THE PERMIAN BRYOZOA OF TASMANIA, NEW SOUTH WALES AND SOUTHERN THAILAND: THEIR TAXONOMY, BIOSTRATIGRAPHY, PALAEOECOLOGY AND BIOGEOGRAPHY.

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Declaration

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ABSTRACT

Permian Bryozoa from the glaciomarine Tasmania and southern Sydney Basins, Australia, and the cold to warm water Shan-Thai Terrane, southern Thailand, are studied following the taxonomic techniques of Morozova (1974), Snyder (1991) and Morozova and Lisitsyn (1996). Previously the fenestrate faunas of these regions have not been examined internally. This study will show that rigorous taxonomic methods, applied to all bryozoan groups, yields the information required for accurate biostratigraphic, palaeoecologic and biogeographic analysis.

The Permian bryozoan faunas of the Tasmania Basin are abundant, but of low diversity. Taxa are from the Fenestrata and Trepostomata and range from the Sakmarian to Kazanian. Thirty-three species are recorded in the genera *Levifenestella, Rectifenestella, Mackinneyella, Parapolypora, Polypora, Polyporella, Pseudopolypora*, and *Shulgapora* (Fenestrata) and *Dyscritella, Dyscritellina, Paralioclema*, and *Stenopora* (Trepostomata). Twenty new species are recorded from the Tasmania Basin :- *Rectifenestella smithae, R. counselensis, Rectifenestella* sp. A, *Mackinneyella granulosa, Parapolypora boraformis, Parapolypora* sp. A & B, *Polyporella protuberans, P. subwoodsi, P. westarmensis, Pseudopolypora banksi, P. bundellaensis, P. tamarensis, P. versonoda, Dyscritella inversa, Dyscritellina megacanthi, Paralioclema wassi, Stenopora aequalis, S. berriedalensis, S. elongata*. Two-thirds of Tasmanian bryozoan species are endemic to the Tasmania Basin, but most genera are cosmopolitan. Future work in other basins may reveal more species in common with other basins.

The bryozoan fauna of the southern Sydney Basin is largely confined to the Kungurian Wandrawandian Siltstone, where abundant well-preserved faunas were collected. Sixteen species are recorded within the genera *Fenestella, Laxifenestella, Levifenestella, Minilya, Rectifenestella, Paucipora, Polypora, Polyporella, Shulgapora* (Fenestrata), and *Dyscritella* and *Stenopora* (Trepostomata). Four new species are recorded, they are:- *Laxifenestella oviferosa, Paucipora ulladullaensis, Dyscritella espinensis* and *Stenopora seriatensis*. Less than half the species from the southern Sydney Basin are endemic to that basin.

Internal examination of fenestrate bryozoans collected for this study has recorded for the first time in Australia *Laxifenestella, Rectifenestella, Pseudopolypora* (previously grouped as *Fenestella*), *Mackinneyella, Parapolypora, Paucipora, Polyporella* and *Shulgapora* (previously grouped as *Polypora*). The trepostome genera *Paralioclema* and *Dyscritellina* are also recorded in Australia for the first time. Review of previously described Permian Bryozoa of Western Australia and the Northern Territory shows the likely presence of *Alternifenestella* and *Exfenestella*, which were not previously formally reported from Australia.

The Permian bryozoan faunas of the Ratburi Limestone, southern Thailand, are diverse and abundant. Thirty-eight species are recorded from Ratburi outcrops on Ko Phi Phi Don, within the following genera:- *Alternifenestella, Fabifenestella, Flexifenestella, Minilya, Rectifenestella, Spinofenestella, Mackinneyella, Polypora, Shulgapora, Reteporidra, Septapora, Synocladia, Penniretepora, Acanthocladia* (Fenestrata), *Paralioclema, Neoeridotrypella* (Trepostomata), *Ascopora, Rhabdomeson, Streblotrypa*, (Cryptostomata), *Cyclotrypa, Eridopora, Fistulipora, Coscinotrypa, Hexagonella* and *Goniocladia* (Cystoporata). Review of previously described fenestrate taxa from the Permian Shan-Thai Terrane also reveals the probable presence of *Paucipora, Polyporella* and *Polyporellina* in Ratburi faunas. Fenestrate bryozoans dominate the fauna, but cystoporates are also important. Thirty new species are recorded from the Ratburi Limestone on Ko Phi Phi Don, they are:- *Fabifenestella subthaiensis, F. carinata, Flexifenestellla hexaformis, Minilya phiphiensis, Spinofenestella lekformis, S. pseudohorologia, S. flanchea, Mackinneyella nodosa, M. supraobesa, Polypora canalis, P. nodulifera, Shulgapora reversa, S. megacyclopora, Reteporidra yongkasemensis, Septopora interformis, S. irregularis, Penniretepora subtropica, Acanthocladia pseudothaiensis, A. suprangularis, Paralioclema phuketensis, Neoeridotrypella subpulchra, Ascopra robusta, A. variablis, Rhabdomeson*

monoformis, Cyclotrypa dendroides, Eridopora thaiensis, Fistulipora megapertura, Coscinotrypa yaiformis and *Goniocladia sp.* A and B.

About three-quarters of the species group is endemic to Ko Phi Phi Don, however future work in surrounding areas and in other Gondwanan and southeast Asian terranes, may reduce this proportion.

The result of more rigorous taxonomic methods has been the identification of short-ranging species and faunal progressions, particularly in the Tasmania Basin. Here, a useful bryozoan biostratigraphy has been developed from the Sakmarian to the Kazanian, that can aid in Australia-wide biostratigraphic relationships. The use of bryozoans in biostratigraphic analysis can provide a means of correlating drill-core material where other macrofossils may not be identifiable. Within fenestrate faunas of the Tasmania Basin, internal examination has revealed a number of species and genera that were previously grouped together as a long-ranging species of variable mesh dimensions. By identifying these separate taxa, species lineages can be seen that are of good use in biostratigraphy.

The bryozoan faunas of the Ratburi Limestone, Ko Phi Phi Don, while highly endemic, show relationships to faunas from other regions and a Late Artinskian to Kungurian age has been determined.

The bryozoan faunas of the Tasmania Basin, southern Sydney Basin and Ratburi Limestone, southern Thailand, show trophic structuring according to mouth and lophophore diameters, and chamber volume in fenestrates. Mouth diameter indicates maximum food particle size able to be ingested. Despite the absence of information on prey preferences, species are separated according to food particle size niches. In the Ratburi Limestone the cystoporates occupy the largest food particle size niches, with the cryptostomes, trepostomes and fenestrates occupying progressively smaller food particle size niches. In the absence of the cystoporates and cryptostomes in the Tasmania and southern Sydney Basins the trepostomes and some fenestrates are expanding into this vacant niche of larger food particles.

Variation in bryozoan colony morphologies can be used in palaeoenvironmental analysis of water energy, substrate and relative sedimentation rates. In the fenestrate mesh, variation in branch thickness, or robustness, is a result of increased number of rows of zooecia, and increased chamber volume in response to food particle preferences, rather than a response to water energy environments.

The bryozoan faunas of the Ratburi Limestone are most similar to those of Western Australia (Westralian Province). They show clear Gondwanan relationships and have a large number of endemic species that show relationships with Western Australia, Timor and Russia. However, there are no endemic genera in the bryozoan fauna, in contrast to the large number of endemic genera in the brachiopod fauna.

The faunas of eastern Australia are dominated by fenestrate taxa and have no endemic genera. The faunas of the Bowen Basin are the most diverse, with generic diversity decreasing towards the higher latitudes of the Tasmania Basin. Dominance of fenestrate taxa also increases toward higher latitudes. Many of the Tasmanian bryozoan genera are cosmopolitan or typical of boreal provinces, indicating a bi-polarity in the distribution of Permian bryozoan faunas.

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CHAPTER ONE

INTRODUCTION

1.1 AIMS

The aim of this study is to collect, describe and assess Permian bryozoan faunas from the Tasmania Basin and southern Sydney Basin, Australia, and the Shan-Thai Terrane of southern Thailand.

These bryozoan faunas, in particular those of the Tasmania and southern Sydney Basins, have not previously been assessed in detail and the level of understanding of these faunas is poor. This study aims to describe the taxonomy and assess the biostratigraphic, palaeoecologic and biogeographic attributes of each of the above areas.

1.1.1 - *Taxonomic history.*

Fenestrata

Fenestrate bryozoans have been studied since the early nineteenth century, but are not yet fully understood. The initial establishment of taxonomic groupings at all levels was based on exterior morphology. Descriptions were sometimes lacking in details of the mesh that would allow taxa to be recognized elsewhere. Descriptions were often qualitative rather than quantitative and many mesh features that are regularly included in descriptions today were absent.

Ulrich (1888, 1890) was one of the first workers to examine the Fenestellidae internally. Ulrich (1890) recognized the granular skeletal layer ("original basal" or "germinal plate") and lamellar skeletal layer for the first time, and noted variation in internal chamber shapes between taxa. Nekhoroshev (1928) also examined internal features of the genus *Fenestella* Lonsdale, and grouped species according to chamber shape. These groupings based on internal morphological structures were thought to be so different that a relationship did not exist between them (Nekhoroshev, 1932). However neither Ulrich (1888,1890) nor Nekhoroshev (1928, 1932) went so far as to divide the genus *Fenestella* Lonsdale according to chamber shape, but used the groupings as a means of defining species.

After examination of numerous Carboniferous and Permian taxa from the Russian platform and Ural Mountains, Shulga-Nesterenko (1951) also grouped species according to chamber shape after internal examination. Despite noting that there were probably different genera and subgenera within *Fenestella*, this was not formalised, and taxa remained grouped according to internal features within the form genus *Fenestella*. The primary consideration in grouping species was based on chamber outline at the zooecial base, but did not consider changes in shape throughout the chamber. Despite a reluctance to separate *Fenestella* into a number of new genera, Shulga-Nesterenko (1951) did note that the separate groupings reflected phylogenetic groupings within the genus.

Elias and Condra (1957) discussed the importance of both internal and external features in discerning fenestrate species, from the Permian of West Texas, and noted that internal features must be established in previously described species where this information is not known. They also stated that the variability of the mesh must be considered, and that this must be done quantitatively for it to be of use in recognizing separate species. However, much of their material was poorly preserved and did not allow consistent detailed internal examination. Where Shulga-Nesterenko (1951) and Nekhoroshev (1928, 1932) grouped species in the first instance on differing chamber shapes, Elias and Condra (1957) grouped species of *Fenestella* according to fenestrule length and the number of rows of nodes. These initial groupings are further broken down into species according to chamber shape, zooecial number, zoarial form and carinal development.

Wass (1968), in a study of the Permian fenestrate fauna of the Bowen Basin, Queensland, used the grouping system of Elias and Condra (1957) for the basis of a keying system, based on fenestrule length, zooecial number per fenestrule, and the stability in occurrence of apertures in relation to the dissepiments. The key system of Wass (1968) was developed, in part, so that non-bryozoan specialists could recognize specimens beyond general inclusion in the Fenestellidae. However, as a taxonomic approach, this grouping system is of little use, as fenestrule size and zooid spacing are less closely associated with the individual zooid than the shape and size of the chamber directly surrounding it. As noted by previous authors (e.g. Shulga-Nesterenko, 1951; Elias and Condra, 1957) taxa with a similar external mesh formulae may exhibit quite different internal features. The zooecial chamber has initial contact with the biological individual zooid and should be considered of most importance, with the details of the mesh and nodes of secondary importance. Changes in the size and shape of the zooecial chamber can be expected to be a more accurate representation of changes in the biology of the individual zooid than dimensions of the mesh.

An important development in the taxonomy of the form genus *Fenestella* came when Morozova (1974) extended the observations of Shulga-Nesterenko and others, and applied the variation in chamber shape as an indication of generic separation within *Fenestella* s.l.. Where previously the genus *Fenestella* s.l. was considered abundant with numerous species ranging from the Lower Silurian to the end of the Permian, 14 separate genera were recognized, that have generally shorter time ranges. Some genera were previously described and were validated by internal examination of chamber outline and other skeletal features. Common Permian genera presented by Morozova (1974) were *Alternifenestella* Termier and Termier, *Fenestella* s.s. Lonsdale, *Minilya* Crockford and *Spinofenestella* Termier and Termier. The remaining genera were newly described from appraisal of Russian material by Morozova (1974), the common Permian genera were *Exfenestella, Fabifenestella, Flexifenestella, Laxifenestella.* The criteria for separation of genera were based first upon internal chamber shapes, in combination with the presence or absence of accessory cells, carinae and nodes, rather than only external morphologic characters.

The genus *Polypora* McCoy, is also widespread and long-ranging, from the Lower Devonian to Late Permian. Like *Fenestella* s.l., *Polypora* was known to exhibit a range of internal features, with variation particularly in chamber shape and number of rows of zooecia. As with studies of *Fenestella* s.l., Shulga-Nesterenko (1949, 1951) distinguished groupings within the genus *Polypora* s.l., but did not separate these groups as independent genera. Miller (1963) revised the genus *Polypora* s.s. from type material and gave a description of internal chamber shapes as elongate hexagonal to irregular polygonal in deep transverse section. Morozova and Lisitsyn (1996) re-examined taxa previously placed in *Polypora* s.l. in a similar manner to *Fenestella* s.l. and again defined a number of separate genera based on their internal morphologies. Some genera were previously described, and were validated by internal examination, such as *Paucipora* Termier and Termier, *Polyporella* Simpson and *Polypora* McCoy. Genera were defined primarily on chamber shape, zooecial row number and accessory cells and structures. New genera described by Morozova and Lisitsyn (1996) were *Pseudopolypora, Polyporellina, Parapolypora, Biarmiella, Mackinneyella* and *Neopolypora.*

Engel (1979) defined two new genera, *Australofenestella* and *Australopolypora*, from the Carboniferous of Australia. Engel (1979) had discussed the large number of species within *Fenestella* s.l. and *Polypora* s.l., and the problem with division between the two on row number, with some species exhibiting two or three rows. The Australian Carboniferous material is largely preserved as external and internal moulds, and Engel (1979) grouped taxa according to apertural size and nature, carina and nodes, in combination with row number. In regard to chamber shapes as a diagnostic feature, Engel (1979) discussed their difficulty of use in random tangential sections where chamber depth is not known. However, serial peels can readily be taken from well preserved material and can reveal changes in shape through the chamber, and are easily produced before final thin sectioning of each specimen. To separate taxa on external, if very well preserved, features of apertures and nodes, will create confusion in taxonomy. The apertures, nodes and carinae are of secondary biologic importance to the actual size and shape of the chamber with which the individual zooid was in closest contact.

The new genera of Morozova (1974) and Morozova and Lisitsyn (1996), while being an important step forward in fenestrate taxonomy, were poorly described in detail. Many species descriptions of Russian material are brief as were the bulk of previous works on Australian faunas (i.e. Crockford, 1941a; 1941b; 1945; and Wass, 1968). The micrometric formulae of Termier and Termier (1971) have been a popular means of quantitative description, however they deal with external characters only. Internal features such as chamber dimensions and the granular and lamellar skeleton were not quantitatively described, despite their importance in differentiating genera and species.

Snyder (1991) extended the Morozova (1974) (and Morozova and Lisitsyn, 1996) approach of internal examination, and used many morphologic characters to define species, to show that the attributes of the individual chamber must reflect soft-part morphology. As the individual soft-bodied zooid is enclosed within the chamber, the size, shape and general character of the chamber may be taken as the closest indication of soft part morphology and therefore variation between species and genera. Snyder (1991) used many morphologic characters, and a statistical approach, to show that species are able to be readily identified and differentiated. Holdener (1994) used discriminant analysis allocation matrices and cluster analysis to show that subsequent authors may use their own data to recognize, statistically, Snyder's (1991) species. McKinney (1994) used cluster analysis and canonical discriminant analysis to re-assess Carboniferous lyre-shaped fenestrate bryozoans from eastern North America. Specimens were measured and then clustered using all available data, into only three species, where previously nine had generally been recognized (McKinney, 1994). In McKinney's (1994) study specimens were examined both externally and internally, but without the range of measurement characteristics of Snyder (1991).

This statistical approach, while appropriate for some faunas, as shown by Snyder (1991), Holdener (1994) and McKinney (1994), may be unsuitable in many circumstances. Where few specimens are available for measurement, any resultant statistical data may not be accurate, and true variation within a species may not be recognized. In this situation, the more traditional method of species recognition by qualitative assessment by the examiner would be more appropriate. A purely statistical approach to the groupings of specimens into separate species may not readily account for environmentally enduced variation in the zoarium, particularly where few specimens are available. However, Holdener (1994) notes that morphs within a species are able to be distinguished.

Snyder (1991) also illustrated the importance of transverse and longitudinal as well as tangential sections for accurate determination of chamber shapes. Morozova (1974) and earlier Russian workers had relied principally on tangential sections only.

Other Groups

The study of the Trepostomata, Cryptostomata and Cystoporata has involved external and internal examination for a longer period of time, and while this study can be expected to identify new species, and probably new generic records for Australia and Thailand, it is not expected that generic placement of previously described species will be significantly altered.

1.1.2 - *Taxonomic methodology used in this study.*

The taxonomic approach of internal examination to study chamber shapes, has not been applied to Gondwanan faunas, and the majority of fenestrate taxa are included in either *Fenestella* s.l. or *Polypora* s.l. By applying the taxonomic approach of Morozova (1974) and Morozova and Lisitsyn (1996) it is expected that the Tasmanian and southern Sydney Basin faunas will reveal a far greater generic diversity than is presently known. The strictly statistical approach of Snyder (1991), Holdener (1994) and McKinney (1994) is not followed here. Instead the material is examined externally and internally and taxa are discerned largely by qualitative assessment. The detailed measurement parameters of Snyder (1991) are the most detailed of any worker to date and are used to accurately describe taxa after they have been grouped together.

Many species in this study are described on a single, or few, specimens. Where taxa are distinct and clearly separable from all other material, species are still described even though only a single specimen may be available. The Gondwanan faunas have received little study in the past, in terms of methodical internal examination, and the Tasmanian faunas in particular are not considered diverse. Much of the material is poorly preserved, but where good material is available, even in limited numbers, it is formally described in order that the true nature of these faunas be shown. It is realized however, that future work with additional material may alter some of the species concepts presented here. Within the Fenestrata some species may show changes in the overall external mesh from proximal to distal parts of the zoarium, however the internal structures remain consistent. Changes in chamber dimensions, where associated with dissepiments and widening or narrowing of the branches, can be expected to be seen in smaller fragments, as the chamber reflects the individual zooid which is not expected to change morphology through the zoarium.

The analysis and description of internal features does have some difficulties that need to be considered when working with fenestrate bryozoans. The appearance of the zooecial chamber varies according to the depth and angle of section. When serial peels are made an accurate determination of the true chamber dimensions can be made, and changes in shape through the chamber are revealed. When comparing material to published figures, differences in the depth and angle of section need to be considered.

The faunas of the Bowen Basin, Queensland, and the Western Australian basins will not be studied, but comments will be made after review of previous works by Crockford (1944a; 1944b; 1944c; 1946; 1957) and Wass (1968).

Within the Shan-Thai Terrane faunas, fenestrate species have largely been described on external features, however Sakagami (1966b; 1968a; 1968b; 1970) illustrated tangential sections of fenestrate bryozoans. Species were still included within either *Fenestella* s.l. or *Polypora* s.l., and where descriptions and illustrations are sufficient, Sakagami's taxa will be placed within the genera of Morozova (1974) and Morozova and Lisitsyn (1996).

1.1.3 - *Biostratigraphy*.

In the past, Gondwanan bryozoan faunas have not been an important group in biostratigraphic studies. The Bryozoa as a group have not been under on-going study, with Joan Crockford the major provider of information on this group. As the fenestrates have largely only been examined externally, their true worth in biostratigraphic analysis has not been recognized. By utilizing the internal examination techniques of Morozova (1974), Snyder (1991) and Morozova and Lisitsyn (1996), it can be expected that taxa will be more readily differentiated both within and between basins. Many species in eastern Australia have previously been taken to be widespread and long-ranging, and more rigorous techniques will separate taxa at generic and specific level. If the true details of bryozoan taxonomic diversity are known they can be of use in biostratigraphic analysis.

Bryozoans occur throughout the marine Permian rocks of Australia, although abundance and preservation vary through time, and between basins. In the Tasmania Basin fenestrate bryozoans are abundant from the Sakmarian to the Ufimian, but are not used for biostratigraphic analysis or comparison. It is expected that by applying internal examination techniques in bryozoan taxonomy a useful biostratigraphy will be revealed within this group. Further, by describing bryozoans in this way, they may be able to be identified from drill core rock samples, where other macrofossil faunas are not often readily identified. If a bryozoan biostratigraphy can be developed and applied to drill core material, the overall biostratigraphic understanding of the basin can be improved.

1.1.4 - *Palaeoenvironment and Palaeogeography.*

Bryozoan faunas have been used in passing in faunal palaeoenvironmental analysis within the Permian. Most comments have been in regard to fenestrate bryozoans as an indicator of quiet water environments. Bryozoans are a major part of the Permian faunas of the Tasmania and southern Sydney Basins, and Shan-Thai Terrane, yet palaeoenvironmental analysis of bryozoans is poor. Much work has been done with modern bryozoan faunas to determine environments to which different taxonomic and morphologic groups are suited. Nelson *et al.* (1988b) demonstrated zoning within bryozoan faunas in relation to water depth and energy, and sedimentation rates. Further, Smith and Nelson (1996) showed experimentally the effects of environment on different bryozoan morphologic types after death of the colony. Using this information from modern faunas, the environmental factors of water energy and sedimentation rate can be inferred for fossil faunas. Changes through time can also be assessed with the Tasmania Basin faunas.

Within modern faunas it is also shown that temperature can effect bryozoan colonization (Barnes, 1996), feeding and growth rates (Sanderson & Thorpe, 1996). Different taxa also select for different food types, whether by food particle size selection or specific prey selection (Bullivant, 1968a; Winston, 1977). Despite the absence of soft tissues in fossil bryozoan faunas feeding capacity and food particle size selection can be determined, as shown by Snyder (1991), after Winston (1977). By determining food particle size selection capabilities in fossil taxa, the presence or absence of trophic structuring within fossil faunas can be assessed. Further, it can be determined whether different taxonomic groups occupy differing ecological niches. The Shan-Thai Terrane faunas are taxonomically diverse and this study will investigate whether different taxonomic groups occupy different food particle size niches. Also are the warmer water Shan-Thai faunas feeding in different food particle size niches, to the low diversity colder water faunas of the Tasmania and southern Sydney Basin faunas?

The difference in likely water temperature between the Tasmania Basin and Shan-Thai Terrane depositional environments also means that the effects of temperature on colonization and growth may be discussed.

1.1.5 - *Biogeography.*

In revealing new genera within *Fenestella* s.l. and *Polypora* s.l., Morozova (1974) and Morozova and Lisitsyn (1996), opened the opportunity for a better understanding of bryozoan biogeography. Various biogeographic studies have been undertaken in the past (e.g. Ross, 1978; 1995; Naimarck *et al.*, 1999; Gilmour & Morozova, 1999) that have considered the distribution of Permian (and Palaeozoic) bryozoans worldwide. However as the Gondwanan faunas are poorly studied they are not accurately represented in such worldwide studies. This study aims to address this problem and contribute to the knowledge of Permian bryozoan biogeography by adding vital information from the Tasmania and southern Sydney Basin.

Within Australia itself, the Tasmania Basin Permian macrofossil faunas are often considered as impoverished eastern Australian faunas. This question cannot be answered in regard to the Tasmanian bryozoans until the taxonomy of Australian bryozoans is brought into line with modern techniques. This study aims to answer this question and further improve the understanding of Australian Permian bryozoan faunas in worldwide biogeography.

1.2 - <u>OUTLINE OF STUDY REGIONS</u>

1.2.1 - *Eastern Australia.*

Permian bryozoans were collected from Tasmania and the south coast of New South Wales. Tasmania is located between approximate latitudes 39° to 44°S, and collection areas in New South Wales about 35°S. The climate for both regions is temperate. Inland New South Wales climate is more variable however. Mean annual rainfall in Tasmania is 624 mm., with mean minimum temperature 4.5°C, and mean maximum 21.8°C. Mean annual rainfall for the New South Wales south coast region is between 900-1200 mm., with approximate mean minimum temperature 8°C and mean maximum 25.8°C. The general climate within Tasmania is cool and dry, and is slightly warmer and wetter on the New South Wales south coast. Within Tasmania, western regions are generally wetter than the average with temperate rainforest developed, and dryer than average in northeastern areas. A mix of eucalypt and temperate rainforest is the natural vegetative cover in both Tasmania and south coast new South Wales, but cultivated farmland is now common.

Permian rocks in Tasmania and New South Wales are of glacial origin, in part or whole, and are of marine or non-marine environments. In the Tasmania Basin Permian rocks are dominantly marine, with intervals of non-marine deposition. In the New South Wales Sydney Basin the Permian rocks are again of marine and non-marine origin, with a more significant freshwater influence than in the Tasmania Basin.

Fieldwork in Tasmania was undertaken in the summers of 1997-98. Samples were collected throughout the state, with localities given in Chapter Two.

Fieldwork in New South Wales was completed in February of 1999. Samples were collected from Wasp Head, Pretty Beach and Ulladulla, with localities given in Chapter Two.

1.2.2 - *Southern Thailand.*

Peninsular Thailand is located between latitudes 6° and 13°N, with high annual rainfall and a tropical climate. Average temperatures in the Phuket region are between 20°C to 25°C, with average humidity between 63% in the dry season and 77% during the long wet season. Rainfall in southern Thailand is high, the rainy season extends from about May to October/November, with 250 mm to 350 mm/month during this time. Vegetative cover in southern Thailand is in its natural state predominantly rainforest, but harvesting is common with rubber, coconut and other fruit plantations in their place. The topography of southern Thailand is of tropical limestone karst islands to low-lying wetlands, and rainforest covered low mountain ranges.

Palaeozoic rocks are widespread in peninsular Thailand, within the Shan-Thai Terrane, that extends into northwest Malaysia, eastern Burma and north into southern China. In the Phuket region Palaeozoic rocks are traditionally divided into the Asselian to Sakmarian Phuket Group of sparsely fossiliferous pebbly mudstones and sandstones, and the Artinskian to Kungurian Ratburi Limestone of fossiliferous limestones.

Field work in southern Thailand was conducted in January of 1998. Samples of Ratburi Limestone were collected from Ko Phi Phi Don in southern Peninsular Thailand. Samples of Phuket Group bryozoans were also collected from Phangnga, Ko Yao Noi and Ko Phi Phi Don, southern Peninsular Thailand. Sample localities are given in Chapter Four.

CHAPTER TWO

PERMIAN LITHO- AND BIOSTRATIGRAPHY OF NEW SOUTH WALES AND TASMANIA.

2.1 - INTRODUCTION

Permian rocks are widespread in eastern Australia, with good outcrops in Tasmania, New South Wales and Queensland. The rocks are, in part, of glacial origin and are both marine and non-marine. In the Tasmania Basin, Permian rocks are dominantly marine with intervals of non-marine deposition. In the New South Wales Sydney Basin, Permian rocks are again of marine and non-marine origin, with a more significant freshwater influence than in the Tasmania Basin.

The biostratigraphy of eastern Australia is based largely on brachiopod, molluscan and palynological data, with each basin having its own biostratigraphic nomenclature.

The eastern Australian bryozoan faunas described in this study were collected from the Tasmania and southern Sydney Basins, and the geology and biostratigraphy of each of these is considered below.

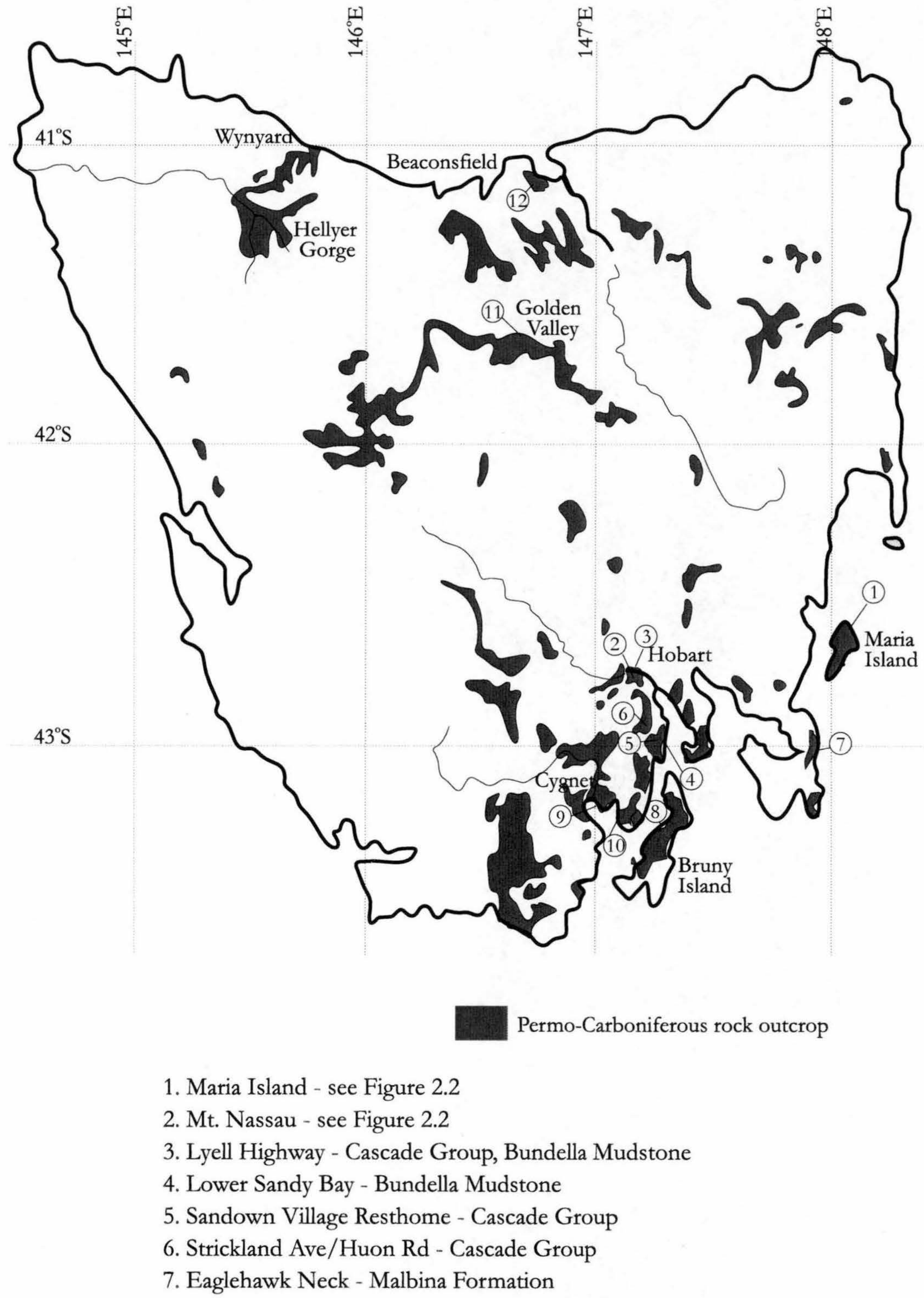
2.2 - REGIONAL GEOLOGY

2.2.1 - *Tasmania Basin*

The Parmeener Supergroup (Banks, 1973) contains the Permian rocks of Tasmania. The group is divided into two subgroups, according to depositional environment. The Lower Parmeener Supergroup, of Late Carboniferous to Late Permian age comprises largely marine units, with non-marine units in the Upper Parmeener Supergroup, of Late Permian to Triassic age. The distribution of Permian rocks in Tasmania is shown in Figure 2.1, with detail of key localities in Figure 2.2. The Parmeener Supergroup overlies a Precambrian to middle Palaeozoic basement. The Lower Parmeener Supergroup is variable across the Tasmania Basin, but in most areas the same basic lithostratigraphy is found. Basal, usually nonfossiliferous, tillite and mudstone with glendonites are overlain by fossiliferous marine mudstone (Bundella Mudstone), with minor thin limestone. A non-marine sequence follows these lower fossiliferous beds, and is itself followed by fossiliferous fine grained rocks. In most areas these beds develop into thick fossiliferous limestones (Berriedale Limestone). Above these limestones are variously fossiliferous sandstone and siltstone (Malbina Formation), with the uppermost marine beds usually poorly fossiliferous mudstone or siltstone (Fern Tree Mudstone) with conglomerate horizons. In all areas the uppermost Permian beds are of non-marine origin. The stratigraphic sequence through time is discussed below, and concentrates on the geology of regions where bryozoans faunas were collected. Stratigraphic relationships are shown in Figure 2.3.

The basement rocks to the Lower Parmeener Supergroup are limestones, siliciclastics, and metamorphic and igneous rocks. Western and eastern terranes were deformed during the Late Devonian Tabberaberan Orogeny, with a suture most probably along the Tamar Fault system (Williams *et al.*, 1989).

Erosion of this basement surface was by glacial action during the Late Palaeozoic. By Late Carboniferous general westward glacial retreat led to deposition of thick sequences of mixtite, tillite, conglomerate and glaciolacustrine claystone. These deposits are thickest in lowstand areas in the northwest, west and southern areas (Clarke, 1989). These thick tillite deposits are named the Wynyard Tillite in the northwest, and the Truro Tillite in southern



1. Maria Island - see Figure 2.2
2. Mt. Nassau - see Figure 2.2
3. Lyell Highway - Cascade Group, Bundella Mudstone
4. Lower Sandy Bay - Bundella Mudstone
5. Sandown Village Resthome - Cascade Group
6. Strickland Ave/Huon Rd - Cascade Group
7. Eaglehawk Neck - Malbina Formation
8. Bruny Island, Ford Bay - Deep Bay and Minnie Point Formation
9. Cygnet, Wheatleys Bay - Bundella Mudstone
10. Cygnet, Deep Bay - Deep Bay Formation
11. Golden Valley - Golden Valley Group
12. Beaconsfield - see Figure 2.2

Figure 2.1 - Distribution of Permo-Carboniferous rocks in the Tasmania Basin. Numbers indicate sites where identifiable faunas were collected. Many other faunas are present, but preservation does not permit internal examination.

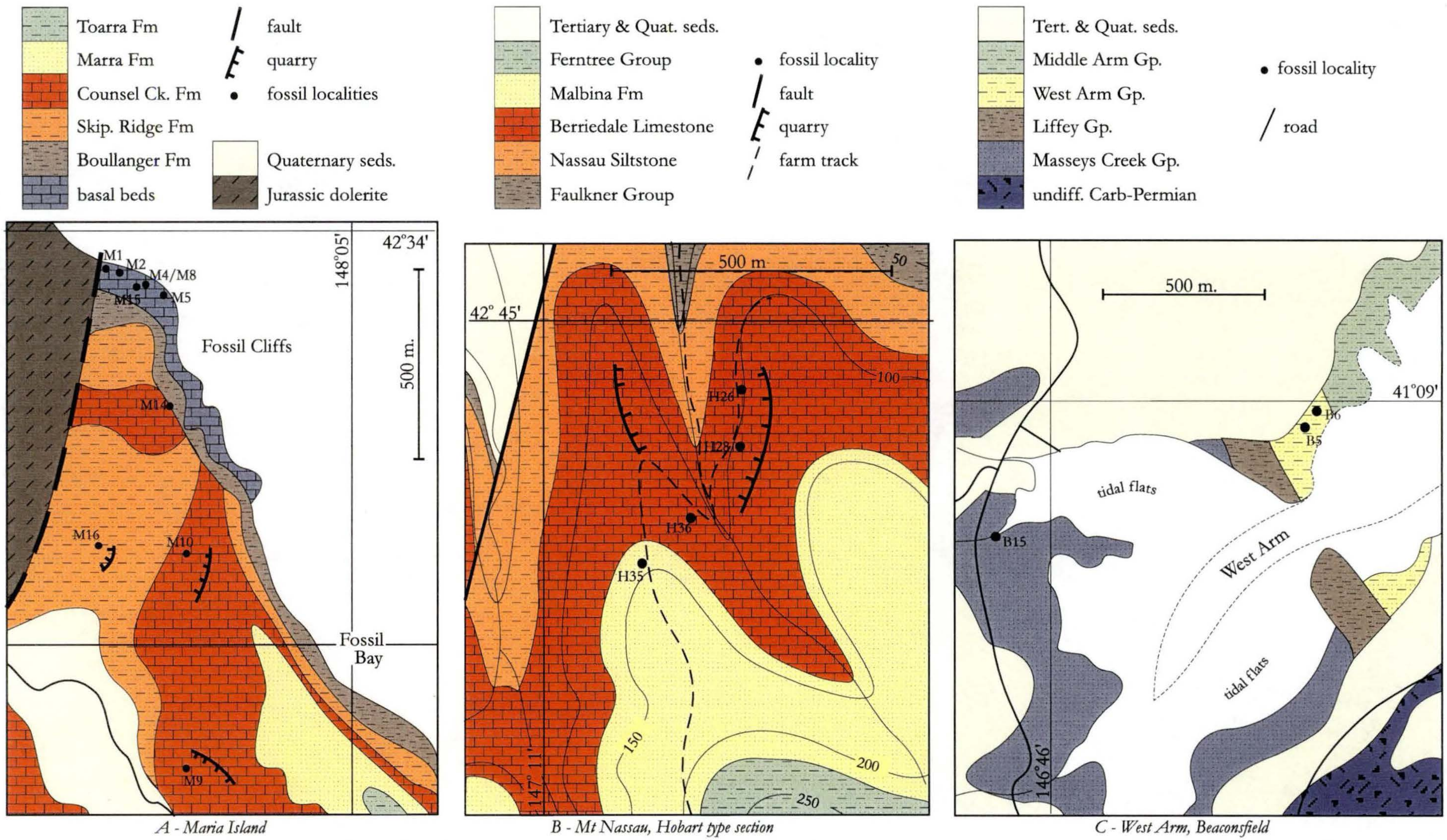


Figure 2.2 - Detailed geology maps for A, Fossil Cliffs, Maria Island, after Clarke & Baillie (1984). B, Mt. Nassau, Hobart, after Leaman (1976). C, West Arm, Beaconsfield, after Gee & Legge (1974). For details of individual fossil localities see Appendix 5.

areas. In highstand or marginal basin areas these tillites are either absent or are much reduced (see Figure 2.4). The palaeontology of the basal tillites is sparse, with some marine fossils indicating periods of wet base ice discharging debris below sealevel (Carey and Ahmad, 1961). Plant remains and microfloras are also recorded and indicate a Microflora Stage 1 and early Stage 2 (Truswell, 1978), or Asselian age (Archbold and Dickins, 1991). The basal tillites are followed in most of the Tasmania Basin by massive bedded pyritic, carbonaceous siltstone with some calcareous concretions. Glendonites are common in these siltstones in southern areas and may be preserved whole or more commonly as moulds of the rosette calcite pseudomorph crystal structure. These beds are known variously as the Quamby Formation in the northwest and the Woody Island Formation in southern Tasmania Basin. Near the base of the siltstone units is the Tasmanite Oil Shale formed by algal blooms (Clarke, 1989). The remainder of the unit contains sparse marine fossils. Some dropstones are present in the Tasmanite Oil Shale, near palaeoshorelines, but they are otherwise uncommon (Clarke, 1989).

By the latest Asselian to earliest Sakmarian continued deposition and a probable marine transgression (Clarke, 1989), allowed the development of rich marine faunas. The Bundella Mudstone of southern Tasmania, and the upper Masseys Creek Group of northern areas were deposited at this time. The rocks are usually well-bedded pebbly mudstone and siltstone with common dropstones. In the east on Maria Island, rocks of the same age are highly fossiliferous with abundant and some very large dropstones. Sakmarian marine faunas are abundant through most of these units, and are particularly common in the "basal beds" of Maria Island and the Bundella Mudstone. The lowermost Maria Island deposits are rich in bryozoans, brachiopods and bivalves, with large dropstones often seen to crush larger bryozoan colonies. In the Darlington Limestone, thick beds of spiriferid and eurydesmid coquinas are interbedded with bryozoan rich siltstones (Clarke and Baillie, 1984). The Bundella Mudstone in the Hobart region is also richly fossiliferous, with abundant brachiopods, bivalves and bryozoans. Bryozoans are found throughout, and may be very abundant in fine laminated horizons. Outcrops of Bundella Mudstone in the shore platform at Lower Sandy Bay have yielded good faunas of fenestrate and trepostomous bryozoans.

In the late Sakmarian, a non-marine sequence was deposited over much of the basin (see Figure 2.4). The sequence is thickest in northern areas, where it is known as the Liffey Group, of mostly well-sorted, quartz-rich sandstone with common carbonaceous and coal horizons (Gee and Legge, 1974). The non-marine sequence is thinner in southern regions, where it is usually known as the Faulkner Group. In the Hobart region the Faulkner Group consists mostly of micaceous siltstone, with mudstone and conglomerate also present (Leaman, 1976). In the Cygnet-Bruny Island region the non-marine sequence is absent, and the fossiliferous marine Hickman Formation directly overlies the Bundella Mudstone (Farmer, 1985).

The stratigraphy above this Sakmarian non-marine sequence is variable through the Tasmania Basin. In the Hobart region the Faulkner Group is overlain by the fossiliferous Artinskian Cascades Group, defined by Banks and Hale (1957). The Cascades Group includes, in stratigraphic order, the Rayner Sandstone, Nassau Siltstone, Berriedale Limestone and Grange Mudstone (Leaman, 1976). The Nassau Siltstone consists of fossiliferous grey-black siltstone, containing common fenestellids and trepostomes, of variable preservation, and brachiopods. Much of the bryozoan material collected from the Nassau Siltstone proved unsuitable for internal examination. Above the Nassau Siltstone are the Berriedale Limestone and Grange Mudstone which occur as lateral facies variations (Leaman, 1976). In the northern Hobart region the limestone facies dominates, but is not seen in southern Hobart regions, where the mudstone facies dominates (Leaman, 1976). The Berriedale Limestone is a richly fossiliferous unit of calcarenite and calcilutite that show pinch and swell effects (Banks and Hale, 1957). Pebbles are common within the limestone, and clastic content increases upwards (Leaman, 1976). Fossils include abundant brachiopods, bivalves and bryozoans, with a few crinoids and gastropods. Bryozoan faunas

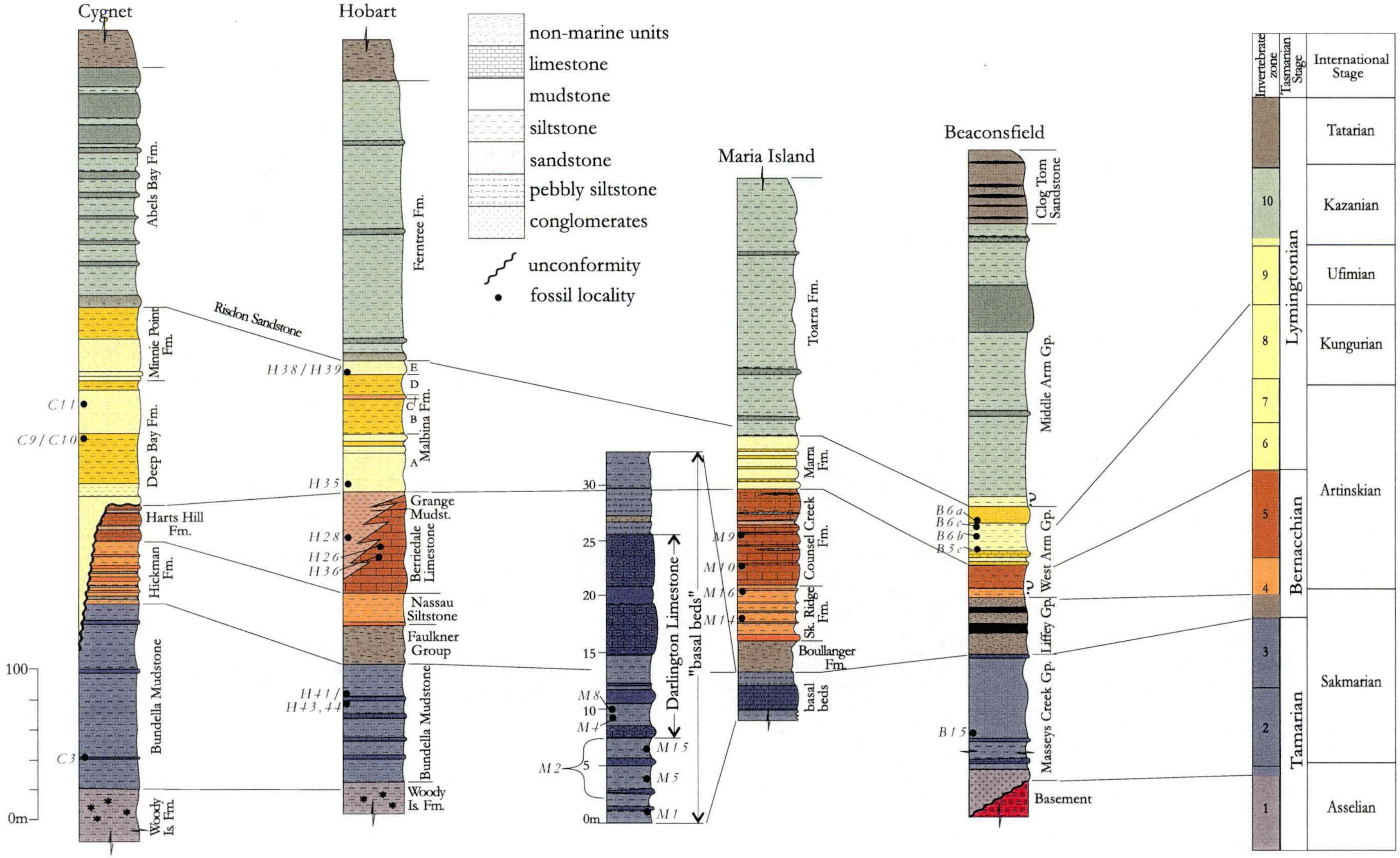


Figure 2.3 - Stratigraphic columns of key areas in the Tasmania Basin. International age correlation from Archbold and Dickins (1991). Tasmanian invertebrate zones and stages from Clarke and Farmer (1976). Refer to Appendix 5 for detailed fossil locality data.

are usually well-preserved, except where locally affected by dolerite intrusions of Jurassic age. A similar sequence is seen on Maria Island with the fossiliferous siltstone and sandstone of the Skipping Ridge Formation (Clarke and Baillie, 1984) conformably overlying the non-marine sequence. The Skipping Ridge Formation is followed conformably by the richly fossiliferous limestone of the Counsel Creek Formation (Clarke and Baillie, 1984). In lower parts of the Counsel Creek Formation, thick-bedded coarse-grained bioclastic limestone dominates, with thin interbedded shale. The limestone is rich in bryozoans, brachiopods, bivalves and crinoids and good bryozoan faunas were collected here. In upper parts, argillaceous limestone dominates with interbedded shale and coarse-grained beds (Clarke and Baillie, 1984).

Artinskian limestones are also present in the Cygnet region, where the marine Hickman Formation conformably overlies the Bundella Mudstone without the non-marine Faulkner Group of Hobart (Farmer, 1985). The Hickman Formation contains a variety of lithologies, including calcareous fossiliferous bioturbated siltstone and fine to coarse-grained sandstone with some unfossiliferous micaceous pyritic mudstone. On the whole the Hickman Formation is highly fossiliferous, containing a marine brachiopod-bivalve fauna, with dropstones present throughout (Farmer, 1985). Shallow water conditions are indicated by large quantities of broken and rolled shell material (Farmer, 1985). The Hickman Formation is followed by the richly fossiliferous limestone of the Harts Hill Formation. The Harts Hill Formation is typically of grey richly fossiliferous bioclastic limestone, with interbedded calcareous bioturbated sandy siltstone. Dropstones are small and are not common (Farmer, 1985). Unfortunately outcrop of this unit is poor, and is best known from drill core.

During this time in the Beaconsfield region in the north of the basin, limestone was not developed, and a depositional hiatus is seen. The only Artinskian rocks in the Beaconsfield region are the fossiliferous and non-fossiliferous siltstone of the lower West Arm Group.

In the late Artinskian to Ufimian, variously fossiliferous siltstone and sandstone were deposited in the southern Tasmania Basin. In the Hobart region siltstone and sandstone are broken into Members A to E of the Malbina Formation, defined by Banks and Read (1962). Member A is of pebbly fine to coarse sandstone and siltstone, with common Artinskian fossils throughout. Most fossils are in the base of sandstone units or associated with pebble bands within sandstone beds. Spiriferid brachiopods are common, and bryozoans locally abundant in some horizons. The siltstone beds are often carbonaceous and pyritic (Banks and Read, 1962). Members B and D are of thick siltstone with some pebbles and rare fossils. They are separated by Member C, a single bed of very pebbly sandstone that does not contain fossils. Member E is of pebbly fossiliferous fine grained sandstone and siltstone, of Ufimian to lowermost Kazanian age. Fossils become more abundant towards the top of the unit, and are well preserved with spines still attached to brachiopods, and fenestrate colonies preserved in life position. Unfortunately in many outcrops weathering has destroyed skeletal material and made many bryozoans unavailable for internal examination. Pebbles within the Malbina Formation are sub-angular to sub-rounded, and are usually concentrated in bands. Only a few pebbles disturb bedding beneath them and can be undoubtedly termed "erratics", or dropstones, fallen from floating icebergs (Banks and Read, 1962).

On Maria Island, rocks deposited during this time are predominantly sandstone with subordinate siltstone of the Artinskian to Ufimian Marra Formation (Clarke and Baillie, 1984). The Marra Formation is richly fossiliferous and is of shallow water origin (Clarke and Baillie, 1984). In the Cygnet region, the sandstone and siltstone of the Artinskian to Kungurian Deep Bay Formation rest unconformably on the Bundella Mudstone in the far south. Towards the northern Cygnet region, the Deep Bay Formation progressively oversteps the Hartman and Harts Hill Formations (Farmer, 1985). The Deep Bay Formation is fossiliferous for the most part and often has bryozoan-rich siltstone horizons. Overlying the Deep Bay Formation, and correlating with the upper part of the Malbina Formation is the fossiliferous sandstone and siltstone of the Ufimian Minnie Point Formation. Both the Deep Bay and Minnie Point Formations have pebbles scattered throughout. In the northern part of the Tasmania Basin around Beaconsfield the rocks deposited at this time are siltstone

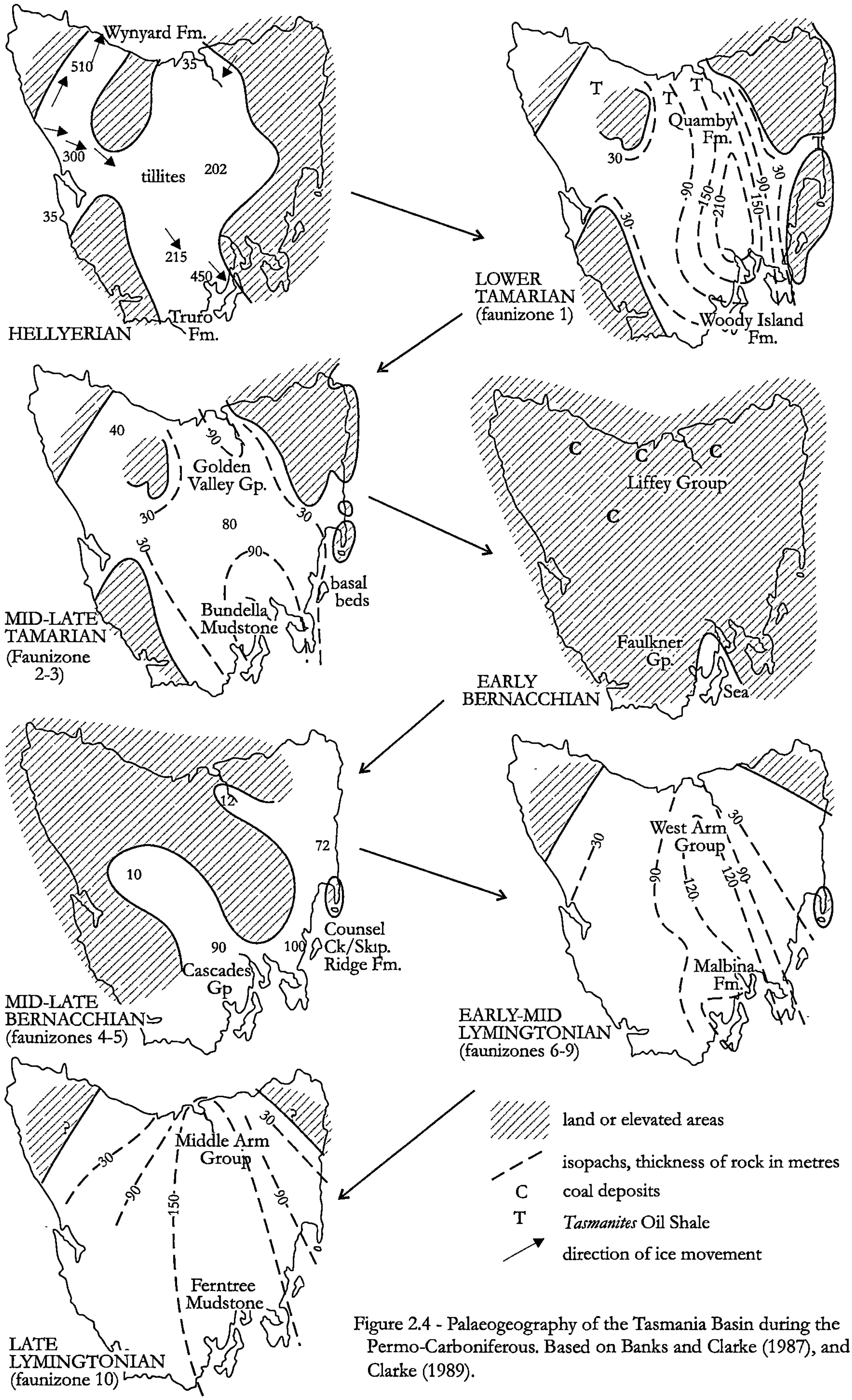


Figure 2.4 - Palaeogeography of the Tasmania Basin during the Permo-Carboniferous. Based on Banks and Clarke (1987), and Clarke (1989).

with minor sandstone of the upper part of the West Arm Group. These rocks are fossiliferous for the most part, and have yielded some useful bryozoan faunas.

Above these sequences of fossiliferous siltstone and sandstone, the rocks are largely unfossiliferous and monotonous. In the Hobart and Cygnet-Kingborough regions the prominent Risdon Sandstone overlies the Malbina and Minnie Point Formations respectively. The Risdon Sandstone is a graded sandstone bed usually a few metres thick, with marine fossils and pebbles in its base. Overlying the Risdon Sandstone are thick monotonous siltstones that are on the whole nonfossiliferous, though there are some marine fossil horizons. These monotonous siltstones are of probable Kazanian age and are known as the Fern Tree Formation (Hobart), Abels Bay Formation (Cygnet-Kingborough) and Toarra Formation (Maria Island). In the northern Tasmania Basin, sandstone is more common in the Middle Arm Group of the Beaconsfield region.

The uppermost Permian units in the Tasmania Basin are of non-marine origin, and are continuous into the Early Triassic. Non-marine sequences of carbonaceous sandstone and siltstone with variable coal horizons were deposited across the basin. They are represented by the Cygnet Coal Measures in the southern Tasmania Basin and the Clog Tom Sandstone in the Beaconsfield region. Spore analysis has shown a Permian age for the Cygnet Coal Measures (Davidson, 1969; Farmer, 1985). On Maria Island these uppermost Permian non-marine beds are apparently absent owing to a disconformity between the Lower and Upper Parmeener Supergroups (Clarke and Baillie, 1984).

2.2.2 - *Southern Sydney Basin*

The Sydney Basin is at the southern end of the large north-south trending Sydney-Gunnedah-Bowen Basin, with the Bowen Basin in the northern end. The rocks collected in this study are from the southernmost onshore region of the Sydney Basin. The southern Sydney Basin is of late Carboniferous to Triassic age, and comprises marine and non-marine sequences. The Permian sequence is predominantly marine with some shallow marine units having laterally equivalent non-marine sequences (Tye *et al.*, 1996). Spatial arrangement of lithostratigraphic units is shown in Figure 2.5. Distribution of Permian sediments of the southern Sydney Basin from Wasp Head to Ulladulla is illustrated in Figure 2.6.

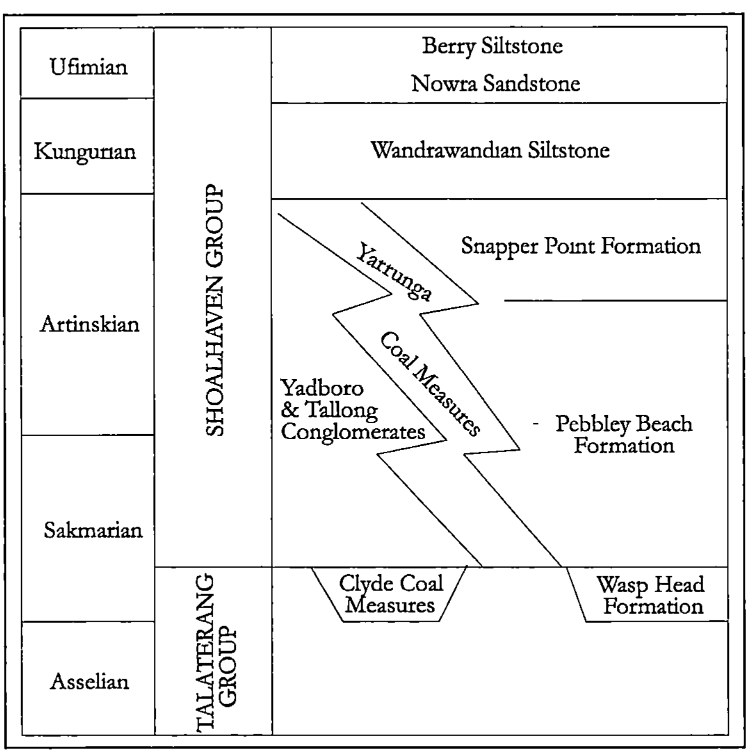


Figure 2.5 - Stratigraphy of the southern Sydney Basin Talaterang and Shoalhaven Groups stratigraphy from Tye *et al* (1996) and international stage correlation from Archbold and Dickins (1991).

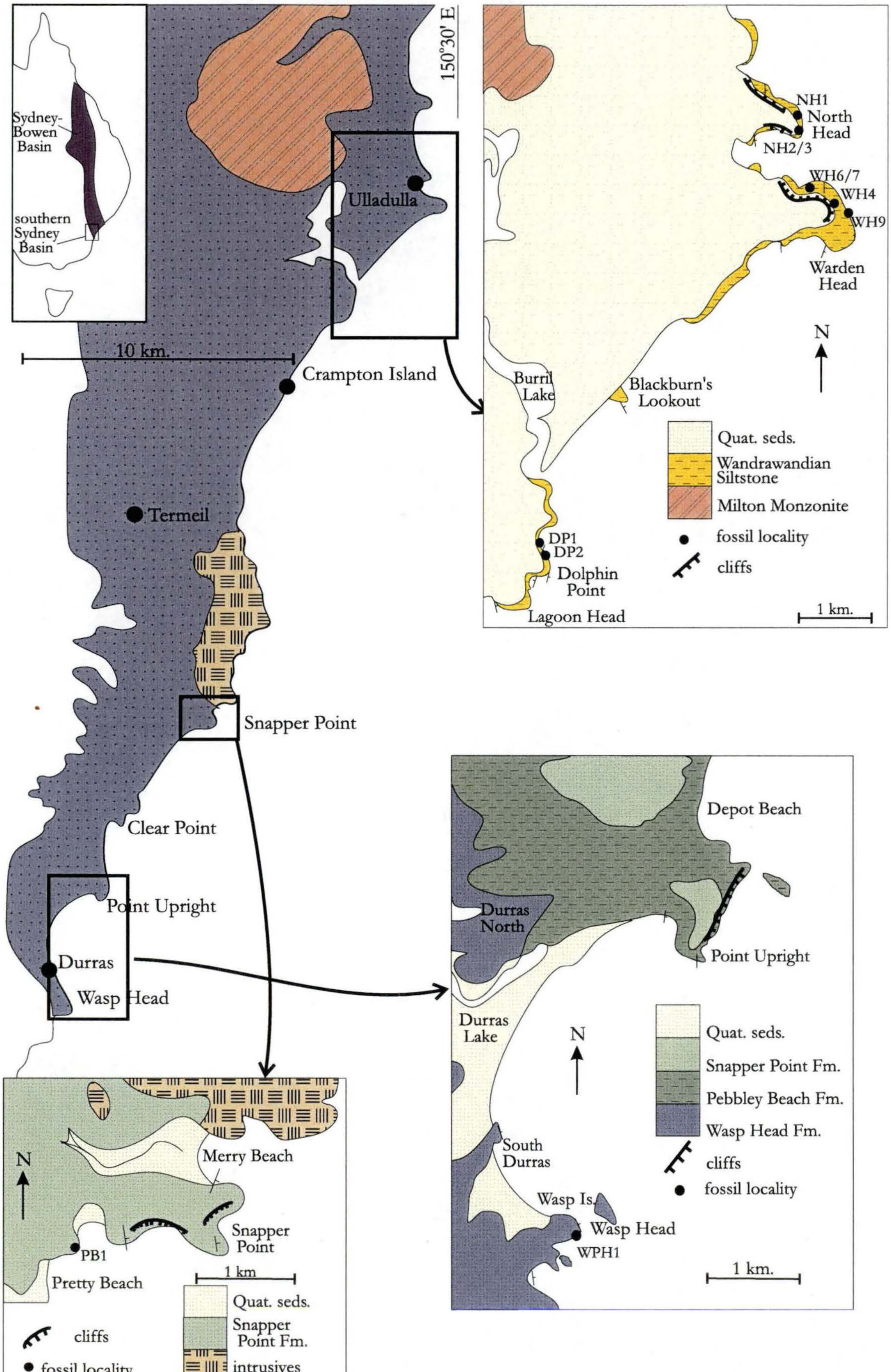


Figure 2.6 - Geology map of the southern Sydney Basin in the Wasp Head to Ulladulla Region. Geology after Tye *et al.* (1996) and Eyles *et al.* (1998), with fossil localities where bryozoans were collected during this study. For details of fossil localities see Appendix 5.

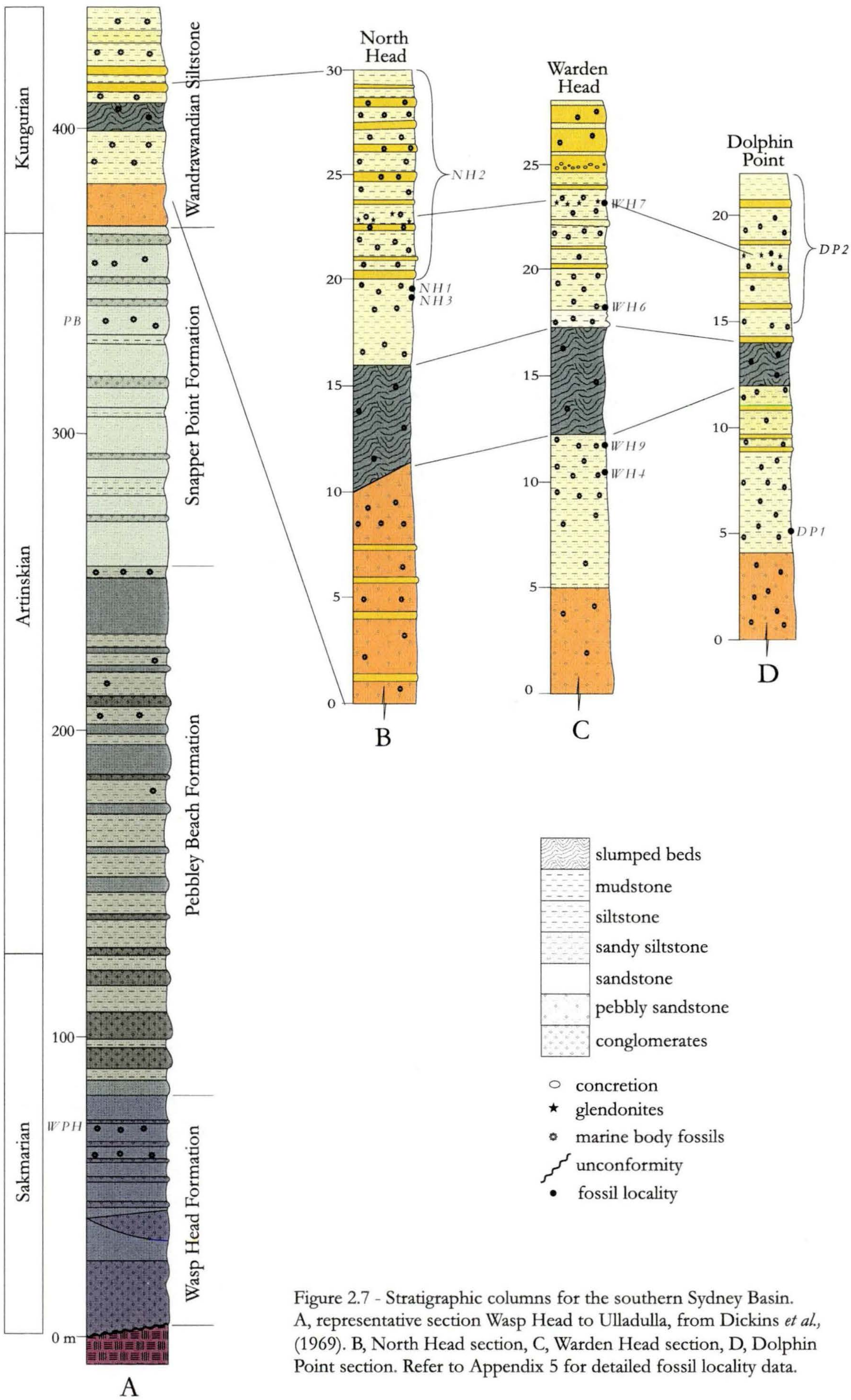


Figure 2.7 - Stratigraphic columns for the southern Sydney Basin. A, representative section Wasp Head to Ulladulla, from Dickins *et al.*, (1969). B, North Head section, C, Warden Head section, D, Dolphin Point section. Refer to Appendix 5 for detailed fossil locality data.

Permian sequences of the southern Sydney Basin belong to the Talaterang and Shoalhaven Groups. The lowermost beds are of Sakmarian age, and of marine and non-marine origin. The Clyde Coal Measures and Wasp Head Formation were developed in north-south oriented sub-basins (Tye *et al.*, 1996), and form the Talaterang Group. The Clyde Coal Measures unconformably overly Ordovician metasediments and were deposited in an onshore basin environment (Tye *et al.*, 1996). The marine Wasp Head Formation, which outcrops only at Wasp Head near Batemans Bay, was deposited east of the Clyde Coal Measure deposits and unconformably overlies Ordovician shale and chert (Tye *et al.*, 1996). Thick breccias form the base of the Wasp Head Formation, with fine to coarse-grained sandstone and conglomerate above (Eyles *et al.*, 1998). The formation represents two fining upwards sequences, with bioturbated and hummocky cross stratified sandstone dominating and many pebble clast layers (Eyles *et al.*, 1998). Brachiopods are common in horizons in the upper part of the formation, with bivalves and bryozoans less frequent. One large trepostome colony (*Stenopora spiculata*) was collected from the upper Wasp Head Formation, at Wasp Head. The breccia units have been interpreted as periglacial or cold climate debris flow deposits (Gostin, 1968).

Disconformably overlying the Talaterang Group is the marine and non-marine Shoalhaven Group. The lowermost Shoalhaven Group units are of lower to middle Sakmarian age. In the west are the coarse clastic alluvial facies of the Yadboro and Tallong Conglomerates (Tye *et al.*, 1996). East of these alluvial deposits are the Yarrunga Coal Measures which abruptly or gradationally overly the Tallong Conglomerate (Tye *et al.*, 1996). Further east again is the marine Pebbley Beach Formation which overlies the Wasp Head Formation. The Yadboro/Tallong Conglomerates, Yarrunga Coal Measures and the Pebbley Beach Formation represent a west to east alluvial to marine environment (Tye *et al.*, 1996).

The Pebbley Beach Formation is dominated by laminated or thin bedded mudstone to fine sandstone, with interbedded hummocky cross-stratified and bioturbated sandstone (Eyles *et al.*, 1998). Granule to pebble conglomerate is common in the lower part of the Pebbley Beach Formation, and occurs throughout the unit (Eyles *et al.*, 1998). The Pebbley Beach Formation is interpreted as a coastal deposit with glendonites and large rounded dropstones indicating a cold climate (Tye *et al.*, 1996). Fossils are sparse within the lower Pebbley Beach Formation, with common bivalves and sporadic brachiopods in the upper part (Runnegar, 1980).

Conformably overlying the Pebbley Beach Formation is the Snapper Point Formation. At this time the Yarrunga Coal Measures and Yadboro/Tallong Conglomerates were still being deposited in western areas. The Snapper Point Formation consists of interbedded fine to medium-grained sandstone, with some siltstone and wave-rippled conglomerate (Eyles *et al.*, 1998). The sandstone shows hummocky cross stratification and trough bedding, is often strongly bioturbated and is of shallow marine origin (Tye *et al.*, 1996). In the lowermost bed *Eurydesma* is abundant, but for the most part the lower part of the unit is unfossiliferous (Runnegar, 1980). Exposures at Snapper Point and Merry Beach have abundant bivalves in some horizons, but brachiopods and bryozoans are rare. One well preserved trepostome colony (*Stenopora* cf. *spiculata*) was collected from the Snapper Point Formation at Pretty Beach.

Conformably overlying the Snapper Point Formation are the fossiliferous siltstone and sandstone of the Wandrawandian Siltstone. The coastal exposures of this formation are of Kungurian age (Runnegar, 1980), and are highly fossiliferous throughout. The contact with the Snapper Point Formation is not seen in coastal exposures. The lowermost beds at Dolphin Point, Warden Head and North Head, Ulladulla, are composed of bioturbated pebbly sandstone with some conglomerate (see Figure 2.7). These lower beds are fossiliferous with abundant bryozoans and brachiopods, but fossils are often limited to particular horizons. These lower sandstone beds are overlain by fossiliferous siltstone and fine-grained sandstone. Siltstone predominates, and in its lower part is plastically deformed. The siltstone has very well preserved faunas of abundant bryozoans and brachiopods, with common bivalves and crinoids. Many brachiopods have spines still attached and are well preserved, and bryozoan colonies may be in life position. Beds thick with bryozoans often have fragmented colonies, and sediments have probably been transported down slope. In the upper parts of coastal exposures of the Wandrawandian Siltstone is a prominent glendonite horizon in fossiliferous siltstone, where bryozoans are abundant. Above the glendonite horizon at Warden Head fossiliferous siltstone gives way to bioturbated fine-grained sandstone and siltstone, with fossils less common.

Numerous bryozoan specimens were collected from the coastal exposures of the Wandrawandian Siltstone.

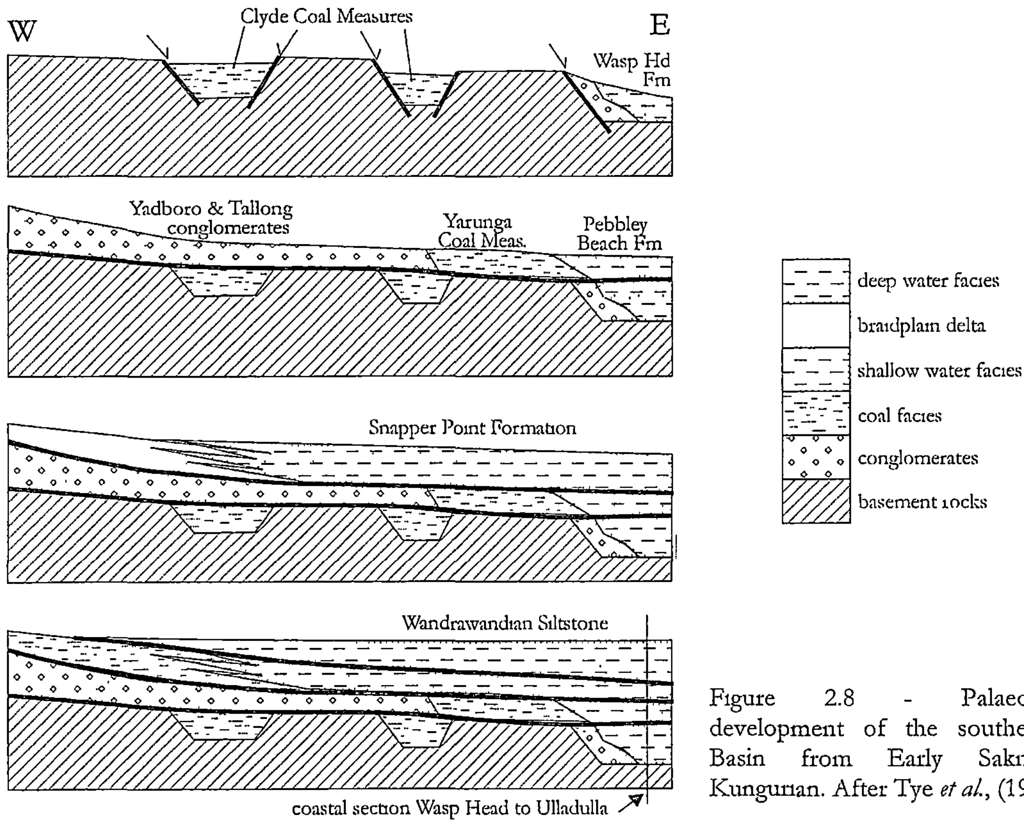


Figure 2.8 - Palaeogeographic development of the southern Sydney Basin from Early Sakmarian to Kungurian. After Tye *et al.*, (1996)

2.3 - <u>BIOSTRATIGRAPHY</u>

2.3.1 - *Introduction*

Eastern Australian Permian basins have a well constrained biostratigraphy, that is based largely upon palynofloras, brachiopods and bivalves. Bryozoans have not played a major role in age determination or correlation of the stratigraphic units, and where they have been used, their accuracy must be questioned. Past taxonomic studies of bryozoans in eastern Australia have not been as rigorous as current taxonomic methods allow. As a result there is a problem of separate taxa being grouped together, and being used erroneously in biostratigraphic comparisons. This does not mean that bryozoans are not a useful biostratigraphic tool, but instead that they must be studied in detail like any other fossil group, before their true worth in biostratigraphic analysis can be realized.

Permian floras and faunas are well developed and recorded in the eastern Australian stratigraphy as a whole, however there is variation across the region, and some local areas may be less developed than others.

Following biostratigraphic faunizones developed in the Bowen Basin by Dickins *et al.*, (1964) faunal zones for the Sydney Basin were constructed by Runnegar (1969). The understanding of the biostratigraphy of the Sydney Basin is quite well developed with Runnegar and McClung (1975) improving Bowen-Sydney Basin correlation with the development of faunal zones based on species assemblages. These species assemblages were based largely on the brachiopod genus *Tomiopsis*, which is common throughout the Permian of eastern Australia and Tasmania. The more recent faunal zones of Briggs (1998) are based largely on the common genus *Echinalosia*, and again use faunal assemblages rather than discrete marker species. As constructed by Briggs (1998), the echinolosiid zones are correlated well with the tomiopsid zones of Runnegar and McClung (1975). However in comparing the Tasmania Basin fauna, problems arise in the three way comparison of the faunizones of Clarke and Banks (1975), Runnegar and McClung (1975) and Briggs (1998). The faunizones of Briggs (1998) and Runnegar and McClung (1975) were not constructed for the Tasmania Basin and the time ranges of *Echinalosia* and *Tomiopsis* species do not correlate as they do in the Sydney-Bowen Basin. As mentioned by Briggs (1998) the taxonomy of Tasmanian brachiopods needs confirmation, as some newly described species may be listed under other species names. While the zonation of Briggs (1998) is important, it is given less emphasis here because of the importance of Tasmanian sequences to this study. Further work with all zonation schemes should, however, help elucidate some of the differences in first and last appearances of individual species in each basin.

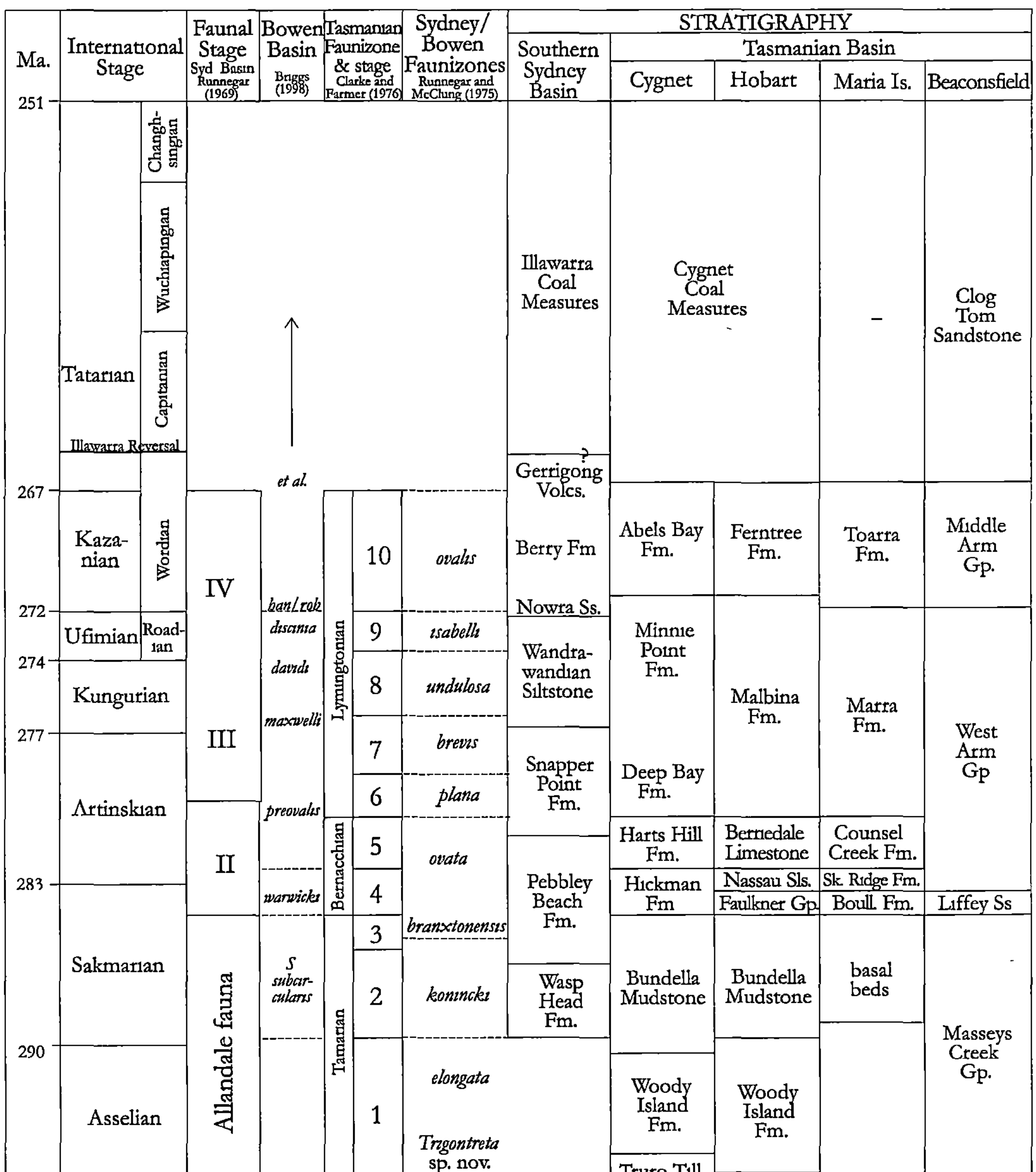


Figure 2.9 - Biostratigraphic correlation chart for the southern Sydney and Tasmania Basins. Based on Archbold and Dickins (1991) Tasmanian faunizones and stratigraphy with consideration to Clarke and Banks (1975), Farmer (1985), Banks and Clarke (1987) and Clarke (1987; 1989, 1990), and comparison to faunal distribution and Sydney Basin faunizone placement given by Archbold and Dickins (1991). Southern Sydney Basin stratigraphy based on Runnegar (1980) and Archbold and Dickins (1991) North American and Chinese stages from Wardlaw (1999).

The correlation of Briggs (1998) faunal zones with International Stages and absolute ages is questioned, following recent work on the age of the Illawarra Reversal in the basal Tatarian. Whilst the position of the Illawarra Reversal is not precisely known in eastern Australia, despite being named from local magnetostratigraphy, it is probably between the Berry Siltstone/Gerrigong Volcanics and the Illawarra Coal Measures (Menning, *pers. comm.*, 1999). The suggested age for the Illawarra Reversal is 265 Ma. (Menning, 1995) and is supported by studies on North American Permian sequences (Wardlaw *et al.*, 1998). Briggs (1998) places the Tatarian slightly higher in the eastern Australian sequence than other workers, and the absolute age boundaries used are in contradiction with the recent work on the Illawarra Reversal.

2.3.2 - *Tasmania Basin*

The faunas of the Lower Parmeener Supergroup are rich and contain palynofloras, brachiopods, molluscs, bryozoans, crinoids, and limited corals and foraminifera. Marine invertebrates are present throughout much of the Permian and have enabled a local biostratigraphic framework to be erected (Clarke and Banks, 1975; Clarke and Farmer, 1976). However the faunas are less diverse than sequences in eastern Australia and make correlation with world standard stages difficult (Clarke, 1989). The faunas can be compared with eastern Australian faunas, as shown by Clarke and Banks (1975) and others. With understanding of the relationships between Tasmanian and eastern Australian faunas, correlation with world standard stages can be better understood. However attempts in comparison of Australian faunas to a world standard are not helped by their geographic separation from type sequences.

In the correlation chart, Figure 2.9, the faunal comparisons suggested by Clarke and Banks (1975), Clarke and Farmer (1976) and Clarke (1990) in constructing Tasmanian biostratigraphic faunizones and stages, are followed. This has produced some differences to Archbold and Dickins' (1991) placement of the older Tasmanian units.

Tasmanian biostratigraphy.

The lowermost Parmeener Supergroup sequences do not contain marine faunas, and their age correlation is based on microfloral elements. The basal tillites show a microflora (Stage I) indicative of a Late Carboniferous age (Truswell, 1978). However the usefulness of this microflora in age determination is questioned by Foster and Waterhouse (1988).

Clarke and Banks (1975) constructed ten informal faunizones based on marine invertebrates. Clarke and Farmer (1976) went on to propose formally the Rekunian Series for late Palaeozoic marine units in Tasmania. The Rekunian Series is broken into four stages, the Hellyerian, Tamarian, Bernacchian and Lymingtonian, and are correlated with the ten faunizones of Clarke and Banks (1975).

The Hellyerian Stage has its reference section in the lower to middle parts of the Wynyard Tillite of Hellyer Gorge, and encompasses the total range of the Stage I microflora in Tasmania (Clarke and Farmer, 1976). The overlying units with marine invertebrate faunas form the basis for the Tamarian to Lymingtonian Stages.

The Tamarian Stage has its reference section in the Tamar valley, in the Masseys Creek Group, and encompasses faunizones 1 to 3 of Clarke and Banks (1975). The Tamarian Stage is characterised by an abundance of *Trigonotreta stokesi*, *Eurydesma*, *Deltopecten*, *Keeneia* and *Pseudosyrinx*. Faunizone 1 is characterized by the presence of *Strophalosia concentrica* (*Strophalosia* sp. of Clarke and Banks (1975), formally described by Clarke (1990)), and is found in the Woody Island Formation, the upper parts of the basal tillites and, in southern areas, the lowermost parts of the Bundella Mudstone. The basal beds of Maria Island do not contain *Strophalosia concentrica*, but have *Strophalosia subcircularis* associated with abundant *Trigonotreta stokesi*, *Deltopecten illawarensis* and *Eurydesma cordatum*. This assemblage is typical of Faunizone 2 of Clarke and Banks (1975), which also includes *Tomiopsis konincki*. *E. cordatum* and *S. subcircularis* are particularly abundant in Faunizone 2, with the former restricted to this zone. *E. cordatum* is abundant in the Darlington Limestone on Maria Island, along with *E.*

hobartense, but is absent in the overlying Spirifer Zone (see Figure 2.3). Faunizone 3 is recognized by the appearance of *Sulciplica stutchburii*, abundant *Pyramus laevis*, with abundant *Trigonotreta stokesi* and *Pseudosyrinx allandalensis* persisting from lower Tamarian beds. Faunas typical of faunizone 2 are present through most of the Bundella Mudstone with *Sulciplica stutchburii* only appearing in uppermost Bundella Mudstone indicating Faunizone 3 of Clarke and Banks (1975). The Tamarian is the equivalent of the Sydney Basin Allandale Fauna and has Stage 2 and 3a microfloras (Clarke and Farmer, 1976).

Overlying the lower marine sequences that form the basis of the Hellyerian and Tamarian is the freshwater Faulkner or Liffey Group. The freshwater beds yield microfloras of Stage 3b age (Truswell, 1978). The resumption of marine sequences above the freshwater beds shows a distinct change in marine faunas, and whilst *Eurydesma hobartense*, *Deltopecten illawarensis*, *Pseudosyrinx* and *Keeneia* persist from the Tamarian, they are not as abundant as in the lower marine sequence.

The Bernacchian Stage has its reference section on Maria Island, and includes the freshwater Boullanger Formation, and the marine Skipping Ridge and Counsel Creek Formations. The Bernacchian Stage encompasses faunizones 4 and 5 of Clarke and Banks (1975). Faunizone 4, which includes the freshwater beds, is characterized by the appearance of *Tomiopsis ovata, Echinalosia preovalis* and *Sulciplica tasmaniensis* in the base of the Skipping Ridge Formation. While there is a gap in the reference section, with the freshwater Boullanger Formation, in the Cygnet region where freshwater units are absent, the Hickman Formation shows an early Bernacchian fauna of *T. ovata, S. stutchburii, E. preovalis* and *Eurydesma hobartense*, and conformably overlies the Tamarian Bundella Mudstone (Farmer, 1985).

Faunizone 5 shows an increased faunal diversity and coincides with predominantly carbonate deposition in the Tasmania basin. The abundance of the *Terrakea pollex* group, *Taeniothaerus subquadratus*, *Sulciplica tasmaniensis* and the rugose coral *Euryphyllum* typify Faunizone 5. Both *T. pollex* and *T. subquadratus* are restricted to this zone. In the Counsel Creek Formation, *Tomiopsis ovata* is common in lower parts, but is replaced in the upper part of the unit by *T. plana* and *T. ingelarensis* (Clarke and Baillie, 1984). The Bernacchian Stage is the equivalent of Fauna I (faunizone 4) and II (faunizone 5) of the Bowen Basin, and Fauna II of the Sydney Basin (Clarke and Farmer, 1976). The Bernacchian Stage in Tasmania is represented by the Hickman and Harts Hill Formations of Cygnet, the Cascades Group of the Hobart region, and the Skipping Ridge and Counsel Creek Formations of Maria Island.

The uppermost stage of the Rekunian Series, the Lymingtonian, is a long ranging stage, and includes all of the marine units above the Bernacchian limestones. These units include the Malbina and Fern Tree Formations of the Hobart region, the Deep Bay, Minnie Point and Abels Bay Formations of Cygnet, the Marra and Toarra Formations of Maria Island and the upper West Arm and Middle Arm Groups of Beaconsfield (Clarke and Banks, 1975). Permian non-marine sequences above these units are not included in the Rekunian Series. The reference section for the Lymingtonian Stage is the siltstone and sandstone in the Cygnet area (Clarke and Farmer, 1976), now known as the Deep Bay, Minnie Point and Abels Bay Formations (Farmer, 1985). Faunizone 6 is marked by the appearance of *Tomiopsis magna, Terrakea concava* and *T. brachythaera*. Older species remain, with *Megadesmus gryphoides* common, and *Sulciplica stutchburii* abundant in Deep Bay sections, after having its appearance in the Tamarian.

Marking the base of faunizone 7 in the Deep Bay section is *Sulciplica transversa* and *Pseudosyrinx ulladullensis*. The disappearance of *Eurydesma, Tomiopsis plana* and *T. brevis* mark the top of faunizone 7, with *T. magna* and *T. undulosa* the remaining representatives of this genus. *Tomiopsis undulosa* appears in the fauna, along with *Fusispirifer avicula,* before the disappearance of *Eurydesma* (Farmer, 1985). *Promytilus mytiliformis* and *Fusispirifer malbinensis* are restricted to faunizones 7 and 8 and *Terrakea concava* is abundant and disappears from the fauna at the time *Tomiopsis isabelli* appears, marking the base of faunizone 9.

Tomiopsis magna is the abundant species through faunizone 9, with *T. isabelli* abundant in faunizone 10. In the upper part of the Deep Bay section there is a distinct change in the faunal assemblage. *Echinalosia ovalis* and *Megadesmus grandis* appear and occur in abundance, along with abundant *F. avicula*, *Etheripecten lemusculus* and *Terrakea brachythaera.* This is a distinct fauna that can be recognized in Malbina E, where fossils are abundant. In overlying units, such as the Fern Tree Formation and Middle Arm Group, fossils are sparse but distinct and indicate the same faunal association as that of the uppermost Deep Bay section and Unit E of the Malbina Formation. Clarke (1987) concluded a Kazanian age for this uppermost marine assemblage of the Tasmania Basin. Clarke and Banks (1975) correlate Faunizones 6 to 9 with the Ulladulla or Fauna III of Runnegar (1969), and Faunizone 10 to Fauna IV of the Sydney Basin.

2.3.3 - *Southern Sydney Basin*

The faunas of the Sydney Basin are diverse and abundant for the most part, in particular in the Allandale Formation, Fenestella Shales and Mulbring Formation. In the southern Sydney Basin where the lithostratigraphy differs from the main part of the basin, good faunas can be found in parts of the Wasp Head, Pebbley Beach and Snapper Point Formations, with abundant faunas in the Wandrawandian Siltstone. Dickins *et al.* (1969) following the stratigraphic work of Gostin (1968) began biostratigraphic correlation of the southern Sydney Basin sequences with Bowen Basin faunal zones of Dickins *et al.* (1964). The development of recognizable faunal zones for the Sydney Basin by Runnegar (1969) greatly helped in the understanding and correlation of the local fauna with that of the Bowen Basin. Further work by Runnegar (1980) in the southern Sydney Basin identified the brachiopod zones of Runnegar and McClung (1975) within these sequences. However as the southern Sydney Basin has many nearshore unfossiliferous intervals, in particular the Pebbly Beach and Snapper Point Formations, continuous fossiliferous sequences, and therefore continuous data on age relationships, are not available (Runnegar, 1980).

Southern Sydney Basin biostratigraphy.

The lowermost unit of the southern Sydney Basin, the Wasp Head Formation, has a distinct fauna that is dispersed over several fossiliferous horizons. The fauna contains elements of the Allandale Fauna of Runnegar (1969), in particular *Eurydesma cordatum*, *Megadesmus globosa* and *Tomiopsis konicki.* Runnegar (1980) recorded all these species as continuing into the base of the Pebbley Beach Formation. The Wasp Head Formation fauna is of the *konicki* zone of Runnegar and McClung (1975), and is comparable to the Bundella Mudstone of Tasmania.

The overlying Pebbley Beach Formation has a limited brachiopod fauna but faunas collected from drill core (Runnegar, 1980) show *Tomiopsis ovata* above the base of the unit along with *Eurydesma cordatum* and *Sulciplica stutchburii.* The *branxtonensis* faunal zone of Runnegar and McClung (1975) is not recognized in the southern Sydney Basin, and neither has it been recognized in the Tasmania Basin. In the Pebbley Beach Formation *T. ovata* appears as *T. konicki* disappears from the sequence and *T. branxtonensis* is not recorded. However the base of the *ovata* zone is taken along with the first appearance of *T. ovata* (Runnegar, 1980). The remainder of the Pebbley Beach Formation does not show any incoming species of biostratigraphic significance and the top of the formation remains within the *ovata* zone; but *Eurydesma cordatum,* which is abundant in lower units (Faunizone 2) in Tasmania, is recorded in the upper Pebbley Beach Formation (Runnegar, 1980).

The basal faunal horizons of the Snapper Point Formation show no significant change in species from the Pebbley Beach Formation. Again a faunal zone of Runnegar and McClung (1975) is probably missing, with *T. plana* not found, and *T. brevis* appearing in the upper half of the unit (Runnegar, 1980). Bivalves are common in the Snapper Point Formation, with abundant *Eurydesma hobartense* in basal units, with *Megadesmus nobilissimus*, *Pyramus concentricus* and *Myonia* sp. common in upper faunal horizons. Brachiopods are less common, with *T. brevis* in upper parts, and the appearance of *T. magna* only in the uppermost part of the unit (Runnegar, 1980). The appearance of *T. magna* and *T. brevis* allows correlation of these faunas with those of lower to Middle Malbina, and the Deep Bay Formation of Tasmania.

The overlying Wandrawandian Siltstone has a diverse and abundant fauna, with the appearance of *T. undulosa*, *T. isabelli* and *Sulciplica transversa* above the base in outcrops in the Ulladulla region. Brachiopods are more diverse than bivalves in the bulk of the Wandrawandian Siltstone. The coastal section about Ulladulla reveals lower Wandrawandian Siltstone beds, with middle and upper parts inland. Bryozoans collected in this study come from the lower Wandrawandian Siltstone in coastal outcrop. Associated bivalve faunas include *Eurydesma hobartense*, *Deltopecten limaeformis*, and *Myonia corrugata*, with common brachiopods *T. undulosa*, *T. isabelli*, *T. ingelarensis*, *Echinalosia preovalis* and *E. maxwelli*. The presence of *Eurydesma hobartense*, *Echinalosia preovalis* and *T. undulosa* followed by *T. isabelli*, indicate similar age relationships to faunizones 7 and 8 of the Tasmania Basin. In upper Wandrawandian Siltstone beds *Eurydesma hobartense* and *Echinalosia preovalis* are absent, with the latter replaced by *E. minima*. *Sulciplica transversa* is common, along with *T. ingelarensis* and *T. angulata*.

Above the Wandrawandian Siltstone, in the Nowra Sandstone, is the appearance of *Echinalosia ovalis*, signaling the base of the *ovalis* Zone of Runnegar and McClung (1975) and its similar age to faunizone 10 of Clarke and Banks (1975).

2.4 - SUMMARY

The geology of both the southern Sydney and Tasmania Basins shows glacial influence with glendonites and dropstones seen at a number of stratigraphic horizons. Environments are marine and non-marine, with marine sequences usually reflecting shallow water environments that are stratigraphically and/or laterally interbedded with non-marine units.

Both basins are fossiliferous, although some units may have a sparse fossiliferous record. The biostratigraphy of both basins is well studied, but there are problems arising with differences in first and last appearances of marker species in the two basins. Despite this difference the sequences of the southern Sydney and Tasmania Basins are able to be compared. Correlation will only improve with further study and the inclusion of faunal groups such as the Bryozoa, that to date have been under utilized.

CHAPTER THREE

EASTERN AUSTRALIAN BRYOZOAN FAUNAS

3.1 - INTRODUCTION

Past work on the Permian Bryozoa of Tasmania has been limited. Early collections by Darwin formed the basis for the first descriptions by Lonsdale in 1844 in Darwin's "Geological Observations on Volcanic Islands" and later in an appendix to Strzelecki (1845). These collections were from Mt Wellington, Mt Dromedary, Spring Hill and the southern parts of Van Diemen's Land.

These early reports contained the first descriptions by William Lonsdale in Darwin (1844), of *Stenopora tasmaniensis*, *S. ovata*, *S. informis*, *Fenestella ampla* (now *Parapolypora ampla*), *Fenestella internata* (now *Polyporella internata*), *F. fossula* and *Hemitrypa sexangula*. Later works by Crockford (1941a; 1944b; 1943) gave further descriptions and neotypes of these species, as holotypes have been lost, and others also occurring in the Permian of Tasmania and eastern Australia. Smith *et al.* (in prep.) discuss further the probable collection site of Darwin's specimens and describe neotypes collected from Lower Sandy Bay, Hobart. Most published collections are from the Hobart region and are not representative of regional or stratigraphic faunas, and the biostratigraphic importance of the Tasmanian Bryozoa is not promoted. *Stenopora crinita* is the only species to be used in Tasmania Basin biostratigraphy so far, where it indicates (along with other taxa) the base of faunizone four in Tasmania, or Fauna II of the Sydney Basin (Clarke and Banks, 1975).

Eastern Australian Permian bryozoan faunas have been a little more thoroughly studied, with Crockford publishing many papers on the faunas of New South Wales and Queensland (Crockford 1941a; 1941b; 1943; 1945; 1946; 1951), after an early study by Laseron (1918). The faunas of the Bowen Basin, Queensland, were presented by Wass (1968) and are better preserved than those of New South Wales. All the above studies have essentially only examined the fenestellids externally. These faunas are fairly diverse, but are mostly preserved as moulds, a factor which will limit their future biostratigraphic use by internal examination, particularly New South Wales faunas. It is shown here that external examination is not sufficient in most cases. If future work on fossil bryozoans is not based on internal examination the taxonomic, biogeographic and biostratigraphic importance of Australian faunas will not be realised.

The abundance and relative stratigraphic continuity of bryozoans throughout the Tasmanian and eastern Australian Permian section makes them an ideal candidate for biostratigraphic analysis, if well preserved faunas can be examined. Currently the stratigraphic relationships between western and eastern Australia and Tasmania are based largely upon brachiopods and palynological data. Complete bryozoan studies in all regions can only aid in the accuracy of faunal relationships between different sections.

A major hindrance to the use of Bryozoa in biostratigraphy in eastern Australia, has been the lack of internal examination. The Fenestellidae is a widely diverse group, and many genera exist, where previously many were grouped into *Fenestella* or *Polypora*. Morozova (1970) divided *Fenestella* into a number of separate genera, by showing that internal features were of generic importance. In doing so it was also shown that some skeletal forms and genera are ancient or derived, and are recognisable worldwide. Morozova and Lisitsyn (1996) repeated this exercise with a revision of the genus *Polypora*, and again revealed a number of separate genera based on internal features.

A good example of the value of internal examination is the case of *Parapolypora ampla* Lonsdale. Previous workers, either bryozoan specialist or non-specialist, have tended to place all coarse polyporids with many rows and flat branches within the species "*ampla*". This study has shown there are in fact five species within this group in Tasmania alone, that are in two separate genera. These separate species are useful biostratigraphic tools, where previously "*ampla*" was thought to exist for most of the Permian in eastern Australia and not to be of biostratigraphic importance.

All specimens are housed in the University of Tasmania School of Earth Sciences collection, with reference numbers prefixed by UTGD. Character definitions and description outlines are given in Appendices One to Four.

3.2 - SYSTEMATIC DESCRIPTIONS.

3.2.1 - *Order FENESTRATA.*

Systematics based on Goryunova (1996) and Boardman *et al.* (1983). The procedures and qualitative terms used in the following descriptions are shown in full in Appendix One.

Phylum BRYOZOA Ehrenberg, 1831
Class STENOLAEMATA Borg, 1926
Order FENESTRATA Elias and Condra, 1957
Family FENESTELLIDAE King, 1849
Subfamily FENESTELLINAE King, 1849

Genus *Laxifenestella* Morozova 1974

Type species - *Fenestella sarytshevae* Shulga-Nesterenko, 1951; Lower Carboniferous, Namurian stage; Russian Platform.

Diagnosis - Colonies are fenestrate with straight to weakly bending branches. Zooecia in two rows, tetragonal-pentagonal at mid chamber level. Superior and inferior hemisepta developed. Carinal wall slightly curved, carina with monoserial usually small and frequent nodes (after Morozova, 1974).

Laxifenestella exserta (Laseron, 1918)
Plate 1; Table 3.1

Fenestella exserta LASERON (1918), p. 195; pl. VII, figs. 1, 2, pl. XII.
Fenestella cavea LASERON (1918), p. 197; pls. XV, XVI.
Fenestrellina exserta (Laseron) CROCKFORD (1941a), p. 403.

Diagnosis - Zoarium of intermediate robustness, mesh spacing close to intermediate. Branches are straight with 9 to 10 branches in 10 mm. Branches are of intermediate robustness and are commonly crushed by collapse of internal chamber walls. Autozooecia are in two rows on the branches with a third row only inserted at the point of, or shortly before, bifurcation.

Dissepiments are of intermediate width, emplacement regular and perpendicular to the branches. Fenestrules are large, ovate to rectangular, with 5 to 5.5 in 10 mm. On the front surface of the branch is a single, narrow carina. A monoserial row of small circular nodes is present along the midline of the carina. Obverse stylets are small and irregular, and evenly spread across the obverse surface. Reverse microstylets are also small and evenly spread across the reverse surface. Reverse macrostylets are absent.

Autozooecial apertures are circular and of uniform lower end intermediate size. Apertures open upwards on the flattened branch surface, and indent the fenestrules. A thin well developed peristome is present. Terminal diaphragms commonly close the apertures at the surface. Autozooecial apertures are uniformly spaced along the branch, with usually 5 to 6 between dissepiment centres.

Autozooecial chambers are large and biserially emplaced. The axial wall trace is straight slightly zigzag. Chamber shape is highly uniform, and is tetragonal pentagonal at mid chamber level. Three dimensionally reconstructed chamber shape a rectangular box. A long well developed vestibule is present. Superior and inferior hemisepta are well developed, but do not appear to be fused.

Lateral wall budding angle is variable (mean 18°) and reverse wall budding angle relatively constant (mean 53°). The internal granular skeletal layer is thin and continuous. Lamellar skeletal layer is of intermediate thickness, but may be astogenetically thickened.

Laxifenestella exserta	X	SD	Min	Max	N	CV
distance between branch centres	0.920	0 143	0 64	1.33	68	15.527
branches in 10 mm.	9.5	0.5	9	10	3	5 263
width branch	0.552	0.048	0 45	0 65	64	8 751
width dissepiments	0.459	0.068	0 3	0.59	63	14.835
fenestrules in 10 mm.	5.125	0 25	5	5.5	4	4.878
fenestrule length	1.345	0.172	1 06	1.875	64	12 767
fenestrule width	0.421	0.109	0 26	0 75	72	26 007
apertures between dissepiment centres	5.114	0.435	4	6	70	8 515
zooecial apertures in 5 mm.	14.333	0.577	14	15	3	4 028
aperture width	0.119	0 008	0 1	0.14	86	6.687
apertural spacing down branch	0.397	0.032	0.31	0.48	97	7 960
apertural spacing across branch	0.382	0.037	0.305	0.51	88	9 703
apertural spacing between branches	0.547	0.107	0.365	0.78	72	19 527
width apertural peristome	0 013	0 003	0.0075	0.02	68	24.716
width of carina	0.028	0 009	0 02	0 04	30	30.166
diameter nodes	0.030	0 008	0.02	0.05	24	27.260
spacing of nodes down branch	0.395	0 078	0.3	0.66	20	19.677
diameter obverse stylets	0.008	0 002	0 005	0.01	78	24.206
spacing obverse stylets	0.017	0 005	0.01	0.03	73	27.156
diameter reverse microstylets	0.007	0 002	0 005	0 013	90	28.785
spacing reverse microstylets	0.020	0 006	0.01	0.04	88	31.388
thickness reverse wall granular layer	0.015	0.004	0.008	0.025	45	28 101
thickness lateral wall granular layer	0.015	0.003	0.01	0.025	53	22.639
thickness frontal wall laminated layer	0.190	0.044	0 145	0.32	19	23 001
thickness reverse wall laminated layer	0.318	0.067	0 21	0.48	36	21 034
chamber length	0 375	0.025	0 32	0.44	52	6 710
chamber depth	0 223	0.026	0 2	0.28	19	11 774
maximum chamber width	0 188	0.018	0.15	0.225	39	9 413
minimum chamber width	0.149	0.021	0.11	0.185	36	13 851
hemisepta distance to prox. cham. edge	0.219	0.032	0.16	0.28	12	14.748
vestibule length	0.163	0 027	0.12	0.22	13	16 678
budding angle reverse chamber wall	53 250	5.893	46	62	16	11 068
budding angle lateral chamber wall	18 444	6.227	7	26	9	33.762
branch thickness	0.808	0 105	0 64	0.96	21	13 006

Table 3.1 - Summary measurements for *Laxifenestella exserta* (Laseron) N = number of measurements, X = mean, SD = standard deviation, CV = coefficient of variation, Min. = minimum value measured, Max = maximum value measured. All measurements in millimetres.

Description - External features - Zoarium of intermediate robustness, form of the colony is unknown, but fragments form undulating to flat expansions. Mesh spacing is close to intermediate, with some astogenetic thickening observed, thickening branches and dissepiments. Mesh is generally uniform, but within fragments there may be variability associated with branching creating a locally open mesh.

Branches are usually straight but appear gently sinuous on the reverse surface. Branch spacing is close and regular, with 9 to 10 branches in 10 mm. Branches are of intermediate robustness and are wide but commonly crushed. Branch thickness appears constant down their length, but upon close examination branches widen gradually towards bifurcation point. Branch surface texture granular, profile flat. Autozooecia are in two rows on the branches with a third row only inserted at the point of, or shortly before, bifurcation.

Dissepiments are of intermediate width and are usually slightly narrower than the branches.

Dissepiment width and emplacement is regular and perpendicular to the branches. Dissepiments are thickened slightly at their junction with the branches throughout most of their depth, but are thin and rod-like at the obverse surface. They do not usually have zooecia positioned opposite them as a result of this thinness. Dissepiments are slightly recessed from both the obverse and reverse surfaces.

Fenestrules are large, elongate oval to rectangular and elongated proximodistally, with 5 to 5.5 in 10 mm. Fenestrule length is consistent, but width is slightly variable. Fenestrule shape is more commonly ovate at the reverse surface, and width often appears greater than at obverse surface. Fenestrule length is consistently greater than width, with a width to length ratio of 3:10, and fenestrule width to branch width ratio of 3:4.

On the front surface of the branch is a single, narrow carina that has a thin well developed granular core. The carina is low and only raises the relief of the obverse surface slightly in the midline of the branch. The carina does not appear to be effected by astogeny, and has a monoserial row of small nodes along its midline. Nodes are circular to slightly elongate proximodistally, and are of intermediate spacing.

Obverse stylets are small and irregular, but are evenly spread across the obverse surface, at close spacing. Reverse microstylets are also small and of irregular size, and are evenly closely spaced across the reverse surface, though spacing is slightly more open than obverse stylets. Reverse macrostylets are absent.

Autozooecial apertures are circular and of uniform intermediate size. Apertures open upwards on the flattened branch surface, and indent the fenestrules without being inclined towards them. A thin well developed peristome is present. Apertural stylets do not appear clearly developed, however obverse stylets come close to the peristomal edge, and may either obscure apertural stylet presence or fulfill their role. Terminal diaphragms commonly close the apertures at the surface, and appear to be spread across the zoarium.

Autozooecial apertures are uniformly spaced along the branch, with 4.5 to 6 between dissepiment centres. Ratio of mean spacing down to across branch approximately 1:1, spacing down (and across) to between branches approximately 3:4. Spacing between branches is somewhat variable according to width of fenestrules.

Heterozooecia are occasionally seen, reflected at the surface by circular features disto-lateral to the zooecial apertures. Heterozooecia are circular in shape and large, and are intermittently developed.

Internal features - Branches are thick and circular to ovate in cross section, with elongation perpendicular to the obverse-reverse surfaces. Ratio of mean branch width to thickness 7:10, and variable, though branch width is not seen greater than thickness.

Autozooecial chambers are of intermediate to large size and are biserially emplaced. Axial wall trace is slightly zigzag near the obverse surface, becoming straight towards the obverse surface. Chamber shape is highly uniform, and is tetragonal pentagonal at the reverse surface and mid chamber levels, becoming rounded tetragonal at the obverse surface. Chamber elongation is oriented proximodistally. Mean ratio of chamber minimum to maximum width 4:5, maximum width to depth 4:5, and depth to length ratio 3:5. Apertures are located at the abaxial distal end of the chamber on a long vestibule. Three dimensionally reconstructed chamber shape a rectangular box.

Superior and inferior hemisepta are well developed, but do not appear to be fused. The superior hemisepta are located distally about the base of the vestibule, with inferior hemisepta located slightly proximal to them at the chamber base.

Lateral wall budding angle is variable with a range of 7° to 26° (mean 18°). Reverse wall budding angle is regular, with a range of 46° to 62° (mean 53°).

Internal granular skeletal layer thin and continuous between reverse and lateral walls, carina, obverse stylets, and is seen to be continuous between branches. Lamellar skeletal layer is of intermediate thickness, but may be astogenetically thickened, increasing branch width and fenestrule length, and also branch thickness. Astogenetic thickening of the lamellar skeletal layer also causes some rounding of the obverse surface.

Discussion - Laseron (1918) described this species from Branxton NSW (Late Artinskian Fenestella Shales) along with *Fenestella cavea*, which was included in *F. exserta* by Crockford (1941a). Crockford (1941a) gave the differences between these species as one of weathering. However the material collected by Laseron for the original descriptions also shows a variation in number of apertures per fenestrule, with 4 to 5 in *exserta* and 6 in *cavea*. This study has shown a continuous range in apertural number with 4.5 to 6 apertures between dissepiment centres. Specimens with 6 apertures have longer fenestrules than those with 4 to 5, and the same distance between apertural centres. As this range is a continuum all specimens are grouped within *L. exserta* as defined by Crockford (1941a).

The specimens from Ulladulla, New South Wales match closely the descriptions given by Laseron (1918) and Crockford (1941a) for *F. exserta* except for a slightly higher mean apertural spacing. The range of measurements still covers that given in Crockford (1941a), and it is believed the difference is from regional faunal variation, as all other features are identical.

Material - Fragments were available for internal examination from the Kungurian Wandrawandian Siltstone at Dolphin Point (UTGD 12726-33), Warden Head (UTGD 127534-37), Ulladulla.

Range - Late Artinskian to Kungurian.

Laxifenestella oviferosa n. sp.
Plate 2; Table 3.2

Holotype - UTGD UTGD 127538 - Kungurian Wandrawandian Siltstone, Dolphin Point, Ulladulla, NSW.

Diagnosis - The zoarium is of intermediate robustness, with fragments forming flat to gently undulating expansions. Mesh spacing is close and regular, with 10 to 13 branches and 8 fenestrules in 10 mm. Branches are wide, thick and straight, and of intermediate robustness, but sometimes crushed. Branch spacing is close and regular. Autozooecia are in two rows. Dissepiments are short and of intermediate width, and are regularly spaced. Fenestrules are large and elongate elliptical to subrectangular.

Autozooecial apertures are circular and of intermediate size. Apertures open parallel to the plane of the obverse surface, and do not usually indent the fenestrules. Aperture spacing is regular with 3 to 4 apertures between dissepiment centres. Thin complete peristomes surround each autozooecial aperture. Apertural stylets are absent. Rounded heterozooecia are present, placed proximo-distally to many apertures and are always larger than autozooecial apertures. The obverse surface of the branch has a single thin low carina down the midline of the branch, with small nodes of intermediate spacing. Obverse and reverse microstylets are irregularly closely spaced across each surface of the branches and dissepiments. Macrostylets are absent.

Autozooecial living chambers are of intermediate size with biserial emplacement and a straight to gently zigzag axial wall trace. Chamber outline is rectangular at mid chamber level. Apertures are located distal abaxially on a long vestibule. Both superior and inferior hemisepta are present, with inferior hemiseptum located in the reverse wall, and superior hemiseptum surrounding the base of the vestibule on the obverse wall. Reconstructed three dimensional chamber form a rectangular box. Reverse wall budding angle high, lateral wall budding angle is about 14°. Granular skeletal layer thin, lamellar layer of intermediate thickness.

Description - External features - Colony form unknown, fragments of intermediate robustness, and forming flat to gently undulating expansions. Mesh spacing is close and regular, with 10 to 13 branches and 8 fenestrules in 10 mm.

Branches are of intermediate robustness, sometimes crushed after preservation in poorly sorted sandstone. Branch spacing is close and regular. Branches are wide with a straight proximodistal trace and gently angular surface profile. Branches are narrow after bifurcation and widen gradually to point of next bifurcation, in expanding portions of the zoarium. In areas where bifurcation is less frequent branches have a regular width. There are two rows of zooecia on the obverse surface of the branch, with row number increasing to three within one to two fenestrules of bifurcation.

Laxifenestella oviferosa n. sp.	X	SD	Min	Max	N	CV
distance between branch centres	0.768	0.121	0 565	1	38	15 796
branches in 10 mm.	12.125	1.436	10	13	4	11 844
width branch	0.479	0 042	0.4	0.58	25	8 692
width dissepiments	0.284	0 036	0 2	0.375	39	12 803
fenestrules in 10 mm.	7 833	0.258	7 5	8	6	3 296
fenestrule length	0.958	0.171	0 09	1 08	35	17 870
fenestrule width	0 331	0 049	0.24	0 41	30	14 813
apertures between dissepiment centres	3.607	0 421	3	4	42	11 672
aperture width	0 123	0 010	0.105	0 14	32	8.474
apertural spacing down branch	0 371	0 033	0.31	0 47	42	8 899
apertural spacing across branch	0.355	0 038	0 28	0 46	39	10 596
apertural spacing between branches	0.493	0.055	0 34	0.57	29	11 219
width apertural peristome	0 015	0.005	0.01	0 025	21	31 110
width of carina	0.027	0 014	0 015	0.05	5	51 719
diameter nodes	0 046	0.013	0.02	0.08	29	28 307
spacing of nodes down branch	0.351	0.051	0.28	0.48	29	14 647
diameter obverse stylets	0 008	0.002	0 005	0.011	32	25.967
spacing obverse stylets	0.019	0.004	0.01	0.025	40	21 737
diameter reverse microstylets	0.007	0.002	0 005	0.01	47	24 791
spacing reverse microstylets	0.018	0.005	0 01	0 03	38	26 516
thickness reverse wall granular layer	0.013	0.003	0.01	0 02	12	23 651
thickness lateral wall granular layer	0.011	0.002	0 01	0.015	16	15 896
thickness frontal wall laminated layer	0.173	0.024	0.14	0.2	6	13 974
thickness reverse wall laminated layer	0.215	0 061	0 12	0 31	15	28 173
chamber length	0.360	0.016	0 34	0.38	4	4 536
chamber depth	0.170	0.014	0 16	0.18	2	8 319
maximum chamber width	0.172	0 022	0.14	0 21	11	12 542
minimum chamber width	0.124	0.017	0 1	0.16	9	13.983
vestibule length	0.147	0.015	0 13	0 16	3	10 415
budding angle lateral chamber wall	14		14	14	1	
branch thickness	0 512	0.035	0.475	0 56	5	6 857
brood chamber diameter	0 153	0 016	0 13	0.18	7	10 491

Table 3.2 - Summary measurements for *Laxifenestella oviferosa* n sp Abbreviations as for Table 3 1, all measurements in millimetres.

Dissepiments are short and of intermediate width relative to the branches. Dissepiment dimensions are constant, and are regularly spaced perpendicular to the branches. Dissepiment surfaces are flush to slightly recessed from obverse and reverse surfaces. Dissepiments are straight and widen at their junction with the branch. Dissepiments do not carry extra zooecia and rows of zooecia on the branch are straight and do not bend onto dissepiments.

