from thorax by irregular row or rows of elliptical pores within weakly developed ridges. Variable number of postabdominal chambers (segments) but no less than 6, trapezoidal to cylindrical in outline; generally increasing rapidly in width but only slightly in height as added. Final 2 to 4 postabdominal chambers increasing in height slowly or not at all, and moderately to rapidly decreasing in width, terminating in a rarely preserved narrow extension with a small aperture. Abdomen and postabdominal chambers separated externally by prominent longitudinal or inclined ridges; internally by an imperforate septal plate with large circular aperture. Septal plate fused with internal side of ridges, approximately midway, such that there is no external expression. Externally, each segment has a single transverse row of circular pores, set within hexagonal pore frames staggered with respect to ridges, generally forming at, or below constriction of the external wall (note that the constriction is not a stricture and does not mark the joint between successive segments). When viewed internally, each segment has 3 rows of circular pores, hexagonally arranged as with the genus *Parvicingula* PESSAGNO and *Amphipyndax* FOREMAN. Generally, on the final few segments test construction is more complex with flattening of diagonally aligned ridges and fusion of septal plate with outer surface, giving this portion of the test a smooth perforate appearance of several rows of hexagonally arranged elliptical to circular pores set within polygonal pore frames.
*Remarks.* – The characteristic arrangement of ridges and circular pores distinguishes *Windalia* n. gen. from other nassellaria. Haig & Barnbaum (1978) identified similar specimens as *Lithostrobus* Büschilli. However, *Lithostrobus* generally has a test wall composed of quincuncially arranged circular to elliptical pores, which on some forms coalesce to form shallow nodes at the junctions of the intervening pore bars, quite distinct from the forms illustrated herein. Renz (1974) placed species of *Windalia* with *Amphipyndax* (?). However, *Windalia* differs from *Amphipyndax* in lacking a large knob-like cephalis and by possessing prominent ridges at joints and not strictures. With *Parvicingula* PESSAGNO, the fusion between ridges and the internal septal plate at successive joints

is continuous to the external surface where it is expressed as an circumferential ridge, not observed with *Windalia*. *Windalia* differs further from *Parvicingula* by having segments generally with only a single row of circular pores between ridges rather than several rows with distinct pores. It differs from *Foremanina* EMPSON-MORIN by having more prominent ridges, and by having only one pore row between ridges at each segment rather than 2–5 rows of distinct pores.

To date, *Windalia* has been observed only in Lower Cretaceous sediments in the southern hemisphere. In all these sediments it is generally common, particularly in and around Australasia. Its exclusion from the Tethyan region suggests that the genus is endemic to the southern hemisphere and probably developed in the extensive Australian epeirc seas and/or associated with unique ocean circulation in the juvenile Indian and Antarctic Oceans.

*Etymology*. – Named for the type locality of the Windalia Radiolarite at Windalia Hill.

*Range*. – Barremian to Albian.

*Occurrence*. – Weddell Sea (ODP Leg 119 Site 693 A), Indian Ocean (ODP Leg 123, Site 765; DSDP Leg 25, Site 249; DSDP Leg 27, Site 259, Site 260, Site 261), Australia (Carnarvon and Surat Basins).

*Windalia epiplatys* (RENZ) emend.
Plate 5, Figs. 22–24

*Amphipyndax* (?) *epiplatys* RENZ 1974, p. 788, pl. 5, figs. 1–3; pl. 12, fig. 2 (refigured pl. 5, fig. 1).

*Diagnosis*. – Test as with genus. Distinct elongate, cylindrical-slightly conical test. Cephalis hemispherical with very small horn at tip. Thorax cylindrical, about as wide as cephalis, slightly porous. Cephalothorax forming prominent cylindrical, knob-like tip. Abdomen trapezoidal, about twice as wide as cephalothorax. First and 2nd postabdominal chambers trapezoidal without constrictions, increasing in width rapidly such that 2nd segment is about twice to three times as wide as abdomen. Next 2 postabdominal segments cylindrical to subcylindrical, increasing in width very slowly, slight constriction may be present within 4th segment. Cephalothorax, abdomen and first 4 postabdominal segments with complex, irregularly developed ridges and elliptical pores, together forming campanulate outline. Next 4 segments subcylindrical to trapezoidal, increasing in width very slowly, with well developed ridges at joints and prominent constriction at single row of circular pores within each segment (as for genus). Ninth segment cylindrical with flattened ridges (without constriction) giving test a smooth perforate appearance. Tenth segment tapering distally rapidly, also with flattened ridges. Remaining 1 or 2 postabdominal segments not preserved on specimens but probably constricting rapidly to small circular aperture or terminal tube.

*Remarks*. – Definition provided by Renz (1974) does not describe in sufficient detail test structure nor allow for the possession of a terminal extension. The complex shape of *Windalia epiplatys* is characteristic for this species and distinguishes it from all other forms of *Windalia*.

*Range*. – Late Aptian to middle Cretaceous (?).

*Occurrence*. – Indian Ocean, Australia.

### *Windalia pyrgodes* (RENZ) emend.
Plate 5, Figs. 1–3, 5, 21, 26

*Amphipyndax* (?) *pyrgodes* RENZ 1974, p. 788, pl. 5, figs. 4–6, pl. 12, fig. 1 (refigured pl. 5, fig. 5).
*Lithostrobus* sp. C HAIG & BARNBAUM 1978, figs. 4k, l.
aff. *Stichomitra* sp. 1 LING & LAZARUS 1990, p. 356, pl. 2, figs. 15, 16; pl. 5, fig. 11.
cf. parvicingulid sp. B BAUMGARTNER 1992, pl. 8, fig. 12.

*Diagnosis.* – Test as with genus. Slender, conical, with prominent stricture within successive postabdominal chambers; cephalothorax broadly conical with small, stout horn (generally not preserved). Consisting of at least 10 postabdominal chambers, trapezoidal in outline; first 7–8 segments increase in height slowly and moderately rapidly in width as added; final 2–3 postabdominal chambers with flattened ridges at joints, increasing in height slowly but constricting rapidly (inverted bell-shaped), terminating in long tubular extension as for genus.
*Remarks.* – Definition provided by Renz (1974) does not describe in sufficient detail test structure nor allow for the possession of a terminal extension. Distinction with *Lithostrobus* as with genus. Distinction between *Windalia pyrgodes* and *Windalia* sp. A is given under the latter species. The specimen *Stichomitra* sp. 1 illustrated by Ling & Lazarus (1990) is incomplete.
*Range.* – Barremian (?) to middle Cretaceous (?).
*Occurrence.* – Indian Ocean, Australia.

### *Windalia* sp. A
Plate 4, Figs. 8–10, 12

*Remarks.* – *Windalia* sp. A differs from *W. pyrgodes* (1) by the biconical shape of its test, and (2) with the widest point of the test at the joint after the 6th–7th segment rather than being the 7th–8th segment.
*Range.* – Late Aptian to Early Albian.
*Occurrence.* – Western Australia.

### *Windalia* sp. B
Plate 5, Figs. 4, 6, 11

*Remarks.* – *Windalia* sp. B differs from *W. pyrgodes* and *W.* sp. A (1) by having a distal portion of the test which is cylindrical, and (2) by having a constriction at the 6th and 7th segments which separate the cylindrical distal portion from a conical proximal portion of the test.
*Range.* – Late Aptian to Early Albian.
*Occurrence.* – Western Australia.

### *Windalia* sp. C
Plate 5, Fig. 17

cf. parvicingulid sp. D BAUMGARTNER 1992, pl. 8, figs. 9–11.

*Remarks.* – Test as with genus. Elongate form, conical proximally and cylindrical distally with at least 11 postabdominal segments.
*Range.* – Aptian-Early Albian.
*Occurrence.* – Indian Ocean, Western Australia.

*Windalia* sp. D
Plate 5, Figs. 16, 18

*Remarks.* – *Windalia* sp. D is characterized by having a greatly inflated spindle-shaped test.
*Range.* – Late Aptian to Early Albian.
*Occurrence.* – Western Australia.

*Note.* – Due to moderate and poor sample preservation and because samples exist over a narrow time range (latest Aptian to Early Albian), it is unclear whether *Windalia* sp. A, sp. B, sp. C and sp. D are distinct species or whether they are heteromorphs of *Windalia pyrgodes*. These forms are left under open nomenclature until a larger database can be assembled fully documenting their relationships.

Genus ***Xitus*** PESSAGNO

*Xitus* PESSAGNO 1977b, p. 55.

*Type species.* – *Xitus plenus* PESSAGNO 1977b.

*Xitus vermiculatus* (RENZ)
Plate 4, Figs. 12, 13

*Eucyrtidium vermiculatum* RENZ 1974, p. 792, pl. 8, figs. 17–19; pl. 11, fig. 22 (refigured pl. 8, fig. 17).
*Xitus spineus* PESSAGNO 1977b, p. 56, pl. 10, figs. 3, 12, 16, 20.
*Xitus vermiculatus* (RENZ), Schaaf 1981, p. 441, pl. 19, figs. 6a–b.
*Xitus* sp. cf. *X. spicularius* (ALIEV), Schaaf 1981, p. 441, pl. 4, fig. 12.
*Novixitus tuberculatus* WU & LI 1982, p. 69, pl. 2, fig. 6.
*Parvicingula* (?) sp. THUROW 1988, p. 403, pl. 6, fig. 10.
*Pseudodictyomitra* sp. A TUMANDA 1989, pl. 8, fig. 10.
cf. *Xitus* sp. indet. SCHAAF 1981, pl. 21, figs. 10a–b.
aff. *Dictyomitra* sp. FOREMAN 1975, p. 615, pl. 1H, fig. 5; pl. 2H, fig. 2.

*Range.* – Berriasian (?) to middle Cretaceous.
*Occurrence.* – California, Japan, Tibet, Pacific and Indian Oceans, Western Australia.

## 6. Discussion: Age and correlation

At present, ammonites offer the most reliable age determination of the type section. The most common forms identified from the Windalia Radiolarite at Winning Station are *Tropaeum* and *Australiceras*, which are widely distributed only in Aptian-Albian strata (Whitehouse 1927; Day 1969, 1974). Day (1969, 1974) further showed that if Australian species of these genera are the same age as their northern European and Madagascan analogues, which have been accurately dated by their association with hoplitids, then only Late Aptian-Early Abbian time is represented by their ranges. Other age-diagnostic ammonite genera (*Aconoceras, Toxoceratoides* and *Sanmartinoceras*) and the belemnite genus *Peratobelus* recorded from the type section are consistent with a Late Aptian-Early Albian age. Although little published data is publicly available, the preceeding Muderong Shale and succeeding Gearle Siltstone have been dated with palynomorphs, foraminifera and nannoplankton by petroleum industry consultants (see Hocking et al. 1987), and together bound the Windalia Radiolarite to the latest Aptian to Early Albian.

Coeval radiolarian-rich sediments have been recorded from outcrops across Australia, but only few studies have dealt seriously with the constituent radiolaria. The Windalia fossil assemblages are similar to those illustrated from the Doncaster Member of the Wallumbilla Formation, Surat Basin, Queensland (Haig & Barnbaum 1978). This formation is also regarded as Upper Aptian-Early Albian based on associated ammonites (similar to those recovered from the Windalia Radiolarite) and more broadly with foraminifera and palynomorphs. The Aptian-Albian Darwin Formation in the Northern Territory (Pietsch 1983) was visited by the author in 1990 and 1992. At outcrop, this formation is lithologically identical to the type Windalia Radiolarite. Radiolaria from the Darwin sediments have only been briefly described by Hinde (1893) and Lloyd (1966) but are comparable to those of the Windalia Radiolarite. Detailed comparison with these assemblages is difficult due to poor illustrations and broad taxonomic descriptions. The middle Cretaceous (Aptian-Cenomanian?) radiolarian assemblages recovered from the eastern Indian Ocean during Deep Sea Drilling Project (DSDP) Leg 27 (Renz 1974) are more diverse than those illustrated here but have many taxa in common; the most notable of which include *W. epiplatys* (RENZ), *W. pyrgodes, A. stocki*, species of *Spongopyle, Artocapsa ultima* TAN, *Crucella messinae* PESSAGNO, *Gongylothorax cephalocrypta* (TAN), and *T. antiqua*. Unfortunately, *A. exilis, A. pleiadesensis, P. excelsa* and *S. renillaeformis*, which compose the dominant taxa in the Windalia Radiolarite, could not be accurately compared with the DSDP Leg 27 fauna illustrated by Renz (1974).

It is not possible, nor the intention of this paper, to construct a radiolarian biozonation based on the limited material recovered from a single section. The large number of specifically unidentifiable taxa and the uncertain stratigraphic ranges of many new and old radiolarian species (especially when applied to the southern hemisphere) make chronostratigraphic correlation and calibration difficult. However, several biostratigraphic trends in radiolarian composition are present at Windalia Hill and in other southern hemisphere sites currently being investigated, and hold promise for future refinement of the Cretaceous radiolarian biozonation. *Windalia pyrgodes* is common in the Windalia Radiolarite and has been recorded from the Doncaster Member, from middle Cretaceous sediments recovered from the eastern Indian Ocean (DSDP Leg 27, Renz 1974) and more recently from the Weddell Sea (ODP Leg 113, Ling & Lazarus 1990). *Windalia epiplatys* has previously been recorded only from DSDP Leg 27. The genus *Windalia* has also been illustrated by Baumgartner (1992), and appears to extend from the Valanginian through to the Albian. Another radiolaria, *Arachnosphaera exilis*, has been recorded, so far, only from the onshore Australian "radiolarites".

No single radiolarian biozonation can be applied to the Cretaceous faunas from the Windalia Radiolarite. Although comparisons are possible, the paucity and absence of many zonal species hinders any direct correlation with the Lower Cretaceous zonations of Pessagno (1977a), Schaaf (1981), Nakaseko & Nishimura (1982) and Sanfilippo & Riedel (1985; which incorporates assemblage data from DSDP Legs 26 (Riedel & Sanfilippo 1974) and 27 (Renz 1974)) and Teraoka & Kurimoto (1986). The semiprobabilistic technique used to construct the apparently refined Cretaceous zonation presented by Schaaf (1985) has been criticized by Guex (1992, p. 190; see also Baumgartner 1992) and shows discrepancies within the data set used and with the zonation of Sanfilippo & Riedel (1985); only the ranges of specific taxa documented by Schaaf (1985) are considered here. Biozonal data extracted from these studies, and others (particularly Taketani 1982, Baumgartner 1984, Yao 1984, Aita 1987; Thurow 1988 and Blome 1992), does, however, help in assigning an age to the Windalia Radiolarite based on radiolaria. Well-documented, biostratigraphically diagnostic taxa include *A. diaphorogona, A. ultima, G. cephalocrypta, H. barbui barbui, Pseudodictyomitra lodogaensis* PESSAGNO, *S. renillaeformis, T. antiqua* and *Xitus vermiculatus* (RENZ) whose concurrent ranges suggest an age of Late Aptian to Early Albian, equivalent to the lower part of the *A. umbilicata* Zone of Sanfilippo & Riedel (1985). Many of the above species, and including *Archaeospongoprunum carrierensis* PESSAGNO, *Archaeodictyomitra sliteri* PESSAGNO, *A. vulgaris* PESSAGNO, *C. messinae, Napora dumitricai* and *N. durhami*, are all common in the *Kozorium zinguli* Zone (Zone 7) of Pessagno (1977a) and suggest only Early Albian time is represented. However, Pessagno (1977a, p. 18) expressed uncertainty with his positioning of the Aptian-Albian boundary in the California Coast Ranges sequence. It is probable that many of these species have ranges extending into the Late Aptian, as seems to be the case at Windalia Hill.

Specific identification of the radiolaria from the Windalia Radiolarite conforms with the original descriptions. Although variations do exist (see remarks for each taxon in the systematic section), placement of such taxa is considered acceptable either due to assumed intraspecific variation or that the original descriptions are sufficiently broad to allow incorporation. Many other forms are either only tentatively compared or left under open nomenclature because of large discrepancies in the ages of similar known species. The Late (latest) Aptian-Early Albian age for the Windalia Radiolarite also indicates that the published ranges of many radiolaria need revision, including *Archaeocenosphaera boria* PESSAGNO, *Mesosaturnalis hueyi* group (PESSAGNO), *Orbiculiforma depressa* WU, *O. mclaughlini* PESSAGNO, *Praeconocaryomma lipmanae* PESSAGNO, *P. prisca* PESSAGNO. These points highlight the current lack of detailed knowledge of many radiolaria in the early to middle Cretaceous, and, in particular, the difficulties in applying biozonations based on low-latitude radiolarian assemblages to the medium and high-latitude Austral region.

## Acknowledgements

This paper results from research undertaken at the University of Western Australia (UWA) in 1987 and current research at the Université de Lausanne (UNIL), Switzerland. Dr David Haig (UWA) and Dr Peter Baumgartner (UNIL) read drafts of the manuscript and offered many useful improvements. The Winning Pastoral Company is acknowledged for allowing access to the field area. The Department of Geology and the Centre for Microscopy and Microanalysis at UWA allowed generous use of their facilities. Franz Hock at the Department of Geology (UWA) assisted in the preparation of the plates. Iain Copp (Geological Survey of Western Australia), Greg Milner (UWA) and Susan Watt (UWA) are thanked for making field work all the more enjoyable. Dr Dave Lazarus and an anonymous reviewer are thanked for their helpful critique of the manuscript.

Continuation of this study at the Université de Lausanne is supported by the Swiss National Science Foundation (project No. 20.27633.89 and 20-36040.92). The following companies are thanked for their support of the current project: BHP Petroleum, Hadson Energy, Lasmo Petroleum, West Australian Petroleum and Woodside Offshore Petroleum.

## REFERENCES


AITA, Y. 1987: Middle Jurassic to Lower Cretaceous radiolarian biostratigraphy of Shikoku with reference to selected sections in Lombardy Basin and Sicily. Sci. Rep. Tohoku Univ., Sendai, 2nd Ser.: Geol. 58/1, 1–91.

ALIEV, K. S. 1965: Radiolyarii nizhnemelovykh otlozheni severo-vostochnogo Azerbaidzhana i ikh stratigraficheskoe znachenie. Izdat. Akad. Azerbaidz. SSR Baku, 1–124.

APTHORPE, M. C. 1979: Depositional history of the Upper Cretaceous of the Northwest Shelf, based upon foraminifera. Aust. Petroleum Expl. Assoc. J. 19, 74–89.

BASOV, V. A., LOPATIN, B. G., GRAMBERG, I. S., DANJUSHEVSKAYA, A. I., KABAN'KOV, V. Y., et al. 1979: Lower Cretaceous lithostratigraphy near Galicia Bank. In: Init. Rep. Deep Sea Drill. Proj. 47 (Ed. by Sibuet, J., Ryan, W. B. F., et al.). U.S. Govt. Printing Office. Washington, D.C., 683–717.

BAUMGARTNER, P. O. 1980: Late Jurassic Hagiastridae and Patuilibracchiidae (Radiolaria) from the Argoli Peninsula (Peloponnesus, Greece). Micropaleontol. 26/3, 274–322, pls. 1–12.

BAUMGARTNER, P. O. 1984: A Middle Jurassic-Early Cretaceous low-latitude radiolarian zonation based on Unitary Associations and age of Tethyan radiolarites. Eclogae geol. Helv. 77/3, 729–837.

BAUMGARTNER, P. O. 1992: Lower Cretaceous radiolarian biostratigraphy and biogeography off NW Australia (Leg 123: Sites 765, 766 and DSDP Site 261, Argo Abyssal Plain and Lower Exmouth Plateau. In: Proc. Ocean Drill. Prog., Sci. Results 123 (Ed. by Gradstein, F. M., Ludden, J. N., et al.). Ocean Drill. Prog. College Station, Texas, 299–342.

BELFORD, D. J. 1959: Stratigraphy and micropalaeontology of the Upper Cretaceous of Western Australia. Sonder. Geologisch. Runds. 47/2, 629–647.

BLOME, C. D. 1992: Radiolarians from Leg 122, Exmouth and Wombat Plateaus, Indian Ocean. In: Proc. Ocean Drill. Prog., Sci. Results 122 (Ed. by von Rad, U., Haq, B. U., et al.). Ocean Drill. Prog. College Station, Texas, 633–647.

BRUNNSCHWEILER, R. O. 1959: New Aconoceratidae (Ammonoidea) from the Albian and Aptian of Australia. Bur. Min. Res. Aust. Geol. Geophys. Bull. 54, 1–19.