Fenestrules are regularly large and elongate oval to subrectangular. Fenestrules increase in size towards the reverse surface, through rounding of the branches and dissepiments, but their shape is not altered. Fenestrules are narrower than the branches, except on occasions in association with bifurcation. Ratio of mean fenestrule width to branch width 7:10, and fenestrule width to length 1:3.

Autozooecial apertures are circular and of intermediate size, with 3 to 4 apertures between dissepiment centres. Apertures open parallel to the plane of the obverse surface, and do not usually indent the fenestrules. Aperture spacing is regular down, across and between branches because of straightness of branches, zooecial rows, and the regularity of the fenestrate mesh. Ratio of mean aperture spacing down to across the branch is almost 1:1, down to between branches 3:4, and across to between branches 3:4. There are 3 to 4 apertures between dissepiment centres. Thin complete peristomes surround each autozooecial aperture. Apertural stylets are not developed. Rounded heterozooecia are seen between many apertures, and at the surface appear as large round apertures with terminal diaphragms present. Heterozooecial apertures are large and always larger than autozooecial apertures. Heterozooecia are usually placed proximo adaxially to autozooecial apertures. On internal examination the heterozooecia are round and sit above the autozooecial chamber living chamber proximally to the vestibule. Where heterozooecia are present autozooecial spacing is slightly wider than usual.

The obverse surface of the branch has a single thin low carina down the midline of the branch. Along the carina is a single row of small round to oval nodes that are of intermediate spacing. Small obverse microstylets are irregularly closely spaced across the obverse surface of the branches and dissepiments. Reverse microstylets are of the same size and spacing as obverse microstylets and again irregularly cover both reverse branch and dissepiment surfaces. Macrostylets are absent.

Internal features - Branches are thick and rounded to slightly ovate in cross section, with their long axis perpendicular to the reverse obverse surfaces.

Autozooecial living chambers are of intermediate size with biserial emplacement and a straight to gently zigzag axial wall trace. Chamber outline is gently pentagonal to tetragonal near the reverse wall, tetragonal in mid chamber level and rounded tetragonal near the obverse surface, with rounding located distally from the influence of the vestibule. Apertures are located distal abaxially on a long vestibule. Both superior and inferior hemisepta are present, with inferior hemisepta located in the reverse wall, and superior hemisepta surrounding the base of the vestibule on the obverse wall. Chamber dimensions are regular with greatest dimension parallel to the obverse reverse surfaces. Ratio of mean minimum to maximum chamber width 3:4, maximum width to depth approximately 1:1, and depth to length approximately 1:2. Reconstructed three dimensional chamber form a rectangular box.

Reverse wall budding angle is difficult to measure in available specimens, but is high, lateral wall budding angle is about 14°. The granular skeletal layer is thin throughout, and is continuous between branches, chambers, apertures and nodes. The skeletal lamellar layer is of intermediate thickness and is thicker on the reverse wall than the obverse.

Discussion - *Laxifenestella oviferosa* n. sp. is similar to *L. exserta* Laseron, but differs in having smaller fenestrules and more closely spaced and smaller autozooecia. Both species occur together in the Wandrawandian Siltstone. The prominent heterozooecia make the species distinctive. *L. oviferosa* n. sp. is only recorded from the Kungurian Wandrawandian Siltstone at Dolphin Point, Ulladulla, New South Wales.

Types - UTGD 127538, holotype; UTGD 127539-40, paratypes.

Etymology - Named for the prominent heterozooecia.

Material - Three specimens were available for internal examination from the Wandrawandian Siltstone (UTGD 127538-40).

Range - Kungurian.

Genus *Levifenestella* Miller 1961

Type species - *Levifenestella maevae* Miller (1961); Lower Carboniferous Limestone Group, Tournaisian Stage, Easky, Ireland.

Diagnosis - Zoarium fenestrate, with two rows of zooecia on the obverse surface of the branch. Obverse surface of branch has an irregularly interrupted narrow threadlike carina, that is without nodes. Age range Carboniferous-Permian (after Miller, 1961).

Levifenestella altacarinata (Crockford, 1941)
Plate 3; Table 3.3

Fenestrellina altacarinata CROCKFORD (1941b), p. 507, pl. XXI, fig. 4.

Diagnosis - Zoarium is of intermediate robustness, overall colony form unknown, but meshes form undulating expansions. Branches are wide, thick, closely spaced and straight to slightly sinuous, with 9 to 12 branches in 10 mm. Autozooecia are in two rows, with increase to three rows only at point of bifurcation. Dissepiments are of uniform intermediate width and regularly placed. Fenestrules are regularly large and oval to subrectangular, with 5.5 to 6 in 10mm.

Along the obverse surface of the branch is a single strong well developed carina of intermediate width. The carina produces a distinct angularity to the obverse surface, and is accentuated by the sloping branch sides. The carina does not carry nodes. Obverse and reverse stylets are of small to intermediate size and irregularly widely spaced across each surface. Autozooecial apertures are uniformly large and circular to elliptical, and are inclined towards the fenestrules but do not indent them. Apertures are regularly spaced along the branch with usually four apertures between dissepiment centres. A thin complete peristome surrounds each aperture, with small indistinct apertural stylets developed.

Autozooecial chambers are large and biserially emplaced with a zigzag axial wall trace. Chamber outline is pentagonal at mid chamber level, with three dimensional reconstructed form a narrow pentagonal box. Apertures are located adaxial distally to the chamber, on a distinct vestibule of intermediate length. Chamber length and depth are greater than maximum width. Hemisepta and heterozooecia are not seen.

Chamber lateral budding angles are slightly variable (mean 35°), as is the reverse wall budding angle (mean 64°). Internal granular skeleton is thin and distinct, lamellar skeletal layer is thick and well developed.

Levifenestella altacarinata	X	SD	Min	Max	N	CV
branches in 10 mm.	10.364	1.027	9	12	11	9 909
distance between branch centres	0 991	0.115	0.76	1 24	40	11 596
width branch	0 611	0 059	0.51	0 78	30	9 682
width dissepiments	0.531	0 062	0.44	0.73	47	11 699
fenestrules in 10 mm	5 875	0.224	5.5	6	16	3 806
fenestrule length	1 272	0.106	1.01	1 54	41	8.336
fenestrule width	0.414	0 074	0 28	0.58	28	17 845
apertures between dissepiment centres	4 133	0.290	4	5	45	7 016
aperture width	0 220	0.021	0.18	0.255	24	9 379
aperture length	0.297	0.025	0 26	0.35	36	8 471
apertural spacing down branch	0 447	0.030	0.38	0.52	47	6 673
apertural spacing across branch	0.404	0.036	0.34	0 48	27	9 014
apertural spacing between branches	0.632	0 123	0 42	0.88	19	19 468
width apertural peristome	0 016	0.004	0.010	0.025	36	24.303
width of carina	0.144	0.034	0.08	0 2	30	23 768
diameter obverse stylets	0.012	0.003	0.008	0 02	50	22.489
spacing obverse stylets	0.077	0.024	0.025	0.13	45	30.599
diameter reverse microstylets	0.011	0 003	0 005	0.02	56	23.847
spacing reverse microstylets	0 078	0.025	0 03	0 125	42	31.394
thickness reverse wall granular layer	0.011	0 003	0 005	0.02	37	25 317
thickness lateral wall granular layer	0.014	0.003	0.01	0.02	31	23 630
thickness frontal wall laminated layer	0.287	0.070	0.17	0 38	27	24.334
thickness reverse wall laminated layer	0 358	0.108	0.18	0 5	33	30.217
chamber length	0 415	0.035	0.36	0 5	30	8 473
chamber depth	0 336	0.030	0 28	0.36	10	8.895
maximum chamber width	0 228	0.030	0 16	0 3	45	13 006
minimum chamber width	0.144	0.035	0 06	0.2	41	24 685
vestibule length	0.124	0.015	0.1	0 14	5	12 230
budding angle reverse chamber wall	63 667	7.248	48	75	27	11.385
budding angle lateral chamber wall	34.846	6.854	27	49	13	19 669
branch thickness	0.931	0.123	0.7	1.1	18	13 241

Table 3.3 - Summary measurements for *Levifenestella altacarinata* (Crockford). Abbreviations as for Table 3.1, all measurements in millimetres.

Description - External features - Zoarium robustness is intermediate, with overall colony form unknown, but meshes form undulating expansions. Mesh spacing is close and regular. Branches are wide, thick and straight to slightly sinuous and are commonly crushed. Branch spacing is close and regular with 9 to 12 branches in 10 mm. The surface profile is angular, with angularity increased by a large carina created by the junction of the sloping branch sides. Autozooecia are in two rows, with increase to three rows only at point of bifurcation.

Dissepiments are of uniform intermediate width, and are slightly but consistently narrower than the branches. Dissepiments are short to intermediate and regularly placed perpendicular to the branches. Dissepiments widen slightly at their junction with the branches, and are slightly recessed from both the obverse and reverse surfaces. Dissepiment recession from the obverse surface is such that dissepiments do not effect aperture placement and orientation. Fenestrules are regularly large and oval to subrectangular, and elongated proximodistally, with 5.5 to 6 in 10 mm. There is little variation in fenestrule shape between obverse and reverse surfaces, with shape more oval only at extreme reverse surface. Ratio of mean fenestrule width to length 1:3, and fenestrule to branch width approximately 2:3.

Autozooecial apertures are uniformly large and circular to elliptical, and open parallel to the sloping branch sides. Apertures are inclined towards the fenestrules but do not indent them. Apertures are regularly spaced along the branch with usually four apertures between dissepiment centres. Ratio of mean aperture spacing down to across branch approximately 11:10, down to between branches 7:10, and across to between branches approximately 3:5. A thin complete peristome surrounds each aperture, with small indistinct apertural stylets developed. Apertural stylets are widely spaced with about 15 surrounding each aperture.

Along the obverse surface of the branch is a single strong high carina of intermediate width. The carina is well developed and straight to slightly sinuous and is a prominent feature of the obverse surface. The carina does not carry nodes. Obverse stylets are of intermediate size and are irregularly widely spaced across the obverse surface, with no discernible difference in spacing between branch and dissepiment surfaces. Many short longitudinal striae are present in the reverse wall. Reverse microstylets are of a similar size and spacing to the obverse stylets, but appearance is effected by depth in wall, and are best seen at the extreme reverse surface.

Internal features - Branches are thick and more or less circular in cross section, with the addition of the carina increasing branch thickness, and creating a distinct angularity to the obverse surface. Ratio of mean branch width to thickness 2:3.

Autozooecial chambers are large with orientation of elongation proximodistal. Chambers are biserially emplaced with a zigzag axial wall trace throughout. Chamber outline is pentagonal near the reverse surface and at mid chamber level, becoming pentagonal-tetragonal near the obverse surface. Chamber shape is uniform, with three dimensional reconstructed form a narrow pentagonal box. Apertures are located adaxial distally to the chamber and are connected by a distinct vestibule of intermediate length. Chamber length and depth are greater than maximum width, and dimensions are relatively constant except for minimum width, which varies according to the depth of measurement in the chamber. Ratio of mean minimum to maximum width 5:8, maximum width to depth approximately 2:3, and depth to length 4:5. Hemisepta and heterozooecia are not seen.

Chamber lateral budding angles are slightly variable with a range of 27° to 49° (mean 35°). Reverse wall budding angle is also variable with a range of 48° to 75° (mean 64°). Internal granular skeleton is thin and distinct with continuity seen between chambers, peristomes, carina and branches. The granular core to the carina is usually slightly wavy in cross section. Lamellar skeletal layer is thick and well developed, and of approximately equal thickness on both obverse and reverse surfaces.

Discussion - In the Sydney Basin *Levifenestella altacarinata* is recorded from the Kungurian Wandrawandian Siltstone. Also known from the Late Artinskian Fenestella Shales, Branxton Crockford (1941b).

Material - Ten specimens were examined from the Wandrawandian Siltstone at Warden Head (UTGD 127541-45) and North Head (UTGD 127546-50), Ulladulla.
Range - Late Artinskian to Kungurian.

Levifenestella expansa (Crockford 1946)
Plate 4; Table 3.4

Fenestrellina expansa CROCKFORD (1946); p.129, text-fig 11.
Fenestella expansa (Crockford) CROCKFORD (1951), Table 4, p. 110.
Levifenestella expansa (Crockford), MILLER (1961), p. 149, Table 1.
Levifenestella ? expansa (Crockford), WASS (1968), p. 45, pl. 12, fig. 3.
Diagnosis - Zoarium robust, forming an undulating expansion. Mesh spacing close to intermediate and irregular. Zooecia are in two rows, with a third row only inserted immediately before bifurcation. Branches are robust, wide and constant with a sinuous proximodistal trace with apertures opening upwards on flat branch sides. Branches are thick and ovate to rounded in cross section. Branch spacing is close and regular. Dissepiments are of intermediate to wide width and are short. Fenestrules are large and variably ovate, elliptical or subrectangular. The single carina is prominent and sinuous, and creates an angularity to the surface profile. Nodes are absent. Apertures are large and circular to slightly ovate. Apertures open upwards parallel to the plane of the obverse surface. A thin complete peristome is present with abundant small apertural stylets. Autozooecial chambers are large, with chamber outline pentagonal to tetragonal at mid chamber level. Axial trace is gently zigzag to sinuous. Vestibule is very long and of consistent length. Three dimensional reconstructed form a rectangular box.

Hemisepta are not developed. Reverse wall budding angle constant and high, lateral wall budding angle also constant.

Description - External features - Zoarium robust, forming an undulating expansion. Mesh spacing close to intermediate, but irregular, due to sinuous branches. Complete zoaria are not seen, but are likely quite large from the size of fragments seen. Autozooecia are in two rows, with a third only inserted immediately before bifurcation.

Branches are robust, wide and regular with a sinuous proximodistal trace and a flattened surface profile, which apertures opening upwards on flat branch sides, and central portion angular from the carina. Branch spacing is close and regular, with 7 to 9 in 10 mm. Branch thickening before and thinning after bifurcation is only slight. Dissepiments are of intermediate to wide width, and are commonly wider than the branches. Dissepiments are very short as a result of branches bending towards each other at dissepiment point. Dissepiment width length and emplacement irregular. Dissepiments are not recessed from the reverse surface, and on the obverse surface are recessed to the level of the zooecial apertures. Fenestrules are variably ovate, elliptical to subrectangular, and elongated proximodistally. Fenestrules are large and variable in size within one colony, with 2 to 5 in 10 mm. Ratio of mean fenestrule width to branch width is almost 1:1, and fenestrule width to length 2:7, but are variable according to fenestrule size.

Apertures are very large and generally circular to slightly ovate. Apertures are regularly spaced with 10 to 12 in 5 mm., and 5 to 12 between dissepiment centres, with the variation depending on fenestrule size. Spacing of apertures is variable between branches, owing to the sinuous branches. Ratio of mean apertural spacing down to across branch 9:10, and down to between about 5:9, varying between 1:1 and 4:1. Apertures open upwards parallel to the plane of the obverse surface. A thin complete peristome is present bearing apertural stylets. Apertural stylets are small, with about 42 surrounding each aperture.

A single wide carina is present on the midline of the front surface of the branch. The carina is prominent and sinuous, and creates an angularity to the central surface profile. Discrete nodes are absent. However, along the midline of the carina are very low, narrow and extremely elongated structures. Their length is irregular, but they are commonly found along the very top of the carina. Obverse stylets are of small to intermediate size and are irregularly spaced across the obverse surface. Reverse microstylets are small and irregularly closely spaced across the reverse surface. Macrostylets are absent.

Levifenestella expansa	X	SD	Min	Max	N	CV
branches in 10 mm	7.5	0 569	7	9	18	7 584
distance between branch centres	1.276	0 241	0 94	1.76	15	18 913
width branch	0 731	0.095	0 55	0.98	56	13.023
width dissepiments	0 711	0.215	0.4125	1 2	42	30 257
fenestrules in 10 mm.	3.323	0.678	2	5	24	20 391
fenestrule length	2.423	0 910	1.1	4 95	51	37 566
fenestrule width	0.687	0.194	0 375	1.375	56	28 288
zooecial apertures in 5 mm	11 350	0.671	10	12	30	5 916
apertures between dissepiment centres	7.326	1.564	5	12	46	21.352
aperture length	0.268	0 021	0.213	0 3	53	7 911
aperture width	0.238	0.023	0.2	0 28	31	9 608
apertural spacing down branch	0 444	0 038	0 375	0.525	54	8.593
apertural spacing across branch	0.491	0 043	0.4	0.56	40	8.863
apertural spacing between branches	0.774	0.234	0.42	1 6	27	30 286
width of carina	0.164	0 036	0 08	0.2	10	22 242
diameter obverse stylets	0.011	0 002	0.008	0 015	14	23.205
spacing obverse stylets	0.035	0.013	0 02	0 07	12	36 570
width apertural peristome	0 017	0.004	0 0125	0.025	21	20.771
number of apertural stylets	42 5	3.937	34	48	14	9.264
diameter apertural stylets	0 010	0.003	0.005	0 015	27	28 549
diameter reverse microstylets	0 012	0.004	0.008	0.02	20	30 288
spacing reverse microstylets	0.020	0.005	0 015	0 03	20	23 257
thickness frontal wall laminated layer	0 362	0.064	0 25	0 47	13	17 715
thickness reverse wall laminated layer	0.334	0.062	0.24	0 44	20	18 739
thickness reverse wall granular layer	0 008	0.002	0.005	0 01	20	25.801
thickness lateral wall granular layer	0 015	0.004	0 01	0 025	24	30 665
chamber length	0.408	0 037	0 34	0.48	40	9 183
chamber depth	0.340	0.030	0 28	0 38	8	8 893
maximum chamber width	0 283	0.042	0 21	0 38	40	14 967
minimum chamber width	0.193	0.056	0 09	0.3	40	28 910
vestibule length	0 249	0 031	0 22	0 32	9	12 293
budding angle reverse chamber wall	69.933	6 573	60	84	15	9.400
budding angle lateral chamber wall	26.5	3 162	22	30	8	11 933
branch thickness	1.101	0.090	0 96	1.24	16	8 162

Table 3.4 - Summary measurements for *Levifenestella expansa* (Crockford). Abbreviations as for Table 3 1, all measurements in millimetres.

<u>Internal features</u> - The branches are ovate to rounded in cross section, and elongated in an obverse-reverse direction. Branches are regularly thick with the ratio of mean branch width to thickness approximately 3:5.

Autozooecial chambers are large with elongation oriented proximodistally. The axial wall trace is gently zigzag near the reverse surface, and sinuous to nearly straight at mid chamber level to near the obverse surface. Autozooecial chamber shape is uniform with outline pentagonal near the reverse surface, pentagonal to tetragonal at mid chamber level and fabiform to elliptical near the obverse surface. The aperture is located at distal abaxial end of living chamber, connected by a well developed vestibule. Vestibule is very long and of consistent length. Chamber dimensions are regular, with ratio of mean maximum to minimum width approximately 3:2, maximum width to depth 5:6, and depth to length also 5:6. Three dimensional reconstructed form a pentagonal rectangular box.

Hemisepta are not developed in this species. Reverse wall budding angle constant, with a range of 60° to 84° (mean 70°), lateral wall budding angle also constant, range 22° to 30° (mean 27°).

Skeletal granular layer is thin with continuity only seen between chamber walls, longitudinal striae and carina. Skeletal lamellar layer thick, on both reverse and frontal walls.

Material - Two fragments of Tasmanian material were examined internally (UTGD 127129, Sakmarian Bundella Mudstone, Hobart; UTGD 127130, lower Artinskian Skipping Ridge Formation, Maria Island). Four additional fragments, preserved as moulds, were examined externally (UTGD 127131, Bundella Mudstone and UTGD 127132 Berriedale Limestone Hobart; UTGD 127133-34, lower Artinskian Counsel Creek Formation, Maria Island). *L. expansa* was first recorded from the Artinskian Lakes Creek Beds (Crockford, 1946), and has also been recorded from the Kungurian ? Oxtrack Formation in the Bowen Basin (Wass, 1968).
Range - Sakmarian to Artinskian - ? Kungurian.

Genus *Minilya* Crockford 1944

Type species - *Minilya duplaris* Crockford 1944b; Noonkanbah Series, Mt Anderson; Lower Permian; Western Australia.
Diagnosis - Branches have two rows of alternating zooecia, with a slight median carina. Nodes are small and in two rows on the carina, placed so that one node is lateral to each zooecial aperture. Zooecia are sub-triangular in outline (After Crockford, 1944b).

Minilya bituberculata (Crockford, 1941)
Plate 5; Table 3.5

Fenestrellina bituberculata CROCKFORD (1941b), p 506, text-fig 2B.
Minilya bituberculata (Crockford) CROCKFORD (1944b), p. 173.
Diagnosis - The zoarium is of intermediate robustness, with mesh spacing close to intermediate and slightly irregular. Branches are wide, thick and robust with a straight proximodistal trace and rounded surface profile. There are 10 to 11 branches in 10 mm. Autozooecia are in two rows with a third only inserted near point of bifurcation.

Dissepiments are narrow and are regularly emplaced perpendicular to the branches. Fenestrules are regularly large and elongate oval, elongated proximodistally, with 5.5 in 10 mm. The front surface of the branch is rounded and does not contain a distinct carina. Along the central portion of the branch is a double row of nodes. Obverse stylets are present, of small to intermediate size and irregularly spaced. Reverse microstylets are also small to intermediate and irregularly spaced. Reverse macrostylets are absent. Autozooecial apertures are regularly large and oval, with axis of elongation inclined disto-abaxially. Apertures open inclined towards the fenestrules on the sloping branch sides, but do not significantly indent the fenestrules. Thin peristomes surround each aperture, with about 27 small stylets. Apertures are regularly spaced down the branch with usually four between dissepiment centres.

Autozooecial living chambers are regularly large and biserially emplaced, with a zigzag axial wall trace. Chamber outline distorted pentagonal at mid chamber level. Three dimensionally reconstructed chamber form a distorted triangular pentagonal box.

Lateral wall budding angle variable (mean 22°), reverse wall budding angle constant (mean 41°). Internal skeletal granular layer is thin and continuous between chamber walls, stylets and between branches. The skeletal lamellar layer is of intermediate thickness.

Description - External features - The zoarium is of intermediate robustness, the form of the colony is not known, but fragments show flat expansions. Mesh spacing is close to intermediate and slightly irregular. Branches are wide and robust with a straight proximodistal trace. Branch spacing is close to intermediate, with 10 to 11 branches in 10 mm. Branch surface is granular with a rounded surface profile. Autozooecia are in two rows with a third inserted near point of bifurcation.

Dissepiments are of constant narrow width relative to the branches. Dissepiments of uniform short length and are regularly emplaced perpendicular to the branches. Dissepiment widen at their junction with the branches, and are only slightly recessed from obverse and reverse surfaces. Stylets cover both surfaces, with an occasional poorly defined low node in the centre of the dissepiment on the obverse surface. Fenestrules are regularly large and elongate oval, and elongated proximodistally, with about 5.5 in 10 mm. Fenestrule length and width are constant, with ratio of mean fenestrule to branch width approximately 4:5, and fenestrule width to length 3:10.

Minilya bituberculata	X	SD	Min	Max	N	CV
branches in 10 mm.	10.5	0.707	10	11	2	6.734
distance between branch centres	0.937	0.117	0.71	1.1	13	12.465
width branch	0.519	0.071	0.34	0.64	18	13.758
width dissepiments	0.261	0.028	0.225	0.32	14	10.819
fenestrules in 10 mm.	5.5	0	5.5	5.5	2	0
fenestrule length	1.474	0.099	1.36	1.7	12	6.749
fenestrule width	0.432	0.074	0.31	0.54	15	17.212
apertures between dissepiment centres	4.077	0.277	4	5	13	6.803
aperture width	0.170	0.009	0.155	0.19	20	5.502
aperture length	0.217	0.017	0.17	0.245	17	7.677
apertural spacing down branch	0.476	0.042	0.425	0.59	18	8.816
apertural spacing across branch	0.394	0.030	0.35	0.44	13	7.607
apertural spacing between branches	0.687	0.111	0.52	0.84	12	16.125
width apertural peristome	0.017	0.003	0.010	0.021	16	19.546
number of apertural stylets	27	4.359	20	35	9	16.144
diameter apertural stylets	0.009	0.002	0.005	0.013	17	25.508
diameter nodes	0.053	0.010	0.04	0.07	20	19.477
spacing of nodes down branch	0.237	0.049	0.14	0.35	19	20.624
diameter obverse stylets	0.011	0.002	0.008	0.015	20	20.016
spacing obverse stylets	0.029	0.008	0.02	0.055	20	28.007
diameter reverse microstylets	0.011	0.003	0.008	0.02	20	26.175
spacing reverse microstylets	0.044	0.012	0.028	0.07	20	26.628
thickness reverse wall granular layer	0.010	0.001	0.008	0.011	20	10.686
thickness lateral wall granular layer	0.014	0.003	0.010	0.02	20	20.652
thickness frontal wall laminated layer	0.182	0.026	0.15	0.24	13	14.496
thickness reverse wall laminated layer	0.162	0.018	0.13	0.195	13	11.313
chamber length	0.409	0.022	0.36	0.44	12	5.461
chamber depth	0.268	0.031	0.21	0.31	10	11.641
maximum chamber width	0.209	0.018	0.18	0.24	17	8.737
minimum chamber width	0.107	0.024	0.08	0.15	17	22.100
budding angle reverse chamber wall	41.333	1.528	40	43	3	3.696
budding angle lateral chamber wall	22.125	5.866	13	32	8	26.513
branch thickness	0.686	0.034	0.63	0.75	14	4.902

Table 3.5 - Summary measurements for *Minilya bituberculata* (Crockford). Abbreviations as for Table 3.1, all measurements in millimetres

Autozooecial apertures are regularly large and oval, with axis of elongation inclined disto-abaxially. Ratio of mean aperture width to length approximately 4:5. Apertures open inclined towards the fenestrules on the sloping branch sides, but indent the fenestrules only slightly. Thin peristomes surround each aperture, with about 27 small stylets. Apertures are regularly spaced down the branch with usually four between dissepiment centres. Ratio of mean aperture spacing down to across branches about 4:5, down to between branches 7:10, and across to between branches 3:5. Spacing between branches is slightly variable according to fenestrule width and aperture placement relative to dissepiments.

The front surface of the branch is rounded and does not show a distinct carina. Along the central portion of the branch is a double row of nodes, that develop from the adaxial apertural edge. The nodes are small and stellate, and their development adaxial proximally to each aperture results in an irregularly alternating row of closely spaced nodes.

Obverse stylets are present across the obverse surface, and are of small to intermediate size and are irregularly spaced. Reverse microstylets are again of small to intermediate size and irregularly spaced, and are spread across the entire reverse surface. Stylets are of similar size on both obverse and reverse surfaces, but are more widely spaced on the reverse surface. Reverse macrostylets are absent.

Internal features - Branches are thick and ovate in cross section, elongated perpendicular to the obverse reverse surfaces. Branches are always thicker than they are wide, with the ratio of mean branch width to thickness 3:4.

Autozooecial living chambers are regularly large and biserially emplaced, with a zigzag axial wall trace throughout. Chamber outline triangular pentagonal near the reverse surface, distorted pentagonal at mid chamber level and rounded pentagonal near the obverse surface. The distal adaxial chamber edge is slightly concave, and proximal adaxial edge slightly rounded at mid chamber level. Apertures are located distal abaxially to the chamber on a poorly defined vestibule. Chamber dimensions are regular except for minimum chamber width that varies at each end of the chamber due to its distorted shape. Ratio of mean chamber minimum to maximum width approximately 1:2, maximum width to depth almost 4:5, and depth to length ratio approximately 2:3. Three dimensionally reconstructed chamber form a distorted triangular pentagonal box. Lateral wall budding angle variable, range 13° to 32° (mean 22 °). Reverse wall budding angle constant, range 41° to 43° (mean 41°).

Internal skeletal granular layer is thin and continuous between chamber walls, stylets, nodes and between branches. The carina does not have a granular core. The skeletal lamellar layer is thin, with frontal wall and reverse wall laminated layers are of similar thickness.

Discussion - Crockford (1941b) described this species from the Late Artinskian Fenestella Shales in the northern Sydney Basin, as *Fenestrellina*, but included the species in *Minilya* upon construction of that genus (Crockford, 1944b). Only one specimen is recorded from the Ulladulla region but is distinct and clearly belongs to *Minilya bituberculata.*

Material - Two specimens were available for internal and external examination (UTGD 127551-52), from the Kungurian Wandrawandian Siltstone, North Head, Ulladulla.

Range - Late Artinskian - Kungurian.

Genus *Rectifenestella* Morozova 1974

Type species - *Fenestella medvedkensis* Shulga-Nesterenko, 1951; Upper Carboniferous, Kasimovian Stage; Russian Platform.

Diagnosis - Zoarium of delicate to intermediate robustness, mesh spacing close to intermediate. Branches are straight, with thin straight dissepiments. Autozooecial chambers are of small to intermediate size, with a pentagonal to triangular outline in mid tangential section. Reverse wall budding angle is high. Hemisepta are poorly developed. Three dimensional reconstructed chamber form moderately to highly cuneate (after Snyder, 1991).

Rectifenestella counselensis n. sp.
Plate 6; Table 3.6

Holotype - UTGD 127135 - Artinskian; Counsel Creek Formation, lower Bernacchi Quarry, Maria Island, Tasmania.

Diagnosis - The zoarium is of delicate to intermediate robustness, with fragments forming flat expansions. Mesh spacing is regular with 12 to 13 branches in 10mm. Branches are straight, thick, and of intermediate to wide width, with a rounded surface profile. Autozooecia are in two rows, with third row only inserted at the point of bifurcation. Dissepiments are short and of narrow to intermediate width, and are regularly spaced perpendicular to the branches. Fenestrules are elongate oval and of intermediate size, with 9.5 to 10.5 in 10 mm.

Apertures are large, circular to ovate and are slightly inclined into the fenestrules. There are 2.5 to 3 apertures between dissepiment centres and 13 to 15 in 5 mm. Peristomes are complete and carry small apertural stylets. Also occurring are large apertural stylets, with one placed abaxially on the peristome, and one adaxially away from the peristomal edge. A single low rounded carina is present, taking up one third to one half the branch width. A monoserial row of large well developed stellate nodes occur along the carina, with 11 to 12 nodes in 5 mm. The obverse surface is evenly covered with small to intermediate stylets. The reverse surface is covered with very small microstylets. Macrostylets are absent.

Autozooecial chambers large and biserially emplaced with a zigzag axial wall trace. Chamber outline in mid tangential section rounded pentagonal. Three dimensional form cuneate. Superior hemisepta poorly developed, inferior hemisepta absent. Reverse and lateral wall budding angles constant.

Rectifenestella counselensis n. sp.	X	SD	Min	Max	N	CV
distance between branch centres	0.797	0.052	0.71	0.89	20	6.483
branches in 10 mm.	12.167	0.408	12	13	6	3 355
width branch	0.421	0.043	0.325	0.525	20	10 148
width dissepiments	0.289	0 070	0.15	0.4	19	24.054
fenestrules in 10 mm.	9 942	0.232	9 5	10.5	13	2 330
fenestrule length	0 743	0 067	0 65	0.9	20	9 081
fenestrule width	0 355	0.037	0 275	0.4125	20	10.370
apertures between dissepiment centres	2.947	0.158	2 5	3	19	5 349
zooecial apertures in 5 mm.	13.893	0 525	13	15	14	3 782
aperture length	0.179	0 007	0 165	0 19	20	4.075
aperture width	0 153	0.010	0 135	0 175	20	6 308
apertural spacing down branch	0 393	0.025	0.355	0 46	20	6 440
apertural spacing across branch	0 392	0.029	0.34	0.44	20	7 483
apertural spacing between branches	0 51	0.068	0.42	0.62	20	13 257
nodes in 5 mm.	11.5	0.5	11	12	5	4 348
diameter nodes	0.162	0 027	0.13	0.22	20	16.834
spacing of nodes down branch	0.456	0.067	0 28	0.59	20	14 765
diameter obverse stylets	0.011	0.002	0 0075	0.015	20	16 855
spacing obverse stylets	0 048	0.011	0 03	0 07	20	22 460
width apertural peristome	0 015	0.004	0.01	0 0225	20	23 742
number of apertural stylets	20 889	3.257	15	25	9	15 594
diameter apertural stylets	0.012	0.003	0 0075	0 02	20	25 921
diameter large apertural stylets	0 058	0 010	0.045	0 085	20	17 892
diameter reverse microstylets	0.010	0 001	0 009	0.0125	20	9 372
spacing reverse microstylets	0.039	0.009	0 025	0 055	20	22 761
thickness reverse wall granular layer	0.012	0.003	0 01	0.02	19	25 897
thickness lateral wall granular layer	0.011	0.002	0.0075	0.015	20	21 217
thickness frontal wall laminated layer	0 257	0.043	0.16	0.325	11	16 727
thickness reverse wall laminated layer	0 750	0.123	0 6	1 04	17	16.399
chamber length	0 326	0 027	0.29	0.38	20	8 171
chamber depth	0.329	0 029	0.28	0.38	19	8 731
maximum chamber width	0.213	0 023	0.18	0.25	20	10 808
minimum chamber width	0.133	0.017	0 09	0.16	20	12 786
vestibule length	0.216	0 022	0.18	0.245	9	10 202
budding angle reverse chamber wall	66.167	4 070	59	71	6	6 151
budding angle lateral chamber wall	20.5	1 883	18	23	12	9 185
branch thickness	1.038	0 120	0.9	1 27	15	11.562

Table 3.6 - Summary measurements for *Rectifenestella counselensis* n. sp. Abbreviations as for Table 3 1, all measurements in millimetres.

Description - External features - Zoarium robustness delicate to intermediate and expansion flat. The form of the colony is not known. Mesh spacing is intermediate (to close) and regular. Autozooecia are in two rows, with third row only inserted at the point of bifurcation. There is only slight thickening and thinning of branches associated with bifurcation, thickening only noticeable with the addition of a third row.

Branches straight externally, appear gently sinuous at mid chamber level, width intermediate to wide with a generally rounded surface profile, except where nodes occur, the size of the node producing a distinctly angular profile. Branches are regularly closely spaced, with 12 to 13 branches in 10 mm horizontally.

Dissepiments variably narrow, approximately half the width of the branches. Dissepiments short, widening slightly at their junction with the branches, and are regularly spaced perpendicular to the branches. Dissepiments thick and only slightly recessed from the reverse surface, slightly recessed from the top of the carina on the obverse surface.

Fenestrules are of regularly intermediate size, with 9.5 to 10.5 occurring in 10 mm. vertically. Fenestrule shape is regularly elongate oval, and they are indented at the obverse surface by apertures. Fenestrules are narrower than branches with mean fenestrule width to branch width ratio approximately 4:5. Mean fenestrule width to length ratio nearly 1:2.

Apertures are large, circular to ovate and are slightly inclined into the fenestrule. Apertures are regularly spaced with 2.5 to 3 between dissepiment centres and 13 to 15 in 5 mm. Apertures are evenly spaced between branches with ratio of mean spacing down to across branch 1:1, and down to between branches 7:9. Surrounding each aperture are thin complete peristomes, with small closely spaced apertural stylets.

A single wide low rounded wide carina is present, and thickens astogenetically to become more rounded. The carina takes up one third to one half the branch width, and its generally rounded profile accentuates the rounding of the branch surface profile. A monoserial row of well developed large circular to stellate nodes occurs along the midline of the carina. Node size and spacing are regular with 11 to 12 nodes in 5 mm and two to three between dissepiment centres. Also occurring are large apertural stylets, with one placed abaxially on the apertural peristome, and one adaxially away from the peristomal edge. The biserial apertural arrangement results in the adaxial stylets giving a biserial arrangement about the central row of large monoserial nodes. The obverse surface is evenly covered with small to intermediate stylets that are of intermediate spacing. The reverse surface of branches and dissepiments are covered with small microstylets, that are of slightly closer spacing than the obverse stylets. Macrostylets are absent.

Internal features - Branches thick and ovate in cross section, with thickness greater than width. Ratio of mean branch width to thickness 2:5.

Autozooecial chambers large and biserially emplaced with a zigzag axial wall trace throughout. Chamber outline in tangential section triangular pentagonal near reverse wall, distorted pentagonal at mid chamber depth and triangular-ovate near obverse surface. The distal edge of the chamber is rounded at mid chamber level. Aperture at abaxial distal end of chamber connected by a well developed long constant vestibule. Chamber dimensions are constant, with only slight variation in widths. Mean minimum to maximum width ratio 3:5, maximum width to depth approximately 2:3, and depth to length 1:1. Outline in longitudinal section parallelogram shaped, with chamber depth and length approximately equal. In transverse section chamber is semicircular-ovate. Reconstructed three dimensional form a cuneate box. Superior hemisepta poorly developed, inferior hemisepta absent.

Reverse wall budding angle constant, with a range of 59° to 71° (mean 66°). Lateral wall budding angle constant, ranging from 18° to 23° (mean 20°). Exterior lamellar skeleton astogenetically thickened. The lamellar skeletal layer is very thick on both reverse and obverse surfaces, creating a long vestibule. Granular skeletal material is of intermediate thickness, with good continuity between chambers, striae and adjacent branches.

Discussion - *Rectifenestella counselensis* is distinguished by the number of fenestrules and branches, and the large blunt round based monoserial nodes on the carina as well as the adaxial-abaxial apertural stylets. This species appears very similar to *Minilya paratriserialis* Snyder of the Mississippian Warsaw Formation in the presence of both apertural stylets and large monoserial nodes upon a carina, however *R. counselensis* is coarser in its mesh size. The placement of *M. paratriserialis* in *Minilya* is doubtful as it displays all the features of *Rectifenestella*, but not the biserial nodes from the original description of *Minilya* by Crockford (1944b).

Types - Holotype UTGD 127135; Artinskian, Counsel Creek Formation, Maria Island, Tasmania.
Etymology - Named for the Counsel Creek Formation, in which the holotype was collected.
Range - Artinskian.

Rectifenestella granulifera (Crockford, 1941)
Plate 7; Table 3.7

Fenestrellina granulifera CROCKFORD (1941b), p. 509, pl. 21, fig. 4; CROCKFORD (1946) p. 132, text-fig. 4.
Fenestella granulifera (Crockford) WASS (1968), p. 67, pl. 15 figs. 2-3.
Diagnosis - The zoarium is robust, with a regular intermediate mesh spacing. Branches are wide thick and straight, with an angular obverse surface profile. Branches narrow after bifurcation and attain their normal proportions gradually, with 10 to 13 in 10 mm. Dissepiments are straight and of intermediate width and length. Fenestrules are large and elliptical to subrectangular, with 7 to 7.5 in 10 mm. Autozooecia are in two rows, with third row only inserted immediately before bifurcation.
Autozooecial apertures are regularly placed with 11 to 13 in 5 mm, and 3 to 4 zooecial apertures between dissepiment centres. Autozooecial apertures are large and circular, and open inclined towards the fenestrule. Peristomes are thin and incomplete, with apertural stylets developed. The single carina is wide and straight, with a single row of regularly spaced large ovate nodes. Obverse surface stylets cover the front surface, and do not appear to be of a regular arrangement. Widely spaced reverse microstylets cover the reverse surface evenly. Reverse macrostylets are large and distinct.
Autozooecial chambers are large and biserially emplaced with a zigzag axial trace. Chamber outline is evenly pentagonal in mid chamber level. Vestibules are distinct, hemisepta are absent. Reverse and lateral wall budding angles high. Reconstructed three dimensional chamber form is a pentagonal box.
Description - External features - The zoarium is of intermediate robustness with a regular intermediate mesh spacing. Zoarial fragments form flat to undulating outward expansions, however the overall form of the colony is unknown. Zoarial supports are not seen.
Branches are robust, wide and thick, with a straight proximodistal trace, and an angular obverse surface profile. Branch spacing intermediate and regular, with 10 to 13 in 10 mm. Branches are of regular width except where associated with bifurcation, narrowing after bifurcation and attaining their normal proportions gradually. Autozooecia are in two rows, with third row only inserted immediately before bifurcation. Branches joined at regular intervals by straight dissepiments of intermediate width and length that widen slightly at their junction with the branches. Dissepiments are slightly recessed on the reverse surface, and on the obverse are level or gently recessed from the lower lip of the inclined apertures. Fenestrules are large and of elliptical to subrectangular shape, elongated proximodistally, with 7 to 7.5 in 10 mm. Their shape is regular except where associated with bifurcation where they may be somewhat triangular, with width greater at one end than the other. Ratio of mean fenestrule width to length is 2:5, fenestrule to branch width 11:10.
There are 3 to 4 regularly spaced autozooecial apertures between dissepiment centres, with 11 to 13 in 5 mm. along the branch. Autozooecial apertures large and circular, and open inclined towards the fenestrule. Ratio of mean apertural spacing down to across the branch is 11:10, and down to between branches 6:10. Peristomes are thin and incomplete, and carry small apertural stylets, with about 16 surrounding each aperture. Apertures may be closed by terminal diaphragms.
The obverse surface carries a single wide straight carina between the two rows of zooecia, that enhances the angularity of the obverse surface. Astogenetic changes may further thicken the carina. On the median line of the carina is a monoserial row of large ovate nodes of regular intermediate spacing. Nodes are high and elongated along the carina. Obverse stylets of intermediate size cover the front surface, and are widely spaced. Reverse microstylets are

of small to intermediate size, and are widely spaced, covering the reverse surface evenly. Reverse macrostylets are distinct and of intermediate size. They tend occur at branch dissepiment junctions, but may occur anywhere on the reverse surface.

Rectifenestella granulifera	X	SD	Min	Max	N	CV
branches in 10 mm.	11 438	1.050	10	13	8	9.181
distance between branch centres	0 925	0.115	0.73	1 14	18	12 444
width branch	0 424	0 037	0.35	0 5	20	8 731
width dissepiments	0 253	0.038	0 2	0.325	20	14 847
fenestrules in 10 mm.	7.163	0 224	7	7 5	15	3 127
fenestrule length	1.178	0.189	0.75	1 5	20	16.050
fenestrule width	0 460	0.081	0 363	0.7	20	17 513
zooecial apertures in 5 mm.	12.042	0.450	11.5	13	12	3.738
apertures between dissepiment centres	3 6	0.417	3	4	20	11 577
aperture length	0.212	0 017	0.188	0 25	19	8 146
aperture width	0 160	0 013	0.135	0.183	15	8 226
apertural spacing down branch	0 399	0.025	0 36	0.45	20	6 146
apertural spacing across branch	0.354	0.034	0 31	0.42	12	9.741
apertural spacing between branches	0.636	0 118	0 4	0 78	16	18 597
diameter nodes	0 136	0.028	0 08	0 19	15	20 395
spacing of nodes down branch	0 752	0.091	0 563	0 88	17	12 061
width of carina	0.152	0 027	0.12	0.22	20	18 061
width apertural peristome	0 011	0.004	0 008	0.02	6	39.126
number of apertural stylets	16	0 816	15	17	4	5 103
diameter apertural stylets	0.007	0 002	0.005	0 01	6	30 619
diameter obverse stylets	0 012	0.003	0.008	0 021	20	24 913
spacing obverse stylets	0.065	0.021	0 04	0.105	20	31 741
diameter reverse microstylets	0 019	0 004	0 015	0.03	20	21.110
spacing reverse microstylets	0.065	0.025	0 035	0 125	20	37 579
diameter reverse macrostylets	0 064	0 016	0 04	0.095	16	25 525
spacing reverse macrostylets	0 358	0 110	0.24	0.54	10	30.812
thickness frontal wall laminated layer	0 193	0.029	0.15	0 21	4	14.921
thickness reverse wall laminated layer	0 232	0 043	0.165	0.285	11	18 460
thickness reverse wall granular layer	0.012	0.003	0 01	0.02	20	27.220
thickness lateral wall granular layer	0 014	0.004	0.01	0.02	14	28 339
chamber length	0 397	0.034	0.32	0 48	20	8 497
chamber depth	0 394	0 047	0.35	0.48	7	11 883
maximum chamber width	0.207	0.021	0 17	0.26	20	9 940
minimum chamber width	0 14	0 026	0 1	0.21	20	18.576
vestibule length	0 115	0.023	0 09	0 16	6	20.393
budding angle reverse chamber wall	69 5	6.238	60	77	7	8 976
budding angle lateral chamber wall	30	5 831	23	38	7	19 437
branch thickness	0.873	0 065	0.788	0.945	8	7 397

Table 3.7 - Summary measurements for *Rectifenestella granulifera* (Crockford). Abbreviations as for Table 3 1, all measurements in millimetres.

<u>Internal features</u> - Branches are regularly thick and elliptical in cross section, with and angular surface profile. The plane of elongation is in an obverse reverse direction. Ratio of mean branch width to thickness 1:2.

Autozooecial living chambers are large, with chamber length and depth approximately equal, and they have a box like shape in longitudinal section. Chambers are biserially emplaced with a zigzag axial trace throughout their development. Chamber shape is highly uniform with chamber outline triangular-pentagonal near the reverse wall, evenly pentagonal at mid chamber level, and becoming ovate-pentagonal near the obverse surface. Apertures are placed at the distal-abaxial end of the chamber, on distinct vestibules of intermediate length. Hemisepta are absent. Ratio of mean minimum to maximum chamber width is 2:3, maximum width to depth approximately 1:2, and depth to length 1:1. Chamber length, depth and maximum width are constant, with minimum width slightly variable.

Lateral wall budding angle slightly variable, range 23° to 28° (mean 30°). Reverse wall budding angle is high and constant with a range of 60° to 77° (mean 69.5°). Reconstructed three dimensional chamber form is a pentagonal box. Chamber length and depth are approximately the same when viewed from the lateral chamber edge. Chamber width is less than length and depth when viewed from the obverse surface.

The exterior lamellar skeleton is of intermediate thickness with some astogenetic thickening. The interior granular skeleton is thin, with the reverse wall granular layer showing moderate astogenetic thickening. Granular skeleton continuity clearly evident between chamber walls, longitudinal striae, carina and nodes.

Discussion - *Rectifenestella granulifera* was first described from the Artinskian Branxton Formation of NSW by Crockford (1941b) from external features only (as *Fenestella granulifera*). It has also been previously recorded from the Artinskian Berriedale Limestone in Tasmania (Crockford, 1951) and from the Kungurian ? Oxtrack Formation, (Wass, 1968), and the Artinskian Lakes Creek Beds, Bowen Basin, Queensland (Crockford, 1946). The external features of this species are distinct, and specimens sectioned from Tasmania are considered to be representative of the species throughout Australia.

Material - Two specimens from Tasmania were available for external examination (UTGD 127123-24), with UTGD 127123 examined internally, from the Artinskian Skipping Ridge Formation, Maria Island.

Range - Artinskian - Kungurian.

Rectifenestella smithae n.sp.
Plate 8; Table 3.8

Holotype - UTGD 127125; Artinskian Skipping Ridge Formation, Maria Island.

Diagnosis - The zoarium is of intermediate robustness, and forms flat to outwardly curved expansions. Mesh spacing close with autozooecia in two rows, third row inserted only immediately before branching.

Branches are thick robust and wide, with 12 to 13 in 10 mm. Dissepiments are of intermediate width, with dimensions and spacing regular. Dissepiments thick and only very slightly recessed from the obverse and reverse surfaces. Fenestrules are ovate to subrectangular and of intermediate to large size, with a mean width to length ratio of 2:5. Fenestrule shape and size are regular, with 7 to 9 in 10 mm. Autozooecial apertures are elliptical to oval, and regularly spaced, with 10 to 13 in 5 mm. Thin peristomes are present, small stylets surrounding each aperture. The single carina is narrow straight and low and runs along the midline of the branch. Along the centre of the carina is a monoserial row of ovate to slightly stellate nodes of variable intermediate size and regular spacing. Obverse stylets of irregular size and spacing cover the front surface of the branch and appear to have no preferred arrangement. Reverse microstylets of small to intermediate size and close spacing are irregularly spread across the reverse surface. Macrostylets absent.

Autozooecial living chambers are large and biserially emplaced, with a zigzag axial wall trace. Orientation of chamber elongation proximodistal. Chamber shape is uniform pentagonal at mid chamber level. Hemisepta are absent. Three dimensional reconstructed chamber form a pentagonal box. Reverse wall budding angle high and constant lateral wall budding angle slightly variable and generally low. Internal granular skeletal layer thin. Lamellar skeletal layer thick in both reverse and frontal walls.

Description - External features - Zoarium of intermediate robustness, forming flat to outwardly curved expansions. Mesh spacing close, with some astogenetic thickening of the skeleton. Autozooecia are in two rows, with a third row inserted only immediately before branching.

Branches are robust and wide, with a straight to slightly sinuous proximodistal trace and a flat to slightly angular surface profile. Branch spacing close with the distance between branch centres regular, with 12 to 13 in 10 mm. Dissepiments are of intermediate width relative to the branch, with a mean dissepiment width to fenestrule length ratio of approximately 4.5:10. Overall dissepiment length short, with dissepiment dimensions and spacing regular. Dissepiments widen at their junction with the branch. Dissepiments are thick and very slightly recessed from the obverse and reverse surfaces. Dissepiments are without extra zooecia or nodes and stylet arrangement is the same as for the remainder of the obverse surface.

Fenestrules are ovate to subrectangular, and of regular intermediate to large size, with 7 to 9 in 10 mm. Fenestrules elongated proximodistally, with a mean width to length ratio of 2:5, and mean fenestrule width to branch width ratio of 6.5:10. Fenestrule shape is more often subrectangular near the reverse surface, and ovate at mid branch level.

Rectifenestella smithae n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	12 719	1.211	11	15	16	9 518
distance between branch centres	0.906	0.144	0.61	1.16	39	15 867
width branch	0 568	0.101	0.38	0.9	67	17.688
width dissepiments	0.397	0.074	0.238	0 663	69	18.555
fenestrules in 10 mm	7 808	0.449	7	9	26	5 750
fenestrule length	0.908	0.124	0 69	1 36	69	13.682
fenestrule width	0.370	0 057	0 25	0 515	69	15 390
zooecial apertures in 5 mm	11.717	0.597	10	13	30	5 097
apertures between dissepiment centres	3 348	0.423	3	4	69	12.627
aperture length	0.201	0 019	0.163	0.25	58	9.244
aperture width	0.169	0.010	0.15	0 2	49	6 089
apertural spacing down branch	0.425	0 046	0.34	0 55	69	10.814
apertural spacing across branch	0.396	0 045	0.31	0 48	59	11 277
apertural spacing between branches	0.561	0.086	0.38	0.86	59	15 322
nodes in 5 mm	9.048	1 024	7	11	21	11.313
diameter nodes	0.108	0.030	0 06	0.17	59	27.542
spacing of nodes down branch	0.563	0.089	0 4	0.77	69	15 726
width of carina	0.09	0.042	0.04	0 18	16	46 259
width apertural peristome	0 018	0.005	0.01	0 03	21	26.342
number of apertural stylets	19.143	2.673	15	22	7	13.961
diameter apertural stylets	0.006	0.002	0.005	0.01	16	28 388
diameter obverse stylets	0 017	0.005	0 01	0 03	59	28.814
spacing obverse stylets	0.063	0 020	0.03	0.135	55	32 074
diameter reverse microstylets	0.018	0 006	0.01	0.04	59	35 716
spacing reverse microstylets	0.053	0.017	0 01	0.11	54	31.998
thickness frontal wall laminated layer	0.272	0.033	0.23	0.35	20	12 011
thickness reverse wall laminated layer	0 403	0.080	0.29	0 63	40	19 912
thickness reverse wall granular layer	0 011	0.004	0.005	0.02	39	34.428
thickness lateral wall granular layer	0.011	0.002	0 005	0.015	24	22.750
chamber length	0.363	0.032	0.295	0 45	46	8 929
chamber depth	0.309	0.028	0 26	0 34	9	9.220
maximum chamber width	0 218	0.023	0.18	0.26	60	10 397
minimum chamber width	0.128	0.020	0.08	0.17	60	15.923
vestibule length	0.253	0.046	0.2	0.34	29	18.181
budding angle lateral chamber wall	18.089	4 581	10	30	35	25.323
budding angle reverse chamber wall	65.5	4.918	57.5	73	20	7 508
branch thickness	1.075	0 131	0.88	1.28	42	12.169

Table 3.8 - Summary measurements for *Rectifenestella smithae* n sp. Abbreviations as for Table 3 1, all measurements in millimetres.

Autozooecial apertures are elliptical to oval, with ratio of mean width to length of 8.5:10. Apertures are regularly spaced along the branch, with 3 to 4 between dissepiment centres, and 10 to 13 in 5 mm. The ratio of mean spacing down to across the branch is 10:11, down to between branches almost 8:10 with across to between branches 7:10. Apertures open upwards, almost parallel to the obverse surface, or only slightly inclined towards the fenestrules. Thin peristomes are present, often incomplete, with 15 to 22 very small stylets surrounding each aperture. Terminal diaphragms are seen occasionally.

On the obverse surface is a single straight low narrow carina, that is widened and flattened by astogenetic thickening. On the midline of the carina is a monoserial row of ovate to slightly stellate nodes of variable intermediate size that are slightly elongated along the carina. Node spacing is regular with 7 to 11 in 5 mm.

Obverse stylets of variable size and wide spacing cover the front surface of the branch and appear to have no preferred arrangement. Longitudinal striae are thin and closely spaced. Reverse microstylets of small to intermediate size and intermediate to wide spacing are irregularly spread across the reverse surface. Macrostylets are absent.

Internal features - Branches are thick and elliptical in cross section with nearly flat sides. Branch width to thickness ratio 1:2. Autozooecial living chambers are large and biserially emplaced, with a zigzag axial wall trace. Greatest chamber dimension is in a proximodistal direction. Chamber shape is uniform with outline triangular to pentagonal near the reverse surface, pentagonal at mid chamber level and pentagonal to ovate near the obverse surface. Apertures are located abaxial-distally at the end of a very long well developed vestibule. Hemisepta are absent. Chamber dimensions are constant except for minimum width which is variable, according to level in chamber. Ratio of mean minimum to maximum width 6:10, maximum width to depth 7:10, and depth to length 8.5:10. Three dimensional reconstructed chamber form a pentagonal box.

Reverse wall budding angle high and constant with a range of 58° to 73° (mean 66°). Lateral wall budding angle slightly variable and generally low with a range of 10° to 30° (mean 18°). Internal granular skeletal layer is thin, but well developed and distinct. Granular skeletal layer shows continuity between chamber walls to carina base and nodes, obverse stylets and between branches. Continuity of the skeletal granular layer is not seen with peristomes and apertural stylets. Lamellar skeletal layer thick in both reverse and frontal walls, and is increased by astogenetic thickening.

Discussion - *Rectifenestella smithae* n. sp. may be difficult to isolate from other Tasmanian fenestrate taxa of similar mesh size, without internal examination.

Types - Holotype UTGD 127125; paratypes UTGD 127126-27.

Etymology - Named for Edith Smith.

Material - Three fragments were examined internally (UTGD 127125-27), with an additional fragment assigned to this species from external examination (UTGD 127128).

Range - Sakmarian to lower Artinskian.

Rectifenestella sparsa (Crockford, 1946)
Plate 9; Table 3.9

Fenestrellina sparsa CROCKFORD (1946), p. 128, text-fig. 7.

Diagnosis - Overall form of the zoarium is unknown but fragments form flat outward expansions. Mesh spacing is variably close to open, depending on association with branching. Branches are of intermediate robustness, but are commonly crushed, despite having wide thick branches. Branch spacing regular with 8 to 11 in 10 mm. Proximodistal trace straight to gently sinuous and obverse surface profile rounded. Autozooecia are in two rows on the obverse surface, with a third row inserted at or immediately preceding bifurcation.

Dissepiments are bar like and notably narrower than branches, regularly placed, and usually perpendicular to the branches. Fenestrules are large and elongate oval to subrectangular, with 4.5 to 5.5 in 5 mm. Along the midline of the branch is a monoserial row of widely spaced large nodes. The front surface of the branch has small obverse stylets that are of intermediate spacing. The reverse surface is covered in evenly spaced small microstylets.

Autozooecial apertures are large and circular, and evenly spaced along the branch, with usually 4 to 5 between dissepiment centres. Apertures open at a steep angle to the obverse surface. A thin incomplete peristome surrounds each aperture and carries about 19 small apertural stylets. Apertures may be closed by a terminal diaphragm.

Autozooecial living chambers are consistently large and emplaced biserially with a zigzag axial wall trace. Chamber shape is moderately uniform, and pentagonal at mid chamber level. The apertures are located distal abaxially to the living chamber, on a poorly defined vestibule. Hemisepta are absent. Three dimensional reconstructed chamber form a pentagonal box. Both granular and lamellar skeletal layers are thin.

Description - External features - Zoarium of intermediate robustness. Overall form of zoarium unknown but fragments form flat outward expansions. Mesh spacing is variably close to open, depending on association with branching. Some specimens show repeated bifurcation laterally across the zoarium, with very open mesh below and close above. Autozooecia are in two rows, with a third row inserted at or immediately preceding bifurcation.

Rectifenestella sparsa	X	SD	Min	Max	N	CV
branches in 10 mm.	9 333	0.866	8	11	9	9 279
distance between branch centres	1.083	0 153	0.8	1 42	41	14.128
width branch	0.549	0.059	0 44	0.66	39	10.721
width dissepiments	0 290	0.064	0.19	0.56	57	22.009
fenestrules in 10 mm.	4.938	0 320	4.5	5 5	8	6 490
fenestrule length	1 657	0.200	1 22	2.15	39	12 091
fenestrule width	0 601	0.143	0 28	0 86	38	23 838
apertures between dissepiment centres	4.681	0.587	4	6	36	12 550
aperture width	0.172	0 015	0 14	0 2	19	8 632
apertural spacing down branch	0 437	0.050	0 34	0 56	33	11 527
apertural spacing across branch	0.386	0.055	0.3	0.5	20	14 225
apertural spacing between branches	0.724	0.133	0.5	0.9	7	18 418
width apertural peristome	0.016	0.003	0.01	0 02	7	21.735
number of apertural stylets	19	4.546	15	25	4	23 927
diameter apertural stylets	0.009	0.002	0.005	0.011	18	18.731
width of carina	0.173	0.023	0 135	0.22	13	13 475
diameter nodes	0 180	0.029	0 12	0.24	16	16 341
spacing of nodes down branch	1.408	0.289	1.04	2	12	20 503
diameter obverse stylets	0.011	0.002	0.008	0 018	40	20.496
spacing obverse stylets	0.044	0.013	0.02	0 08	36	29 888
diameter reverse microstylets	0 013	0 004	0 005	0 02	67	28 446
spacing reverse microstylets	0.044	0 013	0.02	0 075	68	29.196
thickness reverse wall granular layer	0 012	0.004	0.008	0.02	36	29 004
thickness lateral wall granular layer	0 011	0.003	0.0075	0.02	39	24.838
thickness frontal wall laminated layer	0.175	0.027	0.13	0.22	26	15.220
thickness reverse wall laminated layer	0.175	0.070	0 08	0 3	23	40 136
chamber length	0 419	0.040	0 36	0 54	53	9.447
chamber depth	0.400	0 035	0 3	0.44	21	8.777
maximum chamber width	0 237	0.027	0.19	0.3	51	11 359
minimum chamber width	0 115	0 028	0.065	0 18	45	24 515
budding angle reverse chamber wall	57.826	6.140	41	66	23	10.617
budding angle lateral chamber wall	35 222	8.452	25	48	9	23 998
branch thickness	0.766	0.081	0.68	0 89	11	10.508

Table 3.9 - Summary measurements for *Rectifenestella sparsa* (Crockford). Abbreviations as for Table 3 1, all measurements in millimetres.

Branches are of intermediate robustness, and are commonly crushed despite having wide branches. Mean branch spacing intermediate, and as discussed above spacing is variable, but there are usually 8 to 11 branches in 10 mm. Proximodistal trace straight to gently sinuous, with a rounded to angular surface profile. Dissepiments are of narrow to intermediate width, and are always narrower than the branches. Dissepiments are short to long and regularly placed, usually perpendicular to the branches, though may be inclined at a gentle angle. Dissepiments are slightly recessed from the reverse surface and strongly recessed from the obverse. Dissepiment thickness is similar to width, and they appear as thin bars joining the branches. Fenestrules are large and elongate oval to subrectangular, with 4.5 to 5.5 in 10 mm. Fenestrule length is regular but width is slightly variable. Ratio of mean fenestrule to branch width 11:10, fenestrule width to length approximately 1:3.

Autozooecial apertures are uniformly large and circular. Apertures are evenly spaced along the branch and there are usually 4 to 5 between dissepiment centres. Ratio of mean aperture spacing down to across branches is 11:10, down to between branches 3:5 and across to between branches approximately 1:2. Apertures open at a steep angle to the plane of the obverse surface, and are steeply inclined towards the fenestrules but do not indent them. Apertures are surrounded by a thin incomplete peristome, carrying about 19 small apertural stylets. Terminal diaphragms are occasionally seen covering apertures.

A rounded carina is formed along the midline of the obverse branch surface by the junction of the steeply sloping branch sides. Along the midline of the carina is a monoserial row of large ovate to elongate ovate nodes. Nodes are well raised above the surface of the carina and are a prominent feature. Nodes are elongated at their base and elongation can produce a node width to length along carina ratio of 1:4. Nodes are widely spaced along the carina, with one to two per fenestrule.

The front surface of the branch is covered in obverse stylets of small to intermediate size and intermediate spacing. Covering the reverse surface are evenly spaced small distinct microstylets, that help distinguish this species in fragmentary form. Size and spacing of microstylets similar on obverse and reverse surfaces. Reverse macrostylets are absent.

Internal features - Branches are thick and ovate in cross section, with axis of elongation perpendicular to the obverse reverse surfaces. Ratio of mean branch width to thickness 5:7.

Autozooecial living chambers are large and are biserially emplaced with a zigzag axial wall trace from reverse to obverse surfaces. Chamber size and shape are moderately uniform. Chamber outline is triangular near the reverse wall and pentagonal at mid chamber level, becoming rounded pentagonal towards the obverse surface. The apertures are located distal abaxially to the living chamber on a poorly defined vestibule. Ratio of mean minimum to maximum chamber width approximately 1:2, maximum width to depth 3:5, and depth to length almost 1:1, however length is usually slightly greater than depth in each chamber. Hemisepta are absent. Three dimensional reconstructed chamber form a pentagonal box.

Internal granular layer is thin and continuous between chamber walls, nodes, stylets and between branches. In cross section the carina has a limited granular core, formed instead mostly by lamellar skeleton, except where associated with nodes. Internal lamellar skeleton is thin, and of similar thickness on both obverse and reverse surfaces. The thickness of the outer lamellar wall is thin in comparison to chamber depth, resulting in tendency for branches to crush. Lamellar skeleton astogenetically thickened, increasing branch and dissepiment widths and fenestrule dimensions.

Discussion - *Rectifenestella sparsa* was first described by Crockford (1946) as *Fenestrellina* from the Artinskian Lakes Creek Beds of the Bowen Basin Queensland. This is the first record of this species from the Sydney Basin, and internal examination has shown the species to belong to the genus *Rectifenestella.* Distinguished from the similar *R. granulifera* by the coarser mesh of *R. sparsa.*

Material - Seven specimens (UTGD 127553-59) were available for internal examination from the Kungurian Wandrawandian Siltstone, Ulladulla.

Range - Artinskian to Kungurian.

Rectifenestella sp. A.
Plate 10; Table 3.10

Diagnosis - The zoarium is delicate, forming flat to gently undulating outward expansions. Overall colony form unknown, mesh spacing intermediate and regular. Branches are straight and delicate with a gently angular surface profile. Zooecia are in two rows, with third row only inserted immediately before bifurcation. Dissepiments are narrow, straight and regularly placed. Fenestrules are of regularly intermediate size and subrectangular shape. Obverse branch surface capped by a single narrow carina, with a single row of small, closely spaced nodes. Obverse stylets are small and of intermediate spacing. Autozooecial apertures are circular and of intermediate size, with slight peristomes. There are three to four apertures between dissepiment centres.

Autozooecial chambers are of intermediate size and are biserially emplaced with an axial wall trace. Chamber outline is pentagonal at mid chamber level. Internal lamellar skeleton thin. Granular skeletal layer also appears thin, with thin reverse wall, and narrow total branch thickness.

Rectifenestella sp. A	X	SD	Min	Max	N	CV
branches in 10 mm	19.357	1 701	17	22	7	8 787
distance between branch centres	0.52	0.056	0.42	0 6	17	10 707
width branch	0 279	0 031	0.225	0 325	20	11 090
width dissepiments	0 127	0 021	0.1	0 1625	20	16 694
fenestrules in 10 mm.	13	1.225	12	15	9	9 421
fenestrule length	0 689	0 085	0 55	0.825	20	12.260
fenestrule width	0 254	0 046	0.175	0 325	20	18.230
zooecial apertures in 5 mm.	18 6	0 966	17	20	10	5 194
apertures between dissepiment centres	3 475	0.472	3	4	20	13 590
aperture length	0.117	0.008	0 1	0.135	24	6.601
aperture width	0 114	0.037	0 09	0 23	12	32 847
apertural spacing down branch	0.255	0.025	0.2	0.3	30	9.836
apertural spacing across branch	0.217	0 025	0.18	0 26	19	11 364
apertural spacing between branches	0.358	0.040	0 29	0.42	12	11 216
diameter nodes	0 045	0 021	0.03	0.06	2	47.140
spacing of nodes down branch	0 175	0.049	0 14	0.21	2	28.284
width of carina	0 031	0.011	0.02	0.05	5	36.780
diameter obverse stylets	0 009	0.003	0.005	0.015	9	38 710
spacing obverse stylets	0 028	0 008	0 02	0 04	6	26 568
chamber length	0 236	0.017	0 205	0 27	20	7.391
maximum chamber width	0.136	0.011	0 115	0 16	20	7.861
minimum chamber width	0.073	0.014	0 04	0 1	20	19 243

Table 3 10 - Summary measurements for *Rectifenestella* sp A. Abbreviations as for Table 3.1, all measurements in millimetres

Description - External features - Zoarium delicate forming flat to gently undulating outward expansions. Overall colony form is unknown. Mesh spacing intermediate and regular. Branches are straight, delicate and of intermediate spacing, with 17 to 22 in 10 mm. Branches have a gently angular surface profile. Zooecia are in two rows, with third row only inserted immediately before bifurcation. Dissepiments are narrow, and less than half the width of the branches, and of intermediate length. Dissepiments are straight and regularly placed. Fenestrules are of regularly intermediate size and subrectangular shape with long axis oriented proximodistally. There are 12 to 15 fenestrules in 10 mm. Fenestrules are only slightly narrower than the branches, with mean fenestrule to branch width ratio 9:10. Mean fenestrule width to length ratio approximately 1:3.

Autozooecial apertures are circular and of intermediate size. Apertures have slight peristomes, open towards, but do not impinge on, fenestrules. Autozooecial apertures are regularly spaced with 3 to 4 between dissepiment centres, and 17 to 20 in 5 mm. Rows of apertures are straight and zoarial mesh regularity means apertural spacing between branches is also regular. Ratio of mean spacing down branch to across branch almost 6:5, down branch to between branches 7:10, and across to between branches 3:5.

Obverse branch surface capped by a single narrow poorly developed carina, with a monoserial row of small sharp, closely spaced nodes. Obverse stylets are small and of even intermediate spacing.

Internal features - Autozooecial chambers are of intermediate size and are biserially emplaced with an axial wall trace. Chamber outline is pentagonal at the reverse surface and at mid chamber level, becoming fabiform near the obverse surface.

Internal lamellar skeleton thin. Granular skeletal layer also appears thin, with thin reverse wall, and narrow total branch thickness.

Discussion - Internal details are limited as longitudinal and transverse sections of *Rectifenestella* sp. A are not available. But from tangential sections available this species clearly has the pentagonal chamber shape typical of *Rectifenestella.* Distinguished from other eastern Australian species of *Rectifenestella* by fenestrule-branch dimensions, mesh spacing and zooecial number.

Material - *Rectifenestella* sp. A is known from two specimens (UTGD 127497-98) from the lower Artinskian Skipping Ridge Formation, Maria Island, Tasmania.

Range - Lower Artinskian.

Rectifenestella sp. B
Plate 11; Table 3.11

Diagnosis - Colony form is unknown, fragments delicate, with close to intermediate mesh spacing. There are 15 to 18 branches and 12 to 14 fenestrules in 10 mm. Branches are easily crushed, of thin to intermediate width, with a straight proximodistal trace and gently angular surface profile. Branch spacing is close to intermediate and regular. Zooecia are in two rows on the branches with a third row inserted only at point of bifurcation.

Dissepiments are of regular intermediate length and width, and are regularly spaced perpendicular to the branches. Fenestrules are subrectangular to elongate oval and of constant intermediate size. Autozooecial apertures are circular and of uniform intermediate size and are regularly spaced down the branch with usually three between dissepiment centres. Down the midline of the obverse surface of the branch is a thin carina with a single row of small to intermediate sized nodes. Obverse stylets are of small to intermediate size, and are irregularly spaced across the obverse surface. On the reverse surface are small microstylets and small to large macrostylets.

Autozooecial chambers are of intermediate size with the greatest dimension parallel to the obverse reverse surfaces. Chamber emplacement is biserial with a zigzag axial wall trace. Chamber outline is pentagonal at mid chamber level. Three dimensional reconstructed chamber form a cuneate pentagonal box. Reverse wall budding angle is constant, mean 64.5°. Granular skeletal microstructure is thin, lamellar skeleton is of intermediate thickness.

Description - External features - Overall zoarial form is unknown, but fragments are delicate. Mesh spacing is close to intermediate and regular. Branches are of delicate to intermediate robustness, and are easily crushed. Branches are of narrow to intermediate width, with a straight proximodistal trace and gently angular surface profile. Branch spacing is close to intermediate and regular, with 15 to 18 in 10 mm. Zooecia are in two rows on the branches with a third row inserted only at point of bifurcation.

Dissepiments are of regular intermediate length and width relative to the branches. Dissepiments are rounded on both the reverse and obverse surface, and are recessed from each surface. Dissepiments are regularly spaced perpendicular to the branches. Fenestrules are subrectangular to elongate oval and of constant intermediate size, with 12 to 14 in 10 mm. Fenestrule shape becomes larger and more rounded towards the reverse surface. Fenestrules are only slightly narrower than the branches, with ratio of mean fenestrule to branch width 6:7. Ratio of mean fenestrule width to length approximately 3:7.

Autozooecial apertures are of uniform intermediate size. Apertures are circular with a thin peristome, and are apparently without apertural stylets. Apertures open parallel to the plane of the obverse surface, with the abaxial margins impinging on fenestrules. Apertures are regularly spaced down the branch with usually three between dissepiment centres. Ratio of mean apertural spacing down branch to across branch 7:6, down to between branches 4:5, and across to between branches approximately 7:10.

Down the midline of the obverse surface of the branch is a thin carina with a single row of small to intermediate sized nodes. Nodes are of regular intermediate spacing along the carina and are well raised above the surface of the carina.

Obverse stylets are of small to intermediate size, and are of irregular intermediate spacing across the obverse surface of both the branches and dissepiments. Reverse microstylets are small but are generally larger than those on the obverse surface. Reverse macrostylets of variable small to large size are also present. Stylets of the reverse surface are also irregularly spaced and appear on both branch and dissepiment surfaces.

Rectifenestella sp. B	X	SD	Min	Max	N	CV
branches in 10 mm.	16.5	2.121	15	18	2	12 856
distance between branch centres	0.581	0.067	0 41	0.67	25	11.613
width branch	0.310	0.021	0.27	0.35	22	6 906
width dissepiments	0.196	0.024	0.155	0 245	26	12.253
fenestrules in 10 mm.	12.667	1 155	12	14	3	9 116
fenestrule length	0.593	0 079	0 43	0.71	27	13.392
fenestrule width	0.265	0.035	0 2	0.34	23	13.354
apertures between dissepiment centres	2.889	0 289	2	3	27	9.993
aperture width	0.108	0.009	0 09	0.13	24	8 413
apertural spacing down branch	0 308	0 017	0 28	0.36	28	5 672
apertural spacing across branch	0.270	0.023	0.21	0.32	22	8.470
apertural spacing between branches	0.393	0.056	0.24	0 48	20	14 347
width apertural peristome	0.017	0 006	0.01	0 03	16	36 889
width of carina	0.063	0 013	0.035	0.08	13	21 106
diameter nodes	0 060	0.021	0 03	0.093	15	35.239
spacing of nodes down branch	0 345	0.041	0 27	0 43	23	11 814
diameter obverse stylets	0.010	0.002	0.005	0.015	24	21 726
spacing obverse stylets	0 031	0 013	0.015	0 07	29	41 983
diameter reverse microstylets	0.015	0.004	0.01	0 02	30	25 796
spacing reverse microstylets	0 034	0.014	0 018	0.065	30	41 197
diameter reverse macrostylets	0 074	0.031	0 025	0 14	18	42.263
spacing reverse macrostylets	0 222	0.122	0 08	0.44	19	54 842
thickness reverse wall granular layer	0 008	0.002	0 005	0 01	7	23.007
thickness lateral wall granular layer	0.009	0 001	0.008	0 01	6	14 084
thickness frontal wall laminated layer	0 107	0.022	0.08	0 14	6	20.252
thickness reverse wall laminated layer	0.129	0.040	0.07	0.17	8	30.912
maximum chamber width	0 147	0.017	0.12	0.2	24	11 536
minimum chamber width	0 095	0.018	0.06	0.14	23	18.919
chamber length	0.285	0.027	0.23	0.32	20	9 473
chamber depth	0.204	0.026	0.18	0.24	5	12.783
budding angle reverse chamber wall	64.5	4.435	59	69	4	6 876
branch thickness	0.495	0 007	0.49	0 5	2	1 428

Table 3.11 - Summary measurements for *Rectifenestella* sp B Abbreviations as for Table 3.1, all measurements in millimetres

<u>Internal features</u> - Branches are thick and rounded to elliptical in cross section with their long axis oriented perpendicular to the plane of the obverse and reverse surfaces. Nodes produce an angular obverse surface profile. Autozooecial chambers are of slightly variable intermediate size with the greatest dimension parallel to the obverse reverse surfaces. Chamber emplacement is biserial with a zigzag axial wall trace that becomes sinuous towards the obverse surface. Chamber outline is pentagonal near the reverse surface and at mid chamber level, and becomes elliptical towards the obverse surface. Just beneath the obverse surface the apertures are tear drop shaped, and oriented distal abaxially. The aperture is located distal abaxially to the chamber on a short indistinct vestibule. Ratio of mean minimum to maximum chamber width 2:3, maximum width to depth 5:7, and depth to length also 5:7. Heterozooecia and hemisepta are absent. Three dimensional reconstructed chamber form a cuneate pentagonal box.

Reverse wall budding angle is constant, with a range of 59° to 69° (mean 64.5°). Granular skeletal microstructure is thin, lamellar skeleton is of intermediate thickness.

Discussion - This species is distinguished from other eastern Australian species of *Rectifenestella* by its mesh size and apertural spacing, and in particular by the macrostylets on the reverse surface. *Fenestella dispersa* (Crockford, 1943) also has distinct reverse macrostylets, but differs in mesh size. Known only from the Kungurian Wandrawandian Siltstone of North Head, Ulladulla, New South Wales.

Material - Two specimens were available for internal examination from the Wandrawandian Siltstone, Ulladulla, New South Wales (UTGD 127560-61).

Range - Kungurian.

Rectifenestella sp. C
Plate 12; Table 3.12

Diagnosis - Colony form unknown, fragments are delicate and easily crushed. Branches are of intermediate width with a straight proximodistal trace. Branches are regularly closely spaced, and have an angular surface profile. Zooecia are in two rows, with a third row only inserted at point of bifurcation. Dissepiments are short and of intermediate width relative to the branches. Fenestrules are of small to intermediate size and are subrectangular in shape. Autozooecial apertures are of regular intermediate size, with three apertures between dissepiment centres. Apertures have a thin peristome that is apparently without apertural stylets. Down the midline of the branch is a straight carina of intermediate width, with small nodes. Both the obverse and reverse surfaces have small irregularly spaced stylets spread across the branches and dissepiments.

Autozooecial chambers are pentagonal at mid chamber level. Granular skeletal layer is thin, lamellar layer is of intermediate thickness.

Rectifenestella sp. C	X	SD	Min	Max	N	CV
distance between branch centres	0.537	0 059	0 44	0 66	27	11.034
width branch	0 355	0 030	0.32	0 41	16	8 341
width dissepiments	0.212	0.029	0.18	0 29	21	13 619
fenestrule length	0.575	0.035	0.525	0.64	21	6.050
fenestrule width	0.208	0.019	0.18	0 245	13	9.094
apertures between dissepiment centres	3	0	3	3	16	0
aperture width	0 122	0.011	0 11	0 14	11	8.736
apertural spacing down branch	0.252	0.058	0.16	0.32	21	22 994
apertural spacing across branch	0 220	0 046	0 17	0.26	3	20 830
apertural spacing between branches	0.325	0.064	0.28	0.37	2	19 581
width of carina	0 065	0.021	0 05	0.08	2	32 636
diameter nodes	0.052	0.011	0 04	0 07	9	21 469
spacing of nodes down branch	0 255	0 033	0.2	0 3	14	12 754

Table 3 12 - Summary measurements for *Rectifenestella* sp C. Abbreviations as for Table 3 1, all measurements in millimetres.

Description - External features - Overall zoarial form unknown, but fragments form flat to gently reversely curved expansions that are delicate and easily crushed. Mesh spacing is close and regular. Branches are of intermediate width with a straight proximodistal trace. Branches are regularly closely spaced, and have an angular surface profile. Autozooecia are in two rows, with a third row only inserted at point of bifurcation. Dissepiments are short and of intermediate width relative to the branches. Dissepiments are regularly placed perpendicular to the branches. Dissepiments are straight and widen slightly at their junction with the branches. The dissepiments are recessed slightly from both the reverse and obverse surfaces. The dissepiments are free of extra zooecia, and rows of zooecia are straight and do not bend onto them. Fenestrules are of small to intermediate size and are subrectangular in shape. Both fenestrule size and shape are constant. Fenestrules are narrower than the branches, with ratio of mean fenestrule width to branch width 3:5, and fenestrule width to length 3:8. Autozooecial apertures are of regular intermediate size, with three apertures between dissepiment centres. Ratio of mean aperture spacing down to across branches 6:7, down to between branches 3:4, and across to between branches 2:3. A thin peristome surrounds each aperture, and apertural stylets are not seen.

Down the midline of the obverse surface of the branch is a straight carina of intermediate width on which there are small nodes of close to intermediate spacing. Both the obverse and reverse surfaces have small irregularly spaced stylets spread across the branches and dissepiments.

Internal features - Internal features are poorly preserved, but chambers can be seen to be pentagonal in tangential section at mid chamber level. Granular skeletal layer is thin, lamellar layer is of intermediate thickness.

Discussion - *Rectifenestella* sp. C can be distinguished from other eastern Australian species described here by its straight branches and dissepiments, and mesh size. Identified only from the Kungurian Wandrawandian Siltstone, Dolphin Point, Ulladulla, New South Wales.

Material - Two specimens are recorded in the Wandrawandian Siltstone (UTGD 127562-63).

Range - Kungurian.

Remarks - The species of *Rectifenestella* described above are poorly preserved, and unable to be matched to any existing described species from eastern Australia. *Rectifenestella* sp. A, from Tasmania, is very similar to *Fenestella dispersa* (Crockford), described from throughout the Permian of Australia. The holotype of *F. dispersa* is from the Wandrawandian Siltstone at Warden Head, Ulladulla, but no convincing specimens were found in this study. It likely that *F. dispersa*, as described by Crockford (1943) on external features, will show itself to be a number of closely related species after internal examination. As this "species" is very wide ranging, further study of the group as a whole is required before specimens described internally can be confidently assigned to existing small meshed taxa such as *F. dispersa.* However it can be said that *Rectifenestella* is the likely genus of many of the *F. dispersa* group, given Crockford's description of a pentagonal basal chamber shape.

Genus *Fenestella* Lonsdale, 1839

Type species - *Fenestella subantiqua* d'Orbigny, 1849; Silurian, Wenlockian, England.

Diagnosis - Zoarium cup or fan-shaped with a mesh like form. Zooecia on one side of the branch only, in two rows. Branches usually wide and dissepiments narrow. Zooecial chamber shape quadrangular in cross section, with hemisepta developed. Rows separated by a straight narrow carina with a single row of nodes (after Morozova, 1974).

Fenestella sp.
Plate 13; Table 3.13

Diagnosis - Overall colony form is unknown but fragments are delicate, with close mesh spacing. There are 17 to 22 branches and 11 to 13 fenestrules in 10 mm. Zooecia are in two rows. Branches are of intermediate width with a straight proximodistal trace. Dissepiments are short and of intermediate width and are placed at regular intervals perpendicular to the branches. Fenestrules are of intermediate size and regular subrectangular shape. Autozooecial apertures are regularly circular and of intermediate size. Apertures are regularly spaced along the branch with 2.5 to 3 apertures between dissepiment centres. A single straight carina of intermediate width is present with small nodes of intermediate spacing. Obverse stylets of small to intermediate size are irregularly spaced across the obverse surface. Reverse microstylets are also small and irregularly spaced.

Autozooecial chambers are of intermediate size, and biserially emplaced, with chambers of each row either adjacent or alternating. Chamber outline in mid tangential section is quadrangular. Hemisepta are not seen. Three dimensional reconstructed chamber form a quadrangular box. Both granular and lamellar skeletal layers are thin.

Description - External features - Colony form unknown, fragments delicate, forming flat to gently undulating reversely curved expansions. Mesh spacing is close and regular.

Branches are of delicate to intermediate robustness with a straight proximodistal trace. Branches are of intermediate width and are regularly closely spaced, with 17 to 22 in 10 mm. Dissepiments are short and of intermediate width. Dissepiments are placed at regular intervals perpendicular to the branches. Fenestrules are of intermediate size and regular subrectangular shape, with and 11 to 13 in 10 mm. Fenestrules are narrower than the branches with ratio of mean fenestrule width to branch width approximately 3:5, and fenestrule width to length approximately 3:8.

Autozooecial apertures are regularly circular and of intermediate size. A thin peristome is present, apertural stylets are not determinable. Apertures are regularly spaced along the branch with 2.5 to 3 apertures between dissepiment centres. Ratio of mean spacing down to across the branch almost 1:1, down to between branches approximately 4:5.

A single straight carina of intermediate width is present down the midline of the obverse surface of the branch. Along the carina are small nodes of intermediate spacing. Obverse stylets of small to intermediate size are irregularly spaced across the obverse surface. Reverse microstylets are small, and noticeably smaller than obverse stylets, and are irregularly closely spaced. Reverse macrostylets are absent. On both obverse and reverse surfaces stylets have similar spacing on dissepiments and branches.

Fenestella sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	19	2.160	17	22	4	11.370
distance between branch centres	0.582	0.072	0.42	0.69	23	12 383
width branch	0 358	0 025	0.32	0.42	22	7 097
width dissepiments	0 193	0.015	0 16	0 23	26	7 672
fenestrules in 10 mm.	12.100	1 140	11	13 5	5	9 423
fenestrule length	0 619	0 083	0 46	0.78	27	13 340
fenestrule width	0.221	0 026	0 19	0.28	15	11.565
apertures between dissepiment centres	2 841	0.304	2	3 25	22	10.708
aperture width	0 130	0.008	0.12	0 14	7	6 281
apertural spacing down branch	0 264	0.024	0.21	0 3	17	8 967
apertural spacing across branch	0.270	0 032	0 225	0.3	7	11.858
apertural spacing between branches	0.335	0 021	0.32	0 35	2	6.332
width apertural peristome	0 010	0.000	0.01	0 01	2	0 000
width of carina	0.084	0 008	0 08	0.1	6	9 517
spacing of nodes down branch	0.278	0 047	0.2	0.36	12	17 050
diameter obverse stylets	0.011	0 004	0 005	0.02	25	33 375
spacing obverse stylets	0.041	0 016	0.023	0.085	22	38 032
diameter reverse microstylets	0.007	0 002	0 005	0.013	32	30 726
spacing reverse microstylets	0.018	0.004	0 01	0.03	28	23 531
thickness reverse wall granular layer	0.016	0 008	0 01	0 03	17	48 391
thickness lateral wall granular layer	0 010	0.001	0 008	0 013	16	14 342
thickness frontal wall laminated layer	0 130	0.031	0.105	0.165	3	24 019
thickness reverse wall laminated layer	0.142	0 034	0.105	0.19	7	23 845
maximum chamber width	0.114	0 018	0.09	0.15	19	15 741
chamber length	0.276	0.030	0.22	0.35	23	10 819

Table 3.13 - Summary measurements for *Fenestella* sp Abbreviations as for Table 3.1, all measurements in millimetres.

Internal features - Autozooecial chambers are of probable intermediate size, and biserially emplaced, with chambers of each row either adjacent to each other or alternating. The axial wall is straight. Chamber outline is quadrangular throughout the depth of the chamber, becoming slightly rounded towards the obverse surface. Where chambers of each row are alternating chamber outline is still usually rectangular, but slightly pentagonal chambers are seen. Chamber length and width is preserved, but chamber depth is unmeasurable. Ratio of mean chamber width to length is 2:5. Three dimensional reconstructed chamber form a quadrangular box. Hemisepta are not seen in these specimens.

Features of reverse and lateral wall budding angles are not preserved. Both granular and lamellar skeletal layers are thin.

Discussion - Specimens from the Wandrawandian Siltstone attributable to *Fenestella* sp. are poorly preserved, with branches commonly crushed destroying some features. The material available is too poor to define a new species, and is not able to be assigned to an existing eastern Australian species. Known only from the Kungurian Wandrawandian Siltstone at Dolphin Point, Ulladulla, New South Wales.
Material - Three specimens from the Wandrawandian Siltstone were available for internal description (UTGD 127523-25).
Range - Kungurian.

Subfamily - POLYPORINAE Vine, 1883

Genus *Mackinneyella* Morozova and Lisitsyn 1996

Type species - *Polypora ornamentata* Shulga-Nesterenko, 1941; Lower Permian; Southern Urals, The Tra-tau Mountain.
Diagnosis - Zoarium with many shapes, meshworks with large fenestrules. Branches wide, straight or slightly sinuous and semicircular in transverse section. Dissepiments are short and wide and free of extra zooecia. Zooecia usually in five to six rows, with seven to fourteen before and three to seven after a bifurcation. In median tangential section zooecia are rhombic or rounded polygonal. Chambers elongated tubular with a poorly separated vestibule. Zooecial apertures rounded surrounded by abundant capillaries and nodes. Ridges are absent from the obverse surface (after Morozova and Lisitsyn, 1996).

Mackinneyella granulosa new species.
Plate 14; Table 3.14

? *Protoretepora ampla* (Lonsdale) WASS (1968), p. 55, pl. 13, fig. 4.
Holotype - UTGD 12758; late Artinskian to early Kungurian beds, West Arm Group, Beaconsfield, Tasmania.
Diagnosis - Zoarium is robust and fragments form flat to undulating outward expansions. Mesh spacing close, branches robust, straight, thick, very wide and flat to gently rounded on the obverse surface. Carina absent and nodes are small and widely spaced. Dissepiments wide, regularly placed and may carry extra zooecia, though a clear area of dissepimental material free of zooecia is always present. Fenestrules are large, ovate and much narrower than the branches. There are 5 to 7 rows of zooecia, with 8 to 9 before and 4 to 5 after, a bifurcation. Apertures are large, circular to distorted elliptical with long axis oriented abaxial distally, and incomplete peristomes. Apertural stylets are poorly developed and small. Obverse stylets are well developed on the obverse surface and are closely spaced. Reverse microstylets are small and abundant.
Autozooecial chambers are large and polyserially emplaced with a zigzag axial wall trace. Autozooecial chamber outline is rhombic to rounded polygonal in mid chamber section. Vestibules are very long and hemisepta are absent. Overall the chamber has a tubular shape. The reverse wall budding angle is slightly variable, with a mean of 49°. Lateral wall budding angles are low and extremely variable, with adaxial mean 4°, and abaxial mean 19.5°. The exterior lamellar skeleton is thick, with the reverse wall lamellar skeleton thicker than the frontal wall lamellar skeleton. The interior granular skeleton is of intermediate thickness.
Description - External features - Zoarium robust and forming a flat to undulating expansion. The overall form of the colony is not known. Mesh spacing is close and regular, except in rapidly bifurcating areas of the zoarium. The branches are robust, straight, very wide, and flat to gently rounded on the obverse surface. Branch spacing is close and regular, with 3.5 to 5.5 in 10 mm. There are 5 to 7 rows of zooecia, with 8 to 9 before and 4 to 5 after, a bifurcation. The dissepiments are wide and approximately equal to branch width and fenestrule length. Ratio of mean dissepiment width to fenestrule length approximately 1:1, but dissepiments are frequently much wider than the length of the associated fenestrule.

Dissepiments are regularly placed and may carry extra zooecia, though a clear area of dissepimental material free of zooecia is always present. The extra zooecia often continue distally down the branch forming a new row of zooecia. Dissepiments are thick and slightly recessed from the obverse and reverse surfaces. Fenestrules are large and ovate with their length more than twice their width. There are 3 to 3.5 fenestrules in 10 mm. Fenestrules are much narrower than the branches, with ratio of mean fenestrule to branch width almost 1:2, and fenestrule width to length also 1:2. Fenestrules appear more circular on the reverse surface with rounding of the reverse surface of the branches.

Mackinneyella granulosa n. sp.	X	SD	Min	Max	N	CV
rows of zooecia	6.091	0.868	5	8	22	14.249
branches in 10 mm	4.350	0.580	3.5	5.5	10	13.328
distance between branch centres	2 405	0.336	1 82	3.1	15	13.990
width branch	1 416	0 254	1	2.1	16	17.912
width dissepiments	1 318	0.375	0 85	2.12	18	28 449
fenestrule length	1.361	0.162	1 06	1 655	17	11 869
fenestrule width	0.659	0.096	0.4	0 8	19	14.524
fenestrules in 10 mm.	3 35	0.242	3	3.5	10	7 210
autozooecial apertures in 5 mm	12.5	0 667	11	13	10	5 333
apertures between dissepiment centres	7.289	0.631	6	8	19	8 651
aperture length	0 194	0 017	0.163	0 225	38	8.683
aperture width	0 183	0 010	0 165	0.2	34	5 200
apertural spacing down branch	0.435	0 079	0 325	0 62	42	18 230
apertural spacing across branch	0 342	0.034	0 25	0 4	38	10 061
apertural spacing between branches	0 823	0 086	0 73	0.9	3	10 472
diameter nodes	0 045	0 011	0 03	0.07	11	23 311
spacing of nodes down branch	0 673	0.578	0.31	1 34	3	85 861
width peristome	0 016	0.004	0 01	0.025	18	25 825
number of apertural stylets	8.529	1.179	7	10	17	13 821
diameter apertural stylets	0 007	0.002	0.005	0.01	17	29 750
diameter obverse stylets	0 010	0.003	0.005	0.02	40	31.017
spacing obverse stylets	0.027	0 008	0.0125	0 0425	35	28.357
diameter reverse microstylets	0 009	0.002	0.0025	0 015	60	28.597
spacing reverse microstylets	0 021	0.005	0 01	0.035	57	22 323
thickness reverse wall granular layer	0 013	0 003	0.01	0 02	33	25 653
thickness lateral wall granular layer	0.017	0 005	0.01	0 0275	28	29.606
thickness frontal wall laminated layer	0.687	0 142	0.49	0.89	11	20 711
thickness reverse wall laminated layer	0.953	0 296	0.7	2.01	18	31 015
chamber length	0.371	0 063	0.3	0.57	39	16 932
chamber depth	0 41	0 026	0 38	0 44	4	6.298
maximum chamber width	0 234	0.024	0.2	0 295	23	10 116
minimum chamber width	0 103	0 035	0.02	0.16	23	33 800
vestibule length	0 494	0.074	0.44	0.62	5	14 985
budding angle reverse chamber wall	48.571	6 451	41	59	7	13.282
budding angle lateral chamber wall ad	3.556	4.035	0	11	9	113 472
budding angle lateral chamber wall ab	19 5	7 778	14	25	2	39 888
branch thickness	2.475	0 649	1 64	3.2	4	26 213

Table 3.14 - Summary measurements for *Mackinneyella granulosa* n. sp. Abbreviations as for Table 3.1, all measurements in millimetres.

Autozooecial apertures open parallel to the plane of the obverse surface, with incomplete peristomes. Apertures are regularly spaced, with 7 to 8 between dissepiment centres, and 11 to 13 in 5 mm. Ratio of mean spacing down branch to across branch approximately 5:4, down branch to between branches approximately 1:2, and across to between branches 2:5. Apertures are large, circular to elliptical with long axis oriented abaxial distally, although at times may diverge from this at a variety of angles. Apertural stylets are poorly developed and small, and not always readily visible.

A carina is not present and nodes are small and generally widely spaced, such that there is little to raise the surface profile. Stylets are well developed on the obverse surface. They are of small to intermediate size and close to intermediate spacing. On the reverse surface microstylets are small and abundant, and closely spaced. Reverse macrostylets are absent.

Internal features - Branches are ovate in cross section and very thick. The shape of the branch does much to distort branch and fenestrule width if these measurements are taken in thin section. Ratio of mean branch width to thickness approximately 3:5, with long axis perpendicular to the zoarial surface.

Autozooecial chambers are large, with their greatest dimension parallel to proximal and distal lateral walls. Emplacement of chambers is polyserial with a zigzag axial wall trace in mid to deep section, sinuous near the obverse surface. Autozooecial chamber outline is rhombic to rounded polygonal in section near the reverse wall and at mid chamber. Near the surface chambers are ovate. Chamber dimensions are irregular except for chamber width. Ratio of mean minimum to maximum width approximately 3:7, maximum width to depth almost 3:5 and depth to length 11:10. Apertures are located distally to the chambers and connected by a long vestibule. Vestibules are very long owing to a thick frontal laminated wall, but are poorly defined. Hemisepta are absent. Three dimensional reconstructed chamber form an elongate polygonal tube.

The reverse wall budding angle ranges from 41° to 59°, with a mean of 49°. Lateral wall budding angles are low, with adaxial chambers ranging from 0° to 11° (mean 4°), and abaxial chambers ranging from 14° to 25° (mean 19.5°).

The exterior lamellar skeleton is thick, with the reverse wall lamellar skeleton thicker than the frontal wall lamellar skeleton. The interior granular skeleton is of intermediate thickness, but the reverse wall granular layer has unusual preservation in all specimens. The outline of the zooecial chamber may be formed by the lamellar skeleton, and it almost appears that the chamber has come through the granular skeleton removing all trace of it. The cause of this is not known, but may be the result of brood chambers forming within an autozooecial chamber.

Discussion - The description of *Mackinneyella* (Morozova and Lisitsyn, 1996) states that the dissepiments are free of zooecia. Dissepiments may occasionally carry extra zooecia, that are forming part of a new zooecial row, but this is rare. Dissepimental material is always present between the rows and zooecia are not continuous as in *Protoretepora.*

Mackinneyella granulosa is similar in appearance to *M. hinganensis* (Romantchuk) but has a larger mesh size than the later, and is further distinguished from many Russian species by the large mesh size and wide dissepiments.

This species along with *Parapolypora boraformis* and other indeterminate *Parapolypora* spp. have in the past been grouped within *Parapolypora ampla* because of a large mesh size and many rows of zooecia. This study has clearly shown the separation of specimens into different species and genera.

Types - UTGD 127158 holotype, late Artinskian to early Kungurian; UTGD 121759 and 127161 paratypes Kungurian to Ufimian; all from West Arm Group, Beaconsfield, Tasmania.

Etymology - Named for the large abundant obverse stylets.

Material - Specimens of *Mackinneyella granulosa* able to be examined internally are recorded only from the late Artinskian to Ufimian West Arm Group (UTGD 127159-61). However mold specimens from the Artinskian Counsel Creek Formation (UTGD 127162), and the Artinskian to Kungurian Deep Bay Formation (127163), are comparable in measurements of branches, fenestrules, and zooecial row number, spacing and apertural size. These units are of comparable age and the mold specimens may also be of this species. Also comparable on external measurements is *Protoretepora ampla* (CPC 7026) of Wass (1968), from the Artinskian of the Bowen Basin, Queensland. The specimen is clearly not *Parapolypora ampla* as redefined in this study, and from external measurements is most comparable to *M. granulosa.* As yet this specimen has not been examined for its internal structure so placement in this species can not be confirmed.

Range - Artinskian ? to Kungurian.

Genus *Parapolypora* Morozova and Lisitsyn, 1996

Type species - *Parapolypora sparsa* (Morozova, 1970) Upper Permian, Kazanian Stage; Russian Platform.

Diagnosis - Colonies large, fan-shaped, lamellar or funnel-shaped. Fenestrules are large and oval to elongate oval. Branches are wide and oval in cross section, joined by wide zooecia free dissepiments. Zooecia in 5 to 6 rows, 7 to 12 before and 3 to 5 after a bifurcation. Zooecial chambers hexagonal in median tangential section, and tubular in overall form and always overlap the subsequent. Vestibule poorly developed and hemisepta absent. Zooecial apertures circular. Obverse surface without carinae, but has numerous minute stylets and nodes (after Morozova and Lisitsyn, 1996).

Parapolypora ampla (Lonsdale 1844)
Plate 15; Table 3.15

Fenestella ampla LONSDALE, in Darwin (1844), p. 163.
(non) *Fenestella ampla* Lonsdale, LONSDALE in Strzelecki (1845), p. 268, pl. IX, fig. 3b & 3c.
(non) *Protoretepora ampla* (Lonsdale) Etheridge (1892), p. 221.(non) LASERON (1918), p. 189, pl. IV.(non) CROCKFORD (1941a), p. 406. pl. XIX, fig. 4, text-fig 2. (non) WASS (1968), p. 55, pl. 13, fig. 4.
Polypora ampla (Lonsdale) SMITH *et al.* (in prep).

Diagnosis - Zoarium is robust, overall form infundibuliform with the celluliferous surface internal. Mesh spacing is close with very wide branches and short dissepiments. There are 5 to 6 rows of zooecia, with up to 7 to 9 shortly before and 3 to 4 after branching. There are 4.5 to 6.5 branches and 4 to 5 fenestrules in 10 mm. Branches are extremely wide and are ovate in cross section. Branches are usually straight, although those at the base of the zoarium or associated with rapid expansion are commonly curved. Dissepiments are very short and are without consistent extra rows of zooecia, but commonly one or two extra zooecia may be found on the dissepiments or the lateral rows may bend onto them. Fenestrules are large and ovate to elliptical.

Autozooecial apertures are large, circular to slightly oval with incomplete peristomes. Apertural stylets are poorly developed. Obverse stylets are abundant and surround the apertures in sinuous rows. Nodes are not present on the obverse surface. Autozooecial chambers are large with the chamber outline regularly hexagonal in mid tangential section.

Description - External features - Zoarium robust, with overall form infundibuliform with the celluliferous surface internal, and fragments forming an undulating outward expansion,. There are 5 to 6 rows of zooecia, with up to 7 to 9 shortly before and 3 to 4 after branching. In areas of rapid expansion the rapid increase in rows and therefore branch width and fenestrule dimensions associated with branching cause the usually close mesh spacing to be somewhat irregular.

Branches are extremely wide and usually straight, although those at the base of the zoarium or associated with rapid expansion are commonly curved. Branches have a gently rounded surface profile, and the obverse surface is without a carina. Branch spacing is very close, and distance between branch centres is generally regular. There are 4.5 to 6.5 branches in 10 mm. Dissepiments are of intermediate width, and are usually narrower than the branches. Dissepiments are very short, thick and only slightly recessed from the reverse and obverse surfaces. The dissepiments are without clear extra rows of zooecia, but occasionally one or two extra zooecia may be found on the dissepiments or the lateral rows may bend onto them. At all times there is distinct dissepimental material free of any zooecia between the branches. Fenestrules are large and ovate to elliptical, with 4 to 5 in 10 mm. Fenestrules are narrow with fenestrule to branch width, and width to length ratios of approximately 1:2.

Autozooecial apertures are circular to slightly oval and very large. Apertures are regularly spaced down the branch with usually 5 between dissepiment centres, and 9 to 12 in 5 mm. Ratio of mean apertural spacing down to across branches 5:4, down to between branches 7:10, and across to between branches approximately 3:5. Apertures of the central rows open parallel to the plane of the obverse surface, with lateral rows gently inclined towards the fenestrules. Incomplete peristomes are present, upon which a few poorly developed apertural stylets are seen. Not all apertures reveal stylets and where they are present they do not form a complete circle. Often they appear to only be obverse stylets developed very close to the rim of the aperture. Terminal diaphragms are present and appear sporadically throughout the zoarium.

The obverse surface is without either carina or nodes. Obverse stylets are abundant and of intermediate size and wide spacing, surrounding the apertures in sinuous rows. In the deepest part of the obverse surface where apertures can be distinguished from chambers sinuous low longitudinal ridges occur between the rows. These are not seen in the uppermost part of the obverse surface. Reverse microstylets are of variable size, ranging from small to upper end intermediate, and are evenly widely spaced across the reverse surface, though aligned in rough rows along the longitudinal striae. Stylets of obverse and reverse surfaces are of similar size and spacing. Macrostylets are absent.

Three dimensional reconstructed form a short hexagonal tubular box.

Parapolypora ampla	X	SD	Min	Max	N	CV
rows of zooecia	5.047	1.022	3	9	43	20.261
branches in 10 mm.	5 398	0.601	4.5	6 5	22	11 132
distance between branch centres	1.835	0.276	1 33	2 35	19	15 052
width branch	1.295	0 203	0.85	1 65	31	15.666
width dissepiments	1.003	0.167	0 66	1.36	40	16 689
fenestrule length	1 358	0 263	0 92	1.95	37	19 326
fenestrule width	0.599	0 094	0.45	0.83	36	15.680
fenestrules in 10 mm.	4.524	0.361	4	5	21	7.990
zooecial apertures in 5 mm	10.296	0 763	9	12	27	7 409
apertures between dissepiment centres	5 224	0 396	4 5	6	49	7 581
aperture length	0.238	0.014	0.2	0 27	35	6 036
aperture width	0.211	0.025	0 16	0.27	42	11.888
apertural spacing down branch	0.479	0.043	0.4	0.58	59	9 023
apertural spacing across branch	0.388	0.047	0 3	0 54	51	12.015
apertural spacing between branches	0.693	0 190	0.36	1.14	26	27 463
width apertural peristome	0.014	0.004	0.01	0 02	10	31 000
number of apertural stylets	7.25	4.031	3	12	4	55 602
diameter apertural stylets	0 012	0 003	0.008	0.015	13	21.235
diameter obverse stylets	0.016	0 004	0.01	0.025	50	23.569
spacing obverse stylets	0.059	0 018	0.03	0.1	50	30.659
diameter reverse microstylets	0.013	0.005	0 005	0 023	33	36 208
spacing reverse microstylets	0.056	0.018	0 03	0.09	31	32 222
thickness reverse wall granular layer	0.013	0.004	0.008	0.025	46	29 570
thickness lateral wall granular layer	0.016	0.004	0 01	0 025	35	27 433
thickness frontal wall laminated layer	0 228	0.079	0.13	0.38	31	34 524
thickness reverse wall laminated layer	0.283	0 073	0.13	0.38	17	25.957
chamber length	0.446	0 046	0 375	0.54	50	10.280
chamber depth	0.420	0 044	0.34	0 47	14	10 392
maximum chamber width	0.267	0.028	0.21	0 33	54	10 425
minimum chamber width	0.093	0.035	0.02	0 2	53	37 805
vestibule length	0.234	0.040	0.18	0 3	13	16 985
budding angle reverse chamber wall	53 647	6.461	42	66	17	12 043
budding angle lateral chamber wall ad	3.818	3 219	0	10	11	84.314
budding angle lateral chamber wall ab	16.182	4 895	10	24	11	30 252
branch thickness	1 074	0 083	0.92	1.2	14	7 692

Table 3.15 - Summary measurements for *Parapolypora ampla* (Lonsdale). Abbreviations as for Table 3 1, all measurements in millimetres

Internal features - Branches are very thick and ovate to elliptical in cross section, with the reverse surface more rounded than the obverse, and plane of elongation parallel to the obverse reverse surfaces. Mean width to thickness ratio 6:5.

Autozooecial chambers very large, with chamber length only slightly greater than depth. Greatest dimension (length) is parallel to the plane of the reverse surface. Autozooecial chamber outline is diamond shaped to hexagonal near the reverse surface, regularly hexagonal in mid tangential section, and elliptical to ovate near the obverse surface. Apertures are located distally, and connected to the chamber by a slightly variable long vestibule. Apertures of outermost rows are located abaxial-distally. Hemisepta are absent.

Chamber dimensions are regular, except for minimum chamber width which is extremely variable. Ratio of mean minimum to maximum width approximately 1:3 (range < 1:10 to 3:4), maximum width to depth ratio approximately 2:3, and depth to length ratio 9:10. Three dimensional reconstructed form a short hexagonal tubular box.

The interior granular skeleton is thick without apparent astogenetic thickening. The exterior lamellar skeleton is of intermediate thickness.

Discussion - *Parapolypora ampla* (Lonsdale) is distinguishable from *P. boraformis* n. sp. which has similar mesh and zooecial number by the distinct apertural stylets and nodes of that species. *Parapolypora ampla* is similar in appearance to the type species *P. sparsa* (Morozova, 1970), but varies in the number of branches, fenestrules and zooecial spacing.

The name "ampla" has been invariably used for many large meshed polyporids. This study has shown however that *Parapolypora ampla* itself is limited to the Sakmarian (Bundella Mudstone) and is replaced in younger beds by other species. This species is recorded only from the Sakmarian Bundella Mudstone by this author, from the shoreline below Porter's Hill, Lower Sandy Bay (127499-501), and roadcuts on the Lyell Highway near Granton, Hobart (UTGD 127502.

Material - UTGD 25080 (neotype), UTGD 127499-502.

Range - Sakmarian.

Remarks - It is believed Darwin collected his specimens from the Bundella Mudstone at Lower Sandy Bay (Smith *et al.*, in prep.). The neotype of Smith *et al.* (in prep.) closely matches the description of *Fenestella ampla* by Lonsdale (1844), and is collected from Bundella Mudstone, Lower Sandy Bay. The number of rows and internal features distinguish this species as *Parapolypora* rather than *Fenestella* as originally designated by Lonsdale in Darwin (1844).

Strzelecki also collected bryozoan specimens from Tasmania, including specimens placed in *Fenestella ampla* by Lonsdale in Strzelecki (1845). Confusion arises with *Fenestella ampla* Lonsdale (1844) being used as types species for *Protoretepora* de Koninck from reclassification of Strzelecki's specimens. However these are subsequent specimens and the specimen concerned (*F. ampla* Lonsdale in Strzelecki (1845) Pl. IX, fig. 3b) is wrongly assigned to *F. ampla* Lonsdale (1844). Lonsdale figured only one of Darwin's *F. ampla* specimens in Strzelecki (1845), this being fig. 3, Pl. IX, not Pl. IX fig. 3b. The other specimens figured are Strzelecki's not Darwin's, as stated by Crockford (1941a). Specimen fig. 3b of Lonsdale in Strzelecki (1845) is therefore misidentified, and whilst it is clearly *Protoretepora*, it should not be given the name *Protoretepora ampla.*

Parapolypora boraformis n.sp.
Plate 16; Table 3.16

Holotype - UTGD 127156 - Sakmarian; Bundella Mudstone, Lower Sandy Bay, Hobart, Tasmania.

Diagnosis - Zoarium is robust, infundibuliform internal, with mesh spacing close and regular. Branches are straight, very wide and flat on the obverse surface, with 4.5 to 6.5 branches in 10 mm. There are 4 to 6 rows of zooecia, up to 7 or 8 before and 3 to 4 after a bifurcation. Dissepiments are regularly placed and are without extra rows of zooecia, though the rows from the branch may bend onto the dissepiments, but dissepimental material is still clearly present. Fenestrules are large and elongate oval with 4 to 5 in 10 mm vertically. Zooecial apertures are large and circular to slightly oval often closed by a flat terminal diaphragm. There are 5 to 6 zooecial regularly spaced apertures per fenestrule, with 9 to 11 in 5 mm. Apertures open parallel to the plane of the obverse surface. Peristomes are distinct with 13 to 19 distinct apertural stylets surrounding each aperture. The obverse surface is without a carina. Nodes of variable size and spacing are present between zooecial apertures. Obverse stylets are distinct and of intermediate size and reverse microstylets are small and abundant. Branches and dissepiments are evenly rounded on the reverse surface, with many coarse longitudinal striae.

Autozooecial chambers are large, with depth slightly greater than length. Chambers are polyserially emplaced with a zigzag to sinuous axial wall trace. Autozooecial chamber outline regularly pentagonal at mid chamber level. Three dimensional chamber form is a narrow hexagonal box. Reverse wall budding angle is slightly variable, (mean 52°). Lateral wall budding angles are low for both adaxial (mean 3°), and abaxial chambers (mean 8°).

Parapolypora boraformis n. sp.	X	SD	Min	Max	N	CV
rows of zooecia	4.765	0 664	4	6	17	13 940
branches in 10 mm.	6.25	0 957	5	7	4	15 319
distance between branch centres	1.607	0.214	1.3	1.96	25	13.286
width branch	1.168	0 278	0.87	1.86	21	23 817
width dissepiments	0.917	0 090	0.76	1.1	28	9 810
fenestrule length	1.035	0 143	0.825	1 32	25	13 840
fenestrule width	0.503	0.111	0.36	0.8	26	22 003
fenestrules in 10 mm.	5	0	5	5	3	0
apertures between dissepiment centres	5.118	0 376	4.5	6	17	7 351
aperture length	0.194	0.013	0.165	0 215	20	6 918
aperture width	0.172	0.011	0.155	0 19	20	6 628
apertural spacing down branch	0 426	0 051	0.35	0.54	33	11 970
apertural spacing across branch	0.315	0 027	0.26	0.37	38	8 488
apertural spacing between branches	0.569	0.127	0 31	0 82	35	22 332
diameter nodes	0.110	0 041	0 04	0.2	27	36 780
spacing of nodes down branch	0 479	0.117	0 23	0.69	23	24 455
diameter obverse stylets	0.012	0 002	0.01	0.015	20	16 169
spacing obverse stylets	0.088	0 048	0 025	0 2	20	54 605
number of apertural stylets	16.357	1 692	13	19	14	10 344
diameter apertural stylets	0.011	0 003	0.005	0.02	20	28 157
diameter reverse microstylets	0.011	0.006	0 005	0.03	34	53.783
spacing reverse microstylets	0 048	0.021	0 02	0 11	28	42 460
thickness reverse wall granular layer	0.017	0.003	0.013	0.02	17	15 746
thickness lateral wall granular layer	0 011	0.002	0.008	0 015	13	19 481
thickness frontal wall laminated layer	0 195	0 029	0.12	0.25	20	14 748
thickness reverse wall laminated layer	0 306	0 059	0 23	0.42	11	19 378
chamber length	0.372	0.032	0.31	0.46	32	8.708
chamber depth	0.401	0.024	0.36	0.43	11	5 951
maximum chamber width	0.209	0.019	0.18	0 25	29	9 024
minimum chamber width	0.089	0 026	0.03	0 14	29	29 169
vestibule length	0.265	0 044	0.21	0 34	10	16 521
budding angle reverse chamber wall	51.2	6.713	41	63	10	13 112
budding angle lateral chamber wall ad	3	2.082	0	5	7	69 389
budding angle lateral chamber wall ab	12.286	5.438	6	22	7	44 262
branch thickness	0.769	0.088	0 6	0 91	12	11 428

Table 3.16 - Summary measurements for *Parapolypora boraformis* n sp Abbreviations as for Table 3.1, all measurements in millimetres

Description - External features - Zoarium robust and infundibuliform with zooecia internal, and a undulating outwardly expanding surface. Mesh spacing is close and regular.

Branches are very wide with a straight proximal trace. Branch width is variable according to the number of rows, and position relative to bifurcation. The obverse surface is flat to very gently rounded, the wider the branch and greater the number of rows the flatter the profile of the obverse surface. The obverse surface is without a carina. Branches widen gradually as the number of rows of zooecia increase. Branch spacing is close and regular with 4.5 to 6.5 branches in 10 mm horizontally. There are 4 to 6 rows of zooecia, up to 7 or 8 before and 3 to 4 after a bifurcation. Dissepiments are short, regularly placed and of intermediate width. Dissepiments are usually narrower than the branches, except where branches narrow after bifurcation. Dissepiments are without extra rows of zooecia, though the rows from the branch may bend onto the dissepiments, and dissepimental material is still clearly present. Dissepiments may be as wide as the length of the associated fenestrule. Ratio of mean dissepiment width to fenestrule length is 9:10. Fenestrules are large and elongate oval with 4 to 5 in 10 mm. Fenestrules are much narrower than the branches, ratio of mean fenestrule to branch width approximately 2:5, and fenestrule width to length ratio 1:2. The reverse surface of the branch is rounded, and fenestrules may appear more circular near the reverse surface.

Autozooecial apertures are large and circular to slightly oval. Zooecial apertures are often closed by a flat terminal diaphragm, constructed of lamellar skeletal material with a small central core of granular skeletal material. Terminal diaphragms apparently occur in all areas of the zoarium. There are 5 to 6 zooecial apertures between dissepiment centres, with 9 to 11 in 5 mm. Aperture spacing is regular to slightly variable within each branch, but quite variable between branches as lateral zooecial rows bend onto dissepiments. Ratio of mean apertural spacing down to across branch 4:3, down to between branches 3:4, and across to between branches approximately 1:2. Apertures open parallel to the plane of the obverse surface, with abaxial rows only slightly inclined towards the fenstrule. Peristomes thin, complete and well developed, with 13 to 19 distinctive apertural stylets surrounding each aperture.

Nodes are present on the obverse surface between zooecial apertures. Nodes are of variable intermediate size and spacing. Node shape varies from circular to oval to angular. Sinuous ridges occur between rows of zooecia within the frontal wall but are not present at the surface. Obverse stylets are distinct and of intermediate size. They are generally widely spaced, but spacing is somewhat variable across the obverse surface. Obverse stylets are generated deep within the frontal wall laminated layer. On the reverse surface macrostylets are absent, but microstylets are abundant, small and widely spaced, though are more closely spaced than stylets of the obverse surface. On the reverse surface branches and dissepiments are evenly rounded, with many coarse longitudinal striae.

<u>Internal features</u> - In cross section the branches are elliptical to ovate and very thick, with plane of elongation parallel to obverse reverse surface, and a branch width to thickness ratio of 3:2.

Autozooecial chambers are large, with depth slightly greater than length. Chambers are polyserially emplaced with a zigzag axial wall trace near the reverse wall, becoming sinuous towards the obverse surface. Autozooecial chamber outline is pentagonal to diamond shaped near the reverse wall, pentagonal at mid chamber level and pentagonal-ovate near the obverse surface. Apertures are located distally, outermost rows abaxial distal, connected by a long poorly defined vestibule. Chamber dimensions are regular except for minimum width which is highly variable in response to the change from diamond to pentagonal chamber shape. Ratio of mean chamber minimum to maximum width 2:5, maximum width to depth approximately 1:2, and depth to length almost 11:10. Three dimensional chamber form a narrow hexagonal box.

Reverse wall budding angle is slightly variable, with a range of 41° to 63° (mean 52°). Lateral wall budding angles are low for both adaxial and abaxial chambers. Adaxial lateral wall budding angle range is 0° to 5° (mean 3°), abaxial range 6° to 10° (mean 8°).