CAMPBELL, A. S. 1954: Radiolaria. In: Treatise on Invertebrate Paleontology, Part D, Protista 3, Protozoa (Chiefly Radiolaria and Tintinnina) (Ed. by Moore, R. C.). Geol. Soc. Amer. and Univ. Kansas Press. Lawrence, Kansas, USA, D11–D195.

CAMPBELL, A. S. & CLARK, B. L. 1944: Radiolaria from the Upper Cretaceous of middle California. Geol. Soc. Amer., Spec. Pap. 57, i–viii, 1–61.

CASEY, R. 1961: A monograph of the Ammonoidea of the Lower Greensand. Palaeontograph. Soc. (Monograph), pt. 1–3, i–xxxvi, 1–216.

CAYEUX, L. 1897: Contribution a l'etude micrographique des terrains sedimentaires. 1. Etude de quelques depots siliceux secondaires et tertiaires du Basin de Paris et de la Belgique. Mem. Soc. geol. Nord, Lille 4/2, 1–591.

CONDON, M. A. 1954: Progress report on the stratigraphy and structure of the Carnarvon Basin, Western Australia. Bur. Min. Res. Aust. Geol. Geophys. Rec. 15, 163 p.

CONDON, M. A. 1968: The geology of the Carnarvon Basin, part 3: post-Permian stratigraphy; structure; economic geology. Bur. Min. Res. Aust. Geol. Geophys. Bull. 77, 106 p.

CONDON, M. A., JOHNSTONE, D., PRICHARD, C. E. & JOHNSTONE, M. H. 1956: The Giralia and Marilla Anticlines, North West Division, Western Australia. Bur. Min. Res. Aust. Geol. Geophys. Bull. 25, 85 p.

CRESPIN, I. 1946: A Lower Cretaceous fauna in the northwest basin of Western Australia. J. Paleontol. 20/5, 505–509.

DAY, R. W. 1969: The lower Cretaceous of the Great Artesian Basin. In: Stratigraphy and Palaeontology, Essays in Honour of Dorothy Hill (Ed. by Campbell, K. S. W.). Australian National University Press. Canberra, 140–173.

DAY, R. W. 1974: Aptian Ammonites from the Eromanga and Surat Basins, Queensland. Geol. Surv. Queensld., Public. 360, Palaeontol. Pap. 34, 1–19.

DE WEVER, P. 1984: Révision des radiolaires Mesozoique de type Saturnalide, proposition d'une nouvelle classification. Revue de Micropal. 27/1, 10–19.

DE WEVER, P. & THIÉBAULT, F. 1981: Les Radiolaires d'age Jurassique superieur a Crétacé supérieur dans les radiolarites du Pinde-Olonos (Presqu'ile de Koroni; Peloponnese meridional, Greece). Geobios 14/5, 577–609.

DE WEVER, P., GEYSSANT, J. R., AZÉMA, J., DEVOS, I., DUÉE, G., MANIVIT, H. & VRIELYNCK, B. 1986: La coupe de Santa Anna (zone de Sciacca, Sicile): Une synthèse biostratigraphique des apports des macro-, micro- et nannofossiles du Jurassique supérieur et Crétacé inférieur. Revue de Micropal. 29/5, 141–186.

DONOFRIO, D. & MOSTLER, H. 1978: Zur Verbreitung der Saturnalidae (Radiolaria) im Mesozoikum der Nördlichen Kalkalpen und Südalpen. Geol. – Palaontol. Mitteil. Innsbruck 7/5, 1–55.

DREYER, F. 1889: Die Pylombildungen in vergleichend-anatomischer und entwicklungsgeschichtlicher Beziehung bei Radiolarien und bei Protisten überhaupt. Jenaisch. Zeitsch. Naturwissen. 23, 1–138.

DUMITRICA, P. 1970: Cryptocephalic and cryptothoracic Nassellaria in some Mesozoic deposits of Romania. Rev. Roum. Géol., Géophys., Géogr., sér. Géol. 14/1, 41–125.

EDGELL, H. S. 1952: The Micropalaeontology of the Giralia Anticline, North-west Australia. Bur. Min. Res. Aust. Geol. Geophys. Rec. 1952/74 (unpublished).

EHRENBERG, C. G. 1038: Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. Königl. Akad. Wiss. Berlin, Abhandl., Jahre 1838, 59–147.

EHRENBERG, C. G. 1844: Über zwei neue Lager von Gebirgsmassen aus Infusorien als Meeres-Absatz in Nord-Amerika und eine Vergleichung derselben mit den organischen Kreide-Gebilden in Europa und Afrika. Königl. Preuss. Akad. Wiss. Berlin, Bericht, Jahre 1844, 57–97.

EHRENBERG, C. G. 1847a: Über eine halibiolithische, von Herrn R. Schomburgk entdeckte, vorherrschend aus microskopischen Polycystin gebildete, Gebirgsmasse von Barbados. Königl. Preuss. Akad. Wiss. Berlin, Bericht, Jahre 1846, 382–385.

EHRENBERG, C. G. 1847b: Über die mikroskopischen kieselschaligen Polycystinen als mächtige Gebirgsmasse von Barbados und über das Verhältniss der aus mehr als 300 neuen Arten bestehenden ganz eigenthümlichen Formengruppe jener Felsmasse zu den jetzt lebenden Thieren und zur Kreidebildung. Eine neue Anregung zur Erforschung des Erdlebens. Königl. Preuss. Akad. Wiss. Berlin, Bericht, Jahre 1847, 40–60.

EHRENBERG, C. G. 1854: Die systematische Charakteristik der neuen mikroskopischen Organismen des tiefen atlantischen Oceans für den Monatsbericht zum Druck übergeben, deren Verzeichnis im Monat Februar bereits mitgeteilt worden ist. Mber. Preuss. Akad. Wiss., Jahre 1954, 236–250.

EHRENBERG, C. G. 1873: Grössere Felsproben des Polycystinen-Mergels von Barbados mit weiteren Erläuterungen. Königl. Preuss. Akad. Wiss. Berlin, Monatsb., Jahre 1873, 213–263.

EHRENBERG, C. G. 1875: Fortsetzung der mikrogeologischen Studien als Gesammt-Uebersicht der mikropischen Paläontologie gleichartig analysierter Gebirgsarten der Erde, mit specieller Rücksicht auf den Polycystinen-Mergel von Barbados. Königl. Akad. Wiss. Berlin, Abhandl., Jahre 1875, 1–225.

ELLIS, G. 1987: Lower Cretaceous Radiolarian Biostratigraphy and Depositional Environment of the Windalia Radiolarite, Carnarvon Basin, Western Australia. B.Sc. (Hons) Thesis, University of Western Australia (unpublished).

ELLIS, G., BAUMGARTNER, P. O. & HAIG, D. W. 1991: Lower Cretaceous radiolarian biostratigraphy and palaeoceanography from the west Australian margin. In: Proceedings of Interrad VI, Sixth meeting of the international association of radiolarian palaeontologists. Firenze, Italia 1991, 37–38.

EMPSON-MORIN, K. M. 1981: Campanian Radiolaria from DSDP Site 313, Mid-Pacific Mountains. Micropaleontol. 27/3, 249–292.

EMPSON-MORIN, K. 1982: Reexamination of the late Cretaceous radiolarian genus Amphipyndax Foreman. J. Paleontol. 56/2, 507–519.

FOREMAN, H. P. 1966: Two Cretaceous radiolarian genera. Micropaleontol. 12/3, 355–359.

FOREMAN, H. P. 1968: Upper Maestrichtian Radiolaria of California. The Palaeontol. Assoc., Spec. Pap. Palaeontol., London, No. 3, The Palaeontol. Assoc. London. iv + 1-82.

FOREMAN, H. P. 1971: Cretaceous Radiolaria, Leg 7, DSDP. In: Init. Rep. Deep Sea Drill. Proj. 7 (Ed. by Winterer, E. L., Riedel, W. R., et al.). U.S. Govt. Printing Office. Washington, D.C., 1673–1693.

FOREMAN, H. P. 1973a: Radiolaria of Leg 10 with systematics and ranges for the families Amphipyndacida, Artostrobiidae, and Theoperidae. In: Init. Rep. Deep Sea Drill. Proj. 10 (Ed. by Worzel, J. L., Bryant, W., et al.). U.S. Govt. Printing Office. Washington, D.C., 407–474.

FOREMAN, H. P. 1973b: Radiolaria from DSDP Leg 20. In: Init. Rep. Deep Sea Drill. Proj. 20 (Ed. by Heezen, B. C., MacGregor, J. D., et al.). U.S. Govt. Printing Office. Washington, D.C., 249–305.

FOREMAN, H. P. 1975: Radiolaria from the North Pacific, Deep Sea Drilling Project, Leg 32. In: Init. Rep. Deep Sea Drill. Proj. 32 (Ed. by Larson, R. L., Moberly, R., et al.). U.S. Govt. Printing Office. Washington, D.C., 579–676.

FOREMAN, H. P. 1977: Mesozoic Radiolaria from the Atlantic Basin and its borderlands. In: Stratigraphic Micropaleontology of the Atlantic Basin and Borderlands (Ed. by Swain, F. M.). Elsevier, Amsterdam, The Netherlands, 305–320.

FOREMAN, H. P. 1978: Mesozoic Radiolaria in the Atlantic Ocean off the northwest coast of Africa, Deep Sea Drilling Project, Leg. 41. In: Init. Rep. Deep Sea Drill. Proj. 41 (Ed. by Lancelot, Y., Seibold, E., et al.). U.S. Govt. Printing Office. Washington, D.C., 739–761.

FRAKES, L. A., BURGER, D., APTHORPE, M., WISEMAN, J., DETTMANN, M. et al. (Australian Cretaceous Palaeoenvironments Group) 1987: Australian Cretaceous shorelines, stage by stage. Palaeogeog, Palaeoclimat. Palaeoecol. 59, 31–48.

FRIZZELL, D. L. & MIDDOUR, E. S. 1951: Paleocene Radiolaria from southeastern Missouri. Bull. Univ. Missouri Sch. Min. Metall., Techn. Ser. 77, 41 p.

GLAESSNER, M. F. 1955: Report on the examination of Cretaceous rock samples from the Carnarvon Basin, 20/4/55 (unpublished report).

GUEX, J. 1992: Biochronological Correlations. Springer-Verlag. Berlin, 252 p.