Discussion - *Parapolypora boraformis* is very similar to *P. ampla* in mesh size and row number, and occurs within the same lithologic unit. They can be distinguished by the presence of distinct apertural stylets and nodes in *P. boraformis*, and the flatness and general appearance of the obverse surface in tangential section. The exterior lamellar skeleton is also thicker in *P. boraformis* than in *P. ampla*.

Types - UTGD 127156, holotype, and UTGD 127157, paratype.
Etymology - Named for the distinctive apertural stylets. The term "bora" is Aboriginal for a ring of stones or poles.
Range - Sakmarian.

Parapolypora sp. A
Plate 17, Figures 1-3; Table 3.17

Diagnosis - Colony form is unknown, but fragments are robust and form flat outward expansions with close mesh spacing. Branches are thick, robust, wide and straight, with a flat to gently rounded surface profile. The obverse surface is without a carina, and nodes are not observed. Zooecia are in usually 5 rows, with up to 8 before and 3 to 4 after bifurcation. Dissepiments are narrow, width less than half the width of the branches, and without extra zooecia. Fenestrules are oval to subrectangular and large. Apertures are very large and regularly spaced with about 5 between dissepiment centres. Preservation of obverse skeletal structure poor but obverse stylets appear abundant and closely spaced.
Autozooecial chambers are large, polyserially emplaced, with a zigzag axial wall trace. Chamber outline is pentagonal at mid chamber level. Lamellar skeletal structure thick on both reverse and frontal surfaces.

Parapolypora sp. A	X	SD	Min	Max	N	CV
rows of zooecia	5.182	0.588	4	6	22	11.357
distance between branch centres	1 987	0 270	1.56	2.48	14	13.577
width branch	1.296	0.153	1.06	1.64	16	11 820
width dissepiments	0.643	0.119	0.36	0.9	19	18 521
fenestrule length	1.417	0 225	1	1 86	14	15 869
fenestrule width	0.682	0.139	0.4	0.84	13	20 382
apertures between dissepiment centres	4.917	0.359	4	5.5	12	7 299
aperture length	0.241	0 012	0.22	0.26	10	4 870
aperture width	0.221	0.022	0.18	0.26	10	10 053
apertural spacing down branch	0 441	0 047	0.37	0 52	18	10 688
apertural spacing across branch	0.361	0.039	0.32	0 44	18	10.908
diameter obverse stylets	0.024	0 007	0.015	0.035	7	29 463
diameter reverse microstylets	0.016	0.004	0 01	0 02	9	23 808
spacing reverse microstylets	0.098	0.028	0.06	0.14	11	28 335
chamber length	0.373	0.034	0.32	0.46	30	9.207
maximum chamber width	0 292	0 021	0.25	0.33	28	7 288
minimum chamber width	0.113	0 032	0 04	0 18	26	28 526
branch thickness	1.138	0.089	1.01	1.24	5	7 796

Table 3.17 - Summary measurements for *Parapolypora* sp. A. Abbreviations as for Table 3.1, all measurements in millimetres.

Description - External features - Zoarium is robust, forming flat outward expansions that branch rapidly with branches curving toward outer edge. Mesh spacing is close and slightly variable. Branches are robust, wide and straight and closely spaced. The surface profile is flat to gently rounded. The obverse surface is without a carina, and nodes are not observed. Zooecia are in usually 5 rows, with up to 8 before and 3 to 4 after bifurcation. Dissepiments are narrow, width less than half the width of the branches, and without extra zooecia and neither do lateral rows bend onto dissepiments. Dissepiments are thick and recessed from the reverse surface. Fenestrules are oval to subrectangular and large. Fenestrules are narrower than the branches, mean ratio fenestrule to branch width approximately 1:2, fenestrule width to length ratio also approximately 1:2.
Apertures are very large and more or less circular. Apertures are inclined slightly towards the fenestrules and indent them. Apertures are regularly spaced with about 5 between dissepiment centres. The ratio of mean spacing down branch to across branch is 6:5.
Preservation of obverse skeletal structure poor but obverse stylets appear abundant and

closely spaced.

Internal features - Branches are thick and oval in outline with long axis parallel to the obverse surface. Ratio of mean branch width to thickness 9:8. Autozooecial chambers are large, polyserially emplaced, with a zigzag axial wall trace. Chamber outline is pentagonal to diamond shaped near the reverse surface, pentagonal at mid chamber level and rounded pentagonal to oval near the obverse surface. Chamber length is greater than maximum width and dimensions are regular, with minimum width variable. Chamber depth is not accurately known but is probably about equal to chamber length. Apertures are distally placed on the chambers, abaxial distal for outermost rows, and are connected by a long vestibule.

Lamellar skeletal structure thick on both reverse and frontal surfaces.

Discussion - Specimens of this species are poorly preserved, being either significantly recrystallised and/or weathered, and details of obverse reverse stylets, apertural stylets, nodes, etc. are obscured or lost. Therefore while the mesh characteristics define this species as distinct, all of its features cannot be seen for formal description. *Parapolypora* sp. A is distinguished from all other Tasmanian species of *Parapolypora* by the narrow dissepiments and number of rows of zooecia and zooecial spacing. *Parapolypora* sp. A is very similar to *P. ampla*, and is distinguished only by dissepiment width and a slightly more open mesh spacing of the former.

Material - UTGD 127503 Sakmarian Bundella Mudstone, and UTGD 127504-5 from the Artinskian Berriedale Limestone.

Range - Sakmarian to Artinskian.

Parapolypora sp. B

Plate 17, Figures 4-5; Table 3.18

Diagnosis - The overall form of the colony is not known, but fragments are robust and form flat outward expansions, with close regular mesh spacing. Branches are robust, very wide, with a straight to very slightly sinuous proximal trace, with a flattened oval cross section. Dissepiments are short and wide, of similar width to the branches. Fenestrules are large and elongate oval and regularly sized. Autozooecial apertures are large, circular to oval and regularly spaced with 6 to 7 between dissepiment centres. Apertures have wide complete peristomes, and are surrounded by many apertural stylets. The obverse surface is without a carina but large widely spaced nodes are present. Obverse stylets are of intermediate size and spacing.

Autozooecial chambers are of intermediate size, with axis of elongation parallel to the reverse surface. Chamber outline hexagonal at mid chamber level. Both lamellar and granular skeletal layers are thick.

Description - External features - The overall form of the colony is not known, but fragments are robust and form large flat outward expansions. Mesh spacing close and regular. Branches are robust and very wide, with a straight to very slightly sinuous proximal trace, with a flattened to gently rounded surface profile. Branch spacing is close and regular, with 6.5 to 8 branches in 10 mm. Dissepiments are short and wide, of similar width to the branches. Dissepiment width and spacing are regular. Fenestrules are large and elongate oval and regularly sized, with 4 to 5 in 10 mm. Fenestrule width is narrow, with ratio of mean fenestrule to branch width approximately 4:7, and ratio of mean fenestrule width to length approximately 1:3.

Autozooecial apertures are large and circular to oval, and regularly spaced with 6 to 7 between dissepiment centres, and 12 to 14 in 5 mm. Ratio of mean spacing down branch to across branch approximately 7:5. Accurate measurements of aperture spacing between branches are not available, but are more widely spaced than spacing both down and across branch. Apertures have wide complete peristomes, and are surrounded by many apertural stylets.

The obverse surface is without a carina but large widely spaced nodes are present. Obverse stylets are of intermediate size and spacing. Details of the reverse surface are not available.

Internal features - Branches are thick and flattened oval in cross section, with axis of elongation parallel to the obverse surface. Few measurements of chamber dimensions are available, but chambers where seen are of intermediate size, with axis of elongation parallel to the reverse surface. Ratio of mean minimum to maximum width 1:3, maximum width to depth 4:5, and chamber depth to length 3:5. Chamber outline diamond shaped to hexagonal near the reverse surface, hexagonal at mid chamber level and rounded hexagonal to oval near the obverse surface. Both lamellar and granular skeletal layers are thick.

Parapolypora sp. B	X	SD	Min	Max	N	CV
rows zooecia	5.1	0.994	4	7	10	19.499
branches in 10 mm.	7.25	0 524	6 5	8	6	7.233
width branch	0.986	0 124	0.775	1 2	10	12.630
width dissepiments	0.978	0 125	0.775	1 2	10	12.785
fenestrule length	1.488	0 213	1.15	1.825	10	14.288
fenestrule width	0 55	0.05	0.475	0.625	10	9 091
fenestrules in 10 mm.	4.525	0.416	4	5	10	9.190
zooecial apertures in 5 mm.	12.6	0 894	12	14	5	7 099
apertures between dissepiment centres	6.429	0.450	6	7	7	6 998
aperture length	0.217	0.012	0.2	0.24	13	5 764
aperture width	0.173	0.012	0.16	0.195	10	7 106
apertural spacing down branch	0 413	0.035	0 363	0.463	10	8 451
apertural spacing across branch	0.287	0.027	0 26	0.34	7	9 369
chamber length	0.358	0 026	0.32	0.4	9	7 317
chamber depth	0.22	0 014	0.21	0.23	2	6.428
maximum chamber width	0.173	0 013	0.145	0.185	8	7 267
minimum chamber width	0.06	0 019	0 02	0 08	8	32 121

Table 3 18 - Summary measurements for *Parapolypora* sp B. Abbreviations as for Table 3 1, all measurements in millimetres.

Discussion - Only one specimen is available and is quite crushed and poorly preserved. However enough detail is visible to determine this species as distinct from other Tasmanian species of *Parapolypora*. *Parapolypora* sp. B is distinguished from *P. boraformis* which also has distinct apertural stylets by its larger mesh size and apertural spacing. Distinguished from *Parapolypora* sp. *A* and *P. ampla* by its mesh size and the presence of distinct apertural stylets.
Material - Only one specimen recorded (UTGD 127506) from the Artinskian Counsel Creek Formation, Maria Island, Tasmania.
Range - Artinskian.

Genus *Paucipora* Termier and Termier, 1971

Type species - *Polypora hemiseptata* Shulga-Nesterenko, 1951; Middle Carboniferous, Moscovian Stage, Myachkovskian Horizon, Moscow Depression.
Diagnosis - Colonies fan-shaped, fenestrules medium size, branches straight and rounded in cross section. Dissepiments are free of extra zooecia. Zooecia in 2 to 4 rows, with 4 to 6 before, and 2 to 3 after, bifurcation. Two rows may be held almost for the full length of the branch. Median row of zooecial chambers narrow hexagons in median section, lateral rows rounded quadrate. Chambers are intersected by well developed superior and inferior hemisepta, which often almost completely cross the chamber dividing it into three parts. Overall chamber shape box shaped. Zooecial apertures circular and rows separated by thin ridges with small nodes (after Morozova and Lisitsyn, 1996).

Paucipora ulladullaensis n. sp.
Plate 18; Table 3.19

Holotype - UTGD 127565 - Kungurian; Wandrawandian Siltstone, North Head, Ulladulla.
Diagnosis - Zoarium of intermediate robustness, mesh spacing close and regular. Branches

are robust, wide and closely spaced with a straight to sinuous proximodistal. Surface profile is flat to gently rounded. Zooecia are in 2 to 4 rows, with 2 rows held for some distance after bifurcation, and 4 only immediately before bifurcation.

Dissepiments are short and of intermediate width, but width is increased by astogenetic thickening. Dissepiments are emplaced at regular intervals perpendicular to the branches and are free of zooecia. Fenestrules are of intermediate to large size, and elliptical in shape. On the front surface of the branch are narrow carinae between the rows of zooecia, with small nodes along their midline. The front surface of the branch is evenly covered in small closely spaced obverse stylets. Reverse microstylets are also small and closely spaced. Reverse macrostylets are absent.

Autozooecial apertures are circular and evenly spaced with 3 to 4 between dissepiment centres. Apertures open parallel to the obverse surface, and are surrounded by a thin complete peristome. Apertures are often closed by a terminal diaphragm.

Autozooecial chambers are large, with greatest dimension parallel to the distal and proximal lateral walls. Chambers are biserial to polyserially emplaced, with a gently sinuous axial wall trace. Chamber outline is narrowly hexagonal at mid chamber level. Reconstructed three dimensional chamber form an elongated polygonal tube. Intermediate to long vestibules are present. Hemisepta are well developed, and can be seen to divide the chamber. Superior hemisepta are developed about the base of the vestibule, with inferior hemisepta developed on the lower part of the distal lateral wall.

Reverse wall budding angles are low but slightly variable (mean 45°). Lateral wall budding angles are highly variable, with mean adaxial budding angle 3°, and abaxial mean 18°. Granular skeletal layer is thin lamellar skeletal layer of intermediate thickness.

Description - External features - Zoarium is of intermediate robustness, overall form unknown but fragments forming flat to outwardly curving expansions. Mesh spacing is close and regular. Branches are robust, wide and closely spaced with 9 to 11 in 10 mm. Branches have a straight to sinuous proximodistal trace and curve toward each other at the level of the dissepiments. Although branches are sinuous, branch spacing and fenestrule dimensions are regular. Surface profile is flat to gently rounded. Zooecia are in 2 to 4 rows, with 2 rows held for some distance after bifurcation, expanding to 3 for much of the branch, and 4 (to 5) only immediately before bifurcation.

Dissepiments are of intermediate width and short. Dissepiment width is influenced by astogenetic thickening, increasing dissepiment width and decreasing corresponding fenestrule length. Dissepiments are emplaced at regular intervals perpendicular to the branches and are free of zooecia. The dissepiments widen slightly at their junction with the branches at mid branch level, but thin and become somewhat bar like at the obverse surface, and are slightly recessed from the obverse and reverse surfaces. Fenestrules are of intermediate to large size, and elliptical in shape. Fenestrule shape and size are constant, with 6 to 7.5 in 10 mm. Fenestrules are narrower than the branches with fenestrule to branch width ratio approximately 2:3, and fenestrule width to length ratio 2:5.

Autozooecial apertures are of regular intermediate to large size and constantly circular. Apertures are evenly spaced with 3 to 4 between dissepiment centres. Ratio of mean spacing along to across the branch approximately 6:5, down branch to between branch ratio 5:6 and across to between branch ratio 7:10. Apertures open parallel to the obverse surface, and are surrounded by a thin complete peristome. Apertures in lateral rows are slightly inclined towards the fenestrules, but do not significantly indent them. Apertural stylets do not appear to be developed. Apertures are often closed by a terminal diaphragm that is below the level of the front surface, with a prominent central knob of granular skeletal material.

On the front surface of the branch are narrow carinae between the rows of zooecia. Where there are 3 rows there are 2 carinae, and where there are 2 rows, a single median carina. Small nodes of intermediate spacing are placed along the midline of the carinae, and are arranged such that where there are 4 rows of zooecia, 4 nodes surround the apertures of the median row. The nodes are of regular size and shape, and are circular to slightly oval, with elongation along the carina. The front surface of the branch is evenly covered in small closely spaced obverse stylets. Reverse microstylets are of similar size and spacing, to those of the obverse surface, and cover the reverse surface of both branches and dissepiments evenly. Reverse macrostylets are absent.

Paucipora ulladullaensis n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	10.1	0.742	9	11	5	7 343
rows of zooecia	2.935	0 629	2	4	31	21 429
distance between branch centres	0.990	0.126	0.76	1 22	20	12 701
width branch	0.635	0.102	0 45	0 87	24	16 048
width dissepiments	0.533	0.098	0 4	0.76	23	18.369
fenestrules in 10 mm.	6 750	0 645	6	7 5	4	9.563
fenestrule length	1 018	0.137	0 78	1.21	24	13 482
fenestrule width	0.412	0.067	0 27	0.6	31	16 337
apertures between dissepiment centres	3.823	0.355	3	4	31	9.279
aperture width	0.149	0.013	0 1225	0.18	33	8 706
apertural spacing down branch	0.433	0.043	0 34	0.5	36	9.837
apertural spacing across branch	0.352	0.048	0 27	0 46	34	13.768
apertural spacing between branches	0 513	0 075	0 39	0.68	31	14.655
width apertural peristome	0.015	0.003	0 01	0.02	34	22 283
width of carina	0 023	0.005	0.015	0.03	14	23 301
diameter nodes	0.060	0 015	0.035	0.09	28	25 400
spacing of nodes down branch	0.474	0 117	0.32	0.71	21	24 735
diameter obverse stylets	0 008	0.002	0 005	0 01	34	22 753
spacing obverse stylets	0 019	0.004	0.01	0 0275	34	19.766
diameter reverse microstylets	0.007	0.002	0.005	0.01	36	23.105
spacing reverse microstylets	0.019	0 005	0 012	0 03	33	25 535
thickness reverse wall granular layer	0.014	0.003	0.01	0 02	19	23 831
thickness lateral wall granular layer	0.016	0.004	0 01	0 021	27	26.060
thickness frontal wall laminated layer	0.230	0 028	0 17	0.285	16	12 117
thickness reverse wall laminated layer	0 260	0.033	0.18	0.325	18	12.829
chamber length	0.263	0 064	0 14	0.37	19	24.210
chamber depth	0.536	0 064	0 44	0.68	17	11 953
maximum chamber width	0.187	0.017	0.16	0.23	30	9 353
minimum chamber width	0.115	0.026	0.04	0 16	31	22.574
vestibule length	0.143	0 035	0 1	0.21	9	24 206
budding angle reverse chamber wall	45.100	5.705	38	57	10	12 649
budding angle lateral chamber wall - ad	3.333	4 031	0	11	9	120 934
budding angle lateral chamber wall - ab	18.444	7.161	5	28	9	38.824
branch thickness	0.880	0.046	0 81	0.97	15	5.185

Table 3.19 - Summary measurements for *Paucipora ulladullaensis* n. sp Abbreviations as for Table 3.1, all measurements in millimetres.

Internal features - Branches are thick and ovate in cross section, with their axis of elongation perpendicular to the obverse reverse surfaces. Ratio of mean branch width to thickness almost 3:4. Autozooecial chambers are large, with greatest dimension parallel to the distal and proximal lateral walls. Chambers are biserial to polyserially emplaced, with a gently sinuous axial wall trace. Chamber outline is narrowly hexagonal near the reverse surface and at mid chamber level, and irregularly elliptical near the obverse surface, with the superior hemisepta causing inflections in the outline. Lateral chambers, or where there are only two rows, have a rounded pentagonal outline. Apertures are placed distally in median rows, and abaxial distal in lateral rows. Vestibules are present and of intermediate to long length. Autozooecial chamber dimensions are all quite variable, except for maximum width. Ratio of mean minimum to maximum width 3:5, maximum width to depth approximately 1:3, and depth to length 2:1.

Hemisepta are well developed, and when chambers are viewed in median tangential section, can be seen to divide the chamber. Superior hemisepta are developed about the base of the vestibule, with inferior hemisepta developed on the lower part of the distal lateral wall.

Reverse wall budding angles are low but slightly variable, with a range of 38° to 57° (mean 45°). Lateral wall budding angles are highly variable, with adaxial budding angle ranging between 0° and 11° (mean 3°), and abaxial ranging between 5° to 28° (mean 18°). Reconstructed three dimensional chamber form an elongated polygonal tube.

Granular skeletal layer is thin and continuous between chamber walls, hemisepta, stylets and carina and nodes. Lamellar skeletal layer is of intermediate thickness, and is of similar thickness on both reverse and frontal walls.

Discussion - *Paucipora ulladullaensis* is the first species of this genus to be described from Australia. It compares closely in external dimensions with *Polypora pertinax* Laseron, but differs in the number of fenestrules and zooecia in a given distance, with zooecia more closely spaced in *P. pertinax*. *P. pertinax* also shows the thin longitudinal ridges between rows, small nodes, and 2 to 4 (or 5) rows of zooecia. However the type material for this species is unavailable for sectioning, restricting close comparison and accurate generic placement. *P. pertinax* types are from the Sakmarian Allandale beds, and along with the mesh differences it is felt the specimens collected from the Kungurian Wandrawandian Siltstone belong to a separate species, here named *Paucipora ulladullaensis*.

Types - UTGD 127565 holotype; UTGD 127566 paratype; both from the Wandrawandian Siltstone, North Head, Ulladulla, New South Wales.

Etymology - Named for the township of Ulladulla.

Range - Kungurian.

Genus *Polypora* M'Coy, 1844

Type species - *Polypora dendroides* M'Coy 1844; Lower Carboniferous, Tournaisian Stage; Ireland.

Diagnosis - Zoarium of various shapes with zooecia opening to one side only. Meshwork is regular with medium to large fenestrules and straight to sinuous branches joined by non-poriferous dissepiments. Zooecia in four rows on the branches with 5 or 6 before, and 2 to 3 for a short distance after bifurcation. In median tangential section zooecial chambers are regularly hexagonal, rhombic or oval in deep or oblique sections. Zooecial chambers are tubular, constantly overlapping subsequent chambers, and have poorly developed lower hemisepta. Zooecial apertures are circular with apertural stylets present. A carina is not developed on the obverse surface, but nodes and obverse stylets are present (after Morozova and Lisitsyn, 1996; Snyder, 1991).

Polypora dichotoma? Crockford, 1941
Plate 19; Table 3.20

Polypora dichotoma CROCKFORD (1941b), p. 511, pl. XX, fig. 4.

Diagnosis - Colony is infundibuliform with an intermediate to robust mesh. Branches are thick, robust, straight to slightly sinuous and closely spaced with 6 to 8 branches in 10 mm. Surface profile flat to gently rounded with zooecia in 4 to 5 rows. Dissepiments of intermediate width are regularly spaced perpendicular to the branches. Rows of zooecia may bend towards the dissepiments but extra zooecia are not present. Fenestrules are consistently large and oval.

Large round autozooecial apertures are regularly spaced down the branch, with usually 4 to 5 apertures between dissepiment centres. Autozooecial apertures have a thin complete peristome that bears about 30 small apertural stylets. The front surface of the branch is without a carina. Small and large nodes are irregularly spread across the obverse surface. Obverse microstylets are small and irregularly closely spaced across the obverse branch and dissepiment surfaces. Reverse microstylets are also small, reverse macrostylets are absent.

Autozooecial living chambers are large, polyserially emplaced with a zigzag axial wall trace.

Chamber dimensions and shapes regular with greatest dimension parallel to the proximal and distal lateral walls. Chamber outline hexagonal in mid chamber section. Overall three dimensional chamber form a polygonal tube. Hemisepta are absent and heterozooecia are not seen in the material examined. Reverse wall budding angles are constant with mean angle 56°. Lateral wall budding angles are variable, adaxial mean 2°, abaxial mean 17°. Granular skeletal wall thin, lamellar skeletal wall thick.

Polypora dichotoma ?	X	SD	Min	Max	N	CV
branches in 10 mm.	7.833	0 289	7.5	8	3	3 685
rows of zooecia on branch	4.579	0.769	3	6	19	16 784
distance between branch centres	1.468	0 187	1.14	1 79	13	12 723
width branch	1.034	0.091	0.94	1.18	14	8.753
width dissepiments	0.861	0.123	0 66	1.1	18	14.278
fenestrules in 10 mm	6.333	0.577	6	7	3	9 116
fenestrule length	0.999	0 116	0.82	1.28	14	11 656
fenestrule width	0.483	0.081	0 37	0.62	14	16 774
apertures between dissepiment centres	4.477	0 566	4	6	22	12 652
aperture width	0.183	0 010	0.16	0 2	27	5 695
apertural spacing down branch	0 439	0.041	0 38	0 52	27	9.251
apertural spacing across branch	0.329	0 041	0.26	0 445	33	12 468
apertural spacing between branches	0.545	0 106	0.37	0 78	12	19.442
width apertural peristome	0.013	0.004	0.01	0.02	19	29 429
number of apertural stylets	30	1 581	28	32	5	5 270
diameter apertural stylets	0.009	0 002	0.005	0 011	10	21.463
diameter nodes	0.051	0.014	0 03	0 08	32	26.832
spacing of nodes down branch	0 210	0.096	0 095	0.4	29	45 520
diameter nodes2	0.130	0 040	0.08	0.2	17	30.863
diameter obverse stylets	0 009	0 003	0 005	0.015	31	31.156
spacing obverse stylets	0 026	0.007	0 015	0 04	29	25 741
diameter reverse microstylets	0.007	0 002	0.003	0.01	33	29 488
spacing reverse microstylets	0.020	0 005	0 01	0 035	37	26.062
thickness reverse wall granular layer	0.012	0 003	0.01	0.02	14	26.185
thickness lateral wall granular layer	0.012	0.002	0.01	0.015	15	19 770
thickness frontal wall laminated layer	0.316	0 044	0 25	0.38	10	13 990
thickness reverse wall laminated layer	0.620	0.079	0.5	0.68	5	12.700
chamber length	0 274	0.032	0.235	0.3	4	11.683
chamber depth	0 558	0.069	0.48	0.68	8	12 344
maximum chamber width	0.202	0 023	0.18	0.26	20	11.207
minimum chamber width	0.072	0 023	0 04	0 12	16	32.243
budding angle reverse chamber wall	56.444	5.003	49	65	9	8 863
budding angle lateral chamber wall	2	2 449	0	5	4	122 474
budding angle lateral chamber wall	17	1	16	18	3	5 882
branch thickness	1 457	0.167	1.36	1.65	3	11 494

Table 3.20 - Summary measurements for *Polypora dichotoma*? Crockford Abbreviations as for Table 3.1, all measurements in millimetres.

Description - External features - Overall colony form infundibuliform, with fragments forming gently undulating reversely curved expansions. Zoarium intermediate to robust, mesh spacing close and regular. Zooecia are in 4 to 5 rows on the branch, with 3 after, and up to 7 before, bifurcation.

Branches are robust and regularly closely spaced with 6 to 8 in 10 mm. Branches are straight to slightly sinuous, with a flat to gently rounded surface profile. Dissepiments are of regular intermediate width, and are regularly spaced perpendicular to the branches. Dissepiments are slightly recessed from the obverse and reverse surfaces, and widen at their junction with the branch. Rows of zooecia may bend towards the dissepiments but extra zooecia are not present. Fenestrules are consistently large and oval, and are elongated proximodistally, 6 to 7 in 10 mm. Rounding of the reverse surfaces of both branches and dissepiments increases the size and rounding of fenestrules near the reverse surface. Mean ratio of fenestrule width to branch width is approximately 3:7, and mean fenestrule width to length ratio is approximately 1:2.

Autozooecial apertures are large and round, and open parallel to the plane of the obverse surface. Lateral rows of apertures are inclined towards the fenestrules, but do not indent them. Apertures are regularly spaced down the branch, with usually 4 to 5 apertures between dissepiment centres. Ratio of mean apertural spacing down to across the branch 4:3, down to between branches 4:5, and across to between branches 3:5. Autozooecial apertures have thin complete peristomes, with about 30 small apertural stylets.

The front surface of the branch is without a carina. Nodes are present on the obverse surface in apparently two size ranges. One set of nodes is small and irregularly spread across the obverse surface, as is the second set of very large nodes. The larger nodes are covered in small stylets and are well raised above the obverse surface and can be clearly seen in longitudinal sections.

Obverse microstylets are small and of irregular close to intermediate spacing on the obverse branch and dissepiment surfaces. Reverse microstylets are also small, visibly smaller and more closely spaced than obverse stylets. Reverse microstylets are spread across the reverse branch and dissepiment surfaces. Reverse macrostylets are absent.

Internal features - Branches are thick, robust and rounded in transverse section, although the obverse surface is usually more flattened than the reverse. Autozooecial living chambers are large and polyserially emplaced with a strongly zigzag axial wall trace near the reverse surface, becoming sinuous towards the obverse surface. Chamber dimensions and shape regular with greatest dimension parallel to the proximal and distal lateral walls. Chamber outline diamond shaped to hexagonal near the reverse wall, hexagonal in mid chamber section and rounded hexagonal to ovate near the obverse surface. Apertures are located distally to the chamber on an indistinct vestibule. Lateral rows have apertures placed slightly abaxial distal to the chamber. Overall three dimensional chamber form a polygonal tube. Ratio of mean minimum to maximum chamber width approximately 1:3, but is variable according to shape at reverse wall and mid chamber. Ratio of mean maximum chamber width to depth 3:8, and depth to length 2:1. Hemisepta are absent and heterozooecia are not seen in the material examined.

Reverse wall budding angles are constant, with a total range of 49° to 65° (mean 56°). Lateral wall budding angles are variable according to division into abaxial/adaxial and number of rows across the branch. Where there are more rows and spacing is cramped adaxial rows have a regular budding angle, with variation occurring where there are fewer rows and budding is less cramped. Range of adaxial row lateral budding angle 0° to 5° (mean 2°), range of abaxial row lateral wall budding angles 16° to 18° (mean 17°).

Granular skeletal wall thin, with poor apparent continuity between rows and obverse surface features, though can be seen in some sections. Lamellar skeletal wall is regularly thick, and is almost twice as thick in the reverse wall as in the frontal wall.

Discussion - Specimens collected from the Wandrawandian Mudstone at Ulladulla are very similar to *P. dichotoma* Crockford (1941b). However in the original description Crockford (1941b) describes small nodes across the obverse surface, rather than the small and large nodes seen by specimens collected in this study. The discrepancy may be a preservational one, but until this can be proven UTGD 127567-68 are only questionably assigned to *P. dichotoma.*

Material - Two specimens (UTGD 127567-68) were available for internal examination from the Kungurian Wandrawandian Siltstone at North Head, Ulladulla.

Range - Kungurian.

Polypora virga Laseron, 1918
Plate 20; Table 3.21

Polypora virga LASERON (1918), p. 192, pl. VII, pl. VIII, fig. 2; CROCKFORD (1941a), p. 410, pl. XIX, fig. 3; WASS (1968), p. 51, pl. 13, fig. 2.

Diagnosis - Zoarium robust, mesh spacing close, with 6.5 to 8 branches and 5 to 6 fenestrules in 10 mm. Branches are very wide and straight with a flat to gently rounded surface profile and ovate cross section. There are 3 to 4 rows of zooecia, with 5 or 6 before, and 2 to 3 after a bifurcation. Dissepiments are straight, regularly placed, narrow, and either perpendicular or at a slight angle to the branches. Fenestrules are very large and long, irregularly elliptical to subrectangular and usually narrower than branches. The obverse surface is without a carina. Circular-ovate nodes of variable size are widely spaced down the centre of the branch. Obverse and reverse microstylets are prominent and evenly spaced.

There are usually four large circular to ovate autozooecial apertures between dissepiment centres. Peristomes are incomplete and apertural stylets are poorly developed. Autozooecial chambers are large, with their greatest length parallel to the reverse surface. Emplacement is polyserial with a sinuous to zigzag axial trace. Chamber outline is generally hexagonal at mid chamber level. Reverse wall budding angle is high, and variable, ranging from 47° to 71° (mean 60°). Lateral wall budding angle is highly variable. Three dimensional reconstructed form a polygonal tube.

The exterior lamellar skeleton is very thick, and exhibits astogenetic thickening. Interior granular skeleton is also thick, with the reverse wall granular layer affected by astogenetic thickening.

Description - <u>External features</u> - The form of the colony is not shown in the Tasmanian material. Zoarium is robust, forming a flat to outwardly curved expansion. Mesh spacing is slightly irregular and generally close. There are 3 to 4 rows of zooecia polyserially arranged on the obverse surface. There are up to 5 or 6 before, and 2 to 3 after a bifurcation.

Branches are very wide with a straight proximal trace, and a flat to gently rounded surface profile. Branch space is close and regular, with 6.5 to 8 branches in 10 mm. Dissepiments are regularly placed, narrow, short and free of extra zooecia. Dissepiments are usually straight and perpendicular to the branches, but are commonly at a slight angle, distorting the shape of the associated fenestrules. Dissepiments are thick and slightly recessed from the reverse and obverse surfaces. Fenestrules are very large, and irregularly elliptical to subrectangular, with 4.5 to 7 in 10 mm. Fenestrules appear more commonly oval to elliptical at mid branch level, but appear elliptical to subrectangular near the obverse surface, due to thinning of dissepiments. Fenestrule width is slightly variable, but are usually narrower than branches, with a mean fenestrule to branch width ratio of approximately 3:5. Ratio of mean fenestrule width to length 2:5.

Autozooecial apertures are large, circular to ovate, with 9 to 11.5 in 5 mm. There are usually 4 zooecia in the distance of one fenestrule and one dissepiment but occasionally there are 5. Apertures are regularly spaced across the branch, but spacing down and between branch is slightly irregular. Ratio of mean aperture spacing down branch to across branch 6:5, down to between branches approximately 3:5, and across to between branches almost 1:2. Adaxial rows have apertures opening upwards, with abaxial rows only slightly inclined towards the fenestrules. Peristomes are incomplete and apertural stylets are present but poorly developed.

The obverse surface is without a carina. Large circular-ovate nodes are widely spaced down the midline of the branch, with smaller intermediate sized nodes irregularly placed between these. Obverse stylets are prominent and of intermediate size, and intermediate to wide spacing across the obverse surface. Reverse microstylets are of a similar size and spacing to the obverse stylets. Reverse macrostylets are absent.

Polypora virga	X	SD	Min	Max	N	CV
rows of zooecia	3.569	0 495	3	4	36	13.868
branches in 10 mm.	7 167	0 485	6 5	8	18	6 768
distance between branch centres	1.408	0 153	1.16	1 7	13	10.876
width branch	0.911	0 138	0 675	1 163	40	15.116
width dissepiments	0.451	0.106	0 25	0.675	40	23 418
fenestrule length	1.448	0 183	1 038	1.825	40	12 635
fenestrule width	0 595	0.124	0.4	0 975	40	20 775
fenestrules in 10 mm.	5.307	0 528	4.5	7	27	9 942
zooecial apertures in 5 mm.	10 348	0.611	9	11.5	23	5.906
apertures between dissepiment centres	4.149	0.311	4	5	47	7 503
aperture length	0.260	0 018	0.213	0.29	40	6 895
aperture width	0.230	0 016	0 2	0 26	20	6 812
apertural spacing down branch	0.454	0 054	0.37	0.6	40	11.951
apertural spacing across branch	0.371	0.033	0.32	0.43	20	8 884
apertural spacing between branches	0 801	0 104	0 64	0 98	20	12 947
diameter nodes	0.086	0 040	0 04	0.18	13	46 135
spacing of nodes down branch	0.539	0.129	0.38	0.74	7	23 909
nodes in 5mm down the branch	3 889	0.782	3	5	9	20 102
width apertural peristome	0.012	0 003	0.008	0.015	11	22 389
number of apertural stylets	13.500	2.121	12	15	2	15.713
diameter apertural stylets	0.016	0.004	0.01	0.02	5	28 852
diameter obverse stylets	0 014	0.003	0.01	0 02	20	21.696
spacing obverse stylets	0.049	0.013	0.03	0.085	20	25 558
diameter reverse microstylets	0.013	0.003	0.008	0.02	20	25 791
spacing reverse microstylets	0 049	0.010	0.035	0.075	20	19 976
thickness reverse wall granular layer	0.026	0 006	0.015	0 035	12	24 375
thickness lateral wall granular layer	0.021	0.003	0 015	0.025	9	13.416
thickness frontal wall laminated layer	0.412	0 072	0 27	0.52	17	17 546
thickness reverse wall laminated layer	0.411	0 079	0 28	0.495	9	19 337
chamber length	0.423	0.030	0 375	0.49	20	7 044
chamber depth	0.343	0 065	0.26	0.44	7	18 881
maximum chamber width	0.232	0 026	0 19	0 28	20	11 402
minimum chamber width	0.115	0 026	0.075	0 18	20	22 352
vestibule length	0.358	0.063	0.28	0.48	8	17 738
budding angle reverse chamber wall	60.250	8 368	47	71	12	13 889
budding angle lateral chamber wall ad	9 143	6.149	0	17	7	67 254
budding angle lateral chamber wall ab	17.750	6 850	8	23	4	38 589
branch thickness	1.221	0.174	0 94	1.42	7	14.262

Table 3 21 - Summary measurements for *Polypora virga* Laseron. Abbreviations as for Table 3 1, all measurements in millimetres.

<u>Internal features</u> - Branches are ovate in outline, and very thick, accentuated by astogenetic thickening. Branch width to thickness ratio of almost 4:5, however this may be reversed where there are more rows of zooecia before branching with width greater than thickness. Autozooecial chambers are large, with their greatest length parallel to the reverse surface. Chamber emplacement is polyserial with a sinuous to zigzag axial trace. Near the reverse surface chamber outline is hexagonal to diamond shaped, generally hexagonal in mid chamber section, and ovate near the obverse surface. Apertures are placed distally, or abaxial distally, connected to the chamber by slightly variable long vestibules. Hemisepta are absent. Chamber dimensions are generally slightly variable, with only chamber length showing any regularity. Mean minimum to maximum width ratio approximately 1:1, maximum width to depth ratio almost 7:10, and chamber depth to length ratio 4:5.

Reverse wall budding angle is quite high for *Polypora*, and variable, ranging from 47° to 71° (mean 60°). Lateral wall budding angle highly variable, range for adaxial rows 0° to 17° (mean 9°), and range for abaxial rows 8° to 23° (mean 17°). Three dimensional reconstructed form is a polygonal tube.

The exterior lamellar skeleton is very thick, and exhibits astogenetic thickening. Interior granular skeleton is also thick, with the reverse wall granular layer particularly thickened by astogenetic thickening.

Discussion - *P. virga* is distinguished from other *Polypora* species with large zooecia, by the number shape and form of fenestrules, branches and dissepiments.

Material - Specimens available for internal examination have been collected from the Artinskian Berriedale Limestone, Rathbones Quarry, Granton (UTGD 127136), and late Artinskian West Arm Group, Beaconsfield (UTGD 127137-40). Additional specimens only available for external examination have been collected from the upper Artinskian Skipping Ridge Formation, Maria Island (UTGD 127141); the Artinskian Counsel Creek Formation, Maria Island (UTGD 127142-43) and Berriedale Limestone, Rathbone's Quarry, Granton (UTGD 127144); the Kungurian Deep Bay Fm, Bruny Island (UTGD 127145) and Malbina Formation unit A, Rathbone's Farm, Granton (UTGD 127146); and Ufimian/Kazanian unit E of Malbina Formation, Eaglehawk Neck (UTGD 127147). These additional specimens are tentatively included in this species.

Range - Artinskian to Kazanian.

Genus *Polyporella* Simpson, 1895

Type species - *Fenestella fistulata* Hall 1884; Middle Devonian, Hamilton Formation, USA.

Description - Colonies of various shapes, meshworks with small fenestrules, and branches rounded in cross section. Dissepiments non-poriferous. Autozooecial chambers in three rows, with four before and two for a short distance after bifurcation. Zooecial chambers of the median row regularly hexagonal in median tangential section, lateral rows pentagonal to quadrate pentagonal. Vestibules are short and do not cover subsequent zooecia. Short hemisepta. Longitudinal walls dividing rows of zooecia project over the surface as nodal ridges (after Morozova and Lisitsyn, 1996).

Polyporella internata Lonsdale, 1844
Plate 21; Table 3.22

Diagnosis - Zoarium of intermediate robustness, forming an obversely curved outward expansion. Mesh spacing is close and regular, with 8 to 11 branches in 10 mm horizontally. Branches are wide, thick and straight, with the obverse surface rounded. There are usually 3 rows of zooecia, with up to 5 before, and 2 to 3 after bifurcation. Dissepiments are short but wide and may be wider than the length of adjacent fenestrules. Fenestrules are intermediate to large, elongate oval and very often indented by the zooecial apertures. Where there are 3 rows of zooecia there is a low arcuate ridge between the rows. Poorly developed small to intermediate nodes exist, with about 4 in 5 mm. Obverse stylets are arranged in concentric rows about each aperture. Zooecial apertures are quite large and circular to oval. Apertural spacing regular down the branch with usually three between dissepiment centres, with 10 to 12 in 5 mm along the branch. Apertures have a thick operculum and a complete to incomplete peristome with small apertural stylets.

Autozooecial chambers are polyserially emplaced and large with a zigzag wall, and are about as long as deep. Autozooecial chamber outline is diamond to hexagonal at mid chamber level. Where there are two rows chambers are pentagonal to rectangular. Apertures are connected to chambers by a long vestibule. Three dimensional chamber form a polygonal box. Hemisepta are absent.

The reverse wall budding angle is consistent with a mean of 62°, lateral wall budding angle variable. The interior granular skeleton is thick. Exterior lamellar skeleton thick, with frontal wall laminated layer thicker than the reverse wall laminated layer.

Description - External description - The zoarium is of intermediate robustness, and forms an obversely curved outward expansion. Mesh spacing is close and regular, with 8 to 11 branches in 10 mm horizontally. Branches are wide and straight, with the obverse surface rounded. There are usually 3 rows of zooecia, with up to 5 before, and 2 to 3 after bifurcation. Branches are wider and flatter before bifurcation, and if 2 rows after branching the sides of the branch are sloping so as the junction appears keeled. Dissepiments are short and of intermediate width. Dissepiment width however is variable and they are at times wider than the length of adjacent fenestrules, ratio of mean dissepiment width to fenestrule length however, is 7:10. Dissepiments are thick and only slightly recessed from the reverse and obverse surfaces. Fenestrules are intermediate to large, elongate oval and very often indented by the zooecial apertures. There are 6.75 to 8 fenestrules in 10 mm. Fenestrules are narrower than the branches, and the ratio of mean fenestrule to branch width is approximately 1:2, and fenestrule width to length ratio approximately 2:5.

Polyporella internata	X	SD	Min	Max	N	CV
rows of zooecia	2 909	0.696	2	5	66	23 913
branches in 10 mm.	9.263	0 806	8	11	19	8 698
distance between branch centres	1.124	0 148	0.88	1.695	44	13 176
width branch	0.746	0.103	0.56	1	53	13.826
width dissepiments	0.577	0 102	0.35	0 82	59	17.739
fenestrules in 10 mm.	7.355	0 422	6.75	8	31	5 740
fenestrule length	0.848	0 129	0.525	1.225	63	15.223
fenestrule width	0.365	0.062	0.205	0.5	62	17 015
apertures between dissepiment centres	3.242	0.375	3	4	66	11 553
zooecial apertures in 5 mm.	11.464	0.560	10	12	28	4 884
aperture length	0.219	0.017	0.165	0.25	45	7 671
aperture width	0 190	0.015	0 15	0.23	46	7 676
apertural spacing down branch	0 449	0.042	0 375	0.55	65	9 308
apertural spacing across branch	0 356	0.047	0 26	0.46	60	13.248
apertural spacing between branches	0.534	0 078	0 34	0.68	51	14 692
diameter of nodes	0 075	0.017	0 06	0.11	9	23 035
spacing of nodes down branch	0 613	0.240	0 42	1.1	9	39 194
width apertural peristome	0.013	0.003	0 01	0.02	23	23 624
number of apertural stylets	25.429	2.699	21	30	7	10 615
diameter apertural stylets	0 008	0.002	0 005	0 013	31	27 860
diameter obverse stylets	0 010	0.003	0 005	0.015	26	28 548
spacing obverse stylets	0 047	0.011	0 03	0 068	20	22 591
diameter reverse microstylets	0 012	0.004	0 005	0 02	43	32 044
spacing reverse microstylets	0.052	0.013	0 033	0.08	40	24 666
thickness reverse wall granular layer	0 014	0.004	0.008	0.02	41	28 660
thickness lateral wall granular layer	0.013	0.003	0.01	0.02	41	21 476
thickness frontal wall laminated layer	0.307	0.062	0 2	0 43	29	20 299
thickness reverse wall laminated layer	0.307	0.087	0 14	0.48	31	28 431
chamber length	0.406	0 055	0 27	0.52	52	13 525
chamber depth	0.394	0 068	0 25	0.51	19	17 191
maximum chamber width	0.249	0.025	0.215	0.33	53	9 848
minimum chamber width	0 081	0 048	0	0 165	51	59 415
vestibule length	0 233	0 050	0.14	0.33	16	21.590
budding angle reverse chamber wall	61.962	6.251	52	76	26	10.089
budding angle lateral chamber wall	2.5	4	0	12	8	160
budding angle lateral chamber wall	24 545	6 861	15	35	11	27 952
branch thickness	0.978	0 085	0.79	1.1	27	8 681

Table 3.22 - Summary measurements for *Polyporella internata* (Lonsdale). Abbreviations as for Table 3 1, all measurements in millimetres.

Autozooecial apertures are quite large and circular to oval. There are generally 3 and occasionally 4 zooecia between dissepiment centres, with 10 to 12 in 5 mm along the branch. Apertures tend to be circular where branch surface is flat and open, and oval where rows are cramped across the branch. Apertural spacing regular down the branch but slightly variable across and between branches. Ratio of mean spacing down to across branch approximately 6:5, down to between branch approximately 4:5, and across to between branches 1:3. Apertures have a thick operculum that has a central circular area of granular skeletal material. Lateral rows of zooecia open towards the fenestrules and often indent them. Apertures have a complete to incomplete peristome with 21 to 30 small apertural stylets located on the peristome.

Where there are 3 rows of zooecia there is a low arcuate ridge between the rows. Low poorly developed small to intermediate nodes exist at wide intervals, with about 4 in 5 mm. Nodes are always present but development is sporadic within each zoarium and spacing varies widely, and weathering may remove them. Obverse stylets are of small to intermediate size and intermediate to wide spacing. Obverse stylets tend to be arranged in concentric rows about each aperture. The reverse surface of the branch is evenly rounded, with small microstylets of a similar size and spacing to the obverse stylets. Macrostylets are absent.

Internal description - Branches are thick and elliptical to circular in transverse section, with mean branch width to thickness ratio almost 4:5.

Autozooecial chambers are large and polyserially emplaced, and about as long as deep, with a zigzag axial wall trace. Chambers next to dissepiments often swell towards them. Autozooecial chamber outline is diamond to hexagonal shaped near the reverse surface and at mid chamber level, becoming pentagonal to ovate near the obverse surface. Where there are two rows chambers are pentagonal to rectangular. Whether chambers are hexagonal or diamond shaped is controlled largely by the number of rows and degree of cramping of rows in that particular area of the branch. Apertures are placed distally in central rows, and abaxial distally in lateral rows. Apertures are connected to chambers by a long vestibule. Chamber length and depth slightly variable, minimum width extremely variable, due to variation between diamond and hexagonal shape, maximum width regular. Mean minimum to maximum width ratio 3:10, range 1:3 to 0 (where minimum width 0). Mean maximum width to depth ratio approximately 3:5, and mean depth to length ratio approximately 1:1. Three dimensional chamber form a polygonal box. Hemisepta are absent.

The reverse wall budding angle is consistent with a mean of 62°, and a range of 54° to 72°. The lateral wall budding angle varies according to the position of the aperture and the rounding of the obverse surface. Adaxial rows vary from 0° to 12° with a mean of 3°, and abaxial rows have a range of 15° to 35° and a mean of 24°.

The interior granular skeleton is thick. Exterior lamellar skeleton thick, with frontal wall laminated layer thicker than the reverse wall laminated layer.

Discussion - *Polyporella internata* is distinguished from *P. westarmensis* by the number of branches and their thickness, the number of apertures, and the number and arrangement of nodes. In *P. internata*, lateral rows of zooecia may bend towards the dissepiments, but are straight in *P. westarmensis*.

Types - Neotype UTGD 53637, Sakmarian Bundella Musdtone, shoreline below Porter Hill.

Material - Specimens suitable for internal examination are recorded from the Sakmarian Bundella Mudstone, on the shoreline below Porter Hill, Hobart (neotype UTGD 53637, 52063, and 127507-8). Other specimens from the Maria Island (Sakmarian Basal Beds, UTGD 127509; Artinskian Skipping Ridge Formation, UTGD 127510; Artinskian Counsel Creek Formation, 127511) possibly belong to this species but are poorly preserved.

Range - Sakmarian (Sakmarian to mid Artinskian?).

Polyporella protuberans n. sp.
Plate 22; Table 3.23

Holotype - UTGD 127512, Late Artinskian to Kungurian; West Arm Group, Beaconsfield, Tasmania.

Diagnosis - Zoarium robust, mesh spacing close and regular. Branches are robust, thick and wide, and straight with a flat to gently rounded surface profile. Zooecia are in mostly 3 rows, with 2 for some distance after bifurcation. Dissepiments are regularly emplaced, of intermediate width. They are free of extra zooecia, although lateral rows bend towards them. Fenestrules are regularly large and ovate. There are 8 to 9 branches and 7 to 8 fenestrules in

10 mm.

Autozooecial apertures are large and circular, regularly spaced, wıth 3 ½ to 4 ın the distance between dissepiment centres. A thin poorly developed perıstome is present, with indistinct apertural stylets. Distinct circular to ovate nodes are emplaced about the apertures of the central row. Obverse and reverse microstylets are small and densely packed. Large circular reverse macrostylets are found at the junctions of branches and dissepıments. Autozooecial chambers are large with direction of elongation parallel to proximal and distal lateral walls. Autozooecial chamber outline of central rows hexagonal at mid chamber level, lateral rows pentagonal. Central axes become low longitudinal ridges low in the obverse surface. A long vestibule is present of variable length. Hemisepta are absent. Three dımensional reconstructed chamber form a narrow polygonal box. Reverse wall budding angle high, adaxial and abaxial lateral wall budding angles low. Internal granular skeletal layer thin, lamellar skeletal layer thick in both reverse and frontal walls.

Polyporella protuberans n. sp.	X	SD	Mın	Max	N	CV
rows of zooecıa	2 9	0.553	2	4	20	19.052
branches ın 10 mm	8.5	0.5	8	9	3	5 882
dıstance between branch centres	1.057	0 125	0 86	1.33	15	11.792
wıdth branch	0.696	0.073	0.61	0 83	13	10 499
wıdth dissepıments	0.600	0 084	0 465	0 8	15	13 947
fenestrule length	0.745	0 074	0 62	0.845	14	9 934
fenestrule wıdth	0.425	0.055	0.34	0.54	17	12 995
fenestrules ın 10 mm.	7 5	0 5	7	8	3	6 667
apertures between dıssepıment centres	3 925	0 183	3.5	4	20	4 667
aperture length	0 191	0 010	0.18	0.21	20	5 379
aperture wıdth	0.167	0 010	0 15	0 19	20	5 931
apertural spacing down branch	0.372	0.038	0 3	0 44	20	10 289
apertural spacıng across branch	0 355	0.040	0.3	0.44	18	11 284
apertural spacıng between branches	0.517	0.080	0.42	0.66	10	15 529
width apertural peristome	0 013	0.003	0.01	0 018	12	23 755
dıameter nodes	0 089	0.028	0 045	0.14	20	32 020
spacıng of nodes down branch	0.456	0 107	0 29	0.68	20	23.518
dıameter obverse stylets	0 009	0 002	0.005	0 01	20	19.894
spacing obverse stylets	0 026	0.007	0.015	0.04	20	25 035
dıameter reverse microstylets	0.009	0.002	0 005	0.013	20	20 971
spacıng reverse microstylets	0.025	0.006	0 015	0.035	20	22 917
dıameter reverse macrostylets	0 127	0 034	0.07	0.22	20	26 438
spacıng reverse macrostylets	0 843	0 348	0 32	1.65	20	41 285
thıckness reverse wall granular layer	0.009	0 002	0.005	0.015	20	21 169
thıckness lateral wall granular layer	0.013	0 004	0 01	0 025	20	28 128
thickness frontal wall laminated layer	0.263	0 039	0 2	0.32	12	14.918
thıckness reverse wall lamınated layer	0 363	0.057	0.29	0.45	7	15 648
chamber length	0.34	0.028	0.3	0.39	20	8 278
chamber depth	0 385	0.063	0.31	0.5	11	16 217
maxımum chamber wıdth	0 191	0.027	0.16	0.24	20	14.093
mınımum chamber width	0.097	0 038	0 04	0.16	20	38 959
vestibule length	0.165	0 038	0.1	0.2	6	22 918
buddıng angle reverse chamber wall	60 556	6 821	50	69	9	11 264
buddıng angle lateral chamber wall ad	6.4	2.302	4	9	5	35 971
buddıng angle lateral chamber wall ab	20.111	6 585	14	31	9	32 743
branch thickness	0 992	0.090	0 87	1 11	5	9 056

Table 3.23 - Summary measurements for *Polyporella protuberans* n. sp. Abbrevıatıons as for Table 3.1, all measurements ın mıllimetres.

Description - External features - Zoarium robust, mesh spacing close and regular, forming an undulating, possibly fan shaped, outward expansion. Zoarial supports are not seen. Zooecia are in mostly 3 rows, with 2 for some distance after bifurcation and 4 before. Branches widen gradually from 2 rows after, to 4 rows before, bifurcation.

Branches are robust and wide, and of regular width where the normal condition of 3 rows exists. Branch spacing is regular with 8 to 9 branches in 10 mm. The external appearance of the branch is straight, with a flat to gently rounded surface profile. Dissepiments are of intermediate width relative to the branches and may be nearly as wide as the associated fenestrule length. Dissepiments are of short to intermediate length, with both width and length regular, and emplacement at regular intervals. Dissepiments are thick in an obverse reverse direction and are only slightly recessed from each surface. They are free of extra zooecia, although lateral rows frequently bend towards and onto them. Fenestrules are regularly large and ovate, with a width to length ratio of 4:7, with elongation oriented proximodistally. There are 7 to 8 fenestrules in 10 mm. Fenestrule shape remains ovate throughout the zoarium, but size increases towards the reverse surface.

Autozooecial apertures are large, circular to ovate, and regularly spaced with 3 ½ to usually 4 between dissepiment centres. Apertural spacing down branch to across branch almost 1:1, spacing down branch to between branches 7:10 and across branch to between branches approximately 7:10. Apertures of the central row open upwards parallel to the plane of the obverse surface, with lateral rows only slightly inclined towards the fenestrules. A thin poorly developed incomplete peristome is present, with peristomal gap at proximal side of aperture. Small closely spaced apertural stylets are irregularly present and are indistinct and not immediately noticeable.

The front surface of the branch is without a carina. Distinct circular to ovate nodes are present, emplaced about the apertures of the central row. Nodes are of variable size, with most falling in the intermediate size range. Spacing of nodes is irregular, with nodes sometimes emplaced so that there are 4 about each aperture of the central row, but often there are only 2 or 3.

Obverse stylets are small and of close to intermediate spacing. Stylets are closely spaced about apertures of the central row, and extending along the low ridge between the rows. In other areas obverse stylets are of intermediate spacing. Longitudinal striae are closely spaced beneath the reverse surface. Reverse microstylets are of the same size and spacing to the stylets of the obverse surface. Reverse macrostylets are present, most commonly found at the junctions of branch and dissepiment, but may be found in other positions. Macrostylets are large, circular and widely spaced, with spacing variable depending on the placement of dissepiments.

Internal features - Branches are thick and ovate in cross section. Width and depth proportions vary however with the number of rows of zooecia. Where there are 2 to 3 rows the long axis of the branch in cross section is oriented obverse-reversely, but is often parallel to the zoarial surface where there are 4 rows before a bifurcation. Ratio of mean branch width to thickness 7:10.

Autozooecial chambers are large, polyserially emplaced, with a zigzag axial wall trace near the reverse surface, and gently zigzag to sinuous near the obverse surface. Chamber depth is greater than length, so that elongation is parallel to proximal and distal lateral walls. Autozooecial chamber outline of central rows distinctly hexagonal near the reverse surface and at mid chamber level, lateral rows pentagonal, with both central and lateral rows tending towards tetragonal near the obverse surface. Central axes become low longitudinal ridges within the obverse surface, but are not often visible externally. Apertures of the central row of zooecia are placed centrally at the distal end of the chamber, with apertures of lateral rows abaxial distal. A long vestibule is present of variable length. Hemisepta are absent. Ratio of mean maximum to minimum chamber width is approximately 1:2, maximum width to depth almost 1:2, and chamber depth to length approximately 10:9. All chamber dimensions are constant except for minimum chamber width that shows variability from change from hexagonal to nearly tetragonal shape.

Reverse wall budding angle is slightly variable with range of 50° to 69° (mean 61°), adaxial and abaxial lateral wall budding angle are both highly variable with ranges of 4° to 9° (mean 6°), and 14° to 31° (mean 20°) respectively. Three dimensional reconstructed chamber form a narrow polygonal box.

Internal granular skeletal layer is thin with little continuity seen. Lamellar skeletal layer thick on both reverse and frontal walls, with thickness fairly constant.

Discussion - Only one specimen is available for inspection, but is sufficiently preserved to allow a full description. *P. protuberans* n. sp. is readily distinguished from other Tasmanian species of *Polyporella* by the mesh size and zooecial number, as well as the arrangement of obverse surface nodes and stylets and the large stylets of the reverse surface.

Types - UTGD 127512, Late Artinskian to Kungurian beds, West Arm Group, Beaconsfield, Tasmania.

Etymology - Named for the distinctive nodes of the obverse surface, and macrostylets of the reverse.

Range - Late Artinskian to Kungurian.

Polyporella subwoodsi n. sp.

Plate 23; Table 3.24

Holotype - UTGD 127148 - Sakmarian; Darlington Limestone; Maria Island, Tasmania.

Diagnosis - Zoaria robust, mesh spacing very close and generally regular. Zooecia are predominantly in 3 rows, with 4 for a short distance before and 2 for a short distance after bifurcation. Branches wide and thick, ovate in cross section, with a rounded obverse surface. There are 11 to 13 branches in 10 mm. Dissepiments are very short and without extra zooecia. Fenestrules are irregularly elliptical in shape, of intermediate size, with 8.5 to 9 in 10 mm.

Autozooecial apertures are large with well developed distinct apertural stylets. Terminal diaphragms are present with apertural stylets remaining visible about their margins. Distinct nodes are arranged in 2 rows about the apertures of the central row. Obverse stylets are of small to lower end intermediate size and are evenly spread across the obverse surface. Reverse microstylets are small and evenly spread, reverse macrostylets are absent.

Chambers are large and hexagonal in mid tangential section. Vestibules are present but are not always well defined. Lateral wall budding angles of adaxial rows have a range of 0° to 10° (mean 4°), and abaxial rows a range of 10° to 35° (mean 18°). Reverse wall angle is consistent with a range of 44° to 64° (mean 55°). The interior granular and exterior lamellar skeletons are thick. Three dimensional reconstructed chamber form a hexagonal box..

Description - External features - Zoaria robust, overall form probably infundibuliform with the celluliferous surface internal. Mesh spacing very close and generally regular. Zooecia are predominantly in 3 rows, with 4 for a short distance before and 2 for a short distance after bifurcation.

Branches are wide, with a rounded obverse surface profile and straight proximodistal trace. Branches are regularly closely spaced with 11 to 13 in 10 mm. Dissepiments are very short, with width lower end intermediate and narrower than branch width. Dissepiments are without extra zooecia and are thick and slightly recessed from the obverse surface. Fenestrules are irregularly elliptical in shape and of intermediate size, with 8.5 to 9 in 10 mm. Fenestrules are narrower than branches, with ratio of mean fenestrule to branch width approximately 2:5, and fenestrule width to length ratio is also 2:5. Fenestrules are commonly indented by the apertures.

Autozooecial apertures are large and oval. Apertures in central rows open more or less parallel to the plane of the obverse surface, lateral rows, or where there are only 2 rows, apertures are inclined towards the fenestrules. There are usually 3 to 3 ½ apertures between dissepiment centres, with 12 to 14 in 5 mm. down the branch. Spacing of apertures is slightly variable, with ratio of mean aperture spacing down to across branch 9:7, down to between branches approximately 4:5, and across branch to between branch ratio 7:10. Wide peristomes are present, and are usually complete, although the angle and/or depth of section may reveal only incomplete peristomes. Apertural stylets are well developed and distinct, with 16 to 28 (mean 22) surrounding each aperture. Terminal diaphragms are present, and appear to be present throughout the zoarium. Apertural stylets remain visible about the margins of terminal diaphragms.

The front surface of the branch does not have a discrete carina, but distinct ridges occur between rows, particularly evident where there are only 2 rows. Nodes are present and small but distinct, and generally circular in outline. They are arranged in 2 rows about the apertures of the central row. Node arrangement and spacing are such that 4 nodes surround each aperture.

Obverse stylets are of small to intermediate size and are of even intermediate spacing across the obverse surface. Reverse microstylets are small and evenly spread across the reverse surface, with a similar spacing to that of the obverse stylets. Reverse macrostylets are absent.

Polyporella subwoodsi n. sp.	X	SD	Min	Max	N	CV
rows of zooecia	3 182	0.547	2	4	55	17 204
branches in 10 mm	12	1.414	11	13	2	11 785
distance between branch centres	0.990	0 111	0.8	1.28	52	11.175
width branch	0.726	0 099	0 53	0.925	49	13 702
width dissepiments	0.520	0.094	0 325	0 68	47	18.118
fenestrule length	0 784	0 109	0.525	1 02	48	13 964
fenestrule width	0 312	0.048	0 175	0 4	48	15 307
fenestrules in 10 mm	8.75	0.289	8.5	9	4	3 299
zooecial apertures in 5 mm.	13.3	0 632	12.5	14 5	10	4 755
apertures between dissepiment centres	3.269	0.318	3	4	54	9 726
aperture length	0.210	0 012	0 17	0 23	63	5 757
aperture width	0.172	0.009	0 15	0.19	64	4 980
apertural spacing down branch	0.426	0.045	0.32	0 52	69	10 546
apertural spacing across branch	0.329	0.030	0 28	0.41	69	9 201
apertural spacing between branches	0 454	0.076	0.26	0 6	48	16.667
nodes in 5mm down the branch	0 383	0 039	0.325	0.438	10	10 242
diameter nodes	0.068	0 018	0 035	0.12	66	27 104
spacing of nodes down branch	0 377	0.082	0.15	0.53	67	21 675
width apertural peristome	0.015	0.005	0.008	0 025	31	30 536
number of apertural stylets	23	3.638	16	28	22	15 819
diameter apertural stylets	0.009	0.002	0.005	0.015	47	20.508
diameter obverse stylets	0.010	0 002	0.005	0 02	75	22 589
spacing obverse stylets	0.033	0.007	0.02	0.05	74	22 118
diameter reverse microstylets	0.008	0.002	0.005	0.013	78	24.812
spacing reverse microstylets	0 033	0 010	0.015	0.07	76	30 712
thickness reverse wall granular layer	0 012	0 003	0 01	0.02	56	25.585
thickness lateral wall granular layer	0.014	0.004	0.01	0.02	45	26 916
thickness frontal wall laminated layer	0 217	0.033	0.16	0.33	36	15 331
thickness reverse wall laminated layer	0.301	0 043	0.21	0.38	41	14 453
chamber length	0.383	0 037	0.32	0.48	55	9.699
chamber depth	0 369	0 047	0 28	0 45	18	12 792
maximum chamber width	0 210	0.022	0 15	0 28	49	10 689
minimum chamber width	0.085	0 030	0.03	0.14	40	34 851
vestibule length	0.163	0.044	0 1	0.28	13	26 869
budding angle reverse chamber wall	54 767	5.923	43	64	30	10.815
budding angle lateral chamber wall ad	3.778	3.456	0	10	9	91.484
budding angle lateral chamber wall ab	17.9	8.225	10	35	10	45 951
branch thickness	0.841	0 060	0 73	0.94	17	7 110

Table 3 24 - Summary measurements for *Polyporella subwoodsi* n. sp Abbreviations as for Table 3.1, all measurements in millimetres

<u>Internal features</u> - Branches are thick and ovate in cross section. The long axis is variably positioned, sometimes parallel to the plane of the reverse surface, other times in an obverse reverse direction. Mean branch width to thickness ratio 8.5:10, but varying between 3:5 and 11:10.

Autozooecial chambers are large, with the long axis parallel to the reverse wall, although chamber length is only just greater than depth. Chambers are polyserially emplaced with zigzag axial wall traces. Chamber outline of central rows where more than 2 rows exist is hexagonal to occasionally diamond shaped near the reverse surface, hexagonal in mid tangential section and ovate to elliptical near the obverse surface. In lateral rows, and where only 2 rows exist, chambers pentagonal in deep to mid section, and ovate elliptical near the obverse surface. Chamber shape is regular, however minimum chamber width may vary considerably depending on the degree of crowding of the chambers. Apertures are located distally to abaxial distally on the chamber and are connected by a poorly defined vestibule. Chamber length depth and maximum width slightly variable, with minimum width extremely variable. Ratio of mean minimum to maximum width 2:5, maximum width to depth 3:5, and depth to length almost 1:1. Three dimensional reconstructed chamber form a hexagonal tube like box.

Lateral wall budding angles are highly variable, with adaxial rows having a range of 0° to 10° (mean 4°), and abaxial rows a range of 10° to 35° (mean 18°). Reverse wall angle is only slightly variable with a range of 44° to 64° (mean 55°).

The interior granular skeleton is thick, though lateral wall granular layer is variable and the zoarium is often crushed. Continuity is clearly seen between chamber walls, longitudinal striae and nodes, but is less obvious between chamber walls between branches and stylets. The exterior lamellar skeleton is thick, with the frontal wall and reverse wall layers comprising just over one quarter and one third the total branch thickness respectively.

Discussion - Distinguished from *Polyporella internata* (Lonsdale) which has a similar number and dimensions of branches, fenestrules and zooecia by the presence of distinct apertural stylets, obverse stylets and the appearance, number and size of the nodes, and straight zooecial rows, which bend onto the dissepiments in *P. internata*. Distinguished readily from *P. westarmensis* n. sp. by mesh size and number of zooecia.

This species is very similar to the previously described *Polypora woodsi* (Etheridge), for which Crockford (1941a) erected a neotype after the holotype was lost. However, Tasmanian specimens assigned to *P. subwoodsi* are slightly, but consistently, different in fenestrule, branch and dissepiment dimensions and show fewer zooecia. In discussion of the neotype and additional specimens of *Polypora woodsi* Crockford (1941a) states the number of branches being usually 3, with 2 rows being held after branching for up to 4 fenestrules. It would seem likely from this description that *P. woodsi* is better placed in *Polyporella* and that these two species are probably closely related.

Types - Holotype UTGD 127148, paratypes UTGD 127149-51, all from the Sakmarian basal beds Maria Island, Tasmania.

Etymology - Named for its similarity to *P. woodsi* (Etheridge)

Material - Additional to type material is a specimen from the Sakmarian Bundella Mudstone, Lower Sandy Bay, Hobart (UTGD 127152).

Range - Sakmarian.

Polyporella westarmensis n.sp.
Plate 24; Table 3.25

Holotype - UTGD 127153 - Ufimian; West Arm Group, Beaconsfield, Tasmania.

Diagnosis - Zoarium robustness intermediate, mesh spacing close and regular. Branches are wide and thick with 10 to 12.5 in 10 mm, and a straight proximodistal trace. Autozooecia are in 3 rows, with 4 shortly before and 2 for a short distance after bifurcation. The surface profile is hemipolygonal, with the central zooecial row flat, bounded by steeply sloping lateral rows, with the junction between rows sharp. Dissepiments are wide and commonly astogenetically thickened. Rows of zooecia are straight and do not bend onto dissepiments. Fenestrules are of intermediate size and elliptical to ovate, with 6.5 to 8 in 10 mm. The obverse surface has nodes on either side of the median row of zooecia. Reverse and obverse stylets are small but distinct, large reverse macrostylets are present, and are very widely spaced. Autozooecial apertures are large and ovate, regularly spaced with usually 5 between dissepiment centres. Peristomes are incomplete and poorly developed, apertural stylets are not seen.

Autozooecial chambers are of intermediate size, polyserially emplaced with a zigzag axial wall trace. Chamber depth greater than length, so maximum chamber dimension is parallel to proximal and distal chamber walls. Autozooecial chamber outline hexagonal. Reconstructed three dimensional chamber form is a polygonal tube.

Reverse wall budding angle high, lateral wall budding angles variable. The exterior lamellar skeleton is thick, with pronounced astogenetic thickening, particularly of the reverse surface. Reverse wall granular layer of variable thickness

Polyporella westarmensis n. sp.	X	SD	Min	Max	N	CV
rows of zooecia	3	0 392	2	4	27	13 074
branches in 10 mm.	10 977	0.553	10.5	12 5	11	5 037
distance between branch centres	0.900	0 091	0.71	1 16	40	10 159
width branch	0.587	0.066	0.47	0.71	27	11 259
width dissepiments	0.749	0 129	0.55	1.1	27	17 204
fenestrules in 10 mm.	7.159	0.375	6.5	8	11	5 243
fenestrule length	0.726	0 088	0 46	0 82	30	12.146
fenestrule width	0.331	0 041	0.25	0.425	33	12.331
zooecial apertures in 5 mm.	16.250	0.622	15	17	12	3.825
apertures between dissepiment centres	4.878	0.274	4	5.5	37	5.617
aperture length	0.225	0.023	0.188	0.275	27	10 422
aperture width	0 163	0.018	0 135	0 2	32	10 927
apertural spacing down branch	0 306	0.030	0 25	0.38	35	9.693
apertural spacing across branch	0.280	0 022	0.25	0.32	32	7 716
apertural spacing between branches	0 475	0 041	0.4	0 54	11	8.604
diameter nodes	0.056	0.020	0.03	0.12	40	35 268
spacing of nodes down branch	0.307	0.048	0.2	0.44	44	15 583
width apertural peristome	0.012	0.002	0.01	0.015	5	19 444
diameter obverse stylets	0.010	0.002	0.005	0.015	40	21 884
spacing obverse stylets	0.041	0.018	0.018	0.08	30	45 317
diameter reverse microstylets	0.009	0.003	0.005	0.018	40	31.632
spacing reverse microstylets	0 023	0.007	0.01	0.04	40	28.367
diameter reverse macrostylets	0 157	0 015	0 14	0.17	3	9.750
spacing reverse macrostylets	8		8	8	1	
thickness reverse wall granular layer	0 011	0.002	0.008	0.015	40	19.597
thickness lateral wall granular layer	0.010	0.002	0.005	0.015	36	22 184
thickness frontal wall laminated layer	0.267	0.044	0.21	0.34	13	16 429
thickness reverse wall laminated layer	0.678	0.144	0.38	0.91	30	21 224
chamber length	0.288	0 019	0.235	0.32	26	6 557
chamber depth	0.320	0.022	0.29	0.35	8	6 887
maximum chamber width	0.157	0.025	0 1	0 23	24	16 146
minimum chamber width	0.071	0.023	0 02	0.1	22	32.518
vestibule length	0.234	0.043	0.18	0.28	7	18.609
budding angle reverse chamber wall	65.462	6 450	55	74	13	9 853
budding angle lateral chamber wall ad	1	1	0	2	3	100
budding angle lateral chamber wall ab	28.25	3.096	24	31	4	10 958
branch thickness	1.513	0.044	1.47	1.56	4	2 926

Table 3.25 - Summary measurements for *Polyporella westarmensis* n. sp Abbreviations as for Table 3.1, all measurements in millimetres.

Description - External features - Zoarium robustness intermediate, with mesh spacing close. Colony form is unknown, but fragments form undulating outwardly curved expansions. Autozooecia are in 3 rows, with 4 shortly before and 2 for a short distance after bifurcation. Bifurcation is at wide intervals, frequently more than 30 mm, and 3 rows are held for most of the distance between bifurcations.

Branches are wide with a straight proximodistal trace, and there are 10.5 to 12.5 in 10 mm. The surface profile is angular, with the central zooecial row flat, bounded by steeply sloping lateral rows, with the junction between rows sharp. Spacing of dissepiment and branch centres is regular. Dissepiments are wide, with their width at times greater than the length of the associated fenestrule. They are commonly astogenetically thickened, resulting in great variation in dissepiment width, and fenestrule length, to the point that small individual fragments may appear quite different. Dissepiments are regularly placed and lower end intermediate in length and are free of extra zooecia. Dissepiments are thick and flush with the reverse surface, and recessed to the level of the lateral rows of apertures on the obverse surface. Rows of zooecia are straight and do not bend onto dissepiments. Fenestrules are of intermediate size, and elliptical to ovate, becoming more ovate to almost circular with increased astogenetic thickening. There are 6.5 to 8 fenestrules in 10 mm. Fenestrules are narrower than branches, with ratio of mean fenestrule to branch width 3:5. Ratio of mean fenestrule width to length ratio ranging between 2:5 and 1:2, and dissepiment width to fenestrule length approximately 1:1.

Autozooecial apertures are large and ovate, with central row opening parallel to the obverse surface and lateral rows opening inclined towards, but not indenting, the fenestrules. There are 4.5 to usually 5 between dissepiment centres, and 15 to 17 in 5 mm. Apertural spacing is regular down, across and between branches. Ratio of mean aperture spacing down to across branch 10:11, down to between branches approximately 2:3, and across to between branches 3:5. Peristomes are incomplete and poorly developed, so are often not seen. Apertural stylets are not seen.

The obverse surface is without a carina, but has small regularly placed nodes. These are placed either side of the median row of zooecia, such that each aperture has four nodes surrounding it. Their spacing is lower end intermediate, and the same as zooecial spacing due to their arrangement. Only rarely are there extra nodes. Nodes are of variable shape, being ovate to slightly stellate, with most angular and often slightly proximodistally elongated.

Obverse stylets are small but distinct, and arranged usually in a single row along the ridge between the sloping sides and flat front surface. Reverse microstylets are small, and closely spaced across the entire reverse surface. Large reverse macrostylets are present, but are very widely spaced, at up to 8 mm. apart, and may not be seen in all specimens.

Internal features - Branches are very thick and elongate ovate in cross section, with a polygonal obverse profile. Ratio of mean branch width to thickness 2:5.

Autozooecial chambers are of intermediate to large size and are polyserially emplaced with a zigzag axial wall trace. Chamber depth greater than length, so maximum chamber dimension is parallel to proximal and distal chamber walls. Autozooecial chamber outline in the middle rows is hexagonal to diamond shaped near the reverse surface, hexagonal at mid chamber level, and rounded hexagonal to ovate near the obverse surface. In lateral rows or where there are only two rows chamber outline is pentagonal. Apertures are located distally to abaxial-distally to the chamber by a long poorly defined vestibule. Chamber length and depth dimensions regular, widths variable. Ratio of mean minimum to maximum chamber width approximately 2:5, maximum width to depth 1:2, and depth to length 11:10.

Reverse wall budding angle ranges from 55° to 74° (mean 65°). Lateral wall budding angle for adaxial rows is up to 3°, with a range of 24° to 31° (mean 28°) for abaxial rows. The exterior lamellar skeleton is thick, with pronounced astogenetic thickening, particularly of the reverse surface. Reverse wall granular layer is thick with some astogenetic thickening, but the lateral wall granular layer is thin and zoarium is often crushed because of this.

Reconstructed three dimensional chamber form a polygonal tube.

Discussion - *P. westarmensis* n. sp. is readily distinguished by the number of zooecia, and the profile of the obverse surface.

Types - UTGD 127153, holotype; UTGD 127154-55, paratypes, all from Ufimian beds in the upper part of the West Arm Group, Beaconsfield, Tasmania.

Etymology - named for West Arm, Port Dalrymple, where type specimens were collected.

Range - Ufimian.

Polyporella sp.
Plate 25; Table 3.26

Diagnosis - Colony form is unknown, but fragments are of intermediate robustness. Mesh spacing is close and regular, with 10 branches and 6 to 7 fenestrules in 10 mm.

Branches are wide with a straight proximodistal trace and an angular surface profile. There are usually 2 to 3 rows of zooecia, with 4 before and 2 after bifurcation. Branch spacing is close and regular. Dissepiments are of intermediate width and are placed at regular intervals. Fenestrules are large and elongate oval, with both size and shape regular. Autozooecial apertures are large and oval and regularly placed with 3.5 to 4 apertures between dissepiment centres. Apertures are surrounded by a thin complete peristome, with about 30 small apertural stylets. The obverse surface has thin sinuous carinae between the rows of zooecia. Nodes are small, round and distinct, and are often placed such that 4 nodes surround the apertures of the central row. Obverse and reverse microstylets are of small to intermediate size and are irregularly spread across outer surfaces of the branches and dissepiments. Reverse macrostylets are absent.

Autozooecial living chambers are large, with greatest dimension parallel to the obverse reverse surfaces. Chamber emplacement is biserial or polyserial, with a zigzag axial wall trace. Chamber outline hexagonal at mid chamber level. Three dimensional reconstructed chamber form probably a hexagonal box. Hemisepta are absent. Reverse wall budding angle range 48° to 67°. Lateral wall budding angles are not measurable. Skeletal granular layer is thin, skeletal lamellar layer thick.

Description - External features - Colony form is unknown, but fragments form undulating reversely curved expansions, and are of intermediate robustness. Mesh spacing is close and regular. There are usually 2 to 3 rows of zooecia with 4 before and 2 after bifurcation.

Branches are of intermediate robustness, but are commonly crushed or distorted by their preservation in poorly sorted sandstone. Branches are wide with a straight proximodistal trace and an angular surface profile. Branch spacing is close and regular, with about 10 branches in 10 mm. Dissepiments are narrow and of intermediate width relative to the branches. Dissepiments are placed at regular intervals, perpendicular to the branches. Dissepiment surfaces are slightly recessed from the obverse and reverse surfaces, on the obverse to be level with aperture openings of lateral rows. Fenestrules are large and elongate oval, with 6 to 7 in 10 mm. Both size and shape regular at mid chamber level. Fenestrules increase in size towards the reverse surface and are slightly more rounded. Ratio of mean fenestrule width to branch width 3:5, and fenestrule width to length approximately 3:8.

Autozooecial apertures are regularly large and oval, elongated proximodistally, with ratio of mean width to length 4:5. Apertures are regularly placed with 3.5 to 4 apertures between dissepiment centres. Ratio of mean apertural spacing down the branch to across the branch is approximately 1:1, and down to between branches 1:1. Apertures of the central row open parallel to the obverse surface, with lateral rows of apertures inclined towards, but not indenting, the fenestrules. Apertures are surrounded by a thin complete peristome, with about 30 small apertural stylets.

The obverse surface of the branch is angulated by thin sinuous carinae between the rows of zooecia. Where there are 3 rows of zooecia there are 2 carinae, and where there is only 2 rows there is a single carina. Nodes are present along the carina, and are of intermediate spacing. Nodes are small, round and distinct and, where there are 3 rows of zooecia, are often placed so that 4 nodes surround the apertures of the central row. Obverse stylets of small to intermediate size are of irregular intermediate to wide spacing. Reverse microstylets are small and of irregular intermediate spacing across the reverse surface of the branches and dissepiments. Reverse macrostylets are absent.

Internal features - True branch thickness and shape in transverse section are unknown, but branches appear thick.

Autozooecial living chambers are large and of regular dimensions, with greatest dimension parallel to the obverse reverse surfaces. Chamber emplacement is biserial/polyserial, with a zigzag axial wall trace. Chamber shapes are poorly preserved because of crushing of the branches, but are narrow hexagonal to pentagonal near the reverse surface and hexagonal at mid chamber level. Ratio of mean minimum to maximum chamber width 3:10, maximum width to depth 8:9, and depth to length 7:10.

Three dimensional reconstructed chamber form is unclear, but appears to be a hexagonal box. Hemisepta are absent. Reverse wall budding angle constant, with a range of 48° to 67° (mean 56°). Lateral wall budding angles not examinable. Skeletal granular layer is thin, skeletal lamellar layer thick in both obverse and reverse walls.

Polyporella sp.	X	SD	Min	Max	N	CV
rows of zooecia	2.708	0.624	2	4	24	23 043
distance between branch centres	0.926	0.128	0.72	1.18	22	13 797
branches in 10 mm.	10	0	10	10	2	0 000
width branch	0.614	0.076	0.43	0.78	24	12 299
width dissepiments	0.509	0.094	0 34	0 74	25	18 522
fenestrules in 10 mm	6.333	0.577	6	7	3	9 116
fenestrule length	1.000	0 099	0.77	1.17	22	9 885
fenestrule width	0.364	0 057	0 28	0.49	21	15.712
apertures between dissepiment centres	3.694	0.304	3	4	18	8 224
aperture width	0 180	0 012	0 16	0.2	14	6 592
aperture length	0.227	0 016	0 2	0.25	12	7 122
apertural spacing down branch	0.391	0 040	0.34	0.48	16	10 131
apertural spacing across branch	0.384	0 045	0 32	0.46	7	11.816
apertural spacing between branches	0.790	0.014	0.78	0.8	2	1 790
width apertural peristome	0.009	0.001	0 008	0 01	7	13 137
number of apertural stylets	30	0	30	30	2	0 000
diameter apertural stylets	0.010	0.002	0.008	0.013	7	18 631
diameter nodes	0 065	0 018	0.04	0 08	6	27 087
spacing of nodes down branch	0.433	0 121	0.28	0.54	4	28.089
diameter obverse stylets	0.012	0.002	0.008	0 018	23	20 189
spacing obverse stylets	0.050	0.013	0.03	0 075	24	26 334
diameter reverse microstylets	0.011	0 002	0 008	0.018	37	22 459
spacing reverse microstylets	0 043	0 012	0.025	0.065	35	28 257
thickness reverse wall granular layer	0.009	0.002	0.005	0.011	22	16.541
thickness lateral wall granular layer	0.012	0.002	0 01	0.015	7	18 524
thickness frontal wall laminated layer	0.230	0.028	0.21	0.25	2	12.298
thickness reverse wall laminated layer	0.268	0.043	0 195	0.35	17	16 045
chamber length	0.388	0 031	0 35	0 45	10	8 006
chamber depth	0.278	0 028	0 24	0 31	7	10.172
maximum chamber width	0.245	0.025	0 195	0.28	13	10 202
minimum chamber width	0.073	0.038	0	0.13	15	51 613
budding angle reverse chamber wall	56.333	6.481	48	67	9	11 504

Table 3.26 - Summary measurements for *Polyporella* sp Abbreviations as for Table 3.1, all measurements in millimetres.

Discussion - *Polyporella* sp. is similar in appearance to *P. westarmensis* from the Ufimian of Tasmania, but differs in mesh characters and more widely spaced chambers. *Polyporella* sp. is also similar to *Polypora woodsi* Etheridge but differs slightly in dimensions of fenestrules, branches and aperture spacing. The preservation of this species from the Wandrawandian Siltstone at Ulladulla is too poor to describe a new species. An additional specimen is similar in appearance to *Polyporella* sp., and differs only in aperture size and dissepiment width. It's relationship to *Polyporella* sp. is not known, whether it be a variant or separate species.

Material - Two specimens are available for internal examination (UTGD 127569-70) from the Kungurian Wandrawandian Siltstone at North Head, Ulladulla.

Range - Kungurian.

Genus *Pseudopolypora* Morozova and Lisitsyn, 1996

Type species - *Polyporella pavlovae* Gorjunova and Morozova (1979); Upper Permian, Ufimian Stage; central Mongolia.
Diagnosis - Zoarium fan-shaped and lamellar. Meshworks of various sizes, with non-poriferous dissepiments and straight to sinuous branches with a circular cross section. Zooecia are in 2 rows on the branches, with a third row inserted near, and a fourth row immediately before bifurcation. Zooecial chambers are elongate quadrate in median tangential section, and where there are more than 2 rows lateral zooecia are elongate quadrate to hexagonal. Zooecial chamber form an elongated box. Zooecial apertures are circular, each row separated by a poorly defined carina with small nodes (after Morozova and Lisitsyn, 1996).

Pseudopolypora banksi n. sp.
Plate 26; Table 3.27

Holotype - UTGD 127513; Artinskian Skipping Ridge Formation, Maria Island, Tasmania.
Diagnosis - Zoarium robustness intermediate, mesh spacing close and regular. Autozooecia in 2 rows, with 3 and then 4 shortly before bifurcation. Bifurcation is at wide intervals. Branches are wide and thick, with a straight proximodistal trace and circular cross sectional outline. Dissepiments are straight, regularly free of extra zooecia. Fenestrules are elliptical to subrectangular.
The obverse surface has a single poorly defined narrow straight carina. A single row of nodes is emplaced on the carina. Autozooecial apertures are large and open at an angle towards the fenestrules. Peristomes are incomplete and apertural stylets are poorly developed. Autozooecial chambers are of intermediate size, biserially emplaced with a straight to gently zigzag axial wall trace. The exterior lamellar skeleton is thin, and without apparent thickening. Three dimensional reconstructed chamber form a rectangular box. Brood chambers are present, and replace existing autozooecia.
Description - External features - Zoarium robustness intermediate. Overall zoarial form is unknown, but fragments form flat expansions. Mesh spacing close and regular. Autozooecia in 2 rows, with 3 or 4 shortly before bifurcation. Bifurcation at wide intervals of up to 2 cm.
Branches are wide and thick, with a straight proximodistal trace and rounded obverse surface profile. Branch spacing close and regular, with 12 to 15 in 10 mm. Dissepiments are straight, regularly placed and short. Dissepiment width relative to branches is regularly lower end intermediate, and they are free of extra zooecia. Dissepiments are moderately thick, slightly recessed from the reverse surface, and moderately recessed from the obverse surface. There is no regular placement of apertures relative to dissepiments but their width means apertures may be placed opposite dissepiments. Fenestrules are elliptical to subrectangular, elongated proximodistally and upper end intermediate to large in size. Fenestrules are narrower than branches, with a mean fenestrule to branch width ratio of 7:10. Fenestrule width to length ratio is nearly 2:5. There are 9 to 10 fenestrules in 10 mm.
Autozooecial apertures are large and circular to ovate in shape. There are 3 to 4 apertures in the distance between dissepiment centres, and 13 to 17 in 5 mm. Apertural spacing is regular with ratio of mean down to across branch spacing 11:10, down to between branch spacing approximately 7:10, and across to between branch 3:5. Apertures open at an angle towards the fenestrules, but do not indent them. Peristomes are incomplete and apertural stylets are poorly developed.
Heterozooecia are present, and replace existing autozooecia. The aperture formed by each heterozooecium is much larger than that of autozooecial chambers and without a peristome or apertural stylets.
The obverse surface has a single poorly defined narrow straight carina. A single row of nodes is emplaced on the carina. Nodes are ovate and elongated along the carina, and of intermediate size and spacing. The low height of the carina has little effect on the surface

profile of the branch, but when sectioned at the level of a node profile is distinctly angular. Obverse stylets are present and are small and indistinct, and apparently evenly spread over the obverse surface. Reverse microstylets are of irregular small size and widely spaced. Reverse macrostylets are absent.

Pseudopolypora banksi n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm	13.6	1.140	12	15	5	8 384
distance between branch centres	0.713	0.114	0.51	0.93	40	16.048
width branch	0.460	0.064	0.375	0.6	30	13 895
width dissepiments	0.293	0 049	0.2	0.42	30	16 847
fenestrules in 10 mm.	9.25	0 5	9	10	4	5 405
fenestrule length	0 857	0.115	0.675	1.125	30	13 449
fenestrule width	0 318	0 079	0.18	0.5	30	24 992
zooecial apertures in 5 mm.	15.143	1 215	13	17	7	8 023
apertures between dissepiment centres	3.567	0 341	3	4	30	9.553
aperture length	0.186	0.012	0.16	0.21	33	6 507
aperture width	0.142	0.014	0 11	0 17	28	10.005
apertural spacing down branch	0.312	0 018	0.27	0.35	40	5.828
apertural spacing across branch	0.282	0.031	0.21	0 33	33	10 906
apertural spacing between branches	0.463	0.041	0.36	0.58	33	8.830
nodes in 5mm	12.5	0.707	12	13	2	5 657
diameter nodes	0.084	0 028	0.045	0.14	11	32 764
spacing of nodes down branch	0.497	0.095	0.295	0.72	25	19 151
width of carina	0.1	0 020	0.06	0.13	10	19 861
diameter obverse stylets	0.009	0.003	0.005	0.015	38	34 889
spacing obverse stylets	0.027	0.010	0 015	0.05	31	36 132
number of apertural stylets	18.333	2.887	15	20	3	15 746
diameter apertural stylets	0.008	0 002	0.005	0.01	4	27.217
diameter reverse microstylets	0.012	0 004	0.008	0.02	13	32 998
spacing reverse microstylets	0 063	0 023	0.035	0.105	13	36 587
thickness reverse wall granular layer	0.011	0 003	0.005	0.02	40	29 000
thickness lateral wall granular layer	0.011	0 002	0.0075	0.0175	33	19.256
thickness frontal wall laminated layer	0.123	0.024	0.08	0.17	26	19 665
thickness reverse wall laminated layer	0 122	0.029	0.08	0.165	24	23 672
chamber length	0 293	0.022	0.25	0.335	40	7 593
chamber depth	0.315	0 056	0.25	0.42	20	17.732
maximum chamber width	0.188	0.025	0.14	0.245	40	13.370
minimum chamber width	0.145	0.031	0.08	0.21	40	21 485
vestibule length	0.062	0 016	0 04	0 095	19	26.369
budding angle reverse chamber wall	69.676	7.554	49	88	37	10.841
budding angle lateral chamber wall	26 738	6 016	17	39	40	22 500
branch thickness	0 536	0.030	0.485	0.598	40	5 532
brood chamber length	0.273	0.018	0 25	0 29	7	6 510
brood chamber width	0.246	0.017	0.22	0.27	7	7 001

Table 3 27 - Summary measurements for *Pseudopolypora banksi* n. sp. Abbreviations as for Table 3 1, all measurements in millimetres.

Internal features - Branch outline circular to only slightly ovate in cross section. Branches thick, but thickness is only slightly greater than branch width, and ratio of mean width to thickness approximately 4:5.

Autozooecial chambers are large, with mean chamber depth greater than chamber length, such that orientation of chamber elongation is parallel to proximal and distal chamber walls. Chambers are biserially emplaced with a straight to gently zigzag axial wall trace near the reverse surface, becoming straight towards the obverse. Autozooecial chamber outline is pentagonal near the reverse wall, gently pentagonal to rectangular in mid tangential section, and rectangular to ovate near the obverse surface. Heterozooecia are circular and larger than autozooecial chambers, and can be seen to be rounded in mid tangential section. Where heterozooecia are present, adjacent autozooecial chambers have a pentagonal outline.

Apertures are located abaxial-distally to the living chamber on a short vestibule. Hemisepta are absent. Chamber dimensions are slightly variable except for chamber length which is highly regular. Ratio of mean minimum to maximum width almost 4:5, maximum width to depth 3:5, and depth to length approximately 10:11. Lateral wall budding angle is high and variable, ranging between 17° to 39° (mean 27°). Reverse wall budding angle only slightly variable, ranging from 49° to 88° (mean 70°). Three dimensional reconstructed chamber form a rectangular box.

The interior granular skeleton is thin without apparent thickening. The exterior lamellar skeleton is also thin, and again without apparent thickening.

Discussion - *P. banksi* is distinguished from the other species of this genus in Tasmania by the low carina, lack of reverse macrostylets and comparative lamellar skeleton thickness.

Types - UTGD 127513, holotype; UTGD 127514, paratype.

Etymology - Named for Max Banks.

Material - Two specimens, recorded only from the late Sakmarian to lower Artinskian Skipping Ridge Formation, Maria Island.

Range - lower Artinskian.

Pseudopolypora bundellaensis n. sp.
Plate 27; Table 3.28

Holotype - UTGD 127515; Sakmarian; Bundella Mudstone, Lyell Highway, Granton, Hobart, Tasmania.

Diagnosis - Zoarium intermediate to robust, mesh spacing close and regular. There are 9 to 10.5 straight wide branches in 10 mm. Dissepiments are short, of variable narrow to lower end intermediate width. Fenestrules are large and regularly elongate oval, with 6 to 7 fenestrules in 10mm. Zooecia are in 2 rows, increasing to 3 some distance before branching, with 4 only immediately before branching.

Autozooecial apertures are large and open at an angle towards the fenestrules. Nodes are present on the obverse surface on a narrow carina. Nodes are widely spaced with 6 to 7 occurring in 5 mm. Obverse stylets are small and cover the obverse surface evenly. Reverse microstylets are small and are aligned to the longitudinal striae. Reverse macrostylets are small to large, and do not seem to be placed in relation to branches or dissepiments.

Autozooecial chambers are large, biserially emplaced, with a sinuous to straight axial wall trace. Autozooecial chamber outline is pentagonal to rectangular in mid tangential section. Vestibules are present. Hemisepta are absent. Three dimensional reconstructed chamber form a wedge shaped rectangular box.

Description - External features - Zoarium intermediate to robust, fragments forming flat to gently curved outward expansions. The overall form of the colony is not known. Mesh spacing is close and regular. The branches are wide with a straight proximodistal trace. There are 9 to 10.5 branches in 10 mm. The surface profile is rounded, but with a fine carina providing some angularity to the front surface. Zooecia are in predominantly 2 rows, increasing to 3 some distance before branching, with 4 only immediately before branching.

Dissepiments are short and narrow to lower end intermediate in width. Dissepiments vary in width across the colony, and small fragments may show differing dissepiment width means. Dissepiments are thick and only slightly recessed from reverse and obverse surfaces. Dissepiments are free of zooecia. Fenestrules are large, and long with long axis oriented proximodistally. Fenestrules are elongate oval and of regular shape, only differing slightly at points of branching. Fenestrules are narrower than branches, mean fenestrule width to branch width ratio 7:10, mean fenestrule width to length ratio 2:5. There are 6 to 7 fenestrules in 10 mm.

Autozooecial apertures are large and circular to ovate, apparently without peristomes or apertural stylets. There are usually 4 (occasionally 3) autozooecial apertures between dissepiment centres. Aperture spacing down and across branch is regular, with 12 to 14 apertures in 5mm down the branch. Mean spacing ratio of apertures down to across branch almost 1:1, with spacing across branch slightly closer. Mean spacing ratios down, and across, to between branches both approximately 1:2. Apertures open at an angle towards the fenestrules.

On the front surface of the branch is a straight carina of intermediate width. Nodes are present on the obverse surface on the centre line of the carina. They are small and elongated along the carina, and are not well defined. Nodes are regularly widely spaced with 6 to 7 nodes occurring in 5 mm.

Small obverse stylets are present and are widely spaced covering the obverse surface evenly. Reverse microstylets are small and widely spaced along the longitudinal striae. Reverse macrostylets are present, of variable small to large size and are randomly placed.

Pseudopolypora bundellaensis n.sp.	X	SD	Min	Max	N	CV
rows of zooecia	2.3	0.483	2	3	10	21 002
branches in 10 mm.	9.75	0 589	9	10.5	10	6 044
distance between branch centres	1.035	0.109	0 88	1.18	8	10 546
width branch	0 63	0 107	0.5	0.825	10	17 022
width dissepiments	0.433	0.094	0 275	0.6	10	21.808
fenestrules in 10 mm.	6.9	0.459	6	7 5	10	6 659
fenestrule length	1 078	0 141	0.875	1.275	10	13 100
fenestrule width	0.453	0.058	0.375	0 55	10	12 878
zooecial apertures in 5 mm.	13 25	0 717	12	14	10	5.410
apertures between dissepiment centres	3.8	0.422	3	4	10	11 096
aperture length	0 227	0 012	0 21	0.25	13	5.131
aperture width	0 201	0.013	0.18	0.22	14	6 416
apertural spacing down branch	0.388	0.027	0 3625	0.45	10	6 969
apertural spacing across branch	0 371	0 028	0 34	0 42	14	7 441
apertural spacing between branches	0.737	0.170	0.52	0 94	7	23.045
nodes in 5 mm	6.5	0 577	6	7	4	8 882
diameter nodes	0 118	0.035	0.08	0.16	4	29.787
spacing of nodes down branch	0.773	0 032	0 725	0.825	10	4 164
width of carina	0 074	0 016	0.05	0.09	8	21 087
diameter obverse stylets	0.012	0 002	0 01	0 015	8	18 091
spacing obverse stylets	0 054	0.013	0 038	0.073	6	23.834
diameter reverse macrostylets	0.078	0.029	0.04	0.17	20	37 764
spacing reverse macrostylets	0.241	0.109	0 11	0.41	20	45 428
diameter reverse microstylets	0.016	0.006	0 01	0 03	20	34.130
spacing reverse microstylets	0.064	0 015	0.04	0 095	20	23.253
thickness frontal wall laminated layer	0.211	0.035	0 14	0.26	15	16.495
thickness reverse wall granular layer	0.012	0.002	0 01	0 015	7	17 244
thickness reverse wall laminated layer	0.419	0 100	0 27	0 55	8	23.784
thickness lateral wall granular layer	0 010	0 002	0 008	0 013	5	22.017
chamber length	0.373	0.040	0 298	0.45	20	10 688
chamber depth	0.532	0.074	0 44	0.66	11	13 940
maximum chamber width	0.284	0 037	0 2	0 36	20	13 199
minimum chamber width	0.215	0.030	0.16	0 29	20	14.142
vestibule length	0 133	0 021	0 095	0.17	14	15 993
budding angle reverse chamber wall	56.65	4.845	46	67	20	8 553
budding angle lateral chamber wall	15	5.762	8	25	6	38 413
branch thickness	0.859	0.109	0.715	1.05	17	12 733

Table 3.28 - Summary measurements for *Pseudopolypora bundellaensis* n. sp Abbreviations as for Table 3 1, all measurements in millimetres.

<u>Internal features</u> - Branches are thick with an elliptical outline in cross section, showing a rounded reverse surface and angular obverse surface. The long axis is oriented perpendicular to the obverse and reverse surfaces. Ratio of mean branch width to thickness 7:10.

Autozooecial chambers are large, with depth greater than length and long axis perpendicular to the obverse and reverse surfaces. Chambers are biserially emplaced with a gently zigzag axial wall trace near the reverse surface, becoming straight towards the obverse surface. Autozooecial chamber shape is pentagonal near the reverse surface, pentagonal to tetragonal in mid tangential section, and tetragonal to ovate near the obverse surface. Apertures are located abaxial-distally connected to the chamber by an intermediate to long vestibule. Hemisepta are absent. All autozooecial chamber dimensions are slightly variable, with the ratio of mean minimum to maximum width nearly 4:5, maximum width to depth approximately 1:2, and depth to length 7:5. Three dimensional reconstructed chamber form a wedge shaped rectangular box.

Reverse wall budding angle constant with a range of 46° to 67° (mean 57°). Lateral wall budding angle highly variable, range 8° to 25° (mean 15°).

Exterior lamellar skeleton is of intermediate thickness, with astogenetic thickening not evidenced. Interior granular skeleton thin.

Discussion - This species of *Pseudopolypora* is distinguished from other Tasmanian species by the larger mesh form, number of zooecia and small widely spaced nodes.

Types - UTGD 127515 - holotype, Sakmarian Bundella Mudstone, Lyell Highway, Granton, Tasmania.

Etymology - Named for the Bundella Mudstone, from which this species is found.

Range - Sakmarian.

Pseudopolypora tamarensis n. sp.
Plate 28; Table 3.29

Holotype - UTGD 127516; upper West Arm Group, Beaconsfield, Tasmania.

Diagnosis - Zoarium is of intermediate robustness, forming an undulating outward expansion. Branching is at wide intervals and mesh spacing is close, with 14 to 16 branches and 9 to 11 fenestrules in 10 mm. Autozooecia are in two rows, with a third row inserted shortly before branching. Branches are thick and of intermediate to wide width, with a straight proximodistal trace. Dissepiment width one half to one third the length of fenestrules. Fenestrules are ovate to subrectangular and of regularly intermediate size. Fenestrule rounded polygonal on the reverse surface, giving a reticulate appearance, and rectangular on the obverse surface as dissepiment narrow and become thin bars between apertures. Single carina straight high, with a monoserial row of large elongate well developed nodes. Obverse stylets and reverse microstylets are present but macrostylets are absent.

Autozooecial apertures are circular with 3 to 3.5 between dissepiment centres. Apertures open steeply inclined into the fenestrules but do not indent them. A thin incomplete poorly developed peristome is present, without apertural stylets. Autozooecial living chambers are of intermediate size, biserially emplaced, with chamber length approximately equal to depth. Autozooecial chamber outline tetragonal to rectangular at mid chamber level. Hemisepta are absent.

Reverse wall chamber budding angle constant and high, lateral wall budding angle variable but always high. Three dimensionally reconstructed form a rectangular box. Internal granular skeleton thin, lamellar skeleton thick.

Description - <u>External features</u> - Zoarium of intermediate robustness, forming an undulating outward expansion, although complete zoaria are not seen. Mesh spacing is close and generally regular, with moderate astogenetic thickening. Autozooecia are in two rows, with a third row inserted shortly before branching.

Branching is at wide intervals. Branches are of intermediate robustness, with zooecial chambers commonly crushed. Branch width intermediate to wide, and constant, with a straight proximodistal trace, and rounded surface profile, made distinctly angular by a high wide carina. Branch spacing is close to intermediate, and regular, with 14 to 16 in 10 mm. Branches are thick with thickening on the reverse surface at dissepiment branch junction such that reverse surface takes on a polygonal reticulate appearance. Dissepiments are of intermediate width relative to the branches. Dissepiment width to fenestrule length ratio 1:2 to 1:3. Dissepiments are short and emplaced at regular intervals perpendicular to the branches. Dissepiments may be widened by astogenetic thickening. Surface ornamentation as for remainder of branch surface. Dissepiments are thick and not recessed on the reverse surface. On the obverse surface dissepiments are level with the zooecial apertures, with width considerably reduced, such that apertures rarely occur at branch dissepiment junctions. Fenestrules are ovate to subrectangular at mid branch level and are of regularly intermediate size, with 9 to 11 in 10 mm. Fenestrule width to length ratio approximately 2:5. Fenestrule shape is regular at mid branch level, but becomes rounded polygonal on the reverse surface, and more rectangular on the obverse surface as dissepiments and branches narrow. Shape varies little toward proximal end of zoarium, but size increases slightly.

Pseudopolypora tamarensis n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	15	1 414	14	16	2	9 428
distance between branch centres	0 648	0.086	0.52	0 91	42	13.322
width branch	0.389	0 045	0.3	0.5	38	11 553
width dissepiments	0 377	0.078	0.28	0 51	40	20.692
fenestrules in 10 mm.	10 3	0.837	9	11	5	8 123
fenestrule length	0 668	0.090	0.52	0 9	41	13 426
fenestrule width	0.290	0.046	0 22	0.4	39	15.975
apertures between dissepiment centres	3.578	0 461	3	5	45	12 886
aperture length	0.154	0 010	0.14	0.17	9	6 453
aperture width	0.138	0.016	0.12	0 16	8	11.499
apertural spacing down branch	0.311	0.035	0.25	0.39	16	11 119
apertural spacing across branch	0.326	0 044	0 28	0.42	12	13.379
apertural spacing between branches	0.385	0.051	0 34	0.48	10	13 202
node width	0.076	0.009	0 06	0 09	14	12.152
node length	0.165	0.048	0 065	0.3	21	29.385
spacing of nodes down branch	0.396	0.079	0 28	0.59	32	19 869
width of carina	0.115	0 024	0.06	0.15	22	20 852
diameter obverse stylets	0.010	0.004	0 005	0.02	31	34.501
spacing obverse stylets	0.046	0 014	0.025	0 07	26	30 596
diameter reverse microstylets	0.009	0 003	0 0025	0.02	40	38 551
spacing reverse microstylets	0.017	0 005	0 01	0 035	40	30 753
thickness reverse wall granular layer	0.010	0 002	0 005	0 015	40	23 513
thickness lateral wall granular layer	0.009	0.002	0.005	0.01	21	21 771
thickness frontal wall laminated layer	0.208	0.041	0.14	0.28	10	19.634
thickness reverse wall laminated layer	0 582	0.145	0.41	0.82	33	24.971
chamber length	0.249	0.025	0.215	0.31	48	9 981
chamber depth	0.267	0.030	0.2	0.31	20	11.430
maximum chamber width	0.165	0 017	0.14	0.2	33	10 575
minimum chamber width	0.114	0 021	0 08	0 17	31	18 692
budding angle reverse chamber wall	73 870	6.211	67	85	23	8.408
budding angle lateral chamber wall	55.125	11.643	42	77	8	21 121
branch thickness	1.039	0 157	0 87	1.3	14	15 142

Table 3 29 - Summary measurements for *Pseudopolypora tamarensis* n. sp. Abbreviations as for Table 3.1, all measurements in millimetres.

Autozooecial apertures are circular and of intermediate to large size and consistent spacing with 3 to 3.5 (occasionally 4) between dissepiment centres. Ratio of mean apertural spacing down to across branch approximately 1:1, down branch to between branches and across to between are both 4:5. Apertures open steeply inclined into the fenestrules but do not indent them. A thin incomplete poorly developed peristome is present, and does not appear to carry apertural stylets.

On the front surface of the branch is a high, well developed, single carina of intermediate width. The carina is straight and widened by astogenetic thickening, and produces a strong angularity to the obverse surface. Along the midline of the carina is a monoserial row of large well developed nodes. Nodes are of intermediate spacing, and ovate to elongate ovate, with elongation along the carina. Obverse stylets are of small to intermediate size and are of irregular intermediate to wide spacing across the obverse surface. Beneath the reverse surface are 7 to 8 thin longitudinal striae. Reverse microstylets are small and closely and evenly closely spaced across the reverse surface. Reverse macrostylets are absent.

Internal features - Branches thick and elongate elliptical in cross section, with long axis oriented in an obverse reverse direction. Ratio of mean branch width to thickness approximately 2:5.

Autozooecial living chambers are of intermediate size, biserially emplaced, with a gently zigzag axial trace in deep tangential section becoming straight at mid to shallow levels. Chamber length is approximately equal to chamber depth. Autozooecial chamber outline is pentagonal (to tetragonal) near the reverse surface, tetragonal to rectangular at mid chamber level and tetragonal ovate near the obverse surface. Chamber shape near the obverse surface is irregular and distorted by the distal abaxial opening of the apertures. Vestibules are indistinct and quite short. Hemisepta are absent. Chamber dimensions are regular except for the minimum chamber width which shows variability from the change from pentagonal to tetragonal chamber shapes. Ratio of mean minimum to maximum chamber width 7:10, mean maximum width to depth 6:10, with depth to length approximately 1:1. Reverse wall chamber budding angle constant and high with a range of 67° to 85° (mean 74°). Lateral wall budding angle variable but always high, with a range of 42° to 77° (mean 55°). Three dimensionally reconstructed form a rectangular box, appearing as an even sided box when viewed from the lateral edge, and a rectangular box when viewed proximodistally.

The internal granular skeletal layer is thin, with apparent continuity between chamber walls to carina and nodes, with some continuity between branches across dissepiments. Lamellar skeleton of moderate thickness in the frontal wall, and very thick in the reverse wall, with the reverse wall further thickened by astogeny.

Discussion - *P. tamarensis* shows some variability in zoaria between individual specimens despite pooled data showing low coefficients of variation. The holotype UTGD B6bx shows that fenestrules may vary in size, while branch widths remain constant along with chamber, aperture dimensions and spacing.

Distinguished from *P. versonoda* n. sp. also from the West Arm Group principally by the absence of the large reverse macrostylets, and from *P. banksi* n. sp. by mesh dimensions and greater lateral wall budding angle and inclination of apertures into fenestrules in *P. tamarensis.*

Types - UTGD 127516 holotype; UTGD 127517-18 paratypes.

Etymology - Named for the Tamar River region, northern Tasmania, where the type specimens were collected.

Material - Three specimens were availabke for internal examination from Kungurian beds in the West Arm Group, Beaconsfield, Tasmania.

Range - Kungurian.

Pseudopolypora versonoda n. sp.
Plate 29; Table 3.30

Holotype - UTGD 127519, Kungurian; West Arm Group, Beaconsfield, Tasmania.

Diagnosis - Zoarium is infundibuliform with the obverse surface internal. Zoarium robustness intermediate, mesh spacing close and regular, with 15 to 17 branches and 9 to 11 fenestrules in 10 mm. Autozooecia are in predominantly 2 rows, with an increase to 3 and then 4 shortly before bifurcation.

Branches are very thick with a straight proximodistal trace and a rounded surface profile. Dissepiments are wide, short and regularly placed without extra zooecia. Fenestrules are regularly oval. The carina is narrow and poorly defined with a single row of small elliptical to ovate nodes. On the reverse surface small microstylets are widely spaced and evenly distributed across the reverse surface. Distinct small to large reverse macrostylets are also present, after which this species is named. Macrostylets are circular to ovate. Autozooecial apertures are large, open upwards and are only slightly inclined towards the fenestrules. An incomplete peristome is present.

Autozooecial chamber outline in mid tangential section is rectangular. Three dimensional reconstructed chamber form a rectangular box.

Pseudopolypora versonoda n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm	16 167	0 816	15	17	6	5 050
distance between branch centres	0.591	0.058	0.48	0.78	57	9 740
width branch	0 376	0.043	0 28	0.46	45	11.494
width dissepiments	0.497	0.062	0.365	0.62	39	12 564
fenestrules in 10 mm	9.450	0 685	9	11	10	7 250
fenestrule length	0.492	0 073	0.35	0.65	38	14.793
fenestrule width	0 239	0.023	0.2	0.3	50	9 473
zooecial apertures in 5 mm.	17.45	0.438	17	18	10	2 509
apertures between dissepiment centres	3.609	0.410	3	4.25	46	11.374
aperture length	0 168	0.028	0 11	0.22	35	16 746
aperture width	0.142	0.017	0 11	0 18	31	12 158
apertural spacing down branch	0.276	0 025	0.23	0.34	36	9 182
apertural spacing across branch	0.263	0.034	0.21	0.32	23	13 078
apertural spacing between branches	0.347	0.031	0 29	0 4	13	9 068
nodes in 5mm	15		15	15	1	
diameter nodes	0.086	0 029	0.04	0 15	30	33.824
spacing of nodes down branch	0.424	0.066	0.3	0.57	30	15 538
width of carina	0 062	0 021	0 03	0 09	8	34.538
width apertural peristome	0.013	0.004	0.01	0 02	7	30 598
diameter obverse stylets	0.011	0.003	0.005	0.02	52	27 758
spacing obverse stylets	0.043	0 014	0.02	0.095	48	32.619
diameter reverse microstylets	0.010	0.003	0.005	0.02	60	28.089
spacing reverse microstylets	0 052	0.018	0.015	0 1	60	34 256
diameter reverse macrostylets	0 063	0.021	0.025	0.11	60	33.224
spacing reverse macrostylets	0 302	0.133	0 095	0.88	60	44.138
thickness frontal wall laminated layer	0.164	0.034	0 09	0.22	21	20.483
thickness reverse wall laminated layer	0.708	0.159	0 38	0.94	52	22 472
thickness reverse wall granular layer	0.009	0.002	0 005	0.015	60	23 153
thickness lateral wall granular layer	0.015	0.007	0.005	0.03	35	48 230
chamber length	0 253	0 029	0.2	0 33	30	11.469
chamber depth	0 223	0 026	0.19	0 26	9	11.470
maximum chamber width	0.168	0.016	0.13	0.205	43	9.746
minimum chamber width	0.127	0.020	0 08	0.17	42	16 055
vestibule length	0.166	0.036	0 13	0.21	5	21 969
budding angle reverse chamber wall	68 143	8 071	57	79	7	11.844
budding angle lateral chamber wall	23 273	6.482	13	33	11	27 853
branch thickness	1.106	0.105	0.85	1.32	30	9 539

Table 3 30 - Summary measurements for *Pseudopolypora versonoda* n sp. Abbreviations as for Table 3 1, all measurements in millimetres

Description - <u>External features</u> - Zoarium infundibuliform with the obverse surface internal. Zoarium robustness intermediate, mesh spacing close and regular. Autozooecia are in predominantly 2 rows, with an increase to 3 and then 4 shortly before bifurcation.

Branches are of intermediate width and robustness, and are very thick with a straight proximodistal trace and a rounded surface profile. Branch spacing is close and regular, with 15 to 17 branches in 10 mm. Dissepiments are wide, short and regularly placed without extra zooecia. Dissepiments are thickened astogenetically, at times greatly increasing width variation between fragments. Ratio of mean dissepiment width to fenestrule length 1:1, with variation on this according to astogenetic thickening. Dissepiments are thick and only very slightly recessed from the reverse surface, and are level with the apertures on the obverse. Fenestrules are regularly oval and of intermediate size, with 9 to 11 in 10 mm. Fenestrules are of constant width and narrower than the branches, with the ratio of mean fenestrule to branch width approximately 3:5, fenestrule width to length when measured at mid branch level almost 1:2. On the reverse surface thickening of the dissepiments results in fenestrule length being less than dissepiment width and fenestrule shape oval to circular.

Autozooecial apertures are large and circular to slightly ovate. There are 3 to 4 apertures between dissepiment centres, and 17 to 18 in 5 mm. Apertures are generally regularly spaced, with ratio of mean spacing down to across branch almost 1:1, down branch to between branches 4:5, and across to between branches approximately 4:5. Apertures are slightly inclined towards the fenestrules. An incomplete peristome is present.

On the obverse surface of the branch a single straight carina occurs. The carina is narrow and poorly defined, without prominent relief, but when sectioned at a node centre the obverse surface appears angular, rather than rounded. Upon the carina is single row of elliptical to ovate nodes. Nodes are of irregular small to intermediate size, with intermediate spacing, and about 15 in 5 mm.

Obverse stylets of small to intermediate size and intermediate spacing across the obverse surface without any apparent arrangement. On the reverse surface microstylets of small size are present. They are of wide irregular spacing and distributed across the reverse surface, with no particular arrangement. Distinct small to large circular to ovate reverse macrostylets are also present, after which this species is named. The larger macrostylets are placed at dissepiment and branch junctions with smaller macrostylets in between, but this pattern is not rigidly adhered to.

Internal features - In cross section branches are elliptical and with an extensively thickened reverse wall, with the long axis of thickening perpendicular to the plane of the obverse surface. Branch width to thickness ratio approximately 3:10.

Autozooecial chambers are of intermediate size and biserially emplaced. Axial wall trace is gently zigzagged near the reverse surface, and straight to sinuous towards the obverse surface. Chambers are elongated parallel to the reverse surface. Autozooecial chamber outline near the reverse surface is pentagonal, rectangular in mid tangential section, and ovate near the obverse surface. Chamber dimensions are slightly variable, with ratio of mean minimum to maximum width 3:4, maximum width to depth also 3:4, depth to length approximately 9:10. Autozooecial aperture is located abaxial-distally, on a long vestibule, of irregular length according to degree of frontal wall thickening. Hemisepta are absent.

Lateral wall budding angle is low and variable with a range of 13° to 33° (mean 23°). Reverse wall budding angle is high and slightly variable with a range of 57° to 78° (mean 68°). The exterior lamellar skeleton is thick in the frontal wall, and extremely thick in the reverse wall. The reverse wall laminated layer generally exceeds the thickness of the chambers and frontal wall combined, such that it takes up greater than half the branch thickness. The interior granular skeleton is thin. Three dimensional reconstructed chamber form a rectangular box.

Discussion - This species is distinguished from other Tasmanian *Pseudopolypora* by its large reverse macrostylets, wide dissepiments and very thick reverse wall. Based on external measurements of the mesh this species belongs to the 'fossula' group of fenestrates, along with *P. banksi* and *P. tamarensis*, but internal examination distinguishes separate species.

Types - Holotype UTGD 127519; paratype UTGD 127520; West Arm Group, Beaconsfield; Tasmania.

Etymology - Named for the large reverse macrostylets.

Range - Kungurian.

Genus *Shulgapora* Termier and Termier, 1971

Type species - *Polypora abundans* Shulga-Nesterenko 1951.

Diagnosis - Zoarium robust, with zooecia in four to five rows. Dissepiments are free of extra zooecia. Zooecial chambers are long and thin hexagonal to rounded hexagonal. Apertures are usually small and circular, with fine weak ridges between the rows of zooecia, but not carinae. Nodes small and rare. Cyclozooecia are present on both the reverse surfaces of both the branches and dissepiments.

Shulgapora magnafenestrata (Crockford, 1941)
Plate 30; Table 3.31

Polypora magnafenestrata CROCKFORD (1941b), p. 513, pl. XX, fig.5; pl. XXI, fig. 5; WASS (1968), p. 48, pl. 12, fig. 4; pl. 13, fig. 1.

Diagnosis - The zoarium is robust and fragments form flat to undulose outward expansions. Mesh spacing is close and slightly irregular. Branches are flat, robust and wide, straight to broadly curving with 5 to 6 branches occurring in 10 mm. A carina and nodes are absent from the obverse branch surface. Autozooecia in usually 5 rows, with up to 8 before and 4 after bifurcation. Dissepiments are narrow and short and irregularly placed, either perpendicular of at an angle to the branches. Fenestrules are large elongate oval to subrectangular. Fenestrule length is variable with 1.5 to 3 fenestrules in 10 mm.

Autozooecial apertures are large circular and regularly spaced with 6 to 10 between dissepiment centres. Apertures open parallel to the obverse surface and lateral rows do not indent fenestrules. A thin complete peristome is present about the aperture, without apertural stylets. Cyclozooecia are irregularly spaced down the branch between the apertures and the obverse and reverse surfaces of the dissepiments. Terminal diaphragms are irregularly present throughout the zoarium.

Autozooecial living chambers are large and polyserially emplaced with a straight axial wall trace. Autozooecial chamber outline at mid chamber level is elongate quadrate. Hemisepta are absent. Three dimensionally reconstructed chamber form an elongate rectangular box with a flask like vestibule. Lateral and reverse wall budding angles are low. Internal granular skeletal layer is thin, lamellar skeletal layer thick.

Description - External features - The zoarium is robust, colony form unknown, fragments forming flat to undulose outward expansions. Mesh spacing is close, but is slightly irregular. Branches are robust and wide with a straight to broadly curving proximodistal trace. Branch spacing is close with 5 to 6 branches in 10 mm. The surface profile of both the obverse and reverse surfaces is more or less flat with rounded edges. A carina and nodes are absent from the obverse branch surface. Autozooecia are usually in 5 rows, with up to 8 before and 4 after bifurcation. The obverse and reverse surfaces of the branch carry small and closely spaced microstylets. Stylets are developed at shallow depths in the wall and are not observed in deep section.

Dissepiments are regularly narrow and short, and are narrower than the branches. Dissepiments are straight and irregularly placed, usually perpendicular to the branches but may also be at an angle. The dissepiments are recessed slightly from both the reverse and obverse surfaces and flare slightly at their junction with the branches. Dissepiments are free of extra autozooecia and do not effect placement of autozooecial apertures.

Fenestrules are large, elongate oval to subrectangular and elongated proximodistally. Fenestrule shape varies little from obverse to reverse surfaces. Fenestrule length is variable, but is always long with 1.5 to 3 fenestrules in 10 mm. Ratio of mean fenestrule width to length approximately 1:5, and fenestrule to branch width approximately 3:7.

Autozooecial apertures are very large, circular and regularly spaced with 6 to 10 between dissepiment centres (variation because of fenestrule length variation). The ratio of mean apertural spacing down to across the branch is 7:6, down to between branches 3:5 and across to between branches 1:2. Apertures open parallel to the obverse surface and lateral rows do not indent fenestrules. A thin complete peristome is present about the aperture and is without apertural stylets. Terminal diaphragms are irregularly present throughout the zoarium. Between apertures of median rows, and adjacent to lateral rows are large cyclozooecia. Cyclozooecia are irregularly spaced down the branch and the obverse and reverse surfaces of the dissepiments also carry cyclozooecia.

Internal features - Branches are thick and elliptical in cross section with their long axis parallel to the obverse reverse surfaces. Mean ratio of branch width to thickness is 5:3.

Autozooecial living chambers are large and polyserially emplaced with a straight axial wall trace at deep and mid chamber levels that becomes slightly sinuous near the obverse surface.

Autozooecial chamber outline near the reverse wall and at mid chamber level is elongate quadrate to slightly hexagonal and becomes oval towards the obverse surface. Apertures are located distally at the end of a long vestibule. Chamber dimensions and shape are uniform, with chamber width consistently narrower than apertural width. Therefore the vestibule cannot be parallel sided and increases in width from the living chamber to the aperture. Ratio of mean minimum to maximum chamber width approximately 2:3, maximum width to depth 1:2, and depth to length 7:10. Hemisepta are absent. Three dimensionally reconstructed chamber form an elongate rectangular box with a flask like vestibule.

Few measurements of lateral wall budding angles are available but those taken show a range of 11° to 12°. Reverse wall budding angles are slightly variable and also low, with a range of 22° to 34° (mean 29.5°).

Internal granular skeletal layer is thin but shows continuity between chamber walls, apertures and between branches. The lamellar skeletal layer is thick on both reverse and obverse surfaces.

Shulgapora magnafenestrata	X	SD	Min	Max	N	CV
rows of zooecia	5	0 535	4	6	22	10.690
branches in 10 mm.	5 214	0.636	4	6	7	12.201
distance between branch centres	2.058	0.324	1 65	2 84	10	15 762
width branch in	1.369	0.197	1.1	1 71	15	14 381
width dissepiments in	0.596	0.073	0 5	0 78	18	12 225
fenestrules in 10 mm.	2.25	0.520	1 5	3	7	23 130
fenestrule length in	3.389	0.817	2 25	4 9	12	24 102
fenestrule width in	0.640	0 124	0.46	0.88	13	19 422
apertures between dissepiment centres	7 938	1 124	6	10	16	14.156
aperture width	0 254	0 017	0.22	0 28	20	6 563
apertural spacing down branch	0.490	0.037	0 42	0.56	30	7.474
apertural spacing across branch	0 418	0.070	0.32	0.56	32	16 818
apertural spacing between branches	0.840	0.071	0.78	0 96	6	8 418
width apertural peristome	0.014	0.005	0 008	0.025	18	36 380
diameter of cyclozooecia	0.192	0.031	0.15	0.29	21	15 982
diameter obverse stylets	0.005	0 002	0.001	0.008	31	33.915
spacing obverse stylets	0.017	0.005	0 01	0.03	28	32.162
diameter reverse microstylets	0.007	0.003	0.003	0.013	34	33 811
spacing reverse microstylets	0.017	0.006	0.01	0.04	33	34.046
thickness reverse wall granular layer	0.023	0.004	0.02	0.03	8	16.087
thickness lateral wall granular layer	0.021	0 002	0 02	0 025	9	10.444
thickness frontal wall laminated layer	0.245	0.042	0.2	0.32	6	17.075
thickness reverse wall laminated layer	0.361	0 036	0 3	0.4	9	10.027
chamber length	0.493	0.037	0 42	0.56	17	7 480
chamber depth	0.350	0.014	0 34	0.36	2	4 041
maximum chamber width	0.182	0.018	0.15	0 23	23	9 599
minimum chamber width	0.115	0.021	0.08	0.145	16	18 650
vestibule length	0.28	0	0.28	0.28	2	0
budding angle reverse chamber wall	29.5	4 324	22	34	6	14 659
budding angle lateral chamber wall ab	11.5	0.707	11	12	2	6.149
branch thickness	0.833	0 012	0.82	0.84	3	1.386

Table 3.31 - Summary measurements for *Shulgapora magnafenestrata* (Crockford). Abbreviations as for Table 3 1, all measurements in millimetres.

Discussion - In the original description of this species Crockford (1941b) discussed small rounded surface cells, that are here shown to be cyclozooecia. The presence of cyclozooecia remove this species from *Polypora* and place it in *Shulgapora*. As well as *S. magnafenestrata,* Crockford also described a very similar species, *P. linea*, also with flat branches, many rows and "small rounded surface cells". This species is also likely to belong to *Shulgapora* but specimens are not available for internal examination.

Material - Only one specimen was available for internal examination, UTGD 127564, from

the Wandrawandian Siltstone, Dolphin Point, NSW. An additional specimen from the Deep Bay Formation of Cygnet Tasmania, UTGD 127521, was available for external examination. The specimens recorded here are late Artinskian to Kungurian. The holotype is from the Kungurian? Fenestella Shales, with additional specimens from the initial description recorded from the Sakmarian to the Kungurian (Crockford, 1941b). This is a long time frame for a single species, and internal examination of more specimens may reveal separate species with a similar external appearance.
Range - Sakmarian ? Late Artinskian to Kungurian.

3.2.2 - *Order* TREPOSTOMATA.

Systematics based on Goryunova (1996). Description parameters are given in Appendix Two.

Family - DYSCRITELLIDAE Dunaeva and Morozova 1967
Subfamily - DYSCRITELLINAE Dunaeva and Morozova 1967
Genus *Dyscritella* Girty 1911

Type species - *Dyscritella robusta* Girty, 1911; Fayetteville Shale, Arkansas, USA
Diagnosis - Zoaria encrusting or dendroid. Diaphragms rare in autozooecia, absent in exilazooecia. Acanthostyles and exilazooecia abundant. Acanthostyles may be in two sizes. Zooecial wall evenly thickened in exozone.

Dyscritella espinensis n. sp.
Plate 31; Table 3.32

Holotype - UTGD 127571, Kungurian; Wandrawandian Siltstone, Dolphin Point, New South Wales.
Diagnosis - Zoarium is dendroid with thin branches. The exozone is wide and comprises approximately one half of the radius of the branch. Walls in the exozone are evenly thickened. Autozooecial apertures are ovate to elliptical. Exilazooecia are common and rounded circular to and of variable size, with 1 to 11 surrounding each autozooecial aperture. Acanthostyles are large and project above the surface as distinct spines. There are 3 to 9 larger and 0 to 3 smaller acanthostyles around each autozooecial aperture.

Dyscritella espinensis n. sp.	X	SD	Min	Max	N	CV
branch thickness	2.563	0.320	2	3	8	12.505
exozone radius	0.608	0.083	0.5	0.78	8	13.595
angle zooecial tube to surface	81.800	3.994	75	89	10	4.883
wall thickness, endozone	0.014	0.003	0.008	0.02	22	21.875
wall thickness, exozone	0.152	0.030	0.1	0.22	61	19.860
autozooecial width	0.193	0.019	0.15	0.23	61	9.763
autozooecial length	0.312	0.041	0.19	0.47	62	13.044
distance between apertural centres	0.368	0.044	0.26	0.46	55	11.844
exilazooecia width	0.058	0.035	0.01	0.145	52	59.626
exilazooecia length	0.100	0.057	0.03	0.23	47	57.034
acanthostyle diameter	0.083	0.016	0.05	0.12	70	19.601
acanthostyles per autozooecium	7.056	1.308	4	11	36	18.540
exilazooecia per autozooecium	3.162	2.218	1	11	37	70.127

Table 3.32 - Summary measurements for *Dyscritella espinensis* n. sp. Abbreviations as for Table 3.1, all measurements in millimetres.

Description - Zoarium is dendroid with branches of delicate to intermediate robustness. Branches are thin but not commonly crushed. Zooecial walls in the endozone are thin and straight. Zooecial tubes curve gently from the endozone towards the base of the exozone and open at an angle of 75° to 89° to the surface. The exozone is wide and comprises approximately one half of the radius of the branch. Walls in the exozone are evenly thickened and are of intermediate width between adjacent or consecutive apertures, but may be very wide where wall junctions have accumulations of acanthostyles or exilazooecia.

Autozooecial apertures are of intermediate size and are regularly ovate to elliptical. Ratio of mean aperture width to length is approximately 3:5, with the long axis oriented parallel to the growth direction of the branch. Autozooecial apertures follow no apparent ordered arrangement, but are often arranged into rough longitudinal rows parallel to the axis of the branch.

Acanthostyles are large, with a usually distinct granular core. Acanthostyles project above the surface as distinct spines, up to 0.2 mm long, and can be distinguished in hand specimen. Acanthostyles are of a continuous range of small to large sizes, with 4 to 11 surrounding each autozooecial aperture. Most acanthostyles are large and around any given aperture there may be 3 to 9 larger and 0 to 3 smaller acanthostyles.

Exilazooecia are common and rounded circular to ovate with a highly variable, but continuous size range from small to large. Where exilazooecia are small they are usually locally abundant, and where they are large they are more widely spaced. There may be between 1, larger, to 11, smaller, exilazooecia surrounding each autozooecial aperture.

Discussion - *Dyscritella espinensis* n. sp. is similar to *D. restis* Crockford, also from eastern Australian Permian sequences, but is slightly larger and has more abundant acanthostyles and exilazooecia. From *D. porosa* Crockford, again known from eastern Australian Permian strata, *D. espinensis* can be distinguished by larger branches, the shape of the exilazooecia and the extent of the acanthostyles above the surface as spines. *D. espinensis* is similar to *D. brutem* Crockford, of the Noonkanbah Formation Western Australia, in the size of the branches and apertures, but has less acanthostyles and more exilazooecia.

Types - Holotype UTGD 127571, paratypes UTGD 127572-73.

Etymology - Name derived from the French *espine*, for the spine forming acanthostyles.

Material - Known only from the Wandrawandian Siltstone, at Ulladulla. UTGD 127571 (holotype) and 127572 from Dolphin Point, and 127573-76 from North Head Ulladulla, all from Kungurian Wandrawandian Siltstone.

Range - Kungurian.

Dyscritella inversa n. sp.

Plate 32; Table 3.33

Holotype - UTGD 126949, Sakmarian; basal beds, Fossil Cliffs, Maria Island, Tasmania.

Diagnosis - Zoaria dendroid and large, forming a regularly branching mass. Branches of intermediate robustness. Autozooecial apertures oval and of intermediate size. Within monticules apertures smaller with wide interspaces. Acanthostyles are of small to intermediate size and notably less frequent than exilazooecia. Exilazooecia are abundant, and of small to intermediate size.

Exozone wide and comprising one third the radius of the branch.

Description - The zoarium is dendroid and of intermediate robustness. Zoaria large and forming a regularly branching mass. Branch thickness between 5.5 to 9.5 mm.

Autozooecial tubes arise from an imaginary axis and bend sharply at base of exozone to open at 80° to 90° to the surface. Zooecial walls in the endozone are thin and crossed by widely spaced arcuate rows of thin monilae. Walls in exozone evenly thickened by 5 to 7 rows of more or less confluent monilae. The exozone is wide and comprises one third the radius of the branch.

Autozooecia generally oval and arranged in longitudinal rows, with 4.5 to 5.5 autozooecia in 2 mm. Autozooecial apertures of intermediate size throughout most of zoarium, with interspace thickness intermediate. Within monticules however apertures tend to be small and circular with wide interspaces. Acanthostyles of small to intermediate size, with a continuous range of sizes, and not able to be separated into micro or megacanthostyles. Acanthostyles are notably less frequent than exilazooecia, with up to 3 around autozooecia in a single row.

Exilazooecia are abundant and of small to intermediate size. In most areas of the zoarium 2 to 7 surround each autozooecium. However within monticules there may be 8 to 11 exilazooecia surrounding each autozooecial aperture, and are commonly clustered in groups of up to 7 or 8 in autozooecial wall junctions.

Dyscritella inversa n. sp.	X	SD	Min	Max.	N	CV
branch thickness	7.116	1.339	5.5	9 5	8	18 822
exozone radius	1 311	0 314	0.82	1.88	17	23 983
angle zooecial tube to surface	86 5	3.425	80	90	16	3.960
wall thickness, endozone	0.013	0.004	0.005	0.02	51	32 258
wall thickness, exozone	0.143	0.039	0.08	0 24	52	27.384
autozooecial apertures in 2 mm	4.375	0.608	3.5	5.5	12	13.891
autozooecial length	0.299	0.036	0.15	0.37	48	12.125
autozooecial width	0.200	0.023	0.15	0.24	51	11 366
exilazooecia diameter	0 088	0.031	0.03	0.15	51	35.174
acanthostyle diameter	0.064	0.013	0.03	0.08	49	20 365
acanthostyles per autozooecium	2.137	1.114	0	5	51	52.118
exilazooecia per autozooecium	6.294	2.175	2	11	51	34 560
spacing autozooecial centres	0.345	0.031	0.3	0.44	32	9 047

Table 3.33 - Summary measurements for *Dyscritella inversa* n. sp. Abbreviations as for Table 3.1, all measurements in millimetres.

Discussion - *Dyscritella inversa* is similar to *Stenopora punctata* Crockford of the Noonkanbah Formation, Fitzroy Basin (Crockford, 1957), but has larger oval apertures, fewer acanthostyles and autozooecial tubes bend sharply to exozone in *D. inversa* and are gently curved in *S. punctata*. *D. inversa* n. sp. is distinguished from other Tasmanian species of *Dyscritella* by branch thickness, abundance of exilazooecia and the low number of acanthostyles.

Types - Holotype UTGD 126949, paratype UTGD 126950.

Etymology - Name derived from lower number of acanthostyles than exilazooecia.

Material - Recorded from Sakmarian basal beds, immediately below Darlington Limestone, Fossil Cliffs, Maria Island (UTGD 126949 - holotype, and UTGD 126950 - paratype), and Sakmarian Bundella Mudstone, Lower Sandy Bay, Hobart (UTGD 126951).

Range - Sakmarian.

Dyscritella restis Crockford 1943
Plate 33; Table 3.34

Dyscritella restis CROCKFORD (1943), p. 259, pl. XV, fig. 9, text-fig. 2a-b.

Diagnosis - Zoarium delicate dendroid. Endozone three quarters to two thirds the radius of branch. Autozooecia are small and oval, with apertures arranged in rough longitudinal rows. Each aperture is surrounded by 3 to 5 acanthostyles and 2 to 5 small exilazooecia. Acanthostyles are commonly larger than exilazooecia.

Description - Zoarium is dendroid and delicate, with fine slender branches. Monticules are not seen, but acanthostyles are slightly raised above the surface zooarial, resulting in rough surface texture.

Endozone wide and comprises approximately three quarters to two thirds the radius of the branch. Zooecial walls in the endozone are thin, and there are 8 to 9 zooecial tubes across the width of the endozone. Zooecial tubes bend gradually from endozone to exozone. Walls in exozone evenly thickened by a single row of large pyriform monilae.

Autozooecial apertures are small and oval, arranged in rough longitudinal rows. Ratio of mean apertural width to length is 3:5. Each aperture is surrounded by 3 to 5 acanthostyles of intermediate size. Interspaces between apertures are of variable intermediate to wide width. Acanthostyles commonly appear larger than exilazooecia. Exilazooecia are small and often elongated proximodistally, with a mean width to length ratio of approximately 3:4. Exilazooecia are common, with 2 to 5 around each aperture.

Dyscritella restis	X	SD	Min	Max	N	CV
branch thickness	1.8	0.083	1.7	1 9	4	4.626
exozone radius	0.325	0.065	0.25	0 4	4	19 861
zooecial angle endo-exozone	48.333	14.742	37	65	3	30.501
endozone wall thickness	0 015	0.004	0 008	0.02	12	29 287
exozone wall thickness	0 127	0.043	0 075	0.22	11	33 490
autozooecia - length	0.254	0.019	0 225	0.28	9	7 575
autozooecia - width	0.158	0.008	0 15	0.17	8	5 328
exilazooecia - length	0.085	0.029	0.05	0 14	9	33 535
exilazooecia - width	0.062	0.029	0.03	0 1	7	46.420
acanthostyle diameter	0.083	0 015	0.06	0.1	11	17.478
acanthostyles per autozooecium	4.083	0 669	3	5	12	16.373
exilazooecia per autozooecium	4	1.155	2	5	7	28 868
closest apertural spacing	0 268	0.031	0 22	0 32	8	11 737

Table 3.34 - Summary measurements for *Dyscritella restis* Crockford. Abbreviations as for Table 3.1, all measurements in millimetres.

Discussion - *D. restis* is readily distinguished from *D. inversa* n. sp. by zooarial size and the abundance of exilazooecia in the later.
Material - Only one Tasmanian specimen recorded (UTGD 126923) from the Artinskian Counsel Creek Formation, Maria Island. Other fragments of fine dendroid trepostome are seen in thin section but are indeterminate as *D. restis*.
D. restis is previously recorded in eastern Australia from the Allandale Stage, Lower Marine Series, Middlehope, NSW (Crockford, 1943).
Range - Sakmarian to Artinskian.

Genus *Dyscritellina* Morozova 1966

Type species - *Dyscritellina clivosa* Morozova (1966); Upper Permian, Primor'e region, Russia.
Diagnosis - Zooaria dendroid, encrusting or massive. Acanthostyles large and numerous with a range of sizes and shapes. Diaphragms rare.

Dyscritellina megacanthi new species
Plate 34; Table 3.35

Holotype - UTGD 126948, Sakmarian; basal beds, Fossil Cliffs, Maria Island, Tasmania.
Diagnosis - Zoarium dendroid. Acanthostyles in two sizes, megacanthostyles very large, often the same size as autozooecia, with microacanthostyles in clusters between megacanthostyles. Exilazooecia are generally small and not common.

Dyscritellina megacanthi n. sp.	X	SD	Min	Max	N	CV
branch thickness	7	1.601	4	9	9	22 868
exozone radius	1 163	0.181	0.8	1 4	16	15.545
angle zooecial tube endo to exozone	36	1.732	34	37	3	4 811
angle zooecial tube to surface	80.455	9.037	69	92	11	11 233
endozone wall thickness	0.018	0.005	0 01	0.025	30	24 638
exozone wall thickness	0 099	0.032	0 05	0.21	34	32 007
autozooecium - length	0.358	0.038	0.29	0.44	25	10 706
autozooecium - width	0.292	0 047	0.19	0 37	19	16 026
exilazooecia diameter	0.130	0 039	0.06	0 2	22	30.060
megacanthostyle diameter	0.244	0 053	0.16	0 38	28	21 673
microacanthostyle diameter	0.094	0.024	0 04	0 14	28	25.829
megacanthostyles per autozooecium	3.188	0 896	2	6	32	28.103
microacanthostyles per autozooecium	1.25	2.155	0	10	32	172.421
spacing autozooecial centres	0.343	0.029	0 28	0 38	16	8 554

Table 3.35 - Summary measurements for *Dyscritellina megacanthi* n sp. Abbreviations as for Table 3.1, all measurements in millimetres

Description - The zoarium is dendroid, with circular branches 4 to 9 mm in diameter. The exozone is wide and comprises one third to one half the radius of the branch.

Zooecial tubes are thin walled in the endozone. Zooecial tubes bend gradually outwards from the endozone to exozone, and open at 69° to 92° to the outer surface. Crossing the endozone are rows of large monilae, closely to widely spaced.

Zooecial walls are moniliform in the exozone, with 3 to 5 rows of pyriform to oblong monilae. Monilae closely spaced and in outer part of exozone confluent. Walls between autozooecia variably narrow to wide at the level of the monilae. In longitudinal and transverse section, walls in exozone further thickened and distorted by the very large megacanthostyles.

Autozooecia are very large and subcircular to quadrangular in outline. Autozooecia surrounded by 2 to 6 very large megacanthostyles. In monticules there may be up to 10 microacanthostyles accompanying the 2 to 4 megacanthostyles about each aperture.

Exilazooecia are of variable small to intermediate size, dispersed rarely throughout, with 0 to 2 surrounding each autozooecia, only slightly more abundant in monticules.

Discussion - In tangential section *Dyscritellina megacanthi* is superficially similar to *Stenopora spicata* var. *obtusa* Crockford of the Noonkanbah Formation, Fitzroy Basin (Crockford, 1957), with its large acanthostyles and few exilazooecia. However in longitudinal section the distinct large monilae in the endozone of *D. megacanthi* are not seen, and walls are thicker between autozooecia in *S. spicata* var. *obtusa.* Crockford (1957) separated *S. spicata* var. *obtusa* from *Stenopora spicata* Bassler on zoarial form, a feature no longer considered of taxonomic importance in *Stenopora*, and *S. spicata* var. *obtusa* should be considered a junior synonym of *S. spicata.*

This species is easily distinguished from other Tasmanian trepostomes by its very large megacanthostyles, thin walls, and rows of large monilae in the endozone.

Types - Holotype UTGD 126948; paratype UTGD 127061.

Etymology - Species named for its very large acanthostyles.

Material - Two specimens are recorded from the Sakmarian basal beds, Fossil Cliffs, Maria Island (UTGD 126948 and 127061).

Range - Sakmarian.

Family - MONTICULIPORIDAE Nicholson, 1881
Subfamily HETEROTRYPINAE Ulrich, 1890
Genus *Paralioclema* Morozova 1961

Type species - *P. ninae* Morozova, 1961; Upper Devonian, Kunetz Basin, Russia.

Diagnosis - Zoarium branching massive or encrusting. Autozooecial tubes with complete regularly spaced diaphragms. Acanthostyles numerous, mesozooecia of varying number. Permian taxa with thin zooecial walls, acanthostyle size variable within one colony, and wide axial canal in many acanthostyles (after Morozova, 1970).

Paralioclema wassi n. sp.
Plate 35; Table 3.36

Leioclema sp. WASS (1968), p. 30, pl. 7, figs. 1-2, pl. 8, fig. 4.

Holotype - UTGD 126936, Artinskian; Skipping Ridge Formation, Maria Island, Tasmania.

Diagnosis - Zoarium encrusting, autozooecial tubes straight with regularly spaced straight to slightly curved thin diaphragms. Autozooecia surrounded by 3 to 5 acanthostyles, of varying sizes, tending to be larger in monticular areas. Mesozooecia present throughout, smaller than autozooecia and more common in monticular areas.

Description - The zoarium is large and encrusting, 15 cm across and 2 cm thick. Zooecial tubes are straight and extend vertically or at a slight angle from the base to meet the surface at 90°. Autozooecia divided by numerous flat to sloping to slightly concave thin diaphragms. Diaphragms complete and occur in equal numbers in mesozooecia. Diaphragms are thin and fairly regularly spaced, with 6 to 10 in 2 mm

Zooecial walls are narrow, but widen at wall junctions that carry acanthostyles. Zooecial walls seen as a series of oblong confluent overlapping monilae, so wall does not appear strongly beaded.

In tangential section autozooecial apertures are of intermediate size and generally equidimensional circular to quadrangular shape. Autozooecial apertures are surrounded by 3 to 5 acanthostyles restricted to autozooecial wall junctions. Acanthostyles exhibit an even spread of sizes from small to large. The larger acanthostyles occur within monticules. Mesozooecia are of variable size and are generally rare, but are abundant and clustered within monticules. Autozooecia and mesozooecia show no particular orientation.

Paralioclema wassi n. sp.	X	SD	Min	Max	N	CV
zooarial thickness	21	1	20	22	3	4.762
distance between diaphragms	0.277	0.061	0 15	0 4	40	22 084
diaphragms in 2 mm vertically	7.483	0.983	6	10	60	13 133
thickness diaphragms	0 007	0 003	0.004	0 01	20	35 827
zooecial wall thickness - exozone	0.047	0.012	0 03	0 08	40	26.147
autozooecial aperture length	0.288	0.032	0.24	0 355	40	11 060
autozooecial aperture width	0.270	0.029	0.22	0 34	40	10.756
mesozooecia diameter	0.128	0.041	0.05	0.23	40	31.852
acanthostyle diameter	0 086	0 024	0 04	0.125	40	27 966
acanthostyles per autozooecium	3.933	0.778	2	6	60	19.786
closest apertural spacing	0.347	0 037	0.29	0.44	14	10 813

Table 3.36 - Summary measurements for *Paralioclema wassi* n sp. Abbreviations as for Table 3.1, all measurements in millimetres.

Discussion - Additional specimens of *Paralioclema wassi* n. sp. from the Bowen Basin Queensland show similar measurements and are included in this species, despite being of possibly Kungurian to Tatarian age. Means and ranges in diagnostic characters such as number of acanthostyles and diaphragms, their size and form, size of autozooecia and wall thickness match those shown by the holotype, with coefficients of variation closely comparable.

Paralioclema wassi n. sp. is most similar to *Paralioclema grandispinosum* Morozova (Upper Permian, Primor'e) and *Paralioclema neospinigerum* (Yang and Loo) (Upper Permian Primor'e and China). It is distinguished from *P. grandispinosum* by the lower number of diaphragms and smaller acanthostyles and mesozooecia, and from *P. neospinigerum* by diaphragm and mesozooecia number and shape of autozooecia. *Paralioclema wassi* n. sp. is distinguished from both *Paralioclema globosa* Crockford (Permian Western Australia) and *Leioclema porosa* Crockford (Lower Carboniferous, Rockhampton, Queensland) by its more widely spaced diaphragms and acanthostyle size.

Types - UTGD 126936 - from Artinskian Skipping Ridge Formation, Maria Island, Tasmania.

Etymology - Named for Robin Wass, who collected the first specimens of this species from the Bowen Basin, Queensland.

Material examined - Three specimens were examined, UTGD 126936 (holotype), and CPC 7040 and CPC 7041 - from Ufimian to Kazanian ? Blenheim Subgroup, Bowen Basin , Queensland (Wass, 1968).

Range - Artinskian to Kazanian ?

Family STENOPORIDAE Waagen and Wentzel 1886
Subfamily STENOPORINAE Waagen and Wentzel 1886
Genus *Stenopora* Lonsdale 1844

Type species - *Stenopora tasmaniensis* Lonsdale (1844); Permian of Tasmania, Australia.
Diagnosis - Zoaria dendroid, frondescent, encrusting or discoid. Genus can develop one or more morphological forms in same zoarium or species. Autozooecial walls in exozone moniliform, autozooecia without diaphragms. Exilazooecia present but not numerous. Acanthostyles generally abundant, and usually as both megacanthostyles and microacanthostyles.

Stenopora aequalis n. sp.
Plate 36; Table 3.37

Holotype - UTGD 126933; Late Artinskian to early Kungurian West Arm Group, Beaconsfield.
Diagnosis - The zoarium is dendroid and of intermediate robustness. The exozone is wide and comprises approximately one half the radius of the branch. The exozone is thickened by small rounded monilae that do not usually overlap and are separated by a short space of thin zooecial wall. Autozooecial apertures are of intermediate size and typically round to oval, surrounded by 2 to 5 acanthostyles. Exilazooecia are common to abundant, with often as many exilazooecia as acanthostyles about each autozooecium.

Stenopora aequalis n sp	X	SD	Min	Max	N	CV
branch thickness	12 822	3 238	8	17	9	25 253
exozone radius	5 833	0 289	5.5	6	3	4 949
angle zooecial tube to surface	89.429	3 309	85	95	7	3.701
endozone wall thickness	0.015	0.004	0.01	0.02	9	28.868
exozone wall thickness	0.090	0.019	0.05	0.12	30	21 111
autozooecial aperture diameter	0 272	0 024	0 23	0 33	30	8.768
exilazooecia diameter	0.110	0.042	0 05	0.21	30	38 040
acanthostyle diameter	0 095	0 013	0 05	0 12	30	14 262
acanthostyles per autozooecium	4 067	0 740	2	5	30	18 189
closest apertural spacing	0.362	0.050	0 28	0.5	26	13.878

Table 3 37 - Summary measurements for *Stenopora aequalis* n sp. Abbreviations as for Table 3.1, all measurements in millimetres.

Description - The zoarium is dendroid and of intermediate robustness, with branch diameters between 8 to 17 mm. The surface of the available material is smooth and does not reveal monticules. Zooecial tubes are polygonal and thin walled in the endozone, and arcuate rows of small monilae cross the endozone at variable intervals. The zooecial tubes curve into the base of the exozone and open at 85° to 95° to the surface of the zoarium. The exozone is wide and comprises approximately one half the radius of the branch. The exozone is thickened by small rounded monilae that do not usually overlap and are separated by a short space of thin zooecial wall.

Autozooecial apertures are of intermediate size and typically round to oval. Apertures are thick walled in the monticules. In intermonticular areas autozooecia may be less rounded and zooecial walls are narrow at the level of the monilae. Acanthostyles are of intermediate to large size, and are typically found only at the junctions of zooecial walls, with usually 2 to 5 about each aperture. Acanthostyles may be rarely found away from wall junctions within monticules. The acanthostyles are well developed and usually appear of similar proportions in deep and surficial tangential sections. Exilazooecia of small to intermediate size and are rounded to oval in outline. They are common to abundant, with often as many exilazooecia as acanthostyles about each autozooecium, and are usually placed singularly or in small clusters at autozooecial junctions.

Discussion - *Stenopora aequalis* is of similar general appearance to *S. ovata*, particularly in structure of the monilae. However exilazooecia are more abundant, and acanthostyles generally larger in *S. aequalis.* In tangential section the species appears somewhat similar to *Dyscritella inversa*, but is clearly separated from this genus and placed in *Stenopora* upon examination of cross and longitudinal sections.

Types - UTGD 126933, holotype; UTGD 126932, paratype - West Arm Group, Beaconsfield, Tasmania.

Material - Three specimens were examined from late Artinskian to Kungurian beds in the West Arm Group, Beaconsfield, Tasmania.

Etymology - From the Latin *aequalis* for the even number of acanthostyles and exilazooecia.

Range - Late Artinskian to early Kungurian.

Stenopora berriedalensis n. sp.
Plate 37; Table 3.38

Holotype - UTGD 126920; Artinskian: Berriedale Limestone, Granton, Hobart, Tasmania.

Diagnosis - Zoarium coarse dendroid. Acanthostyles are common and of one size. Exilazooecia are frequent and small. Exozone thick walled, with confluent monilae. Exozone about one third radius of branch.

Stenopora berriedalensis n. sp.	X	SD	Min	Max	N	CV
branch thickness	5.571	1.269	3.5	7	14	22 774
thickness exozone	0.972	0.134	0.65	1.28	23	13 819
angle between endo-exozone	42.111	7.026	31	50	9	16 684
angle zooecial tube to surface	73 192	7.679	56	90	26	10 491
wall thickness, endozone	0.012	0 004	0.005	0.02	36	32 469
wall thickness, exozone	0.139	0.033	0.08	0.24	53	23 812
autozooecial length	0.274	0.045	0.205	0 38	54	16 255
autozooecial width	0.173	0.025	0.14	0 26	52	14 267
exilazooecia diameter	0.092	0.047	0 02	0.2	52	50 614
acanthostyle diameter	0.072	0.017	0.04	0 12	47	24 078
acanthostyles per autozooecium	5.813	0.982	4	9	48	16 893
closest apertural spacing	0.320	0.027	0 27	0.38	50	8 332

Table 3 38 - Summary measurements for *Stenopora berriedalensis* n. sp Abbreviations as for Table 3 1, all measurements in millimetres.

Description - The zoarium is dendroid, with cylindrical branches 4.5 to 7 mm in diameter. The exozone is wide and comprises about one third radius of the branch.

Zooecial walls in the endozone are thin, and without arcuate rows of monilae. Zooecial tubes numerous, bending gradually towards exozone, to open at 56° to 74° to the surface.

Walls in exozone evenly thickened by about 4 rows of almost confluent monilae. Autozooecial walls in exozone of intermediate to wide width. Autozooecial apertures are of intermediate size and are circular to oval. Each aperture is surrounded by 4 to 7 acanthostyles of intermediate size, that are generally restricted to junctions of zooecial walls. Acanthostyles are without apparent internal structure and may be oval in section.

Exilazooecia are frequent, of variable rounded shape and are generally small. Exilazooecia occur throughout the zoarium but are never abundant.

Discussion - *Stenopora berriedalensis* is most easily distinguished from *Stenopora ovata* by its almost confluent monilae, size and shape of autozooecia, and the appearance of the acanthostyles. Distinguished from *S. tasmaniensis* by lower number and restriction of acanthostyles to autozooecial junctions, and greater number of exilazooecia, and from *S. etheridgei* by the number of acanthostyles and size and shape of autozooecia.

Types - Holotype, UTGD 126920; paratype UTGD 126921.

Etymology - Named for the Berriedale Limestone from which the type material was collected.

Material - Four specimens were recorded from the following; Artinskian Berriedale Limestone, Rathbones Quarry, Hobart (UTGD 126920 holotype and UTGD 126921 paratype); Ufimian/Kazanian unit E of Malbina Formation, Eaglehawk Neck (UTGD 126922); Artinskian Skipping Ridge Formation, Fossil Bay, Maria Island (UTGD 127065).
Range - Artinskian to Kazanian.

Stenopora crinita Lonsdale (1845)
Plate 38; Table 3.39

Stenopora crinita LONSDALE (1845), in Strzelecki, p. 265, pl. 8, figs 5-5a; CROCKFORD (1945), p. 11, text-fig. 3-4; WASS (1968), p. 27, pl. 5, figs. 2-3, pl. 6, fig. 1.
Stenopora contigua CROCKFORD (1945), p. 14, text-figs. 8-10.
Diagnosis - Zoarium is coarse dendroid, encrusting or discoid. Acanthostyles are not abundant and exilazooecia are rare except in monticules. Wall in exozone with usually widely spaced small monilae. Exozone wide in dendroid forms.

Stenopora crinita	X	SD	Min	Max	N	CV
branch thickness	20.14	16.280	7.7	48	5	80.836
exozone radius	16		16	16	1	
endozone wall thickness	0.016	0 004	0.01	0 02	14	25.121
exozone wall thickness	0.067	0.015	0.04	0.11	42	22.781
autozooecial aperture diameter	0 467	0.072	0.34	0.66	44	15.473
exilazooecial diameter	0.164	0.072	0.04	0.4	37	43 989
acanthostyle diameter	0.032	0.012	0.02	0.06	26	37.006
acanthostyles per autozooecium	5.552	1.055	2	7	29	19 005
closest autozooecial spacing	0.499	0.053	0 42	0.62	33	10.716

Table 3.39 - Summary measurements for *Stenopora crinita* Lonsdale Abbreviations as for Table 3 1, all measurements in millimetres.

Description - Zoarium may be massive dendroid (UTGD 126925), discoid (UTGD 126924) and encrusting (UTGD 126926). Thickness of the zoarium varies according to zoarial form. Where dendroid, branches are up to 50 mm in diameter, discoid 15-20 mm thick and encrusting about 16 mm thick. In all forms internal features are the same. Monticules may or may not be visible in hand specimen.
Autozooecia are polygonal and thin-walled in the endozone. In the exozone walls are thickened by small beaded monilae that are widely spaced with a segment of thin wall between them. At times, whilst not coalescing, monilae may be more closely spaced, and this tends to occur laterally through many walls at any given stage of growth. Despite being thickened by monilae zooecial walls in exozone are narrow. In tangential section autozooecia are large and subpolygonal, and become subcircular within monticules. Acanthostyles are small, but within monticules may be large. Acanthostyles are usually restricted to the junctions of autozooecial walls, but not all junctions, so that there are 2 to 6 about each autozooecium. Acanthostyles are more abundant in the monticules with about 7 surrounding each autozooecium. Exilazooecia are of variable size and are rare except in monticules, where they are still not abundant.
Discussion - *Stenopora contigua* Crockford is here included in *S. crinita* Lonsdale, as autozooecial and wall characters are the same, with the only difference being the discoid zoarial form in *S. contigua*. As zoarial form is no longer given as significant within *Stenopora*, and clear *S. crinita* with discoid form have been found by the author, *S. contigua* is synonomised with *S. crinita*. *Stenopora crinita* is distinguished from *S. ovata* and *S. tasmaniensis* by the spacing of the monilae and the appearance of autozooecia and associated acanthostyles.
Material - Three specimens are recorded from the following; Artinskian Berriedale Limestone, Rathbones Farm Granton (UTGD 126926), late Artinskian West Arm Group, Beaconsfield (UTGD 126924), and Kazanian Unit E of Malbina Formation, Eaglehawk Neck (UTGD 126925).

Stenopora crinita has previously been recorded from Eaglehawk Neck and Fitzgerald (Crockford, 1945). In eastern Australia it is recorded from the Artinskian to Kungurian of the Bowen Basin, Queensland (Wass, 1968), and from the Upper Marine Series of New South Wales (Crockford, 1951).
Range - Artinskian to Kazanian.

Stenopora elongata n. sp.
Plate 39; Table 3.40

Holotype - UTGD 127522; Ufimian beds within West Arm Group, Beaconsfield, Tasmania.
Diagnosis - The zoarium is dendroid, with branch diameters probably 12 to 15.5 mm, but zoaria are readily crushed. The exozone is wide and comprises approximately one third to one half the radius of the branch. The exozone is thickened by closely spaced elongate robust monilae.
Autozooecial apertures are small and oval to rounded, with usually 4 to 7 acanthostyles about each aperture, but within monticules there are up to 10 acanthostyles. Exilazooecia are common throughout the zooarium, and within monticules they are abundant.

Stenopora elongata	X	SD	Min	Max	N	CV
branch thickness	13.75	3.775	9	18	4	27 454
exozone radius	3.9	1 517	2 5	6	5	38 887
angle zooecial tube to surface	81 2	4 087	78	88	5	5 033
endozone wall thickness	0.017	0 002	0.013	0.02	25	14 794
exozone wall thickness	0.085	0.024	0.011	0 15	40	28.097
diameter autozooecial aperture	0.254	0.022	0 21	0 3	40	8 755
exilazooecia diameter	0.083	0.031	0.04	0.18	40	37 779
acanthostyle diameter	0.087	0 019	0 055	0 14	40	21.500
acanthostyles per autozooecium	6.425	1 551	4	10	40	24 134
closest apertural spacing	0.32	0 038	0 25	0.42	40	11.994

Table 3 40 - Summary measurements for *Stenopora elongata* n. sp Abbreviations as for Table 3 1, all measurements in millimetres.

Description - The zoarium is dendroid, with branch diameters between 9 to 18 mm, however the zoarium is often crushed, and true diameters are probably 12 to 15.5 mm. The surface of the available material is weathered and does not reveal monticules, however they are clearly seen in thin section. Zooecial tubes are polygonal and thin walled in the endozone. Although material is crushed arcuate rows of monilae appear to cross the endozone, and zooecial tubes bend sharply at the base of the exozone. The zooecial tubes are straight within the exozone and open at 78° to 88° to the surface of the zoarium. The exozone is wide and comprises approximately one third to one half the radius of the branch. The exozone is thickened by closely spaced elongate robust monilae. Consecutive monilae do not usually overlap, with each row of monilae developing from the outer edge of the last. Monilae tend to be in rows of even sizes, and strongly crushed zooaria shear along the margins between rows.
Autozooecial apertures are of intermediate size and oval to rounded, with no consistent orientation. Zooecial walls are thin between apertures where exilazooecia and acanthostyles are absent. In monticular areas autozooecia are more rounded and zooecial walls thicker. Acanthostyles are of intermediate to large size, with usually 4 to 7 about each aperture. Acanthostyles are usually confined to zooecial wall junctions, but within monticules are between junctions with up to 10 acanthostyles about each aperture. The acanthostyles are well developed and usually appear as blunt spines at the surface. Exilazooecia of small to intermediate size and are rounded to oval in outline. They are common throughout the zooarium, with 1 to 4 about each aperture, however within monticules they are densely packed with up to 11 about each aperture, and may be in two rows.

Discussion - *Stenopora elongata* is similar to *S. aeqaulis*, particularly in appearance of apertures and number of exilazooecia. However the monilae in the exozone of *S. elongata* are strong and closely spaced, but small, rounded and widely spaced in S. *aequalis*.
Types - UTGD 127522, holotype; UTGD 126931, paratype - West Arm Group, Beaconsfield, Tasmania.
Etymology - From the Latin *aequalis* for the even number of acanthostyles and exilazooecia.
Material - Two specimens are recorded from Kungurian to Ufimian beds in the West Arm Group, Beaconsfield, Tasmania.
Range - Kungurian to Ufimian.

Stenopora etheridgei Crockford (1945)
Plate 40; Table 3.41

Stenopora etheridgei CROCKFORD (1945), p. 19, pl. II, fig. 4, text-figs. 14-16.
Diagnosis - Fine dendroid zoarium. Autozooecia oval with abundant acanthostyles in two sizes. Exilazooecia present. Exozone narrow.

Stenopora etheridgei	X	SD	Min	Max	N	CV
branch thickness	5.414	1.915	3.5	8.5	7	35.374
exozone radius	0.784	0.244	0.44	1.14	14	31 139
angle zooecial tube to surface	75.143	7.824	56	83	14	10 412
endozone wall thickness	0.014	0.004	0.01	0.02	27	27 744
exozone wall thickness	0.182	0 060	0.09	0.35	31	32 874
autozooecial aperture - length	0.392	0 051	0 3	0.48	25	12 932
autozooecial aperture - width	0.230	0 035	0 18	0.29	26	15 396
exilazooecia diameter	0.142	0.048	0.05	0 21	16	34.166
acanthostyle diameter	0.057	0 013	0 04	0.08	25	22.649
acanthostyles per autozooecium	8.208	2.000	5	12	24	24 360
closest apertural spacing	0.369	0.042	0 29	0.46	12	11 420

Table 3 41 - Summary measurements for *Stenopora etheridgei* Crockford. Abbreviations as for Table 3.1, all measurements in millimetres.

Description - Zoarium is dendroid, with branches 3.5 to 8.5 mm in diameter. The exozone is relatively narrow, comprising only about one quarter the radius of the branch, with a broad endozone. Zooecial tubes in the endozone are thin walled, and the endozone is crossed by widely spaced rows of arcuate monilae. Tubes bend gradually to the exozone, to open at 55 to 80° to the surface.
Zooecial walls in the exozone are thickened by 3 to 4 rows of overlapping monilae. Zooecial walls are of intermediate to wide width in the exozone, at the level of the monilae. Autozooecia are large and oval with a ratio of mean width to length of about 3:5. Exilazooecia are of small intermediate size and are irregularly spaced, being common in some sections, and rare in others.
Acanthostyles of two sizes surround each aperture. There are 6 to 10 megacanthostyles about each aperture. Microacanthostyles are also present, but are not always seen in tangential section. Abundant shallow microacanthostyles can be seen in longitudinal section.
Discussion - *S. etheridgei* is most readily distinguished from *S. grantonensis* by its coarser size, and narrower exozone relative to endozone.
Material - *S. etheridgei* is recorded from Tasmania for the first time from the Sakmarian Bundella Mudstone, Lower Sandy Bay (UTGD 126927); the Sakmarian/Artinskian Skipping Ridge Formation, Maria Island (UTGD 126928), and the Artinskian Berriedale Limestone, Granton (UTGD 127653).
Crockford (1945) records this species from the Sakmarian Allandale Stage, Lower Marine Series, Polkolbin.
Range - Sakmarian to early Artinskian.

Stenopora grantonensis Crockford (1943)
Plate 41; Table 3.42

Stenopora grantonensis CROCKFORD (1943), p. 265, pl. XV, figs. 3 & 6, text-figs. 1a-c.
Diagnosis - Fine dendroid zoarium. Autozooecia oval with many acanthostyles of two sizes. Monilae in exozone confluent.
Description - The zoarium is dendroid, branches fine and slender, 1.6 to 2.3 mm wide.
Zooecial tube walls in the endozone are thin and generally bending gradually towards the exozone to open at 80 to 90° to the surface. In longitudinal section there are only 6 to 8 zooecial tubes across the width of the branch. The exozone is relatively wide, and comprises about half the radius of the branch.
Walls in the exozone are thickened by 2 to 3 rows of confluent monilae. Zooecial walls are of intermediate to wide width between adjacent autozooecial apertures.
Autozooecia are of intermediate size and oval shape, with a ratio of mean width to length of about 5:9. There are 5 to 7 acanthostyles of small to intermediate size surrounding each aperture in tangential section. Acanthostyles are developed deep in the exozone. Many more microacanthostyles occur, probably up to 15 around each aperture, but are developed at shallow levels in the exozone and are often only seen clearly in longitudinal section.
Exilazooecia occur in low numbers throughout, and are of intermediate size. Monticules are not seen in the Tasmanian material.

Stenopora grantonensis	X	SD	Min	Max	N	CV
branch thickness	2.132	0.322	1.6	2.6	9	15.113
exozone radius	0.436	0.073	0.34	0.57	7	16.753
angle zooecial tube endo- to exozone	47.667	6.653	40	57	6	13.958
angle zooecial tube to surface	73.444	6.267	65	83	9	8.533
endozone wall thickness	0.016	0.005	0.01	0.025	24	30.033
exozone wall thickness	0.152	0.030	0.115	0.21	24	19.749
autozooecium - length	0.318	0.045	0.22	0.44	24	14.193
autozooecium - width	0.171	0.025	0.125	0.22	24	14.832
exilazooecia - length	0.128	0.038	0.09	0.18	4	29.607
exilazooecia - width	0.076	0.034	0.04	0.12	4	43.947
megacanthostyle diameter	0.063	0.010	0.05	0.08	6	16.307
microacanthostyle diameter	0.038	0.007	0.03	0.05	12	18.423
acanthostyle per autozooecium	10.200	1.304	9	12	5	12.783
spacing autozooecial centres	0.330	0.026	0.28	0.375	11	7.988

Table 3.42 - Summary measurements for *Stenopora grantonensis* Crockford. Abbreviations as for Table 3.1, all measurements in millimetres

Discussion - *S. grantonensis* is a common fine dendroid species in the Artinskian limestones of Tasmania and is not recorded to date from other eastern Australian Permian sequences. It is readily distinguished by its wide exozone and abundant mega and microacanthostyles.
Material - Two specimens are recorded from, the Artinskian Skipping Ridge Formation (UTGD 126930), and Artinskian Counsel Creek Formation (UTGD 126929), Maria Island.
Crockford (1943) recorded the holotype form the Artinskian Berriedale Limestone, Granton Quarry, Hobart.
Range - Artinskian.

Stenopora ovata Lonsdale (1844)
Plate 42; Table 3.43

Stenopora ovata LONSDALE (1844), in Darwin (1844) p. 163; LONSDALE (1845) in Strzelecki (1845), p. 263, pl. 8, fig 3-3b; NICHOLSON and ETHERIDGE (1886), p. 173, pl. 3 figs. 1-4; CROCKFORD (1945), p. 15; WASS (1968), p. 25, pl. 4, fig 3-4, pl. 5, 1 & 4.
Stenopora pustulosa CROCKFORD (1945), p. 16, pl. II, fig 2-3, text-fig. 22-23.

Diagnosis - The zoarium is coarse, of dendroid or encrusting form. Acanthostyles prominent and exilazooecia present but not common. Zooecial walls thick with closely spaced monilae. If dendroid exozone comprises one half the radius of branch.

Description - Material collected in this study shows only an encrusting zoarium, but may also be dendroid as described by other authors. Thickness of the encrusting zoarium is between 11.5 to 15 mm, with the exozone comprising the entire width of the zoarium.

Zooecial tubes are polygonal and thin walled where monilae are absent. Monilae are usually separated by a short space of thin zooecial wall, but at times they may overlap.

Autozooecial apertures are large and typically round to oval. In intermonticular areas autozooecia may be less rounded and thin walled. Zooecial walls are of narrow to intermediate width at the level of the monilae. Acanthostyles are of intermediate size, and are typically found only at the junctions of zooecial walls, with usually 4 to 7 about each aperture. Acanthostyles may be found away from wall junctions within monticules. Exilazooecia of variable size are present throughout, but are not common, although they are often grouped together in monticules.

Stenopora ovata	X	SD	Min	Max	N	CV
branch thickness	13.250	2 475	11.5	15	2	18.678
wall thickness betw. monilae	0.018	0.003	0.015	0.02	4	16 496
wall thickness across monilae	0.100	0.027	0.06	0 16	20	26.751
autozooecial diameter	0.433	0.054	0 365	0 6	21	12 428
exilazooecia diameter	0 151	0.057	0.065	0.295	16	37 469
acanthostyle diameter	0 075	0 014	0.06	0.1	20	18 732
acanthostyles per autozooecium	5 381	0 865	4	7	21	16 069
closest autozooecial spacing	0.445	0 047	0.36	0 52	21	10.606

Table 3 43 - Summary measurements for *Stenopora ovata* Lonsdale. Abbreviations as for Table 3 1, all measurements in millimetres.

Discussion - *Stenopora ovata* is distinguished from *S. crinita* by its more closely spaced monilae and the shape and appearance of autozooecia. Distinguished from *S. tasmaniensis* by its usually separated monilae in the exozone, and the size and shape of autozooecia and the number and size of acanthostyles.

Material - In this study *Stenopora ovata* is recorded in Tasmania from the Artinskian Berriedale Limestone (UTGD 53856) at Granton. Specimens that are questionably assigned to this species are recorded from the same locality (UTGD 20075) and from the Artinskian Skipping Ridge Formation, Maria Island (UTGD 126935). A specimen from late Artinskian-early Kungurian horizons in the West Arm Group, Beaconsfield (UTGD 126934) is similar to *S. ovata* but has more numerous and smaller acanthostyles. *Stenopora ovata* has previously been recorded from the Artinskian Berriedale Limestone at various Hobart localities (Crockford 1951), and the Sakmarian Bundella Mudstone and similar aged units on Maria Island, through to Artinskian Berriedale Limestone and Grange Mudstone, Hobart (Smith *et al.* in prep).

Stenopora ovata is recorded in eastern Australia from Singleton (Etheridge, 1891) and Allandale (Walkom, 1913) in New South Wales, and from the Artinskian Buffel Formation, Bowen Basin, Queensland (Wass, 1968).

Range - Sakmarian to Artinskian.

Stenopora seriatensis n. sp.
Plate 43; Table 3.44

Stenopora tasmaniensis Lonsdale WASS (1968), p. 23, pl. 2 figs 3,4, pl. 3 figs. 1-3, pl. 4 figs. 1,2.

Holotype - UTGD 127579, Kungurian Wandrawandian Siltstone, North Head, Ulladulla, NSW.

Diagnosis - Zoaria dendroid, with branch fragments 2 to 3.5 mm in diameter. The exozone is wide, comprising one third to half the radius of the branch. Zooecial tube walls in the endozone are thin and open at a regularly high angle to the surface of the zoarium. Walls in the exozone are smooth and monilae are nearly always confluent. Autozooecial apertures are regularly oval to elliptical. Exilazooecia are common. There are usually about 10 to 12 acanthostyles about each aperture.

Description - Zoaria are dendroid, with branch fragments 2 to 3.5 mm in diameter. Branches may be crushed but many specimens are found complete. The exozone is wide relative to branch thickness and represents one third to one half the radius of the branch. Zooecial tube walls in the endozone are thin and straight. Zooecial tubes are curved at the base of the exozone and open at a regularly high angle to the surface of the zoarium, range 75° to 88° (mean 83.5°). Diaphragms are absent from the zooecial tubes. Walls in the exozone are of intermediate width, thickened by monilae that are nearly always confluent. Autozooecial apertures are regularly oval to elliptical, with their long axis oriented parallel to the growth direction of the branch. Apertures are of a regular size, with ratio of mean width to length approximately 2:3. Spacing between adjacent apertures is also regular. Exilazooecia are always rounded circular to elliptical and of a small to large size continuum. The placement of large or small exilazooecia does not appear to be related to their placement either within or outside of monticular areas. In monticules exilazooecia are more abundant, with 3 to 5 about each aperture, and 0 to 2 about each aperture in intermonticular regions. Acanthostyles are of small to intermediate size and in a continuum rather than bimodal. There are usually about 10 to 12 acanthostyles about each autozooecial aperture.

Stenopora seriatensis n. sp.	X	SD	Min	Max	N	CV
branch thickness	2.750	0.645	2	3 5	4	23 473
exozone radius	0.437	0 069	0.3	0 52	14	15 809
zooecial tube angle to surface	83.500	4.848	75	88	6	5 806
wall thickness endozone	0.015	0.004	0 01	0.021	16	24 176
wall thickness exozone	0.135	0 026	0 09	0.2	61	19.338
autozooecial width	0.216	0 027	0 16	0.29	66	12.322
autozooecial length	0.343	0 039	0.265	0 455	61	11 381
closest apertural spacing	0.385	0 055	0.29	0 51	52	14 236
exilazooecial width	0.085	0 033	0 02	0.165	47	39 130
exilazooecial length	0 132	0.056	0 06	0.295	52	42 372
acanthostyle diameter	0.057	0 013	0.03	0 085	69	23 567
acanthostyles per autozooecium	11.229	1.765	8	15	48	15 721
exilazooecia per autozooecium	1.491	1.359	0	5	55	91 159

Table 3.44 - Summary measurements for *Stenopora seriatensis* n. sp. Abbreviations as for Table 3.1, all measurements in millimetres

Discussion - This species is very similar to *S. tasmaniensis* Lonsdale, common to Sakmarian beds of Tasmania. *S. seriatensis* n. sp. can be distinguished from *S. tasmaniensis* by its thicker walls in the exozone, slightly smaller apertures and greater number of exilazooecia. Monilae in the exozone are nearly always confluent in *S. seriatensis*, and tend to be confluent throughout the width of the exozone. In *S. tasmaniensis* monilae in the exozone may be confluent in the outer exozone but are more often slightly separated in the inner exozone, and separate rows of monilae can be distinguished from each other despite overlapping.

Types - UTGD 127579 holotype, UTGD 127580 paratype - Wandrawandian Siltstone, North Head, Ulladulla.

Etymology - From the Latin *serere* or *series*, for the continuum of sizes in both acanthostyles and exilazooecia.

Material - Eight specimens were available for examination from the Wandrawandian Siltstone, UTGD 127579-83 from North Head, and UTGD 127584-86 from Warden Head, Ulladulla, NSW.

This species was previously recorded from the Kungurian ? Oxtrack Formation, Bowen Basin, Queensland as *S. tasmaniensis* (Wass, 1968).

Range - Kungurian.

Stenopora spiculata Crockford (1945)
Plate 44; Table 3.45

Stenopora spiculata CROCKFORD (1945), p. 13, text-fig. 1-2.
Diagnosis - Zooaria are robust dendroid and frondescent bilaminar. Exozone narrow and comprising about one quarter the radius of the branch in dendroid forms. Endozone crossed by arcuate rows of thin monilae. Zooecial open at 70° to 75° to the outer surface. In the inner part of the exozone monilae are widely spaced, and in the outer part are closely

Stenopora spiculata n. sp.	X	SD	Min	Max	N	CV
zooarial thickness	16.900	3.814	12	22	5	22 571
exozone radius	4.257	1.509	2.8	6	7	35 446
angle of zooecial tube to surface	73	2	71	75	3	2 740
endozone wall thickness	0.011	0.003	0 005	0.02	18	27 796
exozone wall thickness	0.122	0 037	0.06	0.22	32	30 303
autozooecia in 2mm	4.042	0.459	3.5	4.5	6	11 350
autozooecium width	0.287	0.063	0.2	0.4	28	21 903
autozooecium length	0.391	0 079	0 27	0 56	29	20 210
closest spacing autozooecia	0.390	0.058	0.28	0.48	33	14 837
exilazooecium width	0.099	0 033	0 04	0 16	19	33 487
exilazooecium length	0.163	0.063	0.06	0.3	26	38 476
acanthostyle diameter	0.066	0 029	0.025	0 14	30	43 933
acanthostyles per autozooecium	7.296	2.109	4	12	27	28.903

Table 3 45 - Summary measurements for *Stenopora spiculata* Crockford. Abbreviations as for Table 3 1, all measurements in millimetres

spaced but not confluent. Autozooecia are circular to oval and are always rounded at the level of the monilae. Exilazooecia are rare. Autozooecia are surrounded by up to 12 acanthostyles.
Description - The zooaria are dendroid and frondescent bilaminar, zoarial bases not seen. In dendroid zoaria branches are 12 to 22 mm in diameter. Exozone comprising about one quarter the radius of the branch in dendroid forms. In bilaminar material endozone is usually crushed. The endozone is crossed by arcuate rows of thin monilae. Monilae are 0.05 to 0.08mm wide in rows 5 to 6 mm apart. Zooecial walls thin in endozone and arise from an imaginary axis and bend gradually into exozone to open at 70° to 75° to the zoarial surface. In the inner part of the exozone rows of monilae are widely spaced and can be seen to curve across the endozone to form the arcuate rows of monilae discussed above. In the outer part of the exozone about 12 rows of closely spaced but non-confluent small monilae occur.
In the exozone zooecial walls are usually of intermediate width at the level of the monilae. Autozooecia are large and circular to oval and are always rounded at the level of the monilae. Where monilae are absent or not at their widest point autozooecial apertures are rounded polygonal to oval. Exilazooecia are of small to intermediate size and are rare in intermonticular regions but may be in clusters in the monticules. Autozooecia are surrounded by a single row of small to intermediate sized acanthostyles. There are up to 12 acanthostyles about each autozooecium, but in deeper sections acanthostyles are smaller and less frequent, and only seen at zooecial wall junctions.
Discussion - *S. spiculata* is similar in appearance in deep tangential section to *S. crinita*, but can be readily distinguished by the more closely spaced monilae, and more abundant acanthostyles in shallow section.
Material - *Stenopora spiculata* is recorded in Tasmania for the first time from the Sakmarian Bundella Mudstone, Lower Sandy Bay, Hobart (UTGD 56057). Also recorded from the Sakmarian Wasp Head Formation, NSW (UTGD 127577). Recorded by Crockford (1945) from the Sakmarian Allandale Stage, Lower Marine Series, Middlehope, NSW.
A single specimen (UTGD 127578) is recorded from the Artinskian Snapper Point

Formation, Pretty Beach, NSW, that is similar to *S. spiculata* but has smallr more closely spaced autozooecia. This specimen is recorded as *S.* cf. *spiculata* (se Plate 45), but further studies may show it to be an ecological variant.

Range - Sakmarian.

Stenopora tasmaniensis Lonsdale (1844)
Plate 46; Table 3.46

Stenopora tasmaniensis LONSDALE (1844) in Darwin, p. 161; ? LONSDALE (1845) in Strzelecki, p. 262, pl. 8, figs. 2-2e; ETHERIDGE (1891), p. 60, pl. 4, figs. 3-4, pl. 5, figs. 7-8; SMITH *et al.* (in prep.), p. 6. plus figs.

Stenopora johnstoni ETHERIDGE (1891), p. 59, pl. 7, fig. 7; CROCKFORD (1845), p. 20, text-figs. 24-25.

Diagnosis - Zoarium dendroid and frondescent (bilaminar). Large oval to subcircular autozooecia, exilazooecia present and acanthostyles abundant. Monilae in exozone crowded.

Stenopora tasmaniensis	X	SD	Min	Max	N	CV
branch thickness	11.10571	5.182	5.74	> 20	7	46.656
exozone radius	2.600769	2.559	1.17	11	13	98 402
endozone wall thickness	0 014	0 004	0.01	0.02	37	24.929
exozone wall thickness	0.125	0.034	0.06	0.22	100	27.379
autozooecium - length	0.410	0.079	0.27	0 71	103	19.319
autozooecium - width	0.268	0.049	0.17	0 41	100	18.162
exilazooecia diameter	0.127	0 054	0.02	0 26	96	42 891
acanthostyle diameter	0.052	0.015	0.02	0.08	97	28 274
acanthostyles per autozooecium	9.844	2 800	5	16	96	28 442
spacing autozooecial centres	0.404	0.042	0 32	0 54	84	10.408

Table 3.46 - Summary measurements for *Stenopora tasmaniensis* Lonsdale Abbreviations as for Table 3.1, all measurements in millimetres.

Description - Zoaria dendroid, frondescent and bilamellar. Dendroid zoaria are seen on occasion to arise from a frondescent zoarium (UTGD 126937), a feature also described by Wass (1968) and Smith *et al.* (in prep.). Zoarial size varies from 7 to 8 mm thick dendroid branches, and frondescent forms with fronds about 5 mm to greater than 20 mm thick. One frondescent zoarium with thin to thick fronds is at least 60 to 70 cm high and over 100 cm across (Plate 46, Fig. 1).

The surface may or may not show monticules in hand specimen. One frondescent fragment (UTGD 126942) shows many sharp high monticules clustered together, adjacent to a portion of the zoarium that appears, in hand specimen, to be free of monticules (Plate 46, Fig. 2). Monticules vary from pointed to low rounded to externally absent, though all are seen in thin section.

The endozone is commonly crushed in frondescent specimens, but where seen is thin walled with widely spaced arcuate rows of monilae. The exozone comprises about half the radius or thickness of the zoarium.

Zooecial walls in the exozone with closely spaced monilae that are at times confluent. Monilae in early part of exozone separated and confluent in outer part. In thick frondescent forms (UTGD 126943 and UTGD 126944) the greater thickness of the exozone results in a greater distance of separated monilae, but they are confluent in outer part of exozone. Zooecial walls are of intermediate to wide width at the level of the monilae, but slightly separated monilae may show thin walls in tangential section. Autozooecia are oval to subcircular and large, with a ratio of mean width to length of 2:3. Autozooecial apertures show no consistent orientation. There are typically 5 to 16 small to intermediate sized acanthostyles surrounding each autozooecium. However depending on level of section and position relative to monticules acanthostyle frequency may vary, and they are often only found at wall junctions in intermonticular areas. Exilazooecia of small to large size are usually rare. Exilazooecia are however clustered in the monticules, some monticules with clusters of exilazooecia in solid walled areas devoid of autozooecia.

Discussion - *Stenopora tasmaniensis* is distinguished from *S. ovata* and *S. crinita* by its more closely spaced monilae, and the size and shape of autozooecia and the number and size of acanthostyles.

Material - In this study *S. tasmaniensis* is recorded from the Sakmarian Basal Beds, Maria Island (UTGD 126940-45), Sakmarian Bundella Mudstone, Lower Sandy Bay, Hobart (UTGD 126937-38) and Cygnet (UTGD 126947), Sakmarian Masseys Creek Group, Beaconsfield (UTGD 126939) and Sakmarian Golden Valley Group, Golden Valley (UTGD 126946).

Stenopora tasmaniensis has been recorded from stratigraphically higher units by other authors, but specimens directly attributed to this species have not been found. Crockford (1951) makes note of Strzelecki specimens from the Berriedale Limestone, but these have not been seen in thin section. Wass (1968) records *S. tasmaniensis* from the Kungurian to Kazanian of the Bowen Basin. The Bowen Basin specimens are reassigned to *S. seriatensis* n. sp. described above.

Range - Sakmarian.

3.2.3 - ***Discussion of previously described species.***

Descriptions of previously described species were used to determine generic placement of fenestrate taxa within Australia that were not recorded by this study. Unfortunately much of the work done by Crockford did not include a description of even basal chamber shape, and fenestrate material was not examined internally. Because of this many taxa cannot be accurately placed, and remain within *Fenestella* s.l. or *Polypora* s.l.

Some taxa previously described from eastern Australian faunas have already been discussed above. A number of previously described species are not recorded in this study, and unfortunately many are not able to be allocated in the genera of Morozova (1974) and Morozova and Lisitsyn (1996) from the published descriptions. Wass (1968) described the chamber basal shape of fenestrate taxa from the Bowen Basin of Queensland. However most basal shapes are given as either pentagonal or triangular, but as seen above this shape is shared by a number of genera, and a triangular basal shape may develop into pentagonal at mid chamber in many species of *Rectifenestella.* Also, descriptions may vary between authors. Crockford (1946) gives a pentagonal basal chamber shape for *Fenestella canthariformis* Crockford (1941), but Wass (1968) describes a triangular shape. This indicates there are two species placed together within *F. canthariformis.*

Of the numerous species of *Fenestella* described by Crockford (1944a; 1944b; 1944c; 1957) from Western Australia only a few are able to be placed with any certainty within the genera of Morozova (1974). Crockford (1957) gave tangential section figures of *Fenestella hindei* and *Fenestella* sp. *F. hindei* shows a fabiform chamber outline and a single row of nodes, and should be named *Exfenestella hindei. Fenestella* sp. has distinctly triangular to trapezoid chamber outlines, and chambers cross the width of the branch and alternate, as seen in *Alternifenestella* Termier and Termier. *Fenestella lennardi* Crockford, was recorded by Wass (1967) from the Port Keats, Northern Territory, with a chamber shape description of "zooecial base shape triangular with flange, becoming rectangular in upper levels of the branch". Unfortunately no figures are given but this description seems to place *lennardi* within *Rectifenestella* of Morozova (1974). *Fenestella horologia* Bretnall, common in Western Australia and also known in Queensland is discussed in Chapter Five. A number of species placed within *Polypora* by Crockford (1944b; 1957) can be tentatively placed within genera of Morozova and Lisitsyn (1996). *Polypora natalis* Crockford (1957) has 7 to 8 rows of zooecia with the obverse surface "ornamented by clusters of coarse granules", indicating that this species is best placed within *Mackinneyella* of Morozova and Lisitsyn (1996). A number of other polyporid species from Western Australia with between 5 to 9 rows of zooecia, and rhomboidal basal chamber shapes may also belong in the genus *Mackinneyella.* These species are *Polypora wadei* and *P. obesa* Crockford (1957), and *P. multiporifera* Crockford (1944b), but inclusion is tentative as chamber outline is not known throughout the depth of the chamber, and *Parapolypora* may have rhombic chambers at the reverse wall and the more typical hexagonal at mid chamber. *Polypora kimberleyensis* Crockford has 5 to 6 rows of zooecia and round the surface cells (Crockford, 1957), also seen in *Shulgapora magnafenestrata* (Crockford). *P. kimberleyensis* is here placed in *Shulgapora* Termier and Termier on the description of the surface cells. *Polypora lyndoni* Ross (1963) was figured in thin section, and shows three rows of zooecia with a hexagonal outline, that clearly place this species within the genus *Polyporella* Simpson.

3.3 - SUMMARY

The Bryozoa from the Permian of the Tasmania and southern Sydney Basins are an abundant fauna, if limited in diversity. Many species within the Tasmania Basin are endemic, particularly in the Fenestrata, however there are no endemic genera. Endemic species comprise two thirds of the fauna and fenestrate taxa include:-*Rectifenestella smithae*, *R. counselensis* n. sp., *Rectifenestella* sp. A, *Parapolypora ampla* Lonsdale, *P. boraformis* n. sp., *Parapolypora* sp. A and B, *Polyporella internata* Lonsdale, *P. protuberans* n. sp., *P. subwoodsi* n. sp., *Pseudopolypora banksi* n. sp., *P. bundellaensis* n. sp., *P. tamarensis* n. sp., *P. versonoda* n. sp. *Parapolypora ampla* and *Polyporella internata* have previously been recorded from outside the Tasmania Basin as *Protoretepora* and *Fenestella* however without internal examination these occurrences cannot be confirmed. Endemic trepostome species include *Dyscritella inversa* n. sp., *Dyscritellina megacanthi* n. sp., *Stenopora aequalis* n. sp., *S. berriedalensis* n. sp., *S. elongata* n. sp., *S. grantonensis* Crockford. Future studies may also reveal occurrences of "endemic" Tasmanian species in other basins.

In the southern Sydney Basin less than half the species are endemic to that basin (mostly the Wandrawandian Siltstone), and these species include :- *Fenestella* sp., *Laxifenestella oviferosa* n. sp., *Rectifenestella* sp. B and C, *Paucipora ulladullaensis* n. sp., *Polypora dichotoma* Crockford, *Dyscritella espinensis* n. sp.; but again there are no endemic genera.

The genera *Rectifenestella, Laxifenestella, Paucipora, Polyporella, Shulgapora, Parapolypora, Mackinneyella*, *Dyscritellina* and *Paralioclema* are recorded for the first time in Australia from internal examination. Review of previously described taxa also reveals the presence of *Alternifenestella* and *Exfenestella* from the Permian of Western Australia.

The examination of fenestrate taxa internally has revealed many new details, and has separated taxa that were previously grouped together at species level. This is shown by "*Protoretepora ampla*" (now *Mackinneyella granulosa*, *Parapolypora* sp. A and B, *P. ampla*, and *P. boraformis*), "*Fenestella fossula*" (includes *Rectifenestella smithae, Pseudopolypora banksi*, *P. tamarensis*, *P. versonoda*) and "*F. dispersa*" (includes *Rectifenestella* sp. A, B and C). Taxa of the Tasmania Basin also show limited time ranges and are not usually long ranging. As recorded in this study the faunas of the Tasmania and southern Sydney Basins have only *Polypora virga, Shulgapora magnafenestrata, Dyscritella restis, Stenopora crinita, S. etheridgei, S. ovata, S. spiculata* and *S. tasmaniensis* in common.

CHAPTER FOUR

PERMIAN GEOLOGY OF PENINSULAR THAILAND

4.1 - INTRODUCTION

Palaeozoic rocks are widespread in peninsular Thailand, as they are through much of Northern Thailand, Malaysia and surrounding areas. The Palaeozoic rocks of peninsular Thailand are within the Shan-Thai Terrane (or Sibumasu Terrane of Metcalfe, 1996), that extends into northwestern Malaysia, eastern Burma and north into southern China. The Shan-Thai Terrane as discussed here follows Shi and Archbold (1998). However the geological details of parts of the Shan-Thai/Sibumasu Terrane in northeast Burma and South China vary between authors.

In the Phuket region, Palaeozoic rocks are traditionally divided into the Phuket Group and the Ratburi Limestone (see Figure 4.1). However the lithostratigraphic terminology of the Phuket Group is not consistent, in part owing to the difficulty in tracing beds laterally. The Phuket Group is sparsely fossiliferous, with faunal horizons often difficult to trace laterally, while the Ratburi Limestone is richly fossiliferous. Poor bryozoan faunas were collected from the Phuket Group, while abundant bryozoans in the Ratburi Limestone were collected from Ko Phi Phi Don.

4.2 - REGIONAL GEOLOGY PENINSULAR THAILAND

4.2.1 - *Phuket Group*

The sediments beneath the Ratburi Limestone were first named by Brown *et al.* (1951), with the appearance of the terms "Phuket" and "Kanchanaburi" in Thai lithostratigraphy. Since this time the use of these terms has varied, both geographically and stratigraphically (see Figure 4.2). Brown *et al.* (1951) described the lowermost beds, the Phuket Series, as metamorphosed sedimentary rocks and proposed a Cambrian age based on trace fossils. In discussion of the Phuket Series, Brown *et al.* (1951) described slates and shales containing pebbles from the east side of Phuket Island. These are the "pebbly mudstones" discussed by many authors (i.e. Mitchell *et al.*, 1970; Waterhouse, 1982; Hills, 1989), that have yielded Permian faunas (Waterhouse *et al.*, 1981; Waterhouse, 1982). The Thung Song Limestone (Brown *et al.*, 1951) is a carbonate sequence with Ordovician faunas (Wongwanich *et al.*, 1990; Laurie and Burrett, 1992) outcropping east of Phuket, but not in the Phuket area. Brown *et al.* (1951) described the Kanchanaburi Series as overlying the Thung Song Limestone, but did state that relations with older beds were obscure. The Kanchanaburi Series was described as commonly metamorphosed clastic sediments underlying Permian Limestones (Ratburi Limestone).

These clastic sequences underlying the Ratburi Limestone in the Phuket region are variously named the Phuket Group (Mitchell *et al.*, 1970; Bunopas, 1983) or the Kaeng Krachan Group (Waterhouse *et al.*, 1981; Waterhouse, 1982). The Kaeng Krachan Group was described from marine sequences at the Kaeng Krachan damsite in northern peninsular Thailand by Piyasin (1975). These northern sequences are of a wider age span than the rocks in the Phuket region of southern peninsular Thailand, and are difficult to correlate biostratigraphically. The Kaeng Krachan Group of northern peninsular Thailand includes Phuket Group correlates, however only the upper Kaeng Krachan Group is of similar age to the Phuket Group. The Phuket Group is preferred here as it is used to define the rocks of the Phuket region, and does not include older rocks from northern regions.

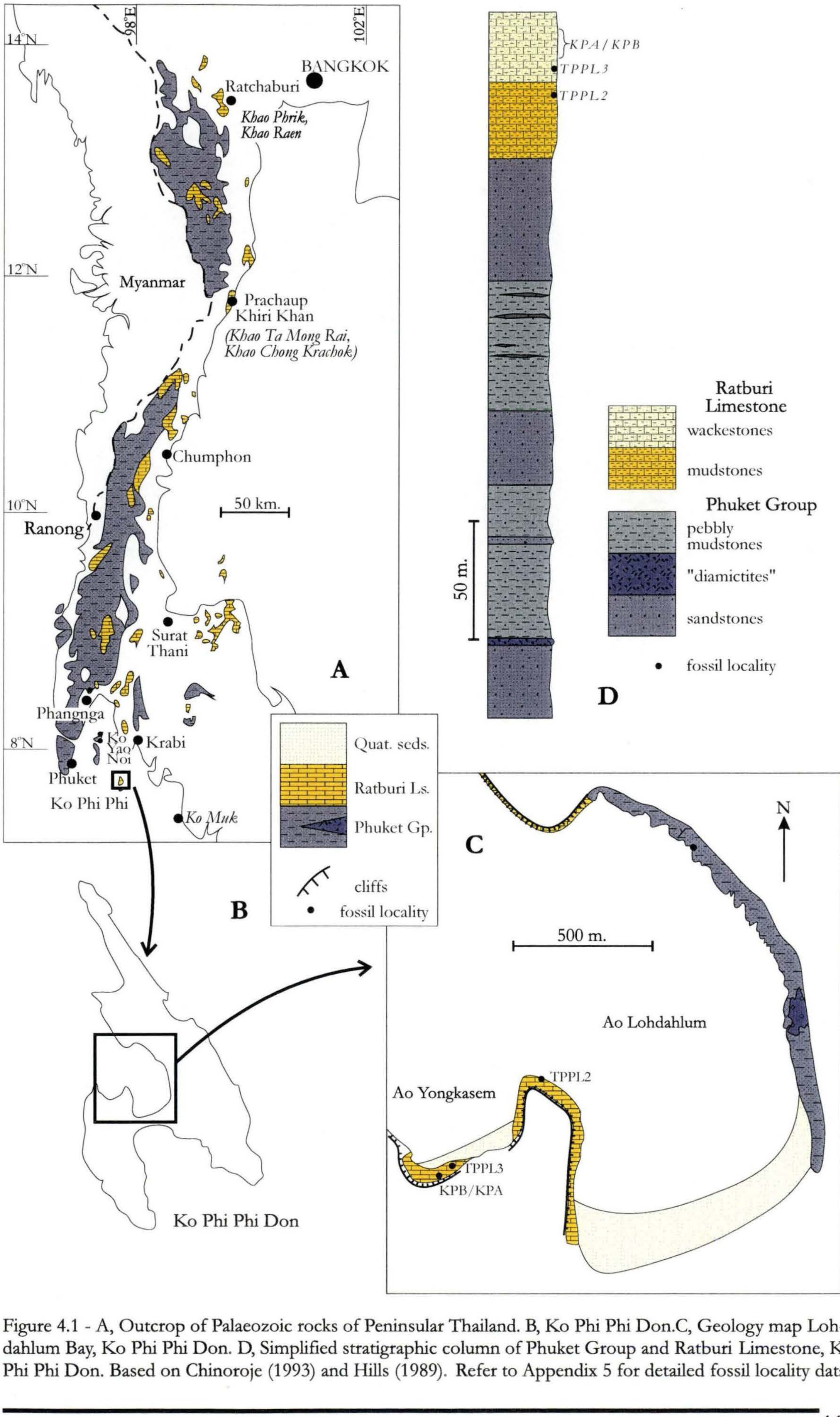


Figure 4.1 - A, Outcrop of Palaeozoic rocks of Peninsular Thailand. B, Ko Phi Phi Don.C, Geology map Lohdahlum Bay, Ko Phi Phi Don. D, Simplified stratigraphic column of Phuket Group and Ratburi Limestone, Ko Phi Phi Don. Based on Chinoroje (1993) and Hills (1989). Refer to Appendix 5 for detailed fossil locality data.

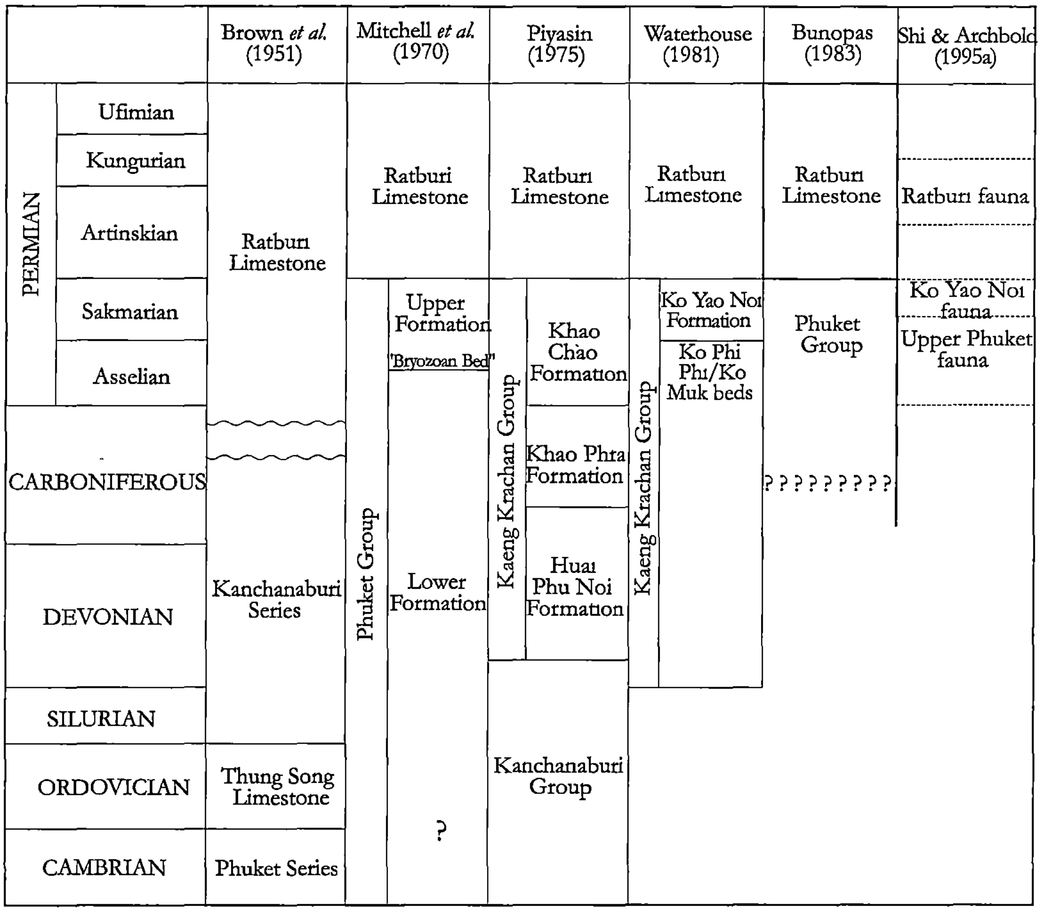


Figure 4 2 - Stratigraphic correlation chart for southern Thailand. Mitchell *et al.* (1970), Waterhouse (1981), Waterhouse *et al* (1981) and Bunopas (1983) are based on stratigraphic sequences in the Phuket region, with Piyasin (1975) based in northern peninsular Thailand.

Mitchell *et al.* (1970) changed the Phuket Series of Brown *et al.* (1951) to group status, after field studies in the Phuket/Phangnga region, and included all outcropping rocks beneath the Ratburi Limestone. Mitchell *et al.* (1970) divided the Phuket Group into the Lower and Upper Formations (see Figure 4.2), and reported the discovery of a fossil horizon rich in Bryozoa. The so named "Bryozoan Bed" separates the Upper and Lower Formations, and is exposed northeast of Phangnga, where a fauna was collected. Unfortunately this material, and that provided by the Thai Department of Mineral Resources, was not sufficiently preserved for adequate identification (see Chapter Five for a further discussion). The Phuket Group consists of sandstones and pebbly mudstones, with the latter common. The pebbly mudstones contain scattered clasts of variable lithologic origin. Mitchell *et al.* (1970) suggested a mass flow origin for these pebbly mudstones, in a continental rise and slope environment. Waterhouse (1982) examined brachiopod faunas from these pebbly mudstones and assigned an early Permian (Asselian) age. Previously Hamada (1960) proposed a Middle or Early Carboniferous age after examination of the same fauna. Waterhouse *et al.* (1981) also described faunas from the Phuket Group on Ko Yao Noi that are of Sakmarian age. The brachiopod faunas also show taxonomic similarities to those of the Permian of Western Australia and Queensland, suggesting a cool-water environment for the pebbly mudstones of the Phuket Group (Waterhouse, 1982) and do not have any species in common with North and Central Thailand Permian faunas. Bunopas *et al.* (1978) and Stauffer (1983) proposed a glaciomarine origin for the Phuket Group, as did Hills (1989). Altermann (1986) argued that the Phuket Group rocks are not glaciomarine, but are of a continental margin origin on the Palaeoeurasian craton, in the northern Tethys. Stauffer and

Lee (1987) replied that deposition on a continental margin does not preclude glacial influence, and despite Waterhouse (1982) concluding that the Phuket Group faunas were not as cold as those of Gondwana, they do represent a cool water fauna, much cooler than that of later Permian rocks in Thailand.

In summary the Phuket Group, in the Phuket region, is of Early Permian age for the most part, and comprises pebbly mudstones of glaciomarine origin with a cool water fauna showing affinities with Gondwana faunas. In northern Peninsular Thailand equivalent rock types to the Phuket Group are within the Kaeng Krachan Formation and include rocks older than Permian. Many authors have named formations within the Phuket Group (see Figure 4.2), but these are not easily traced laterally, so are not discussed in detail here, except where they are of biostratigraphic significance.

4.2.2 - ***Ratburi Limestone***

The Ratburi Limestone outcrops throughout peninsular Thailand with a karst topography. It overlies the Phuket or Kaeng Krachan Groups, and is readily distinguished by its tendency to form tower like karsts in comparison to the more gentle topography of the Phuket Group. Although the Ratburi Limestone extends from northern peninsular Thailand south into northwest Malaysia (as the Chuping Limestone), local outcrops are not extensive and are often fault controlled. Palaeontological studies from individual outcrops have yielded at times conflicting ages and this is due, in part, to the general lack of understanding of the stratigraphic relationships between isolated areas.

In a recent study Chinoroje (1993) has put forward an apparent facies succession within the Ratburi Limestone. Of the four areas examined by Chinoroje (1993), Ratburi, Prachuab Khirikhan and Surat Thani-Phangnga, have an upward sequence of mudstone, wackestone, packestone, grainstone and boundstone. Ko Ang Thong, north of Surat Thani has an alternating succession of mudstone and wackestone. Chinoroje (1993), did not discuss the stratigraphic relationship between regions or outcrops, but this basic facies sequence is a step towards understanding the unit as a whole, rather than as isolated outcrops. The mudstone and wackestones of Chinoroje (1993) are fossiliferous, however the bulk of the rock is micrite, or small bioclastic grains in a micritic cement. Bioclastic content increases upwards, with the occurrence of packestone to grainstone facies, and interstitial spaces are filled by sparry calcite. Algal boundstones are locally present, with fenestrate bryozoa as the main skeletal element, bound by blue-green algae (Chinoroje, 1993).

The Ratburi Limestone on Ko Phi Phi Don, as examined in Lodahlum Bay (Figure 4.1), is of bedded mudstone and wackestones, with fossils becoming common in the wackestones. The thickness of mudstone and wackestone is up to 50 metres, but the section reveals many faults with total stratigraphic displacement unknown. The contact with the Phuket Group was not examinable where bryozoan collections were made, but was described as conformable by Hills (1989). The mudstones are well bedded and for the most part do not contain many fossils, but are commonly bioturbated. The mudstones are dark and well cemented, and in thin section the matrix is micritic with little bioclastic material identifiable. The mudstones give way upwards to wackestones, poorly sorted fine sandstones, that are fossiliferous. Towards the wackestones the mudstones become slightly fossiliferous, with bryozoans, corals and small brachiopods visible in outcrop. The wackestones are grey in colour, and are well cemented, with small bioclastic and other grains in a micritic cement. Fossils are common, with fenestrate and branching bryozoa seen, along with corals, brachiopods and bivalves. Previous authors have remarked on the presence of fenestrate bryozoans and branching corals, and it is likely the latter is a misidentification of branched bryozoans, however corals are present. In both the mudstones and wackestones fossils are best exposed by weathering, and in freshly broken surfaces are difficult to discriminate. Fossils in both mudstones and wackestones show either micritic or sparry calcite fill of internal cavities, and some recrytalisation of micritic cement is seen. The oolitic packestones and grainstones described in Chinoroje (1993), from upper parts of the Ratburi Limestone, are not seen on coastal outcrops of Ratburi Limestone in Lodahlum Bay. In thin section fossil fragments and matrix are silicified, with the replacement of carbonate structures with chalcedony. Silicification is widespread in the wackestones, and occurred during uplift and exposure of the Ratburi Limestone in the Tertiary (Baird and Bosence, 1993).

In comparison with the facies succession given by Chinoroje (1993), the coastal outcrops of Ratburi Limestone in Lodahlum Bay are from lower parts of the Ratburi Limestone. Fossils were collected about 50 metres from the base of the Ratburi Limestone.

The faunal associations of most of the Ratburi Limestone represent a warm water fauna, with diverse and Tethyan faunal elements present. However Burrett *et al.* (in prep.) indicate a cool water trace element signature in the lowermost Ratburi Limestone of Ko Phi Phi Don. A shift in trace elements and carbon-oxygen isotopes indicates marine warming about 20 metres above the base of the limestone (Burrett *et al.,* in prep.) Recent published studies of the sedimentology (Baird and Bosence, 1993) and petrography (Chinoroje, 1993) of the Ratburi Limestone, have revealed further information on the palaeoenvironment of this unit. Chinoroje (1993) concluded that the facies successions through the Ratburi Limestone as a whole represented a shallowing upward sequence on a carbonate platform. Chinoroje (1993) described the Ratburi Limestone as representing a carbonate platform with four sub-environments. Lagoonal sub-environments are represented by bioturbated mudstone and wackestones with low faunal diversity, open platform complex represented by wackestones and packestones, and ooid grainstones and packestone representing shallow water sand shoal sub-environments. A more detailed study by Baird and Bosence (1993), in the Ratburi region, revealed a more complex setting influenced by extensional horst and graben tectonics. However the overall setting of a carbonate platform with wackestones indicating low energy open platform environments, and high energy platform environments represented by boundstone, fossiliferous grainstones and ooid grainstones is similar.

4.3 - BIOSTRATIGRAPHY

The biostratigraphy of Thai Palaeozoic faunas has been studied by many authors, and in particular the age of the Ratburi Limestone has received much attention. Faunas are limited in the Phuket Group, but there is general agreement on their age relationships. However the Ratburi Limestone, whilst having abundant faunas, has yielded conflicting age information. This is in part a result of the poor lithostratigraphic understanding of the unit, and its tendency to form isolated outcrops without recognizable stratigraphic boundaries.

4.3.1 - *Biostratigraphy of the Phuket Group.*

The brachiopod fauna from the upper part of the pebbly mudstones (Lower Formation) were first studied by Hamada (1960), who concluded an Early or Middle Carboniferous age. Faunas from the same stratigraphic level were studied by Waterhouse (1982) from Ko Muk and Ko Phi Phi. Waterhouse (1982) concluded an Early Permian Asselian age from the presence of the genus *Cancrinelloides*, of which there are a number of species from the early Permian of Western Australia. The Western Australian species are now assigned to other genera, and the Thai *Cancrinelloides* (*C. monticulus* Waterhouse) to *Bandoproductus* (Shi and Archbold, 1995a). However while no species are found in common with Western Australia, generic links are strong and indicate a close relationship with the *Lyonia lyoni* Zone from the Carnarvon Basin, Western Australia, of Late Asselian to early Sakmarian age (Shi and Archbold, 1995a).

On Ko Yao Noi, a brachiopod fauna dominated by *Spinomartinia*, is found in the Ko Yao Noi Formation (Waterhouse *et al.*, 1981) of pebbly mudstones, overlain by tuffaceous sandstone and volcanic tuff. *Spinomartinia prolifica* is abundant in the tuffaceous sandstone and tuff in the upper part of the Ko Yao Noi Formation. Associated common species are *Retimarginifera alata, Brachythyrina rectangulus, Orthotetes perplexus, Kutorginella paucispinosa, K. fraterculus* and *Spiriferella modesta*. The *Spinomartinia prolifica* assemblage does not show as strong Western Australian affinities as the Asselian pebbly mudstones of Phuket, and has a large proportion of wide ranging genera (Shi and Archbold, 1995a). Waterhouse *et al.* (1981) discussed the faunal relationships with other areas, and suggested an upper Sakmarian to lower Artinskian age was likely. Waterhouse *et al.* (1981) drew comparisons between both the Sakmarian to lower Artinskian Chihsia Limestone of China, and the Artinskian of the Urals. A similar fauna dominated by *S. prolifica* is found in west Malaysia (Shi and Waterhouse, 1991). Shi and Archbold (1995a) determined a late Sakmarian age for the *Spinomartinia* fauna of Ko Yao Noi, relying mainly on fusulines and ammonoids of Artinskian age in limestones overlying the *Spinomartinia* beds in west Malaysia.

4.3.2 - *Biostratigraphy of the Ratburi Limestone.*

The Ratburi Limestone faunas are diverse and abundant, with foraminifera, brachiopods and bryozoans available for biostratigraphic comparison. Fusulinids indicate a broad age range for Ratburi Limestone beds, ranging from Middle Carboniferous to Middle Permian (Toriyama *et al.*, 1975; Ingavat *et al.*, 1980). Fontaine *et al.* (1994) report on a number of fusulinid horizons and conclude that as the genera present are few or long ranging they are not biostratigraphically useful unless associated with smaller foraminifera. A number of biostratigraphically useful small foram species are present in the Ratburi Limestone, and indicate Middle Permian (Murghabian) ages (Fontaine *et al.*, 1994). Fontaine et al. (1994) collected from throughout Peninsular Thailand, but do not give precise stratigraphic localities positions.

Studies of brachiopod faunas have been undertaken by a number of authors, as they are an abundant group in the Ratburi Limestone, however there is some conflict in age relationships. Grant (1976) collected from a number of lower Ratburi Limestone localities in peninsular Thailand, and determined a late Artinskian age, with faunal correlation to the lower Byro Group of Western Australia, Bitauni fauna of Timor and the upper Amb Formation of the Salt Range, Pakistan. Grant (1976) drew comparisons between Ratburi productids and those of the Wandagee and Cundlego Formations of Western Australia. He recorded abundant specimens of the genus *Bilotina* from Phangnga, which in the Salt Range of Pakistan are confined to the Artinskian Amb Formation; hence Grant gave further evidence for an Artinskian age. Grant (1976) also commented on the presence of *Martiniopsis* in his faunal comparisons, however the concept of this and associated genera has since altered (see Clarke, 1987), rendering comparisons at generic rather than specific level less indicative. Waterhouse *et al.* (1981) argued that Grant (1976) had incorrectly assigned a late Artinskian age, and that the basal part of the Ratburi Limestone (from Grant's material) was of Kungurian age.

Shi and Archbold (1995a) supported a late Artinskian (Late Baigendzhinian) to Early Kungurian age for the Ratburi Limestone brachiopod fauna. Shi and Archbold (1995a) concluded that the Ratburi Limestone fauna is most closely comparable to the Bitauni beds from Timor, which are of Baigendzhinian to Early Kungurian age based on ammonoids (Archbold, 1981), and the upper Amb Formation of the Salt Range. Shi and Archbold (1995a) supported few but significant links to the Cundlego and Wandagee Formations of Western Australia, for which Archbold (1993) gave a Baigendzhinian to earliest Kungurian age. Archbold (1999), after assessment of Western Australian brachiopod faunas in comparison to a world standard proposed a Kungurian age for both the Cundlego and Wandagee Formations.

The above discussion of brachiopod biostratigraphy involves collections from the basal part of the Ratburi Limestone, from various localities in southern Peninsular Thailand. The age of late Artinskian to Early Kungurian for these beds is in contrast to the faunas described by Waterhouse and Piyasin (1970) from Khao Phrik, northern Peninsular Thailand, to which they assigned a Kazanian age, later amended to Kungurian by Waterhouse (1973, 1976).

Bryozoan faunas have been examined largely by Sakagami and reported in a number of papers. Sakagami has reported slightly older ages than those shown by brachiopods and foraminifera. From comparison with bryozoan faunas of Europe, Asia and Western Australia, Sakagami gave Artinskian and late Artinskian ages for bryozoan faunas from peninsular Thailand (Sakagami, 1968a; 1968b). Bryozoan faunas from the Phuket Group at Khao Chong Krachok were assigned an Upper Sakmarian to Lower Artinskian age (Sakagami, 1968c).

Sakagami (1968 a; 1968b) reported faunal affinities between the bryozoa of Thailand and those of the Noonkanbah Formation Western Australia, and the Permian of Timor and the Salt Range, Pakistan. Some of Sakagami's comparisons were based on fenestellid bryozoans, however without modern generic assignment based on internal structures, their accuracy must be questioned. However many of Sakagami's comparisons were based on cystoporates, which at the time of study were considered a more reliable taxonomic group for biostratigraphic comparison.

The fusulinid faunas discussed above are younger than the brachiopod faunas of the Ratburi Limestone. However the brachiopod faunas were from lower Ratburi sequences, beneath the beds that have yielded useful foraminiferal faunas (Fontaine *et al.*, 1994). Unfortunately many palaeontological collections do not have information available on stratigraphic position, or this information is not given. The top of the Phuket Group, in the Phuket region, is of upper Sakmarian (Shi and Archbold, 1995a), or upper Sakmarian to lower Artinskian age (Waterhouse *et al.*, 1981). It is therefore likely that lower Ratburi Limestone beds will yield mid to upper Artinskian ages, with younger beds above. The Ratburi Limestone may also be a time transgressive unit, which would help explain the cinflicting age data, but is complicated often by a lack of precise stratigraphic placement. With the introduction of the facies succession of Chinoroje (1993) isolated outcrops of Ratburi Limestone may be able to be more accurately placed stratigraphically.

4.4 - TECTONIC HISTORY.

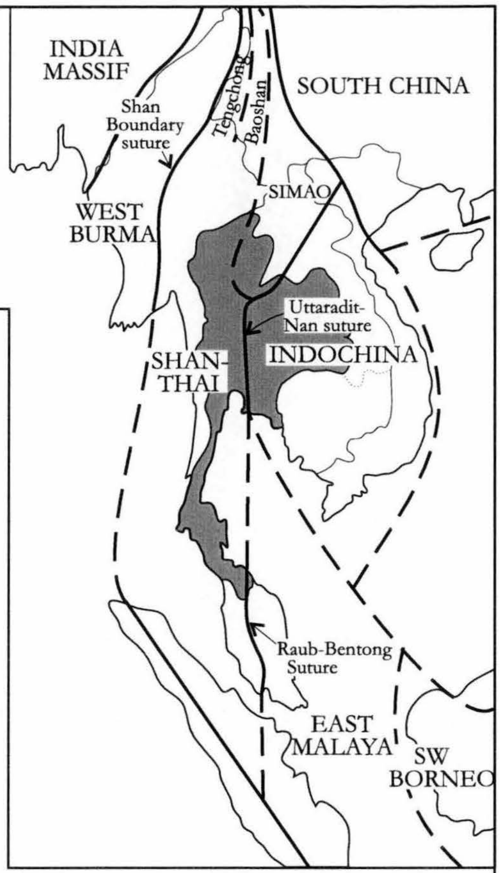
4.4.1 - *Biogeography*

The Palaeozoic rocks of the Shan-Thai Terrane, that outcrop through eastern Burma, peninsular Thailand and western Malaysia, represent quite separate environments, with the glaciomarine Phuket Group, and the warm-water carbonate platform Ratburi Limestone. Further, the faunas of the Phuket Group have affinities with Gondwanan faunas, yet the Ratburi Limestone shows strong Tethyan affinities (Shi and Archbold, 1995a).

South East Asia comprises a number of tectonic terranes of varying age and provinciality, with many Palaeozoic-Mesozoic blocks derived from northern Gondwana (i.e. Metcalfe, 1998; 1999). Shi and Archbold (1998), have recognized three faunal provinces in the Permian of Southeast Asia (see Figure 4.3). The Cathaysian Province was present throughout the Permian, and was based within the Palaeotethys. The Westralian Province developed in the late Sakmarian and persisted through the rest of the Permian, and included Western Australia, India and West Burma terranes. Previously, in the Asselian to early Sakmarian, the Indoralian Province occupied this region and also included the Shan-Thai and West China Terranes.

The Shan-Thai Terrane and associated blocks, in the earliest Permian (Phuket Group pebbly mudstones), are part of the Indoralian Province. The fauna described from the pebbly mudstones in southern Thailand by Waterhouse (1982) is a cool water fauna, and has half of its total brachiopod fauna endemic to the Gondwanan Realm, with remaining genera either cosmopolitan, or temperate (Shi and Archbold, 1998). By the Late Sakmarian, as shown by the *Spinomartinia prolifica* fauna of the Ko Yao Noi Formation in the uppermost Phuket Group (Waterhouse *et al.*, 1981), faunas of the Shan-Thai Terrane show a warm water influence. While the faunal assemblage in the Late Sakmarian is strongly influenced by Gondwanan elements, warm-water palaeo-equatorial taxa are also present, and the abundant species *Spinomartinia prolifica* is endemic to the Shan-Thai Terrane (Shi and Archbold, 1998). Artinskian-Kungurian faunas are represented in the Ratburi Limestone, and while they still

Figure 4.3 - Terrane distribution of South East Asia. Details of boundaries of Shan-Thai Terrane shown. After Shi and Archbold (1998), who separated the Baoshan and Tengchong terranes. Metcalfe (1999) included the later in Shan-Thai (Sibumasu) Terrane, and the East Malaya terrane in the Indochina terrane.



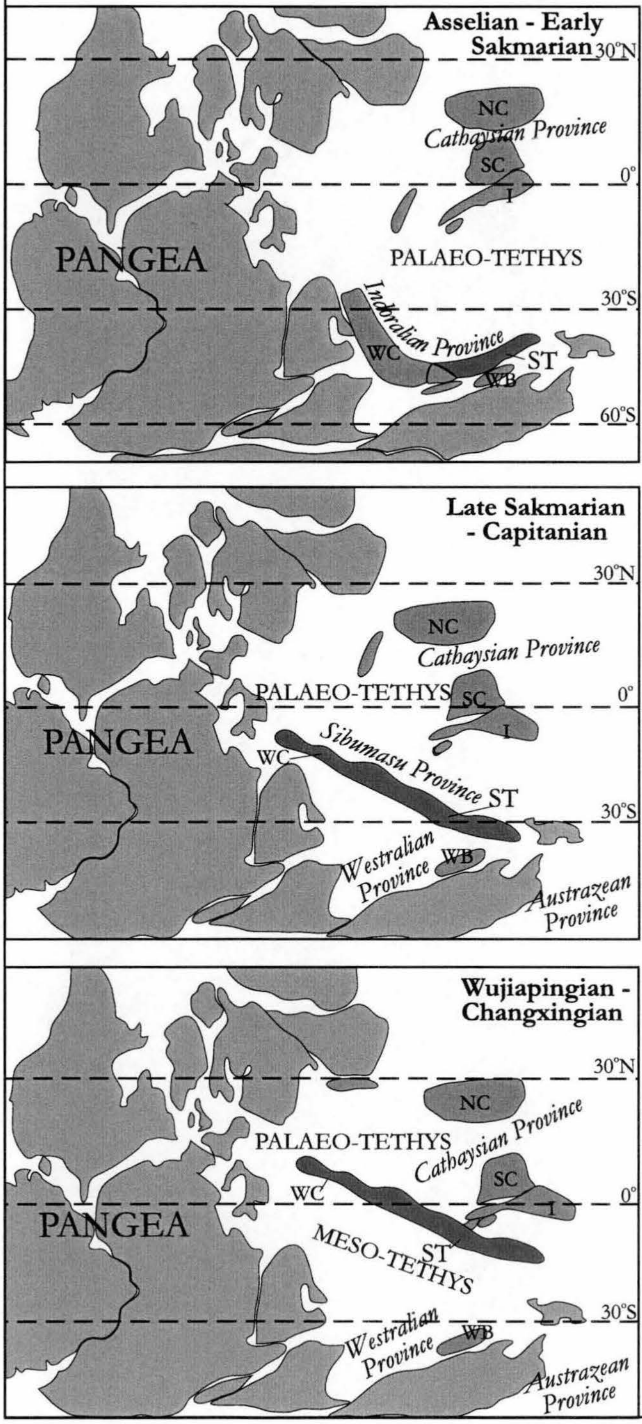


Figure 4.3 - Palaeogeographic reconstruction for the Tethyan region through the Permian. From Shi and Archbold (1998) and including faunal provinces given by those authors. Only terranes shown in Figure 4.3.1 are labelled. NC = North China, SC = South China, I= Indochina, WC = western Cimmerian continent, ST = Shan-Thai (following Shi and Archbold (1998), WB = West Burma.

show some Gondwanan links the fauna is a warm water one with Cathaysian Province influences. However the faunal affinities of the Shan-Thai Terrane show it was not fully incorporated into the Tethyan Cathaysian Province until the latest Permian (Shi and Archbold, 1995a). The transitional faunas of the Shan-Thai and associated terranes, reflecting a change from Gondwanan to Tethyan influences, mark the development of the Sibumasu faunal province (Shi and Archbold, 1998).

4.4.2 - ***Tectonic evolution***

As discussed above the Permian faunal history of the Shan-Thai Terrane is one of initially Gondwanan links that through the Permian become more influenced by Tethyan elements, providing evidence of terrane movement northwards from the Gondwanan landmass. Much of Southeast Asia follows this pattern of terranes derived from the northern margin of Gondwanaland (Metcalfe, 1999 and references therein). Phanerozoic evolution of the Tethys has involved successive rifting of amalgamated terranes from the Gondwanan margin, in the Late Devonian, Early to mid Permian and Late Triassic to Late Jurassic (Metcalfe, 1996). This three fold rifting and accretion sequence also opened and closed successively the Palaeo, Meso and Ceno Tethys (Metcalfe, 1996).

The Shan-Thai Terrane rifted from the northern Gondwanan margin during the second rifting phase, in the Early Permian, as part of a group of terranes known collectively as the Cimmerian continent of Sengor (1979). Opinion on the composition of this Cimmerian continent has varied over time, and now includes the Sibumasu Terrane (Shan-Thai, Tengchong and Boashan), western Cimmerian continent, and the Qiangtang Terrane (Metcalfe, 1999). Note Metcalfe (1999) uses the term Sibumasu as a terrane, where as (Shi and Archbold, 1998) use Sibumasu in reference to a faunal province. Many authors have also included the Lhasa Terrane in the Cimmerian continent, but recent sedimentologic and stratigraphic work has shown a later rifting age (Metcalfe, 1996). The movement of the Shan-Thai Terrane across the Palaeo-Tethys was rapid and had closed this ocean and accreted to the Indochina and East Malaysia terranes by the latest Permian to Triassic. The Raub-Betong Suture, exposed in Malaysia between the southern Shan-Thai Terrane and the East Malaya Terrane represents the closure of the Palaeo-Tethys, and the collision of the Shan-Thai Terrane with East Malaya. Deep marine cherts within the suture zone range in age from Late Devonian to Late Permian (Spiller and Metcalfe, 1995), and limestone clasts within suture mélange are of Early to Late Permian age (Metcalfe, 1989), indicating a latest Permian or Triassic collision of the Shan-Thai and East Malaya Terranes (Metcalfe, 1996). In North Central Thailand the Shan-Thai Terrane is juxtaposed with the Indochina Terrane across the Nan Suture. Triassic fore-arc basin sediments are found in the Shan-Thai Terrane, along with Triassic radiolarian cherts in the Nan Suture, indicating a Triassic collision of the northern Shan-Thai Terrane and Indochina Terrane (Chaodumrong and Burrett, 1997).

4.5 - SUMMARY

Palaeozoic rocks of southern Thailand are within the Shan-Thai Terrane, that also extends into northwest Malaysia, east Burma and southern China. Bryozoa were collected from the Phuket Group and Ratburi Limestone in the Phuket region.

The Phuket Group consists of pebbly mudstone, and sandstone of glaciomarine origin. Faunas within the Phuket Group include bryozoans, brachiopods and molluscs. Brachiopod faunas indicate a lower Permian age, with Asselian faunas in the mudstones of Phuket (Shi and Archbold, 1995a), and Sakmarian to lower Artinskian faunas in the Ko Yao Noi Formation (Waterhouse *et al.*, 1981). Shi and Archbold (1995a) gave a Sakmarian age for the Ko Yao Noi faunas. The Phuket Group faunas show strong affinities with those of Gondwana.

The Ratburi Limestone is a carbonate platform deposit with an upward sequence of mudstone, wackestone, packestone, grainstone and boundstone. Fossils are abundant in the wackestone to boundstone, with the mudstone commonly bioturbated. Bryozoa were collected from mudstone and wackestone on Ko Phi Phi Don. The age of the Ratburi Limestone is not well understood, as outcrops are commonly fault-bounded and faunal collections are not stratigraphically constrained. Furthermore different faunal groups are of varying use in biostratigraphic application. Brachiopod faunas from lower Ratburi Limestone indicate a Late Artinskian to earliest Kungurian age (Shi and Archbold, 1995a). Grant (1976) had given an Artinskian age for brachiopods from the lower Ratburi Limestone, and Waterhouse (1981) gave a Kungurian age for the same fauna. Bryozoan faunas described by Sakagami (1968a; 1968b; 1968c) were assigned an Artinskian age. The faunas of the Ratburi Limestone have strong Tethyan affinities, however both brachiopods and bryozoans show some Gondwanan relationships.

CHAPTER FIVE
SHAN-THAI TERRANE BRYOZOAN FAUNAS

5.1 - INTRODUCTION

Past work on the Permian bryozoan faunas of Thailand has been mostly that of Sumio Sakagami, who published various studies between 1965 and 1984. His early taxonomic studies were widespread across Thailand, but were mostly concentrated within the Ratburi Limestone of central and peninsular Thailand. The sites studied were, listed from north to south, Khao Hin Kling (Sakagami, 1975, 1999); Petchabun (Sakagami, 1967) north central Thailand; Khao Phrik (Sakagami, 1968a); Khao Raen (Sakagami, 1973); Khao Ta Mong Rai (Sakagami, 1968c); Khao Chong Krachok (Sakagami, 1968b); Ko Muk (Sakagami 1966a; 1966b; 1970a) peninsular Thailand (see Fig 4.1). These taxonomic works were discussed in a regional context in palaeobiogeographic studies of Thailand, Malaya, Japan and east Asia (Sakagami, 1970b; 1976; 1985). Sakagami's work showed an affinity between the Thai faunas and those of Western Australia, Timor and Japan, with a lesser relationship to European faunas (Sakagami, 1985).

Despite the large amount of taxonomic information published by Sakagami of the diverse Thai bryozoan faunas, their study is by no means complete. This study concentrates on one local fauna, that of Ko Phi Phi Don, peninsular Thailand, and adds many new species and records of genera to the known Permian bryozoan faunas of Thailand. This study is a contribution to the overall knowledge of Thai bryozoan faunas, but further studies are required to understand the faunal variation within Thailand and its relationship to worldwide faunas.

The richest and most diverse faunas are within the Ratburi Limestone, and it is this unit that is most commonly studied. However despite the abundance of material, internal preservation is often poor, with recrystallisation of delicate skeletal structures and loss of detail. The calcareous skeletons and calcitic cement have often been replaced by silica, commonly as chalcedony. This diagenetic replacement has served to destroy delicate structures within the skeleton, and make the extraction of specimens from the rock difficult. In the descriptions of species given below, some characteristics have not been described due to poor preservation, and in most cases it is as a result of siliceous replacement of the skeleton. The zoarium is usually well preserved, but fine structures such as the stylets and internal lamellar or granular skeleton are often obscured. The visible effect of this replacement is shown in Figure 5.1.

The fauna described from the Ratburi Limestone of Ko Phi Phi Don is diverse, with taxa from the Fenestellidae, Reteporinidae, Septoporidae, Acanthocladiidae, Monticuloporidae, Stenoporidae, Rhabdomesidae, Hyphasmoporidae, Fistuliporidae, Hexagonellidae and Goniocladiidae. A total of 38 species are described of which 30 are new species descriptions. The previously described species are from Thailand, Western Australia, Timor and Russia.

Bryozoans are also present within the Phuket Group, most notably within the "Bryozoan Bed" of Mitchell *et al.* (1970). Specimens were collected from this unit northeast of Phangnga, and from overlying beds on Ko Phi Phi Don. These specimens are poorly preserved as moulds and were not able to be examined internally. The "Bryozoan bed" specimens from Phangnga also show some strain distortion, and external mesh measurements are likely to be inaccurate. As a result, no species were identified from the Phuket Group, and all species described below are from basal Ratburi Limestone sequences on Ko Phi Phi Don.

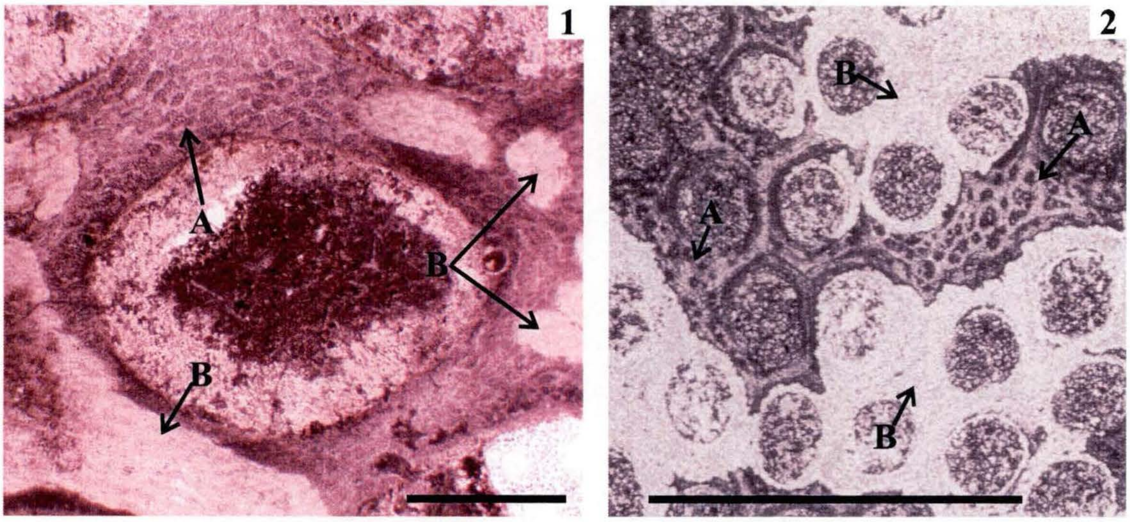


Figure 5.1 - Specimen UTGD TPPL3h, *Reteporidra yongkasemensis*, showing the effects of siliceous replacement. *1*, Petrographic thin section of specimen in transmitted light. Regions of original skeletal material, A, are well preserved and show the detail of the reverse microstylets. Areas that have been replaced by chalcedony, B, do not preserve this detail. *2*, Acetate peel of the obverse surface of the same specimen. Again areas of original skeletal material, A, show the fine detail of the obverse stylets and nature of the apertural rim. In peeled samples, areas replaced by chalcedony, B, do not show any skeletal detail and only record the outline of the boundary between the zoarium and enclosing sediment. Scale bars 1 mm.

All specimens are housed in the University of Tasmania School of Earth Sciences collection, with reference numbers prefixed by UTGD. Character definitions and description outlines are given in Appendices One to Four.

5.2 - SYSTEMATIC DESCRIPTIONS.

5.2.1 - **Order Fenestrata**.

Systematics based Goryunova (1996), and Boardman *et al.* (1983). The descriptive parameters for the following descriptions are given in Appendix One. Parameter details are given in Appendix Four.

Order FENESTRATA Elias and Condra, 1957
Family FENESTELLIDAE King, 1849
Subfamily FENESTELLINAE King, 1849
Genus *Alternifenestella* Termier and Termier 1971

Type species - *Fenestella minor* Nikiforova, 1933; Middle Carboniferous; Donbass.
Diagnosis - Zoaria are fenestrate with straight thin branches and dissepiments. The zooecial chamber outline is trapeziform to triangular trapeziform. Zooecia may lie in a single row on the branch in deep cross sections. The carina is thin with monoserial nodes (after Morozova, 1974).