HAECKEL, E. 1860: Über neue, labende Radiolarien des Mittelmeeres. K. Preuss. Akad. Wiss. Berlin, Monatsber., 794–817.

HAECKEL, E. 1862: Die Radiolarien (Rhizopoda Radiolaria). In: Eine Monographie (Ed. by Georg Reimer). Berlin, Monatsber., I–XV + 572 p.

HAECKEL, E. 1881: Entwurf eines Radiolarien-Systems und Grund von Studien der Challenger-Radiolarien. Z. Natw. med. naturw. Ges. Jena 15/new series 8/3, 418–472.

HAECKEL, E. 1887: Report on the Radiolaria collected by H. M. S. Challenger during the years 1873–1876. Rep. Sci. Result. Voyage H. M. S. Challenger, Zool. 18/1–2, p. i–clxxxviii + 1–1803.

HAIG, D. W. & BARNBAUM, D. 1978: Early Cretaceous microfossils from the type Wallumbilla Formation, Surat Basin, Queensland. Alcheringa 2, 159–178.

HEITZER, I. 1930: Die Radiolarienfauna der mitteljurassischen Kieselmergel im Sonnwendgebirge. Jahrb. Geologisch. Bundesanstalt 80, 381–406.

HINDE, G. J. 1893: Note on a radiolarian rock from Fanny Bay, Port Darwin, Australia. Geol. Soc. Lond., Quart. J. 49/194, 221–226.

HINDE, G. J. 1900: Description of fossil Radiolaria from the rocks of Central Borneo, obtained by Prof. Dr. G. A. F. Molengraaff in the Dutch exploring expedition of 1893–94. In: Borneo-Expeditie: Geologische verkenningstochten in Centraal-Borneo (1893–94) (Ed. by Brill, E. J. & Gerlings, H.). Leiden, Amsterdam, The Netherlands, Appendix 1, 1–51, 54–56.

HOCKING, R. M. 1988: Regional Geology of the Northern Carnarvon Basin. In: The North West Shelf, Australia: Proceedings of the Petroleum Exploration Society of Australia Symposium (Ed. by Purcel, P. G. & Purcel, R. R.). Perth 1988, 97–114.

HOCKING, R. M., MOORS, H. T. & VAN DE GRAAFF, W. J. E. 1987: Geology of the Carnarvon Basin, Western Australia. Geol. Surv. West. Aust., Bull. 133.

IWATA, K. & TAJIKA, J. 1989: Jurassic and Cretaceous radiolarians from the pre-Tertiary system in the Hidaka Belt, Maruseppu region, Northeast Hokkaido. J. Fac. Sci., Hokkaido Univ., Ser. 4: Geol. & Mineral. 22/3, 453–466.

JOHNSTONE, D., CONDON, M. A. & PLAYFORD, P. E. 1958: Stratigraphy of the Lower Murchison River Area and Yaringa North Station, Western Australia. J. Royal Soc. West. Aust. 41, 13–16.

KENNEDY, W. J. & KLINGER, H. C. 1979: Cretaceous faunas from Zululand and Natal, South Africa. The ammonite superfamily Haploceratаceae Zittel, 1884. Ann. South Africa Museum, 77, 85–121.

KOUTSOUKOS, E. A. M. & HART, M. B. 1990: Radiolarians and Diatoms from the mid-Cretaceous Successions of the Sergipe Basin, Northeastern Brazil: palaeoceanographic assessment. J. Micropaleontol. 9/1, 45–64.

KOZLOVA, G. E. & GORBOVETS, A. N. 1966: Radiolyarii verkhnemelovykh i verkhneeotsenovykh otlozhenii Zapadno-Sibirskoi nizmennosti. Trudy Vses. Neft. Nauchn-Issled. Geol. Inst. (VNIGRI) 248, 1–159.

KOZUR, H. & MOSTLER, H. 1981: Beiträge zur Erforschung der mesozoischen Radiolarien. Teil IV: Thalassosphaeracea Haeckel, 1862, Hexastylacea Haeckel, 1862 emend. Petrushevskaya, 1979, Sponguracea Haeckel, 1862 emend. und weitere triassische Lithocycliacea, Trematodiscacea, Actinommacea und Nassellaria. Geol.-paläontol. Mitt., Innsbruck, S, 208 p.

LING, H. Y. & LAZARUS, D. B. 1990: Cretaceous radiolaria from the Weddell Sea: Leg 113 of the Ocean Drill. Prog. In: Proc. Ocean Drill. Prog., Sci. Results 113 (Ed. by Barker, P. F., Kenett, J. P., et al.). Ocean Drill. Prog. College Station, Texas, 353–363.

LIPMAN, R. K. 1952: Materialy k monograficheskomu izucheniyu radiolyarii verkhnemelovykh otlozhenii Russkoi Platformy. Trudy Vses. Nauchn-Issled. Geol. Inst. (VSEGEI), Paleont. Stratigaf., 24–51.

LIPMAN, R. K. 1962: Pozdnemelovye radiolyarii Zapadno-Sibirskoi nizmennosti i Turgaiskogo progiba. Trudy Vses. Nauchn-Issled. Geol. Inst. (VSEGEI) 77/new series, 271–323.

LLOYD, A. R. 1963: Probable Radiolaria from the Lower Cretaceous Bejah Beds, Gibson Desert, Western Australia. Bur. Min. Res. Aust. Geol. Geophys. Rec. 1963/30, 1-5 (unpublished).

LLOYD, A. R. 1966: Lower Cretaceous Radiolaria from the Northern Territory of Australia. Bur. Min. Res. Aust. Geol. Geophys. Bull. Paleontol. Papers, 1966, 92, 115-131.

MARCUCCI, M., BETTINI, P., DAINELLI, J. & SIRUGO, A. 1991: "Bonarelli Horizon" in the central Apennines (Italy): radiolarian biostratigraphy. Cret. Res. 12, 321-331.

MATSUOKA, A. 1986: *Tricolocapsa yaoi* Assemblage (Late Jurassic radiolarians) from the Togano Group in Shikoku, Southwest Japan. J. Geosci. Osaka City Univ. 29, 101-115.

MOORE, T. C. 1973: Radiolaria from Leg 17 of the Deep Sea Drilling Project. In: Init. Rep. Deep Sea Drill. Proj. 17 (Ed. by Winterer, E. L., Ewing, J., et al.). U.S. Govt. Printing Office. Washington, D.C., 797-869.

MORGAN, R. 1980: Eustacy in the Australian Early and Middle Cretaceous. Geol. Surv. NSW, Bulletin 27, 105 p.

NAKASEKO, K. & NISHIMURA, A. 1982: Upper Jurassic and Cretaceous Radiolaria from the Shimanto Group in Southwest Japan. Sci. Rep., College Gen. Educ., Osaka Univ. 30/2, 133-203.

NAKASEKO, K., NISHIMURA, A. & SUGANO, K. 1979: Cretaceous Radiolaria in the Shimanto Belt, Japan. News Osaka Micropaleont., Spec. Vol. 2/2, 1-49.

OZVOLDOVA, L. 1979: Radiolarians from the Rudina beds of the Kysuca series in the Klippen belt from locality Brodno. Annot. Zool. Botan. 128, 1-15.

OZVOLDOVA, L. 1990: Occurrence of Albian radiolaria in the underlier of the Vienna Basin. Geol. Carpathica 41/2, 137-154.

OZVOLDOVA, L. & PETERCAKOVA, M. 1992: Hauterivian radiolaria association from the Luckovska Formation, Manin Unit (Mt. Butkov, western Carpathians. Geol. Caparthica 43/5, 313-324.

OZVOLDOVA, L. & SYKORA, M. 1984: The radiolarian assemblage from Cachticke Karpaty Mts. limestones (the locality Sipkovsky Haj). Geol. Caparthica 35/2, 259-290.

PESSAGNO, E. A. 1963: Upper Cretaceous Radiolaria from Puerto Rico. Micropaleontol. 9/2, 197-214.

PESSAGNO, E. A. 1971: Jurassic and Cretaceous Hagiastridae from the Blake-Bahama Basin (Site 5A, JOIDES Leg 1) and the Great Valley Sequence, California Coast Ranges. Bull. Amer. Paleont. 60/264, 1-83.

PESSAGNO, E. A. 1972: Cretaceous Radiolaria. Part I: The Phaseliformidae, new family, and other Spongodiscacea from the Upper Cretaceous portion of the Great Valley Sequence, part II; Pseudoaulophacidae Riedel from the Cretaceous of California and the Blake-Bahama Basin (JOIDES leg 1). Bull. Amer. Paleont. 61/270, 269-328.

PESSAGNO, E. A. 1973: Upper Cretaceous Spumellariina from the Great Valley Sequence, California Coast Ranges. Bull. Amer. Paleont. 63/276, 49-102.

PESSAGNO, E. A. 1975: Upper Cretaceous Radiolaria from DSDP Site 275. In: Init. Rep. Deep Sea Drill. Proj. 29 (Ed. by Kennett J. P., Houtz, R. E., et al.). U.S. Govt. Printing Office. Washington, D.C., 1011-1029.

PESSAGNO, E. A. 1976: Radiolarian zonation and stratigraphy of the Upper Cretaceous portion of the Great Valley Sequence, California Coast Ranges. Micropaleontol., Spec. Publ. No. 2, 1-95.

PESSAGNO, E. A. 1977a: Upper Jurassic Radiolaria and radiolarian biostratigraphy of the California Coast Ranges. Micropaleontol. 23/1, 56-113.

PESSAGNO, E. A. 1977b: Lower Cretaceous radiolarian biostratigraphy of the Great Valley Sequence and Franciscan Complex, California Coast Ranges. Cush. Found. Foram. Res., Spec. Publ. 15, 1-87.

PESSAGNO, E. A. & POISSON, A. 1979: Lower Jurassic Radiolaria from the Gumuslu Allochton of southwest Turkey (Taurides Occidentales). Bull. Miner. Res. Expl. Inst. Turkey, 92, 47-69.

PESSAGNO, E. A., SIX, W. M. & YANG, Q. 1989: The Xiphostylidae Haeckel and Parvivaccidae, n. fam., (Radiolaria) from the North American Jurassic. Micropaleontol. 35/3, 193-255.