Alternifenestella subquadratopora (Shulga-Nesterenko, 1952)
Plate 47; Table 5.1

Fenestella subquadratopora SHULGA-NESTERENKO (1952), p. 47, pl. IX, fig. 5; GORYUNOVA (1975), p. 84. pl. XIX, fig. 3, pl. XX, fig. 1.
Diagnosis - The zoarium is delicate and the mesh is of regular intermediate to wide spacing. The zooecia are in two rows with a third row only inserted at the point of bifurcation. The branches are delicate and narrow with a straight proximodistal trace. Branch spacing is intermediate and regular with approximately 18 to 20 branches in 10 mm. The dissepiments are uniformly straight, narrow and regularly placed perpendicular to the branches. The

fenestrules are of intermediate size, and are of regular hourglass shape, with 16 to 17 in 10 mm. The autozooecial apertures are circular and of small to intermediate size. The apertures are regularly spaced along the branch with two between dissepiments and 16 to 17 in 5 mm. Around each aperture is a thin complete peristome, that does not hold apertural stylets. Along the midline of the obverse surface of the branch is a thin straight carina, that bears a single row of nodes. The nodes are small, oval and closely spaced. The reverse microstylets are larger than the obverse stylets. Reverse macrostylets are absent.

The autozooecial chambers are of intermediate size, and are biserially emplaced with a very strongly zigzag axial wall trace. Chamber outline is consistent and trapeziform at mid chamber level. The reverse wall budding angle is uniformly high (mean 80°), as is the lateral wall budding angle (mean 33°). The three dimensional reconstructed chamber form is a trapezoid box.

Both the granular and lamellar skeletal layers are thin.

Alternifenestella subquadratopora	X	SD	Min	Max	N	CV
distance between branch centres	0.528	0.033	0 49	0.6	17	6.242
branch width	0 232	0.019	0 21	0 27	17	8 020
dissepiment width	0.091	0 015	0.06	0.12	14	16 726
fenestrule length	0 525	0.031	0 48	0.6	13	5 973
fenestrule width	0.280	0 037	0 2	0 34	15	13 267
apertures between dissepiment centres	2	0	2	2	13	0
aperture diameter	0.092	0.004	0 08	0 098	18	4 677
apertural spacing down branch	0 305	0.015	0.265	0.33	19	5 027
apertural spacing across branch	0 282	0.017	0 24	0 3	20	5.875
apertural spacing between branches	0.304	0.035	0 23	0 35	13	11 657
width peristome	0.011	0 002	0.008	0 018	18	21.950
width carina	0.077	0.006	0 065	0.085	17	8 290
node diameter	0.026	0 006	0 02	0 035	17	22.196
node spacing down branch	0.208	0.021	0 16	0.24	20	9 969
diameter obverse stylets	0 004	0 002	0.003	0.008	19	41 513
spacing obverse stylets	0.013	0.004	0.01	0.02	18	26 642
diameter reverse microstylets	0.009	0 001	0.008	0 011	19	15.793
spacing reverse microstylets	0.048	0.009	0.03	0.065	20	18 011
thickness reverse wall granular layer	0.009	0 002	0.005	0.013	19	19 115
thickness lateral wall granular layer	0 016	0.004	0.01	0.02	19	22 941
thickness frontal wall lamellar layer	0.079	0.016	0.05	0.11	17	20 600
thickness reverse wall lamellar layer	0.065	0.011	0 05	0 08	10	17 391
chamber length	0 213	0.010	0 195	0 23	16	4 663
chamber depth	0.133	0.016	0 11	0.16	12	11 786
maximum chamber width	0.133	0.010	0 115	0.145	20	7 212
minimum chamber width	0.088	0.007	0 08	0 095	6	7 734
vestibule length	0.065	0.024	0 03	0.1	7	37 422
reverse wall budding angle	79.833	7 935	69	88	6	9 940
lateral wall budding angle	32 500	2.881	28	35	6	8 865
branch thickness	0.287	0.022	0 25	0.32	10	7 713

Table 5 1 - Summary measurements for *Alternifenestella subquadratopora* (Shulga-Nesterenko). N = number of measurements, X = mean, SD = standard deviation, CV = coefficient of variation, Min. = minimum value measured, Max. = maximum value measured; All measurements in millimetres.

Description - External features - The zoarium is delicate, overall colony form is not seen, but fragments form flat outward expansions. The mesh is of regular intermediate spacing. The zooecia are in two rows with a third row only inserted at the point of bifurcation. The branches are delicate and narrow with a straight proximodistal trace. The surface profile of the branch is rounded, with the carina producing a slight angularity. Branch spacing is intermediate and regular with approximately 18 to 20 branches in 10 mm. The dissepiments are uniformly straight, narrow and of intermediate length. The dissepiments are regularly placed perpendicular to the branches, and widen slightly at their junction with the branches.

The dissepiments are recessed from both the obverse and reverse surfaces. The fenestrules are of intermediate size, and of a regular hourglass shape, with approximately 16 to 17 in 10 mm. On the reverse surface, fenestrules are elongate oval. The fenestrules are slightly wider than the branches, with the ratio of mean fenstrule to branch width 6:5. The ratio of mean fenestrule width to length is approximately 1:2. The autozooecial apertures are circular and of small to intermediate size. The apertures are regularly spaced along the branch with two between dissepiment centres and approximately 16 to 17 in 5 mm. The spacing of apertures among and between branches is even, with the ratio of mean spacing down to across the branch approximately 11:10, and down to between branches 1:1. Around each aperture is a thin complete peristome, that does not bear apertural stylets. The apertures open more or less parallel to the plane of the obverse surface, and strongly indent the fenestrules. With the regular placement of one aperture opposite each dissepiment and fenestrule, the indentation of the apertures into the fenestrules produces the pronounced hourglass shape of the fenestrules. This hourglass shape develops at mid branch level.

Along the midline of the obverse surface of the branch is a thin straight carina, that bears a single row of nodes. The nodes are small and oval and are closely spaced along the midline of the carina. The nodes have a granular core that is elongated along the carina at the base of the nodes. On the obverse surface small stylets are irregularly and closely spaced across the obverse surface of both the branches and dissepiments. The reverse surface has small microstylets that are of even intermediate to wide spacing across both the branches and dissepiments. Reverse microstylets are larger and more widely spaced than obverse stylets. Reverse macrostylets are absent. Beneath the reverse surface are 4 to 6 short strong longitudinal striae.

Internal features - The branches are thin and rounded in cross section, with the ratio of mean branch width to thickness 4:5.

The autozooecial chambers are of intermediate size, and are biserially emplaced with a very strongly zigzag axial wall trace. Near the reverse surface the chambers cover the entire width of the branch, but can still be seen to be alternating. The greatest chamber dimension is parallel to the plane of the obverse surface, and at an angle to the proximodistal direction of the branch. Chamber outline is consistent through the zoarium. Outlines are distorted triangular to trapeziform near the reverse surface, trapeziform at mid chamber level and near the obverse surface. The aperture is located abaxial distally to the living chamber, on a vestibule of short to intermediate length. Ratio of mean minimum to maximum chamber width 2:3, maximum width to depth 1:1, and depth to length approximately 3:5. The reverse wall budding angle is uniformly high, with a range of 69° to 88° (mean 80°). The lateral wall budding angle is also uniform, with a range of 28° to 35° (mean 33°). The three dimensional reconstructed chamber form is a trapezoid box.

The granular skeletal layer is thin, but shows good continuity between chambers, carinas, nodes and between branches. The lamellar skeleton is thin in both the reverse and frontal walls.

Discussion - The material collected from Thailand shows a more pronounced hour glass shape to the fenestrules, but all micrometric measurements agree with the Russian material.

Material - Only one specimen was collected from the Ratburi Limestone, Ko Phi Phi Don (UTGD 127587).

Range - Artinskian.

Genus *Fabifenestella* Morozova 1974

Type species - *Fenestella praevirgosa* Shulga-Nesterenko, 1951; Upper Carboniferous, Gzhelian stage; Russian Platform.

Diagnosis - Usually fine meshed, with broad branches and straight dissepiments. Zooecia are in two rows. Chamber outline tetragonal in deep tangential section, fabiform near the surface. Carina broad and low, with two rows of alternating nodes (after Morozova, 1974).

Fabifenestella carinata n. sp.
Plate 48; Table 5.2.

Holotype - UTGD 127588; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is of intermediate robustness, and the mesh spacing is close and regular, with branch bifurcation frequent. The branches are robust and wide, with a straight proximodistal trace and strongly angular surface profile. The branches are regularly closely spaced with 10 to 10.5 in 10 mm. The dissepiments are narrow, straight and regularly spaced perpendicular to the branches. The fenestrules are elongate oval and of intermediate to large size, with 7.5 to 8.5 in 10 mm. The autozooecial apertures are circular and of intermediate size. There are 4 to 5 between dissepiment centres and about 16 to 18 in 5 mm. The apertures open subparallel to the plane of the obverse surface, and do not indent the fenestrules. Each aperture is surrounded by a thin peristome. Along the obverse surface of the branch is a wide high angular carina, that forms a very prominent feature of the species. The carina takes up about half the width of the branch. Along the carina is a biserial row of closely spaced circular nodes of intermediate size. Stylets of small to intermediate size are present on the obverse surface.

The autozooecial chambers are of intermediate size, and are biserially emplaced. Chamber outline is fabiform at mid chamber level. The reverse wall budding angle is uniform and high (mean 75°). The lateral wall budding angle is variable (mean 29°). The three dimensional reconstructed chamber form is a fabiform tubelike box. The skeletal granular layer is thin and the lamellar skeleton is thick.

Fabifenestella carinata n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	10.250	0 354	10	10 5	2	3 449
distance between branch centres	0 856	0 076	0 7	1	22	8 824
branch width	0.562	0 051	0 465	0 64	15	9.145
dissepiment width	0.267	0.043	0 213	0.35	18	16 103
fenestrules in 10 mm.	7.833	0 408	7.5	8.5	6	5 212
fenestrule length	0.995	0.094	0.82	1 16	18	9.483
fenestrule width	0.380	0.064	0 26	0.5	14	16 980
apertures between dissepiment centres	4.696	0.446	4	5	23	9 491
aperture diameter	0.100	0 007	0.08	0 11	15	7.457
apertural spacing down branch	0.310	0.025	0.28	0.39	25	7 970
apertural spacing across branch	0 510	0.084	0.395	0.63	15	16.455
apertural spacing between branches	0.394	0 079	0.25	0 49	11	20 131
width peristome	0.017	0.002	0.015	0.02	9	12 295
width carina	0.261	0 059	0 18	0 34	12	22 723
node diameter	0.106	0 014	0.08	0 13	18	13 176
node spacing down branch	0.200	0.043	0.12	0.3	19	21 586
nodes in 5 mm.	29.500	3.536	27	32	2	11 985
diameter obverse stylets	0.017	0 003	0 01	0.02	12	19 082
spacing obverse stylets	0.049	0 012	0 035	0 07	7	25 144
thickness reverse wall granular layer	0.012	0.004	0.008	0.02	8	32 808
thickness lateral wall granular layer	0.012	0.005	0.008	0.02	6	36.620
thickness frontal wall lamellar layer	0 198	0.041	0 13	0 26	15	20 650
thickness reverse wall lamellar layer	0.227	0 083	0.1	0 32	16	36 456
chamber length	0.319	0 025	0 26	0 36	15	7.945
chamber depth	0 147	0.012	0.13	0.17	15	8 115
maximum chamber width	0 152	0.013	0 12	0.18	23	8 803
vestibule length	0 085	0.019	0.06	0.1	4	22 528
reverse wall budding angle	74 769	5 674	64	81	13	7 588
lateral wall budding angle	29.000	9.105	16	48	12	31.398
branch thickness	0.615	0.063	0.495	0.725	21	10.198

Table 5 2 - Summary measurements for *Fabifenestella carinata* n. sp. Abbreviations as for Table 5.1, all measurements in millimetres.

Description - External features - The zoarium is of intermediate robustness, the overall colony form is unknown, but fragments form reversely curved outward expansions. The mesh spacing is close and regular, with some variation in mesh caused by the frequent bifurcation of the branches. Robust zoarial supports extend from the reverse surface. The branches are robust and wide, with a straight proximodistal trace and strongly angular surface profile. The branches are regularly closely spaced with 10 to 10.5 in 10 mm. The dissepiments are narrow relative to the branches. Dissepiments are straight and regularly spaced perpendicular to the branches. They widen only slightly at their junction with the branches. The dissepiments are flush with the reverse surface of the branches, but on the obverse are recessed to be level with the apertures. The fenestrules are of intermediate to large size, and are regularly elongate oval to subrectangular. Fenestrule size is uniform, where not associated with bifurcation, and there are 7.5 to 8.5 in 10 mm. Fenestrules are narrower than the branches, with the ratio of mean fenestrule to branch width 2:3. Ratio of mean fenestrule width to length is 3:8.

The autozooecial apertures are of intermediate size, and are uniformly circular. Apertural spacing is regular with 4 to 5 between dissepiment centres and about 16 to 18 in 5 mm. The apertures are widely spaced across the branch, across a wide carina, and are most closely spaced along the branch. Ratio of mean apertural spacing down to across the branch is 3:5, down to between branches approximately 4:5, and across to between branches 4:3. The apertures open subparallel to the plane of the obverse surface, and do not indent the fenestrules. Each aperture is surrounded by a thin peristome, that does appear to bear stylets, but preservation is poor.

Along the midline of the obverse surface of the branch is a wide high angular carina, that forms a very prominent feature of the species. The carina takes up about half the width of the branch, with the base immediately adjacent to the adaxial margin of each row of apertures. The carina is high and creates the strong angularity of the obverse surface. Along the carina is a biserial row of closely spaced circular nodes of intermediate size.

Stylets of small to intermediate size are present on the obverse surface, but preservation is poor and exact details cannot be seen.

Internal features - The branches are thick and rounded polygonal in cross section, with a rounded reverse and angular obverse surface. The ratio of mean branch width to thickness is approximately 9:10.

The autozooecial chambers are of intermediate size, and are biserially emplaced with a sinuous axial wall trace where the two rows of chambers are in contact. In wider branches the chambers do not increase in size to cover the branch but instead become separated along the axial wall trace. The space between the rows does not appear to be filled with skeletal material, however this may be an artifact of preservation. The greatest chamber dimension is parallel to the plane of the reverse surface, and at an angle to the proximodistal direction of the branch. Chamber outline is rounded tetragonal near the reverse surface, and fabiform at mid chamber level and at the obverse surface. The apertures are located distally to each chamber on a short vestibule. As the chambers are inclined in a abaxial distal direction the placement of the aperture distally still has the apertures at the sides of the branch. The ratio of mean chamber width to depth is approximately 1:1, and depth to length about 4:9. Short superior hemisepta are present about the base of the vestibule. The reverse wall budding angle is uniform and high, with a range of 64° to 81° (mean 75°). The lateral wall budding angle is variable with a range of 16° to 48° (mean 29°). The three dimensional reconstructed chamber form is a fabiform tubelike box.

The skeletal granular layer is thin, with some continuity seen between branches and chambers. The lamellar skeleton is thick; thicker in the reverse wall than in the frontal wall. The carina is constructed of lamellar skeleton and does not show a prominent granular core.

Discussion - *Fabifenestella carinata* n. sp. is easily distinguished by its wide high carina. While mesh characters may be similar to other species, the author is not aware of any other species of *Fabifenestella* with this prominent carina.

Types - UTGD 127588 holotype; UTGD 127589 paratype, Ratburi Limestone.
Etymology - Named for the large prominent carina.
Material - Only the type material listed above was examined.
Occurance - Ratburi Limestone, Ko Phi Phi Don.

Fabifenestella subthaiensis n. sp.
Plate 49; Table 5.3.

Holotype - UTGD 127590; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is of intermediate robustness, with mesh spacing close and regular. Zooecia are in 2 rows, with a third row inserted only at the point of bifurcation. The branches are robust and wide, with a straight proximodistal trace. The branches are closely spaced with 14 to 18 in 10 mm. The dissepiments are of intermediate width and are narrower than the branches. The fenestrules are regularly ovate and of intermediate size, with 10 to 12.5 fenestrules in 10 mm. The autozooecial apertures are circular and regularly spaced with 3 to 4 between dissepiment centres and 17 to 19 in 5 mm. A thin peristome surrounds each aperture. The apertures open almost parallel to the plane of the obverse surface. Down the midline of the obverse surface of the branch is a wide low rounded carina, that takes almost one third the width of the branch. Along the carina is a biserial row of small circular nodes, with 30 to 35 in 5 mm. Small obverse and reverse stylets are present. Macrostylets are not seen but the specimens are poorly preserved.
The autozooecial living chambers are of intermediate size and are biserially emplaced with a zigzag to sinuous axial wall trace. The chamber outline is fabiform at mid chamber level. Superior hemisepta are present about the base of the vestibule. The reverse wall budding angle is variable but usually low (mean 56°) and the lateral wall budding angle is also variable (mean 30°). Three dimensionally reconstructed chamber form is a fabiform tubelike box. The granular skeleton is of intermediate thickness. The lamellar skeleton is thicker in the reverse wall than the frontal wall.
Description - External features - The zoarium is of intermediate robustness, overall colony form is unknown, but fragments form reversely curved outward expansions. The mesh spacing is close and regular. Zooecia are in 2 rows, with a third row inserted only at the point of bifurcation. The branches are robust and wide, with a straight proximodistal trace. Where the branches bifurcate they are curved. The sides of the obverse surface of the branch are flattened, but the surface profile is angular with the addition of a carina. The branches are closely spaced with 14 to 18 in 10 mm. The dissepiments are of intermediate width and are narrower than the branches. The dissepiments are short and straight, and are emplaced at regular intervals perpendicular to the branches. The dissepiments widen slightly at their junction with the branches, and are flush with the reverse surface of the branches. On the obverse surface they are recessed below the level of the apertures. The fenestrules are regularly ovate and of intermediate size. Fenestrules become more rounded towards the reverse surface. There are 10 to 12.5 fenestrules in 10 mm. The fenestrules are narrower than the branches, with ratio of mean fenestrule to branch width 3:5. The ratio of mean fenestrule width to length is 2:5.
The autozooecial apertures are circular and of small to intermediate size. They are regularly spaced with 3 to 4 between dissepiment centres, and 17 to 19 in 5 mm. A thin peristome surrounds each aperture, that may bear apertural stylets, but preservation is poor and stylets are not clearly seen. The apertures open almost parallel to the plane of the obverse surface. Ratio of mean apertural spacing down to across the branch is 7:9, across to between branches is approximately 1:1.
Down the midline of the obverse surface of the branch is a wide low rounded carina, that takes almost one third the width of the branch. Along the carina is a biserial row of nodes. The nodes are small, circular and closely spaced with 30 to 35 in 5 mm. Small obverse and reverse stylets are present, but preservation is poor and their details are not clearly

preserved. Macrostylets are not seen but the specimens are poorly preserved, and in some cross sections granular skeletal material is seen that would normally indicate small macrostylets. Within the reverse wall are many fine longitudinal striae.

Fabifenestella subthaiensis n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	15.750	1 165	14	18	8	7 397
distance between branch centres	0.693	0 060	0 59	0.8	27	8 696
branch width	0 444	0 044	0 36	0.54	59	9 850
dissepiment width	0 360	0 044	0 28	0.52	60	12.296
fenestrules in 10 mm.	10.833	0.807	10	12 5	12	7.451
fenestrule length	0 626	0.067	0 47	0.77	66	10 773
fenestrule width	0.259	0.040	0.175	0 35	56	15 500
zooecia in 5 mm.	17 737	0.586	17	19	19	3 305
apertures between dissepiment centres	3.598	0.432	3	4	66	11 995
aperture diameter	0.099	0 008	0.08	0.115	44	8 275
apertural spacing down branch	0.299	0.024	0.22	0.34	56	8 025
apertural spacing across branch	0 383	0 038	0.28	0.465	55	9 929
apertural spacing between branches	0.367	0.054	0.24	0.46	45	14.698
width peristome	0.015	0 003	0.01	0 02	40	22.128
width carina	0 162	0.032	0 12	0.2	5	19.714
nodes in 5 mm.	32.909	1.578	30	35	11	4.796
node diameter	0.070	0.013	0 04	0.09	46	19 224
node spacing down branch	0 172	0.033	0 1	0 27	47	19 500
thickness reverse wall granular layer	0.014	0.003	0.01	0.02	25	18 952
thickness lateral wall granular layer	0.015	0 004	0 01	0.02	37	26 029
thickness frontal wall lamellar layer	0.158	0 028	0.1	0.21	30	17.876
thickness reverse wall lamellar layer	0.210	0.043	0.14	0 29	29	20.647
chamber length	0.248	0.028	0.2	0.3	18	11.433
chamber depth	0.193	0.056	0.14	0.3	15	28 912
maximum chamber width	0.136	0.017	0 1	0 18	43	12 253
reverse wall budding angle	55.786	13.880	41	77	14	24.880
lateral wall budding angle	29.8	6.033	22	38	10	20 246
branch thickness	0 661	0.046	0.58	0 8	31	6 924

Table 5 3 - Summary measurements for *Fabifenestella subthaiensis* n. sp. Abbreviations as in Table 5 1, all measurements in millimetres.

<u>Internal features</u> - The branches are ovate in cross section, with their direction of elongation perpendicular to the plane of the obverse and reverse surfaces. The ratio of mean branch width to thickness is 2:3.

The autozooecial living chambers are of intermediate size and are biserially emplaced with a zigzag to sinuous axial wall trace. The greatest chamber dimension is parallel to the plane of the reverse surface. The chamber outline is uniform and tetragonal to rounded tetragonal near the reverse surface and fabiform at mid chamber level and towards the obverse surface. The apertures are located abaxial distally to the living chamber on a short vestibule. The ratio of mean chamber width to depth is 5:7, and depth to length is 7:9. Superior hemisepta are present about the base of the vestibule. The reverse wall budding angle is variable but usually low, with a range of 41° to 77° (mean 56°). The lateral wall budding angle is also variable with a range of 22° to 38° (mean 30°). Three dimensionally reconstructed chamber form is a fabiform tubelike box.

The granular skeleton is of intermediate thickness and is continuous between the chambers, carina, nodes, and between branches. The lamellar skeletal layer is thick in the reverse wall, and quite thin in the frontal wall.

Discussion - *Fabifenestella subthaiensis* n. sp. is distinguished from *Fenestella thaiensis* Sakagami (1966b), described from Ko Muk peninsular Thailand, by the greater number and thinner branches in the later, and the fewer zooecia per fenestrule. Sakagami did thin section his material and it can be seen that *thaiensis* belongs in the genus *Fabifenestella*, with its fabiform chambers and double row of nodes. Whilst the two species can be separated they are quite

likely closely related. *F. subthaiensis* n. sp. can be distinguished from most other species of the genus with a similar mesh size, by the greater width of its branches.
Types - UTGD 127590 holotype; UTGD 127591-92 paratypes; Ratburi Limestone, Ko Phi Phi Don.
Etymology - Named for its similarity to *Fabifenestella thaiensis* (Sakagami).
Material - Only the type material listed above was examined.
Occurrence - Ratburi Limestone, Ko Phi Phi Don, southern Thailand.

Genus *Flexifenestella* Morozova, 1974

Type species - *Fenestella eichwaldi* Stuckenburg, 1895; Lower Permian; Central Urals.
Diagnosis - Colonies with firm meshes and broad sinuous branches, and short, nearly reduced dissepiments. Zooecia in 2 rows. Zooecial chamber outline tetragonal in deep cross section, tetragonal-pentagonal or fabiform near the surface, with hemisepta. Carina broad and low with large monoserial nodes (after Morozova 1974).

Flexifenestella hexaformis n. sp.
Plate 50; Table 5.4.

Holotype - UTGD 127593; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is robust, and the mesh spacing is close and regular. The branches are wide and robust with a strongly sinuous proximodistal trace, and about 14 in 10 mm. The dissepiments are wide and very short. The fenestrules are regularly ovate and of intermediate size, with 10 to 10.5 fenestrules in 10 mm. The autozooecial apertures are circular and open parallel to the plane of the obverse surface without indenting the fenestrules. There are usually four apertures between dissepiment centres and 19 to 20 in 5 mm. Along the obverse surface of the branch is a low thin rounded carina that is joined between branches by horizontal carinae appearing on most dissepiments. Large circular nodes of regular size and shape are developed along the carina, and are usually regularly placed at the junction of branch and dissepiment. This regular placement of the nodes produces a repeated hexagonal arrangement of the carina and nodes across the obverse surface of the zoarium.
Small microstylets are irregularly spaced across the obverse and reverse surfaces. Beneath the reverse surface are 8 to 10 short longitudinal striae, that express themselves as corrugations of the reverse surface.
The autozooecial chambers are of intermediate to large size, and are biserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is in a proximodistal direction. The chamber outline is tetragonal to gently pentagonal at mid chamber level. The aperture is located abaxial distally to the living chamber on a distinct vestibule of intermediate length. Hemisepta are well developed. The reverse wall budding angle is high and constant, (mean 69°), and the lateral wall budding angle is low but variable (mean 8°). The reconstructed three dimensional chamber form is a tetragonal box.
The granular skeletal layer is thin and the lamellar skeleton is thick.
Description - External features - The zoarium is robust, overall colony form is unknown, but fragments form flattened outward expansions. The mesh spacing is close and regular. The branches are wide and robust with a strongly sinuous proximodistal trace. The branches are regularly closely spaced with about 14 in 10 mm. The branch profile is flattened, with the margin between branch frontal wall and branch sides a rounded right angle. The dissepiments are wide but very short, and reduced from the sinuosity of the branches. The dissepiments are wider than the branches and placed at regular intervals. The dissepiments are flush with the obverse and reverse surfaces of the branch. The fenestrules are regularly ovate and of intermediate size. There are approximately 10 to 10.5 fenestrules in 10 mm. The fenestrules are narrower than the branches, with a ratio of mean fenestrule to branch width of 5:7. Ratio of mean fenestrule width to length is approximately 3:5.

The autozooecial apertures are circular and of intermediate size. The apertures open parallel to the plane of the obverse surface and do not indent the fenestrules. The apertures are regularly spaced along the branch, but with local variation caused by the flexing of the branches. There are usually 4 apertures between dissepiment centres and 19 to 20 in 5 mm. The ratio of mean apertural spacing down to across the branch is 8:9, across to between the branches also 8:9, and down to between the branches 7:9. A thin peristome surrounds each aperture and bears 17 to 22 small apertural stylets.

Flexifenestella hexaformis n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	14	0	14	14	3	0
distance between branch centres	0.700	0 131	0.48	0.93	39	18 766
branch width	0.461	0.040	0.37	0.55	49	8 746
dissepiment width	0 503	0 067	0 395	0.72	35	13 250
fenestrules in 10 mm.	10.125	0.250	10	10.5	4	2.469
fenestrule length	0.535	0 049	0 45	0 66	44	9 073
fenestrule width	0 336	0.042	0.25	0.44	49	12 410
zooecia in 5 mm.	19 143	0 378	19	20	7	1.974
apertures between dissepiment centres	3 995	0 300	3	4 5	49	7 502
diameter aperture	0.105	0.007	0.09	0.12	35	7 089
apertural spacing down branch	0.289	0 031	0.25	0.365	38	10 607
apertural spacing across branch	0.327	0 043	0.25	0 44	38	13 300
apertural spacing between branches	0.372	0.107	0.17	0 555	39	28 849
width peristome	0 012	0 003	0.008	0 02	22	26 979
number of apertural stylets	20.286	1.799	17	22	7	8 871
diameter apertural stylets	0.009	0 002	0.005	0 013	23	20 388
width carina	0.030	0 008	0 02	0 04	15	26.038
nodes in 5 mm.	10 167	0.408	10	11	6	4 016
node diameter	0 127	0 016	0.08	0.15	16	12 861
node spacing down branch	0 542	0.107	0.32	0.68	12	19 677
diameter obverse stylets	0.012	0 004	0.008	0 023	28	35 495
spacing obverse stylets	0 031	0 010	0 015	0.05	23	31 513
diameter reverse microstylets	0.012	0 004	0.008	0.02	20	35 547
spacing reverse microstylets	0 027	0 008	0.015	0.04	20	28 379
thickness reverse wall granular layer	0.010	0.002	0 005	0 015	39	17 598
thickness lateral wall granular layer	0 015	0 003	0 01	0.02	37	21.674
thickness frontal wall lamellar layer	0.110	0 014	0 085	0.135	36	12 312
thickness reverse wall lamellar layer	0.143	0.028	0.1	0.18	32	19 588
chamber length	0.260	0.020	0 22	0.3	37	7 721
chamber depth	0 223	0 024	0 17	0 28	25	10.819
maximum chamber width	0.198	0.020	0 165	0.25	37	10 361
minimum chamber width	0 150	0 023	0.1	0 2	37	15 072
vestibule length	0.094	0.011	0 08	0.12	19	12 081
reverse wall budding angle	69.350	4.977	63	80	20	7 176
lateral wall budding angle	8 571	2.821	4	14	14	32 908
branch thickness	0.480	0 038	0.4	0 54	33	7 942

Table 5.4 - Summary measurements for *Flexifenestella hexaformis* n. sp. Abbreviations as for Table 5.1, all measurements in millimetres.

Along the obverse surface of the branch is a low rounded carina, that does not influence the surface profile of the branch significantly. The carina runs along the midline of the branch and because of the sinuosity of the branch, is sinuous itself. The carina is joined between branches by carinae of the same size and shape appearing on most dissepiments. Large circular nodes of regular size and shape are developed along the carina, and are usually regularly placed at the junction of branch and dissepiment. This is in combination with the position of the carinae produces a repeated hexagonal arrangement across the obverse surface of the zoarium.

Across the obverse surface are small stylets of irregular intermediate spacing. Microstylets on the reverse surface are of similar size and arrangement. Reverse macrostylets are absent.

Beneath the reverse surface are 8 to 10 short longitudinal striae, that are slightly sinuous. On the sides of the branches, and where they are partially weathered, the longitudinal striae express themselves as corrugations of the reverse surface.

Internal features - The branches are thick and almost semicircular in cross section. The ratio of mean branch width to thickness is almost 1:1.

The autozooecial chambers are of regular intermediate to large size. The chambers are biserially emplaced with a gently zigzag axial wall trace. The greatest chamber dimension is in a proximodistal direction. The chamber outline is regularly rounded tetragonal near the reverse surface, tetragonal to gently pentagonal at mid chamber level, and rounded distorted polygonal near the obverse. The aperture is located abaxial distally to the living chamber on a distinct vestibule of intermediate length. Ratio of mean chamber minimum to maximum width is 3:4, maximum width to depth 8:9, and depth to length 7:8. Hemisepta are well developed. Only a single hemiseptum is present near the distal end of each chamber. Each hemiseptum extends from the floor to the roof of the chamber. Near the reverse surface the hemiseptum extends laterally across the chamber from the abaxial to adaxial margin. The hemiseptum is then restricted and in mid chamber tangential section appears only as a small tick extending from the abaxial margin of each chamber. Near the obverse surface the hemiseptum is curved about the base of the vestibule.

The reverse wall budding angle is high and constant, with a range of 63° to 80° (mean 70°). The lateral wall budding angle is low but variable, with a range of 4° to 14° (mean 9°). The reconstructed three dimensional chamber form is a tetragonal box.

The granular skeletal layer is thin and continuous between chambers and striae of each branch. The carina and nodes do not have granular cores. The lamellar skeleton is thick.

Discussion - *Flexifenestella hexaformis* n. sp. is very similar in appearance to *F. eichwaldi*, but the later has a coarser mesh work formulae, and less prominent hemisepta. *F. hexaformis* can be readily distinguished from other Permian species of the genus by its very flexuous branches, meshwork formula and well developed hemisepta.

Types - UTGD 127593 holotype; UTGD 127594 paratype, both from Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the distinct patterning of the obverse surface formed by the arrangement of carinas and nodes.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Minilya* Crockford 1944

Type species - *Minilya duplaris* Crockford 1944b; Noonkanbah Series, Mt Anderson; Lower Permian; Western Australia.

Diagnosis - Branches with 2 rows of alternating zooecia, and a slight median carina. Nodes are small and in 2 rows on the carina, placed so that one node is lateral to each zooecial aperture. Zooecia are sub-triangular in outline (after Crockford 1944b).

Minilya duplaris Crockford 1944
Plate 51; Table 5.5.

Minilya duplaris CROCKFORD (1944b), p. 173-174; pl. I, figs. 5, 7; text-fig 1 c, d.

Diagnosis - The zoarium is delicate and fragments form flat outward expansions, with branches bifurcating at variable intervals. Branches are of intermediate width and robustness, and are closely spaced with 14.5 to 16 in 10 mm. Dissepiments are of narrow to intermediate width relative to the branches. The fenestrules are of small to intermediate size, with 14 to 15 in 10 mm. Fenestrules are distinctly hourglass shaped from indentation by the apertures. Along the midline of the branch is a low zigzag carina, that bears a double row of nodes. There are approximately 31 to 32 nodes in 5 mm. There are macrostylets of intermediate size on the reverse surface, that are irregularly placed along the branch. Autozooecial apertures are circular and of intermediate size, with 14.5 to 16 in 5 mm. Peristomes are thin and complete.

Autozooecial living chambers are of intermediate size, with greatest dimension in a proximodistal direction. Chambers are emplaced biserially, with a zigzag axial wall trace. Chamber shape is regular, and is triangular at mid chamber level. Three dimensional chamber form a wedge shaped box.

The reverse wall budding angle is high (mean 77°). The lateral wall budding angle is variable (mean 22°). The internal granular skeletal layer is well developed and robust, and the lamellar layer is thick.

Mintlya duplaris	X	SD	Min	Max	N	CV
branches in 10 mm.	15.167	0.764	14 5	16	3	5 036
distance between branch centres	0.601	0 058	0 51	0.74	41	9 623
width branch	0.386	0 043	0 3	0 475	48	11 161
width dissepiment	0.214	0 025	0 18	0 275	55	11 623
fenestrules in 10 mm	14 500	0 707	14	15	2	4 877
fenestrule length	0 429	0.041	0 35	0.55	55	9 529
fenestrule width	0.241	0.038	0.18	0.35	59	15 596
autozooecia in 5 mm.	14.750	0.289	14.5	15	4	1 957
apertures between dissepiment centres	2.037	0.132	2	2.5	54	6 489
aperture width	0.113	0 010	0 1	0 135	33	8.913
apertural spacing down branch	0.314	0.019	0.28	0.36	41	6 047
apertural spacing across branch	0.341	0.033	0.28	0.42	32	9.548
apertural spacing between branches	0.368	0.046	0.3	0.44	30	12.475
width peristome	0.013	0.004	0.01	0.02	6	30 398
width carina	0.117	0.020	0 08	0.14	10	16 999
diameter nodes	0.074	0 023	0 03	0.11	25	30 902
node spacing down branch	0.160	0.016	0 14	0 19	23	9 950
diameter obverse stylets	0.014	0.003	0.01	0.02	12	21.722
spacing obverse stylets	0.032	0.007	0 02	0 04	9	23 684
diameter reverse macrostylets	0.075	0 019	0 04	0.11	30	24 844
spacing reverse macrostylets	0.227	0 059	0 12	0.41	31	26 129
thickness reverse wall granular layer	0.010	0.002	0.0075	0 015	15	17 390
thickness lateral wall granular layer	0.028	0.005	0.02	0.0375	31	16.444
thickness frontal wall lamellar layer	0.134	0.021	0.09	0.18	25	15 450
thickness reverse wall lamellar layer	0.222	0.034	0.15	0 28	28	15 148
chamber length	0 224	0.022	0.16	0 26	48	9 965
chamber depth	0.200	0 027	0 15	0.24	34	13 676
maximum chamber width	0 166	0 038	0.12	0.29	57	22 915
vestibule length	0 070	0.012	0.06	0.08	4	16 496
reverse wall budding angle	76.929	4 323	69	83	14	5 619
lateral wall budding angle	21.500	5.874	14	30	10	27 319
thickness branch	0.568	0.037	0.46	0.62	24	6.428

Table 5.5 - Summary measurements for *Mintlya duplaris* Crockford Abbreviations as in Table 5 1, all measurements in millimetres.

Description - External features -The zoarium is delicate and fragments form flat outward expansions. Mesh spacing is close and regular, with bifurcation at variable intervals. Branches are of intermediate width and robustness, and are closely spaced with 14.5 to 16 in 10 mm. Dissepiments are emplaced at regular intervals perpendicular to the branches. Dissepiments are of narrow to intermediate width relative to the branches, and widen slightly at their junction with the branches. The dissepiments are almost flush with the reverse surface, and on the obverse are recessed to the level of the apertures. In transverse section the dissepiments are elliptical with their widest point towards the obverse surface. The fenestrules are of small to intermediate size, with 14 to 15 in 10 mm. Fenestrules are regularly oval at the midline of the branch, and at the obverse surface are distinctly hourglass shaped from indentation by the apertures. The fenestrules are regularly narrower than the branches, with a fenestrule to branch width ratio of 3:5, and a width to length ratio of approximately 4:7. Branch and fenestrule widths may vary slightly across the zoarium, but their relative proportions remain the same.

Along the midline of the branch is a low zigzag carina, that bears a double row of nodes. The surface profile is angular, with the sides of the branches sloping, but this angularity is reduced by the low carina, and zigzag nature of the nodes. The nodes are regularly closely spaced, with one node beside each aperture, and approximately 31 to 32 in 5 mm. Small stylets are present on both the obverse and reverse surfaces, but preservation is poor and their exact distribution is not obvious. Macrostylets of intermediate size are seen on the reverse surface, and are irregularly widely placed along the reverse surface of the branch.

Autozooecial apertures are circular and of intermediate size, with 14.5 to 16 in 5 mm. The apertures open upwards and their peristomes indent the fenestrules. With one aperture opposite each dissepiment and fenestrule, the fenestrules have an hour glass shape. Peristomes are complete and well developed but are thin. Aperture spacing is regular, with the ratio of mean spacing down to across the branch 4:5, down to between branches 6:7, and across to between branches approximately 4:5.

Internal features - Branches are thick and oval in cross section, with their greatest thickness in an obverse reverse direction. The ratio of mean branch width to thickness is approximately 2:3.

Autozooecial living chambers are regularly of intermediate size, with greatest dimension in a proximodistal direction. Chambers are biserially emplaced with a zigzag axial wall trace. Chamber shape is regular, with chamber outline near the reverse and at mid chamber level triangular, becoming trapezoid towards the obverse surface. The aperture is located abaxial distally to the chamber on a well developed vestibule of intermediate length. The presence of the vestibule influences the trapezoid outline near the obverse surface. Ratio of mean chamber width to depth is 4:5, and depth to length 9:10. In longitudinal section chamber outline is angular near the axial wall, but becomes rounded towards the abaxial margins of each chamber.

Superior hemisepta are clearly developed about the base of the vestibule. The reverse wall budding angle is constant, with a range of 69° to 83° (mean 77°). The lateral wall budding angle is variable, with a range of 14° to 30° (mean 22°).

The internal granular skeletal layer is well developed and robust. Continuity of the granular layer between branches is obscured by poor preservation. The lamellar skeletal layer is thick, and thicker on the reverse surface than in the frontal wall.

Discussion - This species is the type for the genus *Minilya*, and was first described from the Permian of Western Australia. The specimens described from the Ratburi Limestone of Thailand have a slightly lower average number of fenestrules and branches in 10 mm. but are not significantly different.

Within Western Australia *Minilya duplaris* is known from the Mid Artinskian to Early Kungurian Noonkanbah Formation, and the latest Artinskian to earliest Kungurian Wandagee Formation and in Queensland from the Artinskian Lakes Creek Beds (Crockford, 1951).

Material - Three specimens (UTGD 127595-97) were examined from the Ratburi Limestone, Ko Phi Phi Don, Southern Thailand.

Range - Mid Artinskian to Early Kungurian.

Minilya phiphiensis n. sp.
Plate 52; Table 5.6.

Holotype - UTGD 127598; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is delicate with mesh spacing intermediate and regular. The branches are delicate and narrow, with a straight proximodistal trace. Branch spacing is regular with about 20 branches in 10 mm. The dissepiments are regularly emplaced perpendicular to the branches. The fenestrules are of consistent small size and are oval to hourglass shaped. There are about 19 fenestrules in 10 mm.

There are two autozooecial apertures between dissepiment centres and 18 to 19 in 5 mm. Apertures are small, circular and indent the fenestrules, with one placed opposite each dissepiment and one opposite the middle of each fenestrule. Autozooecial apertures are surrounded by a thin complete peristome. A thin low carina is present along the midline of the branch, with a double row of alternating nodes. The nodes are small circular and regularly placed with about 4 between dissepiment centres and 30 to 35 in 5 mm. Both the obverse and reverse surfaces bear small stylets, and the reverse surface has regularly spaced circular macrostylets.

The autozooecial living chambers are small and biserially emplaced with a zigzag axial wall trace. Chamber outline is rounded triangular at mid chamber level. Poorly developed hemisepta are present about the base of the vestibule. The lateral wall budding angle is variable and the reverse wall budding angle is high. Three dimensional chamber form is a rounded wedge shaped box. The internal skeletal granular layer is thin, and the lamellar skeletal layer is thick.

Mimlya phiphiensis n sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	20	0	20	20	2	0
distance between branch centres	0 485	0 059	0.38	0.58	15	12 197
branch width	0.276	0.031	0.225	0.37	25	11 363
dissepiment width	0.143	0 014	0 11	0 163	27	9.485
fenestrules in 10 mm.	19	0	19	19	3	0
fenestrule length	0.397	0 023	0 338	0 44	28	5 817
fenestrule width	0.237	0 028	0.2	0.3	21	11 978
autozooecia in 5 mm	18.667	0.577	18	19	3	3 093
apertures between dissepiment centres	2	0	2	2	15	0
aperture diameter	0.074	0.006	0 065	0 083	12	7 553
aperture spacing down branch	0.267	0 012	0 24	0.29	19	4 556
aperture spacing across branch	0.264	0.020	0.22	0.295	19	7 758
aperture spacing between branches	0.278	0.035	0 21	0 35	16	12.604
width carina	0 090	0 014	0.08	0.1	2	15 713
nodes in 5 mm.	32.333	2.517	30	35	3	7 783
diameter nodes	0.065	0 008	0 05	0.08	16	12 511
spacing of node centres	0.141	0 015	0 11	0.17	20	10 890
diameter reverse macrostylets	0.059	0.017	0.04	0 08	5	28.361
spacing reverse macrostylets	0.278	0.036	0 25	0.33	5	12 819
thickness reverse wall granular layer	0 012	0.002	0.01	0.015	14	18.651
thickness lateral wall granular layer	0.028	0.004	0.02	0.031	17	12 861
thickness frontal wall lamellar layer	0.114	0.020	0.09	0.16	13	17.403
thickness reverse wall lamellar layer	0.213	0.019	0 18	0.26	14	8.994
chamber length	0 200	0 020	0 16	0.225	14	9 944
chamber depth	0.090	0.014	0.08	0.1	2	15 713
chamber maximum width	0.111	0.007	0.1	0.12	14	6 410
lateral wall budding angle	9 400	5 320	5	18	5	56 593
thickness branch	0.444	0 024	0.38	0.465	11	5 312

Table 5.6 - Summary measurements for *Mimlya phiphiensis* n sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Description - External features - The zoarium is delicate, overall colony form unknown, but fragments form gently outwardly curved expansions. Mesh spacing is intermediate and regular. Autozooecia are in two rows with a third row only inserted at the point of bifurcation. The branches are delicate and narrow, with a straight proximodistal trace. The branches widen rapidly before, and regain their normal proportions soon after, bifurcation. The obverse surface of the branch has a low angular profile. Branch spacing is regular with about 20 branches in 10 mm. The dissepiments are of regular narrow width and intermediate length, and are regularly emplaced perpendicular to the branches. The dissepiments widen slightly at their junction with branches, and are slightly recessed from the reverse surface, and are level with the apertures on the obverse. The fenestrules are of consistent small size with about 19 in 10 mm. The fenestrules are hourglass shaped at the obverse surface from indentation by the apertures, and oval at the midline of the branch and near the reverse surface. Fenestrules are only slightly narrower than the branches and the mesh has a ratio of mean fenestrule to branch width of 6:7. Fenestrules are elongated proximodistally, with a width to length ratio of 3:5.

The autozooecial apertures are regularly spaced, with two between dissepiment centres and 18 to 19 in 5 mm. The apertures are of similar spacing within and between branches, producing an even coverage of the zoarial surface. The ratio of mean apertural spacing down to across the branch is 1:1, and down to between branches is again approximately 1:1. Apertures are consistently small and circular and open parallel to the plane of the obverse surface. The apertures indent the fenestrules, and with one placed opposite each dissepiment and fenestrule, the hourglass shape of the fenestrules is produced. Autozooecial apertures are surrounded by a thin complete peristome. Apertural stylets are not seen but preservation is poor.

The obverse surface of the branch bears a thin low carina along the midline of the branch, which bears a double row of alternating nodes. The nodes are small circular and regularly placed with about 4 between dissepiment centres and 30 to 35 in 5 mm. Both the obverse and reverse surfaces bear small stylets but preservation is poor and their spacing is not accurately determinable. The reverse surface has circular macrostylets of irregularly small to intermediate size, that are regularly widely spaced.

Internal features - The branches are oval in cross section, with the axis of elongation perpendicular to the plane of the obverse and reverse surfaces. The branches are of medium to thick thickness, with a ratio of mean width to thickness of 3:5.

The autozooecial living chambers are small and biserially emplaced with a zigzag axial wall trace. Greatest chamber dimension is parallel to the reverse surface. Chamber outline is regular and is rounded triangular near the reverse wall and at mid chamber level, becoming rounded trapezoid to oval near the obverse surface. The aperture is located abaxial distal to the chamber on a short vestibule. Ratio of mean chamber width to depth is 6:5, and depth to length approximately 3:7. Poorly developed hemisepta are present about the base of the vestibule. The lateral wall budding angle is variable, with a range of 5° to 18° (mean 9°). The reverse wall budding angle is high. Three dimensional chamber form is a rounded wedge shaped box. The internal skeletal granular layer is thin, but continuity is difficult to assess owing to preservation. The lamellar skeletal layer thick, and is thicker on the reverse surface than the obverse.

Discussion - This species of *Minilya* is distinguished by its small mesh size, and small chamber and apertures. *Minilya phiphiensis* n. sp. is distinguished from *M. megacapillaris* (Sakagami, 1968a) by its smaller mesh size, narrower dissepiments and smaller apertures. *M. phiphiensis* is distinguished from *M. tuberculata* Krutchinina by the smaller size and form of the mesh in the later.

Types - UTGD 127598 holotype.

Etymology - Named for the island of Ko Phi Phi Don southern Thailand, where this species was found.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Rectifenestella* Morozova, 1974

Type species - *Fenestella medvedkensis* Shulga-Nesterenko, 1951; Upper Carboniferous, Kasimovian Stage; Russian Platform.

Diagnosis - Zoarium of delicate to intermediate robustness, mesh spacing close to intermediate. Branches are straight, with thin straight dissepiments. Autozooecial chambers are of small to intermediate size, with a pentagonal to triangular outline in mid tangential section. Reverse wall budding angle is high. Hemisepta are poorly developed. Three dimensional reconstructed chamber form moderately to highly cuneate (after Snyder, 1991).

Rectifenestella pulchradorsalis (Bassler, 1929)
Plate 53; Table 5.7.

Fenestella pulchradorsalis BASSLER (1929), p. 74, pl. CCXL, figs. 10-13, pl. CCXLII, figs. 1-4; SAKAGAMI (1968c), p. 60, table 7, pl. X, fig. 2.

Diagnosis - The zoarium is of intermediate robustness, and the mesh spacing is close and regular. The branches are robust and wide, with a straight to sinuous axial wall trace. The branches are closely spaced with about 13.5 in 10 mm. The dissepiments are wide, short and straight and widen at their junction with the branches. The fenestrules are oval and of intermediate size, with 8 to 9 in 10 mm. The autozooecial apertures are oval and of intermediate to large size. The apertures are regularly spaced with 3 to 4 between dissepiment centres and 14 to 15 in 5 mm. Each aperture is surrounded by a thin complete peristome with 18 to 25 small apertural stylets. Along the obverse surface of the branch is a low rounded sinuous carina bearing circular to oval nodes of intermediate size. There are 8 to 9 nodes in 5 mm. Across the obverse and reverse surfaces are small stylets, of variable size. On the reverse surface are small macrostylets of irregular spacing.

Autozooecial living chambers are of intermediate to lower end large size, and are biserially emplaced with an axial wall trace. The chamber outline is pentagonal at mid chamber level. Hemisepta are absent. The reverse wall angle is high, and the lateral wall budding angle low (mean 17°). Three dimensionally reconstructed chamber form is a cuneate pentagonal box. The granular skeletal layer is thin but well-developed, and the lamellar skeletal layer is thick.

Description - <u>External features</u> - The zoarium is of intermediate robustness. Whilst the overall colony form is not seen in the material studied, fragments form flattened outward expansions. The mesh spacing is close and regular. The branches are robust and wide, with a straight to sinuous axial wall trace. Externally the branches appear straight, but have a gently sinuous carina, and in thin section are more clearly sinuous. The branches are closely spaced with about 13.5 in 10 mm. The surface profile of the branches is gently angular. The dissepiments are wide and are of similar width or slightly wider than the branches. The dissepiments are short and straight and widen at their junction with the branches. They are emplaced at regular intervals perpendicular to the branches. The obverse and reverse surfaces of the dissepiments are slightly recessed. The fenestrules are oval and of intermediate size. The fenestrules are of regular size and shape, with 8 to 9 in 10 mm. The fenestrules are narrower than the branches with the ratio of mean fenestrule to branch width approximately 4:5. The ratio of mean fenestrule width to length is approximately 1:2.

The autozooecial apertures are oval and of intermediate to large size. The ratio of mean apertural width to length is approximately 3:4. The apertures open upwards parallel to the plane of the obverse surface, and do not indent the fenestrules. The apertures are regularly spaced with 3 to 4 between dissepiment centres and 14 to 15 in 5 mm. The ratio of mean aperture spacing down to across the branch is approximately 1:1, although apertures are slightly more closely spaced across the branch than down. The ratio of mean aperture spacing down to between branches is approximately 3:4. Each aperture is surrounded by a thin complete peristome that bears 18 to 25 small apertural stylets.

Along the midline of the obverse surface of the branch is a low rounded carina, that is slightly sinuous, bending towards the dissepiments. Along the carina is a single row of widely spaced circular to oval nodes of intermediate size. There are usually two nodes between dissepiment centres, and there are 8 to 9 in 5 mm.

Across the obverse and reverse surfaces are small stylets, of variable size. Preservation is poor and their distribution is difficult to determine. On the reverse surface are small macrostylets of irregular distribution. There are 7 to 8 short longitudinal striae within the reverse wall.

<u>Internal features</u> - The branches are rounded in cross section with a gently angular obverse surface. The direction of elongation is in an obverse reverse direction. The ratio of mean branch width to thickness is 9:10.

Autozooecial living chambers are of intermediate size, and are biserially emplaced with an axial wall trace. The greatest chamber dimension is in a proximodistal direction. The chamber outline is regularly triangular to pentagonal near the reverse wall, pentagonal at mid chamber level, becoming rounded towards the obverse surface. The chambers are slightly cuneate, most apparent in mid section, where the distal end of each chamber is curved convex, with an indistinct angle between lateral and axial walls. The apertures are located abaxial distally to the body of the living chamber on a short indistinct vestibule. The ratio of mean minimum to maximum chamber width is 1:3, maximum width to depth is 9:10, and depth to length is 7:10. Hemisepta are absent. The reverse wall angle is difficult to measure from the available specimens but is high. The lateral wall budding angle is slightly variable, with a range of 13° to 22° (mean 18°). Three dimensionally reconstructed chamber form is a cuneate pentagonal box.

The granular skeletal layer is thin but well-developed, with continuity of the skeleton between chambers, nodes and between branches. A thick plug of granular material is evident in the centre of dissepiments when they are cross sectioned. The lamellar skeletal layer is thick, and is thicker in the reverse wall than in the frontal wall.

Rectifenestella pulchradorsalis	X	SD	Min	Max	N	CV
branches in 10 mm.	13.500	0.000	13.5	13 5	2	0
distance between branch centres	0.761	0 078	0 62	0 88	18	10 259
branch width	0.437	0 031	0.385	0.5	30	7 070
dissepiment width	0.451	0 034	0.36	0 52	27	7 549
fenestrules in 10 mm	8 625	0.479	8	9	4	5 550
fenestrule length	0.763	0.085	0.6	0.88	29	11 137
fenestrule width	0 362	0 032	0 288	0.43	28	8 892
zooecia in 5 mm.	14 857	0.378	14	15	7	2 544
apertures between dissepiment centres	3 696	0 314	3	4	28	8 507
aperture length	0.158	0 009	0 14	0 175	17	5 929
aperture width	0 121	0 008	0.11	0.135	16	6 264
apertural spacing down branch	0.352	0 021	0 32	0.405	20	5 924
apertural spacing across branch	0.332	0.035	0 26	0 4	20	10 545
apertural spacing between branches	0.483	0 091	0.33	0.61	20	18 739
width peristome	0.025	0.005	0.015	0.033	13	21 213
number of apertural stylets	22.200	2 950	18	25	5	13.286
diameter apertural stylets	0.011	0 002	0.008	0.015	17	19 797
width carina	0 065	0.015	0 04	0 08	6	23 332
nodes in 5 mm.	8.400	0 548	8	9	5	6 521
node diameter	0.096	0 010	0.075	0.115	11	10 638
node spacing down branch	0.644	0.143	0 44	1	15	22 152
diameter obverse stylets	0 012	0 003	0 008	0 018	11	24.873
diameter reverse microstylets	0.014	0 004	0.01	0.02	12	24 734
diameter reverse macrostylets	0 048	0.010	0 04	0 06	3	21 534
thickness reverse wall granular layer	0.012	0 002	0.01	0.015	16	16 922
thickness lateral wall granular layer	0 012	0.004	0.008	0.02	18	28 541
thickness frontal wall lamellar layer	0 095	0.017	0 07	0.13	12	17.517
thickness reverse wall lamellar layer	0.152	0 022	0.125	0.21	16	14 268
chamber length	0.324	0.024	0 26	0.355	20	7 255
chamber depth	0 228	0.021	0 19	0.25	11	8 996
maximum chamber width	0.204	0.017	0.17	0.24	20	8 496
minimum chamber width	0.071	0 032	0 01	0 14	20	44 457
lateral wall budding angle	17.833	3.189	13	22	6	17.880
branch thickness	0.482	0.022	0 44	0.51	19	4 577

Table 5.7 - Summary measurements for *Rectifenestella pulchradorsalis* (Bassler). Abbreviations as for Table 5.1, all measurements in millimetres.

Discussion - The meshwork formulae of the material available match those given by Bassler (1929) and Sakagami (1968c) for *Fenestella pulchradorsalis* Bassler. The material from this study is similar in appearance to those in the specimen figured by Bassler in Plate CCXLII fig 4. However despite having a similar meshwork formula, the present specimens are dissimilar in appearance to another Bassler specimen (Plate CCXL, Fig. 12), and that shown by Sakagami (1968c). It is possible that there was more than one species included under the name *pulchradoralis* by Bassler (1929). Bassler did not appear to assign types, and the description of variants listed under the species were poor it is difficult to separate material. It is likely that further study of bryozoan faunas in this region will reveal more than one species with very similar meshes.

Internal examination in this study and that of Sakagami (1968c) has revealed the species belongs in the genus *Rectifenestella.*

Material - One specimen (UTGD 127599) was examined from the Ratburi Limestone, Ko Phi Phi Don.

Range - Artinskian?.

Genus *Spinofenestella* Termier and Termier, 1971

Type species - *Fenestella spinulosa* Condra 1902; Lower Permian, Wolf Camp Formation; North America.

Diagnosis - Branches straight, usually thick and broad, with slender dissepiments. Zooecia in 2 rows, with a triangular outline in cross section, may be triangular pentagonal before bifurcation. Carina narrow and high with monoserial nodes (after Morozova, 1974).

Spinofenestella flanchea n. sp.
Plate 54; Table 5.8.

Holotype - UTGD 127600, Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is of intermediate robustness, and the mesh spacing is close and regular. The branches are of intermediate robustness, with a straight proximodistal trace and an angular surface profile. There are 18 to 19 branches in 10 mm. The dissepiments are of intermediate width and are regularly spaced perpendicular to the branches. The fenestrules are oval and of intermediate size, with 13 to 14 in 10 mm. The autozooecial apertures are ovate and of intermediate size. The apertures are regularly spaced with usually 3 between dissepiment centres, and about 20 in 5 mm. The apertures open nearly parallel to the plane of the obverse surface, and do not significantly indent the fenestrules. The apertures are surrounded by a thin but well developed high peristome bearing 15 to 20 small apertural stylets. Along the midline of the obverse branch surface is a straight, low, rounded carina, bearing a single row of circular to oval nodes. There are 13 to 14 nodes in 5 mm. Reverse macrostylets are present, of intermediate size and variable wide spacing.

The autozooecial living chamber is of intermediate size. The chambers are biserially emplaced with a zigzag axial wall trace. Chamber length and depth are approximately equal. Chamber outline is rounded triangular at mid chamber level. The reverse wall budding angle is high (mean 86°). The lateral wall budding angle is variable (mean 30°). The three dimensionally reconstructed chamber form is a rounded wedge shaped box. An elongate wedge of granular material is present distally to each dissepiment in the reverse wall. The lamellar skeleton is thick, and thicker in the reverse wall than the frontal wall.

Description - External features - The zoarium is of intermediate robustness. The overall colony form is unknown, but fragments form flat outward expansions. The mesh spacing is close and regular. The branches are of intermediate robustness, with a straight proximodistal trace and an angular surface profile. The branches are regularly closely spaced with 18 to 19 in 10 mm. The dissepiments are of intermediate width and are always narrower than the branches. Dissepiments are short and regularly spaced perpendicular to the branches. Dissepiments are straight, and widen slightly at their junction with the branches. They are flush with the reverse surface, and on the obverse are recessed below the level of the apertures. The fenestrules are regularly oval and of intermediate size, with 13 to 14 in 10 mm. They become almost circular towards the reverse surfaces, but depending on the local arrangement of branches and dissepiments may be rounded polygonal. The fenestrules are slightly narrower than the branches, with the ratio of mean fenestrule to branch width 5:6. The ratio of mean fenestrule width to length is 1:2, but over the zoarium fenestrule length may vary.

The autozooecial apertures are ovate and of intermediate size. The ratio of mean aperture width to length is 4:5, and the long axis of the apertures is oriented proximodistally at the external surface. The apertures are regularly spaced with usually three between dissepiment centres, and about 20 in 5 mm. While the apertures are regularly spaced, there is no regular arrangement with fenestrules and dissepiments. The apertures open nearly parallel to the plane of the obverse surface, and do not significantly indent the fenestrules. The ratio of mean apertural spacing down to across the branch is approximately 1:1, and down to between branches is 3:4. The apertures are surrounded by a thin but well developed high peristome, that is a distinctive feature in external examination. The peristome is less apparent on internal examination. Surrounding each aperture are 15 to 20 small apertural stylets.

Spinofenestella flanchea n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	18.5	0.408	18	19	4	2 207
distance between branch centres	0.549	0 029	0 5	0 6	20	5 200
branch width	0.299	0.035	0.24	0.375	21	11 620
dissepiment width	0 194	0.022	0 15	0.24	30	11 442
fenestrules in 10 mm.	13.700	0 447	13	14	5	3 264
fenestrule length	0.495	0.061	0.385	0.61	31	12.287
fenestrule width	0.248	0 031	0 2	0 3	26	12 345
zooecia in 5 mm	20	0	20	20	2	0
apertures between dissepiment centres	2 946	0.157	2 5	3	28	5 345
aperture length	0.118	0 010	0.1	0.14	18	8.289
aperture width	0.094	0.006	0.085	0 1	19	6 375
aperture spacing down branch	0.249	0 020	0.19	0 28	19	7.864
aperture spacing across branch	0 240	0.025	0 2	0.3	17	10 494
aperture spacing between branches	0.325	0.049	0.25	0.46	19	15 048
width peristome	0 014	0 003	0 01	0.02	14	20 795
number of apertural stylets	17.500	3.536	15	20	2	20.203
diameter of apertural stylets	0.008	0 002	0.005	0.01	5	26.146
nodes in 5 mm.	13.333	0.577	13	14	3	4.330
node diameter	0.069	0 012	0.045	0 09	20	16 888
node spacing down branch	0.360	0 014	0.32	0.38	20	3 865
diameter reverse macrostylets	0.073	0 017	0.04	0.11	19	23 044
spacing reverse macrostylets	0.472	0.179	0 16	0 75	19	37 924
thickness reverse wall granular layer	0.011	0 002	0 01	0 015	8	16 323
thickness lateral wall granular layer	0.028	0 007	0.015	0 035	13	24.618
thickness frontal wall lamellar layer	0 136	0 017	0.1	0 16	12	12 442
thickness reverse wall lamellar layer	0.251	0.020	0 23	0.29	10	8.012
chamber length	0.194	0 018	0.16	0.23	20	9.302
chamber depth	0.179	0.011	0.16	0.195	12	5.979
maximum chamber width	0.128	0.013	0 11	0.16	20	10 037
reverse wall budding angle	85.571	2.637	82	90	7	3.081
lateral wall budding angle	30.143	7 244	23	45	7	24.032
branch thickness	0.568	0.036	0 52	0.63	11	6 282

Table 5.8 - Summary measurements for *Spinofenestella flanchea* n. sp Abbreviations as for Table 5.1, all measurements in millimetres.

Along the midline of the obverse branch surface is a straight low rounded carina, bearing a single row of nodes. The nodes are circular to oval and of small to intermediate size. They are of regular intermediate spacing, with about two between dissepiment centres and 13 to

14 in 5 mm. Small stylets are present on both the obverse and reverse surfaces, but are poorly preserved and their exact size and spacing is not determinable. Reverse macrostylets are present, of intermediate size and variable wide spacing that does not appear to be in relation to branch and dissepiment junctions. A few longitudinal striae are present within the reverse wall. There is often one prominent stria along the midline of the reverse of the chambers, with smaller striae outside this.

Internal features - The branches are oval in cross section, with an angular obverse surface. The direction of elongation is perpendicular to the plane of the obverse and reverse surfaces. The ratio of mean branch width to thickness is approximately 1:2.

The autozooecial living chamber is of a consistent intermediate size. The chambers are biserially emplaced with a zigzag axial wall trace. Chamber length and depth are approximately equal. Chamber outline is rounded triangular near the reverse wall and at mid chamber level, becoming rounded trapezoid towards the obverse surface. The aperture is located abaxial distally to the living chamber on a poorly defined vestibule. The vestibule distorts the chamber outline at the obverse surface and has an inclined ovate outline. Ratio of mean chamber width to depth is 5:7 and depth to length is approximately 1:1. The reverse wall budding angle is high and uniform, with a range of 82° to 90° (mean 86°). The lateral wall budding angle is variable with a range of 23° to 45° (mean 30°). The three dimensionally reconstructed chamber form is a rounded wedge shaped box.

The internal skeletal granular layer is thick, particularly between chambers near the reverse wall. An elongate wedge of granular material is present distally of each dissepiment in the reverse wall. These structures may be for the purpose of strengthening the mesh. The lamellar skeleton is thick, and thicker in the reverse wall than the frontal wall.

Discussion - *S. flanchea* n. sp. is dissimilar to other species of the genus, with its very protruded apertural rims, rounded triangular chambers and granular skeletal deposits.

Types - UTGD 127600 holotype.

Etymology - From *flanche*, derived from the Latin origin of the word flange, meaning a protruding rim.

Material - Only one specimen (UTGD 127600) was available for external and internal examination, but is distinct and clearly separable from other species.

Range - Ratburi Limestone, Ko Phi Phi Don.

Spinofenestella horologia (Bretnall 1926)
Plate 55; Table 5.9.

Fenestella horologia BRETNALL (1926); p. 15, pl. I, fig. 6.

Fenestrellina horologia (Bretnall) CROCKFORD (1944c); p. 13, pl. IV, fig.3.

Fenestella horologia Bretnall WASS (1966); p. 92, pl. 2, figs. 1,3-4, 6; non *Minilya duplaris* Crockford (1944b) WASS (1966); pl. 2, figs. 2, 5.

Diagnosis - The zoarium is delicate and the mesh spacing is regular, and of close to intermediate spacing. The branches are straight and of intermediate width, spacing is close and regular, with 18 to 19 in 10 mm. The obverse surface of the branch has flattened sides, with the carina producing only a low angle apex. Dissepiments are narrow. The fenestrules appear hourglass shaped at the obverse surface and there are 18 to 19 in 10 mm. Autozooecial apertures are regularly spaced with 2 to 2.5 between dissepiment centres, and 19 to 20 in 5 mm. Apertures are circular and there is one aperture opposite each dissepiment and one opposite the midline of the fenestrule. Thin complete peristomes surround each aperture. Along the midline of the branch is a low straight carina, bearing a single row of closely spaced nodes, with 23 to 24 in 5 mm.

The autozooecial living chambers are of intermediate size, and are biserially emplaced with a zigzag axial wall trace. Chamber shapes are uniform and chamber outline is triangular at mid chamber level. The lateral wall budding angle is variable (mean 14°). The reverse wall budding angle is constant and high (mean 85°). Three dimensional reconstructed chamber shape is a wedge shaped box. The skeletal granular layer is thin and the lamellar skeletal layer is of intermediate thickness.

Description - External features - The zoarium is delicate, with fragments forming reversely curved outward expansions. Zooecia are in 2 rows, with a third row only inserted at the point of bifurcation which occurs at varying intervals. The mesh spacing is regular, and of close to intermediate spacing. The branches are of intermediate robustness, and are straight and of intermediate width. Branch spacing is close and regular, with 18 to 19 in 10 mm. The obverse surface of the branch has flattened sides, with the carina producing only a low angle apex. Dissepiments are narrow and of intermediate length. They are emplaced at regular intervals perpendicular to the branches. The dissepiments are slightly recessed from the obverse and reverse surfaces. The fenestrules are of regular small to intermediate size, and there are 18 to 19 in 10 mm. Fenestrules are oval to subrectangular at the midline of the branch and appear hourglass shaped at the obverse surface. The fenestrules are slightly narrower than the branches, with a fenestrule to branch width ratio of approximately 6:7. Ratio of mean fenestrule width to length is approximately 2:3.

Spinofenestella horologia	X	SD	Min	Max	N	CV
branches in 10 mm.	18.500	0 707	18	19	2	3.822
distance between branch centres	0.549	0 063	0.48	0.66	8	11 502
branch width	0.312	0.029	0.25	0.355	24	9 299
dissepiment width	0.123	0.018	0 1	0.16	26	14.466
fenestrules in 10 mm	18 500	0.707	18	19	2	3 822
fenstrule length	0.412	0 025	0.375	0.48	26	6 100
fenestrule width	0.265	0.022	0.225	0 325	25	8 363
autozooecia in 5 mm.	19 500	0 707	19	20	2	3 626
apertures between dissepiment centres	2.079	0.187	2	2 5	19	9 010
aperture diameter	0.098	0 006	0.09	0.11	15	5 762
apertural spacing down branch	0.272	0.015	0 24	0.305	19	5.523
apertural spacing across branch	0.287	0.019	0 26	0 32	19	6 632
apertural spacing between branches	0.320	0 032	0.25	0.365	18	10 041
width peristome	0 014	0.002	0 01	0 0175	14	15 427
nodes in 5 mm	23.500	0 707	23	24	2	3 009
node diameter	0.069	0 009	0 06	0.085	16	13 126
nodes spacing	0.219	0.013	0.2	0 24	10	5 913
thickness reverse wall granular layer	0.010	0.001	0.008	0 011	9	14 052
thickness lateral wall granular layer	0.015	0.003	0 01	0.02	14	20 669
thickness frontal wall lamellar layer	0.067	0 016	0.04	0.09	12	23 789
thickness reverse wall lamellar layer	0.119	0.012	0 1	0.14	12	10 488
chamber length	0.219	0 014	0.19	0 24	18	6 266
chamber depth	0 134	0 008	0.12	0 14	15	6 111
chamber maximum width	0 150	0.013	0 125	0 18	20	8 786
reverse wall budding angle	85.429	3.457	80	90	7	4 047
lateral wall budding angle	14 250	4.787	10	21	4	33 594
branch thickness	0 341	0.023	0.31	0.39	14	6 735

Table 5.9 - Summary measurements for *Spinofenestella horologia* (Bretnall). Abbreviations as for Table 5 1, all measurements in millimetres.

Autozooecial apertures are regularly spaced with 2 to 2.5 between dissepiment centres, and 19 to 20 in 5 mm. Apertures are circular and of intermediate size, and open parallel to the plane of the obverse surface. Usually there is one aperture opposite each dissepiment and one opposite the midline of the fenestrule, and the apertures indent the fenestrules resulting in the hour glass shape of the fenestrules at the obverse surface. Apertures are evenly spaced within and between branches. Ratio of mean apertural spacing down to across branches alomost 1:1, and down to between approximately 7:8. Thin complete peristomes surround each aperture, apertural stylets are not seen, but preservation is poor.

Along the midline of the branch is a low straight carina, bearing a single row of nodes. The nodes are circular and of small to intermediate size. The nodes are regularly closely spaced with 23 to 24 in 5 mm. The nodes are a prominent feature of the obverse and extend well above the apex of the carina. Obverse and reverse stylets are present, but poor preservation prevents an assessment of their distribution.

Internal features - The branches are circular to oval in cross section, with the axis of elongation perpendicular to the plane of the obverse and reverse surfaces. The ratio of mean branch width to thickness is 9:10.

The autozooecial living chambers are of intermediate size, and are biserially emplaced with a zigzag axial wall trace. The greatest dimension of the living chamber is oriented parallel to the reverse surface. Chamber shapes are uniform, with chamber outline triangular near the reverse surface and at mid chamber level, becoming almost trapezoid towards the obverse surface. The aperture is placed abaxial distal to the chamber on a short vestibule. The vestibule distorts the chamber shape producing the trapezoid outline near the obverse surface. Ratio of mean chamber width to depth is 10:9, and depth to length is 3:5. Short superior hemisepta are developed about the base of the vestibule. The lateral wall budding angle is variable, with a range of 10° to 21° (mean 14°). The reverse wall budding angle is constant and high, with a range of 80° to 90° (mean 85°). Three dimensional reconstructed chamber shape is a wedge shaped box.

The skeletal granular layer is thin and is probably continuous between branches, chambers and nodes, but preservation is poor. The lamellar skeletal layer is of intermediate thickness, and is thicker in the reverse wall than the frontal wall.

Discussion - *Spinofenestella horologia* (Bretnall) was redescribed by Crockford (1944), as *Fenestella horologia*, from Bretnall's material. The specimen from the Permian of Thailand agrees closely with the measurements given by Crockford (1944c), and thin sectioning has revealed the assignment of the species to the genus *Spinofenestella.*

Wass (1966) included *Minilya duplaris* Crockford in *Fenestella horologia*, after considering the double rows of *M. duplaris* did not warrant generic separation. As discussed by Morozova (1974) the genus *Minilya* Crockford is valid, and therefore *duplaris* is not included in *Spinofenestella horologia.*

Material - UTGD 127601, Ratburi Limestone, Ko Phi Phi Don.

Range - *Spinofenestella horologia* is a wide ranging species and has been recorded from the Sakmarian to ?lower Kungurian of Western Australia (Bretnall, 1926; Crockford 1944b; 1944c), and the Artinskian of the Bowen Basin, Queensland (Wass 1966; 1968). Sakagami recorded *S. horologia* from Khao Chong Krachok, Peninsular Thailand (Sakagami 1968b), a locality that he later indicated as of Sakmarian to Lower Artinskian age (Sakagami 1970a).

Spinofenestella lekformis n. sp.

Plate 56; Table 5.10.

Holotype - UTGD 127602; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is delicate, with mesh spacing close and regular. There are 2 rows of zooecia on the branch, with a third row only inserted at the point of bifurcation. The branches are regularly closely spaced with 21 to 24 in 10 mm. The branches are thin and straight with a low angular surface profile. The dissepiments are short and of narrow to intermediate width and are emplaced at regular intervals perpendicular to the branches. The fenestrules are small, with 21 to 22 in 10 mm. The fenestrules are subrectangular to oval to hourglass shaped. The autozooecial apertures are small, circular and regularly spaced with 2 between dissepiment centres, and 20 to 23 in 5 mm. Apertures are regularly spaced with one opposite each dissepiment and one opposite the midline of the fenestrule. Apertures open parallel to the plane of the obverse surface, and indent the fenestrules slightly. Apertures are surrounded by a thin complete peristome. Along the midline of the branch is a low thin, straight carina that bears 20 to 24.5 circular nodes in 5 mm. Obverse and reverse stylets are present. Reverse macrostylets are absent.

The autozooecial living chambers are of small to intermediate size, biserially emplaced with a zigzag axial wall trace. The chamber outline is regularly triangular throughout. The aperture is located abaxial distally to the living chamber on a short vestibule. Short hemisepta are present about the base of the vestibule. The reverse wall budding angle is high and the lateral wall budding angle is variable. The three dimension reconstructed chamber shape is a triangular box. The skeletal granular layer is thin and the lamellar skeletal layer is of intermediate thickness.

Spinofenestella lekformis n. sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	22.2	1 304	21	24	5	5.873
distance between branch centres	0.489	0.028	0.42	0.56	56	5 775
branch width	0 278	0.023	0.22	0.33	56	8 339
dissepiment width	0.159	0.019	0.12	0.2	53	12 053
fenestrules in 10 mm.	21 25	0 418	21	22	6	1 969
fenestrule length	0.332	0.028	0.25	0 37	53	8 344
fenestrule width	0 198	0.015	0 15	0.225	52	7.782
autozooecia in 5 mm.	21	1.069	20	23	8	5 091
apertures between dissepiment centres	2	0	2	2	54	0
aperture width	0.086	0 007	0 07	0 1	45	8 401
apertural spacing down branch	0.253	0 013	0 225	0.28	56	4 998
apertural spacing across branch	0.263	0 021	0 22	0 3	51	8 011
apertural spacing between branches	0.255	0.033	0.2	0.32	51	12.733
width peristome	0 013	0.003	0.01	0.025	32	25.959
nodes in 5 mm	22.167	2.066	20	24.5	6	9 318
node diameter	0.087	0 018	0 05	0 12	38	20 587
node spacing down branch	0.234	0.019	0.2	0.27	49	8 225
diameter obverse stylets	0.007	0.002	0.005	0 01	10	34 291
spacing obverse stylets	0 032	0 007	0 02	0 04	6	21.573
thickness reverse wall granular layer	0.011	0.002	0.01	0 02	26	21.339
thickness lateral wall granular layer	0.020	0 004	0.013	0 03	33	21 961
thickness frontal wall lamellar layer	0.107	0.035	0.04	0.16	27	32 647
thickness reverse wall lamellar layer	0.195	0 072	0.115	0 37	36	36 749
chamber length	0 196	0 019	0 165	0.24	56	9 490
chamber depth	0 152	0.016	0.13	0.185	30	10 796
maximum chamber width	0.128	0 012	0 11	0.16	50	9 203
vestibule length	0.050	0.011	0.04	0.07	6	21.909
reverse wall budding angle	78.071	3 832	73	84	14	4.909
lateral wall budding angle	22 846	4.543	17	31	13	19 886
branch thickness	0.472	0 064	0.36	0.62	31	13.656

Table 5.10 - Summary measurements for *Spinofenestella lekformis* n. sp Abbreviations as for Table 5.1, all measurements in millimetres.

Description - External features - The zoarium is delicate, with fragments forming flat outward expansions. Overall colony form is not shown by the available material. The mesh spacing is close and regular. There are 2 rows of zooecia on the branch, with a third row only inserted at the point of bifurcation. The branches are of delicate to intermediate robustness, and are regularly closely spaced with 21 to 24 in 10 mm. The branches are thin and straight with a low angular surface profile. The dissepiments are short and of narrow to intermediate width relative to the branches. The dissepiments are straight and are emplaced at regular intervals perpendicular to the branches. The reverse surface of the dissepiments is flush with the reverse wall of the branches, and the obverse surface is recessed to the level of the autozooecial apertures. Both branches and dissepiments may be significantly thickened by astogeny, increasing their width and thickness. The fragmentary nature of the specimens means the portion of the zoarium affected by this astogenic thickening is not known (the measurements below do not include thickened zoarial portions). The fenestrules are of regularly small size, with 21 to 22 in 10 mm. The fenestrules are subrectangular to oval at the midline of the branch and become slightly hourglass shaped towards the obverse surface of the zoarium. The fenestrules tend to be more oval than subrectangular on the reverse surface of the zoarium. The fenestrules are narrower than the branches, with the ratio of mean fenestrule to branch width 5:7. The ratio of mean fenestrule width to length is 3:5.

The autozooecial apertures are small, circular and regularly spaced with 2 between dissepiment centres, and 20 to 23 in 5 mm. Apertural size and shape are uniform, and apertures are regularly placed with one opposite each dissepiment and one opposite the midline of the fenestrule. Apertures open parallel to the plane of the obverse surface, but indent the fenestrules slightly to produce their gently hourglass shape at the obverse surface. Apertural spacing within and between branches is regular and even. Ratio of mean apertural spacing down to across to between branches 1:1:1, giving an efficient surface coverage by the zooecia. Apertures are surrounded by a thin complete peristome, that does not appear to carry apertural stylets, but preservation is poor.

Along the midline of the branch is a low thin and straight carina that bears a single row of nodes. The nodes are circular and of small to intermediate size. They are regularly closely spaced with 20 to 24.5 in 5 mm. Small obverse and reverse stylets are present, and appear closely and evenly spaced across the surfaces of both the branches and dissepiments. Reverse macrostylets are absent.

Internal features - The branches are elongate oval in cross section, with their direction of elongation perpendicular to the plane of the obverse and reverse surfaces. The ratio of mean branch width to depth is 3:5.

The autozooecial living chambers are of regularly small to intermediate size, and are biserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is oriented parallel to the reverse surface. The chamber outline is regularly triangular throughout, with the vestibule distorting the chamber outline to trapezoid near the obverse surface. The aperture is located abaxial distally to the living chamber on a short vestibule. The ratio of mean chamber width to depth is 6:7, and depth to length 7:9. Short hemisepta are present about the base of the vestibule. The reverse wall budding angle is uniform and high, with a range of 73° to 84° (mean 78°). The lateral wall budding angle is variable, with a range of 17° to 31° (mean 23°). Three dimensionally reconstructed chamber form a triangular box.

The skeletal granular layer is thin, but poor preservation obscures details of its continuity. The lamellar skeletal layer is of intermediate thickness, and is thicker in the reverse wall than in the frontal wall.

Discussion - *Spinofenestella lekformis* n. sp. is distinguished from other species of the genus by its fine mesh size.

Etymology - The name is derived from the Thai word "lek", meaning small, for the small mesh size of this species.

Types - UTGD 127602 holotype; UTGD 127603-4 paratypes.

Material - Known only from the type material listed above.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Spinofenestella pseudohorologia n. sp.
Plate 57; Table 5.11.

Holotype - UTGD 127605; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is delicate, with close to intermediate regular mesh spacing. Zooecia are in 2 rows, with a third row only inserted at the point of bifurcation. The branches are thin, delicate and straight with a rounded surface profile. The dissepiments are thin and straight. The fenestrules are of intermediate size, and are strongly hourglass shaped. The autozooecial apertures are uniformly circular and of intermediate size. The apertures are placed with one opposite each dissepiment and one opposite the midline of the fenestrule. The apertures are regularly spaced within and between branches. The peristomes are thin and complete but do not bear apertural stylets.

Along the midline of the branch on the obverse surface is a narrow low straight carina that bears very high sharp nodes that are closely spaced. Small obverse stylets are developed, as well as one large stylet between each aperture. Reverse microstylets are small and irregularly spaced across the surfaces of both the branches and dissepiments. Reverse macrostylets are small and are aligned along the longitudinal striae in the reverse wall.

The autozooecial living chambers are intermediate in size, and are biserially emplaced with a zigzag axial wall trace. The chamber outline is triangular to trapezoid at mid chamber level. Apertures are placed abaxial distally to the living chamber on a short vestibule. The three dimensionally reconstructed chamber form is a triangular box. The granular skeletal layer is usually thin and continuous. The lamellar skeleton is very thin in both the reverse and frontal walls.

Spinofenestella pseudohorologia n. sp.	X	SD	Min	Max	N	CV
distance between branch centres	0.512	0.038	0 44	0 6	31	7 329
branch width	0 273	0.023	0.22	0.31	26	8 304
dissepiment width	0.105	0.010	0.08	0 12	30	9 631
fenestrule length	0.441	0.023	0.4	0.48	29	5 304
fenestrule width	0.251	0.019	0.22	0.28	26	7 432
apertures between dissepiment centres	2	0	2	2	28	0
aperture diameter	0.109	0 005	0.1	0.12	32	4 589
aperture spacing down branch	0.275	0.010	0.26	0.3	31	3.701
aperture spacing across branch	0.280	0.023	0.24	0.34	29	8.364
aperture spacing between branches	0.273	0.030	0 22	0 32	24	10 987
width peristome	0 011	0.002	0 008	0.015	23	20 198
width carina	0 030	0 006	0.02	0.04	10	20.787
node diameter	0 030	0 010	0.02	0.06	35	32 893
node spacing down branch	0 224	0 015	0.2	0.28	40	6 823
diameter large apertural stylets	0.034	0 006	0 023	0.045	21	17.078
diameter obverse stylets	0.005	0.002	0.003	0 01	27	47 106
spacing obverse stylets	0 023	0.010	0 01	0 05	27	42.025
diameter reverse microstylets	0 004	0 001	0.0025	0.005	7	37 417
spacing reverse microstylets	0 024	0 006	0 015	0.03	7	25 014
diameter reverse macrostylets	0.048	0 022	0.018	0.09	14	46.084
spacing reverse macrostylets	0.099	0.024	0.06	0.13	9	24.482
thickness reverse wall granular layer	0.010	0.002	0.008	0.015	17	16 900
thickness lateral wall granular layer	0.020	0.002	0.015	0 025	14	10 963
thickness frontal wall lamellar layer	0.033	0 011	0.015	0 05	9	35 044
thickness reverse wall lamellar layer	0.037	0.012	0 02	0.06	10	33 641
chamber length	0.216	0.016	0.18	0.25	37	7.208
chamber depth	0.153	0.008	0 14	0 16	9	5 455
maximum chamber width	0.157	0.009	0 14	0 17	35	5.631
branch thickness	0.248	0.013	0 22	0 26	10	5.309

Table 5.11 - Summary measurements for *Spinofenestella pseudohorologia* n sp Abbreviations as for Table 5 1, all measurements in millimetres.

Description - External features - The zoarium is delicate, overall colony form is unknown, but fragments form flat outward expansions. The mesh spacing is close to intermediate and regular. Zooecia are in two rows, with a third row only inserted at the point of bifurcation. The branches are thin, delicate and straight with a rounded surface profile. The branch spacing is close to intermediate and regular. The dissepiments are thin and of intermediate width. The dissepiments are straight and regularly placed perpendicular to the branches. They are recessed from both the obverse and reverse surfaces, with thickness approximately equal to width. The fenestrules are of intermediate size, and are strongly hourglass shaped. Fenestrules are only slightly narrower than the branches, with the ratio of mean fenestrule to branch width 9:10. The ratio of mean fenestrule width to length is 4:7.

The autozooecial apertures are uniformly circular and of intermediate size. The apertures are regularly spaced with 2 between dissepiment centres. The apertures are placed with 1 opposite each dissepiment and 1 opposite the midline of the fenestrule, and indent the fenestrules producing the hour glass shape of the fenestrules. The apertures open almost parallel to the plane of the obverse surface. The apertures are also regularly spaced within and between branches and the ratio of mean apertural spacing down to across and between branches is 1:1. The peristomes are thin and complete but do not bear apertural stylets.

Along the midline of the branch on the obverse surface is a narrow low straight carina that does not produce an angular surface profile. Along the carina are very high sharp nodes that are closely spaced. The nodes are strongly elongate at their base along the carina, but become circular with a small diameter towards their apex.

The obverse surface has two sets of stylets. Small obverse stylets are developed, mostly distributed along the base of the carina and around the apertures, with a few only on the dissepiments. Between the apertures of each row is one large stylet that in thin section can be seen to develop from the proximal chamber edge of each zooecia. Reverse microstylets are small and of irregular intermediate spacing across the surfaces of both the branches and dissepiments. Reverse macrostylets are small and are aligned along the longitudinal striae in the reverse wall.

Internal features - The branches are thin and circular to oval in cross section, with the direction of elongation usually parallel to the plane of the obverse and reverse surfaces. Ratio of mean branch width to thickness is 10:9.

The autozooecial living chambers are of regularly intermediate size, and are biserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is parallel to the plane of the reverse surface. The chamber outline near the reverse wall is triangular, triangular to trapezoid at mid chamber level, and trapezoid near the obverse surface. Apertures are placed abaxial distally to the living chamber on a short vestibule. The development of the vestibule and aperture creates the change from a triangular to trapezoid outline. The ratio of mean chamber width to depth is approximately 1:1, and depth to length is approximately 5:7. The three dimensionally reconstructed chamber form is a triangular box. The granular skeletal layer is usually thin, but in some areas is quite thick between the chambers near the reverse wall. The cause of this is unknown. The granular layer is continuous between chambers, carina, nodes and branches. The lamellar skeleton is very thin in both the reverse and frontal walls.

Discussion - *Spinofenestella pseudohorologia* has a very similar mesh formula and zooecial spacing to *S. horologia* (Crockford 1944a). It can be distinguished however by the thin branches, the very high nodes, and the presence of the large obverse stylets. Although the details of the budding angles of the reverse and lateral walls are not known it is believed the other features of the zoarium make the species distinct enough for description.

Types - UTGD 127605 holotype, UTGD 127606 paratype, Ratburi Limestone, Ko Phi Phi Don.

Etymology - named for its similarity to *S. horologia* (Bretnall, 1926).

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Subfamily - POLYPORINAE Vine, 1883

Genus *Mackinneyella* Morozova and Lisitsyn 1996

Type species - *Polypora ornamentata* Shulga-Nesterenko, 1941; Lower Permian; Southern Urals, The Tra-tau Mountain.

Diagnosis - Zoarium with many shapes, meshworks with large fenestrules. The branches are wide, straight or slightly sinuous and semicircular in transverse section. Dissepiments are short and wide and free of extra zooecia. Zooecia usually in 5 to 6 rows, with 7 to 14 before and 3 to 7 after a bifurcation. In median tangential section zooecia are rhombic or rounded polygonal. Chambers elongated tubular with a poorly separated vestibule. Zooecial apertures rounded surrounded by abundant capillaries and nodes. Ridges are absent from the obverse surface (after Morozova and Lisitsyn, 1996).

Mackinneyella nodosa n. sp.
Plate 58; Table 5.12.

Holotype - UTGD 127607, Ratburi Limestone Ko Phi Phi Don.

Diagnosis - The zoarium is robust and the colony is a fan shaped reversely curved expansion. The zooecia are in usually 5 rows with up to 8 before and 4 after bifurcation. The branches are robust and wide and with a straight proximodistal trace and a rounded surface profile. The branch spacing is intermediate, with 4 to 5 branches in 10 mm. The dissepiments are narrow and are regularly placed perpendicular to the branches. The fenestrules are large and subrectangular to elongate oval, with about 5 in 10 mm. The autozooecial apertures are circular and of intermediate size. The apertures are regularly spaced down the branch with usually 5 between dissepiment centres, and approximately 11.5 to 12 in 5 mm. The apertures open parallel to the obverse branch surface, and the lateral rows of apertures open towards the fenestrules, but indent them only slightly. Large circular nodes are arranged between the autozooecial apertures on the obverse surface. Obverse and reverse stylets are present. Large circular reverse macrostylets are closely spaced along the reverse surface of the branch.

The autozooecial living chambers are of intermediate to large size, and are polyserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and distal chamber walls. The chamber outline is regularly rhombic to rounded rhombic at mid chamber level. The reverse wall budding angle is regular and low, mean 51°. The lateral wall budding angle is variable. Median rows have lateral wall budding angles of 3° to 4°, with the angle increasing up to 41° for the outermost lateral rows. The three dimensionally reconstructed chamber form is an elongated polygonal tube.

The granular skeletal layer is thin but well developed and the lamellar skeletal layer is of intermediate thickness.

Description - External features - The zoarium is robust and the colony is a fan shaped reversely curved expansion. The colony base is a solid calcified series of rootlets. The mesh is of intermediate spacing, and bifurcation is frequent. The zooecia are in usually 5 rows with up to 8 before and 4 after bifurcation. The branches are robust and wide and with a straight proximodistal trace and a rounded surface profile. The branch spacing is regularly intermediate, with 4 to 5 branches in 10 mm. The dissepiments are narrow and are approximately half the width of the branches. The dissepiments are of intermediate length and are regularly placed perpendicular to the branches. The dissepiments do not carry extra zooecia nor do the rows of zooecia bend onto them. The reverse and obverse surfaces of the dissepiments are recessed from each zoarial surface. The fenestrules are large and subrectangular to elongate oval. Fenestrules are of regular size and shape, and there are about 5 in 10 mm. The fenestrules are of similar width or slightly narrower than the branches, with the ratio of mean fenestrule to branch width 9:10. The ratio of mean fenestrule width to length is 3:7.

The autozooecial apertures are circular and of intermediate size. The apertures are regularly spaced down the branch with usually 5 between dissepiment centres, and approximately 11.5 to 12 in 5 mm. The ratio of mean apertural spacing down to across the branch is approximately 7:5, down to between branches 3:5 and across to between branches 3:7. The apertures open parallel to the obverse branch surface, and as the surface profile is rounded the lateral rows of apertures open towards the fenestrules, but indent them only slightly. Details of the apertural peristome or stylets are not seen.

The obverse surface of the branch is without a carina. Large circular nodes are arranged between the autozooecial apertures on the obverse surface. The nodes are placed between apertures of adjacent rows, and apertures of the same row, so that node spacing is similar to apertural spacing. Obverse and reverse stylets are present, but their details are difficult to determine, although those of the obverse surface are larger than those on the reverse. Large circular reverse macrostylets are closely spaced along the reverse surface of the branch. The reverse macrostylets are smaller and more closely spaced than the nodes of the obverse

surface. Numerous short indistinct longitudinal striae are present within the reverse wall.
Internal features - The branches are rounded triangular in cross section with width and depth similar. The greatest branch width is towards the obverse surface of the branch. The ratio of mean branch width to thickness is between 9:10 and 1:1.

The autozooecial living chambers are of intermediate to large size, and are polyserially emplaced with a zigzag axial trace. The greatest chamber dimension is parallel to the proximal and distal chamber walls. The chamber outline is regularly rhombic to rounded rhombic near the reverse wall and at mid chamber level, becoming oval towards the obverse surface. The aperture is located distally to the chamber in median rows, and abaxial distal in lateral rows. The aperture is at the end of a long but often indistinct vestibule. The ratio of mean chamber maximum width to depth is 5:6, and depth to length is approximately 2:5. The reverse wall budding angle is regular and low, with a range of 46° to 59° (mean 51°). The lateral wall budding angle is variable according to row number and the position of the rows. Median rows have lateral wall budding angles of 3° to 4°, with the angle increasing up to 41° for the outermost lateral rows. The three dimensionally reconstructed chamber form is an elongated polygonal tube.

The granular skeletal layer is thin but well developed, with continuity seen between chamber walls, longitudinal striae and between branches. The nodes on the obverse surface are of lamellar skeletal material. The lamellar skeletal layer is of intermediate thickness and is of similar thickness in both the reverse and frontal walls.

Mackinneyella nodosa n sp.	X	SD	Min	Max	N	CV
rows of zooecia	4.769	0 587	4	6	26	12 309
branches in 10 mm.	6.875	0.854	6	8	4	12 421
distance between branch centres	1 471	0.210	1.04	1 8	16	14 282
branch width	0.843	0.099	0.64	0.98	29	11.793
dissepiment width	0 393	0.046	0 3	0.5	27	11 588
fenestrules in 10 mm.	5	0	5	5	3	0
fenestrule length	1.724	0.131	1 59	2.22	27	7.605
fenestrule width	0.762	0 157	0.42	1.14	22	20 580
apertures between dissepiment centres	5.260	0 436	4 5	6	25	8 287
aperture diameter	0.118	0 009	0 1	0 13	26	7 337
apertural spacing down branch	0.423	0.035	0.345	0.5	31	8 306
apertural spacing across branch	0.305	0.026	0.25	0 36	31	8 581
apertural spacing between branches	0.702	0.171	0.45	0.98	12	24 285
diameter nodes	0.140	0.029	0 1	0.2	26	20 905
node spacing down branch	0.326	0.077	0 2	0 48	28	23 721
diameter reverse macrostylets	0.120	0.025	0.08	0.165	15	20 654
spacing reverse macrostylets	0.252	0.059	0.145	0 36	12	23 215
thickness reverse wall granular layer	0.012	0.003	0 0075	0 02	16	25.607
thickness lateral wall granular layer	0.020	0.006	0 0125	0.035	19	28.899
thickness frontal wall lamellar layer	0.169	0.035	0 12	0 22	14	20.446
thickness reverse wall lamellar layer	0.270	0.043	0 2	0 33	11	15.827
chamber depth	0.556	0.023	0.52	0.59	8	4 070
chamber length	0.218	0.016	0 2	0 24	6	7 338
maximum chamber width	0.185	0.019	0.15	0.225	34	10 161
vestibule length	0.125	0 018	0.11	0 16	6	14 085
reverse wall budding angle	50.500	5 127	46	59	8	10 152
lateral wall budding angle - adaxial	3.500	0.707	3	4	2	20 203
lateral wall budding angle - abaxial	31.000	8 287	22	41	4	26 731
branch thickness	0.897	0 042	0 82	0.95	12	4 672

Table 5.12 - Summary measurements for *Mackinneyella nodosa* n sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Discussion - *M. nodosa* n. sp. is distinguished from other species with an open mesh by its shorter fenestrules, zooecial spacing and the strong nodes. *M. nodosa* n. sp. is very different in appearance to *M. supraobesa* n. sp. also from the Ratburi Limestone which has almost

circular fenestrules and a close mesh spacing.
Types - UTGD 127607 holotype; UTGD 127608 paratype, Ratburi Limestone, Ko Phi Phi Don.
Etymology - Named for the large distinct nodes of the obverse surface.
Material - Only the type material listed above was examined.
Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Mackinneyella supraobesa n. sp.
Plate 59; Table 5.13.

Holotype - UTGD 127609; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is robust and the mesh close and regular. Strong zoarial supports are developed from the reverse branch surfaces. The zooecia are in 6 to 8 rows on the branches, with 8 to 9 before and 4 to 5 after bifurcation. The branches are very wide and robust with a flattened to gently rounded surface profile. There are 4 to 4.5 branches in 10 mm. The dissepiments are nearly as wide as the branches and widen gradually from their centre towards the branch junction. The lateral rows of zooecia commonly bend onto the dissepiments but extra rows are not present. The fenestrules are large, and regularly circular to gently oval, with 5 to 5.5 fenestrules in 10 mm. The autozooecial apertures are circular and of intermediate size, and there are usually 5 between dissepiment centres. The apertures open parallel to the obverse branch surface with apertures of lateral rows opening slightly inclined towards the fenestrules. Circular nodes of small to intermediate size are irregularly spaced down the branch between the zooecia. Across the obverse surface small stylets are developed that may form small clusters, however preservation is poor. Macrostylets of intermediate size are developed on the reverse surface, and are aligned to the longitudinal striae within the reverse wall.
The autozooecial living chambers are of intermediate size and are polyserially emplaced with a zigzag axial wall trace. The chamber outline in tangential section is rounded rhombic at mid chamber level. The reverse wall budding angle is low, mean 56°. The lateral wall budding angle is highly variable from 3° to 46°. The three dimensionally reconstructed chamber form is an elongated polygonal tube. The granular skeletal layer is thin but well developed. The lamellar skeletal layer is thick.
Description - External features - The zoarium is robust, overall colony form is unknown, but fragments form flattened outward expansions. The mesh spacing is close and regular. Strong zoarial supports that are at least 6.5 mm long, are developed from the reverse branch surfaces. The zooecia are in 6 to 8 rows on the branches, with 8 to 9 before and 4 to 5 after bifurcation. Row number increase rapidly after bifurcation.
The branches are very wide and robust with a straight proximodistal trace and a flattened to gently rounded surface profile. Branch spacing is close and regular with 4 to 4.5 branches in 10 mm. The dissepiments are of intermediate width and are approximately the same width as the branches. The dissepiments are short and widen gradually from their centre towards the branch junction. The dissepiments are flush with the reverse surface and are slightly recessed from the obverse surface. The dissepiments are regularly placed perpendicular to the branches. The lateral rows of zooecia commonly bend onto the dissepiments but extra rows are not present. The fenestrules are large and regularly circular to gently oval. If fenestrules are oval the axis of elongation is in a proximodistal direction. Fenestrule size and shape are regular with 5 to 5.5 fenestrules in 10 mm. The fenestrules are significantly narrower than the branches, with the ratio of mean fenestrule to branch width 1:2. The ratio of mean fenestrule width to length is 5:6. Fenestrule length is less than the width of corresponding dissepiments.
The autozooecial apertures are regularly circular and of intermediate size. The apertures are regularly spaced down the branch with usually 5 between dissepiment centres and approximately 11 to 12 in 5 mm. The ratio of mean apertural spacing down to across the branch is 9:7, down to between branches 7:9, and across to between branches 3:5. The

apertures open parallel to the obverse branch surface that is flat to gently rounded. Apertures of lateral rows may open slightly inclined towards the fenestrules but do not indent them. The apertures are surrounded by a thin complete peristome, that is without apertural stylets. Terminal diaphragms are occasionally seen.

The obverse surface of the branch is without a carina. Circular nodes of small to intermediate size are irregularly spaced down the branch between the zooecia. Across the obverse surface small obverse stylets are developed that are irregularly spaced, however preservation is poor and exact details are not known. Small microstylets are developed on the reverse surface, and are evenly spread across the surfaces of both the dissepiments and branches. Macrostylets of intermediate size are developed on the reverse surface of branches and dissepiments, and are aligned to the longitudinal striae within the reverse wall. The longitudinal striae are short and thin with up to 15 beneath the reverse surface of each branch.

Mackinneyella supraobesa n sp	X	SD	Min	Max	N	CV
rows of zooecia	6.792	0.932	5	8	24	13 716
branches in 10 mm.	4 667	0 289	4.5	5	3	6 186
distance between branch centres	2.154	0.133	1 98	2 42	11	6 189
branch width	1.488	0.163	1.22	1.75	22	10 980
dissepiment width	1.310	0 104	1.1	1.54	34	7 924
fenestrules in 10 mm.	5 200	0.274	5	5 5	5	5 267
fenestrule length	0.929	0.120	0 64	1 16	29	12 943
fenestrule width	0 763	0.100	0 5	0.98	26	13 082
apertures between dissepiment centres	5 060	0 416	4	6	25	8 228
aperture diameter	0.136	0.011	0 115	0.16	28	8 104
apertural spacing down branch	0.431	0 041	0 36	0 535	28	9 451
apertural spacing across branch	0.332	0.047	0 26	0.42	27	14 097
apertural spacing between branches	0 559	0.219	0 108	1.14	20	39 223
width peristome	0.009	0.002	0 008	0.013	20	16 678
diameter reverse macrostylets	0 083	0 019	0 06	0.125	36	22 718
spacing reverse macrostylets	0.131	0.034	0.08	0 24	35	25 662
thickness reverse wall granular layer	0 010	0.002	0 008	0 015	21	20.135
thickness lateral wall granular layer	0.015	0.003	0 01	0 02	28	19 640
thickness frontal wall lamellar layer	0 188	0.030	0 14	0.24	22	16 059
thickness reverse wall lamellar layer	0.472	0 024	0.425	0 51	15	5 124
chamber depth	0.221	0 021	0 18	0.25	15	9 415
chamber length	0.440	0.020	0.42	0 46	3	4 545
maximum chamber width	0 160	0 013	0 14	0.185	22	8 211
minimum chamber width	0 025	0 021	0	0.06	28	84 160
vestibule length	0.15	0.02	0 13	0.17	3	13 333
reverse wall budding angle	55.667	3 215	52	58	3	5 775
lateral wall budding angle - adaxial	6.000	3.606	3	10	3	60 093
lateral wall budding angle - abaxial	29.750	13.426	16	46	4	45 128
branch thickness	1.104	0 052	1 02	1.18	11	4 743

Table 5 13 - Summary measurements for *Mackinneyella supraobesa* n sp. Abbreviations as for Table 5.1, all measurements in millimetres.

Internal features - The branches are thick and elliptical in cross section, with the direction of elongation parallel to the obverse reverse surfaces. The greatest width is towards the obverse surface. The ratio of mean branch width to thickness is 4:3.

The autozooecial living chambers are of intermediate size. The zooecia are polyserially emplaced with a zigzag axial wall trace. The direction of chamber elongation is parallel to the proximal and distal lateral walls in the median rows. The direction of elongation rotates in the lateral rows that are associated with dissepiments to become almost parallel to the plane of the obverse and reverse surfaces, and inclined abaxial distally.

The chamber outline in tangential section is somewhat variable according the position of the chamber on the branch. In median rows chamber outline is rounded rhombic near the reverse surface and at mid chamber level, becoming rounded pentagonal to oval near the obverse surface. In lateral rows that bend onto the dissepiments the chamber outline is curved elongate elliptical in tangential section. The aperture is located distally to the orientation of greatest chamber dimension, on a long but somewhat indistinct vestibule. The ratio of mean minimum to maximum chamber width is approximately 1:6, maximum width to depth 5:7, and depth to length 1:2. The reverse wall budding angle is low, with a range of 52° to 58° (mean 56°). The lateral wall budding angle is highly variable according to row position, with median rows showing budding angles from 3° and lateral rows up to 46°. The three dimensionally reconstructed chamber form is an elongated polygonal tube.

The granular skeletal layer is thin but well developed, with continuity seen between chamber walls, striae and nodes. The granular layer is also continuous between branches but the granular layer within the dissepiments is not always strongly developed. The lamellar skeletal layer is thick, and is thicker in the reverse surface than in the frontal wall.

Discussion - *Mackinneyella supraobesa* n sp. is of a similar mesh size to *Polypora obesa* Crockford from the Artinskian Noonkanbah Formation, Western Australia (Crockford, 1957). The species can be distinguished by the more closely spaced apertures, thinner dissepiments and consistently oval fenestrules. *M. supraobesa* n sp. is similar in appearance to *Polypora koninckiana* Waagen and Pichl, recorded from Thailand by Sakagami (1999), but of smaller mesh size. *Polypora koninckiana*, as shown by Sakagami (1999) has a rhombic chamber outline and should likely be placed within the genus *Mackinneyella* of Morozova and Lisitsyn (1996).

Types - UTGD 127609 holotype; UTGD 127610 paratype, both of Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for its similarity to *Polypora obesa* Crockford.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Polypora* M'Coy 1844

Type species - *Polypora dendroides* M'Coy 1844; Lower Carboniferous, Tournisian Stage; Ireland.

Diagnosis - Zoarium of various shapes with zooecia opening to one side only. Meshwork is regular with medium to large fenestrules and straight to sinuous branches joined by non-poriferous dissepiments. Zooecia in 4 rows on the branches with 5 or 6 before, and 2 to 3 for a short distance after bifurcation. In median tangential section zooecial chambers are regularly hexagonal, rhombic or oval in deep or oblique sections. Zooecial chambers are tubular, constantly overlapping subsequent chambers, and have poorly developed lower hemisepta. Zooecial apertures are circular with apertural stylets present. A carina is not developed on the obverse surface, but nodes and obverse stylets are present. (After Morozova and Lisitsyn (1996) and Snyder (1991))

Polypora canalis n. sp.
Plate 60; Table 5.14.

Holotype - UTGD 127611; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is of intermediate robustness and mesh spacing is close and regular. The autozooecia are usually in 4 rows. The branches are robust and wide with a straight proximodistal trace and a flat to gently rounded surface profile. Branch spacing is close and regular, with 8 to 10 in 10 mm. The dissepiments are of intermediate width, and are regularly spaced perpendicular to the branches. On the reverse surfaces of both the branches and dissepiments is a distinct groove running parallel to their length. This groove is continuous and is connected at branch and dissepiment junctions. The fenestrules are large and oval with 7 to 7.5 fenestrules in 10 mm. The autozooecial apertures are regularly circular and of intermediate size. The apertures open parallel to the obverse surface of the branch and do not indent the fenestrules. Apertures are regularly spaced down the branch with 3.5 to 4 between dissepiment centres, and 13 to 14 in 5 mm.

The obverse surface of the branch has small nodes polyserially placed along the branch between the apertures. Small stylets are present on the obverse and reverse surfaces. The reverse surface also bears small irregularly spaced macrostylets.

The autozooecial living chambers are of intermediate to large size, and are polyserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is parallel to the obverse and reverse surfaces. The chamber outline is hexagonal at mid chamber level. The reverse wall budding angle is slightly variable, mean 50°. The lateral wall budding angle is highly variable between median and lateral rows. Three dimensionally reconstructed chamber form is a hexagonal box. The granular skeletal layer is thin but well developed. The lamellar skeleton is thin to intermediate, and is of similar thickness in both the reverse and frontal walls.

Polypora canalis n sp.	X	SD	Min	Max	N	CV
rows of zooecia	3.952	0.623	3	5	42	15 758
branches in 10 mm.	9	1	8	10	3	11 111
distance between branch centres	1.170	0 096	0.96	1 36	24	8 248
branch width	0.718	0.089	0.56	0 9	44	12 381
dissepiment width	0.491	0 074	0.36	0.675	34	15 141
fenestrules in 10 mm.	7 300	0.274	7	7.5	5	3.752
fenestrule length	0 827	0 064	0.68	0.93	35	7 797
fenestrule width	0.501	0 061	0.35	0 595	37	12 208
autozooecia in 5 mm.	13.500	0 577	13	14	4	4 277
apertures between dissepiment centres	3.676	0 377	3	4	37	10 248
aperture diameter	0.098	0 006	0 08	0.11	32	6 463
apertural spacing down branch	0.366	0 030	0 3	0.42	33	8 291
apertural spacing across branch	0.297	0 029	0.24	0.38	23	9 795
apertural spacing between branches	0 510	0 090	0 365	0.62	14	17 618
width peristome	0 010	0 002	0 008	0 015	11	22.887
diameter nodes	0.062	0.019	0.04	0.09	6	31 472
diameter obverse stylets	0.018	0 005	0.01	0 025	20	28 501
spacing obverse stylets	0 049	0.014	0.03	0.07	19	27 989
diameter reverse microstylets	0.010	0 004	0 005	0.02	13	36 740
diameter reverse macrostylets	0.045	0 017	0.02	0.08	17	37 479
spacing reverse macrostylets	0.433	0 352	0.14	1.15	10	81 347
thickness reverse wall granular layer	0.012	0.003	0.01	0.02	19	21 956
thickness lateral wall granular layer	0.013	0 003	0.01	0.02	23	25 726
thickness frontal wall lamellar layer	0.104	0.021	0.06	0.15	22	19.873
thickness reverse wall lamellar layer	0.123	0.017	0.1	0.17	20	13.891
chamber length	0.321	0.035	0.24	0 42	22	11.060
chamber depth	0 282	0.022	0.23	0 32	21	7 736
maximum chamber width	0.169	0.019	0.14	0.22	30	11 493
minimum chamber width	0 041	0 030	0	0.1	28	73.813
vestibule length	0.074	0 028	0.05	0.13	7	37.781
reverse wall budding angle	50.364	8 021	32	63	22	15.926
lateral wall budding angle - adaxial	6.500	5.260	2	12	4	80 922
lateral wall budding angle - abaxial	18.857	7.151	7	28	7	37 924
branch thickness	0 485	0.029	0 455	0 55	19	5 930

Table 5.14 - Summary measurements for *Polypora canalis* n. sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Description - External features - The zoarium is of intermediate robustness, and while overall colony form is unknown, fragments form flattened outward expansions. Mesh spacing is close and regular. The autozooecia are in 3 to 5 rows. Bifurcation is at regular intervals with up to 6 before, and 2 to 3 after branching. The branches are robust and wide with a straight proximodistal trace and a flat to gently rounded surface profile. Branch spacing is close and regular, with 8 to 10 in 10 mm. The dissepiments are of intermediate width, and are narrower than the branches. Dissepiments are of intermediate length and are regularly spaced perpendicular to the branches. The dissepiments widen slightly at their junction with the branches, and are level with the obverse and reverse surfaces of the branch. On the reverse surfaces of both the branches and dissepiments is a distinct groove running parallel to their length. This groove is continuous and is connected at branch and dissepiment junctions. Where the zoarium is astogenetically thickened this groove may be filled and not readily evident. The fenestrules are large and oval to almost circular. Fenestrule size is regular and there are 7 to 7.5 fenestrules in 10 mm. The fenestrules are narrower than the branches with a mean fenestrule to branch width ratio of 7:10. The ratio of mean fenestrule width to length is 3:5.

The autozooecial apertures are regularly circular and of intermediate size. The apertures open parallel to the obverse surface of the branch and do not indent the fenestrules. The apertures are surrounded by a thin peristome that does not bear apertural stylets. Apertures are regularly spaced down the branch with 3.5 to 4 between dissepiment centres, and 13 to 14 in 5 mm. The ratio of mean apertural spacing down to across the branch is 5:4, down to between branches 5:7 and across to between branches 3:5.

The obverse surface of the branch is without a carina, but has small nodes polyserially placed along the branch between the apertures. The true spacing of the nodes is difficult to determine as the available material is poorly preserved on the obverse surface. Small stylets are present on the obverse and reverse surfaces, and are closely spaced on both the branches and dissepiments. The reverse surface also bears small irregularly spaced macrostylets.

Internal features - The branches are rounded polygonal in cross section, with a gently rounded surface profile and the direction of elongation parallel to the obverse and reverse surfaces. The groove on the reverse surface of the branch can be clearly seen to have a rounded concave outline. The ratio of mean branch width to thickness is 3:2.

The autozooecial living chambers are of intermediate to large size, and are polyserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is parallel to the obverse and reverse surfaces. The chamber outline is regular and rhombic to hexagonal near the reverse surface, hexagonal at mid chamber level becoming rounded hexagonal to ovate near the obverse surface. The aperture is located distally to the living chamber, on a vestibule of variable short to intermediate length. Chambers in lateral rows have apertures opening abaxial distal to the living chamber. The ratio of mean minimum to maximum chamber width is 1:4, maximum width to depth 3:5 and depth to length 7:8.

The reverse wall budding angle is slightly variable, with a range of 32° to 63° (mean 50°). The lateral wall budding angle is highly variable, and varies from 2° in median rows to up to 28° in lateral rows. Three dimensionally reconstructed chamber form is a hexagonal box.

The granular skeletal layer is thin but well developed, with continuity clearly seen between chambers, apertures, striae and between adjacent branches. The lamellar skeleton is of thin to intermediate thickness, and is of similar thickness in both the reverse and frontal walls. The groove on the reverse of the branches and dissepiments is within lamellar skeleton, and is not associated with granular skeletal material.

Discussion - *Polypora canalis* n. sp. has a similar mesh work formula to other species recorded from the region, notably *P. macrops* Bassler from Timor (Bassler, 1929), and *P. quadricella* Sakagami from Khao Chong Krachok, Thailand (Sakagam, 1968b). *P. canalis* n. sp. can be readily distinguished from other species by the very distinctive groove or canal in the reverse surfaces of the branch and dissepiments.

Types - UTGD 127611 holotype; UTGD 127612 paratype, from the Ratburi Limestone, Ko Phi Phi Don.

Etymology - From *canâlis*, Latin for channel, indicating the channel or groove in the reverse surface.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Polypora nodulifera n. sp.
Plate 61; Table 5.15.

Holotype - UTGD 127613 Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is of intermediate robustness, and the mesh spacing is intermediate and regular. Autozooecia are usually in 4 rows. The autozooecial rows are straight and do not bend onto the dissepiments. The branches are robust and wide, with a straight proximodistal trace and rounded angular surface profile. There are approximately 6.5 to 7 branches in 10 mm. The dissepiments are narrow, and are regularly placed. The fenestrules are very large and subrectangular to elongate oval. There are about 3 fenestrules in 10 mm. The autozooecial apertures are regularly circular and of intermediate size. Apertural spacing is regular with usually 7 to 8 between dissepiment centres, and about 10 to 11 in 5 mm. The lateral rows of apertures indent the fenestrules slightly. The apertures are surrounded by a thin peristome that does not bear apertural stylets. Nodes of variable intermediate size are polyserially emplaced between the apertures on the obverse surface. Nodes are usually larger than the mean in the median rows, and smaller in lateral areas of the branch. Small closely spaced stylets are present on the obverse and reverse surfaces of the branch. Large circular macrostylets are present on the obverse surface of the branch.

The autozooecial living chambers are of intermediate size, and are polyserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and distal lateral walls. Chamber outlines are regularly rhombic at mid chamber level. The reverse wall budding angle is low and the lateral wall angle is variable from median to lateral rows. The three dimensionally reconstructed chamber form is a rhombic tube. The granular skeletal layer is well developed between chambers, but is not well defined at the reverse wall or between dissepiments. The lamellar skeletal material is of intermediate thickness in both the reverse and frontal walls.

Description - External features - The zoarium is of intermediate robustness, overall colony form unknown, but fragments form flattened to gently reversely curved outward expansions. The mesh spacing is intermediate and regular. Autozooecia are in 3 to 5, usually 4, rows. There are up to 6 rows before, and 3 after, bifurcation. The autozooecial rows are straight and do not bend onto the dissepiments. The branches are robust and wide, with a straight proximodistal trace and a rounded to rounded angular surface profile. Branch spacing is regularly intermediate and there are approximately 6.5 to 7 branches in 10 mm. The dissepiments are narrow, and are much narrower than the branches. The dissepiments are regularly placed but vary from perpendicular to the branches, to inclined. Dissepiments are of intermediate length, and widen slightly at their junction with the branches. Horizontal striae are seen on the reverse and obverse surfaces of the dissepiments, and the dissepiments are slightly recessed from the obverse and reverse surfaces. The fenestrules are very large and subrectangular to elongate oval. The fenestrules are only slightly narrower than the branches, and the ratio of mean fenestrule to branch width is approximately 9:10. The ratio of mean fenestrule width to length is approximately 1:4. There are about 3 fenestrules in 10 mm. The autozooecial apertures are regularly circular and of intermediate size. Apertural spacing is regular with usually 7 to 8 between dissepiment centres, and approximately 10 to 11 in 5 mm. The ratio of mean apertural spacing down to across the branch is 3:2, down to between branches approximately 3:2 and across to between branches 4:9. The apertures open parallel to the obverse surface, and with the rounded surface profile the lateral rows indent the fenestrules slightly. The apertures are surrounded by a thin peristome that does not bear apertural stylets.

Nodes of variable intermediate size are polyserially emplaced between the apertures on the obverse surface. Nodes are usually larger than the mean in the median rows, and smaller in lateral areas of the branch. The obverse surface of the branch is without a carina, but with larger nodes in the median area the branch may appear slightly angular. The nodes are circular and raised above the plane of the obverse surface, and are of close to intermediate spacing. Small stylets are evenly and closely spaced on the obverse and reverse surfaces of the branch. Size and spacing of stylets is the same on both the obverse and reverse surface. Large circular macrostylets are present on the obverse surface of the branch, and are well raised above the plane of the reverse surface. Size, shape and spacing of the reverse macrostylets are the same as node size, shape and spacing on the obverse surface. Within the reverse surface longitudinal striae are indistinct.

Polypora nodulifera n sp.	X	SD	Min	Max	N	CV
rows of zooecia	3 773	0.528	3	5	22	14 006
distance between branch centres	1 488	0 145	1.22	1 76	9	9 774
branch width	0 780	0.095	0 55	0 93	20	12 150
dissepiment width	0.349	0.073	0 25	0 52	11	20 794
fenestrule length	2.925	0.262	2.5	3 33	11	8 968
fenestrule width	0.694	0.125	0.53	0 9	10	18 076
apertures between dissepiment centres	7 533	0 667	6.5	9	15	8 857
aperture diameter	0.116	0.014	0 1	0.15	29	11.750
apertural spacing down branch	0.465	0.047	0 38	0.564	29	10 058
apertural spacing across branch	0.304	0.030	0 22	0.35	29	9.715
apertural spacing between branches	0.685	0 152	0.43	0.82	8	22 236
width peristome	0.013	0.002	0 01	0.018	15	18 970
diameter nodes	0.110	0 025	0.07	0.16	34	22 453
node spacing down branch	0.256	0 064	0 15	0.45	33	24 920
diameter obverse stylets	0.009	0 003	0 005	0 018	40	29.201
spacing obverse stylets	0.016	0.004	0.01	0.03	40	27.889
diameter reverse microstylets	0.009	0 001	0 005	0 01	38	15.929
spacing reverse microstylets	0.015	0.003	0.01	0.02	39	16.621
diameter reverse macrostylets	0.113	0.024	0 075	0.155	24	21.205
spacing reverse macrostylets	0.285	0.067	0.16	0 42	21	23 602
thickness reverse wall granular layer	0.015	0.004	0.01	0.02	17	26.259
thickness lateral wall granular layer	0.035	0 011	0.02	0.053	25	30 845
thickness frontal wall lamellar layer	0.167	0.013	0.14	0.18	12	7 490
thickness reverse wall lamellar layer	0.130	0.017	0.1	0.16	12	12 711
chamber length	0 383	0.037	0.33	0.44	6	9 714
chamber depth	0.197	0 008	0.18	0.205	7	4.105
maximum chamber width	0 177	0.012	0.16	0.2	34	6 519
vestibule length	0.083	0.015	0.07	0.1	3	18 330
reverse wall budding angle	54.400	6 877	46	65	5	12.642
lateral wall budding angle - adaxial	8 200	4 970	5	17	5	60.609
lateral wall budding angle - abaxial	35.600	10.922	26	53	5	30 681
branch thickness	0 628	0 087	0.54	0.8	12	13.872

Table 5.15 - Summary measurements for *Polypora nodulifera* n. sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Internal features - The branches are elliptical in cross section, with the direction of elongation parallel to the obverse and reverse surfaces. The ratio of mean branch width to thickness is 5:4.

The autozooecial living chambers are of intermediate size, and are polyserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and distal lateral walls. Chamber outlines are regularly rhombic near the reverse wall and at mid chamber level, and become rounded rhombic towards the obverse surface. The aperture is located distally to the living chamber on a vestibule of intermediate length. In lateral rows the aperture and vestibule are oriented abaxial distally. The ratio of mean chamber maximum width to depth is 9:10, and depth to length 1:2. The reverse wall budding angle is low, with a range of 46° to 65° (mean 54°). The lateral wall angle is variable from median to lateral rows. In median rows the budding angle may be as low as 5° and increases towards the outermost row at up to 53°. The three dimensionally reconstructed chamber form is a rhombic tube.

The granular skeletal layer is well-developed between chambers, but is not well-defined at the reverse wall or between dissepiments. The granular cores of the stylets are clearly seen within both the reverse and frontal walls, and the nodes and reverse macrostylets have diffuse granular material at their centres. The lamellar skeletal material is of intermediate thickness in both the reverse and frontal walls.

Discussion - Of other Permian species *Polypora nodulifera* n. sp. is most similar to *P. multiporifera* Crockford (1944b) of Western Australia, but has a more regular meshwork and fewer rows of zooecia and larger nodes.

The consistent rhombic chamber shape is not a common feature of the genus *Polypora.* However *P. nodulifera* does not show the aggregations of capillaries of *Mackinneyella*, and row number is too great for *Polyporellina*, and neither are the reverse macrostylets restricted to dissepiment and branch junctions. The species is therefore retained in *Polypora,* that itself shows some variation and probably requires reassessment as discussed by Snyder (1991).

Types - UTGD 127613 holotype; UTGD 127614-15 paratypes, all from Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the distinct and numerous nodes of the obverse and reverse surfaces.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Shulgapora* Termier and Termier 1971

Type species - *Polypora abundans* Shulga-Nesterenko 1951.

Diagnosis - Zoarium robust, with zooecia in 4 to 5 rows. Dissepiments are free of extra zooecia. Zooecial chambers are long and thin hexagonal to rounded hexagonal. Apertures are usually small and circular, with fine weak ridges between the rows of zooecia, but not carinas. Nodes are small and rare. Cyclozooecia are present on both the reverse surfaces of both the branches and dissepiments.

Shulgapora megacyclopora n. sp.
Plate 62; Table 5.16.

Holotype - UTGD 127616; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is robust, with 6 to 7 rows of autozooecia. The branches are robust and wide, with a straight proximodistal trace and a rounded surface profile. The branches are rounded triangular in cross section. There are 4 to 5 branches in 10 mm. The dissepiments are narrow and straight, widening slightly at their junction with the branches. The fenestrules are large and subrectangular in outline, but may be irregularly polygonal where associated with bifurcation. There are 2.5 to 3 fenestrules in 10 mm.

The autozooecial apertures are circular and of intermediate size. The apertures of the middle rows open upwards, but the lateral rows are steeply inclined towards the fenestrules and indent them significantly. The apertures have an protruding rim. Apertural stylets are absent. The apertures are regularly spaced on each branch, with usually 8 to 9 between dissepiment centres, and approximately 12 to 12.5 in 5 mm. The obverse surface of the branch is without a carina, but has small circular nodes irregularly spaced between the rows of zooecia. Large cyclozooecia are present and are usually placed proximally to each aperture of the same row. The cyclozooecia may also be found on the dissepiments and the reverse surface of the branch.

On the reverse surface are distinct rounded large macrostylets. Beneath the reverse surface are numerous fine short longitudinal striae.

The autozooecial chambers are of intermediate size, and polyserially emplaced. The chamber outline is elongate pentagonal to almost quadrate at mid chamber level. Hemisepta are absent. The reverse wall budding angle is low and slightly variable, mean 39°. The lateral wall angle is variable according to its distance from the centre of the branch. The three dimensionally reconstructed form is a polygonal tube.

The granular skeleton is thin and the lamellar skeleton is thick.

Description - External features - The zoarium is robust, overall colony form is unknown. The mesh spacing is intermediate, but may vary according with bifurcation, as fenestrules are much wider before and narrower after branching. The autozooecia are usually in 6 to 7 rows with up to 10 before and 5 after bifurcation. The branches are robust and wide, with a straight proximodistal trace and a rounded surface profile. The branches are at their widest towards the obverse surface and are much thinner near the reverse surface. Branch spacing is close to wide depending on bifurcation, which is frequent. There are 4 to 5 branches in 10 mm. The dissepiments are narrower than the branches and of intermediate length. Dissepiments are straight and widen slightly at their junction with the branches. The dissepiments are regularly emplaced and are usually perpendicular to the branches but may also be at an angle. They are flush with the reverse surface but are slightly recessed from the obverse surface. The fenestrules are large and subrectangular in outline, but may be irregularly polygonal where associated with bifurcation. There are 2.5 to 3 fenestrules in 10 mm. The fenestrules are of regular size and shape, and vary little between the obverse and reverse surfaces, except to increase in size towards the obverse. The fenestrules are only slightly narrower than the branches, with the ratio of mean fenestrule to branch width 6:7. The ratio of mean fenestrule width to length is 1:3.

Shulgapora megacyclopora n. sp.	X	SD	Min	Max	N	CV
rows of zooecia	6 742	0.930	5	9	31	13 791
branches in 10 mm	4.667	0 577	4	5	3	12.372
distance between branch centres	2 062	0 410	1 47	3.02	22	19 873
branch width	1.199	0.174	0 9	1.6	28	14.526
dissepiment width	0.597	0 094	0.455	0 92	26	15 702
fenestrules in 10 mm.	2.667	0.289	2 5	3	3	10.825
fenestrule length	2.987	0.351	2 43	3 9	19	11 745
fenestrule width	1.031	0.253	0.64	1.68	20	24 503
apertures between dissepiment centres	8.885	1.083	7	11	13	12 191
aperture diameter	0 115	0 010	0.1	0.15	51	8 568
apertural spacing down branch	0.412	0.029	0 34	0.465	52	7.126
apertural spacing across branch	0.277	0 026	0.22	0.34	55	9 366
apertural spacing between branches	0.830	0.269	0 44	1.55	30	32 364
width peristome	0.010	0 002	0 008	0.015	16	21 394
diameter cyclozooecia	0.178	0.024	0.11	0 215	29	13 446
node diameter	0.060	0.015	0 04	0 09	11	25 820
node spacing down branch	0 344	0 090	0.22	0.45	9	26 123
diameter obverse stylets	0 015	0.004	0.01	0.02	10	28.176
spacing obverse stylets	0.036	0.005	0.03	0 04	4	13 206
diameter reverse macrostylets	0 101	0.017	0 06	0 13	35	17 034
spacing reverse macrostylets	0 279	0 075	0.16	0.49	28	26 792
thickness reverse wall granular layer	0.014	0.003	0 01	0.02	12	22 988
thickness lateral wall granular layer	0.016	0.004	0 01	0 02	12	25 827
thickness frontal wall lamellar layer	0.174	0 025	0.14	0.2	6	14 344
thickness reverse wall lamellar layer	0 395	0.041	0.36	0.44	4	10.438
chamber length	0 451	0.033	0.4	0 54	22	7 351
chamber depth	0.182	0.018	0 14	0.21	25	9.951
maximum chamber width	0.143	0 012	0.12	0.16	43	8 746
minimum chamber width	0 026	0.026	0	0.1	45	99 892
vestibule length	0 162	0.031	0 1	0.22	13	19 182
reverse wall budding angle	38.545	6 069	21	47	22	15 745
lateral wall budding angle - adaxial	7.333	5 132	3	13	3	69.976
lateral wall budding angle - abaxial	46.200	7.596	38	55	5	16 442
branch thickness	0.961	0.058	0 89	1 08	8	6.077

Table 5.16 - Summary measurements for *Shulgapora megacyclopora* n. sp. Abbreviations as for Table 5.1, all measurements in millimetres.

The autozooecial apertures are uniformly circular and of intermediate size. The apertures of the middle rows open upwards parallel to the plane of the obverse surface, but the lateral rows are steeply inclined towards the fenestrules and indent them significantly. The apertures are exserted and protrude above the obverse surface, and are strongly exerted in the lateral rows, as to appear as tube like extensions into the fenestrules. Apertural stylets are absent. The apertures are regularly spaced on each branch, with usually 8 to 9 between dissepiment centres, and approximately 12 to 12.5 in 5 mm. The ratio of mean aperture spacing down to across the branch is 3:2, down to between branches 1:2, and across to between branches 1:3.

The obverse surface of the branch is without a carina, but has small circular nodes irregularly spaced between the rows of zooecia. The nodes are of intermediate spacing. The nodes are less prominent in external view than the extruded apertural rims, and may not be readily apparent. Prominent on the obverse surface in some areas are large cyclozooecia that are larger than the apertures. The cyclozooecia are irregularly placed and are not seen in all portions of the obverse, but may be clustered in some regions. The cyclozooeia are usually placed proximally to each aperture of the same row. The cyclozooecia may also be found on the dissepiments and the reverse surface of the branch.

The obverse and reverse surfaces carry small stylets of irregular intermediate spacing. On the reverse surface are distinct rounded large macrostylets that are irregularly and widely spaced across the branches and dissepiments. Beneath the reverse surface are numerous fine short longitudinal striae.

Internal features - The branches are thick and rounded triangular in cross section. The ratio of mean branch width to thickness is 6:5.

The autozooecial chambers are of intermediate size, and polyserially emplaced with a zigzag axial wall trace that straightens towards the obverse surface. The greatest chamber dimension is parallel to the proximal and distal lateral walls in chambers of the middle rows, but in lateral rows the axis becomes inclined abaxial distally. The chamber outline is variable across the zoarium according to the number of rows, but within local areas is usually uniform. The chamber outline is rhombic near the reverse surface, and elongate pentagonal to almost quadrate at mid chamber level, becoming rounded pentagonal to rhombic towards the obverse surface. The aperture is located distally to the chamber along the axis of elongation. The aperture is at the end of a long distinct vestibule. Chamber dimensions are constant, except for minimum width, which varies from the reverse to obverse surface according to the changing chamber outline. The ratio of mean minimum to maximum chamber width is approximately 1:5, maximum width to depth 4:5, and depth to length 2:5. Hemisepta are absent. The reverse wall budding angle is low and slightly variable, with a range of 21° to 47° (mean 39°). The lateral wall angle is variable according to its distance from the centre of the branch. Budding angles for chambers of the median, and middle rows may be 0° to 3°, more or less steadily increasing to a maximum of 38° for chambers of the outermost lateral row. The three dimensionally reconstructed form is a polygonal tube.

The granular skeleton is thin with good continuity seen between chambers, nodes, striae and between rows. The lamellar skeleton is thick in both the reverse and frontal walls.

Discussion - This species cannot be allied with any species of *Shulgapora* known to the author. *S. megacyclopora* n. sp. can be readily distinguished by its mesh size, apertures with extruded rims indenting the fenestrules and cyclozooecia that are larger than autozooecial apertures. None of the material described from various localities of the Ratburi Limestone within Thailand can be compared to *S. megacyclopora* n. sp.

Types - UTGD 127616 holotype; UTGD 127617-18 paratypes; all from the Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the characteristic cyclozooecia that are larger than apertures.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Shulgapora reversa n. sp.
Plate 63; Table 5.17.

Holotype - UTGD 127619; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is intermediate to robust, and mesh spacing is close. Autozooecia are in 5 to 6 rows with up to 7 before and 4 after bifurcation. The branches are robust, straight and very wide with a gently rounded to flattened surface profile. The dissepiments are narrow, straight and regularly emplaced perpendicular to the branches. The fenestrules are very large and subrectangular. The autozooecial apertures are large and circular to oval, and regularly spaced with usually eight between dissepiment centres. The apertures are surrounded by a thin incomplete peristome, that does not bear apertural stylets. The obverse surface is without carinas, nodes or stylets. On the reverse surface are large cyclozooecia, appearing on both the dissepiments and branches. The cyclozooecia are not seen on the obverse surface.
The autozooecial apertures are of intermediate size, and are polyserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is parallel to proximal and distal lateral walls. Chamber outline is elongate hexagonal to quadrate at mid chamber level. The aperture is located distally on a long vestibule. Hemisepta are absent. The reverse wall budding angle is low and constant with a mean of 54°. The lateral wall budding angles are variable, adaxial angle mean 3°, and abaxial angle mean 22°. Three dimensionally reconstructed chamber form is an elongate tube.
The granular skeletal layer is thin, and the lamellar skeleton is thick.

Shulgapora reversa n sp.	X	SD	Min	Max	N	CV
rows of zooecia	5.273	0.786	4	7	11	14 912
distance between branch centres	1.505	0.300	1.2	2.02	6	19 906
branch width	0 930	0.065	0 82	1.02	11	6 992
dissepiment width	0.480	0.117	0.38	0.75	11	24.294
fenestrule length	2 742	0.259	2.3	3.11	9	9 458
fenestrule width	0.609	0.124	0 35	0 76	10	20 354
apertures between dissepiment centres	8	0.926	7	10	8	11.573
aperture width	0 151	0.010	0 125	0.16	17	6.442
aperture length	0.188	0.010	0 17	0.21	16	5 594
apertural spacing down branch	0.396	0 024	0.35	0.46	20	5 945
apertural spacing across branch	0.248	0.018	0 22	0.28	15	7 085
apertural spacing between branches	0.613	0.134	0 45	0.84	7	21.784
width peristome	0.013	0 003	0.01	0.018	7	22.361
diameter cyclozooecia	0 133	0.016	0 1	0.16	16	11 823
thickness reverse wall granular layer	0.018	0.002	0.015	0 02	6	13 719
thickness lateral wall granular layer	0.010	0.004	0 008	0.015	6	35 327
thickness frontal wall lamellar layer	0 176	0.014	0 16	0.2	7	7 952
thickness reverse wall lamellar layer	0.405	0.047	0.32	0.44	6	11 555
chamber length	0.379	0 033	0.34	0.43	10	8 835
chamber depth	0.150	0 011	0.13	0.16	10	7 470
maximum chamber width	0 114	0.011	0 1	0 13	8	9 758
minimum chamber width	0.042	0.014	0.02	0.06	8	33.735
vestibule length	0.190	0 041	0.16	0.25	4	21 487
reverse wall budding angle	53.750	2.986	50	57	4	5 555
lateral wall budding angle - adaxial	3	3.606	0	7	3	120.185
lateral wall budding angle - abaxial	22.250	11.673	10	38	4	52 461
branch thickness	0.834	0.059	0.74	0 9	5	7.073

Table 5.17 - Summary measurements for *Shulgapora reversa* n. sp Abbreviations as for Table 5 1, all measurements in millimetres.

Description - External features - The zoarium is intermediate to robust, overall colony form is unknown. Mesh spacing is close, but somewhat irregular, with fenestrules widening before and narrowing after bifurcation. Autozooecia are in 5 to 6 rows with up to 7 before, and 4 after, bifurcation. The branches are robust, straight and very wide with a gently rounded to flattened surface profile. The branches are closely spaced with approximately 6 to 7 in 10 mm. The dissepiments are narrow, and are much narrower than the branches. The dissepiments are straight and regularly emplaced perpendicular to the branches. The dissepiments widen at their junction with the branches, and are not recessed from the obverse and reverse surfaces. The fenestrules are very large and subrectangular. There are approximately 3 fenestrules in 10 mm. Fenestrule shape is consistent, with fenestrule length proximodistally much greater than width. The fenestrules are narrower than the branches, and the ratio of mean fenestrule to branch width is 2:3. Ratio of mean fenestrule width to length is 1:5.

The autozooecial apertures are uniformly large and circular to oval, with the ratio of mean width to length 4:5. The apertures are regularly spaced with usually 8 between dissepiment centres and approximately 12 to 13 in 5 mm. Ratio of mean aperture spacing down to across the branch is approximately 5:8, down to between branches approximately 2:3, and across to between branches 2:5. The apertures of the middle rows open parallel to the plane of the obverse surface, with the lateral rows slightly inclined towards the fenestrules but not indenting them. The apertures are surrounded by a thin incomplete peristome, that does not bear apertural stylets.

The obverse surface is without a carina or nodes. Stylets are also absent from the obverse and reverse surfaces. On the reverse surface are large cyclozooecia, appearing on both the dissepiments and branches. The cyclozooecia are not seen on the obverse surface. The cyclozooecia are surrounded by a thin peristome that is slightly raised above the reverse surface of the branch. Within the reverse wall are numerous thin short longitudinal striae.

<u>Internal features</u> - The branches are thick and rounded to ovate in cross section. The direction of elongation is usually parallel to the obverse and reverse surfaces, but after bifurcation is often perpendicular. The ratio of mean branch width to thickness is 11:10.

The autozooecial apertures are of intermediate size, and are polyserially emplaced with a zigzag axial wall trace. The greatest chamber dimension is parallel to proximal and distal lateral walls. Chamber depth is approximately the same as the aperture diameter, so chambers appear as a bent almost parallel sided tube in lateral view. Chamber outline is elongate hexagonal to quadrate near the reverse wall and at mid chamber level, becoming ovate towards the obverse surface. The aperture is located distally on a long vestibule. The maximum chamber width is narrower than the aperture width so the vestibule flares outwards and upwards towards the obverse surface. The ratio of mean minimum to maximum chamber width is 3:8, maximum width to depth 3:4, and depth to length 2:5. Hemisepta are absent. The reverse wall budding angle is low and constant, with a range of 50° to 57° (mean 54°). The lateral wall budding angles are variable, adaxial angle with a range of 0° to 7° (mean 3°), and abaxial angle with a range of 10° to 38° (mean 22°). Three dimensionally reconstructed chamber form is an elongate tube.

The granular skeletal layer is thin, and the lamellar skeleton is thick.

Discussion - *Shulgapora reversa* n. sp. is readily distinguished by its large mesh, large apertures and cyclozooecia on the reverse surface only. *S. magnafenestrata* Crockford of eastern Australia has a slightly larger mesh and importantly cyclozooecia on the obverse surface. *S. kolvae* Stuckenburg from the Permian of Russia is of a similar mesh size, but has large cyclozooecia on the obverse surface. *S. reversa* n. sp. is only known from one specimen but is distinct enough to be formally described.

Types - UTGD 127619 holotype, Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the restriction of the cyclozooecia to the reverse surface.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Family RETEPORINIDAE Dunaeva and Morozova, 1974
Subfamily RETEPORIDRINAE Dunaeva and Morozova, 1974
Genus *Reteporidra* Nickles and Bassler, 1900

Type species - *Reteporella undulata* Simpson, 1883; Devonian, North America.
Diagnosis - Zooecia in 5 or more rows on anastomosing or nearly anastomosing branches. Branches robust and fenestrules large. Zooecial chamber outline rhombic to hexagonal. Each chamber overlaps the previous chamber.

Reteporidra yongkasemensis n. sp.
Plate 64; Table 5.18.

Holotype - UTGD 127620; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is robust and the colony fan shaped, with a stout calcified root-like base. The autozooecia are in usually 6 to 7 rows on the branches. The branches are wide and robust, and anastomosing, with 3 to 4.5 in 10 mm. The fenestrules are very large and regularly oval to elliptical. There are usually 2.5 to 3 fenestrules in 10 mm. The autozooecial apertures are circular, large, and regularly spaced down the branch. There are usually 8 to 10 apertures between the base of one fenestrule and the next. The apertures are surrounded by a thin peristome, that is without apertural stylets. Obverse stylets of intermediate size cover the obverse surface and often extend right up to the apertural margin. The obverse surface of the branch has small circular nodes that are irregularly developed and spaced across the surface of the branch. On the reverse surface small microstylets are closely spaced, and are clustered together in groups.

The autozooecial living chambers are large and polyserially emplaced with an irregular zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and distal lateral walls. The chamber outline is rhombic to rounded rhombic at mid chamber level. The aperture is located distally to the living chamber on a long indistinct vestibule.

The reverse wall budding angle is low and regular, mean 57°. The lateral wall budding angle in median rows ranges between 0° and 10°, and increases to 28° for the outermost lateral rows. The three dimensionally reconstructed chamber form is a rounded rhombic tube. The skeletal granular layer is thin, and often indistinct. The lamellar skeleton is thick in both the reverse and frontal walls.

Description - External features - The zoarium is robust and the colony fan shaped, with a stout calcified root-like base. The autozooecia are in usually 6 to 7 rows on the branches. The branches are wide and robust, and anastomosing. The branches are regularly closely spaced with 3 to 4.5 in 10 mm. The surface profile of the branch is flat to gently rounded. The fenestrules are very large and regularly oval to elliptical. There are usually 2.5 to 3 fenestrules in 10 mm. The fenestrules are only slightly narrower than the branches, with the ratio of mean fenestrule to branch width is 7:9. The ratio of mean fenestrule width to length is approximately 1:2.

The autozooecial apertures are circular and very large. The apertures are regularly spaced down the branch, with usually 8 to 10 between the base of one fenestrule and the next. There are approximately 11.5 to 12 apertures in 5 mm. The ratio of mean apertural spacing down to across the branch is 10:7. The apertures are surrounded by a thin peristome, that is only seen to be complete very near to the plane of the obverse surface. Apertural stylets are absent.

Obverse stylets of intermediate size and spacing cover the obverse surface and often extend right up to the apertural margin. The obverse surface of the branch has small circular nodes that are irregularly developed and spaced across the surface of the branch. Often the nodes are adjacent to the apertures and may originate from the apertural rim of peristome. On the reverse surface small microstylets are closely spaced, and are clustered together in groups. The clusters of microstylets are raised above the reverse surface of the branches, and have

Reteporidra yongkasemensis n. sp.	X	SD	Min	Max	N	CV
rows of zooecia	6.571	0.787	5	7	7	11 973
distance between branch centres	2 392	0 685	1.64	3.4	5	28 640
branch width	1.468	0.144	1.18	1.81	18	9 792
fenestrule length	2.443	0.262	2	2 86	15	10.723
fenestrule width	1.143	0 198	0.72	1.5	16	17 323
apertures between dissepiment centres	9.179	0.912	8	11	14	9.932
aperture diameter	0.217	0.009	0 2	0.23	20	4 375
apertural spacing down branch	0.423	0.047	0.34	0.5	20	11 045
apertural spacing across branch	0 299	0.020	0 26	0.34	20	6 648
width peristome	0.010	0.000	0.01	0.01	2	0 000
diameter nodes	0.063	0.014	0 04	0.08	8	21.974
node spacing down branch	0.424	0.203	0.16	0.78	7	47 798
diameter obverse stylets	0.013	0.004	0.005	0 02	20	33 179
spacing obverse stylets	0.030	0.010	0.02	0 055	20	33 372
diameter reverse microstylets	0 009	0 002	0.005	0.011	20	21 818
spacing reverse microstylets	0.018	0.003	0.013	0.025	20	16 533
diameter reverse macrostylets	0 091	0.025	0.055	0.16	20	27.591
spacing reverse macrostylets	0.118	0.034	0.06	0.17	13	29 054
thickness reverse wall granular layer	0 016	0.004	0.01	0 02	14	26 911
thickness lateral wall granular layer	0.016	0.003	0 01	0.02	19	20.969
thickness frontal wall lamellar layer	0.528	0.081	0.38	0 64	12	15 418
thickness reverse wall lamellar layer	0.691	0 105	0 56	0.9	11	15 241
chamber length	1.212	0.093	1 1	1 36	10	7.659
chamber depth	0.256	0.023	0.22	0.3	14	9 132
maximum chamber width	0.231	0.031	0 18	0.32	20	13 344
reverse wall budding angle	57.385	5.606	49	66	13	9 769
lateral wall budding angle - adaxial	5 111	2.892	0	10	9	56 574
lateral wall budding angle - abaxial	19.167	7 083	9	28	6	36 954
branch thickness	1.921	0.101	1.67	2.04	12	5 260

Table 5.18 - Summary measurements for *Reteporidra yongkasemensis* n. sp. Abbreviations as for Table 5.1, all measurements in millimetres.

been measured as macrostylets. The macrostylets are large and closely spaced. The longitudinal striae within the reverse surface are thin and indistinct.

Internal features - The branches are oval to elliptical in cross section, with the direction of elongation perpendicular to the obverse and reverse surfaces. The ratio of mean branch width to thickness is 3:4.

The autozooecial living chambers are very large and polyserially emplaced with an irregular zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and distal lateral walls. The chamber outline is rhombic to rounded rhombic near the reverse wall and at mid chamber level, becoming ovate towards the obverse surface. Chamber outlines are consistent, and show little variation in overall shape where associated with anastomosing branch points. The ratio of mean chamber maximum width to depth is 9:10, and depth to length approximately 1:5. Chamber width and depth are only slightly larger than apertural diameter, and the ratio of mean chamber width to aperture diameter is 9:10 to 1:1. The aperture is located distally to the living chamber on a long vestibule. The vestibule is indistinct because of the small difference between chamber width and aperture diameter.

The reverse wall budding angle is low and regular, with a range of 49° to 66° (mean 57°). The lateral wall budding angle is variable from median to lateral rows. Budding angle in median rows ranges between 0° and 10°, and increases to 28° for the outermost lateral rows. The three dimensionally reconstructed chamber form is a rounded rhombic tube.

The skeletal granular layer is thin, and often indistinct. The granular skeleton between chambers and at the reverse wall is clearly visible, but it is difficult to differentiate between granular and lamellar skeleton in the frontal wall. The lamellar skeleton is thick in both the reverse and frontal walls.

Discussion - *Reteporidra yongkasemensis* n. sp. is distinguished from other Permian species of the genus known to the author by its large mesh and apertures, and the distinctive arrangement of stylets on the reverse surface.

Sakagami (1968c) described *Protoretepora lamellata* from the Permian of Thailand. This species has anastomosing branches and should be placed within *Reteporidra*. Whilst *R. lamellata* is similar in appearance, *R. yongkasemensis* has a much larger mesh and more widely spaced, and larger, apertures.

Types - UTGD 127620, holotype; Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for Ao Yong Kasem (Yong Kasem Bay), where the specimens were collected on Ko Phi Phi Don.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Family SEPTOPORIDAE Morozova, 1962

Genus *Septopora* Prout, 1859

Type species - *Septopora cestriensis* Prout, 1859; Mississippian, Illinois, USA.

Diagnosis - Mesh fenestrate, zoarium flabellate or leaf-like expansion. Zoarium with abundant primary branches, increasing by bifurcation or interpolation of lateral branches. Lateral branches extend from primary branches and connect adjacent primary branches to form the fenestrules. Zooecial apertures in 2 rows on both primary and lateral branches. Cyclozooecia present between apertures on both primary and lateral branches, and may be present on either or both the reverse and obverse surface (after Nickles and Bassler, 1900).

Septopora interformis n. sp.

Plate 65; Table 5.19.

Holotype - UTGD 127621; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is of intermediate robustness, with overall colony form flabellate. Mesh spacing is wide, but highly variable. Both the primary and lateral branches are wide and of intermediate robustness, with a straight proximodistal trace and a rounded surface profile. There are usually 6 to 7 primary branches in 10 mm, but there may be up to 10. The lateral branches are narrower than the primary branches, and are regularly placed at an angle to the primary branch. The fenestrules are of highly variable shape, usually rounded crescent shaped, but may be irregularly ovate. There are usually 6.5 to 9 fenestrules in 10 mm.

The autozooecial apertures are regularly ovate and large, with 3 to 4 between lateral branch centres, and 15 to 16 in 5 mm. A thin complete peristome surrounds each aperture but is without apertural stylets. Small circular cyclozooecia are present between the autozooecial apertures, and can be found on the reverse and obverse surfaces of both the primary and lateral branches. A low rounded poorly defined carina is present along the midline of the primary branch. Along the carina are large ovate stellate widely spaced nodes.

The autozooecial living chambers are of intermediate size and a biserially emplaced. In the primary branches chamber outline is tetragonal at mid chamber level, and in the lateral branches chambers are rounded pentagonal to pentagonal. The reverse wall budding angle is constant, mean 79°. The lateral wall budding angle is low, mean 5°. The three dimensionally reconstructed chamber form is a tetragonal box (primary branches) or a pentagonal box (lateral branches).

The granular skeletal layer is thin and the lamellar skeletal layer is thick.

Description - External features - The zoarium is of intermediate robustness, with overall colony form flabellate. Mesh spacing is wide, but highly variable, according to primary branch bifurcation and interpolation of lateral branches.

The primary branches are wide and of intermediate robustness, with a straight proximodistal trace and a rounded surface profile. Spacing of primary branches is irregular, there are usually 6 to 7 in 10 mm, but there may be up to 10. The lateral branches are also wide and of intermediate robustness and are straight with a rounded surface profile. The lateral branches are narrower than the primary branches, with the ratio of mean primary to lateral branch width 4:3. The lateral branches are regularly spaced along the primary branch and extend at about 70° to the direction of growth of the primary branch. The lateral branches of adjacent primary branches join in their approximate centre, and there may be a small area free of zooecia in this region. The lateral branches are flush with the primary branches on the obverse surface, but are somewhat recessed on the reverse. The fenestrules are of highly variable shape depending on the arrangement of the lateral branches. They are usually rounded crescent shaped, with the greatest dimension horizontal. Fenestrule size increases after a bifurcation, and immediately after a bifurcation or interpolation may be irregularly ovate with the greatest dimension vertical. There are usually 6.5 to 9 fenestrules in 10 mm.

The autozooecial apertures are regularly ovate and large. The apertures are regularly spaced with 3 to 4 between lateral branch centres, and 15 to 16 in 5 mm. Apertural spacing is the same down both the primary and lateral branches. The narrower width of the lateral branches results in apertural spacing across lateral branches being closer than on the primary branches. The ratio of mean apertural spacing down to across the primary branches is 8:9, and down to across the lateral branches 4:3. A thin complete peristome surrounds each aperture but is without apertural stylets. Small circular cyclozooecia are present between the autozooecial apertures, and can be found on the reverse and obverse surfaces of both the primary and lateral branches. The cyclozooecia are irregularly spaced and may be locally abundant.

A low rounded poorly defined carina is present along the midline of the primary branch. Along the carina are large ovate stellate widely spaced nodes. Nodes were not seen on the lateral branches in the material examined. Preservation of the material was insufficient to determine the nature of obverse and reverse stylets.

Septopora interformis n sp.	X	SD	Min	Max	N	CV
branches in 10 mm.	7.125	2.016	5.5	10	4	28 289
distance between branch centres	1.560	0 483	0.75	2.22	11	30 956
branch width	0.688	0 100	0.4	0.85	25	14 570
lateral branch width	0 510	0 108	0.38	0 75	21	21 098
fenestrules in 10 mm	8 188	1 252	6 5	10	8	15 289
fenestrule length	0.649	0 064	0 56	0.75	9	9 802
fenestrule width	1.289	0.268	0 84	1.6	9	20 831
zooecia in 5 mm.	15 5	0.5	15	16	7	3 226
apert. between lateral branch centres	3.350	0.462	3	4	20	13 782
aperture length	0.164	0.010	0 15	0.18	16	5.852
aperture width	0.142	0 009	0.13	0.16	19	6.228
apertural spacing down branch	0.330	0 018	0.295	0 37	20	5 546
apertural spacing across branch	0.375	0 030	0.33	0.44	20	7.941
apertural spacing between lateral br.	0.741	0 077	0.63	0.87	11	10 335
apertural spacing across lateral br.	0.244	0 020	0.21	0.28	14	8 245
width peristome	0.007	0 002	0.005	0 01	10	24.998
nodes in 5 mm	5.000		5	5	1	
diameter cyclozooecia	0.060	0 009	0.05	0.08	20	14 864
thickness reverse wall granular layer	0.012	0 004	0 008	0.02	7	36 153
thickness lateral wall granular layer	0 012	0 003	0 008	0 015	7	26 591
thickness frontal wall lamellar layer	0.189	0 029	0 14	0.24	9	15 308
thickness reverse wall lamellar layer	0.273	0 034	0.22	0.32	8	12 522
chamber length	0 271	0 012	0.26	0.3	10	4 481
chamber depth	0.175	0.007	0 16	0.185	9	4 286
maximum chamber width	0.155	0 013	0.14	0.175	13	8 252
reverse wall budding angle	79.286	3 039	73	82	7	3 834
lateral wall budding angle	4.778	1.202	3	7	9	25 155
branch thickness	0.680	0.046	0 6	0.73	6	6 835

Table 5.19 - Summary measurements for *Septopora interformis* n sp. Abbreviations as for Table 5 1, all measurements in millimetres

Internal features - The primary branches are as thick as they are wide and are circular in cross section, with the ratio of mean branch width to thickness 1:1.

The autozooecial living chambers are of intermediate size and are biserially emplaced. The axial wall trace is straight on the primary branches and gently zigzag on the lateral branches. The greatest chamber dimension is parallel to the plane of the obverse and reverse surfaces. On the primary branches chamber outline is tetragonal near the reverse wall and at mid chamber level, becoming elliptical towards the obverse surface. On the lateral branches chamber outlines are rounded pentagonal to pentagonal near the reverse wall and at mid chamber level. The aperture is located abaxial distal to the living chamber. The reverse wall budding angle is constant and high, with a range of 73° to 82° (mean 79°). The lateral wall budding angle is low, with a range of 3° to 7° (mean 5°). The three dimensionally reconstructed chamber form is a tetragonal box (primary branches) or a pentagonal box (lateral branches).

The granular skeletal layer is thin, but preservation does not show it characters fully. The lamellar skeletal layer is thick, and is thicker in the reverse wall than in the frontal wall.

Discussion - *Septopora interformis* n. sp. is similar to *S. orientalis* Bassler, of the Permian of Timor (Bassler, 1929) and Russia (Morozova 1970). *S. interformis* has a similar mesh size to *S. orientalis*, but is much more irregular, and has large nodes and a low carina. *S. orientalis* does not have nodes but has a distinct carina. *S. interformis* has a smaller mesh than *S. exornata* from the Permian of Pamir (Goryunova, 1975), but has a similar appearance and both species have large nodes. While *S. interformis* can be distinguished from *S. exornata* and *S. orientalis* it is likely that the group are closely related, with *S. interformis* sharing features of the other two species.

Both *S. kamakurae* and *S. kawamatae* Sakagami of the Permian of Japan (Sakagami, 1961) have finer meshes, and *S. ornata* Crockford of Western Australia (Crockford, 1944a) has more closely spaced apertures.

Types - UTGD 127621 holotype, UTGD 127622 paratype; Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for its apparent intermediate form between *S. exornata* and *S. orientalis*.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Synocladia* King, 1849

Type species - *Retepora virgulacea* Phillips, 1829; Permian, England.

Diagnosis - Zoarium a flabellate expansion. Primary branches robust and numerous, and increase by bifurcation or interpolation of lateral branches. The lateral branches join with those of adjacent primary branches. The zooecia are in 3 or more rows on the branches. There are usually elevated ridges between the rows of zooecia (after Nickles and Bassler, 1900).

Synocladia irregularis n. sp.
Plate 66; Table 5.20.

Holotype - UTGD 127623; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is robust, overall colony form is unknown. The mesh spacing is open but irregular. The zooecia are in 2 to 3 rows on both the primary and lateral branches. Both the primary and lateral branches are wide and robust, with a straight proximodistal trace and a flattened to gently rounded surface profile. Branch spacing is wide and irregular, with approximately 5 to 5.5 primary branches in 10 mm. The fenestrules are large and irregularly ovate to rounded crescent shaped. There are approximately 5 to 5.5 in 10 mm.

The autozooecial apertures are regularly large and circular, with thin complete peristomes. There are 6 to 7 between lateral branch centres, and approximately 15 in 5 mm. The apertures are spaced the same on both primary and lateral branches. Large cyclozooecia are irregularly spaced between the apertures of both the primary and lateral branches, and are also present on the reverse surfaces of the branches.

Intermediate sized stellate nodes are irregularly widely spaced between the apertures on the primary branches. Small stylets are closely spaced across the obverse and reverse surfaces of both the primary and lateral branches. Small macrostylets are closely and evenly spaced across the reverse surface of both the primary and lateral branches.

The autozooecial living chambers are large, and are biserially emplaced with a straight to sinuous axial wall trace. On the primary branches the chamber outline is tetragonal at mid chamber level, and tetragonal to usually pentagonal on the lateral branches. The reverse wall budding angle is constant and low, mean 51°. The lateral wall budding angle is low but variable, mean 4°. The three dimensionally reconstructed chamber form is a tetragonal tube. The skeletal granular layer is thin but well developed, and the lamellar skeleton is thick.

Synocladia irregularis n. sp.	X	SD	Min	Max	N	CV
rows zooecia primary branch	2.500	0.535	2	3	8	21 381
rows zooecia lateral branch	2.500	0.535	2	3	8	21.381
distance between branch centres	1.943	0 394	1.25	2 33	6	20 253
primary branch width	0.810	0 064	0.7	0.92	13	7 901
lateral branch width	0.865	0.081	0.76	1.04	11	9.384
fenestrule length	1.101	0 123	0.93	1 33	8	11 158
fenestrule width	1.010	0.304	0.66	1.43	5	30 096
apert. between lateral branch centres	6.500	0 824	5	8	15	12 673
aperture diameter	0.195	0 013	0.18	0.22	20	6 615
apertural spacing down branch	0.333	0 023	0.3	0.38	20	6.913
apertural spacing across branch	0.342	0 035	0.26	0 39	19	10 229
apertural spacing between lateral br.	0.790	0 111	0.64	0 98	6	14 004
width peristome	0.006	0 001	0 003	0 008	18	24.674
node diameter	0 098	0.025	0 06	0.14	9	25 677
diameter obverse stylets	0.008	0 002	0.005	0 01	20	19 237
spacing obverse stylets	0 021	0.005	0 015	0.03	18	22 450
diameter cyclozooecia	0 138	0.012	0 12	0 17	20	8 345
diameter reverse microstylets	0.005	0 002	0.001	0 008	20	38 262
spacing reverse microstylets	0.016	0.006	0.01	0.03	20	36.481
diameter reverse macrostylets	0.025	0 011	0 01	0.05	14	45 431
spacing reverse macrostylets	0.161	0.056	0 08	0.25	14	34.705
thickness reverse wall granular layer	0.014	0 002	0.01	0.018	10	17 891
thickness lateral wall granular layer	0.021	0.004	0 018	0.035	13	21 515
thickness frontal wall lamellar layer	0.401	0.057	0.31	0 46	8	14.188
thickness reverse wall lamellar layer	0.381	0 045	0.33	0.46	8	11 850
chamber length	0.287	0.029	0 24	0.35	17	10.007
chamber depth	0.383	0 031	0 34	0.44	9	8 041
maximum chamber width	0.196	0.017	0 17	0 24	20	8.821
vestibule length	0.226	0.060	0 14	0 3	5	26.475
reverse wall budding angle	51 286	1.799	49	54	7	3 509
lateral wall budding angle	3.889	2.892	0	9	9	74 354
branch thickness	1.172	0 101	1.01	1.36	14	8 587

Table 5 20 - Summary measurements for *Synocladia irregularis* n sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Description - External features - The zoarium is robust, overall colony form is unknown. The mesh spacing is open but irregular, according to bifurcation of primary branches and interpolation of lateral branches. The zooecia are in 2 to 3 rows on both the primary and lateral branches.

The primary branches are wide and robust, with a straight proximodistal trace and a flattened to gently rounded surface profile. Branch spacing is wide and irregular, with approximately 5 to 5.5 primary branches in 10 mm. The lateral branches are of a similar or slightly wider width than the primary branches, and are also straight with a flattened to gently rounded surface profile. The lateral branch extend at an angle, at regular intervals along the primary branches. The lateral branches are flush with the obverse and reverse surfaces of the primary branch. The fenestrules are large and irregularly ovate to rounded crescent shaped. The size and shape of the fenestrules vary with spacing of the primary branches, and the junction of the lateral branches. There are usually 5 to 5.5 fenestrules in 5 mm. The fenestrules are generally ovate immediately after a bifurcation and become larger and more clearly crescent shaped towards the next bifurcation of interpolation of lateral branches.

The autozooecial apertures are regularly large and circular, with thin complete peristomes that are without apertural stylets. The apertures are regularly spaced with 6 to 7 between lateral branch centres, and approximately 15 in 5 mm. The apertures are spaced the same on both primary and lateral branches. The ratio of mean apertural spacing down to across the branches is almost 1:1, and down the primary branch to between lateral branches 3:7. The apertures open upwards parallel to the obverse surface, and do not indent the fenestrules. Large cyclozooecia are irregularly spaced between the apertures of both the primary and lateral branches, and are also present on the reverse surfaces of the branches.

The obverse surface of the branch is without a carina. Intermediate sized stellate nodes are irregularly widely spaced between the apertures on the primary branches. Small stylets are closely spaced across the obverse and reverse surfaces of both the primary and lateral branches. Small macrostylets are closely and evenly spaced across the reverse surface of both the primary and lateral branches, and are aligned along the longitudinal striae.

Internal features - The branches are ovate to elliptical in cross section, with their long axis perpendicular to the plane of the obverse and reverse surfaces. The ratio of mean primary branch width to thickness is 7:10.

The autozooecial living chambers are large, and are biserially emplaced with a straight to sinuous axial wall trace. The greatest chamber dimension is parallel to the proximal and distal lateral walls. On the primary branches the chamber outline is tetragonal near the reverse wall and at mid chamber level, becoming ovate towards the obverse surface. Chamber outline is tetragonal to usually pentagonal on the lateral branches. The aperture is located distally to the living chamber on a long vestibule. Chamber outlines and dimensions are regular, with the ratio of mean maximum width to depth 1:2, and depth to length 4:3. The reverse wall budding angle is constant and low, with a range of 49° to 54° (mean 51°). The lateral wall budding angle is low but variable, with a range of 0° to 9° (mean 4°). The three dimensionally reconstructed chamber form is a tetragonal tube (primary branches) or a pentagonal tube (lateral branches).

The skeletal granular layer is thin but well developed, with continuity seen between chambers, apertures, nodes and cyclozooecia and between adjacent branches. The lamellar skeletal layer is thick, and of similar thickness in both the reverse and frontal walls.

Discussion - *Synocladia irregularis* n. sp. is most similar to the Western Australian species *S. teicherti* Crockford (1957) and *S. spinosa* Crockford (1944a). *S. irregularis* can be distinguished from *S. teicherti* by the greater number of rows and closer spacing of zooecia in the later, and from *S. spinosa* by the much larger nodes in that species.

Types - UTGD 127623 holotype; Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for its irregular mesh and zooecial row number.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Family ACANTHOCLADIIDAE Zittel, 1880
Subfamily DIPLOPORARIINAE Vine, 1883
Genus *Penniretepora* Orbigny, 1849

Type species - *Retepora pluma* Phillips, 1827; Lower Carboniferous, England.

Diagnosis - Zoarium pinnate, both main branch and lateral branches with 2 rows of zooecia. Lateral branches alternate of the main branch in the same plane. The lateral branches are without dissepiments. A carina is present along the midline of the main branch, with or without a single row of nodes. A less defined carina is present on the lateral branches. Zooecial chamber outline variably tetragonal to triangular.

Penniretepora subtropica n. sp.
Plate 67; Table 5.21.

Holotype - UTGD 127624, Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is delicate, with 2 rows of zooecia on both the main and lateral branches. The lateral branches alternate along the main branch, originating in pairs. Both the main and lateral branches are thin and delicate, with a low angular surface profile. The lateral branches are narrower than the main branch. The lateral branches are short with often only 2 to 3 zooecia, and originate at a high angle to the main branch. The lateral branches are regularly spaced, with 12 in 10 mm along each side of the main branch. The autozooecial apertures are small and circular and open inclined towards the side of the branches. The apertures are evenly spaced with 2 apertures between lateral branch centres and 13 in 5 mm along the main branch.

Along the midline of the main and lateral branches is a low carina, that on the main branch carries a row of widely spaced small circular nodes. The carina of the lateral branches originates from the carina of the main branch. Small stylets are evenly spaced across the obverse and reverse surfaces of the main and lateral branches.

The autozooecial living chambers are of small to intermediate size, and are biserially emplaced with a wide zigzag axial wall trace. The chamber outline is the same on both main and lateral branches, and is rounded triangular at mid chamber level. The chambers are located slightly abaxial distally to the living chamber on a long vestibule. The autozooecial chambers are separated between each row, increasing the spacing of the apertures in comparison to the size of the chamber. The reverse wall budding angle is consistently high, mean 81°. The lateral wall budding angle is quite variable. The three dimensionally reconstructed chamber form is an almost upright triangular box.

The granular skeletal layer is thin but well developed. The lamellar skeletal layer is thick, and is thicker in the reverse wall than in the frontal wall.

Description - External features - The zoarium is delicate, with 2 rows of zooecia on both the main and lateral branches. The main branch bifurcates at wide intervals, with new branches extending at right angles to the initial main branch. The lateral branches alternate along the main branch, originating in pairs, so that while they do alternate, they almost appear to bifurcate at the same level of the branch.

The main branch is thin and delicate, with a straight to gently curved proximodistal trace and a low angular surface profile. The lateral branches are also thin and delicate, and are narrower than the main branch. The lateral branches are short with often only 2 to 3 zooecia. The lateral branches originate at a high angle to the main branch, with a range of 67° to 80° (mean 73°). The lateral branches are regularly spaced, with 12 in 10 mm along one side of the main branch.

The autozooecial apertures are small and circular, without a peristome or stylets. The apertures open inclined towards the side of the branches but do not protrude from the branch edge. The apertures are evenly spaced with 2 apertures between lateral branch centres, regularly placed with one placed opposite the base of the lateral branch, and one opposite the intervening space. There are 13 apertures in 5 mm along the main branch. The ratio of mean apertural spacing down to across the branch is 7:6.

Along the midline of the main and lateral branches is a low carina. The carina is more prominent on the main branch and here carries a row of widely spaced small circular nodes. The carina of the lateral branches originates from that of the main branch, and alternates in the same way as the branches themselves. Small stylets are evenly spaced across the obverse and reverse surfaces of the main and lateral branches. Macrostylets are not seen on the reverse surface.

Penniretepora subtropica n. sp.	X	SD	Min	Max	N	CV
lateral branches in 10 mm.	12	0	12	12	3	0
distance between lateral branch centres	0.795	0 043	0.73	0 9	17	5 343
width main branch	0.632	0 024	0.58	0 675	17	3 733
width lateral branch	0.340	0 049	0.28	0.45	17	14 401
lateral branch angle	73 429	4 117	67	80	7	5 607
zooecia in 5 mm.	13	0	13	13	2	0
zooecia between lateral branch centres	2	0	2	2	10	0
aperture diameter	0 082	0.003	0.08	0.085	3	3 535
apertural spacing down branch	0 413	0 027	0.37	0 46	14	6 638
apertural spacing across branch	0 352	0.023	0.32	0.39	10	6 434
diameter obverse stylets	0.007	0.002	0 005	0.01	20	26 658
spacing obverse stylets	0.022	0.006	0.015	0 035	20	26 079
thickness reverse wall granular layer	0 009	0 002	0.008	0.015	12	23 094
thickness lateral wall granular layer	0.106	0.009	0 09	0 12	13	8.844
thickness frontal wall lamellar layer	0.181	0.019	0 16	0.22	7	10 405
thickness reverse wall lamellar layer	0.297	0 035	0.2	0.34	14	11 764
chamber length	0.171	0 011	0 16	0.195	13	6 530
chamber depth	0 182	0 013	0 17	0 218	13	7 240
maximum chamber width	0.139	0.012	0 12	0.16	17	8.304
reverse wall budding angle	80 600	2.951	75	84	10	3 662
lateral wall budding angle	5.600	2 702	3	10	5	48 247
thickness main branch	0.683	0.039	0.62	0 72	12	5 692
thickness lateral branch	0.340		0 34	0 34	1	

Table 5.21 - Summary measurements for *Penniretepora subtropica* n. sp Abbreviations as for Table 5 1, all measurements in millimetres.

Internal features - The main branch is ovate in cross section, with its axis of elongation perpendicular to the plane of the obverse and reverse surfaces. The lateral branches are not as thick as the main branch and are circular in cross section.

The autozooecial living chambers are of small to intermediate size, and are biserially emplaced with a wide zigzag axial wall trace. The chamber outline is the same on both main and lateral branches, and is rounded triangular near the reverse and at mid chamber levels, becoming ovate to pyriform near the obverse surface. The chambers are located slightly abaxial distally to the living chamber on a long vestibule. The rows of autozooecial chambers are separated, increasing the spacing of the apertures in comparison to the size of the chamber. The ratio of mean chamber maximum width to depth is 3:4, and depth to length almost 1:1. The reverse wall budding angle is consistently high, with a range of 75° to 84° (mean 81°). The lateral wall budding angle is quite variable, with a range of 3° to 10° (mean 51°). The three dimensionally reconstructed chamber form is an almost upright triangular box.

The granular skeletal layer is thin but well developed. The lamellar skeletal layer is thick, and is thicker in the reverse wall than in the frontal wall. The chambers between each row are well separated, but internal skeletal preservation is not consistent throughout the specimen. It is not clear whether granular or lamellar skeleton separates the chambers so widely, although it is probably lamellar skeletal material.

Discussion - *Penniretepora subtropica* n. sp. is most similar to *P. tropica* and *P. microtropica*, both described by Sakagami (1966b) from Ko Muk. *P. subtropica* can be distinguished by its narrower main and lateral branches, and slightly wider spacing of both zooecia and lateral branches. Of the West Australian Permian species, *P. subtropica* n. sp. is similar to *P. granulata* Crockford (1944a), but can be distinguished by the very wide spacing of the lateral branches in the later.

Types - UTGD 127624 holotype, Ratburi Limestone, Ko Phi Phi Don.
Etymology - Named for its similarity to *P. tropica* Sakagami (1966b).
Material - Only the type material listed above was examined.
Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Subfamily ACANTHOCLADIINAE Zittel 1880
Genus *Acanthocladia* King, 1849

Type species - *Keratophytes anceps* Schlotheim, 1820; Permian.
Diagnosis - Zoarium pinnate, with a thick main branch and numerous lateral branches. Lateral branches arranged alternately on each side of the main branch at an oblique angle. There are no dissepiments between lateral branches. Zooecia in more than 2 rows on main branch. Chamber outline variable elongate rhombic, hexagonal to quadrate.

Acanthocladia pseudothaiensis n. sp.
Plate 68; Table 5.22.

Holotype - UTGD 127625, Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is robust, with the zooecia usually in 3 to 5 rows on the main branch, and usually 4 to 6 rows on the lateral branches.
The main branch is straight, robust and very wide, with a rounded surface profile. The lateral branches are not as wide or thick as the main branch. There are 4 to 4.5 lateral branches in 10 mm along one side of the main branch. The lateral branches arise at a mean angle of 66° from the main branch.
The autozooecial apertures are regularly spaced down the main branch, with 5 to 7 apertures between lateral branch centres, and 11 to 12 apertures in 5 mm along the branch. The autozooecial apertures are circular and of intermediate size.
The obverse surface is without carinae but has circular nodes of intermediate size arranged between the rows of apertures. The obverse and reverse surfaces of the branch are covered with small closely spaced stylets. Large macrostylets are present on the reverse surface.
The autozooecial living chambers are large and polyserially emplaced with a gently zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and lateral chamber walls. The chamber outline in the main branch is rounded rhomboidal to almost quadrangular at mid chamber levels, and rhomboidal to pentagonal on lateral branches. The reverse wall budding angle is low and regular, mean 46°. The lateral wall budding angle is variable between 2° and 18°. The three dimensionally reconstructed chamber form is an elongate rounded polygonal tube.
The skeletal granular layer is thin but well-developed, and the lamellar skeleton is very thick.
Description - External features - The zoarium is robust, with a strong main branch, and wide lateral branches. The zooecia are usually in 3 to 5 rows on the main branch, with usually 4 to 6 rows on the lateral branches.
The main branch is straight, robust and very wide, with a rounded surface profile. The lateral branches are also straight and robust, with a rounded surface profile, but are not as wide or thick as the main branch. The lateral branches are regularly spaced along the main branch with 4 to 4.5 in 10 mm along one side of the main branch. The lateral branches arise at a regular angle from the main branch. The total range of the lateral branch angle is 49° to 70°, with a mean of 66°.
The autozooecial apertures are regularly spaced down the main branch, with 5 to 7 apertures between lateral branch centres. The ratio of mean apertural spacing down to across the branch is 5:4. There are 11 to 12 apertures in 5 mm along the branch. The apertural spacing is similar on both the main and lateral branches. The autozooecial apertures are circular and of intermediate size. Discrete peristomes are absent. The apertures open parallel to the profile of the obverse surface, and lateral rows of apertures are inclined

at an angle to the plane of the obverse surface.

The obverse surface is without carinae between the rows of zooecia. Circular nodes of intermediate size are arranged between the rows of apertures. Node spacing is regularly close to intermediate. The obverse and reverse surfaces of the branch are covered with small closely spaced stylets, that are evenly spaced across the main and lateral branches. Large macrostylets are present on the reverse surface, and are closely and regularly spaced. The reverse micro- and macrostylets are of a generally similar size and spacing to the obverse stylets and nodes of the obverse surface.

Acanthocladia psuedothaiensis n.sp.	X	SD	Min	Max	N	CV
rows of zooecia, main branch	3.778	0.751	3	6	27	19.881
rows of zooecia, lateral branches	5 000	0 743	4	7	30	14.856
lateral branches in 10 mm.	4.200	0 258	4	4 5	10	6.148
distance between lateral branch centres	2 531	0 152	2 25	2 9	25	5 986
width main branch	1.506	0.265	1.03	2.28	26	17.625
width lateral branch	1.157	0.158	0.91	1.47	25	13.636
zooecia in 5 mm.	11.571	0 535	11	12	7	4.619
lateral branch angle	62.150	5.687	49	70	20	9 151
zooecia between lateral branch centres	5.974	0.485	5	7	19	8 122
aperture diameter	0.139	0.011	0.11	0.16	51	7.884
apertural spacing down branch	0.463	0 054	0.34	0.62	54	11 684
apertural spacing across branch	0.368	0 035	0.3	0.44	50	9 617
diameter nodes	0 106	0 016	0 08	0 14	14	15 055
node spacing down branch	0 274	0 047	0 2	0 38	14	17 304
diameter obverse stylets	0 009	0.002	0 01	0.011	29	16.774
spacing obverse stylets	0.018	0.005	0 01	0 03	32	27.958
diameter reverse microstylets	0.009	0.002	0.01	0 011	20	21.240
spacing reverse microstylets	0.019	0 003	0.02	0.03	19	15 576
diameter reverse macrostylets	0 131	0 023	0 1	0 18	25	17 142
spacing reverse macrostylets	0.302	0.072	0 15	0 48	24	23 887
thickness reverse wall granular layer	0 016	0.004	0.01	0 02	16	22.822
thickness lateral wall granular layer	0.022	0 005	0 013	0.03	29	21 855
thickness frontal wall lamellar layer	0.346	0 030	0 3	0.4	15	8 777
thickness reverse wall lamellar layer	0.622	0.205	0 4	1.16	13	32 926
chamber length	0.479	0.058	0 38	0.64	17	12.104
chamber depth	0 228	0.028	0 2	0.28	18	12.215
maximum chamber width	0 187	0.020	0 14	0 24	55	10.764
minimum chamber width	0 090	0.037	0	0 17	54	41.655
vestibule length	0.346	0 089	0.22	0.43	8	25 794
reverse wall budding angle	45 933	5.861	34	54	15	12 760
lateral wall budding angle - adaxial	3.600	1 140	2	5	5	31 672
lateral wall budding angle - abaxial	15.200	2 387	12	18	5	15 707
thickness main branch	1.333	0.308	1 03	1.93	6	23 105
thickness lateral branch	0.7		0.7	0.7	1	

Table 5.22 - Summary measurements for *Acanthocladia pseudothaiensis* n. sp. Abbreviations as for Table 5.1, all measurements in millimetres

Internal features - Both the main and lateral branches are elliptical in cross section, with their long axis parallel to the plane of the obverse and reverse surfaces. The lateral branches are almost half the thickness of the main branch, and are flush on the obverse surface, but strongly recessed on the reverse surface.

The autozooecial living chambers are large and polyserially emplaced with a gently zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and lateral chamber walls. The chamber outline in the main branch is rounded rhomboidal to almost quadrangular near the reverse surface and at mid chamber levels, and becomes ovate towards the obverse surface. In lateral branches chamber outlines are rhomboidal to pentagonal. Chamber dimensions are regular, except for minimum chamber width, which varies greatly according to the rhomboidal or nearly quadrate shape of the chambers on the main branch. The ratio of mean minimum to maximum chamber width is approximately 1:2, maximum width to depth 4:5, and depth to length almost 1:2. The apertures are located distally to the living chamber on a long and distinct vestibule. The reverse wall budding angle is low and regular, with a range of 34° to 54° (mean 46°). The lateral wall budding angle is variable according to positioning in adaxial or abaxial rows. In median rows the lateral wall budding angle is as low as 2° and increases up to 18° in outermost lateral rows. The three dimensionally reconstructed chamber form is an elongate rounded polygonal tube. The skeletal granular layer is thin but well developed, with continuity seen between chambers of the main and lateral branches. The obverse and reverse nodes and stylets are apparently developed within lamellar skeleton, but this may be an artifact of preservation. The lamellar skeleton is very thick, particularly on the reverse surface of the main branch. The lamellar skeleton is thicker in the reverse wall than in the frontal wall.

Discussion - *Acanthocladia pseudothaiensis* n. sp. is a robust species, and can be readily distinguished from most species by the number of rows of zooecia and branch thickness. *A. pseudothaiensis* n. sp. is very similar to *A. thaiensis* Sakagami (1968a) from the Ratburi Limestone at Khao Phrik. *A. pseudothaiensis* can be distinguished only by the greater number of zooecia in 5 mm and the absence of reverse macrostylets in *A. thaiensis*.

Types - UTGD 127625 holotype, UTGD 127626-28 paratypes; all from the Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for its similarity to *A. thaiensis*.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Acanthocladia suprangularis n. sp.
Plate 69; Table 5.23.

Holotype - UTGD 127629, Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is robust, with zooecia usually in 4 to 5 rows on the main branch, and 4 to 6 rows on the lateral branches. The main branch is straight, robust and very wide with a rounded surface profile and straight proximodistal trace. The lateral branches are also robust, but not as wide as the main branch. There are 4 to 4.5 lateral branches in 10 mm along one side of the main branch. The lateral branches arise at a high and regular angle from the main branch, typically 75° to 85°.

The autozooecial apertures are regularly circular and of intermediate size, and are evenly spaced, with 5.5 to 7 between lateral branch centres and 10 to 12 in 5 mm along the main branch. Circular nodes of small to intermediate size are irregularly developed on the obverse surface. On both the reverse and obverse surfaces of the branch small closely spaced stylets are developed, and large macrostylets are developed on the reverse surface of the main branch.

The autozooecial living chambers are large and polyserially emplaced with a straight to gently zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and distal lateral walls. The chamber outline is rectangular to occasionally hexagonal at mid chamber level, and is rhombic to hexagonal in the lateral branches. The reverse wall budding angle is low but slightly variable, mean 43°. The lateral wall budding angle is highly variable. The three dimensionally reconstructed chamber form is elongate rectangular box.

The skeletal granular layer is thin and the lamellar skeleton is thick.

Description - External features - The zoarium is robust, with a wide main branch and wide lateral branches. The zooecia are in usually 4 to 5 rows on the main branch, and usually 4 to 6 rows on the lateral branches. The main branch is thick and rounded and appearing as strong and riblike when viewed from the reverse. The lateral branches are slightly more flattened on the reverse and are strongly recessed from the plane of the reverse main branch surface.

The main branch is straight, robust and very wide with a rounded surface profile and straight proximodistal trace. The lateral branches are also wide and robust, and quite short. The lateral branches are evenly spaced alternately along the main branch, with 4 to 4.5 in 10 mm along one side of the main branch. The lateral branches arise at a high and regular angle from the main branch. The lateral branch angle is typically 75° to 85°, with a total range of 73° to 89° and a mean of 81°.

The autozooecial apertures are regularly circular and of intermediate size, without an apparent peristome. The apertures are evenly spaced along the branch, with 5.5 to 7 between lateral branch centres and 10 to 12 in 5 mm. along the main branch. The ratio of mean apertural spacing down to across the branch is 5:4. The apertures are of similar spacing on both the main and lateral branches. The apertures open parallel to the surface profile of the rounded obverse branch surface.

The obverse branch surface is without carinae between the rows of zooecia. Circular nodes of small to intermediate size are irregularly developed between the apertures on the obverse surface. On both the reverse and obverse surfaces of the branch small closely spaced stylets are developed, and are evenly spaced across the surfaces of both the main and lateral branches. Large macrostylets are irregularly developed on the reverse surface of the main branch. The reverse macrostylets are often not well expressed, and may be covered by skeletal thickening at the base of the zoarium.

Acanthocladia suprangularis n. sp.	X	SD	Min	Max	N	CV
rows of zooecia, main branch	4.538	0.647	4	6	26	14 253
rows of zooecia, lateral branches	5 429	0 836	4	7	28	15 395
lateral branches in 10 mm	4 050	0 158	4	4 5	10	3.904
distance between lateral branch centres	2.543	0 204	2.1	2.9	28	8.018
width main branch	1.979	0.224	1 4	2 3	18	11 343
width lateral branch	1.394	0.128	1.13	1.61	36	9 181
zooecia in 5 mm	11 000	0.707	10	12	12	6 428
lateral branch angle	81 000	4.583	73	89	13	5 658
zooecia between lateral branch centres	6.156	0.397	5.5	7	16	6 442
aperture diameter	0.137	0.016	0.09	0 17	38	11.858
apertural spacing down branch	0.450	0.026	0.4	0.52	44	5 881
apertural spacing across branch	0.366	0.039	0.3	0.48	48	10.642
diameter nodes	0 088	0 019	0.06	0.12	19	21.239
node spacing down branch	0 229	0 064	0.125	0.35	15	27.861
diameter obverse stylets	0.008	0 002	0.005	0 015	55	27 067
spacing obverse stylets	0.017	0.003	0.01	0.025	51	19.468
diameter reverse microstylets	0.008	0.002	0.005	0.011	28	26 408
spacing reverse microstylets	0.018	0.005	0.01	0 03	26	25.529
diameter reverse macrostylets	0.143	0.027	0.09	0.195	22	18 987
spacing reverse macrostylets	0.283	0 065	0.2	0.42	20	22 938
thickness reverse wall granular layer	0.016	0.004	0.01	0 02	17	22.403
thickness lateral wall granular layer	0.016	0.004	0 01	0.025	27	22 649
thickness frontal wall lamellar layer	0.415	0.100	0 24	0.58	17	24.205
thickness reverse wall lamellar layer	0.759	0 148	0.6	0.98	9	19.493
chamber length	0.509	0.061	0.4	0 62	19	12 021
chamber depth	0.216	0.041	0.16	0 3	20	19.249
maximum chamber width	0.185	0.019	0 15	0.22	27	10 523
minimum chamber width	0.124	0.031	0.06	0.18	23	25.051
vestibule length	0.448	0 032	0 42	0.48	4	7.154
reverse wall budding angle	43.333	6.011	31	54	21	13 872
lateral wall budding angle - adaxial	7.625	4 033	0	12	8	52.896
lateral wall budding angle - abaxial	20 727	11 208	8	44	11	54 073
thickness main branch	1.83	0.414	1.42	2 3	5	22 643

Table 5.23 - Summary measurements for *Acanthocladia suprangularis* n sp. Abbreviations as for Table 5 1, all measurements in millimetres.

<u>Internal features</u> - The main branch is circular to ovate in cross section, with the direction of elongation usually parallel to the plane of the obverse and reverse surface. The lateral

branches are not as thick as the main branch and are circular in outline.

The autozooecial living chambers are large and polyserially emplaced with a straight to gently zigzag axial wall trace. The greatest chamber dimension is parallel to the proximal and distal lateral walls. The chamber outline is hexagonal to rectangular near the reverse surface, rectangular to occasionally hexagonal at mid chamber level and becoming ovate towards the obverse surface. The chamber outline in the lateral branches is more commonly rhombic to hexagonal than rectangular. The aperture is located distally to the living chamber on a long and usually distinct vestibule. Chamber dimensions are slightly variable, with the ratio of mean minimum to maximum chamber width 2:3, maximum width to depth 6:7, and depth to length 3:7. The reverse wall budding angle is low but slightly variable, with a range of 31° to 54° (mean 43°). The lateral wall budding angle is highly variable depending on the position of the chamber. In median rows the lateral wall budding angle may be as low as 0°, increasing steadily to 44° in outermost lateral rows. The three dimensionally reconstructed chamber form is elongate rectangular box.

The skeletal granular layer is thin but well developed about the chambers of both the main and lateral branches. The lamellar skeleton is thick, and is much thicker in the reverse wall than in the frontal wall.

Discussion - *Acanthocladia suprangularis* n. sp. is very similar to *A. pseudothaiensis* n. sp. described above from the same units. *A. suprangularis* can only be distinguished by the consistently higher angle of the lateral branches, and slightly thicker branches. A number of specimens of each species were available for study and the difference in the lateral branch angle was consistent.

A. suprangularis can be distinguished from the robust *A. tundrica* Krutchinina from Permian units of the Arctic (Morozova and Krutchinina, 1986), by the greater number of zooecia along the branch.

Types - UTGD 127629 holotype, UTGD 127630-32 paratypes; all from the Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the high angle of the lateral branches.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

5.2.2 - ***Order Trepostomata.***

Systematics after Goryunova (1996) and Boardman *et al.* (1983). Description parameters given in Appendix Two.

Order TREPOSTOMATA Ulrich, 1882
Suborder AMPLEXOPORINA Astrova, 1965
Family MONTICULIPORIDAE Nicholson, 1881
Subfamily HETEROTRYPINAE Ulrich, 1890

Genus *Paralioclema* Morozova, 1961

Type species - *P. ninae* Morozova, 1961; Upper Devonian, Kunetz Basin, Russia.

Diagnosis - Zoarium branching massive or encrusting. Autozooecial tubes with complete regularly spaced diaphragms. Acanthostyles numerous, mesozooecia of varying number. Permian taxa with thin zooecial walls, acanthostyle size variable within one colony, and wide axial canal in many acanthostyles (after Morozova, 1970).

Paralioclema phuketensis n. sp.
Plate 70; Table 5.24.

Holotype - UTGD 127633; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is robust and dendroid, with the exozone one third the radius of the branch. The zooecial tubes are thin walled in the endozone, and unevenly thickened in the exozone. The zooecial walls in tangential section are of regularly narrow to intermediate thickness. Within the zooecial tubes are thin straight to slightly concave diaphragms, that are usually very widely spaced in the endozone, and quite closely spaced in the outer exozone.

The autozooecial apertures are small and rounded polygonal, and are regularly spaced with 4 to 5 in 2 mm. The acanthostyles are large, with 0 to 3 about each autozooecial aperture. The exilazooecia are of small to intermediate size.

Description - The zoarium is robust and dendroid, but the branching characteristics are unknown. The exozone is of intermediate width and comprises one third the radius of the branch. The zooecial tubes are thin walled in the endozone. In the central endozone zooecial tubes are oriented longitudinally, and bend towards the base of the exozone. The tubes curve sharply into the exozone, the angle between the outer endozone and inner exozone variable, with a mean angle of 57°. The zooecial tubes are straight within the exozone and meet the surface at a high angle, range 87° to 94 (mean 90°). The exozone in parts of the zoarium may have thin overgrowths of further exozonal material. The zooecial walls in the exozone are unevenly thickened by usually confluent monilae. The zooecial walls in tangential section are of regularly narrow to intermediate thickness.

Within the zooecial tubes are thin straight to slightly concave diaphragms. The diaphragms are irregularly spaced, but are usually very widely spaced in the endozone, becoming quite closely spaced in the outer exozone.

The autozooecial apertures are of variable size and shape, but are usually of intermediate size and rounded polygonal shape. The apertures show no regular orientation or arrangement. The autozooecial apertures are regularly spaced with 4 to 5 in 2 mm.

The acanthostyles are of a variable but continuous large size. The acanthostyles are not abundant, with 0 to 3 about each autozooecial aperture. The exilazooecia are of small to intermediate size and are irregularly spaced. The exilazooecia are not abundant, but may be locally clustered.

Paralioclema phuketensis n. sp.	X	SD	Min	Max	N	CV
branch thickness	7.886	0.773	6.9	9	7	9 807
thickness exozone	1.454	0.252	1.06	1.9	17	17 314
angle zooecial tube endo to exozone	56.500	11 156	36	74	12	19 745
angle zooecial tube to surface	89.800	1.932	87	94	10	2 152
wall thickness endozone	0.005	0.002	0 003	0.008	34	33 318
wall thickness exozone	0.117	0.015	0.085	0 16	37	13 198
autozooecial length	0.310	0 055	0.22	0 4	40	17 719
autozooecial width	0.212	0 046	0.14	0 3	34	21.709
spacing subsequent apertural centres	0 447	0 067	0.345	0.58	28	14.941
spacing adjacent apertural centres	0.305	0.046	0.23	0.4	31	15 037
exilazooecia diameter	0.108	0.050	0.04	0.22	34	46 880
acanthostyle diameter	0.159	0.037	0.085	0.24	37	23 382
acanthostyles about autozooecium	1.675	0 797	0	3	40	47 584
diaphragm thickness	0 013	0 005	0.005	0.025	36	38 546
distance between diaphragms	0.403	0 288	0.04	1.1	25	71 331

Table 5 24 - Summary measurements for *Paralioclema phuketensis* n. sp. Abbreviations as for Table 5.1, all measurements in millimetres.

Discussion - *P. phuketensis* n. sp. is similar in appearance to *P. minax* Morozova in tangential section, but has more rounded apertures and smaller acanthostyles.

Types - UTGD 127633 holotype, UTGD 127634 paratype; Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the nearby tourist island of Ko Phuket, southern Thailand.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Family STENOPORIDAE Waagen and Wentzel, 1886
Subfamily ERIDOTRYPELLINAE Morozova, 1960

Genus *Neoeridotrypella* Morozova, 1970

Type species - *Neoeridotrypella pulchra* Morozova, 1970; Upper Permian, Kazanian, Russian Platform.
Diagnosis - Zoaria dendroid or encrusting. Autozooecia are circular, oval or polygonal, not arranged in a repetitive order. Wall thin in endozone, irregularly thickened in exozone. Capillaries numerous and randomly arranged in the walls. Diaphragms or heterophragms present in some species. Exilazooecia are generally lacking. Acanthostyles abundant and of variable size (after Gilmour *et al.*, 1997).

Neoeridotrypella subpulchra n. sp.
Plate 71; Table 5.25.

Holotype - UTGD 127635; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is delicate and dendroid. The exozone is thin and comprises only one quarter the radius of the branch. The autozooecial apertures are circular to oval, without regular orientation or arrangement, and about 5 in 2 mm. Exilazooecia are irregularly spaced. There are 2 to 4 large acanthostyles about each autozooecium. Smaller acanthostyles are irregularly developed.

Neoeridotrypella subpulchra n. sp.	X	SD	Min	Max	N	CV
zoarial thickness	3 358	0 386	3	3.9	4	11.505
exozone thickness	0.438	0.095	0.3	0 5	4	21 634
angle autozooecial tube to surface	77 250	4.992	72	82	4	6 462
wall thickness endozone	0.026	0.007	0.02	0 04	9	24 926
wall thickness exozone	0 106	0.018	0.08	0.145	20	16.716
autozooecial aperture diameter	0.342	0.038	0 28	0.42	20	10.999
distance between apertural centres	0.406	0.052	0.34	0.58	20	12 820
exilazooecia diameter	0.131	0.037	0 075	0.22	22	28.493
megacanthostyle diameter	0.164	0.014	0.14	0 18	8	8.598
megacanthostyles about autozooecium	3 000	0 926	2	4	8	30 861
microacanthostyle diameter	0.106	0.013	0.08	0 12	11	12 275
micracanthostyles about autozooecium	3.231	2.713	0	8	13	83 966

Table 5 25 - Summary measurements for *Neoeridotrypella subpulchra* n. sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Description - The zoarium is delicate and dendroid. The base of the zoarium is encrusting about a cylindrical object and the dendroid form is rapidly developed. Branching characters are unknown.
The exozone is thin and comprises only one quarter the radius of the branch. The zooecial tubes are thin walled in the endozone and curve gradually towards the exozone to open at approximately 75° to 80° to the zoarial surface. The walls in the exozone are unevenly thickened by confluent monilae, and are of narrow to intermediate thickness. The autozooecial apertures are circular to oval, without regular orientation or arrangement. The autozooecial apertures are of intermediate to large size and evenly spaced, with about 5 in 2 mm. Exilazooecia are of small to intermediate size, and are irregularly spaced. The acanthostyles are in two sizes, with 2 to 4 large acanthostyles about each autozooecium. Smaller acanthostyles are irregularly developed with 0 to 8 surrounding each autozooecium.
Discussion - *N. subpulchra* is similar to *N. pulchra* of the Russian Platform (Morozova, 1970) and North America (Gilmour and Walker, 1986), but differs in having a narrow exozone and larger autozooecial apertures.
Types - UTGD 127635, holotype; Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for its similarity to *N. pulchra* Morozova, 1970.
Material - Only the type material listed above was examined.
Occurrence - Ratburi Limestone, Ko Phi Phi Don.

5.2.3 *Order Cryptostomata.*

Systematics based on Boardman *et al.* (1983). Description parameters are given in Appendix Two.

Order CRYPTOSTOMATA Vine, 1884
Suborder RHABDOMESINA Astrova and Morozova, 1956
Family RHABDOMESIDAE Vine, 1883
Genus *Ascopora* Trautschold, 1876

Type species - *Millepora rhombifera* Phillips, 1836; Carboniferous, Yorkshire, England.
Diagnosis - Zoarium dendroid, branch diameters usually constant between bifurcations. Apertures rhombically arranged. Axial region formed by a cylindrical bundle of 4 to 30 zooecia. Axial zooecia polygonal in cross section with thin walls. Autozooccial divergence from axial bundle mostly between 20° to 45°. Zooecial bend abrupt, with living chambers commonly oriented at 90° to branch surface. Longitudinal arrangement of zooecia regular. Autozooecial diaphragms rare. One or 2 acanthostyles proximal to each zooecial chamber. Paurostyles common, in single or double rows between apertures (after Boardman *et al.*, 1983).

Ascopora robusta n. sp.
Plate 72; Table 5.26.

Holotype - UTGD 127636; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is robust, about 5.5 mm in diameter. There are about 26 to 28 tubes in the axial bundle. The axial bundle comprises about one fifth the diameter of the branch. The zooecial tubes diverge from the axial bundle at about 45°. The zooecial tubes meet the branch surface at a high angle. The zooecial tubes are thin walled in the axial bundle and endozone and are evenly thickened in the exozone.
The autozooecial apertures are regularly oval and are rhombically arranged. There are 3.5 to 4 apertures in 2 mm longitudinally, and 4 to 5 in 2 mm diagonally. Large circular acanthostyles are irregularly placed about the apertures. About 15 to 19 paurostyles surround each aperture in a single row, and occasionally they may be in 2 rows.

Ascopora robusta n. sp.	X	SD	Min	Max	N	CV
branch thickness	5.564	0.105	5.435	5.65	4	1 896
exozone thickness	1.493	0.154	1 24	1 81	12	10.309
diameter axial bundle	1 194	0.070	1 08	1 275	8	5 859
diameter axial zooecia	0.189	0 019	0 16	0 22	14	10.091
angle of divergence from axial bundle	47.833	3.664	41	53	12	7 660
angle zooecial tube to surface	76 917	5 017	69	86	12	6.523
wall thickness endozone	0.013	0.003	0 01	0.02	20	27.016
wall thickness exozone	0.264	0.038	0 21	0.36	20	14 370
aperture length	0.329	0.047	0 27	0 46	20	14 426
aperture width	0 193	0 019	0 16	0.225	20	9 953
apertural spacing longitudinally	0.568	0 116	0.43	0 82	20	20 345
apertural spacing diagonally	0.412	0 043	0.36	0.53	20	10 533
spacing axes longitudinal rows	0.374	0.026	0 33	0.43	20	6 970
acanthostyle diameter	0.151	0.020	0 12	0 2	20	13 328
paurostyle diameter	0 037	0 007	0 03	0.06	20	19 801
paurostyles about aperture	17.750	1 488	15	19	8	8 383

Table 5 26 - Summary measurements for *Ascopora robusta* n. sp. Abbreviations as for Table 5.1, all measurements in millimetres.

Description - The zoarium is dendroid and robust, about 5.5 mm in diameter. The axial bundle of zooecia is well defined, with about 26 to 28 tubes. The tubes are polygonal in outline. The axial bundle comprises about one fifth the diameter of the branch. The zooecial tubes diverge from the axial bundle at a consistent angle, with a range of 41° to 53° (mean 48°). The zooecial tubes are straight in the endozone and bend sharply from the endozone to the base of the exozone. The zooecial tubes are straight in the exozone and meet the branch surface at a high angle, with a range of 69° to 86° (mean 77°). The zooecial tubes are thin walled in the axial bundle and endozone and are evenly thickened in the exozone. Widely spaced arcuate rows of monilae cross the axial bundle and endozone, and merge with the base of the exozone.

The autozooecial apertures are regularly oval and of consistent intermediate to large size. The apertures are arranged in longitudinal and diagonal rows. The longitudinal rows of zooecia are evenly spaced. The ratio of mean aperture width to length is 3:5. The apertures are locally evenly spaced longitudinally and diagonally, but spacing may vary across the zoarium. There are 3.5 to 4 apertures in 2 mm longitudinally and 4 to 5 in 2 mm diagonally.

Large circular acanthostyles are irregularly placed about the apertures. The acanthostyles may be placed at the ends of each aperture in the same longitudinal row, or in the wall between adjacent rows, but level with the ends of the apertures. There is usually one acanthostyle associated with each aperture, but often there are none. Paurostyles are small and abundant, and develop in the outer exozone, so are not visible in deep tangential section. About 15 to 19 paurostyles surround each aperture in a single row, and occasionally they may be in 2 rows.

Discussion - *A. robusta* is most comparable to *A. magna* Sakagami, from Khao Phrik (Sakagami, 1968a), but has larger and more widely spaced zooecial apertures, with larger acanthostyles.

Types - UTGD 127636 holotype; Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the robust zoarium.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Ascopora variablis n. sp.
Plate 73; Table 5.27.

Holotype - UTGD 127638; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is of intermediate robustness with branches of variable diameter. There are usually about 40 to 45 tubes in the axial bundle, which comprises one fifth to one quarter the diameter of the branch. The zooecial tubes diverge from the axial bundle at about 43°. The boundary between the endozone and exozone is abrupt when viewed in transverse section. Zooecial walls are thick in the exozone.

The autozooecial apertures are regularly elliptical and are evenly rhombically arranged. There are about 4 apertures in 2 mm longitudinally, and 5 to 6 in 2 mm diagonally.

Large circular acanthostyles placed at the ends of each aperture in the same longitudinal row. Paurostyles are small and abundant, with approximately 13 to 17 surrounding each aperture in a single row.

Description - The zoarium is dendroid and of intermediate robustness, but branches are of variable diameter. The axial bundle of zooecia is poorly defined in transverse section but is clearly visible in longitudinal section. There are usually about 40 to 45 tubes in the axial bundle but this number is reduced for smaller zoaria. The tubes are polygonal in outline within the axial bundle. The axial bundle comprises about one fifth to one quarter the diameter of the branch. The zooecial tubes diverge from the axial bundle at a consistent angle, with a range of 38° to 52° (mean 44°). The zooecial tubes are straight in the endozone and bend sharply from the endozone to the base of the exozone. The boundary between the endozone and exozone is abrupt when viewed in cross section. The zooecial tubes meet the branch surface at a high angle, with a range of 73° to 92° (mean 83°). The zooecial tubes are thin walled in the axial bundle and endozone. In the exozone the zooecial walls are thick. The zooecial walls achieve maximum thickness at the base of, and maintain the same width throughout, the exozone.

The autozooecial apertures are regularly elliptical and of a consistently small size. The ratio of mean aperture width to length is 1:2. The apertures are evenly rhombically arranged and are evenly spaced longitudinally and diagonally. There are about 4 apertures in 2 mm longitudinally, and 5 to 6 in 2 mm. diagonally

Large circular acanthostyles placed at the ends of each aperture in the same longitudinal row. There is usually one acanthostyle associated with each aperture, but often 1 or 2 positions are missed. Paurostyles are small and abundant, with approximately 13 to 17 surrounding each aperture in a single row. However preservation is poor and consistency of paurostyle development cannot be assessed.

Ascopora variablis n sp.	X	SD	Min	Max	N	CV
branch thickness	4 278	1.041	3.28	5.36	8	24 339
exozone thickness	0.940	0.291	0.51	1.335	43	30 918
diameter axial bundle	0 972	0 130	0.78	1 14	16	13 342
number zooecial tubes in axial bundle	34.400	12.759	19	45	5	37 091
diameter axial zooecia	0.147	0.022	0.11	0.2	41	14.710
angle of divergence from axial bundle	43.618	3.742	38	52	34	8 579
angle zooecial tube to surface	83 179	4.695	73	92	39	5 645
wall thickness endozone	0.011	0.003	0.0075	0 02	47	26 237
wall thickness exozone	0.167	0.023	0.12	0.22	60	13 932
aperture length	0.291	0 037	0.2	0.395	60	12.569
aperture width	0.143	0.018	0.1	0 19	60	12 750
apertural spacing longitudinally	0.517	0.059	0 4	0 66	60	11.366
apertural spacing diagonally	0 390	0.040	0 32	0 48	60	10.287
spacing axes longitudinal rows	0.278	0.036	0 2	0 36	60	13 110
acanthostyle diameter	0 156	0.020	0.11	0.2	38	12 910
paurostyle diameter	0.045	0.005	0.035	0.05	18	11 802
paurostyles about aperture	15 13	1 246	13	17	8	8 241

Table 5.27 - Summary measurements for *Ascopora variablis* n sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Discussion - *A. variablis* is most readily distinguished by the distinct boundary between the endozone and exozone, and the very even thickness of the zooecial walls in the exozone. Despite a variation in branch diameter between different specimens, the nature of the exozone remains the same, as do the dimensions associated with zooecial size, spacing and development. It is considered that the branch thickness is associated with juvenile specimens or ecologic variation.

Types - UTGD 127638 holotype, UTGD 127637 and 127639 paratypes; Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the variation in zoarial diameter.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Rhabdomeson* Young and Young, 1874

Type species - *Millepora gracilis* Phillips, 1841; Carboniferous, North Devon, England.

Diagnosis - Zoarium usually dendroid, some zoaria or parts of zoaria conical. Cylindrical branch diameters constant between bifurcations. Apertural arrangement rhombic. Axial region formed by single hollow axial cylinder. Axial cylinder diameter usually greater than that of autozooecia. Zooecial divergence from axial cylinder 20° to 45°. Zooecial bend generally abrupt. Diaphragms rare. In cylindrical branches exozonal branches generally half radius of branch or less. One or 2 acanthostyles occur proximal to zooecial chambers, paurostyles few to common (after Boardman *et al.*, 1983).

Rhabdomeson monoformis n. sp.
Plate 74; Table 5.28.

Holotype - UTGD 127640; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is a delicate cylindrical branch about 2 mm in diameter. The axial cylinder is wide and comprises approximately one third the diameter of the branch. The exozone is thin and comprises one third the radius of the branch. The zooecial tubes diverge at a low angle to the axial cylinder, and curve very gently through the endozone and base of the exozone to meet the branch surface at an oblique angle. The zooecial walls are thick in the endozone and increase in thickness through the exozone. The autozooecia are rhombically arranged. The autozooecial apertures are small and oval, with 3 to 3.5 apertures in 2 mm longitudinally. Acanthostyles are numerous and surround the aperture and are not restricted to the proximal end of each aperture. The acanthostyles are of one size, with 11 to 13 about each aperture. Paurostyles absent.

Rhabdomeson monoformis n. sp.	X	SD	Min	Max	N	CV
branch thickness	2.017	0.029	2	2.05	3	1.431
diameter axial cylinder	0 612	0.008	0.605	0 62	3	1 249
exozone thickness	0 285	0 081	0 2	0 38	4	28 289
angle of divergence from axial cylinder	31.000	5.177	22	37	6	16.700
angle zooecial tube to surface	58.833	5.565	52	66	6	9 459
wall thickness endozone	0.018	0 005	0 01	0.028	15	27 617
wall thickness exozone	0.114	0.020	0.08	0 155	20	17.785
aperture length	0.395	0.034	0.36	0 48	20	8 693
aperture width	0.242	0.013	0 2	0.26	20	5 504
apertural spacing longitudinally	0.599	0.074	0.5	0.74	7	12 368
apertural spacing diagonally	0.368	0 045	0 31	0 46	11	12.196
apertures in 2mm longitudinally	3.100	0.224	3	3 5	5	7 213
acanthostyle diameter	0.062	0.006	0.05	0.07	20	9.516
acanthostyles about aperture	12.333	0.707	11	13	9	5 733

Table 5.28 - Summary measurements for *Rhabdomeson monoformis* n sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Description - The zoarium is a delicate cylindrical branch about 2 mm in diameter, branching characteristics unknown. The axial cylinder is large and straight, and comprises approximately one third the diameter of the branch. The exozone is thin and comprisesone third the radius of the branch, and is without diaphragms. The zooecial tubes diverge at a low angle to the axial cylinder, with a range of 22° to 37° (mean 31°). The zooecial tubes curve very gently through the endozone and base of the exozone, and meet the branch surface at a oblique angle. Range of zooecial tube angle to branch surface is 52° to 66° (mean 59°). The zooecial walls are thin in the inner endozone and increase in thickness towards and through the exozone.
The autozooecia are generally rhombically arranged, but this pattern may be obscure in parts of the zoarium. The autozooecial apertures are of intermediate to large size and oval in outline. The ratio of mean apertural width to length is 3:5. The apertures are regularly spaced longitudinally and diagonally, with 3 to 3.5 apertures in 2 mm longitudinally. Acanthostyles are numerous and surround the aperture and are not restricted to the proximal end of each aperture. The acanthostyles develop in the outer endozone to inner exozone, and have a prominent core. The acanthostyles extend above the surface as sharp spines. The acanthostyles are of small to intermediate size, with 11 to 13 about each aperture. Paurostyles are absent.
Discussion - R. *monoformis* n. sp. is distinguished from all other species of the genus, by the numerous acanthostyles of one size. This characteristic is not typical of *Rhabdomeson*, but R.

monoformis is placed here because of the axial cylinder that is diagnostic of the genus.
Types - UTGD 127640 holotype; Ratburi Limestone, Ko Phi Phi Don.
Etymology - Named for the single size of the acanthostyles.
Material - Only the type material listed above was examined.
Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Family HYPHASMOPORIDAE VINE, 1886

Genus *Streblotrypa* Vine, 1885
Subgenus *Streblotrypa (Streblascopora)* Bassler, 1952

Type species - *Streblotrypa fasciculata* Bassler, 1929; Permian, Soefa, Timor, Indonesia.
Diagnosis - Zoarium dendroid, branch diameter constant between bifurcations. Longitudinal ridges separate apertural rows. Metapores densely packed between autozooecia. Common beyond distolateral margin of zooecial apertures. Axial region a well defined bundle of axial zooecia. More than 10 zooecia in axial bundle. Zooecial divergence from axial region 20° to 30°, zooecial bend generally abrupt. Living chamber oriented about 90° to branch surface. Hemisepta rare or absent (after Boardman *et al.*, 1983).

Streblotrypa (Streblascopora) komukensis (Sakagami, 1970)
Plate 75; Table 5.29.

Streblascopora komukensis SAKAGAMI (1970a), p. 62, pl. XII, figs. 1-3.
Diagnosis - The zoarium is delicate, with a diameter of about 1 to 1.2 mm. The axial bundle has 18 to 25 zooecial tubes, and comprisesone third the diameter of the branch. The zooecia diverge from the axial bundle at a low angle, and the tubes open at 85° to 91° to the branch surface. Hemisepta are seen in the endozone.
The autozooecial apertures are arranged in longitudinal rows, with straight to sinuous longitudinal ridges between the rows. The apertures are small and oval, with 3 to 4 in 2 mm longitudinally. There are usually 10 to 12 metapores between subsequent apertures, arranged in 2 to 3 rows.

S. (Streblascopora) komukensis	X	SD	Min	Max	N	CV
branch thickness	1.118	0.051	1.07	1 2	5	4 578
diameter axial cylinder	0.365	0.108	0.26	0.52	6	29.495
number tubes in central bundle	21.500	4.950	18	25	2	23.022
exozone thickness	0 179	0 028	0.14	0 225	8	15 372
angle of divergence from axial cylinder	12 000	3 665	7	19	8	30.538
angle zooecial tube to surface	87.250	2.630	85	91	4	3.014
wall thickness endozone	0 016	0.023	0.01	0.125	24	145 525
wall thickness exozone	0.173	0 032	0.12	0.22	18	18.576
aperture length	0.182	0.023	0 14	0.22	15	12.365
aperture width	0.100	0.013	0.08	0.12	17	12 522
apertural spacing longitudinally	0.626	0.076	0.52	0.75	17	12 116
apertural spacing diagonally	0.369	0 064	0.24	0.46	14	17 435
apertures in 2mm longitudinally	3.688	0.372	3	4	8	10 088
metapore diameter	0.024	0 007	0.013	0.04	19	30 410
metapore between apertures	10 500	1.269	9	13	10	12 089

Table 5.29 - Summary measurements for *Streblotrypa (Streblascopora) komukensis* (Sakagami). Abbreviations as for Table 5 1, all measurements in millimetres.

Description - The zoarium is dendroid and delicate, with a diameter of about 1 to 1.2 mm. Branching characteristics are unknown, one bifurcation is partially seen, but the zoarium is broken at this point.
The axial bundle has 18 to 25 zooecial tubes, and is clearly defined. The axial bundle

comprises one third the diameter of the branch. The zooecia diverge from the axial bundle at a low angle, with a range of 7° to 19° (mean 12°). The bend into the vestibule is sharp, and the tubes open at 85° to 91° to the branch surface. The tubes are thin walled in the endozone and are evenly thickened in the exozone. Hemisepta are occasionally seen in endozone, but preservation is poor, and true characters of hemisepta are not visible.

The autozooecial apertures are arranged in longitudinal rows, with straight to sinuous longitudinal ridges between the rows. The apertures are small and oval, with the ratio of mean width to length 5:9. The apertures are regularly spaced, both within the same row and between rows. There are 3 to 4 apertures in 2 mm longitudinally.

The metapores arise from the autozooecial tube wall at the base of the exozone, and bend sharply to the branch surface. The metapores are small with a rounded outline. There are usually 10 to 12 metapores between subsequent apertures, arranged in 2 to 3 rows.

Discussion - *Streblotrypa (Streblascopora) komukensis* (Sakagami) was first described from the Ratburi Limestone of Ko Muk by Sakagami (1970a) as *Streblascopora*. This genus has since been given subgenus status within *Streblotrypa*. *S. (S.) komukensis* is similar to *S. (S.) marmionensis* Bretnall of Western Australia, but differs in the presence of hemisepta in *komukensis*, and the lower divergence angle of the zooecial tubes.

Material - Three specimens (UTGD 127641-42) were examined from the Ratburi Limestone, Ko Phi Phi Don.

Occurrence - Ratburi Limestone, Ko Phi Phi Don and Ko Muk.

5.2.4 - ***Order Cystoporata.***

Systematics based on Boardman *et al.* (1983). Description parameters given in Appendix Three.

Order CYSTOPORATA Astrova, 1964
Suborder FISTULIPORINA Astrova, 1964
Family FISTULIPORIDAE Ulrich, 1882
Genus - *Cyclotrypa* Ulrich 1896

Type species - *Fistulipora communis* Ulrich,1890; Cedar Valley Formation, Middle Devonian, Iowa.

Diagnosis - Zoarium encrusting or ramose. Monticules low with a central cluster of vesicles surrounded by large zooecia. Autozooecia circular and surrounded by vesicular tissue. Zooecial tubes with thin diaphragms. Lunaria absent. Vesicles as low blisterlike cysts, decreasing in height from endo to exozone (after Boardman *et al.*, 1983).

Cyclotrypa dendroides n. sp.
Plate 76; Table 5.30.

Holotype - UTGD 127643; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is robust and ramose. The zooecial apertures are evenly and regularly circular and of small size. Lunaria are absent. There are usually 5.5 apertures in 2 mm. The monticules show a central area of vesicular or solid tissue, and a ring of small to intermediate sized zooecia. The endozone is wide and comprises one half to one third the branch diameter. The zooecial tubes are circular, and bend gradually towards the exozone, to meet the zoarial surface at right angles. Diaphragms are widely spaced in the endozone, and more closely spaced in the exozone.

In the central endozone the vesicles are long and elongate, with a few blisterlike vesicles seen at the endozone exozone boundary, before being obscured by the dense tissue of the exozone.

Description - External features - The zoarium is robust and ramose. The specimen was buried in rock and the surface was not available for external examination, but thin sectioning reveals numerous monticules. The monticules show a central area of vesicular or solid tissue, and a ring of small to intermediate sized zooecia. A zooecium of intermediate size may or may not be present in the centre of the monticule.

The zooecial apertures are evenly and regularly circular and of small size. Apart from the regular arrangement about monticules, the zooecia are not regularly arranged in intermonticular areas. Lunaria are absent. The apertures are closely spaced with usually 5.5 apertures in 2 mm.

Cyclotrypa dendroides n sp	X	SD	Min	Max	N	CV
thickness zoarium	9		9	9	1	
zooecial diameter	0.204	0.012	0.185	0.23	20	5.905
zooecial diameter, monticule	0.257	0.017	0.23	0 3	20	6 665
number of autozooecia in 2mm	5.432	0.420	5	6.5	11	7 726
distance between apertural centres	0.327	0.040	0.26	0 4	20	12 181
wall thickness, endozone	0 009	0.002	0 005	0.01	15	21.670
number vesicles in 1mm horizontally	7.200	0.837	6	8	5	11.620
rows of vesicles between autozooecia	1.200	0.523	0	2	20	43.596

Table 5.30 - Summary measurements for *Cyclotrypa dendroides* n. sp. Abbreviations as for Table 5.1, all measurements are in millimetres.

Internal features - The endozone is wide and comprises one half to one third the branch diameter. The zooecial tubes are circular throughout both the endozone and exozone. The tubes are oriented proximodistally in the centre of the exozone, and bend gradually towards the exozone, to meet the zoarial surface at right angles. The zooecial tubes contain diaphragms, that are widely spaced in the endozone, and more closely spaced in the exozone.

The zooecial tubes are separated by vesicular material, that is replaced by dense tissue at or near the base of the exozone. In the central endozone the vesicles are long and elongate, with a few blisterlike vesicles seen at the endozone exozone boundary, before being obscured by dense tissue. In tangential section the vesicles are irregularly polygonal and angular. There are usually 1 to 2 rows of vesicles between zooecial tubes, and there are 6 to 8 vesicles in 1 mm in tangential section.

Discussion - *Cyclotrypa dendroides* n. sp. exhibits a ramose or dendroid zoarium which is not common within *Cyclotrypa*, but has been recorded in Russian faunas. *C. dendroides* n. sp. can be distinguished from *C. multiformis* Goryunova (1964) by the open vesicular material in the exozone and more closely spaced diaphragms in the later. *C. distincta* Morozova from the Arctic region (Morozova and Krutchinina, 1986), is also similar, but again differs in the open vesicular tissue of the exozone, and its slightly larger and more widely spaced zooecial apertures.

Types - UTGD 127643, holotype, Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the ramose or dendroid form of the zoarium.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Eridopora* Ulrich, 1882

Type species - *Eridopora macrostoma* Ulrich, 1882; Glen Dean Formation, Upper Mississippian, Kentucky.

Diagnosis - Zoarium encrusting. Monticules small and flush with a cluster of central vesicles. Autozooecia hemispherical in basal layer in cross section. Autozooecia isolated by vesicular tissue. In exozone autozooecia either oblique to the zoarial surface with a pyriform aperture, or subperpendicular to the surface with apertures more circular. Lunarium large. Vesicles in endo and exozone small low blisters. Stereom thin at the surface (after Boardman *et al.*, 1983).

Eridopora thaiensis n. sp.
Plate 77; Table 5.31.

Holotype - UTGD 127644, Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is delicate and encrusting. The autozooecial apertures are pyriform to rounded triangular and of intermediate size. The apertures are of regular intermediate spacing, with usually 3 to 4 apertures in 2 mm. diagonally. Monticules have a central enlarged triangular aperture in a cluster of vesicular tissue. The lunarium is thin but large, and comprising approximately three quarters of the circumference of the aperture. The autozooecial tubes are circular and separated by 1 to 2 rows of vesicular tissue. The tubes are at an angle to the zoarial. The vesicles are blisterlike in cross section. In tangential section there are usually 10 to 11 vesicles in 1 mm horizontally. Thin straight to curved diaphragms are present within the zooecial tubes.
Description - External features - The zoarium is delicate and encrusting. Monticules are not conspicuous, but can be seen in thin section, with a central enlarged triangular aperture in a cluster of vesicular tissue. The apertures do not show a regular arrangement about the monticule and its central triangular apertures. The autozooecial apertures are pyriform to rounded triangular and of intermediate size. The apertures are of regular intermediate spacing, with usually 3 to 4 apertures in 2 mm diagonally. The lunarium is thin but large, and comprising approximately three quarters of the circumference of the aperture. The lunarium is located at the apex of the aperture, opposite the more rounded margin. The lunarium does not indent the aperture in the holotype, but the paratype shows a distinct inflection by the ends of the lunarium into the aperture.

Eridopora thaiensis n. sp.	X	SD	Min	Max	N	CV
thickness zoarium	1		1	1	1	
zooecial dimension - aa	0.315	0 038	0.23	0.4	39	12 050
zooecial dimension - bb	0.267	0 049	0 18	0.38	35	18 269
lunarial dimension - cc	0.253	0.023	0.2	0.31	23	9 010
number of autozooecia in 2mm	3.656	0.478	3	4.5	32	13 083
distance between apertural centres	0.514	0 067	0 41	0.68	37	13.053
wall thickness, endozone	0 013	0 004	0 0075	0 025	37	29 662
number vesicles in 1mm horizontally	10.220	1 242	8.5	14	25	12 156
rows of vesicles between autozooecia	1.95		0	3	40	0.000
thickness lunaria	0.020	0 004	0.015	0 03	19	19 279
autozooecial angle from vertical	27.833	2 639	24	30	6	9.483

Table 5.31 - Summary measurements for *Eridopora thaiensis* n. sp. Abbreviations as for Table 5 1, all measurements in millimetres.

Internal features - The autozooecial tubes are circular and separated by 1 to 2 rows of vesicular tissue. The tubes are at an angle to the zoarial surface, and influence the shape of the aperture in tangential section. The vesicles are of consistent size and shape throughout the zoarium, and are blisterlike in cross section. Where only a single row of vesicles is seen between tubes they may appear box like. In tangential section the vesicles are irregularly polygonal, of a regular size, with usually 10 to 11 in 1 mm horizontally. Most of the thickness of the zoarium is made up of vesicular material between the zooecial tubes, with only a very thin layer of stereom at the surface. Thin straight to curved diaphragms are present within the zooecial tubes and are widely spaced.
Discussion - *Eridopora thaiensis* n. sp. is similar in appearance to *E. major* Bassler, from the Permian of Timor (Bassler, 1929) and Pamir (Goryunova, 1975). *E. thaiensis* n. sp. can be distinguished from *E. major* by its smaller and more closely spaced zooecial tubes, and the larger lunaria. *E. thaiensis* n. sp. is distinguished from *E. permiana* Crockford, from the Artinskian Noonkanbah Formation of Western Australia (Crockford, 1957), by the closer spacing of the apertures and absence of diaphragms in the later. However the new species is closely allied with both *E. major* and *E. permiana.*

Types - UTGD 127644 holotype, UTGD 127645, paratype; Ratburi Limestone, Ko Phi Phi Don.
Etymology - Named for the country in which it was found.
Material - Only the type material listed above was examined.
Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Fistulipora* M'Coy, 1849

Type species - *Fistulipora minor* M'Coy, 1849; Lower Carboniferous, Great Britain.
Diagnosis - Zoarium encrusting, massive or ramose. Monticules elevated or flush, with central cluster of vesicle and ring of larger zooecia with lunaria radially arranged. Autozooecia long and tubular with planar or curved diaphragms. Autozooecia partly or completely isolated by moderately large angular vesicles. Lunaria present through endozone and exozone, radius of curvature shorter than that of autozooecial wall (after Boardman *et al.* 1983).

Fistulipora horowitzi Sakagami, 1970
Plate 78; Table 5.32.

Fistulipora horowitzi SAKAGAMI (1970a), p. 47.
Fistulipora ramosa Sakagami SAKAGAMI (1966a), p. 150, pl. V, figs. 5 and 15, text-fig. 3c; SAKAGAMI (1968a), p. 49, pl. IX, fig. 2.

Diagnosis - The zoarium is ramose and robust. The autozooecial apertures are ovate and of intermediate size. The lunarium is thin, and the ends of the lunaria indent the autozooecial aperture. Each lunaria occupies one third to one half the circumference of the aperture. There are usually 3.5 to 4 apertures in 2 mm. diagonally at the external surface. The endozone is wide and occupies two thirds to three quarters of the radius of the branch. The zooecial tubes are oriented longitudinally in the central endozone, and bend gradually outwards into the exozone. The exozone is up to 1 mm thick. The zooecial tubes are separated by 1 to 4 rows of vesicles. Straight diaphragms are irregularly spaced within the zooecial tubes.

Fistulipora horowitzi	X	SD	Min	Max	N	CV
width zoarium	6.600	0 283	6.4	6 8	2	4 285
zooecial dimension - aa	0.296	0.025	0.26	0.355	20	8 378
zooecial dimension - bb	0 267	0.024	0.24	0.32	20	8 806
lunarial dimension - cc	0 138	0.018	0 1	0 17	20	13 320
lunarial dimension - dd	0.208	0.012	0 18	0.23	20	5 971
number of autozooecia in 2mm	3.925	0 315	3	4 5	20	8 030
distance between apertural centres	0.545	0 090	0.41	0 69	20	16 546
wall thickness, endozone	0.014	0.004	0 01	0.02	20	26 970
number vesicles in 1mm horizontally	7.538	0.923	6	9.5	13	12 248
rows of vesicles between autozooecia	2.000	0.858	1	4	20	42 920
thickness lunaria	0 026	0 007	0 018	0.04	20	26 747
diameter autozooecial tube, endozone	0.244	0 029	0.18	0.3	20	11.903

Table 5.32 - Summary measurements for *Fistulipora horowitzi* Sakagami. Abbreviations as for Table 5 1, all measurements in millimetres

Description - External features - The zoarium is ramose and robust, about 6.5 mm. in diameter. The branches are smooth and without raised monticules. The autozooecial apertures are ovate and of intermediate size, with a distinct indentation by the lunaria at the external surface. The lunarium is thin, but distinct and well developed. The ends of the lunaria indent the autozooecial aperture, and each lunaria occupies one third to one half the circumference of the aperture. The autozooecial apertures are regularly of intermediate spacing. There are usually 3.5 to 4 apertures in 2 mm. diagonally at the external surface. The apertures are evenly spread in approximate longitudinal and diagonal rows. The lunaria are

not regularly arranged, but most are oriented within the same hemisphere. The outer surface of the zoarium has small stylets evenly spaced between the apertures.
Internal features - The endozone is wide and occupies two thirds to three quarters of the radius of the branch. The zooecial tubes are long and tubular, and are straight and oriented longitudinally in the central endozone. The tubes bend gradually outwards into the exozone, to meet the external surface at right angles. The zooecial tubes are separated by 1 to 4 rows of vesicles, that are small with about 8 vesicles in 2 mm. In tangential section vesicles form irregular polygons. In longitudinal section the vesicles of the endozone are very elongate, up to 2 mm long, but gradually decrease in length towards the exozone to become box-like and 0.6 to 0.8 mm long. The outer part of the mature zone is of stereom about 1 mm thick. Straight diaphragms are irregularly spaced within the zooecial tubes.
Discussion - *Fistulipora horowitzi* Sakagami was first described from the Ratburi Limestone of Ko Muk (Sakagami 1966a) as *F. ramosa*, a name already occupied by a Devonian species of the United States. Sakagami (1970a) renamed the Thai species *F. horowitzi*. Sakagami has recorded *F. horowitzi* from the Ratburi Limestone of Ko Muk (Sakagami 1966a) and Khao Phrik (Sakagami 1968a), and describes some variation in the species. The specimen collected from Ko Phi Phi Don is identical to the previously described specimens, but has slightly more widely spaced diaphragms.
Material - UTGD 127646, Ratburi Limestone Ko Phi Phi Don.
Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Fistulipora megapertura n. sp.
Plate 79; Table 5.33.

Holotype - UTGD 127647; Ratburi Limestone, Ko Phi Phi Don.
Diagnosis - The zoarium is encrusting, 3 to 3.5 mm thick. The zooecial apertures are very large, and elliptical to ovate. The apertures are widely spaced with 2.5 to 3 apertures in 2 mm. A peristome surrounds the apertural rim and the lunarium is moderately thick. The lunaria occupy about two thirds of the circumference of the zooecial tube. The lunaria are oriented in the same direction in local areas of the zoarium. The vesicles are blisterlike in longitudinal section, with 6 to 7 vesicles in 1 mm. In tangential section the vesicles form irregularly sized polygons. There is usually only one row of vesicles between zooecia, and 4 to 5 in 1 mm horizontally. Diaphragms are occasionally seen within the zooecial tubes, and are widely spaced. The exozone is narrow.

Fistulipora megapertura n sp.	X	SD	Min	Max	N	CV
thickness zoarium	3.3		3.3	3.3	1	
zooecial dimension - aa	0.551	0 052	0.48	0 66	20	9.442
zooecial dimension - bb	0 426	0 029	0.395	0.48	18	6 706
lunarial dimension - cc	0.108	0.032	0 06	0.16	7	29.787
lunarial dimension - dd	0.276	0 020	0 25	0.3	7	7 211
number of autozooecia in 2mm	2.900	0 150	2.5	3	20	5 157
distance between apertural centres	0 741	0.049	0.64	0.88	20	6.564
wall thickness, endozone	0.011	0 002	0 01	0.015	16	15 868
number vesicles in 1mm horizontally	4.479	0.711	3	5.5	12	15 869
number vesicles in 1mm vertically	6.682	0.405	6	7	11	6 054
rows of vesicles between autozooecia	1.200	0.834	0	3	20	69 459
thickness lunaria	0.106	0.021	0 08	0.16	14	19.968

Table 5 33 - Summary measurements for *Fistulipora megapertura* n. sp Abbreviations as for Table 5 1, all measurements in millimetres.

Description - External features - The zoarium is encrusting and delicate, with thickness of the holotype 3 to 3.5 mm. Monticules are not visible on the external surface. The zooecial apertures are very large, and elliptical to ovate. They are not arranged into obvious diagonal or longitudinal rows, but the long axes of the apertures are all oriented in the same general direction. The apertures are widely spaced with 2.5 to 3 apertures in 2 mm. The large size of the apertures results in 50 to 60% of the zoarial surface consisting of apertures. A peristome surrounds the apertural rim and the lunarium is moderately thick. The lunaria are not well raised above the zoarial surface and at the outermost surface of the zoarium the lunaria appear to only occupy about one third of the circumference of the aperture. Upon internal examination where zooecial tubes are surrounded by vesicular tissue rather than dense stereom the lunaria can be seen to occupy about two thirds of the circumference of the zooecial tube. The lunaria are oriented in the same direction in local areas of the zoarium.

Internal features - The zooecia are tubular and extend at a high angle from the base of the zoarium, and meet the zoarial surface at the same high angle. The vesicles are blisterlike, and are the same size throughout the zoarium. There are 6 to 7 vesicles in 1 mm vertically and usually 4 to 5 in 1 mm horizontally. In tangential section the vesicles form irregularly sized polygons, with usually 1 row between zooecia, but there may be up to 3 rows. Straight diaphragms are occasionally seen within the zooecial tubes, and are widely spaced. The mature zone is narrow with most of the thickness of the zoarium made up of zooecial tubes surrounded by vesicular material, with stereom only at the outermost zoarial surface.

Discussion - *Fistulipora megapertura* n. sp. is readily distinguished from other Permian species known to the author by its very large apertures. *F. megastoma* from the Permian of Japan (Sakagami, 1961) also has large apertures, but has circular zooecia, with weak lunaria. *F. megapertura* n. sp. is most closely compared to *F. vacuolata* from the Noonkanbah Formation, Western Australia (Crockford, 1944a), but the later has polygonal vesicles in longitudinal section, rather than the blister shape of *F. megapertura* n. sp.

Type - UTGD 127647, holotype, Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the very large zooecial apertures.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Fistulipora satoi ? Sakagami, 1966
Plate 80; Table 5.34.

Fistulipora satoi SAKAGAMI (1966a) p. 145, pl. V, figs. 3-5, text-figs.2c,d.

Diagnosis - The zoarium is encrusting and multilayered, each layer 2 to 3 mm. thick. The autozooecial apertures are regularly ovate and of intermediate to large size. The lunarium indents the zooecial tube only slightly, and occupies about one third to one half the circumference of the zooecia. The apertures are arranged in diagonal rows, with the lunarium oriented in the same direction in local areas. There are 3 to 3.5 apertures in 2 mm diagonally. The zooecial tubes are separated by 2 to 4 rows of evenly sized vesicles. The vesicles are evenly quadrate in longitudinal section, and form irregular rounded polygons in tangential section. There are usually about 8 vesicles in 1 mm horizontally, and about 10 to 11 in 1 mm vertically.

Fistulipora satoi ?	X	SD	Min	Max	N	CV
zooecial dimension - aa	0.360	0 019	0.32	0 38	20	5 210
zooecial dimension - bb	0.314	0.020	0 28	0.36	20	6 298
lunarial dimension - cc	0.173	0 013	0.145	0.2	20	7 599
lunarial dimension - dd	0.255	0 012	0.24	0.28	20	4 515
number of autozooecia in 2mm	3.300	0.340	3	4	20	10 311
distance between apertural centres	0.579	0 061	0 5	0 7	20	10.547
wall thickness, endozone	0.013	0 003	0.01	0 02	14	25 429
number vesicles in 1mm horizontally	8.417	0 669	7 5	9.5	12	7 943
number vesicles in 1mm vertically	10.688	0.704	10	12	8	6.587
rows of vesicles between autozooecia	2.538	0.660	2	4	13	26 009
thickness lunaria	0.044	0.007	0 04	0.055	4	17 143

Table 5 34 - Summary measurements for *Fistulipora satoi* ? Sakagami. Abbreviations as for Table 5 1, all measuremennts in millimetres.

Description - External features - The zoarium is encrusting and multilayered, each layer 2 to 3 mm thick. Monticules are not seen on the external surface.

The autozooecial apertures are regularly ovate and of intermediate to large size. The lunarium is thin but distinct, and is further accentuated in the material examined by secondary mineralisation. The lunarium indents the zooecial tube only slightly, and occupies about one third to one half the circumference of the zooecia. The apertures are arranged in diagonal rows, with the lunarium oriented in the same direction as those closest to themselves. The apertures are of intermediate to wide spacing, with 3 to 3.5 in 2 mm diagonally.

Internal features - The zooecial tubes are tubular and recumbent at their base, curving gradually upwards to meet the zoarial surface at right angles. The zooecial tubes are separated by 2 to 4 rows of evenly sized vesicles. The vesicles are evenly quadrate in longitudinal section, and do not increase or decrease in size significantly from the base to the surface of the zoarium. The vesicles form irregular rounded polygons in tangential section. There are usually about 7.5 to 9.5 vesicles in 1 mm horizontally, and about 10 to 11 in 1 mm vertically. The outer one third of the zoarium is of stereom, but vesicles may still be seen within this material. Within the zooecial tubes are widely spaced diaphragms, with approximately 2 to 3 in 2 mm.

Discussion - The material examined (UTGD 127648) is similar to *Fistulipora satoi* Sakagami in some respects but variable in others. The zooecial apertures in UTGD 127648 have a higher mean than that given by Sakagami (1966a) for *F. satoi*, but are comparable in the total apertural size range. The general description of the zoarium and internal features of the zooecial tube form, spacing and diaphragms is the same, but UTGD 127648 differs in the density of the vesicle tissue. Vesicles are of a consistent size and shape through the zoarium in both *F. satoi* and UTGD 127648, but they are smaller and more closely packed in the later. This may represent an ecologic variation, but without more specimens of *F. satoi*, UTGD 127648 can only be questionably assigned to that species.