PETRUSHEVSKAYA, M. G. & KOZLOVA, G. E. 1972: Radiolaria: Leg 14, Deep Sea Drilling Project. In: Init. Rep. Deep Sea Drill. Proj. 14 (Ed. by Hayes, D. E., Pimm, A. C., et al.). U.S. Govt. Printing Office. Washington, D.C., 495-648.

PIETSCH, B. A. 1983: Darwin 5073, 1:100,000 geological map series explanatory notes. Northern Territory Geol. Surv. Darwin, 28 pp.

RAGGATT, H. G. 1936: Geology of the northwest basin, Western Australia with particular reference to the stratigraphy of the Permo-Carboniferous. J. Royal Soc. New South Wales 52, 100-174.

RENZ, G. W. 1974: Radiolaria from Leg 27 of the Deep Sea Drilling Project. In: Init. Rep. Deep Sea Drill. Proj. 27 (Ed. by Veevers, J. J., Heirtzler, J. R., et al.). U.S. Govt. Printing Office. Washington, D.C., 769-841.

RIEDEL, W. R. & SANFILIPPO, A. 1970: Radiolaria, Leg 4, Deep Sea Drilling Project. In: Init. Rep. Deep Sea Drill. Proj. 4 (Ed. by Bader, R. G., Gerard, R. O., et al.). U.S. Govt. Printing Office. Washington, D.C., 503-575.

RIEDEL, W. R. & SANFILIPPO, A. 1974: Radiolaria from the southern Indian Ocean, DSDP Leg 26. In: Init. Rep. Deep Sea Drill. Proj. 26 (Ed. by Davies, T. A., Luyendyk, B. P., et al.). U.S. Govt. Printing Office. Washington, D.C., 771–814.

RÜST, D. 1885: Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen des Jura. Palaeontographica 31/3, 269–321.

RÜST, D. 1898: Neue Beiträge zur Kenntniss der Fossilen Radiolarien aus Gesteinen des Jura und der Kreide. Palaeontographica 45, 1–67.

SANFILIPPO, A. & RIEDEL, W. R. 1985: Cretaceous Radiolaria. In: Plankton Stratigraphy (Ed. by Bolli, H. M., Saunders, J. B. & Perch-Nielsen, K.). Cambridge University Press. Cambridge, UK, 573–630.

SCHAAF, A. 1981: Late Early Cretaceous Radiolaria from Deep Sea Drilling Project Leg 62. In: Init. Rep. Deep Sea Drill. Proj. 62 (Ed. by Thiede, J., Vallier, T. L., et al.). U.S. Govt. Printing Office. Washington, D.C., 419–470.

SCHAAF, A. 1984: Les Radiolaires du Crétacé inferieur et moyen: Biologie, Systematique, Biochronologie et Paleoenvironment. Thèse, L'Universite Louis Pasteur, 189 pp.

SCHAAF, A. 1985: Un nouveau canevas biochronologique du Crétacé inferieur et moyen: les biozones a radiolaires. Sci. Geologique, Bull. 38/3, 227–269.

SQUINABOL, S. 1903: Le Radiolaire dei noduli selciosi nella Scaglia degli Euganei. Contribuzione I. Riv. Ital. Paleont. 9, 105–151.

SQUINABOL, S. 1904: Radiolarie cretacee degli Euganei. Atti Mem. r. Accad. Sci. Lett. Arti Padova (n.s.) 20, 171–244.

SQUINABOL, S. 1914: Contributo alla conoscenza dei Radiolarii fossili del Veneto. Appendice – Di un genera di Radiolari caratteristico del Secondario. Mem. Ist. Geol. Univ. Padova 2, 249–306.

STEIGER, T. 1992: Systematik, Stratigraphie und Palökologie der Radiolarien des Oberjura-Unterkreide-Grenzbereiches in Osterhorn-Tirolikum (Nördliche Kalkalpen, Salzburg und Bayern). Zitteliana 19, 1–188.

STEVENS, G. R. 1965: The Jurassic and Cretaceous belemnites from New Zealand and a review of the Jurassic and Cretaceous belemnites of the Indo-Pacific region. Geol. Surv. New Zeal., Palaeontol. Bull. 36, 1–283.

SUYARI, K. 1986: Restudy of the Northern Shimanto Subbelt in eastern Shikoku. J. Sci., Univ. Toku. 19, 45–54.

SUYARI, K. & KUWANO, Y. 1986: Radiolarian age of the Torinosu group, Shikoku, Japan, Part 2. J. Sci., Univ. Toku. 19, 37–43.

TAKETANI, Y. 1982: Cretaceous radiolarian biostratigraphy of the Urakawa and Obira areas, Hokkaido. Sci. Rep. Tokohu Univ., Sendai, 2nd Ser.: Geol. 52/1–2, 1–75.

TAKETANI, Y. & KANIE, Y. 1992: Radiolarian age of the lower Yezo Group and the upper part of the Sorachi Group in Hokkaido. In: Centenary of Japanese Micropaleontology (Ed. by Ishizaki, K. & Saito, T.). Terra Scientific Publishing Company. Tokyo, 365–373.

TAN, S. H. 1927: Over de samenstelling en het onstaan van krijt-en mergelgesteenten van de Molukken. In: Geologische onderzoekingen in den oostelijken Oost-Indischen Archipel (Ed. by Brouwer, H. A.). Jb. Mijnwezen Nederl.-Indië, Jaarg. 55 (1926), Verhand., 3rd gedeelte, 5–198.

TERAOKA, Y. & KURIMOTO, C. 1986: Cretaceous stratigraphy of the Shimanto Terrane in the Uwajima area, West Shikoku, Southwest Japan, with reference to the stratigraphic distribution of mega- and radiolarian fossils. Bull. Geol. Surv. Japan 37/8, 417–453.

THUROW, J. 1988: Cretaceous radiolarians of the North Atlantic Ocean: ODP Leg 103 (Sites 638, 640 and 641) and DSDP Legs 93 (Site 603) and 47 B (Site 398). In: Proc. Ocean Drill. Prog., Sci. Results 103 (Ed. by Boillot, G., Winterer, E. L., et al.). Ocean Drill. Prog. College Station, Texas, 379–418.

TUMANDA, F. 1989: Cretaceous radiolarian biostratigraphy in the Esashi Mountain area, Northern Hokkaido, Japan. Sci. Rep. Inst. Geo. Univ. Tsukuba, Sec. B, Geol. Sci. 10, 1–44.

WHITEHOUSE, F. W. 1924: Dimitobelidae, a new family of Cretaceous Belemnites. Geology Magazine 61, 410–416.

WHITEHOUSE, F. W. 1926: Reconnaissance geology of the marine Cretaceous deposits of Australia. Rep. Aust. Assoc. Advance Sci. 43, 275–280.

WHITEHOUSE, F. W. 1927: The Cretaceous Ammonoidea of Eastern Australia. Mem. Queensld. Mus. 8, 195–242.

WU, H. 1986: Some new genera and species of Cenomanian Radiolaria from southern Xizang (Tibet). Acta Micropalaeont. Sinica 3/4, 347–360.

WU, H. & LI, H. 1982: Radiolaria from the olistostrome of Zongzhuo Formation, Gyangze, South Xizang, Tibet. Acta Palaeont. Sinica 21/1, 64–71.

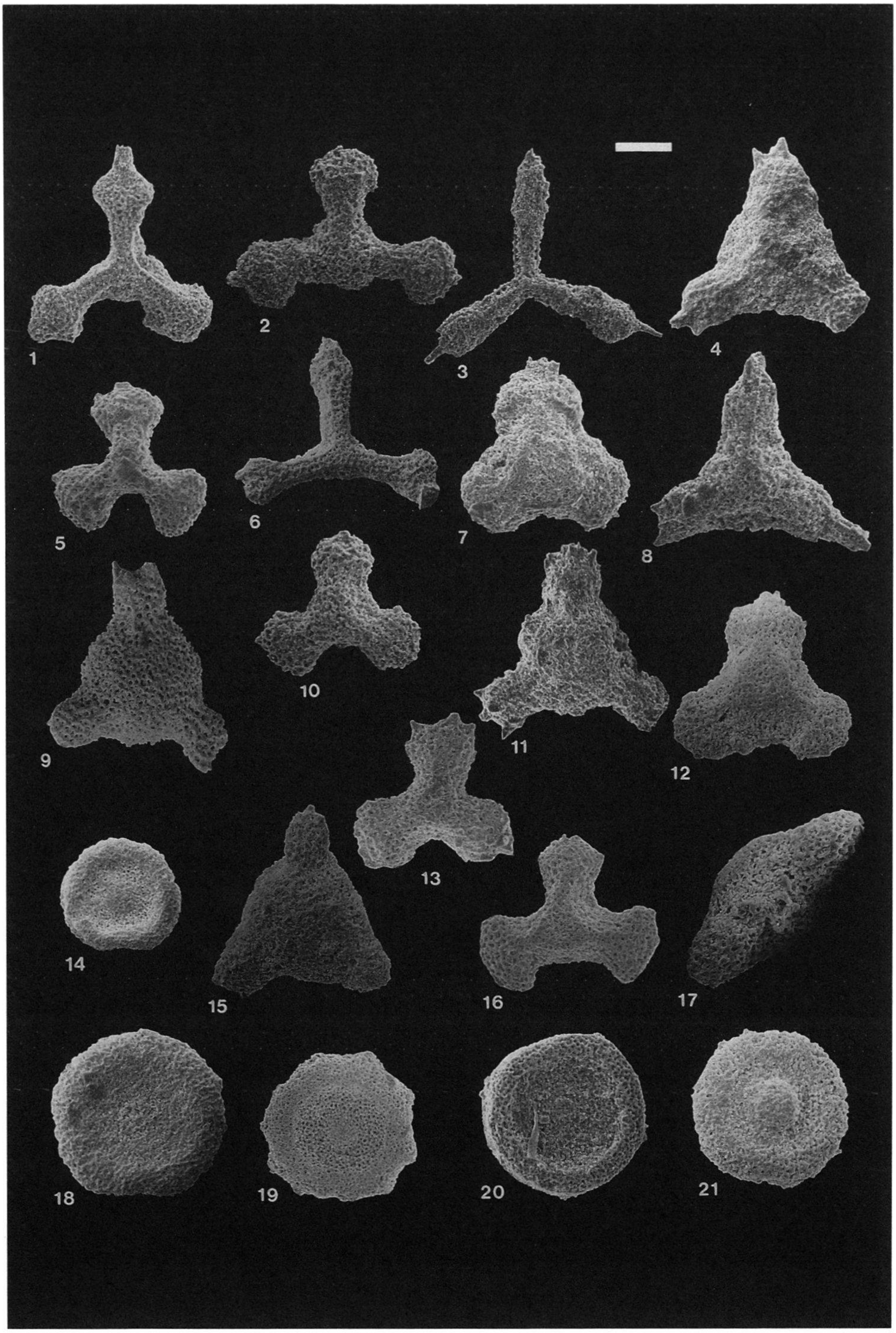
YAO, A. 1979: Radiolarian fauna from the Mino Belt in the northern part of the Inuyama Area, Central Japan, Part II: Nassellaria I. J. Geosci. Osaka City Univ. 22, 21–72.

YAO, A. 1984: Subdivision of the Mesozoic complex in Kii-Yura area, southwest Japan and its bearing on the Mesozoic basin development in the southern Chichibu terrane. J. Geosci. Osaka City Univ. 27, 41–103.

Manuscript received 16 April 1993
Revision accepted 20 July 1993

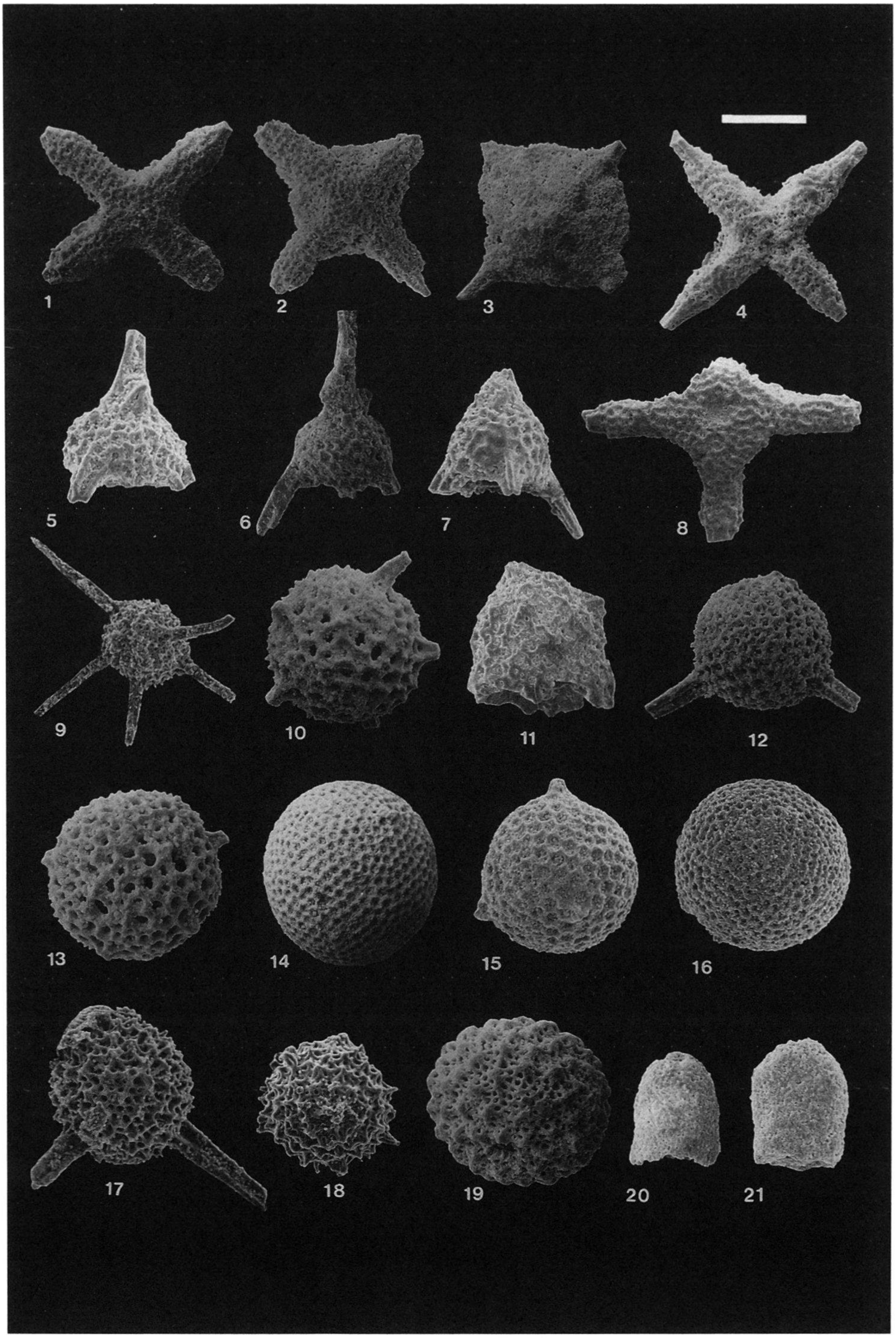
## Plate 1

| | |
|---|---|
| Figs. 1, 6 | *Angulobracchia crassa* OZVOLDOVA<br>(1: WIND8, C-37095, 1004UWA91, sc. = 130 µm; 6: WIND15, C-37096, 196LAUS91, sc. = 110 µm) |
| Fig. 2 | *Paronaella* sp.<br>(WIND8, C-37097, 1016UWA91, sc. = 100 µm) |
| Fig. 3 | *Paronaella* (?) sp.<br>(WIND8, C-37098, 1013UWA91, sc. = 100 µm) |
| Figs. 4, 8 | *Patulibracchium* sp.<br>(4: WIND15, C-37108, 185LAUS91, sc. = 100 µm; 8: WIND15, C-37109, 969UWA91, sc. = 90 µm) |
| Figs. 5, 10, 13 | *Paronaella* spp.<br>(5: WIND4, C-37102, 1747UWA87, sc. = 90 µm; 10: WIND8, C-37103, 1017UWA92, sc. = 100 µm; 13: WIND4, C-37104, 1748UWA87, sc. = 100 µm) |
| Figs. 7, 12, 16, 17 | *Patulibracchium* (?) sp.<br>Note the distinctive raised triangular portion on both sides of the test.<br>(7: WIND15, C-37105, 941UWA91, sc. = 100 µm; 12, 17: WIND15, C-37106, 226LAUS91, sc. = 100 µm & 75 µm, 16: WIND4, C-37107, 955UWA87, sc. = 100 µm) |
| Figs. 9, 11, 15 | *Paronaella diastimusphere* n. sp.<br>(9: holotype WIND15, C-37099, 943UWA91, sc. = 115 µm; 11: paratype WIND15, C-37100, 198LAUS91, sc. = 115 µm; 14: paratype WIND4, C-37101, 245LAUS91, sc. = 115 µm) |
| Figs. 14, 18 | *Spongodiscus renillaeformis* CAMPBELL & CLARK<br>(14: WIND4, C-37110, 1274LAUS93, sc. = 100; 18: WIND15, C-37111, 1273LAUS93, sc. = 100 µm) |
| Figs. 19 | *Orbiculiforma* sp.<br>(WIND5, C-37112, 988UWA87, sc. = 120 µm) |
| Fig. 20 | *Orbiculiforma mclaughlini* PESSAGNO<br>(WIND8, C-37113, 1006UWA91, sc. = 110 µm) |
| Fig. 21 | *Orbiculiforma depressa* WU<br>(WIND15, C-37203, 1258LAUS93, sc. = 100 µm) |


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

## Plate 2

| | |
|---|---|
| Figs. 1–4 | *Crucella messinae* PESSAGNO<br>Note increase in growth of patagium with increasing test size.<br>(1: WIND15, C-37114, 224LAUS91, sc. = 120 µm; 2: WIND15, C-37115, 258LAUS91, sc. = 140 µm; 3: WIND15, C-37116, 192LAUS91, sc. = 180 µm; 4: WIND15, C-37117, 190LAUS91, sc. = 120 µm) |
| Figs. 5, 6 | *Napora dumitricai* PESSAGNO<br>(5: WIND15, C-37119, 1532UWA87, sc. = 80 µm; 6: WIND15, C-37120, 161LAUS91, sc. = 100 µm) |
| Fig. 7 | *Napora* sp. cf. *N. durhami* Pessagno<br>(WIND15, C-37121, 1526UWA87, sc. = 80 µm) |
| Fig. 8 | *Crucella* sp.<br>(WIND4, C-37122, 93LAUS91, sc. = 120 µm) |
| Fig. 9 | *Acaeniotyle* (?) sp. A<br>(WIND8, C-37123, 1071UWA91, sc. = 115 µm) |
| Figs. 10, 13 | *Haliomma* sp.<br>(10: WIND15, C-37126, 197LAUS91, sc. = 95 µm; 13: WIND15, C-37127, 253LAUS91, sc. = 85 µm) |
| Fig. 11 | *Spongopyle stauromorphos* RENZ<br>(WIND5, C-37118, 1247LAUS93, sc. = 95 µm) |
| Figs. 12, 15 | *Triactoma* sp.<br>(12: WIND15, C-37128, 263LAUS91, sc. = 100 µm; 15: WIND4, C-37129, 1744UWA87, sc. = 105 µm) |
| Figs. 14, 16 | *Archaeocenosphaera euganea* (SQUINABOL)<br>(14: WIND4, C-37130, 96LAUS91, sc. = 100 µm; 16: WIND8, C-37131, 1123UWA91, sc. = 100 µm) |
| Fig. 17 | *Alievium* (?) sp. A<br>(WIND8, C-37124, 1126UWA91, sc. = 80 µm) |
| Fig. 18 | *Praeconocaryomma lipmanae* PESSAGNO<br>(WIND8, C-37125, 1014UWA91, sc. = 80 µm) |
| Fig. 19 | *Acaeniotyle* (?) sp. B<br>(WIND19, C-37132, 313LAUS91, sc. = 130 µm) |
| Fig. 20 | *Spongopyle* sp. cf. *S. insolita* KOZLOVA<br>(WIND4, C-37204, 1246LAUS93, sc. = 95 µm) |
| Fig. 21 | *Spongopyle ecleptos* RENZ<br>(WIND4, C-37205, 1242LAUS93, sc. = 95 µm) |


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

## Plate 3

Fig. 1 *Protoxiphotractus* (?) *rugosa* TAN
(WIND15, C-37133, 261LAUS91, sc. = 85 μm)

Fig. 2 *Archaeospongoprunum* sp.
(WIND8, C-37134, 1002UWA91, sc. = 95 μm)