Material - UTGD 127648, Ratburi Limestone, Ko Phi Phi Don.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Family HEXAGONELLIDAE Crockford, 1947

Genus *Coscinotrypa* Hall, 1886

Type species - *Clathropora carinata* Hall 1883; Middle Devonian, Falls of the Ohio, Jeffersonville, Indiana, North America.

Diagnosis - Zoarium bifoliate, cribrate with fenestrules bordered by a rim of solid stereom. Lunaria are radially arranged around fenestrules, with lunaria on side of autozooecia away from branch centre. The mesotheca is tri-layered and regularly undulatory in transverse view. Autozooecia are hemispherical in cross section at mesotheca, with their size decreasing from endo to exozone. Vesicular tissue forming large blisters in outer endozone, small in inner exozone, with stereom through most of exozone. Numerous small acanthostyles in stereom (after Boardman *et al.*, 1983).

Coscinotrypa yaiformis n. sp.
Plate 81; Table 5.35.

Holotype - UTGD 127649; Ratburi Limestone, Ko Phi Phi Don.

Diagnosis - The zoarium is robust cribrate, with large ovate fenestrules. There are 1 to 1.5 fenestrules in 10 mm. The branches are wide and thick with about 8 to 10 rows of zooecia. The branches and rows of zooecia anastomose. The autozooecial apertures are small and elliptical, with usually 3 to 4 in 2 mm longitudinally, and 3.5 to 4 in 2 mm diagonally. Lunaria are not seen about the aperture, but each aperture is surrounded by a distinct peristome.

The autozooecia arise from a straight to gently undulating mesotheca, and curve rapidly upwards to be straight throughout the exozone. The exozone is wide and comprises almost the entire thickness of the branch and is without vesicular tissue. Thin diaphragms occur rarely within the zooecial tubes.

Description - External features - The zoarium is robust cribrate, with large fenestrules forming a mesh of intermediate spacing. The fenestrules are ovate and regularly spaced, in more or less longitudinal and diagonal rows. There are 1 to 1.5 fenestrules in 10 mm. The ratio of mean fenstrule width to length is 2:3. The borders of the fenestrules have an area of solid stereom free of zooecia.

The branches are wide and thick with about 8 to 10 rows of zooecia. The branches and rows of zooecia anastomose. The branches are symmetrical and ovate in cross section with a gently rounded profile on each surface.

The autozooecial apertures are small and elliptical, and of regular size and spacing. The apertures are arranged in rough longitudinal rows in the branches, and the rows curve around the fenestrule ends where the branches anastomose. The apertures are of intermediate to wide spacing, with usually 3 to 4 in 2 mm longitudinally, and 3.5 to 4 in 2 mm diagonally. Lunaria are not seen about the aperture, but each aperture is surrounded by a distinct peristome of granular skeletal material.

Coscinotrypa yaiformis n. sp.	X	SD	Min	Max	N	CV
fenestrule length	5.900	0.141	5.8	6	2	2.397
fenestrule width	3.950	0 071	3 9	4	2	1 790
branch width	4.031	0.505	3.4	5	9	12 531
branch thickness	4.325	0.742	3.8	4.85	2	17.167
aperture length	0.255	0.024	0.2	0.285	20	9.350
aperture width	0.159	0.017	0.14	0.19	20	10.493
width peristome	0.022	0.006	0 01	0.03	20	27 682
apertural spacing longitudinally	0 642	0 075	0 52	0.86	20	11.633
apertures in 2mm longitudinally	3.558	0.458	3	4	13	12.879
apertural spacing diagonally	0.500	0.041	0.44	0.59	20	8 104
apertures in 2mm diagonally	3.679	0 372	3	4	14	10.125
stereom thickness in exozone	2.080	0.174	1.96	2.28	3	8.382
width endozone	0 167	0.031	0.14	0.2	3	18.330

Table 5.35 - Summary measurements for *Coscinotrypa yaiformis* n. sp. Abbreviations as for Table 5.1, all measurements in millimetres.

Internal features - The autozooecia arise from a straight to gently undulating mesotheca. The autozooecia are hemispherical in cross section, and can be seen to curve rapidly upwards in longitudinal section. The autozooecia tubes are straight throughout the exozone. The endozone is thin, with only one row of blisterlike vesicles separating the zooecial tubes. The exozone is wide and comprises almost the entire thickness of the branch and is without vesicular tissue. Thin diaphragms occur rarely within the zooecial tubes.

Discussion - *Coscinotrypa yaiformis* n. sp. is distinct within the genus for its apparent lack of lunaria. In comparison to other species of *Coscinotrypa* that are without or have indistinct lunaria, *C. yaiformis* can be distinguished by the size of the fenestrules and size and spacing of the autozooecia. *C. orientalis* Sakagami was described from Khao Ta Mong Rai, peninsular Thailand (Sakagami, 1968c), and has indistinct lunaria, but *C. yaiformis* differs in having smaller apertures and larger fenestrules.

Types - Holotype UTGD 127649; Ratburi Limestone, Ko Phi Phi Don.

Etymology - Named for the large size of the mesh, from the Thai word "yai" meaning large.

Material - Only the type material listed above was examined.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

Genus *Hexagonella* Waagen and Wentzel, 1886

Type species - *Hexagonella ramosa* Nickles and Bassler, 1900 (subsequent designation); *Productus* Limestone, Permian, Salt Range, Pakistan.

Diagnosis - Zoarium bifoliate, compressed to subcylindrical. Monticules flush, with a central cluster of vesicles and radiating rows of autozooecia. Each monticule is also surrounded by an elevated hexagonal pattern of ridges within the vesicular tissue. The mesotheca is thin and straight. Autozooecia recumbent and widely separated by vesicular tissue from mesotheca to zoarial surface. Diaphragms sparse and straight. Lunaria present from outer endozone to zoarial surface. Vesicles large in endozone, boxlike in exozone, small and subangular in cross section (after Boardman *et al.*, 1983).

Hexagonella khaophrikensis Sakagami, 1968
Plate 82; Table 5.36.

Hexagonella khaophrikensis SAKAGAMI (1968a) p. 52, pl. X, figs. 1-3.

Diagnosis - The zoarium is robust and bifoliate, subcylindrical in cross section. The apertures are circular and of small to intermediate size. Interconnected ridges within the vesicular material can be seen. There are usually 3.5 to 4 apertures in 2 mm. The lunaria are inconspicuous, and their true nature and dimensions cannot be confirmed. The autozooecia tubes are straight and circular in cross section, and are separated by usually 2 rows of vesicles. The vesicles reduce in height from the endo to exozone. Only a thin layer of stereom is present at the zoarial surface. The vesicles are irregularly polygonal in tangential section and there are usually 5 to 8 vesicles in 1 mm horizontally. Straight thin diaphragms are widely spaced within the zooecial tubes.

Description - External features - The zoarium is robust and bifoliate, subcylindrical in cross section. The thickness of the zoarium is about 5 mm. The apertures are circular and of small to intermediate size. The apertures do not appear to have any regular arrangement. Monticules are not evident, but interconnected ridges within the vesicular material can be seen upon thin section examination. The apertures are of regular intermediate spacing with usually 3.5 to 4 in 2 mm. The lunaria are inconspicuous, and their true nature and dimensions cannot be confirmed.

Hexagonella khaophrikensis	X	SD	Min	Max	N	CV
thickness zoarium	5.250	0.354	5	5 5	2	6 734
autozooecial diameter	0.251	0 016	0 23	0.29	20	6.275
number of autozooecia in 2mm	3.654	0.389	3	4	13	10 651
distance between apertural centres	0.483	0 060	0.35	0 58	20	12 442
wall thickness, endozone	0.011	0.002	0.008	0.015	20	19 494
number vesicles in 1mm horizontally	6 647	1.284	5	9	17	19.318
rows of vesicles between autozooecia	2 235	0.752	1	3	17	33.662
vesicle length, early endozone	0 154	0 034	0.1	0.22	12	21.887
vesicle length, exozone	0.111	0.020	0.08	0.14	13	18 228

Table 5 36 - Summary measurements for *Hexagonella khaophrikensis* Sakagami Abbreviations as for Table 5.1, all measurements in millimetres.

Internal features - The autozooecia tubes are straight and circular in cross section. The zooecial tubes arise from a thin straight mesotheca at an angle, and then curve rapidly upwards to open perpendicular to the zoarial surface. The zooecial tubes are separated by usually 2 rows of vesicles. The vesicles are somewhat irregular nearest to the mesotheca, and then become rectangular as the zooecial tubes straighten. The vesicles reduce in height to become boxlike towards the outer part of the zoarium. The vesicular tissue is prominent, and extends almost to the zoarial surface, with only a thin layer of stereom. The vesicles are irregularly polygonal in tangential section and there are usually 5 to 8 vesicles in 1 mm horizontally. Straight thin diaphragms are widely spaced within the zooecial tubes.

Discussion - *H. khaophrikensis* was first recorded from the Ratburi Limestone, Khao Phrik (Sakagami, 1968a). It is distinguished from other species of the genus by its arrangement of vesicular tissue, and the very thin mature layer at the surface.

Material - UTGD 127650, Ratburi Limestone, Ko Phi Phi Don.

Occurrence - Ratburi Limestone, Ko Phi Phi Don, Khao Phrik.

Family GONIOCLADIIDAE Waagen and Pichl, 1885
Genus *Goniocladia* Etheridge, 1876

Type species - *Carinella cellulifera* Etheridge, 1873; Lower Carboniferous, Braidwood, England.
Diagnosis - Zoarium bifoliate with narrow branches, that may anastomose to form large fenestrules. The mesotheca is vertical and protrudes as a ridge on the rounded reverse surface, and as a carina on the obverse. Autozooecia are in two or three rows on either side of the carina. Apertures are indented by lunaria. Vesicles are blisterlike and laminated (after Boardman *et al.*, 1983).

Goniocladia sp. A.
Plate 83, Figures 5-6; Table 5.37.

Diagnosis - The branches are regularly anastomosing and form regular elongate hexagonal fenestrules. There are 3 to 4 branches in 10 mm horizontally. The fenestrules are large and there are 1.75 to 2 fenestrules in 10 mm vertically. The zooecial apertures are large and circular.

Goniocladia sp. indet.	X	SD	Min	Max	N	CV
branches in 10 mm.	3.667	0.577	3	4	3	15.746
branch width	0.994	0.138	0.8	1.26	12	13 901
branch thickness	3.090	0.014	3 08	3.1	2	0.458
fenestrules in 10 mm.	1.833	0.144	1.75	2	3	7.873
fenestrule length	4.773	0 547	3.98	5.75	12	11.453
fenestrule width	3 093	0.486	2.5	4.3	11	15.714
aperture diameter	0.228	0.019	0 2	0.24	4	8 321

Table 5.37 - Summary measurements for *Goniocladia* sp. A. Abbreviations as for Table 5.1, all measurements in millimetres.

Description - The zoarium is robust, and has regularly anastomosing branches that form very regular elongate hexagonal fenestrules. The branches are regular spaced with 3 to 4 in 10 mm horizontally. The branches are thin and of regular width, with an angular surface profile. The branches are much thicker than they are wide, and have an almost square reverse surface profile. The ratio of branch width to thickness is 1:3. In transverse section the widest point of the branch is towards the obverse surface.
The fenestrules are large and regularly elongate hexagonal, and are of the same shape on both the obverse and reverse surfaces. There are 1.75 to 2 fenestrules in 10 mm vertically. The fenestrules are longer than they are wide, with the ratio of mean fenestrule width to length 2:3.
Large circular apertures are seen, but preservation is too poor to accurately determine their spacing and arrangement.
Discussion - Preservation of the material is poor, with almost all internal and fine features lost. However the specimen is recorded as it has a distinctive regular mesh, that may in the future allow assignment to a described species.
Material - UTGD 127651; Ratburi Limestone, Ko Phi Phi Don.
Occurrence - Ratburi Limestone Ko Phi Phi Don.

Goniocladia sp. B.
Plate 83, figures 1-4, Table 5.38.

Diagnosis - The zoarium is robust with anastomosing branches that are irregularly spaced with 2 to 3 branches in 10 mm horizontally. The branches are wide with a rounded to rounded angular surface profile. The fenestrules are large and formed by the irregular anastomosing of the branches. There are 1.5 to 2 fenestrules in 10 mm vertically. There are 3 rows of apertures on each side of the carina. The apertures are large and circular, and regularly spaced, with 9 to 12 apertures in the length of each fenestrule.

Description - The zoarium is robust with anastomosing branches that form a fenestrate meshwork. The branches are irregularly widely spaced with 2 to 3 branches in 10 mm. horizontally. The branches are wide with a rounded to rounded angular surface profile. The branches are thick, with an elliptical outline in cross section. The greatest branch width is towards the reverse surface in cross section view. The ratio of mean branch width to thickness is approximately 1:2. The fenestrules are large and formed by the irregular anastomosing of the branches. There are 1.5 to 2 fenestrules in 10 mm. vertically. The fenestrules are irregular rounded polygonal in outline, and are of similar shape on both the obverse and reverse surfaces. The mesotheca is expressed at the surface as a rounded carina, but this is quite weathered in most of the zoarium. There are 3 to possibly 4 rows of apertures on each side of the carina. The apertures are large and circular. The apertures are regularly spaced, with 9 to 12 apertures in the length of each fenestrule.

Goniocladia sp. indet.	X	SD	Min	Max	N	CV
rows of zooecia	7	0 816	6	8	4	11 664
branches in 10 mm.	2.750	0 500	2	3	4	18.182
branch width	1 385	0 123	1.22	1.65	11	8.911
branch thickness	2 48		2 48	2 48	1	0
fenestrules in 10 mm.	1.5	0	1.5	1.5	3	0
fenestrule length	5.151	0.737	4.05	6	10	14.315
fenestrule width	3 044	1.072	1.8	4 7	8	35 204
apertures per fenestrule	10 500	2.121	9	12	2	20.203
aperture diameter	0 190	0 013	0.17	0.2	6	6.657

Table 5.38 - Summary measurements for *Goniocladia* sp B. Abbreviations as for Table 5.1, all measurements in millimetres

Discussion - The material is poorly preserved internally and fine details of the obverse surface are lost so the species cannot be described fully. The mesh is somewhat larger than *Goniocladia timorensis* Bassler, recorded from the Permian of Timor (Bassler, 1929), Western Australia (Crockford, 1944a) and from Ko Muk, Thailand (Sakagami, 1966a). *Goniocladia laxa* Bassler, also previously recorded from Ko Muk (Sakagami, 1966a), has narrower branches and a smaller and more variable mesh than the material examined here.

Material - UTGD 127652, Ratburi Limestone, Ko Phi Phi Don.

Occurrence - Ratburi Limestone, Ko Phi Phi Don.

5.2.5 - *Revision of previously described taxa.*

Much of the work done by Sumio Sakagami on the Permian Bryozoa of southern Thailand has included tangential sections of fenestrate taxa. Preservation has unfortunately removed details of nodes in many cases, but a number of fenestrate taxa are able to be reassessed in accordance with the taxonomy of Morozova (1974) and Morozova and Lisitsyn (1996). Both *Fenestella megacapillaris* Sakagami from the Ratburi Limestone, Khao Phrik (Sakagami, 1968a) and *F.* cf. *paratuberculifera* Yang and Loo from Khao Hin Kling (Sakagami, 1975) show two rows of nodes and zooecial chambers with a triangular outline in tangential section. These two species should therefore be placed within *Minilya* Crockford. *Fenestella retiformis* Sakagami, from Khao Ta Mong Rai (Sakagami, 1968c) has triangular zooecial chamber outlines but only one row of nodes, indicating its placement in *Spinofenestella* Termier & Termier. *Spinofenestella horologia*, also record by Sakagami (1968b) from Khao Chong Krachok, has already been discussed previously in this chapter. A number of species previously described from southern Thailand have only a single row of nodes and a pentagonal chamber outline, and should be included in *Rectifenestella* Morozova. Species where a pentagonal chamber shape could be seen in figured material are :- R. *pulchradorsalis* (Bassler) (Sakagmai, 1968c); and see also above for discussion of this species), R. *krachokensis*

(Sakagami, 1968b) and *R. basleoensis* (Bassler) (Sakagami, 1968b). *Fabifenestella thaiensis* (Sakagami, 1966b) has already been discussd above, with the related species *Fabifenestella subthaiensis* n. sp. *Fenestella jabiensis* Waagen and Pichl, as described by Sakagami (1970a) from Ko Muk, should also be included in *Fabifenestella* Morozova, from the chamber shape and two rows of nodes figured by Sakagami. However the original specimens of Waagen and Pichl has not been seen and may differ from material shown by Sakagami (1970a), and prove the Thai material to be a separate species.

Of the polyporid taxa previously described from the Shan-Thai Terrane, a number have suitable figures and descriptions allowing them to be removed from *Polypora* and placed within the genera of Morozova and Lisitsyn (1996). *Polypora gigantea* Waagen and Pichl, as shown by Sakagami (1962) from Pulau Jong, Malaysia has rounded rhombic chambers and would be better placed within the genus *Mackinneyella*, along with *Polypora koninckiana* Waagen and Pichl described by Sakagami (1999) from Khao Hin Kling.

The material collected for this study did not include specimens of *Polyporella* Simpson, but *Polypora* sp. indet. described by Sakagami (1975) from Khao Hin Kling, has 3 clear rows of zooecia with a hexagonal outline, and should be placed in that genus. *Polypora quadricella* Sakagami from Khao Chong Krachok, has usually 4 rows of zooecia with an elongate quadrate or elongate hexagoinal chamber outline. Hemisepta are not discussed and cannot be seen in the figures of Sakagami (1968b), but this species may belong in *Paucipora* Termier and Termier. Morozova and Lisitsyn (1996), in their description of *Polyporellina* included *P. fritzi* of Sakagami (1970a), from Ko Muk, in their list of species included in that genus.

Polyporella, Polyporellina and *Paucipora* were not described from material collected from Ko Phi Phi Don for this study, but may be included as genera found within the Shan-Thai Terrane from review of previous works.

5.3 - <u>SUMMARY</u>

The bryozoan fauna of the Ratburi Limestone on Ko Phi Phi Don is diverse and abundant, with representatives from the Fenestrata, Trepostomata, Cryptostomata and Cystoporata. Fenestrates dominate the fauna, with 14 genera. Cystoporates and cryptostomates are also important, represented by 6 and 3 genera, respectively. Trepostomes are not common and are only represented by 2 genera.

Thirty-eight species are recorded from Ratburi outcrops on Ko Phi Phi Don, within the following genera:- *Alternifenestella, Fabifenestella, Flexifenestella, Minilya, Rectifenestella, Spinofenestella, Mackinneyella, Polypora, Shulgapora, Reteporidra, Septapora, Synocladia, Penniretepora, Acanthocladia* (Fenestrata), *Paralioclema, Neoeridotrypella* (Trepostomata), *Ascopora, Rhabdomeson, Streblotrypa*, (Cryptostomata), *Cyclotrypa, Eridopora, Fistulipora, Coscinotrypa, Hexagonella* and *Goniocladia* (Cystoporata). Review of previously described fenestrate taxa from the Permian Shan-Thai Terrane also reveals the probable presence of *Paucipora, Polyporella* and *Polyporellina* in Ratburi faunas. Thirty new species are recorded from the Ratburi Limestone on Ko Phi Phi Don, they are:- *Fabifenestella subthaiensis, F. carinata, Flexifenestellla hexaformis, Minilya phiphiensis, Spinofenestella lekformis, S. pseudohorologia, S. flanchea, Mackinneyella nodosa, M. supraobesa, Polypora canalis, P. nodulifera, Shulgapora reversa, S. megacyclopora, Reteporidra yongkasemensis, Septopora interformis, S. irregularis, Penniretepora subtropica, Acanthocladia pseudothaiensis, A. suprangularis, Paralioclema phuketensis, Neoeridotrypella subpulchra, Ascopra robusta, A. variablis, Rhabdomeson monoformis, Cyclotrypa dendroides, Eridopora thaiensis, Fistulipora megapertura, Coscinotrypa yaiformis* and *Goniocladia sp.* A and B.

Of the 38 species described above from the Ratburi Limestone of Ko Phi Phi Don, many are new and endemic, with only 8 species previously described, and there are no endemic genera. Much of the fauna shows similarities with taxa outside southern Thailand, with species showing affinities with those of Western Australia, Timor, and Russia.

CHAPTER SIX

BRYOZOAN BIOSTRATIGRAPHY

6.1 - INTRODUCTION

The Bryozoa are not commonly used in biostratigraphic determination, particularly in Gondwanan terranes. However this does not preclude their application after accurate taxonomic determination. Within Australian Permian rocks, where existing biostratigraphy is based largely on brachiopods and molluscs, an understanding of bryozoan faunas and taxonomy can provide biostratigraphic information where other faunas are absent, or cannot be readily extracted. The first step in achieving this is to compare ranges of bryozoan taxa to other groups to understand their age relationships and ranges. Within the Tasmania Basin, bryozoan ranges are given in comparison to the existing biostratigraphic faunizones of Clarke and Banks (1975). The bryozoan fauna within Tasmania is largely endemic and comparison with other regions for age determinations is not productive at this stage. While the study of bryozoan faunas for biostratigraphic purposes is in its early stages, it can be seen that bryozoan taxa do have distinct ranges, and species successions can be seen through time. As bryozoans can be identified from fragments within core material, after thin sectioning, an understanding of their biostratigraphy can only improve the age relationships within and between the Tasmania and other basins.

Bryozoans have been used in the past in biostratigraphic studies of the Permian of South East Asia. Faunas of peninsular Thailand Permian rocks also show a high degree of endemism, but they can be more readily compared with faunas of other regions for biostratigraphic analysis. The bryozoan taxa described in this study, from Ko Phi Phi Don, will be compared to bryozoan faunas from other regions. While the age range of the entire Ratburi Limestone cannot be determined, the age relationships of basal sequences exposed on Ko Phi Phi Don, will be discussed.

6.2 - TASMANIA AND SOUTHERN SYDNEY BASINS.

6.2.1 - *Tasmania Basin*

A number of bryozoan taxa have been taken as present throughout most of the Permian, and as a result are not used biostratigraphically. The concept of some fenestrate taxa as long ranging and widespread has developed from studies based on external taxonomic examination. Thorough internal examination reveals that many of these long ranging forms represent a number of taxa, that for both phylogenetic and phenotypic reasons have developed similar mesh characters. Internal examination readily reveals true taxonomic variation.

A good example of this is the use of the name "*Protoretepora ampla*" to define coarse fenestrate specimens with several rows of zooecia, without internal taxonomic examination. Initially described by Lonsdale (1844) from the Permian of Tasmania (see Chapter 3), as *Fenestella ampla*, it has been recorded from both eastern and Western Australia from the Early to Late Permian. This study has revealed that specimens that would have been referable to "*ampla*" can be separated into two genera and five species within the Tasmania Basin alone. It is likely, that while some of the Tasmanian species will occur elsewhere in Australian Permian sequences, many related taxa are yet to be identified. Specimens previously referred to "*ampla*" reflect a morphologic and taxonomic grouping, with subtle changes in internal features through the Permian. Redescription of this species, previously held to be long ranging, has revealed a succession of species that are limited in time and are of biostratigraphic use, at least within the Tasmania Basin (see Figure 6.1). *Parapolypora ampla* (as redescribed in this study) is confined to the Tamarian, or early to middle Sakmarian, and is replaced in late Sakmarian to early Artinskian rocks by an as yet undescribed species. *Parapolypora boraformis* coexists with *P. ampla*, and is also limited to the Tamarian. *Mackinneyella granulosa* is an unrelated species showing a coarse morphology, that is a distinctive aspect of the Tasmanian fauna in the Artinskian to Ufimian. As discussed in Chapter 3, specimens referred to *Protoretepora ampla* by Wass (1968) from the Artinskian of the Bowen Basin may also belong to this species.

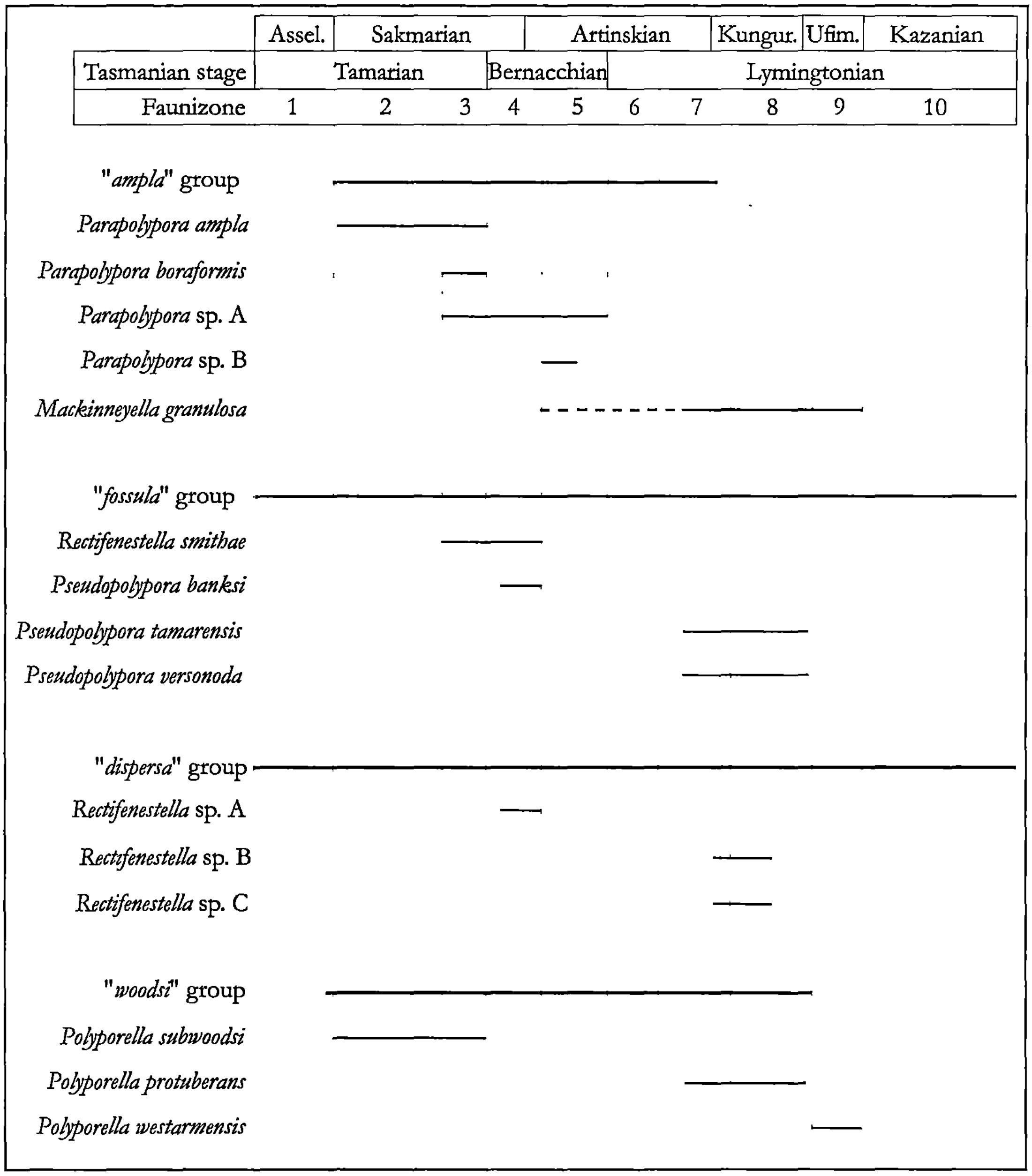


Figure 6 1 - Distribution of component taxa that in past taxonomic procedures were referable to "*Protoretepora ampla*", "*Fenestella fossula*", "*Fenestella dispersa*" and "*Polypora woodsi*". See text for discussion.

The grouping of separate taxa also occurs within the previously described *Fenestella fossula, F. dispersa* and *Polypora woodsi. F. fossula* was also described by Lonsdale (1844), and no suitable material from the likely type locality in Bundella Mudstone Lower Sandy Bay Hobart (Smith *et al.*, in prep.) is available for thorough internal examination. This species is recorded throughout the Permian of eastern Australia. However during this study, a number of specimens, that upon external examination were referable to this species, were revealed again to be within separate genera and species after internal examination (see Figure 6.1).

A similar pattern is seen with *F. dispersa*, and *P. woodsi* (see Figure 6.1), where specimens loosely grouped together on external examination were shown to represent a number of distinct species upon internal examination. As discussed in Chapter Three *Fenestella dispersa*, if a suitable specimen from the type locality can be found, is likely to be within the genus *Rectifenestella*. The species *Polypora woodsi*, defined on external features only is of Artinskian age in the Sydney Basin, but of Sakmarian to Artinskian age in Western Australia (Crockford, 1951). Within the Tasmania Basin a number of specimens, that on initial external examination showed similar mesh measurements to *P. woodsi*, have since been described as separate species after internal examination. It is likely that *P. woodsi*, initially described from the Sydney Basin, is a similar and closely related species to the *P. woodsi* of Western Australia, but may not necessarily be conspecific.

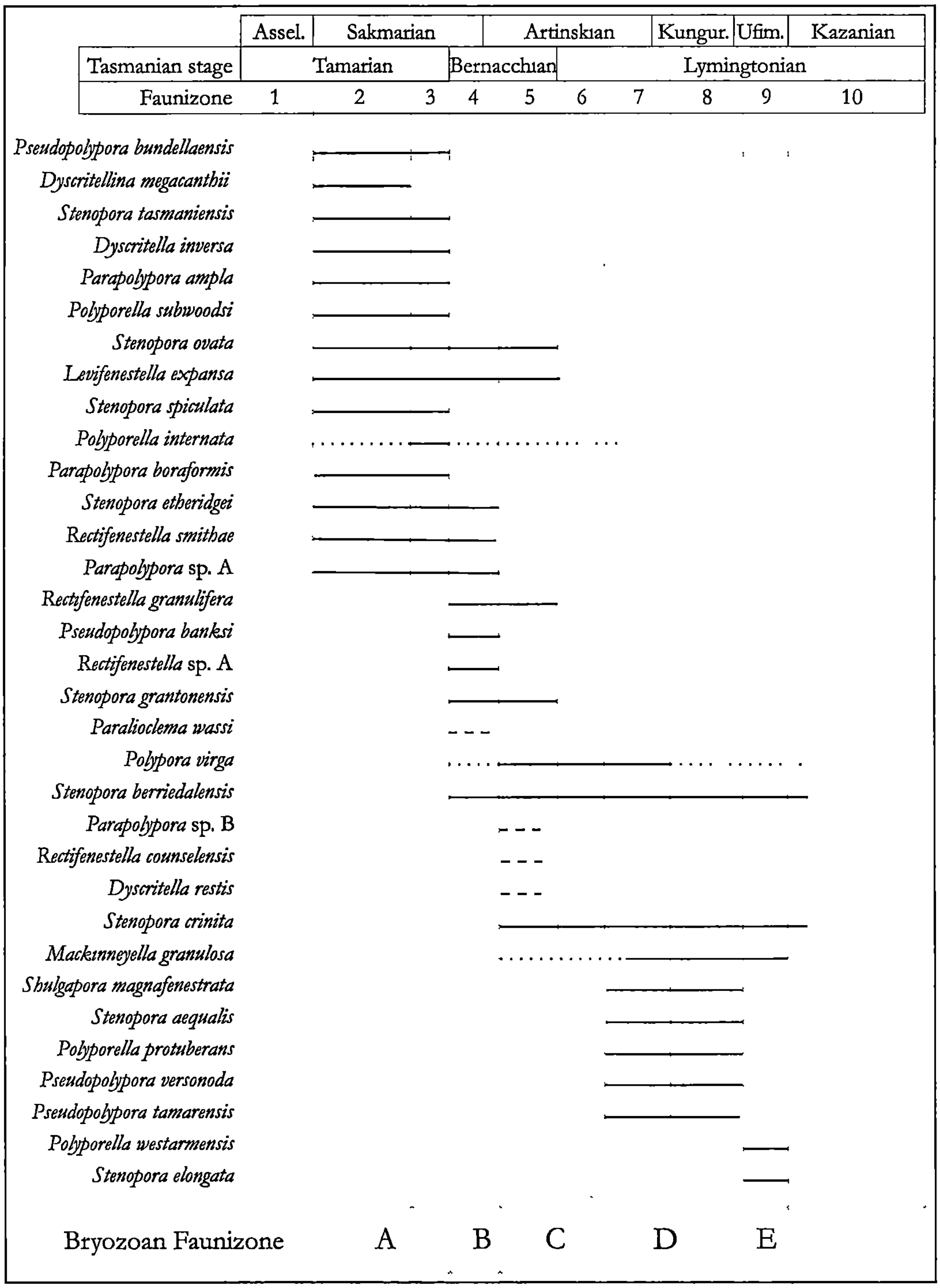


Figure 6.2 - Distribution of bryozoan species within the Tasmania Basin. Faunizones and Tasmanian stages from Clarke and Banks (1975), and Clarke and Farmer (1976).

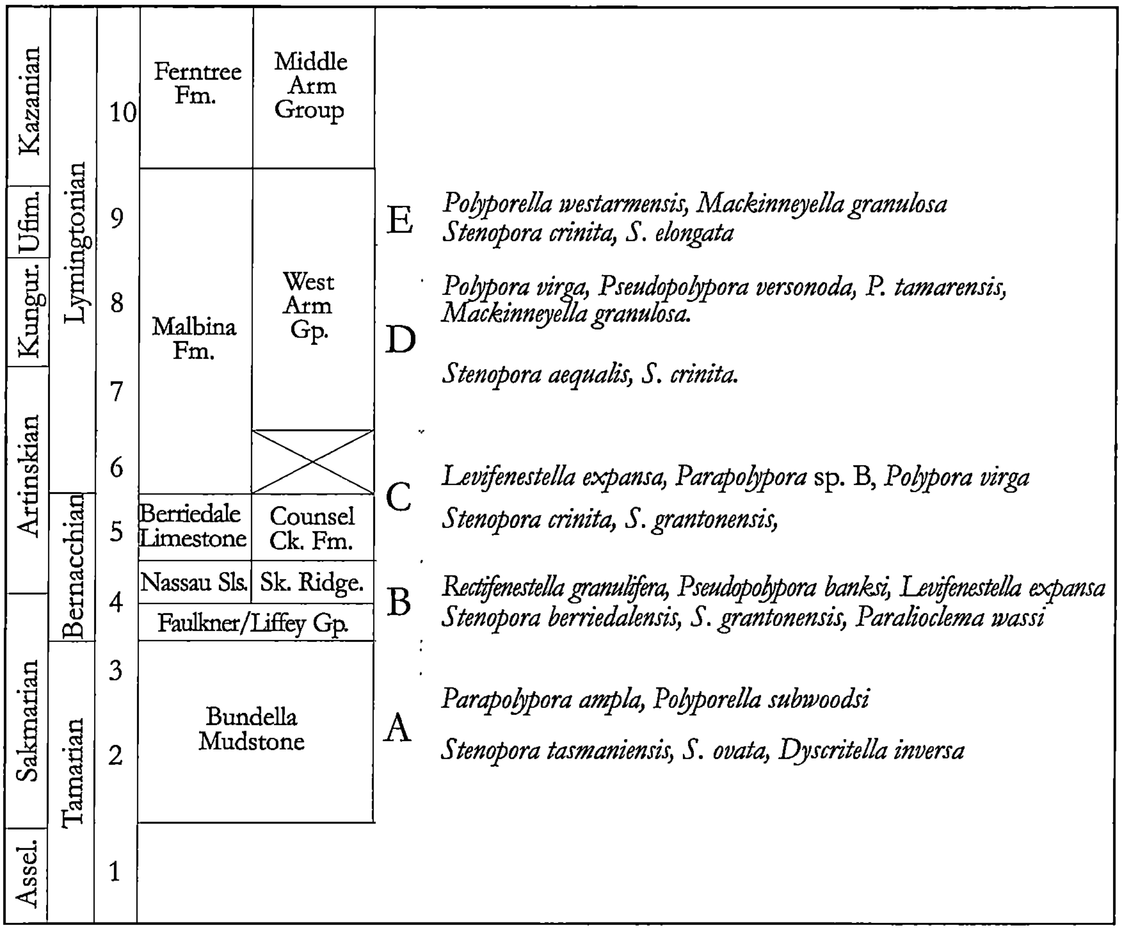


Figure 6.3 - Proposed bryozoan faunizones for the Tasmania Basin fauna Faunizones A to E are shown in comparison to the ten Faunizones of Clarke and Banks (1975), the Tasmanian Stages of Clarke and Farmer (1976) and international stages. For each of the Faunizones A to E the distinguishing and/or common bryozoan taxa are listed.

Bryozoan faunizones

A total of 33 species have been identified from the Tasmania Basin in this study, with many more likely to be revealed with future work. On the whole, bryozoan taxa are not long ranging within the Tasmania Basin (see Figure 6.2), and bryozoan faunal assemblages can be recognized (see Figure 6.3), from which bryozoan faunizones A to E are proposed. Bryozoan faunas are not common in the basal marine units, with the first significant bryozoan faunas in the Bundella Mudstone. Prominent fenestrate taxa in Faunizone A are *Parapolypora ampla* (as redefined in this study) and *Polyporella subwoodsi.* These species are common and are readily recognized. Also occurring, though less frequently, are *Parapolypora boraformis*, *Polyporella internata* and *Rectifenestella smithae*. *Levifenestella expansa* is also present, and extends into younger rocks. Other taxa are present, but as yet have not been able to be confidently identified. Trepostomous taxa of Faunizone A are typified by *Stenopora tasmaniensis*, *S. ovata* and *Dyscritella inversa*. *Stenopora tasmaniensis* is abundant, and occurs throughout the Tasmania Basin, but is particularly common in the Bundella Mudstone of the Hobart region, and in the basal beds and Darlington Limestone of Maria Island. *Dyscritellina megacanthi* is a distinctive species, and has not been recorded outside the basal beds and lower Darlington Limestone of Maria Island, and appears confined to Faunizone 2 of Clarke and Banks (1975). *Stenopora ovata* (as redefined by Smith *et al.* (in prep.) extends into the overlying Berriedale Limestone, where its forms encrusting as well as dendroid zoaria. Faunizone A is equivalent to the brachiopod Faunizones 2 and 3 of Clarke and Banks (1975).

Bryozoan taxa are at their most diverse in the marine rocks immediately overlying the freshwater beds. The faunas of the Nassau Siltstone, Berriedale Limestone and basal Malbina Formation are separated into two faunizones. At this time bryozoan faunas are abundant across the basin, both in siltstone and richly fossiliferous limestone. While diverse, species may only be represented by one or two specimens, and Faunizone B is less readily distinguished than Faunizone A. It is expected that further work will extend the ranges of some of these species, and clarify Faunizone B. However the fauna is still recognizable by the distinct change in species from Faunizone A, and by the diversity of genera, species and mesh form. *Parapolypora ampla* and *P. boraformis* are absent from the fauna, with *Parapolypora* instead represented by an as yet undescribed species that co-occurs with *P. ampla* and *P. boraformis* in Faunizone A. The appearance of the distinct fenestrate species *Rectifenestella granulifera* and *Pseudopolypora banksi,* along with *R. counselensis,* and *Levifenestella expansa* that continues from Faunizone A, also define Faunizone B. The trepostome species *Paralioclema wassi, Stenopora grantonensis* and *S. berriedalensis* also appear in the fauna at this time. Faunizone B includes faunas from the Nassau Siltstone and Skipping Ridge Formation, and is equivalent to brachiopod Faunizone 4 of Clarke and Banks (1975).

Many species do not range beyond the end of Faunizone B, and several new species appear in the Berriedale Limestone and correlates, resulting in a distinct change in the fauna. The appearance of *Stenopora crinita* and the abundance of *Polypora virga* typify Faunizone C. *Stenopora ovata* is absent from the fauna at this level. Specimens described as *Mackinneyella granulosa* also appear at this time, however the material has not been examined internally. Faunizone C includes faunas from the Berriedale Limestone/Counsel Creek Formation and the Malbina unit A. Faunizone C is the equivalent of brachiopod Faunizones 5 and 6 of Clarke and Banks (1975), and spans the Bernacchian/Lymingtonian boundary of Clarke and Farmer (1976).

Above the limestones of southern Tasmania, preservation of bryozoan skeletal material is poor, and Faunizones D and E are mostly known from northern Tasmania Basin outcrops. The appearance and abundance of the distinctive fenestellids *Pseudopolypora tamarensis, P. versonoda* and the trepostome *Stenopora aequalis,* mark the base of, and are distinctive elements of Faunizone D, along with *Mackinneyella granulosa, Polypora virga* and rare *Shulgapora magnafenestrata.* Faunizone D includes bryozoan faunas from the West Arm Group, and is equivalent to brachiopod Faunizones 7 and 8 of Clarke and Banks (1975).

Bryozoans are sparse in Faunizone E, but in northern Tasmania *Stenopora aequalis* is replaced by *S. elongata*, where it co-occurs with the common and distinct *Polyporella westarmensis.* In southern Tasmania *Stenopora berriedalensis* is recorded from rocks overlying Faunizone E. Faunizone E includes faunas from the uppermost West Arm Group, and is equivalent to brachiopod Faunizone 9 and 10 of Clarke and Banks (1975). However bryozoans are poorly known in Faunizone 10 of Clarke and Banks, because of poor preservation, and all taxa recorded are also known from Faunizone 9. Bryozoan Faunizone E therefore includes all the upper marine beds, but future work may reveal a separate bryozoan zonation in Malbina E and younger units.

6.2.2 - ***Southern Sydney Basin.***

As the majority of specimens were collected from the lower Wandrawandian Siltstone of Kungurian age, a basin wide biostratigraphy cannot be determined for the southern Sydney Basin. However taxa that are in common with the Tasmania Basin, *Stenopora spiculata* and *Shulgapora magnafenestrata*, occur at similar stratigraphic levels. *Stenopora spiculata* is recorded from the Sakmarian Wasp Head Formation in the southern Sydney Basin, and the Bundella Mudstone in the Tasmania Basin. These units share a similar brachiopod fauna, and *S. spiculata* was also recorded from the Sakmarian Allandale Formation by Crockford (1945).

Shulgapora magnafenestrata is recorded in this study from the Kungurian Wandrawandian Siltstone in the southern Sydney Basin, and the late Artinskian to Kungurian Deep Bay Formation in the Tasmania Basin. The holotype of this species was described from the Kungurian ? Fenestella Shales of New South Wales (Crockford, 1941b). Also recorded from the Wandrawandian Siltstone are *Fenestella fossula, Polypora woodsi, P. virga* (Crockford, 1941a) and *F. dispersa* (Crockford, 1943). *Polypora virga* is within Artinskian to Kungurian rocks in the Tasmania Basin, and also within the Fenestella Shales (Crockford, 1951). As discussed above the species names *F. fossula, F. dispersa, P. woodsi* are of little use for biostratigraphic purposes, as these appear to be form groups that include a number of taxa.

The remaining taxa from the Wandrawandian Siltstone are either new species as yet unrecorded elsewhere, or are previously recorded from that unit, and add little biostratigraphic information at this stage. There does however appear to be some differentiation within the Wandrawandian Siltstone, with species either occurring throughout or restricted in their range (see Figure 6.4).

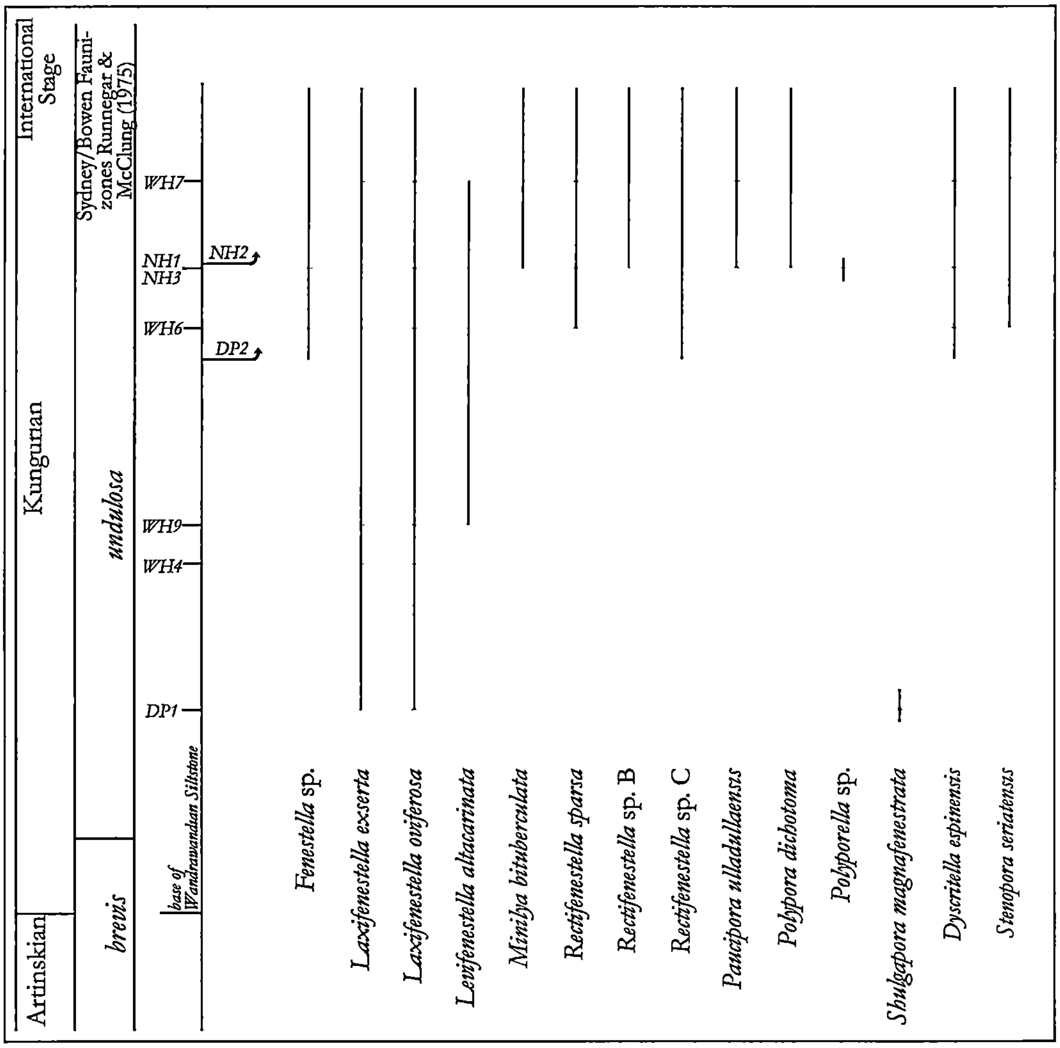


Figure 6.4 - Distribution of bryozoan taxa within the lower Wandrawandian Siltstone, as exposed at North Head and Warden Head, Ulladulla, and Dolphin Point south of Ulladulla, New South Wales

Phylogeny of some eastern Australian taxa.

The phylogenetic relationships of Australian bryozoan taxa have not been studied in detail by previous authors. However without accurate generic placement of many fenestrate species understanding of true phylogenetic relationships would have been severely limited.

Inferred phylogenetic relationships are presented in Figure 6.5 for genera where a number of species are available for internal examination. The phylogeny given below is a preliminary attempt and further work may be expected to alter some relationships, however it is regarded as a useful starting point.

Many species shown in Figure 6.5 are restricted to the Tasmania Basin, and with *Parapolypora* and *Pseudopolypora* the proposed phylogeny is restricted to this basin. *Parapolypora* *ampla*, as redescribed in Chapter Three, is at this time considered confined to the Tasmania Basin, and giving rise to *Parapolypora* sp. A. *Parapolypora boraformis* is similar in overall appearance to *P. ampla*, and differs only in details of apertural stylets and obverse surface ornamentation. It is likely that *P. boraformis* is derived from *P. ampla*, and in turn that *Parapolypora* sp. B, with a larger mesh but similar ornamentation to *P. boraformis,* is derived from that species.

Relationships with *Pseudopolypora* are less clear, however, *P. bundellaensis* shows typical features of that genus, whereas *P. banksi, P. tamarensis* and *P. versonoda*, are less typical in having two rows for long distances with long straight branches that bifurcate at wide intervals. It is inferred that after the arrival of the genus in the Tasmania Basin, a local morphology developed, that to date is not seen elsewhere.

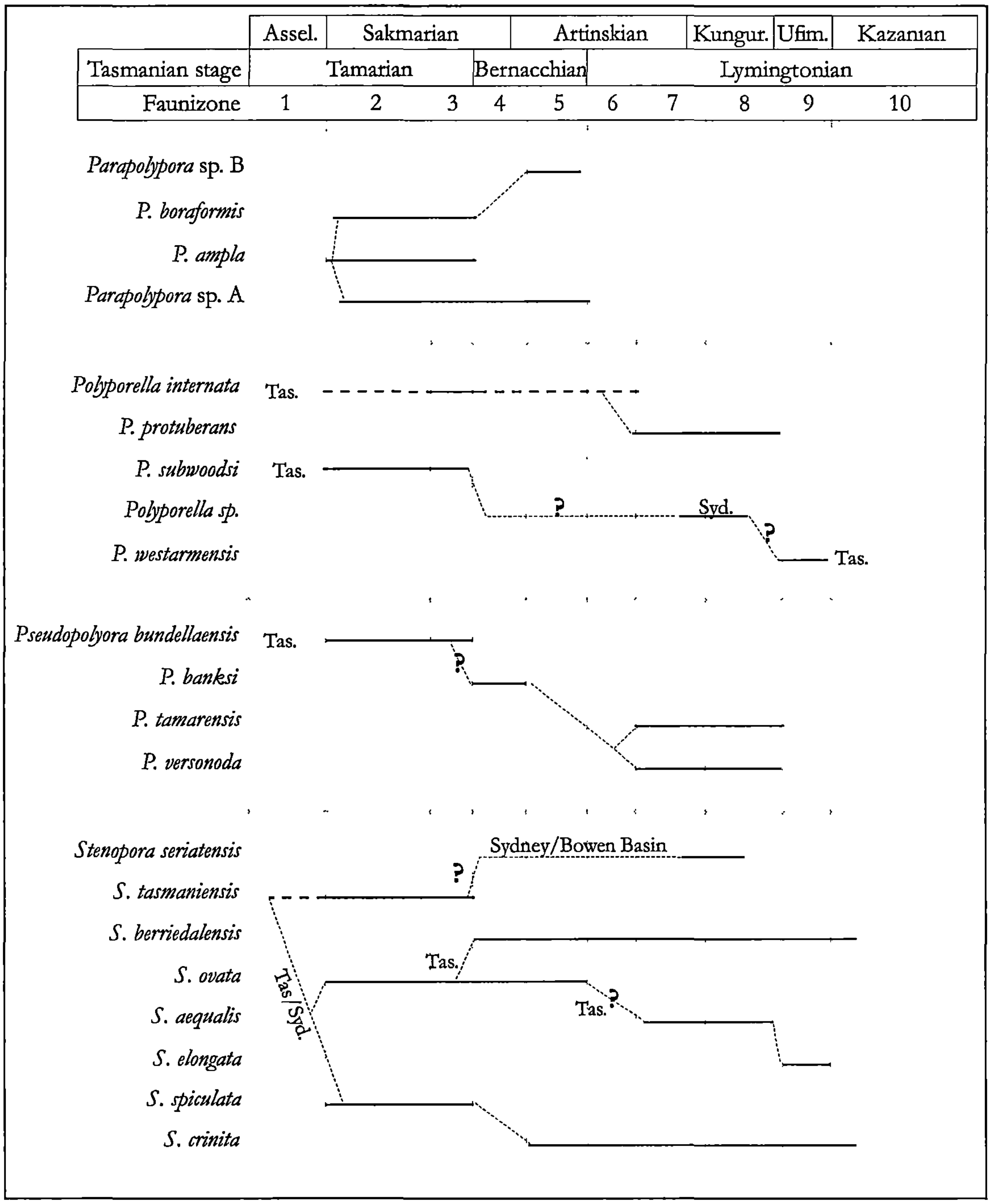


Figure 6.5 - Inferred phylogenetic relationships for species of the genera *Parapolypora, Polyporella, Pseudopolypora* and *Stenopora* found within the Tasmania and southern Sydney Basins.

Polyporella is a common genus in the Tasmania Basin and is likely to have many representatives in eastern and Western Australia. Within the Tasmanian species, there are two basic morphologic types. The first shows chambers of slightly variable shape in rows that bend towards the dissepiments and is represented by *P. internata* and *P. protuberans*. The second, which includes *P. subwoodsi* and *P. westarmensis*, is of more regular chambers in rows that are quite straight and do not bend adjacent to the dissepiments. *P. subwoodsi* from the Sakmarian is replaced in younger (Ufimian) rocks by *P. westarmensis*, that shows a different mesh size, and strongly developed nodes. It is possible that *Polyporella* sp. from the Kungurian Wandrawandian Siltstone is an intermediate species, as it also shows the straight rows of zooecia and strong nodes.

The genus *Stenopora* is well developed in the Tasmania Basin, and has many representatives. Not all species are shown in Figure 6.5, but after grouping species by morphology it appears that this genus was developing in a number of regions, rather than speciating in one region and dispersing to other areas. As proposed by Wass (1968) the three common species from the Permian of eastern Australia, *Stenopora tasmaniensis*, *S. ovata* and *S. crinita*, appear to be related. Figure 6.5 shows an inferred phylogeny from *S. tasmaniensis* to *S. ovata*, with a reduction in acanthostyle number. *S. crinita* is probably derived from *S. ovata*, through *S. spiculata*. *S. spiculata* shows a limited acanthostyle number, but has the bead-like monilae of *S. ovata*, that are widely spaced like the elongate monilae of *S. crinita.*

While there is a significant time separation, the similarity of *S. tasmaniensis* and *S. seriatensis* suggests that the latter was derived from *S. tasmaniensis*. *S. seriatensis* is confined to the Sydney and Bowen Basins, but it is unclear where it initially evolved. Likewise local speciation from a widespread species may have occurred in the Tasmania Basin, with *S. aequalis* inferred to be derived from *S. ovata*. *S. aequalis* has a similar wall structure to *S. ovata*, but thicker walls and larger acanthostyles. Further, *S. elongata* is similar to *S. aequalis*, with both species found within the West Arm Group of the northern Tasmania Basin. *S. elongata* of Ufimian age is most likely derived from the late Artinskian to Kungurian *S. aequalis* with a change in apertural shape, and the lengthening of the monilae.

6.3 - SOUTHERN THAILAND

Most of the bryozoan taxa recorded in this study from Ratburi Limestone are new, with only a few species previously described from outside the Ratburi Limestone. Of the new species described, some are distinct and not readily comparable to non Thai species, or are similar to previously described Ratburi species. About one third of the newly described species are comparable to species outside the Ratburi Limestone. When combined with previously described taxa the Ratburi Limestone fauna, is however able to be compared with faunas outside southern Thailand, and reveals consistent age information.

Previously described species occurring outside the Ratburi Limestone.

Four species occur outside the Ratburi Limestone and show consistent age information. *Alternifenestella subquadratopora* (Shulga-Nesterenko), was initially described from the Artinskian of Russia, and is also known from the Artinskian of Pamir (Goryunova, 1975). *Rectifenestella pulchradorsalis* (Bassler), also recorded by Sakagami (1968) from Ko Ta Mong Rai, was first described from Permian of Timor (Bassler, 1929). Archbold (1981) gives a Late Artinskian to Early Kungurian age for the Timor beds from reassessment of ammonoid faunas.

Two species occur from Western Australia - *Minilya duplaris* Crockford and *Spinofenestella horologia* (Bretnall). *Minilya duplaris* is recorded in Western Australia from the Wandagee (Carnavon Basin) and Noonkanbah Formations (Canning Basin), with *S. horologia* also found in the Callythara Formation (Carnavon) and Nura Nura Member (Canning) (Crockford, 1951; 1957). Brachiopod faunas of the Carnavon Basin indicate a Late Sakmarian (Sterlitamakian) age for the Callythara Formation, with the Wandagee Formation of Kungurian age (Archbold, 1999). The Canning Basin Nura Nura Member is comparable to the Callythara Fm and is also of Late Sakmarian age, with the Noonkanbah Formation ranging from mid Artinskian to Kungurian (Archbold, 1999).

The age relationships given above indicate a mid Artinskian to Kungurian age for the bryozoan fauna of basal Ratburi Limestone on Ko Phi Phi Don.

New species comparable to taxa outside the Ratburi Limestone.

A number of new species described in this study from the basal Ratburi Limestone on Ko Phi Phi Don are similar in appearance to previously described taxa from Russia, North America and Timor with many showing similarities to Western Australian taxa.

Flexifenestella hexaformis is a distinctive species and closely comparable to *F. eichwaldi,* known from the Late Artinskian of the Central Urals (Morozova, 1970) and the Artinskian of Pamir (Goryunova, 1975). Of similar age in Russian sequences is *Minilya tuberculata* Krutchinina, which shows mesh characters comparable to *M. phiphiensis* of southern Thailand. *Polypora nodulifera* of the Ratburi Limestone has larger nodes and fewer zooecia than *P. multiporifera* of the Wandagee and Noonkanbah Formations of Western Australia, but is of similar appearance and mesh character. *Synocladia irregularis* has similar mesh characters but less developed nodes than *S. spinosa* of the Cundlego Formation of Western Australia (Crockford, 1944a). Archbold (1999) gives a Kungurian age for the Cundlego Formation on reassessment of brachiopod faunas and their comparison with international stages. *Septopora interformis* is of similar mesh form to separate taxa from both the Early Permian of Pamir and the Artinskian of Timor, as does *Eridopora thaiensis*, which is similar to *E. major* of Timor (Bassler, 1929) and Pamir (Goryunova, 1975). *Eridopora thaiensis* is also comparable to *E. permiana* of the Artinskian to Kungurian Noonkanbah Formation of Western Australia (Crockford, 1957). *Streblotrypa komukensis*, first described by Sakagami (1970a) from Ratburi Limestone of Ko Muk, resembles *S. marmionensis* which is widespread in Sakmarian to Early Kungurian rocks of Western Australia and also occurs in the Permian of Timor.

The above Ratburi taxa are all comparable to Early Permian species elsewhere, with only *Paralioclema phuketensis* and *Neoeridotrypella subpulchra* showing a relationship to Late Permian taxa. *N. subpulchra* is named for its similarity to *N. pulchra* from the Kazanian of the Russian Platform (Morozova, 1970) and North America (Gilmour and Walker, 1986). *Paralioclema phuketensis* is unlike other species of the genus from Thailand but is similar in form to *P. minax* of the Late Permian of Russia (Morozova, 1970).

While there is a spread of age relationships, most taxa, except *P. phuketensis* and *N. subpulchra*, indicate an Artinskian to Kungurian age. Importantly age indications are consistent between Western Australia, Timor and most Russian comparative taxa.

The combination of previously described and related species indicates a Late Artinskian to Kungurian age for the Ratburi Limestone on Ko Phi Phi Don. This is in agreement with the age concluded by Shi and Archbold (1995a). However the Ratburi Limestone has yielded conflicting ages from different authors and faunal groups. The age of Late Artinskian to Kungurian is only appropriate for the Ratburi Limestone of Ko Phi Phi Don, in Ao Yongkasem.

Unfortunately as no bryozoan taxa were able to be examined internally from the Phuket Group, no age information can be gained from the Bryozoa of that unit. Furthermore, before Bryozoa from the Phuket Group can be considered for biostratigraphic comparison they must be examined internally. As discussed above for the fenestrates of the Tasmania Basin, external examination only can lead to the mistaken belief that some fenestrate taxa are widespread. This has been shown within the Tasmanian taxa to be at times incorrect, and it would be prudent not to assign taxa on external examination only.

6.4 - SUMMARY

While Bryozoa have not been commonly used for biostratigraphic analysis within Gondwanan rocks, more detailed taxonomic study has revealed a greater diversity of species within this group. Many species are short ranging, and species and faunal successions can be identified within the Tasmania Basin. Taxa previously believed to be long ranging in the

Permian of Australia, may instead be groups of phylogenetically or phenotypically related taxa. In the Tasmania Basin the study of bryozoans through the Permian has allowed construction of a bryozoan zonation. Many species are short ranging and form the basis for the bryozoan Faunizones A to E. Further work in the taxonomy of bryozoans in other basins is required to understand species successions and relationships between basins. The bryozoan fauna of the Tasmania Basin shows a high degree of endemism. However it can be expected that other Australian basins may reveal related taxa, that can still be of use in biostratigraphic analysis. Only a few species co-occur between the Tasmania, Sydney and Bowen Basins. However species occurrences are at similar stratigraphic levels, and further work may reveal a bryozoan biostratigraphy that can be applied across eastern Australia that can be applied where other faunal groups are lacking.

Bryozoan faunas provide the scope for a biostratigraphic zonation comparable with other benthic organisms. As bryozoan fragments may identified from drill-core material, they may prove more useful than other fossil groups in basin-wide biostratigraphic analysis.

The bryozoan fauna of the basal Ratburi Limestone in southern Thailand is of Late Artinskian to Kungurian age. While only a few species are known outside the Ratburi Limestone, a number of endemic species show close relationships with faunas of Western Australia, Timor and Russia.

CHAPTER SEVEN

PALAEOECOLOGY AND PALAEOENVIRONMENT

7.1 - INTRODUCTION

Bryozoan colonies are of variable size and morphology, with feeding zooids as the individual units. Colony morphology varies in response to genotypic and environmental pressures, both within and between taxa. The individual feeding zooid is of consistent size and morphology, within the same species, irrespective of colony size or morphology. Bryozoa can be studied both in terms of their taxonomy and colonial response to environmental changes, and the niche differentiation of each species in response to the feeding attributes and requirements of the individual zooid.

Rates of respiration and metabolism in organisms vary in response to body size, generally decreasing with increasing body size (Schmidt-Nielsen, 1983). Despite bryozoans forming often large colonies, they behave metabolically as groups of minute individuals (Bullivant, 1968b).

Colony morphologies of Recent bryozoans have been variously classified by different authors (e.g., Schopf, 1969; Nelson *et al.*, 1988a; 1988b; Hageman *et al.*, 1997; 1998). The morphological classification of Hageman *et al.* (1998) is the most useful for application to fossil species, as it is the most detailed and allows for the morphological differences between fossil and Recent species. However, little is given about the environments that may correspond to each morphological variant. Studies such as those of Annoscia and Fierro (1973), Nelson *et al.* (1988b), James and Bone (1991) and Smith and Nelson (1996) show more directly the relationship between Recent bryozoan colony morphology and environment. The morphologies displayed by a fossil fauna can therefore be used to determine aspects of past environments.

One aspect of morphology that remains poorly understood is environmental distribution within fenestrate bryozoans, as this group is only a small component of modern bryozoan faunas. Yet in fossil faunas, such as that of the Tasmania Basin, fenestrate bryozoans may form, in some units, the majority of the faunal morphological type. In analysis of modern faunas fenestrate bryozoans are compared to other morphological types, but variation within erect rigid fenestrates is not studied in detail. This issue is addressed at the end of this chapter.

Feeding mechanisms and rates within the individual zooids of the colony were studied by Bullivant (1968a; 1968b), Strathmann (1973) and Winston (1977). Despite the relative age of these studies the principles within them remain largely uncontested, and form the basis for many recent ecological and environmental studies. Whilst there is great variation within living species in their precise feeding rates and response to food groups, there is a correlation between soft part morphology and feeding ability. While soft part morphology within fossil Bryozoa cannot be determined, Snyder (1991) applied the data given by Winston (1977) for living Bryozoa. Soft and hard part relationships given by Winston (1977) were used to assess some aspects of soft part morphology within fossil bryozoans. Most of the taxa studied by Winston (1977) were gymnolaemates rather than stenolaemates, and showed a degree of variation in morphological proportions. However, the relationships shown by Snyder (1991) in his analysis of Mississippian fenestrate faunas reveal that separate morphological characters are related within fossil species, and can provide useful palaeoecologic information within fossil faunas, such as food particle size selection and niche separation.

Following the work of Winston (1977) and Bullivant (1968b), studies of the variables that affect feeding rates in bryozoans have been made. Sanderson and Thorpe (1996) showed that bryozoan feeding rates increase with temperature, as shown by Menon (1972), but also that separate species have differing optimum feeding rate temperatures. Menon (1972) also demonstrated that culturing bryozoans at varying temperatures affected their feeding rates, and that they could become acclimatised, to some degree, to varying temperature regimes.

In this chapter a description and assessment of the palaeoecologic implications of the bryozoan faunas of the Tasmania Basin, southern Sydney Basin and Shan-Thai faunas is presented. A discussion of the different temperature environments and their effects on bryozoan faunal attributes is also given.

7.2 - TASMANIA BASIN FAUNAS.

7.2.1 - *Faunal diversity.*

The bryozoan faunas from the Permian of the Tasmania Basin are represented by the Fenestrata and Trepostomata only, with the fenestrate bryozoans dominating in both abundance and diversity. A total of 13 genera is recorded in this study, drawing from the families Fenestellidae (Fenestrata, 9 genera), Dyscritellidae, Monticuliporidae, Stenoporidae (Trepostomata, 4 genera). In this study 33 species are recorded, of which 20 are new. Combining this information with previous studies there are a total of 37 species in 16 genera (11 within Fenestrata, 5 within Trepostomata). However it must be remembered that many more species and genera are likely to be present, owing to the number of indeterminate colonies, of differing external morphology to the described species.

Lithologic unit	Bundella Ms	basal beds	Darlington Ls	Golden Valley Gp	Masseys Creek Gp	Berriedale Ls	Cascades Gp	Skipping Ridge Fm	Counsel Creek Fm	Weston Mudstone	West Arm Gp	Malbina Fm, unit A	Deep Bay Fm	Malbina Fm, unit E	Minnie Point Fm
Tasmanian faunizone	2+3	2	2	2+3	2	5	4+5	4	5	7 + 8	6 to 9	7	7+8	10	9
International Stage	Sakmarian					Artinskian						Kungur		Ufimian	
Leiofenestella expansa	ef						ef	ef	ef						
Rectifenestella conni selensis									ef						
Rectifenestella granulifera								ef							
Rectifenestella smithae	ef							ef							
Rectifenestella sp A								ef							
Mackinneyella granulosa									ef		ef		ef		
Parapolypora ampla	ef														
Parapolypora boraformis	ef														
Parapolypora sp A	ef					ef									
Parapolypora sp B									ef						
Polypora virga						ef		ef	ef		ef	ef	ef	ef	
Polyporella internata	ef		?					?	?						
Polyporella protuberans											ef				
Polyporella subwoodsi	ef		ef												
Polyporella westarmensis											ef				
Pseudopolypora banksi								ef							
Pseudopolypora bundellaensis	ef														
Pseudopolypora tamarensis											ef				
Pseudopolypora versonoda											ef				
Shulgapora magnafenestrata										ef			ef		
indeterminate fenestrates	ef	ef	ef	ef	ef	ef	ef	ef	ef	ef	ef	ef	ef	ef	ef
Dyscritella inversa	eb	eb													
Dyscritella restis									eb						
Dyscritellina megacanthi		eb													
Paraliocleina wassi								en							
Stenopora aequalis											eb				
Stenopora berriedalensis						eb		eb						eb	
Stenopora crinita						en					en			eb	
Stenopora elongata											eb				
Stenopora etheridgei	eb					eb		eb							
Stenopora grantonensis								eb	eb						
Stenopora ovata						eb		en							
Stenopora spiculata	eb														
Stenopora tasmanensis	eb,efo	eb,efo		eb	eb										
indeterminate trepostomes	eb,efo	eb,efo	eb,efo	eb	eb	en,eb	en,eb	eb	eb		en,eb	en,eb	en,eb	eb	en,eb

Table 7.1 - Distribution of Tasmania Basin taxa, according to lithologic unit. Taxa given are only those recorded in this study. Apparent diversity is restricted in some units according to preservation. For example the basal beds of Maria Island have an abundant fenestrate fauna, yet specimens are fragmentary and difficult to extract reducing the apparent diversity of this unit. Also records colony morphologic type, ef = erect fenestrate, eb = erect branching, en = encrusting, efo = erect foliose

Generic diversity within the two orders represented is low, and most species are contained within only a few of these genera. *Pseudopolypora, Parapolypora, Polyporella* and *Stenopora* dominate the fauna, but with the number of species represented species diversity is moderate, if limited at the generic or ordinal level.

The above discussion considers the Tasmania Basin as a whole, from the Sakmarian to the Kazanian, and not all taxa are represented in each unit (see Table 7.1). The main units from which specimens were collected are the Sakmarian Bundella Mudstone (and equivalents), the Artinskian Cascade Group (and equivalents) and the late Artinskian West Arm Group. Species diversity is highest in the Sakmarian and Artinskian, and is notably reduced in the Kungurian and Ufimian (see Table 7.1).

Despite a lower diversity than other faunas of the same age, faunal abundance is high, with a large number of specimens preserved in many units. In the Sakmarian abundant faunas are found in the Bundella Mudstone within the Hobart region and from the basal beds of Maria Island. This faunal abundance continues through the Artinskian, with faunas throughout the Tasmania Basin generally rich at this time. Greatest bryozoan abundance in the Artinskian is within the Cascade Group from the Hobart region. Bryozoan abundance decreases after the Artinskian, as it does with other faunal groups in the Tasmania Basin.

7.2.2 - *Colony morphologies and palaeoenvironmental indications.*

Unlike modern bryozoans, the Permian faunas of the Tasmania Basin show a limited number of colony morphologies. As the fauna is dominated in diversity and abundance by the Fenestrata, the dominant morphology is fenestrate, or erect rigid fenestrate of Nelson *et al.* (1988b). Within this group there is variation between delicate and robust meshes, with most fenestellids of intermediate robustness, and most polyporids intermediate to robust. Fenestrate morphology varies from the fine branches and thin dissepiments of *Rectifenestella sp. A*, through to the wide thick branches and dissepiments of *Mackinneyella granulosa* and the *Parapolypora* species group. The Trepostomata show more varied morphologies, both within and between species. Following the classification of Nelson *et al.* (1988b) the morphologies shown by the trepostomous Bryozoa within the Tasmanian faunas are; encrusting unilaminate (e.g. *Stenopora crinita* variant, *Paralioclema wassi*); erect rigid foliose (*S. tasmaniensis* variant); erect rigid branching - delicate (e.g. *Dyscritella restis*, *S. grantonensis*) to intermediate (*S. tasmaniensis* variant) to robust (e.g. *S. spicata*, *S. ovata, S. crinita* variant).

	PREFERRED ENVIRONMENTAL CONDITIONS			
	SUBSTRATE	WATER ENERGY	SEDN RATE	SHELF DEPTH
ZOARIAL GROWTH FORM	Hard Partic. Flex.	Low Mod High	Low Mod. High	Inner Mid Outer
Encrusting unilaminate	VC MC MC	MC C VC	VC	VC MC
Erect rig. delicate branching	VC C	VC	VC MC	C VC
Erect rigid robust branching	VC MC	MC VC MC	VC MC	C VC
Erect rig bilaminar foliaceous	C C	C C	VC	MC VC MC
Erect rigid fenestrate	VC MC	C VC	VC MC	MC VC MC

Table 7.2 - Comparison of zoarial growth form and substrate, energy, sedimentation and depth environments, adapted from Nelson *et al.* (1988b). VC = very common, MC = moderately common, C = common

The morphologies of zoarial fragments in the fossil record are a reflection of the types of environments in which they lived. However, before burial zooaria will be abraded and the resultant fossil fauna may differ from the initial living fauna (Smith and Nelson, 1996). High energy environments will have the most abrasive effect, however of the morphologies seen in the Tasmanian faunas only encrusting species are likely to have lived in high energy conditions, and these may be expected to survive as fragments (Smith and Nelson, 1996). In low energy environments there would be little abrasion and fossil faunas could be considered representative of living faunas (Smith and Nelson, 1996). The taxa represented in the Permian of the Tasmania Basin are assumed to be a nearly complete record of the life assemblages, as the overall fauna indicates low to moderate energy.

Studies of recent bryozoan assemblages reveal an association between bryozoan morphology and hydraulic energy, substrate and sedimentation rate, as shown in Table 7.2. Of particular use are the studies of Nelson and Hancock (1984) and Nelson *et al.* (1988b) relating morphology to water depth and energy, and Smith and Nelson (1996) to water energy. Using this information for fossil faunas, encrusting unilaminate bryozoans are most common in moderate to high energy (often shallow water) environments, and in moderate energy environments will be well preserved, Smith and Nelson (1996). Delicate erect rigid branching morphologies are most common in low energy or mid to outer shelf environments. Robust erect rigid branching morphologies are most common in moderate energy, or inner to mid shelf environments. Erect rigid fenestrate or foliose morphologies are most common in low to moderate energy environments, or inner to outer shelf environments (Nelson *et al.*, 1988b).

As water energy is not dependent on water depth, and may be effected by local topography, the relationship of bryozoan morphologies will be discussed in terms of hydraulic energy. Table 7.1 above shows bryozoan morphology for each lithologic unit, and the number of taxa exhibiting each. The units discussed below are those where bryozoans form a significant part of the fossil assemblage.

Maria Island - basal beds.

The basal beds of Maria Island have abundant bryozoans, with spiriferid brachiopods and eurydesmid bivalves forming the coquinas of in the Darlington Limestone. Bryozoans are mostly erect rigid fenestrate, delicate erect branching, and erect foliose forms. Fenestrate and foliose (bilaminar) forms dominate the assemblage. The brachiopods are mostly small but moderately thick shelled, with bivalves either pectinoid or large and thick shelled. The abundance of fenestrate and foliose forms suggests a low to moderate energy environment. However as many of the specimens are fragmentary, the dead colonies may have been transported a short distance. Some large foliose colonies do exist, complete or as large fragments, such as the large *Stenopora tasmaniensis* colony shown in Plate 46, Figure 1. This colony has thick bilaminar fronds, and this may indicate low to moderate water conditions.

Darlington Limestone

The bryozoan faunas within the Darlington Limestone vary through the unit. Within the eurydesmid and spiriferid coquinas bryozoans are rare, and these beds have been described as indicating high energy environments forming shell ridges in shallow water, possibly associated with a barrier beach (Brill, 1982). However between these coquinites are fine bryozoal siltstones, in which the dominant bryozoan morphology is erect fenestrate, with some delicate branching forms and scattered spiriferids. The presence of the fenestrate bryozoans indicates low to moderate water energy, clearly not the high energy environments of the coquinites. Brill (1982) suggested there may have been lagoons shoreward of the shell ridges, and the fenestrate faunas are likely to have been from this environment, or alternatively in quiet shallow water seaward of the shell ridges. The alternation of shell coquinas and bryozoal siltstone would reflect the advance and retreat of the barrier beach.

Skipping Ridge Formation

The Skipping Ridge Formation is of interbedded fine sandstone and siltstone with brachiopods, and fenestrate and delicate branching bryozoans. The bryozoan distribution indicates alternating low to moderate hydraulic energy (fine sandstone) and low energy environments with the presence of delicate branching forms in the siltstones. In the upper part of the unit large encrusting specimens are found on a pectinid shell (see *Parahoclema wassi*, Plate 35, Figure 1). This was an isolated specimen in poor outcrop, and no additional information is available. The presence of encrusting bryozoans usually indicates moderate to high energy environments (Nelson *et al.*, 1988b). In consideration of the lower energy indicators lower in the unit, a low energy environment of low sedimentation is also possible, where an encrusting specimen would not be buried.

Counsel Creek Formation

The Counsel Creek Formation has a diverse fauna with abundant stalked crinoids, bivalves, brachiopods and bryozoans of fenestrate and delicate branching morphologies. Given the presence of fenestrate and branching bryozoans, with stalked crinoids, a low energy environment seems likely.

Hobart region - Bundella Mudstone

The Bundella Mudstone bryozoan fauna is of fenestrate and branching forms of delicate to intermediate robustness, and foliose morphologies. Fenestrate morphologies dominate the bryozoan assemblage and bivalves and brachiopods are also common to abundant. The bryozoan assemblage indicates low energy environments, in keeping with the fine-grained lithology. At Lower Sandy Bay foliose *Stenopora tasmaniensis* (UTGD 126937) develops branching morphologies in the same colony. The original morphology was foliose, and the colony may have developed the branching form after colony breakage and/or partial burial in sediment.

Berriedale Limestone

The Berriedale Limestone has a diverse bryozoan, molluscan and brachiopod fauna with some stalked crinoids. The bryozoan morphologies are dominantly of fenestrate and delicate to intermediate branching forms, with encrusting bryozoans common in local horizons. The encrusting bryozoans appear as cross sections in large blocks and cover the sediment rather than encrusting about a solid substrate. The range of bryozoan morphologies indicates low energy environments, with the encrusting forms recording periods of low sedimentation.

Malbina Formation

Faunas are sporadically preserved in the Malbina Formation, but fenestrate and branching bryozoans occur throughout the fossiliferous horizons. These morphologies are also seen infrequently in poorly fossiliferous beds. In the fossiliferous siltstone of Malbina Formation unit A, encrusting forms are also found and these form radiating encrusting mats that are morphologically well preserved. Growth as radiating mats on the sediment surface, suggests a low energy, low sedimentation environment. Unfortunately internal preservation is poor and none of the specimens collected could be identified beyond inclusion in the Trepostomata. Banks and Read (1962) suggested a low energy, low O_2 water environment from the laminated carbonaceous siltstones of Malbina A that also contain pyrite. The encrusting mat-like bryozoan forms agree with this low energy environment, and may be analogous to algal mats in quiet water environments. These encrusting mats are also found in the Deep Bay Formation at Ford Bay, Bruny Island, and at Deep Bay, Cygnet. In the upper fossiliferous beds, Malbina Formation Unit E, fenestrate bryozoans are well preserved with some infundibuliform specimens found upright in growth position, as also reported by Banks and Read (1962). Delicate to robust branching forms are also found, and together with the well preserved fenestrate forms indicate a low energy environment.

Northern Tasmania - West Arm Group.

The abundant bryozoan faunas within the West Arm Group are separated into a bryozoal siltstone of fenestrate and branching forms, overlain by poorly sorted fine sandstone and siltstone bearing fenestrate, intermediate branching and encrusting forms. The bryozoal siltstones with fenestrate and branching forms suggest low energy environments. The overlying poorly sorted fine sand and silt suggest rapid sedimentation in a changeable environment. Low energies are indicated by fenestrate forms which are often of large well preserved zooaria. determined from the bryozoan morphologies. High energies are indicated by the more robust encrusting morphologies.

7.2.3 - ***Trophic structuring.***

Within fossil faunas soft part morphologies cannot be directly determined or measured, but by analogy with modern bryozoan faunas some aspects of fossil bryozoan soft tissues can be determined. Snyder (1991) applied the data given by Winston (1977) to determine the mouth and lophophore diameters of each individual zooid. The equation derived by Snyder (1991) to determine mouth diameter was from the mean of all the data given by Winston (1977). Despite some variation in the modern bryozoans the method appears valid given the strong correlation shown by Snyder (1991) for independent characters. Assuming that even spacing across the zoarial surface would be most efficient, Snyder (1991) also derived an equation for determining lophophore diameter after analysis of the modern gymnolaemate *Cryptosula pallasiana* (Moll). Starcher and McGhee (2000) discuss lophophores within fossil fenestrates as possibly having an asymmetric shape in some taxa. This is not determinable using methods of Snyder (1991). However the oval apertures found in some taxa may indicate an asymmetric lophophore.

The equations derived by Snyder (1991) are as follows -

Mouth diameter = 40% diameter of the zooecial aperture.

Lophophore diameter = 1.5 times closest apertural spacing.

The diameter of the mouth determines the maximum food particle size that a zooid may ingest. Variation in food particle size able to be ingested indicates niche differentiation or trophic structuring within bryozoan faunas (Winston, 1977). If the zooecial aperture is able to be measured in fossil species it is possible to determine trophic ordering within a fauna, although prey items will remain unknown beyond the generalization of phytoplankton. If a zooid is ingesting larger grains it would follow that body size will also increase. This has been shown by Snyder (1991), after analysis of Winston's data and his fossil fauna studies. Following the reasoning in taxonomic determinations, the closest approximation of the true zooid body is in the size and shape of the living chamber. Thus approximate zooid body size can be determined by calculating the volume of the living chamber.

<u>*Soft morphology analysis of the Tasmanian faunas*</u>

The mouth diameter was determined by calculating 40% of the mean zooecial diameter. Where apertures were oval the mean of the smallest dimension was used. The lophophore diameter was determined by multiplying the mean closest apertural spacing 1.5 times.

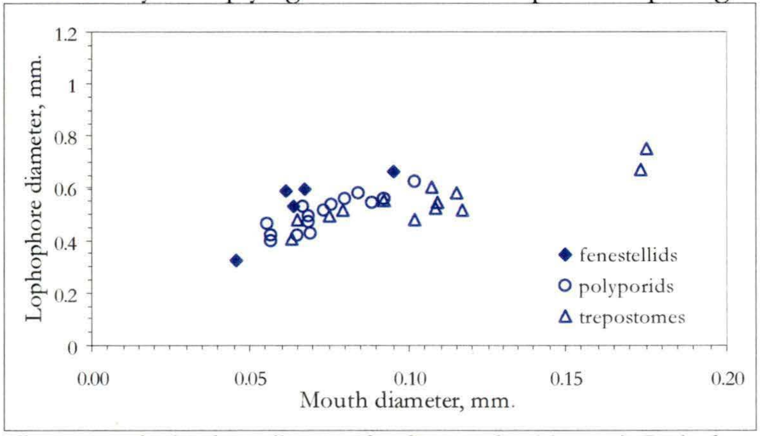


Figure 7.1 - Mouth diameter vs. lophophore diameter for the complete Tasmania Basin fauna

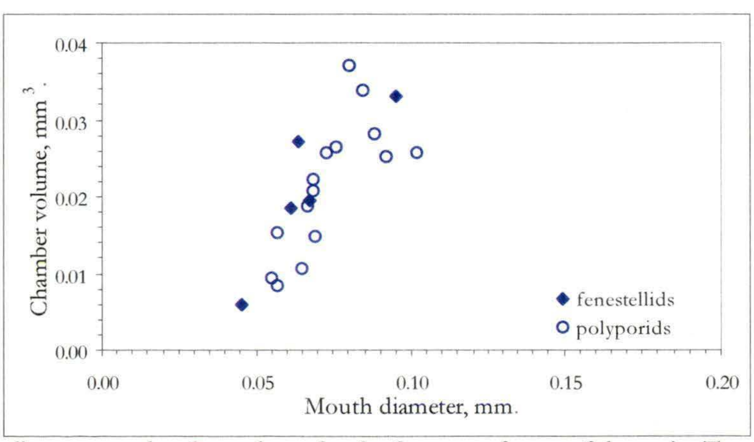
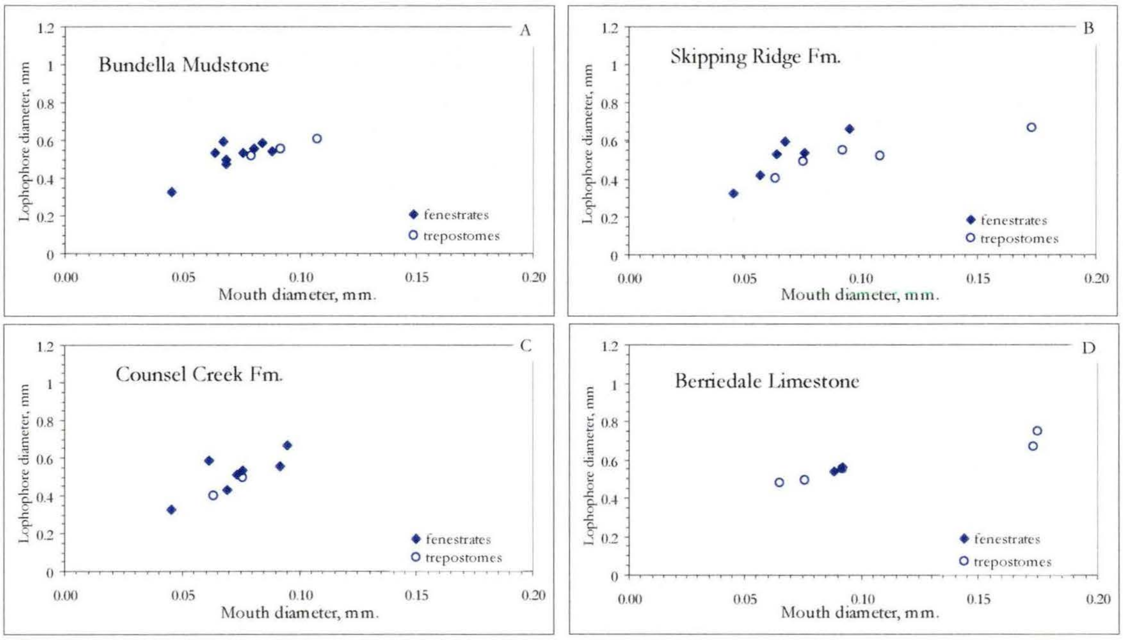


Figure 7.2 - Mouth diameter vs. chamber volume for the fenestrate faunas of the entire Tasmania Basin.

In the Tasmanian fossil faunas, as with modern taxa, calculated lophophore diameter increases with mouth diameter (see Figure 7.1). Mouth diameter is variable across the fauna, indicating niche separation or trophic structuring according to food particle size selection capabilities. Fenestellid species show the lowest mean mouth diameter, and the trepostomes the highest. However there is some variation within each of these groups.

In comparing chamber volume and mouth diameter (Figure 7.2), it can be seen that as mouth diameter increases in fossil faunas, indicating increasing food particle size able to be ingested, chamber volume also increases to accommodate the larger food items. It is impossible to know what each species was selecting as prey, as it has been shown in some modern species, but the spread of mouth sizes suggests that different species had different preferred prey items. Modern bryozoans feed on a range of prey items, and while it has been shown that some modern species will select particular bacterial or algal species on which to feed, and will reject other food particles from the lophophore (Winston, 1977), the prey items of most species are unknown. The variation shown in both figures above may be related to mechanical or biologic variation in selection or non-selection of particular food particles.



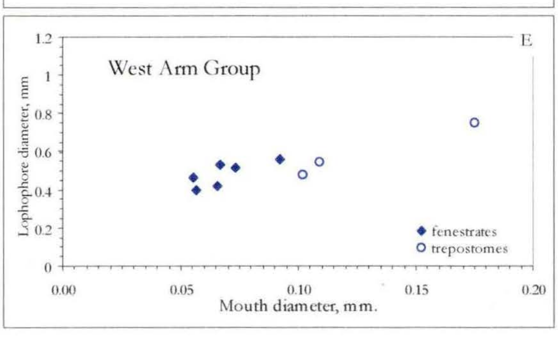


Figure 7.3 - Mouth diameter vs. lophophore diameter for each of the following units - A, Bundella Mudstone, Hobart; B, Skipping Ridge Formation and C, Counsel Creek Formation, Maria Island; D, and Berriedale Limestone, Hobart; E, West Arm Group, Beaconsfield. Data included are only those of species collected in this study.

To assess accurately the presence of niche differentiation or trophic structuring within a fauna, they need to be considered on a unit by unit basis. When only the species from a single unit that were associated with each other in life assemblages are considered, a range of mouth sizes is still shown, as seen in Figure 7.3. Only those units in which a number of species were identified are given above. Because of preservational problems many species are not recorded, but even without a complete faunal group a trend in the data is still clearly visible. In the Sakmarian Bundella Mudstone the bryozoan species with the smallest mouth size, *Rectifenestella* sp. A, had a mouth size of 0.045mm diameter, and would have been able to ingest food particles up to this size. The species with the largest mouth diameter in the

Bundella Mudstone, *Stenopora tasmaniensis*, had a mouth size of 0.11 mm diameter. *S. tasmaniensis* would have been able to ingest food particles up to 0.11 mm, over twice the diameter of *Rectifenestella* sp. A, and the two species may not have had to compete with one another for food. Other species of the Bundella Mudstone faunal association were spread between these two limits. In the late Artinskian West Arm Group the data are more openly spread. The species with the largest mouth size, *Stenopora crinita*, had a mouth diameter of 0.175mm, and would have been capable of ingesting food particles up to this size.

7.3 - SOUTHERN SYDNEY BASIN FAUNAS

7.3.1 - *Faunal diversity.*

The bryozoan faunas from the southern Sydney Basin are rich and diverse, with the most prominent faunas in the Sakmarian Allandale Fm., the late Artinskian Fenestella Shales and the late Artinskian to lower Ufimian Wandrawandian Siltstone. Preservation of these faunas is variable and the best faunas come from the Wandrawandian Siltstone where skeletal remains are well preserved. Therefore the ecological information given below is largely for the Wandrawandian Siltstone, at Ulladulla, where the age of this unit is Kungurian.

The bryozoan faunas of the Wandrawandian Siltstone collected for this study from Ulladulla are represented by the Fenestrata and Trepostomata only, with fenestrate faunas dominating in abundance and diversity. From the Wandrawandian Siltstone 16 species in 11 genera are recorded, with an additional species from each of the stratigraphically lower Wasp Head Formation and Snapper Point Formation. Combined with the earlier studies of Crockford (1941a; 1941b; 1943) and Laseron (1918) a total of 23 species is now known from the Wandrawandian Siltstone. Many more are likely to be present, and should be revealed by future studies.

			Wandrawandian Siltstone		
Lithologic unit	Wasp Head Fm	Snapper Point Fm.	Warden Head	North Head	Dolphin Point
International Stage	Sakm	Art	Kungurian		
Fenestella sp					ef
Laxifenestella exserta			ef	ef	ef
Laxifenestella oviferosa					ef
Levifenestella altacarinata			ef	ef	
Mimilya bituberculata				ef	
Rectifenestella sparsa			ef	ef	ef
Rectifenestella sp b				ef	
Rectifenestella sp c					ef
Paucipora ulladullaensis				ef	
Polypora dichotoma				ef	
Polyporella sp				ef	ef
Shulgapora magnafenestrata					ef
Dyscritella espinensis				eb	eb
Stenopora seriatensis			eb	eb	
Stenopora spiculata	efo				
Stenopora cf *spiculata*		eb			

Table 7.3 - Distribution of southern Sydney Basin species, according to lithologic unit. Taxa given are only those recorded by this study. Morphologic type is also represented, ef = erect rigid fenestrate, eb = erect rigid branching.

Generic diversity is low within both the Fenestrata and Trepostomata, but given that the fauna is collected mostly from one unit, diversity is higher than that shown by the Tasmania Basin faunas. The genera *Laxifenestella, Rectifenestella* and *Stenopora* dominate the fauna in species diversity, with *Laxifenestella exserta, Levifenestella altacarinata, Rectifenestella sparsa, Dyscritella espinensis* and *Stenopora seriatensis* the most commonly recorded species.

In the Sakmarian Wasp Head Formation, brachiopods dominate the fauna, with bryozoans rare, with only one large foliose colony, *Stenopora spiculata*, recorded in this study. One branching colony of *Stenopora* cf. *spiculata* is recorded from the Snapper Point Formation. Poorly preserved fenestrate and other trepostomous bryozoans are seen rarely through Pebbley Beach Formation and outcrops of Snapper Point Formation at Snapper Point. Within the fine-grained beds of the Kungurian Wandrawandian Siltstone at Ulladulla, fenestrate bryozoans dominate the fauna over brachiopods, bivalves and crinoids. In the coarser sandstone beds fenestrate and trepostomous bryozoans are still common, and may locally dominate the fauna.

7.3.2 - **Colony morphologies and palaeoenvironmental indications**.

The dominant colony morphology of the Wandrawandian Siltstone is erect rigid fenestrate of Nelson *et al.* (1988b). This follows the diversity and abundance of fenestrate over trepostomous bryozoans within this unit. Fenestrate morphology, like that within the Tasmania Basin, is variable between the fine branches and thin dissepiments of the *Rectifenestella* spp., to the wide branches and dissepiments of *Polypora dichotoma*. Within the Wandrawandian Siltstone trepostomous morphology is limited to delicate erect branching forms. The only trepostomous colonies recorded elsewhere are the robust erect rigid foliaceous colony from the Wasp Head Formation (*Stenopora spiculata*), and the robust erect rigid branching colony from the Pebbly Beach Formation (*S.* cf. *spiculata*).

As discussed above in section 7.2, colony morphology is a reflection of life environments, particularly hydraulic energy. The presence of well-preserved skeletons, particularly within the Wandrawandian Siltstone, is an indication that the effects of life environment on destruction of certain morphologies (Smith and Nelson, 1996) would have been minimal. The fossil faunas can be taken as a reasonable estimation of living Wandrawandian Siltstone hard-bodied faunas, but further collection can only improve this understanding.

The predominantly erect rigid fenestrate forms, along with delicate branching forms indicate low energy environments. The abundance of bryozoans, in some cases forming mudstone coquinas (Eyles *et al.*, 1998) indicates low sedimentation rates interrupted by turbidity flows depositing beds with less abundant, and often fragmented, bryozoans. Facies analysis of the Wandrawandian Siltstone by Eyles *et al.* (1998) has determined low energy conditions in an offshore setting, with episodic turbidity current flows.

7.3.3 - **Trophic structuring**.

Soft morphology analysis of Wandrawandian Siltstone faunas

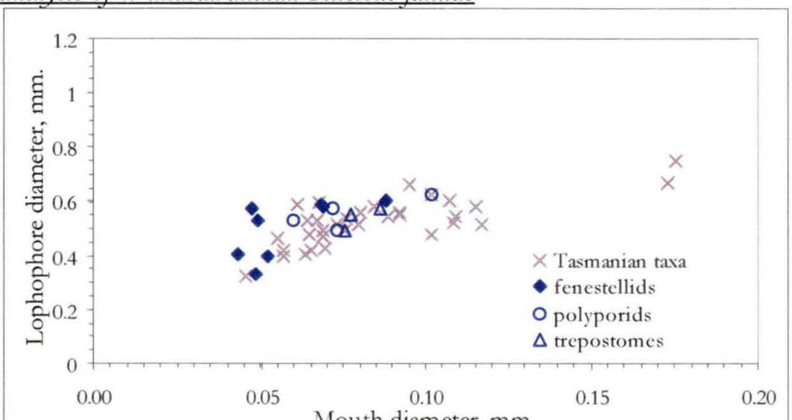


Figure 7.4 - Calculated mouth diameter vs. lophophore diameter for the Wandrawandian Siltstone faunas recorded in this study. Tasmanian taxa included for comparison. Mouth diameter = 40% aperture diameter, lophophore diameter = 1.5 x closest apertural spacing.

As discussed above in 7.2.3, some aspects soft body morphology can be determined from skeletal fossil remains. The following data are taken from the species recorded in this study from the Wandrawandian Siltstone.

As with the Tasmanian faunas shown in Figures 7.1 and 7.3, there is a relationship between the soft part morphology of mouth diameter and lophophore diameter in Wandrawandian Siltstone bryozoan faunas (Figure 7.4). The fenestellid taxa show the smallest mouth and lophophore diameters, and can be assumed to be selecting the smallest food particles. Polyporid and trepostomous taxa have a similar range of mouth and lophophore diameters and can be assumed to be selecting larger food particles than the fenestellid taxa. In comparison with Tasmanian taxa, the two faunas are similar for the bulk of taxa, although mean mouth and lophophore diameter is slightly lower for the Wandrawandian Siltstone fauna.

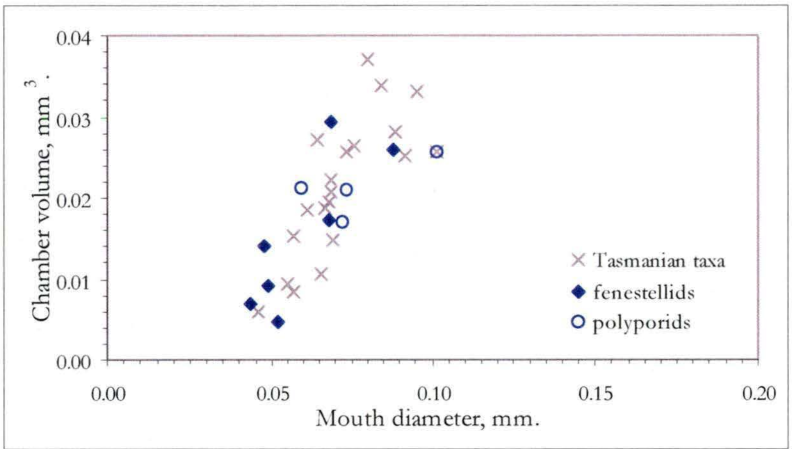


Figure 7.5 - Calculated mouth diameter vs. chamber volume for the Wandrawandian Siltstone fenestrate taxa recorded in this study. Tasmanian taxa included for comparison.

As seen in Figure 7.5 above, chamber volume increases with mouth diameter as larger particles are able to be ingested by the individual zooid. The spread of data indicates variation within the fauna of food particle size and species selection, and the efficiencies in assimilating food for each species.

7.4 - SOUTHERN THAILAND FAUNAS.

7.4.1 - **Faunal diversity.**

species	morphology	species	morphology
Alternifenestella subquadratopora	ef	*Synocladia irregularis*	ef
Fabifenestella carinata	ef	*Penniretepora subtropica*	ep
Fabifenestella subthaiensis	ef	*Acanthocladia pseudothaiensis*	ep
Flexifenestella hexaformis	ef	*Acanthocladia suprangularis*	ep
Minilya duplaris	ef	*Paralioclema phuketensis*	eb
Minilya phiphiensis	ef	*Neoeridotrypella subpulchra*	eb
Rectifenestella pulchradorsalis	ef	*Ascopora robusta*	eb
Spinofenestella flanchea	ef	*Ascopora variablis*	eb
Spinofenestella horologia	ef	*Rhabdomeson monoformis*	eb
Spinofenestella lekformis	ef	*Streb(Streblasco) komukensis*	eb
Spinofenestellas pseudohorologia	ef	*Cyclotrypa dendroides*	eb
Mackinneyella nodosa	ef	*Eridopora thaiensis*	enm
Mackinneyella subobesa	ef	*Fistulopora horowitzi*	eb
Polypora canalis	ef	*Fistulopora megapertura*	enm
Polypora nodulifera	ef	*Fistulopora satoi ?*	enm
Shulgapora reversa	ef	*Coscinotrypa yaiformis*	ef
Shulgapora megacyclopora	ef	*Hexagonella khaophrikensis*	efo
Reteporidra yongkasemensis	ef	*Goniacladia* sp. indet.	ef
Septapora interformis	ef	*Goniacladia* sp. indet.	ef

Table 7.4 - Species morphology list for the Ratburi Limestone, Ko Phi Phi Don. ef = erect rigid fenestrate, ep = erect pinnate, eb = erect rigid branching, enm = encrusting multilaminar, efo = erect rigid foliose.

The bryozoan fauna of the Ratburi Limestone on Ko Phi Phi Don, southern Thailand, is diverse and abundant. Taxa recorded in this study are drawn from the orders Fenestrata (14 genera), Trepostomata (2 genera), Cryptostomata (3 genera) and Cystoporata (6 genera). Unlike the faunas of eastern Australia where fenestrates and trepostomes are the only groups present, the southern Thailand faunas are more diverse at ordinal level. The southern Thailand faunas are still dominated by the Fenestrata, but Cystoporata are also important, and the Trepostomata, important in eastern Australian faunas, are only a small component of the Shan-Thai fauna.

Species and generic diversity is high in the Ratburi Limestone of Ko Phi Phi Don, with 38 species recorded in 25 genera. Genera with more than two species represented are *Spinofenestella* and *Fistulipora*. However no species or genus is notably dominant in diversity or abundance, with the number of records of each species varying between one and four.

Within the Ratburi Limestone of Ko Phi Phi Don, bryozoans are abundant and are an important aspect of the faunas, along with brachiopods, bivalves, crinoids and rugose corals. Bryozoa are present throughout the unit, and in bioclastic limestone beds are often the dominant faunal group, along with small brachiopods.

7.4.2 - *Colony morphologies and palaeoenvironmental indications.*

Erect rigid fenestrate morphologies dominate the fauna (Table 7.4), and this morphology is found within both the Fenestrata and Cystoporata (*Coscinotrypa* and *Goniacladia*). The Acanthocladiidae (Fenestrata) show erect rigid pinnate morphologies. Erect pinnate is not given by Nelson *et al.* (1988b) as this morphology is not applicable to modern faunas, but is used here to describe more accurately the Acanthocladiidae. The Trepostomata and Cryptostomata both show only erect rigid branching morphologies, with both delicate (*Rhabdomeson monoformis*) and robust (*Paralioclema phuketensis*) forms seen. The Cystoporata show the most variable morphologies, with erect rigid branching (e.g., *Cyclotrypa dendroides* and *Fistulipora horowitzi*) erect fenestrate (e.g., *Goniacladia*) erect foliose (*Hexagonella khaophrikensis*) and encrusting multilaminar (e.g., *Eridopora thaiensis* and *Fistulipora megapertura*).

The dominance of fenestrate forms in the fauna indicates low to moderate energies, with local environments of moderate (encrusting forms) and low energy (delicate branching). The preservation of the multilaminar encrusting forms, that in modern faunas prefer moderate to high energy environments, is good and they are readily destroyed after death in high energy environments (Smith and Nelson, 1996). It is likely that the Ratburi Limestone at Ko Phi Phi Don did not extend beyond moderate energy. This is in keeping with the depositional setting proposed by Baird and Bosence (1993), where wackestone, from which the bryozoan faunas were collected, is given to indicate low energy carbonate platform environments.

7.4.3 - *Trophic structuring.*

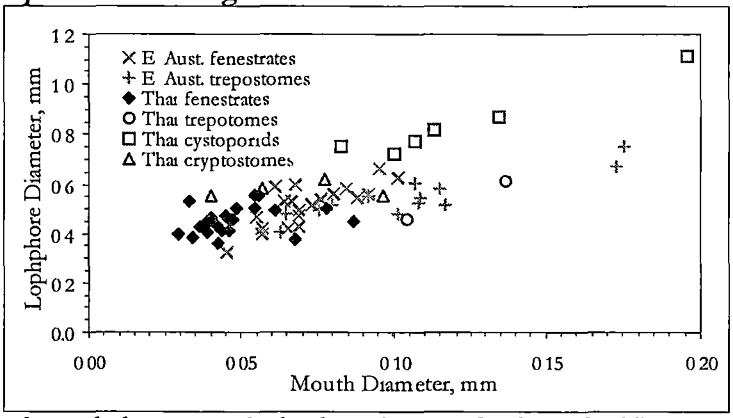


Figure 7 6 - Calculated mouth diameter vs. lophophore diameter for the Ratburi Limestone, Ko Phi Phi Don. Eastern Australian taxa included for comparison. Mouth diameter = 40% aperture diameter, lophophore diameter = 1.5x closest apertural spacing.

The diversity of bryozoans in the Ratburi Limestone shows, more clearly than the eastern Australian faunas, trophic separation at ordinal level. The fenestrates, trepostomes, cryptostomes and cystoporates are clearly separated in feeding capabilities.

As seen in Figure 7.6 above, the Fenestrata have the smallest mouth and lophophore diameters in the Ratburi Limestone, with increasing size shown by the cryptostomes, trepostomes and cystoporates respectively. Given that bryozoans with smaller mouth diameters will ingest the smallest food particles, the fenestrates will be feeding on the smaller food particles or phytoplankton species. The cystoporates, with larger mouths, will be able to access larger food particles or select the larger phytoplankton species. Following Winston (1977) and her comments that bryozoans, as suspension feeders, will exhibit trophic structuring within a fauna, there is clear trophic ordering within the Ratburi fauna, at species and order level.

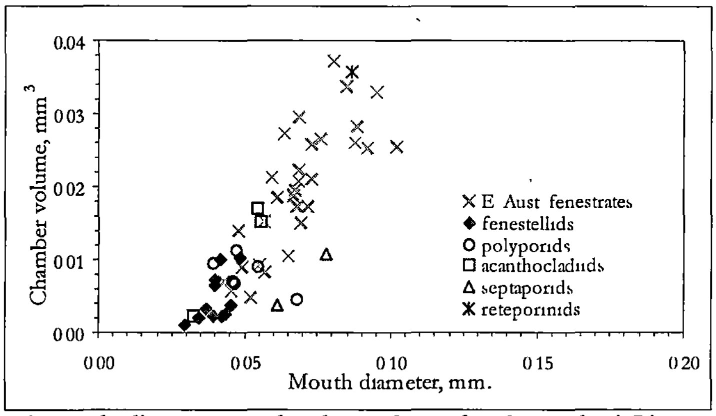


Figure 7.7 - Calculated mouth diameter vs. chamber volume for the Ratburi Limestone fenestrate fauna. Eastern Australian fenestrates included for comparison

As with the eastern Australian faunas it can be seen, in Figure 7.7, that as mouth diameter increases in the Ratburi Limestone faunas, so does chamber volume. The larger the food particle able to be ingested the larger body size required to assimilate them. Again trophic structuring is seen, this time between fenestrate families. The smallest mouth diameters, and therefore size of food particles able to be ingested, are seen in the fenestellids with the reteporinids showing the largest mouth diameter and chamber volumes within the fenestrates. In comparison to the eastern Australian fenestrate taxa, the Ratburi fenestrates have smaller mouth diameters and chamber volumes, with the exception of *Reteporidra yongkasemensis*.

7.5 - COMPARISON OF EASTERN AUSTRALIAN AND SOUTHERN THAILAND PERMIAN BRYOZOAN FAUNAS.

7.5.1 - *Trophic structuring.*

The Ratburi Limestone fenestrate faunas have generally smaller mouth diameters and chamber volumes than their counterparts in eastern Australia. This may reflect either a different feeding pattern, or that only smaller food particles were available. As discussed above in comparison of mouth and lophophore diameter across all faunal groups, in the Ratburi Limestone, fenestrate taxa are selecting the smaller food particles, and cystoporates the larger particles. The cryptostomes, and importantly the cystoporates, are absent from eastern Australian faunas. In the absence of the cystoporates that can exploit the larger food particles, and perhaps confine the fenestrates to small food particles only, the eastern Australian faunas have an extra niche available to them, this being the niche of large food particles. From the comparison of mouth and lophophore diameters as an indication of feeding ability it would appear that the eastern Australian fenestrate and trepostome species are expanding into this niche. The eastern Australian taxa have developed larger mouths so that they can exploit the larger food particles that may be available to them, in the absence of the cryptostomates and cystoporates.

Within the eastern Australian faunas the trepostomes are exploiting larger food particles than the fenestrates, with some overlap of their ranges. While the presence of larger mouthed groups in the Ratburi Limestone may be limiting the fenestrates to small food particles by competitive pressure, the fenestrates are able to exploit larger grains if that competition is removed. However the largest mouth diameter of the eastern Australian is still somewhat smaller than the Ratburi cystoporates, perhaps indicating a limit on mouth size within fenestrates. Starcher and McGhee (2000), suggest this may be related to either the physiology of stenolaemates or the functioning of the fenestrate meshwork. While the fenestrates may be limited, this does not appear to be true for the stenolaemates as a whole. The cystoporate *Fistulipora megapertura* of the Ratburi Limestone has a lophophore diameter of 1.11 mm, and all the cystoporates of that fauna have large lophophores. The largest reported gymnolaemate lophophore diameter is 1.42mm, for the ctenostome *Flustrellidra hispida* (Winston, 1977). While the lophophore diameter for *F. megapertura*, a stenolaemate, is still smaller than the largest modern gymnolaemate, it shows the capability of stenolaemates to develop large lophophore and mouth diameters. Therefore the stenolaemates have the ability to exploit most food particles available to bryozoans as a group.

7.5.2 - *Temperature, colonization, feeding and growth rates.*

Temperature plays an important role in the activity and metabolism of bryozoans (Menon, 1972). It has been experimentally shown that feeding and growth rates increase with increasing temperature for the same species (Menon, 1972; Sanderson and Thorpe, 1996). When a modern species is grown experimentally at different temperatures, the zooids exhibit higher feeding rates with increasing temperature, and as a result the colony growth rate increases. However different species have different optimum feeding temperatures (Sanderson and Thorpe, 1996). Menon (1972) cultivated colonies of the same species, from the same original colony, within the laboratory at different constant temperatures (6°, hereafter low, and 12°, 18° and 22°, hereafter high). Colonies grown at low temperatures had initially lower growth rates than colonies at high temperatures. However after a period of 180 days, colony growth rate was comparable or higher than high temperature colonies, even if total colony size attained at that time was smaller. Given time, these low temperature colonies may have outgrown the high temperature colonies (Menon, 1972). Regeneration of degenerated individual zooids at different temperatures revealed a similar pattern. After an initially slow regeneration rate, colonies at low temperatures regenerated much faster than those at high temperatures, which show a decreased regeneration rate over time (Menon, 1972). This suggests that species may become acclimatized to lower temperatures, and that over time will be more successful. Perhaps the individual zooid, whilst initially showing an increased activity (feeding) in high temperatures, cannot maintain this activity over time.

Colonization rates of bryozoans and other marine encrusters are also affected by temperature. Artificial surfaces laid in marine Antarctica showed only a 12% maximum colonization rate (percentage cover of an artificial surface) after 21 months immersion (Barnes, 1996). This is in comparison to 75% colonization after 9 months in Patagonian waters (López Gappa, 1989), 98% in one year, Italy (Pisano and Boyer, 1985) and 80 % in one year, Jamaica (Jackson, 1977).

While the eastern Australian faunas are not diverse, numerous specimens are preserved, with many large colonies. In comparison, the Shan-Thai Terrane faunas show a high faunal diversity, but zoaria are not as large as the cold water Tasmanian faunas. Carbonate geochemistry and petrology indicates seawater at less than 4°C, for the Tasmanian Sakmarian/Artinskian (Rao and Green, 1982). Given the above experimental results, it would appear that bryozoan species with a low temperature threshold will be able to settle in cold water conditions and develop large colonies. Temperature will however inhibit faunal diversity, as not all taxa will be capable of acclimatising to lower water temperatures.

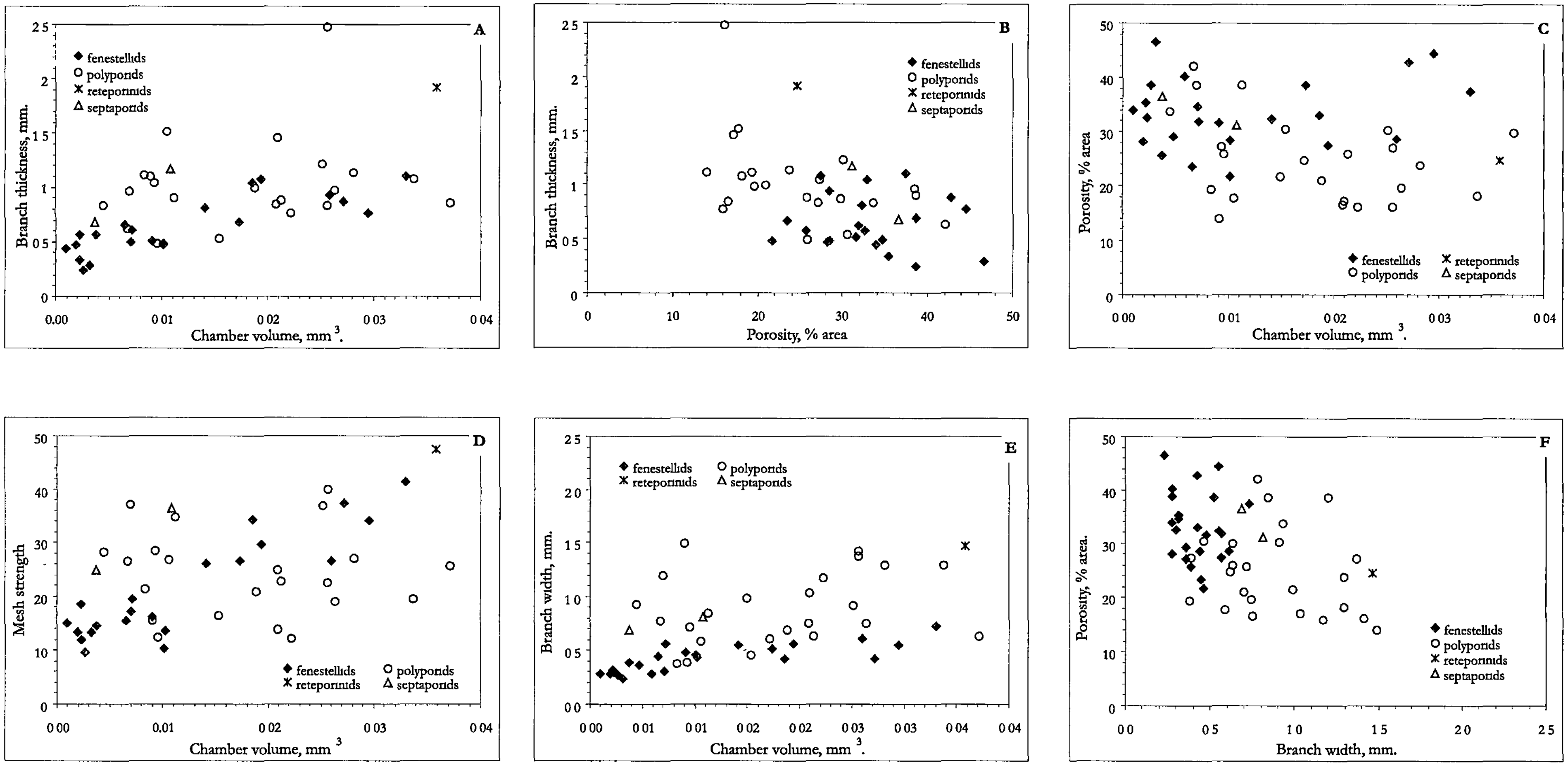


Figure 7.8 - Comparison of branch thickness, chamber volume, porosity and estimated mesh strength. Taxa are those recorded in this study from the Tasmania and Sydney Basins, and the Ratburi Limestone, southern Thailand.

After initially low colonization, feeding and growth rates, the surviving colonies may be capable of out living colonies of warm water environments. Conversely while initial colonization, feeding and growth may be high in warm water faunas life expectancy and overall size of the colony may be reduced, by either competition with other colonies for space, and the perhaps the inability to maintain high growth and zooid regeneration rates over time.

7.6 - ANALYSIS OF FENESTRATE MESH

In the above palaeoenvironmental sections mesh strength variations within fenestrate morphologies were not considered, and the group was discussed as a whole. It might be expected that the more robust fenestrate meshes are developed as a response to increasing water energy, and the more robust the stronger the mesh.

While no experimental work has been done on the strength of various fenestrate meshes (either as a biologic or mechanical entity), the possible causes of variation in mesh size are discussed below.

With increasing chamber volume, branch thickness and width increase to accommodate the larger chambers. This is shown in Figure 7.8A and E, where a good correlation is seen, particularly with the fenestellids. Branch width and thickness is generally higher in polyporids than fenestellids of similar chamber volumes, as branch proportions must increase to accommodate the extra rows of zooecia.

Porosity of the fenestrate mesh was calculated by determining the area of the colony surface taken up by fenestrules, and is expressed as a percentage of the entire colony surface area. In Figure 7.8B an approximately inverse relationship is seen between branch thickness and mesh porosity. Despite the delicate appearance of some of the fine meshed fenestellids they exhibit a larger area of fenestrules to skeletal material. Perhaps this is an adaptation to the apparent skeletal weakness of having thin delicate branches. Despite a relationship between branch thickness to chamber volume and mesh porosity, there is little correlation between mesh porosity and chamber volume.