Figs. 3, 4 *Archaeospongoprunum carrierensis* PESSAGNO
(3: WIND15, C-37135, 246LAUS91, sc. = 105 μm; 4: WIND15, C-37136, 949UWA91, sc. = 105 μm)

Fig. 5 *Archaeospongoprunum* sp. cf. *A. tehamaensis* PESSAGNO
(WIND15, C-37138, 150LAUS91, sc. = 90 μm)

Fig. 6 *Archaeospongoprunum* sp. cf. *A. praelongum* PESSAGNO
(WIND19, C-37139, 344LAUS91, sc. = 100 μm)

Fig. 7 *Archaeospongoprunum klingi* PESSAGNO
(WIND15, C-37137, 264LAUS91, sc. = 100 μm)

Figs. 8, 9 *Acaeniotyle longispina* (SQUINABOL)
(8: WIND15, C-37140, 218LAUS91, sc. = 105 μm; 9: WIND4, C-37141, 1743UWA87, sc. = 100 μm)

Fig. 10 *Acaeniotyle diaphorogona* FOREMAN
(WIND15, C-37142, 1740UWA87, sc. = 100 μm)

Fig. 15 *Alievium* (?) sp. B
(WIND15, C-37143, 1997UWA91, sc. = 85 μm)

Fig. 11 *Archaeospongoprunum diversispina* SQUINABOL
(WIND8, C-37144, 980UWA91, sc. = 105 μm)

Fig. 12 *Mesosaturninus hueyi* group (PESSAGNO)
(WIND8, C-37145, 1000UWA91, sc. = 100 μm)

Fig. 13 *Stylosphaera pusillus* CAMPBELL & CLARK emend. Foreman
(WIND4, C-37146, 1753UWA87, sc. = 75 μm)

Fig. 14 *Stylosphaera* sp. cf. *S. hastatus* (CAMPBELL & CLARK)
(WIND8, C-37147, 1137UWA91, sc. = 115 μm)

Figs. 16, 17 *Praeconocaryomma prisca* PESSAGNO
(16: WIND19, C-37148, 347LAUS91, sc. = 110 μm; 17: WIND19, C-37149, 353LAUS91, sc. = 115 μm)

Fig. 18 aff. *Staurocyclia martini* RÜST
(WIND8, C-37150, 1011UWA91, sc. = 175 μm)

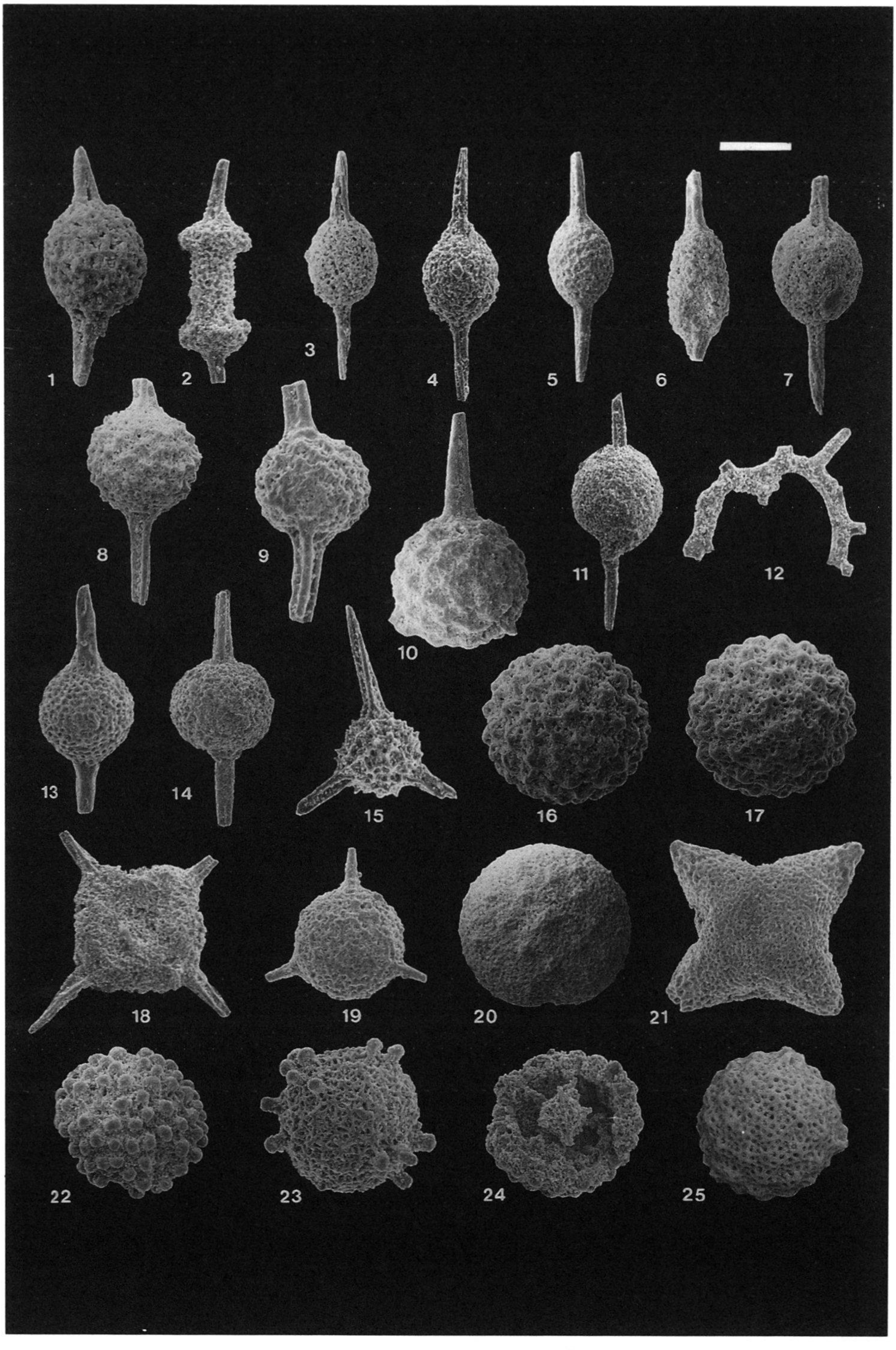
Fig. 19 *Spongotripus* sp. cf. *Tripodictya triacummata* LIPMAN
(WIND15, C-37151, 1533UWA87, sc. = 100 μm)

Fig. 20 *Patellua* sp.
(WIND19, C-37152, 290LAUS91, sc. = 125 μm)

Fig. 21 *Histastrum aster* LIPMAN
(WIND15, C-37153, 1738UWA87, sc. = 85 μm)

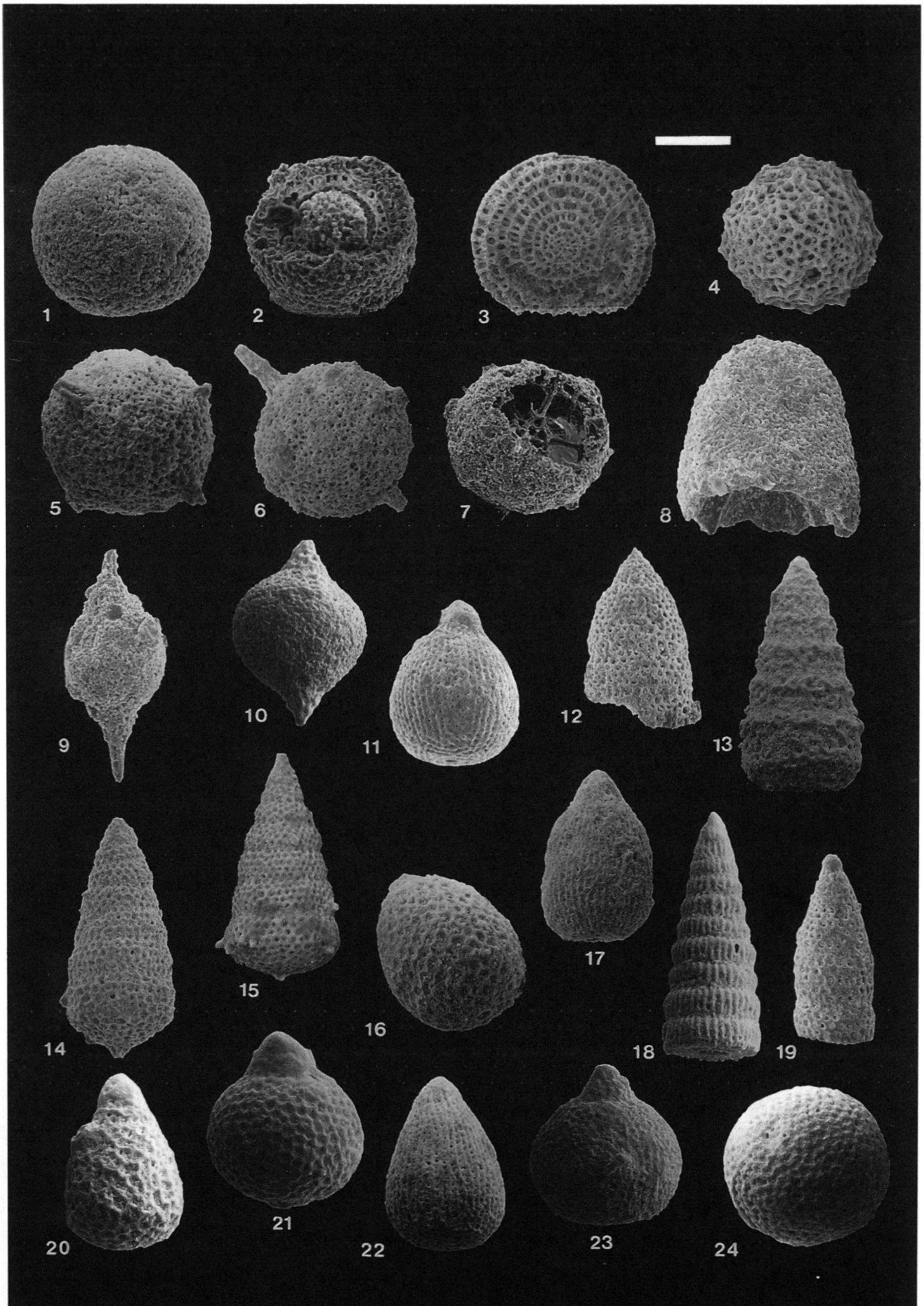
Figs. 22–24 *Praeconocaryomma excelsa* n. sp.
(22: WIND4, C-37154, 847UWA87, sc. = 110 μm; 23: WIND4, C-37155, 840UWA87, sc. = 120 μm; 24: WIND4, C-37156, 851UWA87, sc. = 100 μm)

Fig. 25 *Acaeniotyle* sp. cf. *A. diaphorogona* FOREMAN
(WIND15, C-37157, 1735UWA87, sc. = 95 μm)


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

## Plate 4

| | |
|---|---|
| Figs. 1–3 | *Arachnosphaera exilis* (HINDE)<br>(1: WIND19, C-37158, 351LAUS91, sc. = 105 µm; 2: WIND4, C-37159, 975UWA87, sc. = 60 µm; 3: WIND4, C-37160, 1670UWA87, sc. = 105 µm) |
| Fig. 4 | Actinommid gen. and sp. indet<br>(WIND4, C-37161, 1384UWA87, sc. = 100 µm) |
| Figs. 5–7 | *Actinomma* (?) *pleiadesensis* n. sp.<br>(5: WIND15, C-37162, 234LAUS91, sc. = 115 µm; 6: WIND15, C-37163, 214LAUS91, sc. = 125 µm; 7: WIND15, C-37164, 1529UWA87, sc. = 125 µm) |
| Fig. 8 | *Spongopyle galeata* RENZ<br>(WIND4, C-37206, 1244LAUS93, sc. = 85 µm) |
| Fig. 9 | *Spongatractus biconstrictus* RÜST<br>(WIND8, C-37165, 1133UWA91, sc. = 100 µm) |
| Fig. 10 | *Spongatractus* sp. cf. *S. biconstrictus* RÜST<br>(WIND19, C-37166, 358LAUS91, sc. = 110 µm) |
| Fig. 11 | *Tricolocapsa* sp.<br>(WIND15, C-37162, 1530UWA87, sc. = 70 µm) |
| Fig. 12 | *Stichocapsa* sp.<br>(WIND15, C-37170, 1265LAUS93, sc. = 100 µm) |
| Fig. 13 | *Xitus vermiculatus* (RENZ)<br>(WIND15, C-37171, 174LAUS91, sc. = 78 µm) |
| Figs. 14, 15 | *Artocapsa ultima* (TAN)<br>(14: WIND4, C-37173, 969UWA87, sc. = 100 µm; 15: WIND4, C-37174, 1742UWA87, sc. = 110 µm) |
| Fig. 16 | *Gongylothorax cephalocrypta* (TAN)<br>(WIND15, C-37172, 177LAUS91, sc. = 50 µm) |
| Figs. 17, 22 | *Tricolocapsa antiqua* (SQUINABOL)<br>(17: WIND19, C-37168, 340LAUS91, sc. = 75 µm; 22: WIND4, C-37169, 60LAUS91, sc. = 85 µm) |
| Fig. 18 | *Pseudodictyomitra lodogaensis* PESSAGNO<br>(WIND4, C-37175, 17LAUS91, sc. = 85 µm) |
| Fig. 19 | *Amphipyndax stocki* (CAMPBELL & CLARK)<br>(WIND15, C-37176, 1263LAUS93, sc. = 100 µm) |
| Fig. 20 | Nassellarian gen. and sp. indet<br>(WIND4, C-37177, 78LAUS91, sc. = 88 µm) |
| Figs. 21, 23 | *Hemicryptocapsa* sp. cf. *H. simplex* DUMITRICA<br>(21: WIND4, C-37178, 9LAUS91, sc. = 56 µm; 23: WIND4, C-37179, 70LAUS91, sc. = 74 µm) |
| Fig. 24 | *Holocryptocanium barbui barbui* DUMITRICA<br>(WIND4, C-37180, 66LAUS91, sc. = 95 µm) |


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

## Plate 5

Figs. 1–3, 5, 21, 26 *Windalia pyrgodes* (Renz)
(1: WIND15, C-37181, 956UWA91, sc. = 120 μm; 2: WIND8, C-37182, 1138UWA91, sc. = 110 μm; 3: WIND19, C-37183, 332LAUS91, sc. = 95 μm; 21: WIND15, C-37184, 981UWA91, sc. = 45 μm, note septal partition with wide aperture; 26: WIND15, C-37185, 960UWA91, sc. = 55 μm, note short terminal extension and constricted aperture)

Figs. 4, 6, 11 *Windalia* sp. B
(4: WIND15, C-37186, 125LAUS91, sc. = 105 μm; 6: WIND15, C-37187, 133LAUS91, sc. = 120 μm; 11: WIND4, C-37188, 970UWA87, sc. = 110 μm)

Figs. 7, 14 *Archaeodictyomitra vulgaris* (Pessagno)
(7: WIND4, C-37189, 58LAUS91, sc. = 80 μm; 14: WIND4, C-37190, 71LAUS91, sc. = 65 μm)

Figs. 8–10, 12 *Windalia* sp. A
(8: WIND19, C-37192, 311LAUS91, sc. = 95 μm; 9, 12: WIND14, C-37193, 1707UWA87, sc. = 110 μm & 55 μm; 10: WIND8, C-37194, 1129UWA91, sc. = 125 μm)

Fig. 13 *Mita* sp.
(WIND15, C-37195, 138LAUS91, sc. = 45 μm)

Fig. 15 *Archaeodictyomitra sliteri* Pessagno
(WIND4, C-37191, 1749UWA87, sc. = 80 μm)

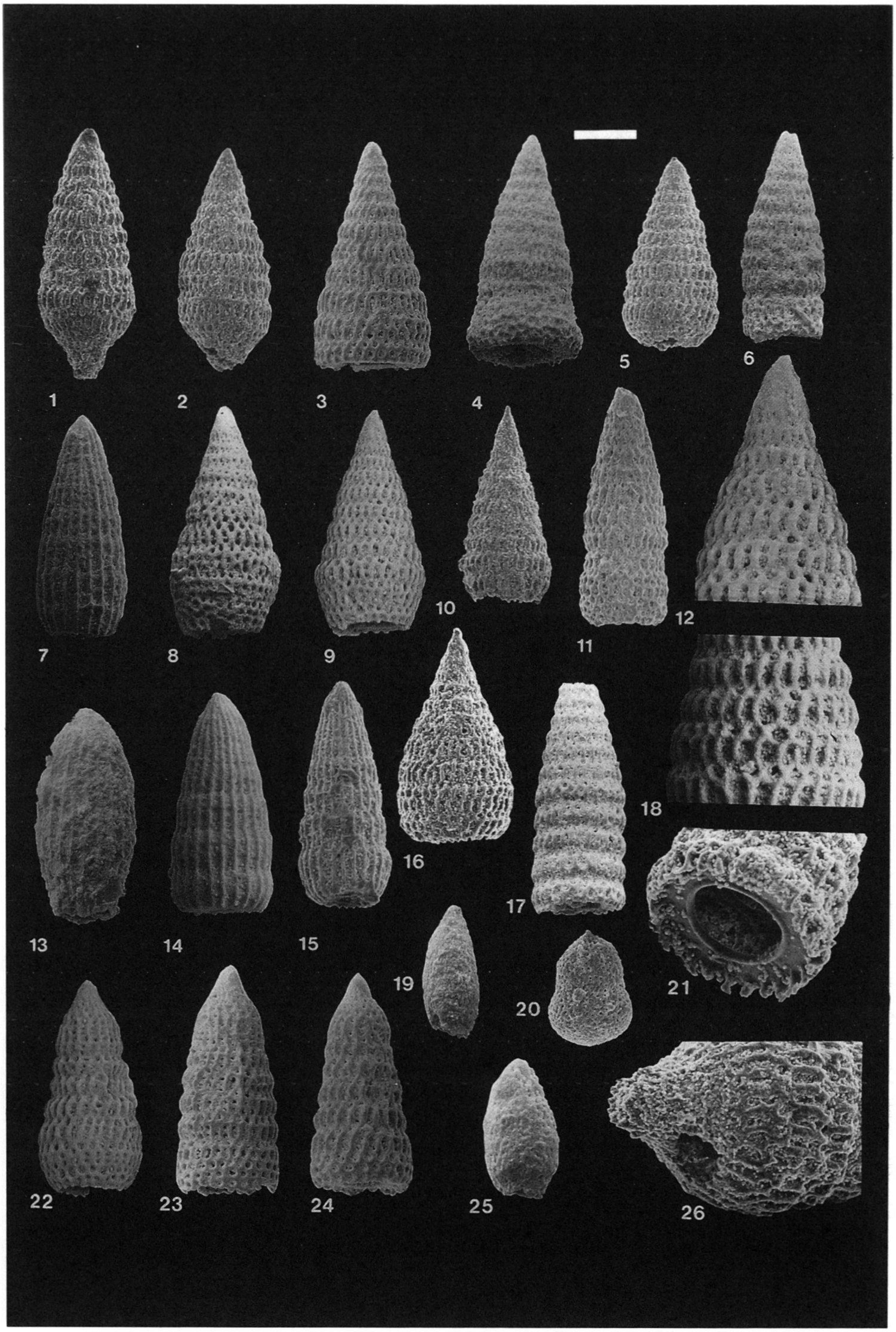
Figs. 16, 18 *Windalia* sp. D
(16: WIND8, C-37196, 1101UWA91, sc. = 95 μm; 18: WIND4, C-37197, 95LAUS91, sc. = 50 μm, note arrangement of ridges and pores characteristic for the genus *Windalia*)

Fig. 17 *Windalia* sp. C
(WIND15, C-37199, 130LAUS91, sc. = 90 μm)

Figs. 19, 25 *Cyrtocalpia operosa* Tan
(19: WIND15, C-37198, 1255LAUS93, sc. = 60 μm; 25: WIND5, C-37207, 1254LAUS93, sc. = 60 μm)

Fig. 20 *Dicanthocapsa* sp. cf. *D. ancus* (Foreman)
(WIND15, C-208, 1262LAUS93, sc. = 60 μm)

Figs. 22–24 *Windalia epiplatys* (Renz)
(22: WIND4, C-37200, 1753UWA87, sc. = 105 μm; 23: WIND19, C-37201, 304LAUS91, sc. = 107 μm; 24: WIND19, C-37202, 308LAUS91, sc. = 95 μm)


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26