Mesh strength, as shown in Figure 7.8D was estimated by multiplying mesh porosity by branch thickness. This calculation enhanced advantages of both a mesh with low surface area to present resistance to water flow (e.g., high porosity), and thick branches that would give a colony strength perpendicular to water flow. Estimated mesh strength is compared to the independent measurement of chamber volume, to determine whether apparent mesh strength increases with increasing chamber volume. As a group the correlation is poor, but within the fenestellids, where there are always two rows per branch, a trend does exist. As chamber volume increases so does estimated mesh strength. This suggests that, at least within the fenestellids, mesh strength, mesh size, branch width and thickness are an artifact of increasing chamber volume. As shown previously in this chapter, chamber volumes increase with mouth diameter and the size of food particles able to be ingested. It appears that mesh strength, and branch width and thickness, are related to feeding habits rather than water energy environment. However mesh porosity is inversely related to branch thickness and width, and perhaps the more delicate species are compensating low branch strength with a higher porosity, in order to increase overall mesh strength. The meaning of the lack of correlation between mesh porosity and chamber volume is unclear, and perhaps suggests further niche differentiation between taxa with the same food particle size preferences.

The indication that branch width and thickness are a function of chamber volume agree with the findings of Starcher and McGhee (2000), in their analysis of theoretical fenestrate morphology. In examining theoretical morphospace within fenestrate bryozoans Starcher and McGhee (2000) suggested fenestrates have a constructional response to scale. Fenestrate bryozoans, requiring a continuous filtering surface, must increase branch width and spacing with increasing zooid domain area, or lophophore size. As discussed above lophophore and mouth diameter, and therefore chamber volume, are related to food particle size. Polyporids must increase branch width, with their increased number of rows of zooecia, and both fenestellids and polyporids must increase branch width as chamber volume increases in response to increasing mouth diameters and food particle size. As larger mouth diameters mean a larger food particle size able to be ingested, increasing branch width is a response to feeding and differentiation, rather than a response to increasing water energy.

7.7 - SUMMARY

The bryozoan faunas from the Permian of southern Thailand are more diverse than those from the Permian of the Tasmania and southern Sydney Basins. However the same range of colony morphologies is seen, and all can be used in palaeoenvironmental analysis. Fossil bryozoan colony morphologies may be used to determine water energy and approximate sedimentation rates following the work of Nelson *et al.* (1988b) and others, on modern bryozoan faunas. Fenestrate and branching colonies demonstrate low to moderate energy environments where these bryozoans are common in the Tasmania and southern Sydney basin, and Shan-Thai Terrane faunas. The sediment encrusting trepostomes of the Tasmania Basin indicate low energy and low sedimentation rates where this bryozoan morphology is present.

The palaeoecology of fossil bryozoan faunas can also be estimated, as shown by Snyder (1991). As mouth diameter increases, allowing ingestion of larger food particles, chamber volumes also increase as zooid body size increases to accommodate the larger food particles. Trophic structuring can be seen in fossil bryozoan faunas, whereby different species occupy different food particle size niches. In the diverse Shan-Thai faunas trophic structuring is also seen at the ordinal level, where the Fenestrata occupy the smallest food particle size niches with the Cryptostomata, Trepostomata and Cystoporata occupying respectively larger food particle size niches. In the Tasmania and southern Sydney Basin faunas, the absence of cryptostomes and cystoporates, has allowed the fenestrates and trepostomes expand into the larger food particle size niches.

In the Fenestrata branch width and thickness increase with increasing chamber volume and zooecial row number. Mesh strength, a function of mesh porosity and branch thickness, also increases with chamber volume. Because chamber volume increases with food particle size selection, it is suggested that mesh variation in fenestrates is due to food selection rather than a direct response to water energy environment.

Water temperature affects bryozoan colonization, feeding and growth rates. Colonization rates are lower in cold water than in warm water (Barnes, 1996). Feeding and growth rates increase with temperature within the same species (Menon, 1972; Sanderson and Thorpe, 1996). However bryozoans may become acclimatized to low temperatures (Menon, 1972). While feeding and growth rates may be initially higher at higher temperatures, over time, they may be outgrown by the same species at low temperatures. Therefore in the cold water environments of the Permian of the Tasmania Basin, where although colonization rates are low, feeding and growth rates may be increased and maintained over time to produce large colonies. In the warm water environment of the Permian Shan-Thai Terrane, where colonization rates are high, initial feeding and growth rates are high, but cannot be maintained over time.

CHAPTER EIGHT

GONDWANAN BRYOZOAN BIOGEOGRAPHY

8.1 - INTRODUCTION

Permian bryozoan faunas occurred throughout the world and in all marine climatic zones. Their biogeography has been studied by a number of authors, with significant works coming from Sakagami (1976; 1985), Ross (1978; 1995) Ross and Ross (1990; 1996) and Gilmour and Morozova (1999).

Ross (1978) defined ten biogeographic regions in the worldwide distribution of Permian bryozoans. Within the Gondwanan region the faunas of Western Australia, Malaysia, Thailand and the Salt Range of Pakistan, are considered as one biogeographic region, the "southern Tethys" of Ross (1978; 1995). The "Tasman Geosyncline" of Ross (1978) includes the Bowen Basin of Queensland and the Sydney and Tasmania Basins, along with the bryozoan faunas of New Zealand. Gilmour and Morozova (1999) divided biogeographic provinces according to boreal tropical and notal climatic zones, and further subdivided these regions. The notal zone included Western Australia and was separated from Thailand and Malaysia which were retained in the tropical climatic zone. Gilmour and Morozova (1999) also placed New Zealand faunas into a separate province, following unpublished work by Gilmour.

In the Gondwanan and Southeast Asian region non-bryozoan biogeographic studies use a different terminology again. The faunal provinces described by Archbold (1983), Shi and Archbold (1995b) and Archbold and Shi (1996) are specific to the Permian of the western Pacific, and incorporate New Zealand, Australia, southeast Asia, India-Tibet, China, Japan and eastern Siberia. In particular, the Westralian, Austrazean and Cimmerian-Sibumasu faunal provinces are of relevance to this study.

In all the above works the bryozoan faunas of the Tasmania, Sydney and Bowen Basins have been grouped together as one faunal province. However in this chapter it will be shown that there is also biogeographic zonation within eastern Australia and, along with New Zealand bryozoan faunas, needs to be considered in more detail than has been possible in the past. The inclusion of new records from this study, and the redefinition of the genera *Fenestella* and *Polypora*, allows for a more detailed analysis of the Tasmania Basin faunas in respect to regional and global biogeography.

8.2 - GONDWANAN BIOGEOGRAPHY

In the Permian, the Australian continent was grouped together with Antarctica and India in southern Pangaea, along with terranes that would later become parts of New Zealand and Asia. In the Asselian to early Sakmarian the Australian continent was situated between approximately 45° and 70°S, and had shifted northwards to between about 30° and 60° by the Late Sakmarian, where it remained until the Late Permian (Metcalfe, 1996).

The region underwent a major glaciation in the Early Permian (Asselian), after climatic cooling through the Carboniferous and development of glacial deposits in the Late Carboniferous. In the Early Permian terrestrial glaciation was widespread along with glacial deposits associated with marine faunas (Dickins, 1985). Through the remainder of the Early Permian "dropstones" are common in some areas, and at least indicate floating ice from a distant source, with warming in most areas in the Late Permian (Dickins, 1985).

Post-Sakmarian faunas of the eastern Australian region, including the Bowen, Sydney and Tasmania Basins and New Zealand form the Austrazean Province (Archbold, 1983). In the

Asselian and Early Sakmarian eastern Australia is included in the Indoralian Province along with Western Australia and southern Thailand, but faunas became distinct after the close of major glaciation in western areas. The Westralian Province (Archbold, 1983) developed at this time and coincided with the rifting of southeast Asian terranes (including the Shan-Thai Terrane) from Gondwana. The rifted terranes formed the Cimmerian Province (Archbold, 1983) and included elements of Gondwanan and Cathaysian faunas. By the Late Permian the Shan-Thai Terrane had been assimilated within the Cathaysian Province of the central Tethys.

The following discussion is in relation to the Austrazean, Westralian and Cimmerian Provinces of Archbold (1983), Shi and Archbold (1995b; 1998), and Archbold and Shi (1996), and are shown in Figure 8.1. Although these provinces were recognized from brachiopod, rather than bryozoan, faunas, they are focused on the Gondwanan region, in contrast to the global studies of Ross (1978; 1995) and Gilmour and Morozova (1999). The Austrazean Province is equivalent to the "Tasman Geosyncline" of Ross (1978) and the East-Australian and New Zealandian Provinces of Gilmour and Morozova (1999). The Westralian and Cimmerian Provinces are equivalent to the "southern Tethys" region of Ross (1978) and the West-Australian and Thailand-Malaysian Provinces, respectively, of Gilmour and Morozova (1999).

8.2.1 - *Austrazean province*

The Austrazean Province of Archbold (1983) includes the Tasmania, Sydney and Bowen Basins along with New Zealand. The brachiopod faunas reveal a low generic diversity but a relatively high level of endemism (Shi and Archbold, 1995b). Brachiopod faunas show a general increase in diversity from Tasmania (lowest) north to the Bowen Basin (highest) (Archbold, 1983). This trend is also followed by the bryozoans, as will be discussed below.

In general, the bryozoans of the Austrazean Province are less diverse than in lower latitude faunas. However while this may be true at ordinal and generic level, there may be many species represented in one genus, increasing the diversity within the fauna of bryozoans that were able to establish themselves in higher latitudes. The four orders Fenestrata, Trepostomata, Cryptostomata and Cystoporata are represented in the Austrazean Province. The fauna is however dominated by the fenestrate bryozoans, with the greatest number of genera and species found here. There are no endemic genera.

Between basins in the Austrazean Province, there is however, a degree of variation. The faunas of the Bowen Basin, Queensland are the most diverse, with all the above orders present. The fenestrate bryozoans still dominate the fauna (Crockford, 1951; Wass, 1968; Ross, 1996), however the Cryptostomata and Cystoporata show greater abundance and diversity in the Bowen Basin, than elsewhere in eastern Australia. The bryozoan faunas of the Bowen Basin show a closer relationship to those of the Westralian Province than the faunas of New Zealand and the Sydney and Tasmania Basins. The cystoporate *Metelipora*, previously only known from the Sakmarian of the Russian Platform, is also recorded from the Bowen Basin (Morozova, *pers. comm.*, 1998).

The faunas of the Sydney Basin are dominated by the Fenestrata, with common Trepostomata and rare Cryptostomata. Representatives of the Cystoporata are not known to this author from the Sydney Basin. There are 18 genera recognized by this study in the Sydney Basin, 13 Fenestrata, 4 Trepostomata and one cryptostomate (see Figure 8.2). The fauna is dominated by the genera *Laxifenestella, Rectifenestella, Polyporella, Polypora, Dyscritella* and *Stenopora. Paucipora* is also recorded here for the first time, and while it is only known from one species there may be other representatives in previously described faunas that as yet have not been examined internally. This is probably also true of many other fenestrate genera. *Shulgapora* is known from the Sakmarian to at least the Kungurian, with *Mimilya* and *Levifenestella* confirmed in the Latest Artinskian to Kungurian, but may occur elsewhere. *Parahoclema* is known from rare specimens in the Tasmania and Bowen Basins, but as yet is

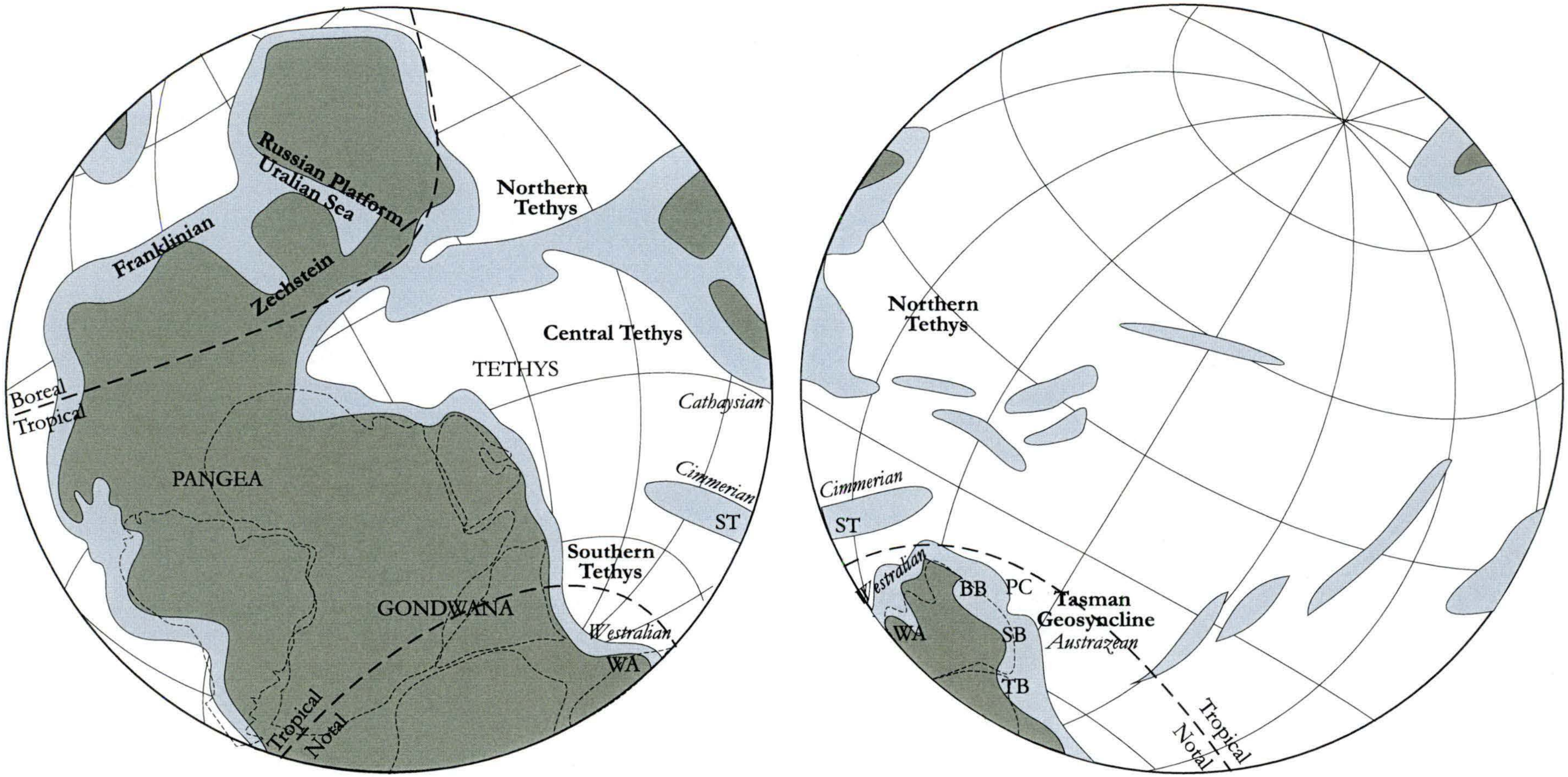


Figure 8.1 - Permian palaeogeography (Early Permian). Base map from Ross (1995)The boundaries of notal, tropical and boreal climatic zones from Gilmour and Morozova (1999). Bryozoan biogeographic provinces of Ross (1978; 1995) in bold type. Gondwanan provinces from Shi and Archbold (1998) in italics. WA = Western Australia, ST = Shan-Thai Terrane, BB = Bowen Basin, SB = Sydney Basin, TB = Tasmania Basin. PC = Productus Creek Group, New Zealand.

not known from the Sydney Basin. Despite the differences between the faunas of the Bowen and Sydney Basins at ordinal and generic level, there are a few species in common in the genera *Stenopora, Polyporella* (*Polypora woodsi*), *Shulgapora*, *Polypora*, *Levifenestella* and *Fenestella* s.l.

The Permian bryozoan fauna of the Productus Creek Group, New Zealand, have representatives from the Fenestrata, Trepostomata, Cryptostomata and Cystoporata, with a total of 38 genera, and is dominated by the fenestrates (Gilmour and Morozova, 1999). The presence of the cystoporates and a greater number of cryptostomate genera indicates a closer relationship of the Productus Creek Group faunas with those of the Bowen Basin, than with the Sydney or Tasmania Basins.

The Tasmania Basin bryozoan faunas are dominated by the Fenestrata, with Trepostomata also very common, and a total of 15 genera. Spry and Banks (1962) reported *Streblotrypa (Streblascopora) marmionensis* from the Quamby Group of Tasmania, but no cryptostomates have been recorded by this author. The genera *Rectifenestella, Polyporella, Parapolypora, Pseudopolypora* and *Stenopora* dominate the fauna, each with a number of species known. Also common is *Levifenestella* in the Sakmarian and Artinskian, *Polypora* and *Dyscritella* and *Stenodiscus*, which is common in the Berriedale Limestone, and *Mackinneyella*, common in the late Early Permian. Generic and species diversity is highest in the Artinskian with 24 species in 13 genera. *Dyscritellina* occurs in the Sakmarian, yet in the Permian of northern Pangaea is only known from the Kazanian of the Northern Tethys and the North American Cordillera. Gilmour and Morozova (1999) recorded *Dyscritellina* from the Productus Creek Group (Late Permian?) of New Zealand. The occurrence of *Dyscritellina* in the Sakmarian of the Tasmania Basin suggests the genus originated in Gondwana, but apart from the New Zealand occurrence there are no other records from the region, and dispersion patterns cannot be determined. *Shulgapora* occurs in the late Early Permian of the Tasmania Basin, as it does in the remainder of the Austrazean Province.

Most of the genera in the Tasmania and Sydney Basins are of either a cosmopolitan or boreal distribution. This supports the idea of a bi-polarity in the distribution and development of bryozoans suggested by Gilmour and Morozova (1999) in regard to the notal faunas of New Zealand and eastern Australia.

8.2.2. - *Indoralian, Westralian and Cimmerian Provinces.*

The Westralian and Cimmerian Provinces were described by Archbold (1983), and the Indoralian by Shi and Archbold (1995a) based on the distribution of brachiopod faunas. The Cimmerian Province comprises the Himalayan Subprovince (including Timor, northwest, central and south Tibet) and the Sibumasu Subprovince (Shan-Thai Terrane and Irian-Jaya) (Archbold and Shi, 1996).

The Indoralian Province was short-lived and included Asselian to earliest Sakmarian faunas from both eastern and Western Australia, India, Kashmir and the Shan-Thai Terrane. Brachiopod faunas indicate a cool-water climate and bryozoan faunas are dominated by the Fenestrata. The rifting of the Shan-Thai and other terranes (Cimmerian province) from the Gondwanan margin in the Late Sakmarian, combined with southward expansion of the warm Tethyan climatic zone, allowed the development of the transitional Sibumasu Subprovince (Shi and Archbold, 1998). Brachiopod faunas progressively show less similarity to Gondwanan (Westralian) faunas and increasing similarity to Cathaysian faunas of the Central Tethys. The Sibumasu transitional province is recognized through the Artinskian and early Kungurian, but was assimilated with the Cathaysian Province by the Kazanian (Archbold and Shi, 1996).

The lower Ratburi Limestone bryozoan faunas of Ko Phi Phi Don are of Late Artinskian to Kungurian age, and were developed at the time that the Sibumasu Subprovince of Archbold and Shi (1996) was well established. Unfortunately older faunas from the Phuket Group could not be examined in detail in terms of their taxonomy. However the bryozoan faunas of the Phuket Group are dominated by Fenestrata, and are generally similar to the cool-water notal faunas of Western and northern eastern Australia. The bryozoan faunas of the

Ratburi Limestone are diverse with numerous representatives from the Fenestrata, Cryptostomata, Trepostomata and Cystoporata, and a total of at least 53 genera. However the fauna in general shows a dominance by the Fenestrata, in number of species and specimens, followed by the Cystoporata and the Cryptostomata. The Trepostomata is the least abundant and diverse group of the Ratburi Limestone. Of the fenestrates *Fabifenestella, Minilya, Spinofenestella, Mackinneyella, Polypora* and *Acanthocladia* are common, with *Shulgapora, Septopora* and *Synocladia* also frequent. The cystoporates *Fistulipora*, *Cyclotrypa* and *Goniacladia* are prominent, with *Ascopora* the dominant cryptostomate. As discussed in Chapter Six many species are endemic (new), but further work, particularly in the fenestrates of the Timor and West Australian regions may alter this. Also at species level the fauna shows closer affinities with West Australian faunas, than elsewhere. However a number of species show similarities to taxa from Russia, indicating a northern Tethys influence. The influence of the West Australian (Westralian Province) bryozoan faunas indicates either a closer proximity, or few faunal barriers between the Shan-Thai Terrane and Gondwana in the Late Artinskian to Kungurian.

The fauna shows a mix of cosmopolitan, boreal and tropical genera, and reflects the mixing of the cooler-water Indoralian-Westralian faunas with the Cathaysian faunas of the Central Tethys. Despite the brachiopod fauna showing a high degree of endemism at generic level (Shi and Archbold, 1998), there are no endemic bryozoan genera. However further taxonomic study may change this. Naimark *et al.* (1999) state that high-levels of endemism occur in bryozoan favourable basins rather than the most isolated basins, and that fenestellids will show increasing dominance in ecologically unfavourable regions. The dominance of fenestrate bryozoans and the apparent absence of endemic genera in the Ratburi Limestone fauna indicate that the region was not favourable for bryozoan evolution and faunas were drawn from local regions with fenestrates showing dominance by their ability to exist in less favourable basins. However the influence of the Cathaysian faunas increased diversity and the prominence of the Cystoporates in the fauna.

In comparison with the bryozoan faunas of the Austrazean Province, those of the Shan-Thai Terrane (or Sibumasu Subprovince) are much more diverse at generic level, however many genera contain only one or two species. In the Austrazean, where the fauna is less diverse at generic level, a number of genera are represented by up to three or four species, increasing the faunal diversity at species level.

8.3 - <u>NUMERIC COMPARISON OF AUSTRAZEAN, WESTRALIAN AND SIBUMASU (CIMMERIAN) PROVINCES</u>.

Numerical comparison of the bryozoan faunas of the Austrazean, Westralian and Sibumasu provinces is hampered by a lack of taxonomic detail in the faunas, particularly those from the Sydney and Bowen Basins, and Western Australia. As discussed in Chapter Three, some species previously placed within the genera *Fenestella* s.l. and *Polypora* s.l. have been shown to be a number of separate species grouped together on external appearances. Further, some previously described fenestrate "species" have been shown to belong to more than one genus, after internal examination. It is therefore difficult to use previously published species lists for comparison between different faunas.

Faunal comparison is more readily achieved at generic level, however the total number of genera able to be determined will be a minimum value, for the following reasons - 1) the non-recognition of the new genera of *Fenestella* s.l. and *Polypora* s.l. described by Morozova (1974) and Morozova and Lisitsyn (1996); 2) the Tasmania Basin bryozoan faunas cover the Sakmarian to the Kazanian, but those of the southern Sydney Basin are limited to the Kungurian, and the Shan-Thai faunas, the Late Artinskian to Kungurian. The data compiled in Figure 8.2 incorporate genera from throughout the Permian, and include data from Ross and Ross (1996) and Gilmour and Morozova (1999). Not all occurrences are listed, except for genera from the Tasmania and Sydney Basins. All genera recorded in this study, plus the more common genera from the literature, are included.

	Tasmania	Sydney	Bowen	New Zealand	Western Australia	Thailand	cosmopolitan
Fenestrata - *Alternifenestella*			?	x	?	x	x
Fabifenestella						x	
Fenestella		x					
Flexifenestella						x	
Laxifenestella		x		x			
Levifenestella	x	x	x				
Minilya		x	x	x	x	x	x
Rectifenestella	x	x	x	x	x	x	x
Spinofenestella			x		x	x	
Mackinneyella	x	?	x		x	x	x
Parapolypora	x	?	?		x		x
Paucipora		x				x	
Polypora	x	x	x	x	x	x	x
Polyporella	x	x	x	x	x	x	x
Polyporellina						x	
Pseudopolypora	x						
Shulgapora	x	x	x	x	x	x	x
Protoretepora	x	x	?		x	?	x
Reteporidra						x	
Septopora			x		x	x	
Synocladia			x		x	x	
Penniretepora			x		x	x	
Acanthocladia			x		x	x	
Ptilopora		x	x				
Thamniscus			x		x	x	
Trepostomata - *Batostomella*		x					
Dyscritella	x	x	x	x	x	x	x
Dyscritellina	x			x	x		
Girtypora					x	x	
Hinganella					x	x	
Neoeridotrypella						x	
Paralioclema	x		x	x	x	x	x
Pseudobatostomella				x	x	x	
Stenopora	x	x	x	x	x	x	x
Stenodiscus	x	?	x	x	x	x	x
Cryptostomata - *Ascopora*					?	x	
Megacanthopora					x	x	
Neorhombopora					x	x	
Ogbinopora					x	x	
Rhabdomeson				x	x	x	
Rhombopora		x	x	x	x		
Saffordotaxis			x	x	x	x	x
Streblotrypa	?		x	x	x	x	x
Cystoporata - *Coscinotrypa*					x	x	
Cyclotrypa						x	
Eridopora				x	x	x	
Etherella					x		
Evactinostella				x	x		
Fistulamina				x	x	x	
Fistulipora			x	x	x	x	x
Goniocladia			x		x	x	
Hexagonella					x	x	
Liguloclema			x		x	x	
Sulcoretepora					x	x	
minimum total	15	18	33	38	41	53	16
% cosmopolitan	80	61	49	34	39	28	
% genera in common - Tasmania	100	61	40	26	32	23	
Sydney Basin		100	42	26	29	21	
Bowen Basin			100	34	61	41	
Productus Creek Gp NZ				100	49	44	
Western Australia					100	68	
Shan-Thai Terrane						100	

Figure 8.2 - Comparison table of selected genera in Tasmania, Sydney and Bowen Basins; Western Australia, Shan-Thai Terrane and Productus Creek Group, New Zealand. Additional data from Engel and Ross (1993), Ross and Ross (1996) and Gilmour and Morozova (1999). Total number of genera a minimum value, see text for discussion.

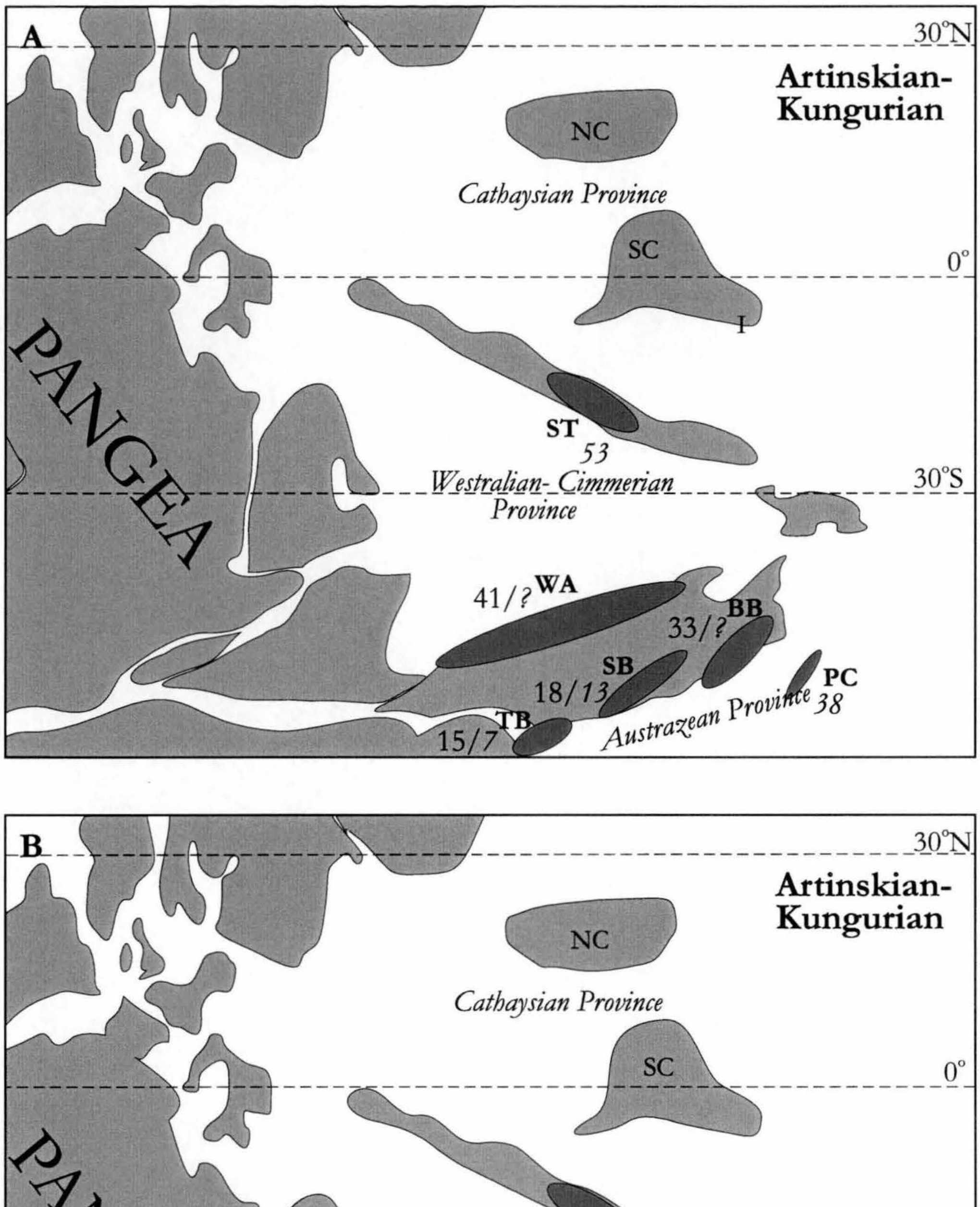


Figure 8.3 - Gondwanan palaeogeography in the Artinskian to Kungurian. Base map after Shi and Archbold (1998). NC = northern China, SC = southern China, WA = Western Australia, ST = Shan-Thai Terrane, BB= Bowen Basin, SB = Sydney Basin, TB = Tasmania Basin, PC = Productus Creek Group, New Zealand. (A) minimum total of genera, number in Kungurian in italics. (B) Percent fauna consisting of cosmopolitan genera.

8.3.1 - ***Generic comparison.***

Figure 8.2 shows the minimum number of genera present in each region, throughout the Permian. In the bryozoan faunas of the Productus Creek Group, New Zealand, the Tasmania, Sydney and Bowen Basins, Western Australia and the Shan-Thai Terrane, there are at least sixteen genera that are regionally cosmopolitan, occurring in four of the six faunas.

As shown in Figures 8.2 and 8.3A the Shan-Thai Terrane, Sibumasu Subprovince, has the largest number of genera, with a minimum total of 53. The data include genera recorded in this study from the Late Artinskian to Kungurian Ratburi Limestone, with additional data from Ross and Ross (1996) and Sakagami (1976). The Western Australian faunas, of the Westralian Province, contain a minimum total of 39 genera across the Permian, with an unknown number restricted to the Late Artinskian to Kungurian (compiled from common genera in Crockford, 1944a; 1944b; 1944c; 1957; Ross and Ross 1996). In the Permian of the Austrazean Province, the Bowen Basin bryozoan fauna contains at least 33 genera (compiled from Crockford, 1951; Wass, 1968; Ross and Ross, 1996), the Sydney Basin has at least 18 and the Tasmania Basin 15 (compiled from this study and Crockford, 1951). The fauna from the Late Permian? Productus Creek Group, New Zealand, contains 38 genera (Gilmour and Morozova, 1999). In the Kungurian there are at least 13 genera from the Sydney Basin and 7 from the Tasmania Basin.

Regardless of whether the above data are considered in terms of the entire Permian, or restricted to the Kungurian, there is a clear trend shown within the faunas listed from the Gondwanan region. Tasmania, of the highest southern latitudes, shows the lowest generic diversity, and the Shan-Thai fauna, of the lowest latitudes, the highest diversity.

In the Gondwanan region the Shan-Thai Terrane faunas are comparable to those of Western Australia, Bowen Basin and Productus Creek Group, New Zealand, with respectively, 68%, 44%, and 41% of Shan-Thai genera also occurring in those faunas. The Shan-Thai faunas are dissimilar to those from the Sydney and Tasmania Basins, with respectively, 23% and 21% Shan-Thai genera in those faunas. The genera that co-occur in the Shan-Thai, Sydney and Tasmanian faunas are the cosmopolitan genera. From the above data the Shan-Thai Terrane faunas (Sibumasu Subprovince) are most closely related to those of Western Australia (Westralian Province). The brachiopod faunas of the Cimmerian Province show a transitional fauna with many endemic genera (Archbold and Shi, 1996), however this is not as clearly seen in the bryozoans. There are no endemic genera in the Shan-Thai Terrane, and 68% of the fauna is shared with the Westralian Province of Western Australia. The bryozoa of the Westralian and Cimmerian Provinces might be considered as one faunal province, with variation seen across the province. The bryozoan faunas of Western Australia and the Shan-Thai Terrane are probably better considered as a combined Westralian-Cimmerian Province, of similar geographic range as the "southern Tethys" region of Ross (1978; 1995). The bryozoan faunas of the Cathaysian Province of Fang (1985) have not been examined here, and they would need to be examined before a conclusion on the status of the bryzoan fauna of the Shan-Thai Terrane could be confirmed. Likewise, a re-study of the Bowen Basin faunas is also needed before their true relationship to the Western Australian faunas can be demonstrated.

The bryozoan faunas of the Austrazean Province show variation in their degree of similarity to each other. The Bowen Basin fauna is the most diverse at generic level, and only about 40% also occur in either the Tasmania or Sydney Basins, and these are mostly the cosmopolitan genera. The Sydney and Tasmanian Basins show a strong similarity to each other with 61% of genera in the Sydney Basin also occurring in the Tasmania Basin. The Tasmania Basin shows the least diverse fauna with 80% of the Tasmania Basin genera cosmopolitan.

The data for New Zealand only include genera discussed by Gilmour and Morozova (1999) and are incomplete, but within the Austrazean Province the fauna is most similar to that of the Bowen Basin. Of the genera known to occur in the Productus Creek Group 34% also occur in the Bowen Basin, in comparison to 26% in the Sydney and Tasmania Basins.

Gilmour and Morozova (1999) suggest that bryozoan diversity is not necessarily higher in tropical climatic zones, than in boreal or notal zones, at least in the Late Permian. The Austrazean Province (or East-Australian and New Zealandian provinces) is defined as notal by Gilmour and Morozova (1999). The faunas of the province as a whole are certainly diverse from species to ordinal level, in keeping with the idea that notal provinces may have as higher taxonomic diversity as tropical provinces. However, within the Austrazean province generic diversity is higher in northerly parts (Bowen Basin) and lower at higher southern latitudes (Tasmania Basin) (Figures 8.3A and 8.4A). The high generic diversity of the bryozoan faunas of the Productus Creek Group, New Zealand, indicates a proximity to the Bowen Basin faunas of eastern Australia. The Productus Creek, Bowen Basin and Western Australian faunas, all included in the notal zone of Gilmour and Morozova (1999), are quite close to that boundary between notal and tropical zones. Faunal changes in response to latitude will be variable and progressive, and perhaps the subjective boundary line between notal and tropical needs to be moved further southward. As shown above there is still a trend of lower faunal diversity towards the southern pole, and the faunas of New Zealand and the Bowen Basin appear to be influenced by the warmer Tethyan faunas, at least during the Late Permian. The most northerly boreal faunas, from the East Arctic-Mongolia-Transbaikal, are more diverse at both ordinal and generic level (Gilmour and Morozova, 1999) than the bryozoan faunas of the Tasmania and Sydney Basins. However, there are a number of fenestrate and trepostome genera in common between the northern boreal and southern notal faunas, showing a bi-polarity in the distribution of the Permian bryozoa.

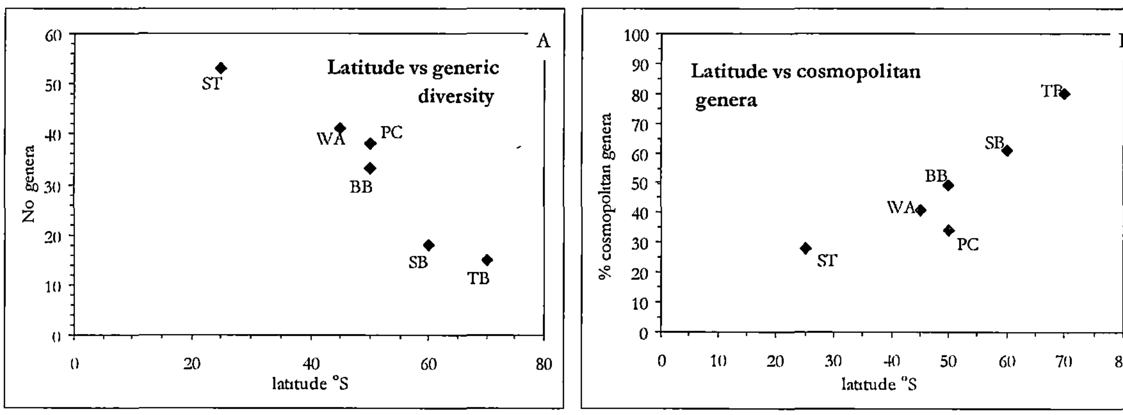


Figure 8.4 - Graphical presentation of faunal changes in response to latitude. A, Latitude vs. generic diversity. B, Latitude vs. percent fauna consisting of cosmopolitan genera. ST = Shan-Thai Terrane, WA = Western Australia, PC = Productus Creek Group, New Zealand, BB = Bowen Basin, SB = Sydney Basin, TB = Tasmania Basin.

In the Tasmania Basin, 80% of bryozoan genera are cosmopolitan, in the Sydney Basin 61%, Bowen Basin 49%, Productus Creek Group, New Zealand 34%, Western Australia 39% and Shan-Thai Terrane 28% (Figures 8.3B and 8.4B). The Tasmanian fauna is at the highest southern latitudes and shows the highest proportion of cosmopolitan genera, and the Shan-Thai Terrane, at the lowest latitudes, the least proportion of cosmopolitan genera. Apart from the New Zealand data there is a general decrease in proportion of cosmopolitan genera from high to low latitudes, as shown in Figure 8.3B. As with generic diversity there is a trend with the Austrazean Province from north to south, with increasing proportions of the fauna consisting of cosmopolitan genera towards the higher southern latitudes of the Tasmania Basin.

8.4 - SUMMARY

The bryozoan faunas of the Tasmania and Sydney Basins are within the Austrazean Province of Archbold (1983) and the Tasman Geosyncline of Ross (1978). The faunas are dominated by the Fenestrata, and while they may show a limited diversity at ordinal and generic level, each genus may contain a number of species. Within the Austrazean Province there is a differentiation between faunas in the north (Bowen Basin) and south (Tasmania Basin). The Fenestrata, Trepostomata, Cryptostomata and Cystoporata all occur in the Bowen Basin, with the fenestrates dominant. In the higher southern latitudes of the Tasmania Basin the fauna is represented by the Fenestrata and Trepostomata only, and general faunal diversity is low, with the fenestrates dominant. Gilmour and Morozova (1999) state that bryozoan faunas of boreal and notal climatic zones may be as diverse as those of tropical climatic zones. However while the notal Austrazean Province may be diverse as a whole, within the province there is a decrease in diversity from lower to higher latitudes. The Tasmania and Sydney Basins share most of their genera. The Bowen Basin shares cosmopolitan genera with the Tasmania and Sydney Basins, and tropical genera with faunas from Western Australia, Productus Creek Group and Shan-Thai Terrane. The Tasmania and Sydney Basin faunas are impoverished in comparison to the Bowen Basin and New Zealand faunas. They are also less diverse at ordinal and generic level than the faunas of the most northerly boreal provinces.

The bryozoan faunas of the Ratburi Limestone, Shan-Thai Terrane, are within the Sibumasu Subprovince of Archbold and Shi (1996). The faunas are diverse with representatives from the Fenestrata, Cystoporata, Cryptostomata and Trepostomata, with faunal dominance in that order. There is an absence of endemic bryozoan genera in the Sibumasu Subprovince, despite many endemics in the brachiopod fauna (Shi and Archbold, 1998). Within the Bryozoa, endemism is low and fenestellids show increasing dominance in regions not favourable for bryozoan evolution (Naimark, *et al.*, 1999). While the bryozoan faunas of the Sibumasu Subprovince may have been in an unfavourable environment for bryozoan evolution, the proximity of both the cooler-water Westralian, and warmer-water Cathaysian faunas, increased the overall diversity and abundance of the Sibumasu fauna.

CHAPTER NINE
CONCLUSIONS

9.1 - TAXONOMY

The application of the taxonomic techniques developed by Morozova (1974), Morozova and Lisitsyn (1996) and Snyder (1991) has revealed a number of new fenestrate species, and new records of genera in the bryozoan faunas of the Tasmania and southern Sydney Basins, and the Shan-Thai Terrane of southern Thailand. By using the descriptive parameters of Snyder (1991) the bryozoan taxa of these faunas are more accurately defined, and will be able to be more readily recognized by future workers. This applies not only to the Fenestrata, but also to the Trepostomata, Cryptostomata and Cystoporata.

Faunal diversity has been increased at both generic and species level in the Tasmania and southern Sydney Basins, where previously most fenestrate taxa were grouped into *Fenestella* s.l. and *Polypora* s.l. Likewise the faunas of the Shan-Thai Terrane, southern Thailand, a large number of new species of fenestrates are recognized across a variety of genera.

9.1.1 - *Tasmania Basin fauna.*

Bryozoa from the Permian of the Tasmania Basin are abundant, but are represented by the Fenestrata and Trepostomata only. In total there were 31 species in 13 genera. Spry and Banks (1962) reported the cryptostomate *Streblotrypa (Streblascopora) marmionensis* from the Quamby Mudstone, however no representatives of the Cryptostomata have been found by this author. The type material of *Protoretepora* de Koninck was collected from Tasmania, but this author has found no additional material.

There are no endemic genera, but there are a number of endemic species. Endemic species comprise two thirds of the fauna and include the fenestrate species :- *Rectifenestella smithae*, *R. counselensis* n. sp., *Rectifenestella* sp. A, *Parapolypora ampla* Lonsdale, *P. boraformis* n. sp., *Parapolypora* sp. A and B, *Polyporella internata* Lonsdale, *P. protuberans* n. sp., *P. subwoodsi* n. sp., *Pseudopolypora banksi* n. sp., *P. bundellaensis* n. sp., *P. tamarensis* n. sp., *P. versonoda* n. sp.. Laseron (1918) tentatively recorded *P. internata* from the Sydney Basin (as *Fenestella* s.l.), and *Parapolypora ampla* has been reported (as *Protoretepora*) from the Bowen and Sydney Basins, and Western Australia (Crockford, 1951; Wass, 1968). However without internal examination these occurrences cannot be confirmed outside of the Tasmania Basin. Endemic trepostomes include *Dyscritella inversa* n. sp., *Dyscritellina megacanthi* n. sp., *Stenopora aequalis* n. sp., *S. berriedalensis* n. sp., *S. elongata* n. sp., *S. grantonensis* Crockford.

The examination of fenestrate taxa internally has revealed many new details, and separated taxa that were previously grouped together at species level. This is shown by the taxa "*Protoretepora ampla*" (now *Mackinneyella granulosa*, *Parapolypora* sp. A and B, *P. ampla*, and *P. boraformis*), "*Fenestella fossula*" (includes *Rectifenestella smithae*, *Pseudopolypora banksi*, *P. tamarensis*, *P. versonoda*) and "*F. dispersa*" (includes *Rectifenestella* sp. A, B and C).

9.1.2 - *Southern Sydney Basin fauna.*

In the southern Sydney Basin the bryozoan fauna is represented by the Fenestrata, Trepostomata and Cryptostomata. This study recorded 17 species in 11 genera. As with the Tasmania Basin there are no endemic genera, but slightly less than half the species are endemic to the southern Sydney Basin (mostly the Wandrawandian Siltstone). These endemic species include :- *Fenestella* sp., *Laxifenestella oviferosa* n. sp., *Rectifenestella* sp. B and C, *Paucipora ulladullaensis* n. sp., *Polypora dichotoma* Crockford, *Dyscritella espinensis* n. sp.

The genera *Rectifenestella, Laxifenestella, Paucipora, Polyporella, Shulgapora, Parapolypora, Mackinneyella*, *Dyscritellina* and *Paralioclema* are recorded for the first time in Australia from internal examination. In addition the genera *Protoretepora, Ptilopora, Batostomella*, *Stenodiscus*, and *Rhombopora* are recorded from the Sydney Basin by Crockford (1951). Review of previously described taxa also reveals the presence of *Alternifenestella* and *Exfenestella* from the Permian of Western Australia.

9.1.3 - *Southern Thailand fauna.*

The bryozoan fauna from the Shan-Thai Terrane, Thailand, in the Ratburi Limestone of Ko Phi Phi Don is diverse and abundant, with representatives from the Fenestrata, Trepostomata, Cryptostomata and Cystoporata. Fenestrata dominate the fauna, with 14 genera. Cryptostomates and cystoporates are also important, represented by 4 and 6 genera respectively. Trepostomes are not common and are only represented by 2 genera. Additional genera in all orders are recorded from the Shan-Thai Terrane by Sakagami (1976; 1985). Despite the diversity of the fauna there are no endemic genera. Thirty-eight species are recorded from Ratburi outcrops on Ko Phi Phi Don, within the following genera :- *Alternifenestella, Fabifenestella, Flexifenestella, Minilya, Rectifenestella, Spinofenestella, Mackinneyella, Polypora, Shulgapora, Reteporidra, Septopora, Synocladia, Penniretepora, Acanthocladia* (Fenestrata), *Paralioclema, Neoeridotrypella* (Trepostomata), *Ascopora, Rhabdomeson, Streblotrypa,* (Cryptostomata), *Cyclotrypa, Eridopora, Fistulipora, Coscinotrypa, Hexagonella* and *Goniocladia* (Cystoporata). Review of previously described fenestrate taxa from the Permian Shan-Thai Terrane also reveals the probable presence of *Paucipora, Polyporella* and *Polyporellina* in Ratburi faunas.

Fenestrate bryozoans dominate the fauna, but cystoporates are also important. Thirty new species are recorded from the Ratburi Limestone on Ko Phi Phi Don, they are:- *Fabifenestella subthaiensis, F. carinata, Flexifenestellla hexaformis, Minilya phiphiensis, Spinofenestella lekformis, S. pseudohorologia, S. flanchea, Mackinneyella nodosa, M. supraobesa, Polypora canalis, P. nodulifera, Shulgapora reversa, S. megacyclopora, Reteporidra yongkasemensis, Septopora interformis, S. irregularis, Penniretepora subtropica, Acanthocladia pseudothaiensis, A. suprangularis, Paralioclema phuketensis, Neoeridotrypella subpulchra, Ascopra robusta, A. variablis, Rhabdomeson monoformis, Cyclotrypa dendroides, Eridopora thaiensis, Fistulipora megapertura, Coscinotrypa yaiformis* and *Goniocladia sp.* A and B.

Many species in the Ratburi Limestone of Ko Phi Phi Don are new and endemic, with only eight species previously described. However many of the "endemic" species are fenestrates that are differentiated by internal examination. Future studies in the region will no doubt record some of these in other sections, and perhaps within other Permian terranes. Much of the fauna shows similarities with taxa outside southern Thailand, with species showing affinities with those of Western Australia, Timor, and Russia.

9.2 - BIOSTRATIGRAPHY

While Bryozoa have not been commonly used for biostratigraphic analysis within Gondwanan rocks, more detailed taxonomic study has revealed a greater diversity of species within this group. Species previously believed to be long ranging in the Permian of Australia, may be instead groups of phylogenetically or phenotypically related taxa. Many of the new and redescribed species are short ranging and distinct, and are suitable for use in biostratigraphic analysis. The detailed study of the Sakmarian to Kazanian bryozoan faunas of the Tasmania Basin has led to the proposal of a bryozoan zonation, comprising Faunizones A to E. These faunizones are distinct, and include species assemblages that commonly occur together in one horizon. Species successions can be seen within the Tasmania Basin and separate the faunal assemblages into Faunizones A to E. As bryozoans may be identified from small fragments, drill-core samples may be used in biostratigraphic analysis where brachiopod and molluscan faunas may be indeterminable. Recognition of Faunizones A to E in subsurface material will greatly improve the understanding of non-outcropping areas of the Permian of the Tasmania Basin.

Further work in the taxonomy of bryozoans is required to fully appreciate species successions and relationships both within the Tasmania Basin and between other basins of eastern Australia. It can be expected that with detailed studies through the Permian of other

Australian basins, the geographic range of some taxa will be increased and many related taxa identified. With further study bryozoans may be used in biostratigraphic analysis throughout Australia.

The bryozoan fauna of the lower Ratburi Limestone, Ko Phi Phi Don, southern Thailand is of Late Artinskian to Kungurian age. These bryozoan faunas, while highly endemic, show relationships to Artinskian to Kungurian faunas of Western Australia, Timor and Russia, and a Late Artinskian to Kungurian age has been determined. This age applies only to the fauna from the Ratburi Limestone of Ao Yongkasem, Ko Phi Phi Don. The Ratburi Limestone has yielded a range in ages in different localities, and may be a transgressive unit, and outside Ko Phi Phi Don the unit may be of a younger age.

9.3 - PALAEOECOLOGY AND PALAEOENVIRONMENT

The bryozoan faunas from the Permian of the Tasmania and southern Sydney Basins and the Shan-Thai Terrane, southern Thailand, show the same range of colony morphologies. All can be used in palaeoenvironmental analysis, as studies of modern bryozoan faunas have shown different morphologies dominate in different environments. Fenestrate and branching colonies demonstrate low to moderate energy environments where these bryozoans are common in the Tasmania and southern Sydney Basins, and Shan-Thai Terrane faunas. In the Darlington Limestone, of the Tasmania Basin, bryozoal siltstones are intercalated with coarse brachiopod and bivalve coquinas. These repeated units probably record the advance and retreat of a high energy shell barrier, with an associated lagoon or seaward quiet water environment. In the Shan-Thai Terrane bryozoan faunas from the lower Ratburi Limestone reveal good preservation and morphologies that reflect the low energy carbonate platform environments suggested by Baird and Bosence (1993).

Taxa that encrust hard surfaces normally indicate high energy environments, however, the unidentified soft-sediment encrusting trepostome of the Tasmania Basin indicates low energy environments and low sedimentation rates in the upper marine section of the Tasmanian Permian.

The palaeoecology of fossil bryozoan faunas can also be estimated, as shown by Snyder (1991). As mouth diameter increases, allowing ingestion of larger food particles, chamber volumes also increase as zooid body size increases to accommodate the larger food particles. Trophic structuring can be seen in fossil bryozoan faunas, whereby different species occupy different food particle size niches. In the diverse Shan-Thai faunas trophic structuring is also seen at the ordinal level, where the Fenestrata occupy the smallest food particle size niches with the Cryptostomata, Trepostomata and Cystoporata occupying respectively larger food particle size niches. The cystoporates are able to ingest the largest particles available to the bryozoans as a group. In the Shan-Thai Terrane faunas, and probably other faunas where all orders are represented, the cystoporates can dominate the large food particle niche and limited the niche expansion of other bryozoan groups. The fenestrates in such faunas are restricted and dominate only in smallest food particle niches. In the Tasmania and Sydney Basin where the faunas are made up principally by the Fenestrata and Trepostomata, the trepostomes occupy the largest food niches, but there is some overlap with the fenestrates.

In the absence of cryptostomes and cystoporates, the fenestrates and trepostomes have extra niches open to them, and increase mouth size and chamber volume to take advantage of the larger food particles.

In the Fenestrata the form of the mesh might be considered to be a response to varying hydraulic energy environments, where coarse meshed fenestrates might be the most robust. However some delicate meshed taxa have high porosities and may be better suited to higher water flow than some robust taxa. Analysis of the fenestrate mesh has shown that branch width and thickness increase with increasing chamber volume and zooecial row number. Mesh strength, a function of mesh porosity and branch thickness, also increases with chamber volume. Chamber volume increases with food particle size selection, as a response to food particle availability and trophic structuring. Mesh variation in fenestrates is therefore due to food selection rather than a direct response to water energy environment. As the chamber volume increases to assimilate larger particles, so do branch width and thickness, increasing the apparent robustness of the fenestrate mesh.

Water temperature effects bryozoan colonization, feeding and growth rates. Colonization rates are lower in cold water than in warm water (Barnes, 1996). Feeding and growth rates increase with temperature within the same species (Menon, 1972; Sanderson and Thorpe, 1996). However it has been shown that bryozoans may become acclimatized to low temperatures (Menon, 1972). Feeding and growth rates may be initially higher at higher temperatures, but over time, they may be outgrown by the same species at low temperatures. Therefore in the cold water environments of the Permian of the Tasmania Basin, where colonization rates are low, feeding and growth rates may be increased and maintained over time to produce large colonies. In the warm water environment of the Permian Shan-Thai Terrane, where colonization rates are high, initial feeding and growth rates are high, but cannot be maintained over time.

9.4 - BIOGEOGRAPHY

The bryozoan faunas of the Tasmania, Sydney and Bowen Basins are within the Austrazean Province of Archbold (1983) or the Tasman Geosyncline of Ross (1978; 1995). The faunas are dominated by the Fenestrata, and while they may show a limited diversity at ordinal and generic level, each genus may contain a number of species. Within the Austrazean Province there is a differentiation between faunas in the north (Bowen Basin) and south (Tasmania Basin). The Fenestrata, Trepostomata, Cryptostomata and Cystoporata all occur in the Bowen Basin, with the fenestrates dominant. In the higher southern latitudes of the Tasmania Basin the fauna is represented by the Fenestrata and Trepostomata only, and general faunal diversity is low, with the fenestrates dominant. Gilmour and Morozova (1999) state that bryozoan faunas of boreal and notal climatic zones may be as diverse as those of tropical climatic zones. However while the notal Austrazean Province may be diverse as a whole, there is a decrease in diversity from lower to higher latitudes. Faunal changes in response to latitude will be gradational, and within the notal Austrazean Province, the highest southern latitude faunas of the Tasmania Basin are still less diverse and impoverished in comparison with the tropical and northern notal faunas. In the most northern high latitude faunas (Arctic-Mongolia-Transbaikal) of the Northern Hemisphere, faunas are less impoverished at ordinal level, however overall generic diversity is low (from Gilmour and Morozova, 1999). Southward towards the boreal tropical climatic zone boundary of Gilmour and Morozova (1999) bryozoan faunas are more diverse with an increased number of genera.

The Bowen Basin and Productus Creek Group, New Zealand, faunas are the most diverse within the Austrazean Province, and include genera also found in the tropical climatic zone. These faunas compare more closely to the Westralian Province than the faunas of the Tasmania and Sydney Basins.

The bryozoan faunas of the Ratburi Limestone, Shan-Thai Terrane, are within the Sibumasu Subprovince of Archbold and Shi (1996). The faunas are diverse with representatives from the Fenestrata, Cystoporata, Cryptostomata and Trepostomata, with faunal dominance in that order. Despite many endemics in the brachiopod fauna (Shi and Archbold, 1998), there is an absence of endemic bryozoan genera in the Sibumasu Subprovince. In the global distribution of Bryozoa, endemism is low and fenestellids show increasing dominance in regions not favourable for bryozoan evolution (Naimarck, *et al.*, 1999). While the bryozoan faunas of the Sibumasu Subprovince may have been in an unfavourable environment for bryozoan evolution, the proximity of both the cooler-water Westralian and warmer-water Cathaysian faunas increased the overall diversity of the Sibumasu Subprovince as genera could be drawn from both regions.

9.5 - FURTHER WORK

This study has attempted to modernize the understanding of the Bryozoa of the Tasmania, southern Sydney Basins, and the Ratburi Limestone, Shan-Thai Terrane. While much new information has been brought to light, continued study in these regions can only improve the understanding of these faunas. As well, the faunas from the remainder of the Sydney Basin, and the Bowen Basin are now showing a need for further study, as are the faunas of Western Australia.

A bryozoan biostratigraphy was proposed in Chapter Six for the Permian of the Tasmania Basin. This biostratigraphic zonation will be hindered by the lack of work throughout the Permian of other Australian basins, as well as by the faunal differences highlighted in Chapter Eight. While the bryozoan biostratigraphy may be of use within the Tasmania Basin, to fully appreciate the use of bryozoans in biostratigraphic analysis across Gondwana, other basins must also be studied in detail.

REFERENCES

Annoscia, E. and Fierro G., 1973: Bryozoan Ecology in Relation to Sediment Texture in the "Golfo dell'Asinara" (Sardinia, Italy). *In:* Living and Fossil Bryozoa; International Bryozoology Association Conference, Proceedings. *Ed.* Larwood, G.P. pp. 53-64. Academic Press, London.

Archbold, N.W., 1981: Permian brachiopods from Western Irian Jaya. *Geological Research and Development Centre, Paleontology Series, 2*: 1-25.

Archbold, N.W., 1983: Permian marine invertebrate provinces of the Gondwanan Realm. *Alcheringa, 7*: 59-73.

Archbold, N.W., 1993: A zonation of the Permian brachiopod faunas of Western Australia. *In.* Gondwana Eight: Assembly, Evolution and Dispersal. *Eds.* Findlay R.H., Unrug R., Banks M.R., Veevers J.J. pp. 313-321. A.A. Balkema, Rotterdam.

Archbold, N.W., 1999: Permian Gondwanan correlations: The significance of the Western Australian marine Permian. *Journal of African Earth Sciences, 29*: 63-75.

Archbold, N.W. and Shi, G.R., 1996: Western Pacific Permian marine invertebrate palaeobiogeography. *Australian Journal of Earth Sciences, 43*: 635-642.

Altermann, W., 1986: The Upper Palaeozoic pebbly mudstone facies of peninsular Thailand and western Malaysia - Continental margin deposits of Palaeoeurasia. *Geologische Rundschau, 75*: 371-381.

Archbold, N.W. and Dickins, J.M., 1991: Australian Phanerozoic Timescales: 6. A standard for the Permian system in Australia. *Bureau of Mineral Resources, Australia Record,1989/36*:17 p.

Baird, A. and Bosence, D., 1993: The sedimentological and diagenetic evolution of the Rat Buri Limestone, Peninsular Thailand. *Journal of Southeast Asian Earth Sciences, 8*: 173-180.

Banks, M.R., 1973: General geology. *In* The Lake Country of Tasmania. *Ed.* Banks M.R. pp.25-34. Royal Society of Tasmania.

Banks, M.R. and Hale, G.E.A., 1957: A type section of the Permian System in the Hobart area. *Papers and Proceedings of the Royal Society of Tasmania, 91*: 41-64.

Banks, M.R. and Read, D.E., 1962: The Malbina Siltstone and Sandstone. *Papers and Proceedings of the Royal Society of Tasmania, 96*: 19-31.

Banks, M.R. and Clarke, M.J., 1987: Changes in the Geography of the Tasmania Basin in the Late Palaeozoic. *In.* Gondwana Six: Stratigraphy, Sedimentology, Paleontology. Ed. McKenzie, G.D. *American Geophysical Union Monograph, 41*: 1-14.

Barnes, D.K.A., 1996: Low levels of colonisation in Antarctica: the role of bryozoans in early community development. *In* Bryozoans in Space and Time. *Eds.* Gordon, D.P., Smith, A.M. and Grant-Mackie, J.A. *Proceedings 10th International Bryozoology Conference, Wellington, New Zealand, 1995.* pp. 19-28. NIWA, Wellington.

Bassler, R.S., 1929: The Permian Bryozoa of Timor. *Palaeontologie von Timor, 16*: 37-89, 23 pl.

Boardman, R.S., Cheetham, A.H., Blake, D.B., Utgaard, J., Karklins, O.L., Cook, P.L., Sandberg, P.A., Lutaud, G. and Wood, T.S., 1983: Treatise on Invertebrate Paleontology. Part G, Bryozoa revised, Vol. 1: Introduction, Order Cystoporata, Order Cryptostomata. University of Kansas and the Geological Society of America. 625pp.

Bretnall, R.W., 1926: Descriptions of some Western Australian fossil Polyzoa. *Western Australia Geological Survey Bulletin, 88*: 7-33.

Briggs, D.J.C., 1998: Permian Productidina and Strophalosiidina from the Sydney-Bowen Basin and New England Orogen: Systematics and biostratigraphic significance. *Association of Australasian Palaeontologists Memoir, 19.* 258p.

Brill, K.G., 1982: Palaeoenvironment of the Darlington Limestone (Early Permian), Tasmania. *Papers and Proceedings of the Royal Society of Tasmania, 116*: 67-84.

Brown, G.F., Buravas, S., Charaljavanaphet, J., Jalichandra, N., Johnston, W.D., Sresthaputra, V. and Taylor, C.J., 1951: Geologic Reconnaissance of the Mineral Deposits of Thailand. *US Geological Survey Bulletin 984.*

Bullivant, J.S., 1968a: The rate of feeding of the bryozoan *Zoobotryon verticillatum. New Zealand Journal of Marine and Freshwater Research, 2*: 111-134.

Bullivant, J.S., 1968b: The method of feeding of lophophorates (Bryozoa, Phoronida, Brachiopoda). *New Zealand of the Journal of Marine and Freshwater Research, 2*: 135-146.

Bunopas, S., Pitakpaivan, K., Soitroo, J. and Vella, P., 1978: Preliminary palaeomagnetic results from Thailand sedimentary rocks. *In.* Proceedings GEOSEA III. *Ed.* Nautalaya, P. pp. 25-32.

Bunopas, S., 1983: Paleozoic succession in Thailand. *Proceedings of the Workshop on Stratigraphic correlation of Thailand and Malaysia. Volume One, Technical Papers*: 39-76.

Burrett, C.F., Hills, J.W., Rao, C.P., Raksaskulwong, L., Tantiwanit, W., Glenister, B.F. and Furnish, W.M., *in prep.* The end of the Permian glaciation in Thailand.

Carey, S.W. and Ahmad, N., 1961: Glacial marine sedimentation. *In* Geology of the Arctic. *Ed.* Raasch, G.E. *Proceedings 1st Geological Symposium, 2*: 865-894.

Chaodumrong, P. and Burrett, C.F., 1997: Early Late Triassic continental colliding between Shan-Thai and Indochina terranes as indicated by occurrence of fan delta red beds of Pha Daeng Formation, central north Thailand. *The International Conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific. Bangkok, Thailand August 1997.* p.143-157.

Chinoroje, O., 1993: Petrographic studies of Permian carbonates in southern Thailand. *Journal of Southeast Asian Earth Sciences, 8*: 161-171.

Clarke, M.J., 1987: Late Permian (late Lymingtonian = ?Kazanian) brachiopods from Tasmania. *Alcheringa, 11*: 261-289.

Clarke, M.J., 1989: Lower Parmeener Supergroup. *Geology and Mineral Resources of Tasmania. Special Publication, 15*: 295-309.

Clarke, M.J., 1990: Late Paleozoic (Tamarian; Late Carboniferous - Early Permian) cold-water brachiopods from Tasmania. *Alcheringa, 14*: 53-76.

Clarke, M.J. and Banks, M.R., 1975: The stratigraphy of the lower (Permo-Carboniferous) parts of the Parmeener Super-Group, Tasmania. *In* Gondwanan Geology. *Ed.* Campbell, K.S.W. *Proceedings of the 3rd International Gondwana Symposium, Canberra*: 453-467.

Clarke, M.J. and Farmer, N., 1976: Biostratigraphic nomenclature for Late Palaeozoic rocks in Tasmania. *Papers and Proceedings of the Royal Society of Tasmania, 110*: 91 - 109.

Clarke, M.J. and Baillie, P.W., 1984: Maria. *Geological Atlas 1:50,000 Series, Geological Survey Tasmania, Explanatory Report. Sheet:* 77. 39p.

Crockford, J.M., 1941a: Permian Bryozoa of eastern Australia. Part I. A description of some previously named species of Fenestrellinidae (Fenestellidae). *Journal and Proceedings of the Royal Society of New South Wales, LXXIV*: 397-418.

Crockford, J.M., 1941b: Permian Bryozoa of eastern Australia. Part II. New species from the Upper Marine Series of New South Wales. *Journal and Proceedings of the Royal Society of New South Wales, LXXIV*: 502-516.

Crockford, J.M., 1943: Permian Bryozoa of eastern Australia. Part III. Batostomellidae and Fenestrellinidae from Queensland, New South Wales, and Tasmania. *Journal and Proceedings of the Royal Society of New South Wales, LXXVI*: 260-266.

Crockford, J.M., 1944a: Bryozoa from the Permian of Western Australia. Part I. Cyclostomata and Cryptostomata from the North-West Basin and Kimberley District. *Proceedings of the Linnean Society of New South Wales, 69*: 139-175.

Crockford, J.M., 1944b: Bryozoa from the Wandagee and Nooncanbah Series (Permian) of Western Australia. *Journal of the Royal Society of Western Australia, 28*: 165-185.

Crockford, J.M., 1944c: A revision of some previously described species of Bryozoa from the Upper Palaeozoic of Western Australia. *Journal of the Royal Society of Western Australia, 28*: 187-199.

Crockford, J.M., 1945: Stenoporids from the Permian of New South Wales and Tasmania. *Proceedings of the Linnean Society of New South Wales, 70*: 9-24.

Crockford, J.M., 1946: A bryozoan fauna from the Lake's Creek quarry, Rockhampton, Queensland. *Proceedings of the Linnean Society of New South Wales, 70*: 125-134.

Crockford, J.M., 1951: The development of bryozoan faunas in the Upper Palaeozoic of Australia. *Proceedings of the Linnean Society of New South Wales, 76*: 105-122.

Crockford, J.M., 1957: Permian Bryozoa from the Fitzroy Basin, Western Australia. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin 34*: 132 p.

Darwin, C., 1844: Geological observations on volcanic islands. *In* The geology of the voyage of the Beagle. Smith Elder, London.

Davidson, J.K., 1969: Upper Permian and Lower Triassic sedimentation and palynology of the La Perouse area. *Unpublished Honours Thesis, University of Tasmania.*

Dickins, J.M., 1985: Late Palaeozoic glaciation. *Journal of the Australian Bureau Mineral Resources, 9*: 163-169.

Dickins, J.M., Gostin, V.A. and Runnegar, B., 1969: The Age of the Permian Sequence in the Southern Part of the Sydney Basin. *In* Stratigraphy and Palaeontology, Essays in Honour of Dorothy Hill. *Ed.* Campbell, K.S.W., pp.211-225. Australian National University Press.

Dickins, J.M., Malone, E.J. and Jensen, A.R., 1964: Subdivision and correlation of the Permian Middle Bowen Basin Beds, Queensland. *Bureau Mineral Resources, Geology and Geophysics, Australia, Report 70*: 1-12.

Elias, M.K. and Condra, G.E., 1957: *Fenestella* from the Permian of West Texas. *Geological Society of America, Memoir. 70*: 158p.

Engel, B.A., 1979: Fenestrate bryozoans with large apertural form in the Carboniferous of eastern Australia. *Proceedings of the Linnean Society of New South Wales, 103*: 135-170.

Engel, B.A. and Ross, J.R.P, 1993: Bryozoa. *In* Palaeontology of the Permian of Western Australia. *Ed.* Swarko, S.K. *Geological Survey of Western Australia Bulletin 136*. pp 34-44.

Etheridge, R.Jnr., 1891: A monograph on the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales. *Memoirs of the Geological Survey of New South Wales. Palaeontology, 5.*

Etheridge, R.Jnr., 1892: Geology and Palaeontology of Queensland and New Guinea.

Eyles, C.H., Eyles, N. and Gostin, V.A., 1998: Facies and allostratigraphy of high-latitude, glacially influenced marine strata of the Early Permian southern Sydney Basin, Australia. *Sedimentology, 45*: 121-161.

Fang, Z.J., 1985: Preliminary investigation into the Cathaysian faunal province. *Acta Palaeontologica Sinica*, 24: 344-348.

Farmer, N., 1985: Kingborough. *Geological Atlas 1:50,000 Series, Geological Survey Tasmania, Explanatory Report. Sheet 88*: 105p.

Fontaine, H., Chonglakmani, C., Amnan, I.B. and Piyasin, S., 1994: A well-defined Permian biogeographic unit: Peninsular Thailand and northwest Peninsular Malaysia. *Journal of Southeast Asian Earth Sciences, 9*: 129-151.

Foster, C.B. and Waterhouse, J.B., 1988: The *Granulatisporites confluens* Oppel-zone and Early Permian marine faunas from the Grant Formation on the Barbwire Terrace, Canning Basin, Western Australia. *Australian Journal of Earth Sciences, 35*: 135-157.

Gee, R.D. and Legge, P.J., 1974: Beaconsfield. *Geological Atlas One Mile Series, Geological Survey Tasmania, Explanatory Report. Sheet 30.* Second edition.

Gilmour, E.H., McCulloch, M.E. and Wardlaw, B.R., 1997: Bryozoa of the Murdock Mountain Formation (Wordian, Permian), Leach Mountains, northeastern Nevada. *Journal of Paleontology 71*: 214-236.

Gilmour, E.H. and Morozova, I.P., 1999: Biogeography of the Late Permian Bryozoans. *Paleontological Journal, 33*: 36-51.

Gilmour, E.H. and Walker, R.C., 1986: Bryozoans from the Phosphoria Formation (Permian), southeastern Idaho. *Contributions to Geology, 24*: 191-209.

Goryunova, R.V., 1964: Rannekazanskie fistuliporidy Russkoi platformy. *Paleontogecheskii Zhurnal, 3*: 47-51. In Russian.

Goryunova, R.V., 1975: Permian Bryozoa of the Pamirs. *Academy of Sciences USSR, Transactions of the Institute of Paleontology, 148.* 128p. In Russian.

Goryunova, R.V., 1996: Phylogeny of the Paleozoic bryozoans. *Russian Academy of Science, Transactions of the Paleontological Institute, 267.* 165p. In Russian.

Gostin, V.A., 1968: Stratigraphy and sedimentology of the Lower Permian sequence in the Durras-Ulladulla area, Sydney Basin, New South Wales. *Unpublished Ph.D. Thesis, Australian National University.*

Grant, R.E., 1976: Permian Brachiopods from Southern Thailand. *Journal of Palaeontology Memoir, 9*: 1-269.

Hageman, S.J., Bone, Y., McGowran, B. and James, N.P., 1997: Bryozoan colonial growth-forms as paleoenvironmental indicators: Evaluation of methodology. *Palaios, 12*: 405-419.

Hageman, S.J., Bock, P.E., Bone, Y. and B., M., 1998: Bryozoan growth habits; Classification and analysis. *Journal of Paleontology, 72*: 418-436.

Hamada, T., 1960: Some Permo-Carboniferous fossils from Thailand. *Scientific Papers of the College of General Education, University of Tokyo, 10*: 337-361.

Hills, J.W., 1989: The geology of the Phuket District of Thailand. *Unpublished Honours Thesis, University of Tasmania*, 144p.

Holdener, E.J., 1994: Numerical taxonomy of fenestrate bryozoans: Evaluation of methodologies and recognition of intraspecific variation. *Journal of Paleontology, 68*: 1201-1214.

Ingavat, R., Toriyama, R. and Pitakpaivan, K., 1980: Fusuline zonation and faunal characteristics of the Ratburi Limestone in Thailand and its equivalents in Malaysia. *Geology and Palaeontology of Southeast Asia, 21*: 43-62.

Jackson, J.B.C., 1977: Competition on marine hard substrata: the adaptive significance of solitary and colonial strategies. *American Naturalist, 111*: 743-767.

James, N.P. and Bone, Y., 1991: Origin of a cool water, Oligo-Miocene deep shelf limestone, Eucla Platform, southern Australia. *Sedimentology, 38*: 323-341.

Laseron, C.F., 1918: Notes on some Permo-Carboniferous Fenestellidae with descriptions of new species. *Journal of the Royal Society of New South Wales, 52*: 181-202.

Laurie, J.R. and Burrett, C.F., 1992: Biogeographic significance of Ordovician brachiopods from Thailand and Malaysia. *Journal of Paleontology, 66*: 16-23.

Leaman, D.E., 1976: Hobart. *Geological Atlas 1:50,000 series, Geological Survey Explanatory Report, Sheet 82.*

Lonsdale, W., 1844: Descriptions of six species of corals, from the Palaeozoic formation of Van Diemen's Land. *Appendix to Darwin 1844*: 179-185.

Lonsdale, W., 1845: Fossil fauna. Palaeozoic Fauna. *In* Strzelecki, P.D.de. 1845, Physical descriptions of New South Wales and Van Diemen's Land. London. p. 262-269.

López Gappa, J.J., 1989: Overgrowth competition in an assemblage of bryozoans settled on artificial substrata. *Marine Ecology Progress Series, 51*: 121-130.

McKinney, F.K., 1994: The bryozoan genera *Lyropora* and *Lyroporidra* (Order Fenestrida, Family Polyporidae) in Upper Mississippian (Chesterian) rocks of eastern North America. *American Museum Novitates, 3111*: 31p.

Menning, M., 1995: A numerical time scale for the Permian and Triassic periods; An integrated time analysis. *In* The Permian of northern Pangea, Vol. I, Paleogeography, paleoclimates, stratigraphy. *Eds.* Scholle, P.A., Peryt, T.M. and Ulmer-Scholle, D.S. pp. 77-97.

Menon, N.R., 1972: Heat tolerance, growth and regeneration in three North Sea bryozoans exposed to different constant temperatures. *Marine Biology, 15*: 1-11.

Metcalfe, I., 1989: Triassic sedimentation in the Central Basin of Peninsular Malaysia. *In.* Proceedings of International Symposium on Intermontane Basins: Geology and Resources. *Eds.* Thanasuthipitak, T. and Ounchanum, P. pp. 173-186.

Metcalfe, I., 1996: Gondwanaland dispersion, Asian accretion and evolution of Eastern Tethys. *Australian Journal of Earth Sciences, 43*: 605-623.

Metcalfe, I., 1998: Palaeozoic and Mesozoic geological evolution of the SE Asian region: Multidisciplinary constraints and implications for biogeography. *In* Biogeography and Geological Evolution of SE Asia. *Eds.* Hall, R., Holloway, J.D. and Rosen, B.R. SPB Publishing. pp. 25-41.

Metcalfe, I., 1999: Gondwana dispersion and Asian accretion: An overview. *In* Gondwana Dispersion and Asian Accretion. *Ed.* Metcalfe, I. IGCP 321 Final Results Volume. A.A. Balkema. pp. 9-28.

Miller, T.G., 1961: New Irish Tournaisian fenestellids. *Geological Magazine, 6*: 493-500.

Miller, T.G., 1963: The bryozoan genus *Polypora* M'Coy. *Palaeontology, 6*: 166-171.

Mitchell, A.H.G., Young, B. and Jantaranipa, W., 1970: The Phuket Group, Peninsular Thailand: a Palaeozoic ?geosynclinal deposit. *Geological Magazine, 107*: 411-428.

Morozova, I.P., 1970: Late Permian bryozoans. *Academy Science USSR, Transactions of the Paleontological Institute, 122.* 314p. In Russian.

Morozova, I.P., 1974: Revision of the bryozoan genus *Fenestella. Paleontological Journal, 8*: 167-180.

Morozova, I.P. and Krutchinina, O.N., 1986: Permian Bryozoa of the Arctic (Western Sector). 144p. Academy of Science USSR. In Russian.

Morozova, I.P. and Lisitsyn, D.V., 1996: Revision of the Genus *Polypora* M'Coy, 1844. *Paleontologicheskii Zhurnal:* 38-47. In Russian.

Naimark, E.B., Markov, A.V. and Goryumova, R.V., 1999: Biogeography of Paleozoic Bryozoans: Quantitative analysis. *Paleontological Journal, 33*: 263-271.

Nekhoroshev, V.P., 1928: Developmental history of Paleozoic bryozoans of the Family Fenestellidae. *Geol. Konitet. Izv, 47*: 479-518.

Nekhoroshev, V.P., 1932: A microscopic method for investigation of Paleozoic bryozoans of the Family Fenestellidae. *Vses. Geologorazv. Ob'yedin. Izv, 51*: 279-303.

Nelson, C.S. and Hancock, G.E., 1984: Composition and origin of temperate skeletal carbonate sediments on South Maria Ridge, northern New Zealand. *New Zealand Journal of Marine and Freshwater Research, 18*: 221-239.

Nelson, C.S., Keane, S.L. and Head, P.S., 1988a: Non-tropical carbonate deposits on the modern New Zealand shelf. *Sedimentary Geology, 60*: 71-94.

Nelson, C.S., Hyden, F.M., Keane, S.L., Leask, W.L. and Gordon, D.P., 1988b: Application of bryozoan zoarial growth-forms studies in facies analysis of non-tropical carbonate deposits in New Zealand. *Sedimentary Geology, 60*: 301-322.

Nicholson, H.A. and Etheridge, R.Jnr., 1886: On the Tasmanian and Australian species of the genus *Stenopora* Lonsdale. *Annals & Magazine of Natural History, 17*: 173-187.

Nickles, J.M. and Bassler, R.S., 1900: A synopsis of American fossil Bryozoa including bibliography and synonymy. *United States Geological Survey Bulletin, 173.* 663p.

Pisano, E. and Boyer, M., 1985: Development pattern of an infralittoral bryozoan community in the western Mediterranean Sea. *Marine Ecology Progress Series, 27*: 195-202.

Piyasin, S., 1975: Geology of the Uttaradit Sheet. NE 47-11. 68 p.

Rao, C.P. and Green, D.C., 1982: Oxygen and carbon isotopes of Early Permian cold-water carbonates, Tasmania, Australia. *Journal of Sedimentary Petrology, 52*: 1111-1125.

Ross, J.R.P., 1963: Lower Permian Bryozoa from Western Australia. *Palaeontology, 6*: 70-82.

Ross, J.R.P., 1978: Biogeography of Permian Ectoproct Bryozoa. *Palaeontology, 21*: 341-356.

Ross, J.R.P., 1995: Permian Bryozoa. *In* The Permian of northern Pangea. Vol. 1, Paleogeography, paleoclimates and stratigraphy. *Eds.* Scholle, P.A., Peryt, T.M. and Ulmer-Scholle, D.S. Springer Verlag. pp. 196-209.

Ross, J.R.P. and Ross, C.A., 1990: Late Palaeozoic bryozoan biogeography. *In* Palaeogeography and biogeography. *Eds.* McKerrow, W.S. and Scotese, C.R. *Geological Society (London), Memoir, 12*: 353-362.

Ross, J.R.P. and Ross, C.A., 1996: Bryozoan evolution and dispersal, and Palaeozoic sea-level fluctuations. *In* Bryozoans in Space and Time. *Eds.* Gordon, D.P., Smith, A.M. and Grant-Mackie, J.A. *Proceedings 10th International Bryozoology Conference, Wellington, New Zealand, 1995.* pp. 243-258.

Runnegar, B., 1969: Permian Fossils from the Southern Extremity of the Sydney Basin. *In* Stratigraphy and Palaeontology, Essays in Honour of Dorothy Hill. *Ed.* Campbell, K.S.W., pp. 276-298. Australian National University Press.

Runnegar, B. and McClung, G., 1975: A Permian Time Scale for Gondwanaland. *In* Gondwanan Geology. *Ed.* Campbell, K.S.W. *Proceedings of the 3rd International Gondwana Symposium, Canberra*: 425-442.

Runnegar, B., 1980: Biostratigraphy of the Shoalhaven Group. *New South Wales Geological Survey Bulletin, A Guide to the Sydney Basin, 26*: 376-382.

Sakagami, S., 1961: Japanese Permian Bryozoa. *Special Papers Palaeontological Society of Japan, 7.* 58p.

Sakagami, S., 1962: Bryozoa from Pulau Jong, the Langkawi Islands, Northwest Malaya. *Geology and Palaeontology of Southeast Asia, 1*: 135-141.

Sakagami, S., 1966a: The Permian bryozoan fauna of Ko Muk, Peninsular Thailand with the description of the Cyclostomata. *Geology and Palaeontology of Southeast Asia, 2*: 141-155.

Sakagami, S., 1966b: The cryptostomatous Bryozoa from Ko Muk, Peninsular Thailand. *Geology and Palaeontology of Southeast Asia, 2*: 157-168.

Sakagami, S., 1967: On the Paleozoic Bryozoa collected by R. D. Stewart, near Petchabun, Thailand. *Geology and Palaeontology of Southeast Asia, 3*: 39-45.

Sakagami, S., 1968a: Permian Bryozoa from Khao Phrik, near Rat Buri, Thailand. *Geology and Palaeontology of Southeast Asia, 4*: 45-66.

Sakagami, S., 1968b: Permian Bryozoa from Khao Chong Krachok, Peninsular Thailand. *Geology and Palaeontology of Southeast Asia, 4*: 67-81.

Sakagami, S., 1968c: Permian Bryozoa from Khao Ta Mong Rai, Peninsular Thailand. *Geology and Palaeontology of Southeast Asia, 5*: 47-67.

Sakagami, S., 1970a: Addition to the Permian Bryozoa from Ko Muk, Peninsular Thailand. *Geology and Palaeontology of Southeast Asia, 8*: 43-68.

Sakagami, S., 1970b: On the Paleozoic Bryozoa of Japan and Thai-Malayan Districts. *Journal of Paleontology, 44*: 680-692.

Sakagami, S., 1973: Permian Bryozoa from Khao Raen, near Rat Buri, Thailand. *Geology and Palaeontology of Southeast Asia, 12*: 75-89.

Sakagami, S., 1975: Permian Bryozoa from Khao Hin Kling, near Phetchabun, North-Central Thailand. *Geology and Palaeontology of Southeast Asia, 16*: 33-43.

Sakagami, S., 1976: Palaeobiogeography of the Permian Bryozoa on the basis of the Thai-Malayan District. *Geology and Palaeontology of Southeast Asia, 17*: 155-172.

Sakagami, S., 1985: Paleogeographic Distribution of Permian and Triassic Ectoprocta (Bryozoa). *In* The Tethys; Her Paleogeography and Paleobiogeography from Paleozoic to Mesozoic. pp. 171-184. Tokai University Press, Tokyo.

Sakagami, S., 1999: Permian bryozoans from some localities in the Khao Hin Kling area near Petchabun, North-central Thailand. *Bulletin of the Kitakyushi Museum of Natural History, 18*: 77-103, plates 18-25.

Sanderson, W.G. and Thorpe, J.P., 1996: Effects of temperature on the feeding activity of some temperate intertidal Bryozoa. *In* Bryozoans in Space and Time. *Eds.* Gordon, D.P., Smith, A.M. and Grant-Mackie, J.A. *Proceedings 10th International Bryozoology Conference, Wellington, New Zealand, 1995.* pp. 271-282.

Schmidt-Nielsen, K., 1983: Animal Physiology: Adaption and environment. Cambridge University Press. 619p.

Schopf, T.J.M., 1969: Paleoecology of Ectoporocts (Bryozoans). *Journal of Paleontology, 43*: 234-244.

Sengor, A.M.C., 1979: Mid-Mesozoic closure of Permo-Triassic Tethys and its implications. *Nature, 279*: 590-593.

Shi, G.R. and Archbold, N.W., 1995a: Permian brachiopod faunal sequence of the Shan-Thai Terrane; biostratigraphy, palaeobiogeographical affinities and plate tectonic/ palaeoclimatic implications. *Journal of Southeast Asian Earth Sciences, 11*: 177-187.

Shi, G.R. and Archbold, N.W., 1995b: A quantitative analysis on the distribution of Baigendzhinian-early Kungurian (Early Permian) brachiopod faunas in the western Pacific region. *Journal of Southeast Asian Earth Sciences, 11*: 189-205.

Shi, G.R. and Archbold, N.W., 1998: Permian marine biogeography of SE Asia. *In* Biogeography and Geological Evolution of SE Asia. *Eds.* Hall, R., Holloway, J.D. and Rosen, B.R. SPB Publishing. pp. 57-72.

Shi, G.R. and Waterhouse, J.B., 1990: Sakmarian (Early Permian) brachiopod biogeography and constraints on the timing of terrane rifting, drift, and amalgamation in SE Asia, with reference to the nature of the Permian "Tethys". *The Australasian Institute of Mining and Metallurgy Pacific Rim 90 Congress, 2*: 271-276.

Shi, G.R. and Waterhouse, J.B., 1991: Early Permian brachiopods from Perak, west Malaysia. *Journal of Southeast Asian Earth Sciences, 6*: 25-39.

Shulga-Nesterenko, M.I., 1949: An attempt of phylogenetic analysis of bryozoans of the family Fenestellidae. *Trudy Paleontologiceskogo Instituta, 20*: 293-316. In Russian.

Shulga-Nesterenko, M.I., 1951: Carboniferous fenestellids of the Russian Platform. *Akad. Nauk SSSR Paleont. Inst. Trudy, 32*: 3-156. In Russian.

Shulga-Nesterenko, M.I., 1952: New Lower Permian bryozoans of Priuralya. *Transactions of the Paleontological Institute, 37*: 83p. In Russian.

Smith, A.M. and Nelson, C.S., 1996: Differential abrasion of bryozoan skeletons: taphonomic implications for palaeoenvironmental interpretation. *In* Bryozoans in Space and Time. *Eds.* Gordon, D.P., Smith, A.M. and Grant-Mackie, J.A. *Proceedings 10th International Bryozoology Conference, Wellington, New Zealand, 1995*. pp. 305-314.

Smith, E., Banks, M.R., Wass, R.E., and Reid C.M., in prep: A review of Permian species described by Lonsdale in 1844 and 1845. *Alcheringa.*

Snyder, E.M., 1991: Revised taxonomic procedures and paleoecological applications for some North American Mississippian Fenestellidae and Polyporidae (Bryozoa). *Palaeontographica Americana, 58*: 275 p.

Spiller, F.C.P. and Metcalfe, I., 1995: Late Palaeozoic radiolarians from the Bentong-Raub suture zone, and the Semanggol Formation of Peninsular Malaysia - initial results. *Journal of Southeast Asian Earth Sciences, 11*: 217-224.

Spry, A.H. and Banks, M.R., 1962: The Geology of Tasmania. *Journal of the Geological Society of Australia, 9(2)*: 362p.

Starcher, R.W. and McGhee, G.R.J., 2000: Fenestrate theoretical morphology: geometric constraints on lophophore shape and arrangement in extinct Bryozoa. *Paleobiology, 26*: 116-136.

Stauffer, P.H., 1983: Unraveling the mosaic of Paleozoic crustal blocks in Southeast Asia. *Geologische Rundshau, 72*: 1061-1080.

Stauffer, P.H. and Lee, C.P., 1987: The Upper Palaeozoic pebbly mudstone facies of peninsular Thailand and western Malaysia - Continental margin deposits of Palaeoeurasia - Discussion. *Geologische Rundshau, 76*: 945-948.

Strathmann, R.R., 1973: Function of lateral cilia in suspension feeding of lophophorates (Brachiopoda, Phoronida, Ectoprocta). *Marine Biology, 23*: 129-136.

Strzelecki, P.D.de., 1845: Physical descriptions of New South Wales and Van Diemen's Land. London.

Termier, H. and Termier, G., 1971: Bryozoaires du Paleozoique superieur de l'Afghanistan (Upper Paleozoic Bryozoa of Afghanistan). *Documents des Laboratoires de Geologie de la Faculte des Sciences de Lyon, 47*: 52p.

Toriyama, R., Hamada, T., Igo, H., Ingavat, R., Kanmera, K., Kobayashi, T., Koike, T., Ozawa, T., Pitakpaivan, K., Piyasin, S., Sakagami, S., Yanagida, J. and Yin, E.H., 1975: The Carboniferous and Permian Systems in Thailand and Malaysia. *Geology and Palaeontology of Southeast Asia, 15*: 39-76.

Truswell, E.M., 1978: Palynology of the Permo-Carboniferous in Tasmania: an interim report. *Bulletin of the Geological Survey of Tasmania, 56*: 1-39.

Tye, S.C., Fielding, C.R. and Jones, B.G., 1996: Stratigraphy and sedimentology of the Permian Talaterang and Shoalhaven Groups in the southernmost Sydney basin, New South Wales. *Australian Journal of Earth Sciences, 43*: 57-69.

Ulrich, E.O., 1888: A list of the Bryozoa of the Waverly Group in Ohio, with descriptions of new species. *Denison University Scientific Laboratories Bulletin, 4*: 62-96.

Ulrich, E.O., 1890: Palaeozoic Bryozoa. *Illinois State Geological Survey, 8*: 283-688.

Walkom, A.B., 1913: Stratigraphical Geology of the Permo-Carboniferous System in the Maitland-Branxton District: with some notes on the Permo-Carboniferous Palaeogeography of New South Wales. *Proceedings of the Linnean Society, New South Wales, 38*: 114-145.

Wardlaw, B., Spinosa, C. and Glenister, B.F., 1998: An important datum in the Gaudalupian: the Illawarra Reversal, numerical age and conodont zonation. *International Symposium: Stratotypes of the Upper Permian of the Volga Region. Abstracts:* 183.

Wardlaw, B.R., 1999: Notes from the SPS Chair. *Permophiles Newsletter, 35*: 1.

Wass, R.E., 1966: On the species *Fenestella horologia* Bretnall and *Minilya duplaris* Crockford. *Proceedings of the Linnean Society of New South Wales, 91*: 90-95.

Wass, R.E., 1967: Permian Polyzoa from the Port Keats district, Northern Territory. *Proceedings of the Linnean Society of New South Wales, 92*: 162-170.

Wass, R.E., 1968: Permian Polyzoa from the Bowen Basin. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin, 90*: 134 p.

Waterhouse, J. B., 1973: Permian brachiopod correlations for Southeast Asia. *Geological Society Malaysia Bulletin, 6*: 187-210.

Waterhouse, J.B., 1976: World correlations for Permian marine faunas. *Papers of the Department of Geology, University of Queensland, 7*: 1-232.

Waterhouse, J.B., 1981: Age of the Ratburi Limestone of Southern Thailand. *Department of Mineral Resources, Bangkok, Thailand; Geological Survey Memoir, 4*: 3-39.

Waterhouse, J.B., 1982: An early Permian cool-water fauna from pebbly mudstones in south Thailand. *Geological Magazine, 119*: 337-354.

Waterhouse, J.B., Pitakpaivan, K. and Mantajit, N., 1981: Early Permian brachiopods from Ko Yao Noi and near Krabi, southern Thailand. *Department of Mineral Resources, Bangkok, Thailand; Geological Survey Memoir, 4*: 45-213.

Waterhouse, J.B. and Piyasin, S., 1970: Mid-Permian brachiopods from Khao Phrik, Thailand. *Palaeontographica. Abteilung A: Palaeozoologie-Stratigraphie, 135*: 83-192.

Williams, E., McCleneghan, M.P. and Collins, P.L.F., 1989: Mid-Palaeozoic Deformation, Granitoids and Ore Deposits. *In* Geology and Mineral Resources of Tasmania. *Eds.* Burrett, C.F. and Martin, E.L. *Geological Society of Australia Special Publication, 15*: 238-292.

Winston, J.E., 1977: Feeding in Marine Bryozoans. *In.* Biology of Bryozoans. *Eds.* Woollacott, R.M. and Zimmer, R.L. pp. 233-268. Academic Press, New York.

Wongwanich, T., Burrett, C.F., Tansathein, W. and Chaodumrong, P., 1990: Lower to mid Paleozoic stratigraphy of mainland Satun Province, southern Thailand. *Journal of Southeast Asian Earth Sciences, 4*: 1-9.

APPENDIX ONE

DESCRIPTION PARAMETERS - FENESTRATA

Based on Snyder (1991) .

External features

1. Zoarial characters

Robustness - delicate (frequently broken), intermediate, robust (zoaria usually large) - a qualitative assessment.
Outward expansion - flat, obversely or reversely curved, undulating, infundibuliform.
Mesh spacing - close (fenestrule width < branch width), intermediate (fenestrule width ≅ branch width), open (fenestrule width > branch width).
Mesh uniformity - regular or irregular.
Zoarial supports - placement and degree of development.

2. Branch characters

Autozooecia - Number of rows of autozooecia per branch, and number before and after bifurcation.
Robustness - delicate (fragile, frequently crushed), intermediate (moderate preservation), robust (wide, thick and well preserved).
Width - narrow (<0.30 mm), intermediate (0.30 - 0.39 mm), wide (0.39 - 1 mm), very wide (> 1 mm).
Proximodistal trace - straight, sinuous (bending towards dissepiments), broadly curved.
Spacing - close (distance between branch centres < 2 × branch width) intermediate (distance between branch centres 2 - 2.5 × branch width), wide (distance between branch centres > 2.5 × branch width).
- Number of branches in 10 mm
- regular (Coefficient of variation, CV < 20), irregular (CV > 20).

Surface profile - rounded, flat or angular.

3. Dissepiments

Width - narrow (< 0.5 × branch width), intermediate (0.5 - 1 × branch width), wide (> 1 × branch width).
- uniformity of width, constant (CV < 20), variable (CV > 20).

Length - short (fenestrule width < branch width), intermediate (fenestrule width ≅ branch width), long (fenestrule width > branch width).
- uniformity of length, constant (CV < 20), variable (CV > 20).

Emplacement - regular or irregular, and angle to branch.
Positioning - Even, recessed or highly recessed from obverse/reverse surfaces.
Ornamentation - striae and/or stylets on obverse/reverse surfaces.

4. Fenestrules

Size - small (length < 0.4 mm; width < 0.24 mm), intermediate (length 0.4 - 0.9 mm; width 0.24 - 0.34 mm), large (length > 0.9 mm; width > 0.34 mm).
Shape - rectangular, subrectangular, elongate oval, elliptical, ovate, square.
Number - Number of fenestrules in 10 mm
Regularity - Size, regular or irregular, shape, regular or irregular; variation in size and shape between obverse and reverse surfaces, and throughout zoarium.
Relative width - Mean fenestrule to branch width ratio.
Length/width - Mean fenestrule width to length ratio; and uniformity of this ratio (regular CV < 20; variable CV > 20).

5. Autozooecial apertures

Size - small (length < 0.09 mm; width < 0.07), intermediate (length 0.09 - 0.15 mm; width 0.07 - 0.12 mm), large (length 0.15 - 0.21 mm; width 0.12 - 0.18 mm), very large (length > 0.21 mm; width > 0.18 mm).
Shape - circular, ovate, elliptical, and uniformity of shape.
Spacing - number of apertures between dissepiment centres, and number in 5 mm
Relative spacing - mean ratio of apertural spacing down to across branch, down to between and across to between; variability of these ratios.
Attitude - angle of aperture to plane of obverse surface (parallel, inclined into fenestrule).
- projection into fenestrule and indentation of fenestrule.

Peristome - width - thin (<0.025 mm), intermediate (0.025 - 0.05 mm), wide (> 0.05 mm).
- degree of development (poorly or well-developed).
- complete or incomplete

Apertural stylets - number and size of stylets surrounding aperture.
Terminal diaphragm - presence, thickness and nature.

6. Carina

Number - single or multiple.
Width - narrow (< 0.05 mm), intermediate (0.05 - 0.15 mm), wide (> 0.15 mm or > 0.5 × branch width).
Trace - continuous or intermittent, straight, sinuous or anastomosing.
Position - straight or curving around apertures.
Profile - degree of development and effect on branch surface profile.

7. Nodes

Emplacement - monoserial or biserial and degree of development.
Size - small (< 0.07 mm), intermediate (0.07 - 0.12 mm), large (> 0.12 mm).
Shape - circular, ovate, elongate along keel, stellate.
Uniformity - uniformity of size and shape, regular (CV < 25), variable (CV > 25).
Location - on keel, on branch, in a straight line or anastomosing.
Spacing - close (< 0.025 mm), intermediate (0.025 - 0.8 mm), wide (> 0.8 mm).
- number in 5 mm
- uniformity of spacing - regular (CV < 25), variable (CV > 25).

8. Obverse stylets

Size - small (< 0.01 mm), intermediate (0.01 - 0.02 mm), large (> 0.02 mm).
Spacing - close (< 0.025 mm), intermediate (0.025 - 0.05 mm), wide (> 0.05 mm), and location across surface.
Uniformity - uniformity of size and spacing, regular (CV < 20), variable (CV > 20).

9. Longitudinal striae

Number - few or numerous.
Spacing - close or wide.
Robustness - thin and delicate to wide and robust (qualitative parameter)

10. Reverse microstylets

Size - small (< 0.018 mm), intermediate (0.018 - 0.026 mm), large (> 0.026 mm).
Spacing - close (< 0.025 mm), intermediate (0.025 - 0.05 mm), wide (> 0.05 mm), and location across surface.
Uniformity - uniformity of size and spacing, regular (CV < 20), variable (CV > 20).

11. Reverse macrostylets
Size - small (< 0.05 mm), intermediate (0.05 - 0.08 mm), large (> 0.08 mm).
Shape - circular, ovate, irregular.
Spacing - close (< 0.05 mm), intermediate (0.05 - 0.15 mm), wide (> 0.15 mm), and location across surface.
Uniformity - uniformity of size and spacing, regular (CV < 20), variable (CV > 20).

12. Heterozooecia
Type - cyclozooecia, ovicells, microzooecia.
Shape - circular, ovate, elliptical.
Size - small to large and size relative to autozooecia.
Emplacement - position and regularity of position.

<u>Internal features</u>

1. Branch
Shape in transverse section - ovate, circular, polygonal, semicircular.
Thickness - thin (< 0.3 mm), intermediate (0.3 - 0.39 mm), thick (> 0.39 mm).
Direction of elongation - parallel/perpendicular to obverse/reverse surfaces, and ratio of mean branch width to thickness.

2. Autozooecial living chamber
Size - small (volume < 0.0017 mm^3), intermediate (volume 0.0017 - 0.013 mm^3), large (volume 0.013 - 0.025 mm^3), very large (> 0.025 mm^3.).
Emplacement - monoserial, biserial (alternating or adjacent) or polyserial (alternating or adjacent).
Axial wall trace - straight, zigzag, sinuous, and change in axial wall trace from reverse to obverse surfaces.
Orientation of elongation - length and depth equal, elongate proximodistally parallel to obverse/reverse surfaces, or parallel to proximal and distal chamber walls.
Chamber outline - near reverse wall, in mid chamber, near obverse surface (triangular, rectangular, square, ovate, elliptical, tetragonal, pentagonal, hexagonal, rhombic).
Chamber outline uniformity - highly uniform, uniform, variable, highly variable.
Vestibule length - short (< 0.06 mm), intermediate (0.06 - 0.12 mm), long (> 0.12 mm), and variability of length (regular, CV < 15; variable, CV > 15).
Aperture - Location of aperture relative to living chamber.
Chamber ratios - ratio of mean minimum to maximum width; maximum width to depth; depth to length, and variability of ratios.
Hemisepta - degree of development, shape, inferior or superior.
Lateral wall budding angle - mean, range, variability (regular, CV < 10; variable CV > 10).
Reverse wall budding angle - mean, range, variability (regular, CV < 10; variable CV > 10).
Heterozooecia - shape in deep and shallow section.
Shape - Three dimensional shape.

3. Skeletal microstructure
Granular layer - thickness (thin, thick) and continuity between nodes, stylets, striae, keels etc.
Lamellar layer - thickness (thin, thick) and relative thickness in obverse/reverse wall.

<u>NB</u> - "*Diagnosis*" of each species contains characteristic features and brief description of mesh.

APPENDIX TWO

DESCRIPTION PARAMETERS - TREPOSTOMATA AND CRYPTOSTOMATA

1. Zoarial characters
   Form - dendroid, encrusting, frondescent, bilamellar; and range of morphologies shown.
   Robustness - delicate, intermediate, robust (qualitative)
   Zoarial thickness - mean and range.
   Surface texture - smooth or with visible monticules.
   Zoarial base - mode of attachment if known.

2. Zooecial tubes
   Shape - in transverse section, rounded or polygonal
   Angle - angle from endozone to exozone, and exozone to zoarial surface; for Cryptostomata include divergence angle from axial bundle.
   Number - number of tubes in endozone in longitudinal section; for Cryptostomata number of tubes in axial bundle in transverse and longitudinal section.

3. Endozone
   Zooecia - wall thickness
   Monilae - presence/absence and nature of monilae in endozone.

4. Exozone
   Wall - wall thickness between zooecia, narrow (< 0.1 mm), intermediate (0.1 - 0.15 mm), wide (> 0.15mm).
   Monilae - shape (beadlike, pyriform, elongate), number of rows and spacing or overlapping of monilae.

5. Autozooecial apertures
   Size - small (length < 0.2 mm; width < 0.12 mm), intermediate (length 0.2 - 0.38 mm; width 0.15 - 0.22 mm), large (length > 0.38 mm; width > 0.22 mm).
   Shape - circular, ovate, polygonal.
   Orientation - regular or irregular.
   Spacing - distance between apertural centres (closest dimension).

6. Acanthostyles
   Size - small (< 0.05 mm), intermediate (0.05 - 0.1 mm), large (> 0.1 mm), and division into micro- and macroacanthostyles.
   Shape - circular, ovate, polygonal; distinct core and/or outer perimeter.
   Number - mean and range of number surrounding each autozooecial aperture.
   Arrangement - arrangement about autozooecial aperture.
   Consistency - appearance across zoarium, and relative to depth in zoarial wall.
   Monticules - changes to acanthostyles in monticular areas.

7. Exilazooecia
   Size - small (< 0.1 mm), intermediate (0.1 - 0.2 mm), large (> 0.2 mm).
   Shape - circular, ovate, polygonal, and variability in size and shape.
   Frequency - rare, common, abundant, and mean and range of number about each autozooecial aperture.
   Arrangement - arrangement about autozooecial aperture.
   Monticules - changes to acanthostyles in monitcular areas.

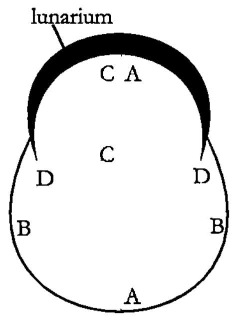
APPENDIX THREE

DESCRIPTION PARAMETERS - CYCLOSTOMATA

External features

1. Zoarial characters
   Robustness - delicate, intermediate, robust (qualitative parameter)
   Form - massive, encrusting, ramose/dendroid.
   Surface texture - smooth or with visible maculae.

2. Autozooecial aperture
   Size - (AA) small (< 0.25 mm), intermediate (0.25 - 0.35 mm), large (> 0.35mm)
   Dimensions - A-A, B-B, C-C, D-D, as shown.
   Shape - circular, ovate, polygonal.
   Arrangement - orientation about maculae.
   Spacing - close (< 0.35 mm), intermediate (0.35 - 0.6 mm), wide (> 0.6 mm), number in 2 mm diagonally, and distance between centres.
   Maculae - variation in nature and size of aperture in maculae.



3. Lunarium
   Development - presence/absence and degree of development in deep and shallow section.
   Size - proportion of autozooecial perimeter.
   Orientation - orientation about maculae, or through zoarium.

Internal features

1. Autozooecia
   Shape - in deep section - circular, ovate, polygonal.
   Size - larger/smaller or the same as for external measurements.
   Wall - thickness and regularity of thickness.

2. Vesicles
   Shape - box, blisters, polygonal; in tangential and transverse section.
   Size - size and consistency of size through zoarium.
   Spacing - number in 1 mm, horizontally and vertically; number between autozooecial apertures.
   Density - packing arrangement through zoarium.

3. Diaphragms
   Spacing - number in 2 mm, and regularity.
   Nature - straight, curved (concave or convex) and regularity of curvature.

4. Exozone
   Thickness - narrow (< ¼ width), intermediate (¼ - ½ width), wide (> ½ width).
   Degree of development - proportion of zoarial thickness, and packing of stereom.

APPENDIX FOUR

FOSSIL PREPARATION METHODS

All specimens from the Tasmania and Sydney Basins were collected from outcrops where the brachiopod and molluscan faunas were well known. The Tasmania and Sydney Basin bryozoan faunas were therefore of a known age. The Shan-Thai Terrane faunas were collected from outcrops where the lithostratigraphy was determinable.

The bryozoan specimens from the Tasmania and Sydney Basins did not lend themselves to further cleaning, however many of the Ratburi Limestone specimens were extracted from bulk material by dissolution in acetic acid.

Faunas from each basin were grouped according to external appearance and the external features were measured and described. In Tasmania and Sydney Basin faunas specimens that had celluliferous surfaces buried in the rock matrix had their external features measured, where possible, in thin section.

All specimens were then prepared for acetate peel and thin section analysis of internal structures.

Acetate peel preparation

All specimens were set in epoxy resin and cut to reveal tangential, transverse and longitudinal surfaces. The surface to be examined was ground to the desired level and polished with 3 micron aluminium oxide powder. Specimens were dried and etched in a weak solution of formic acid. Etching times were varied according to specimen and lithology. After etching specimens were dried and the Tasmania and Sydney Basin specimens were soaked in industrial grade acetone until reaction with organic constituents had ceased. As much of the Ratburi Limestone material was siliceous, etching was poor. However the use of chemicals such as hydrofluoric acid did not enhance the quality of the etch owing to the replacement style of the chalcedony.

All specimens were then covered in acetone on the prepared surface, and an acetate peel slide lightly pressed onto that surface. Specimens were then left to dry and the acetate peel removed. The above process was repeated until a complete record of the specimen from the reverse to obverse surface was gained. The final peel surfaces was then prepared for thin sectioning as a permanent record of each sample.

All specimens were examined under a petrographic microscope, and the parameters given in Appendices One to Three were measured. Specimens that were previously grouped together were assessed and described, separating specimens where internal features were different between specimens with the same or similar external features.

Taxonomic groups were then described and figured.

UTGD #	Locality #	Sample #	Species	Lithostratigraphy	Area	Stage	Easting	Northing	Map Title
126920	H26	H26as	*Stenopora berriedalensis*	Berriedale Limestone	Granton	Bernacchian	515400E	5266800N	New Norfolk 1:25 000
126921	H26	H26bs	*Stenopora berriedalensis*	Berriedale Limestone	Granton	Bernacchian	515400E	5266800N	New Norfolk 1:25 000
126922	H38	H38as	*Stenopora berriedalensis*	Malbina Fm, unit E	Eaglehawk Neck	Lymingtonian	567000E	5237750N	Taranna 1:25 000
126923	M10	M10as	*Dyscritella restis*	Counsel Creek Fm	Maria Island	Bernacchian	588600E	5285250N	Maria Is Nat Pk 1:50,000
126924	B6a	B6aas	*Stenopora crinita*	West Arm Gp	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25 000
126925	H39	H39as	*Stenopora crinita*	Malbina Fm, unit E	Eaglehawk Neck	Lymingtonian	567000E	5237750N	Taranna 1:25 000
126926	H36	H36as	*Stenopora crinita*	Berriedale Limestone	Granton	Bernacchian	515300E	5266600N	New Norfolk 1:25 000
126927	H44	H44as	*Stenopora etheridgei*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25 000
126928	M14	M14as	*Stenopora etheridgei*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk. 1:50,000
126929	M9	M9as	*Stenopora grantonensis*	Skipping Ridge Fm	Maria Island	Bernacchian	588550E	5284700N	Maria Is. Nat Pk. 1:50,000
126930	M14	M14bs	*Stenopora grantonensis*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk 1:50,000
126931	B6c	B6cas	*Stenopora elongata*	West Arm Gp	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25 000
126932	B6b	B6bas	*Stenopora aequalis*	West Arm Gp	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25 000
126933	B6b	B6bbs	*Stenopora aequalis*	West Arm Gp	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25 000
126934	B5c	B5cas	*Stenopora cf ovata*	West Arm Gp	Beaconsfield	Lymingtonian	481300E	5444450N	Bell Bay 1:25 000
126935	M16	M16as	*Stenopora ovata*	Skipping Ridge Fm	Maria Island	Bernacchian	588250E	5285250N	Maria Is Nat. Pk 1:50,000
126936	M16	M16as	*Paraliioclema wassi*	Skipping Ridge Fm	Maria Island	Bernacchian	588250E	5285250N	Maria Is Nat Pk 1:50,000
126937	H43	H43cs	*Stenopora tasmaniensis*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25 000
126938	H43	H43as	*Stenopora tasmaniensis*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25 000
126939	B15	B15as	*Stenopora tasmaniensis*	Massey's Creek Gp	Beaconsfield	Tamarian	480300E	5444100N	Bell Bay 1:25 000
126940	M1	M1as	*Stenopora tasmaniensis*	Basal Beds, Maria Island	Maria Island	Tamarian	588350E	5286000N	Maria Is Nat Pk 1:50,000
126941	M1	M1bs	*Stenopora tasmaniensis*	Basal Beds, Maria Island	Maria Island	Tamarian	588350E	5286000N	Maria Is Nat Pk 1:50,000
126942	M1	M1es	*Stenopora tasmaniensis*	Basal Beds, Maria Island	Maria Island	Tamarian	588350E	5286000N	Maria Is Nat Pk 1:50,000
126943	M2	M2as	*Stenopora tasmaniensis*	Basal Beds, Maria Island	Maria Island	Tamarian	588400E	5286000N	Maria Is Nat Pk. 1:50,000
126944	M5	M5as	*Stenopora tasmaniensis*	Basal Beds, Maria Island	Maria Island	Tamarian	588500E	5285900N	Maria Is. Nat. Pk. 1:50,000
126945	M15	M15cs	*Stenopora tasmaniensis*	Basal Beds, Maria Island	Maria Island	Tamarian	588400E	5285900N	Maria Is Nat Pk 1:50,000
126946	GV7	GV7as	*Stenopora tasmaniensis*	Glencoe Fm	Golden Valley	Tamarian	477350E	5390850N	Montana 1:25 000
126947	C3	C3as	*Stenopora tasmaniensis*	Bundella Mudstone	Lymington	Tamarian	501850E	5216500N	Lymington 1:25 000
126948	M1	M1cs	*Dyscritellina megacanthi*	Basal Beds, Maria Island	Maria Island	Tamarian	588350E	5286000N	Maria Is Nat Pk 1:50,000
126949	M15	M15as	*Dyscritella inversa*	Basal Beds, Maria Island	Maria Island	Tamarian	588400E	5285900N	Maria Is Nat Pk 1:50,000
126950	M15	M15bs	*Dyscritella inversa*	Basal Beds, Maria Island	Maria Island	Tamarian	588400E	5285900N	Maria Is. Nat. Pk 1:50,000
126951	H43	H43bs	*Dyscritella inversa*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25 000
127061	M5	M5	*Dyscritellina megacanthi*	Basal Beds, Maria Island	Maria Island	Tamarian	588500E	5285900N	Maria Is Nat Pk. 1:50,000
127065	M14	M14cs	*Stenopora berriedalensis*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk 1:50,000
127123	M14	M14a	*Rectifenestella granulifera*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk 1:50,000

UTGD #	Locality #	Sample #	Species	Lithostratigraphy	Area	Stage	Easting	Northing	Map Title
127124	M14	M14a'	*Rectifenestella granulifera*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat. Pk. 1:50,000
127125	M14	M14f	*Rectifenestella smithae*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is. Nat. Pk 1:50,000
127126	M14	M14y	*Rectifenestella smithae*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk 1:50,000
127127	M14	M14z	*Rectifenestella smithae*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is. Nat Pk 1:50,000
127128	H43	H43c	*Rectifenestella smithae*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25,000
127129	H41	H41z	*Levifenestella expansa*	Bundella Mudstone	Granton	Tamarian	514500E	5267200N	New Norfolk 1:25,000
127130	M14	M14g	*Levifenestella expansa*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat. Pk 1:50,000
127131	H43	H43a	*Levifenestella expansa*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25,000
127132	H25	H25d	*Levifenestella expansa*	Berriedale Limestone	Lower Sandy Bay	Bernacchian	528750E	5248650N	Taroona 1:25,000
127133	M9	M9a	*Levifenestella expansa*	Counsel Creek Fm	Maria Island	Bernacchian	588550E	5284700N	Maria Is Nat Pk 1:50,000
127134	M10	M10d	*Levifenestella expansa*	Counsel Creek Fm	Maria Island	Bernacchian	588600E	5285250N	Maria Is Nat Pk 1:50,000
127135	M10	M10j	*Rectifenestella counselensis*	Counsel Creek Fm	Maria Island	Bernacchian	588600E	5285250N	Maria Is Nat Pk 1:50,000
127136	H26	H26a	*Polypora virga*	Berriedale Limestone	Granton	Bernacchian	515400E	5266800N	New Norfolk 1:25,000
127137	B5c	B5c1	*Polypora virga*	West Arm Group	Beaconsfield	Lymingtonian	481300E	5444450N	Bell Bay 1:25,000
127138	B5c	B5c4	*Polypora virga*	West Arm Group	Beaconsfield	Lymingtonian	481300E	5444450N	Bell Bay 1:25,000
127139	B5c	B5ca	*Polypora virga*	West Arm Group	Beaconsfield	Lymingtonian	481300E	5444450N	Bell Bay 1:25,000
127140	B5c	B5c7	*Polypora cf virga*	West Arm Group	Beaconsfield	Lymingtonian	481300E	5444450N	Bell Bay 1:25,000
127141	M14	M14i	*Polypora virga*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat. Pk 1:50,000
127142	M9	M9e	*Polypora virga*	Counsel Creek Fm	Maria Island	Bernacchian	588550E	5284700N	Maria Is Nat Pk 1:50,000
127143	M10	M10f	*Polypora virga*	Counsel Creek Fm	Maria Island	Bernacchian	588600E	5285250N	Maria Is Nat Pk. 1:50,000
127144	H28	H28a	*Polypora virga*	Berriedale Limestone	Granton	Bernacchian	515400E	5266750N	New Norfolk 1:25,000
127145	C11	C11a	*Polypora virga*	Deep Bay Fm	Cygnet	Lymingtonian	529300E	5215700N	Lymington 1:25,000
127146	H35	H35d	*Polypora virga*	Malbina Fm	Granton	Lymingtonian	515250E	5266500N	New Norfolk 1:25,000
127147	H38	H38f	*Polypora virga*	Malbina Fm	Eaglehawk Neck	Lymingtonian	567000E	5237750N	Taranna 1:25,000
127148	M4	M4ay	*Polyporella subwoodsi*	Darlington Limestone	Maria Island	Tamarian	588455E	5285905N	Maria Is Nat. Pk. 1:50,000
127149	M4	M4aa	*Polyporella subwoodsi*	Darlington Limestone	Maria Island	Tamarian	588455E	5285905N	Maria Is Nat Pk 1:50,000
127150	M4	M4af	*Polyporella subwoodsi*	Darlington Limestone	Maria Island	Tamarian	588455E	5285905N	Maria Is Nat Pk 1:50,000
127151	M4	M4az	*Polyporella subwoodsi*	Darlington Limestone	Maria Island	Tamarian	588455E	5285905N	Maria Is Nat Pk 1:50,000
127152	H43	H43l	*Polyporella subwoodsi*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25,000
127153	B6a	B6aa	*Polyporella westarmensis*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25,000
127154	B6a	B6at	*Polyporella westarmensis*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25,000
127155	B6a	B6ay	*Polyporella westarmensis*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25,000
127156	H43	H43cf	*Parapolypora boraformis*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25,000
127157	H43	H43j	*Parapolypora boraformis*	Bundella Mudstone	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25,000
127158	B6b	B6bv	*Mackinneyella granulosa*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25,000

UTGD #	Locality #	Sample #	Species	Lithostratigraphy	Area	Stage	Easting	Northing	Map Title
127159	B6c	B6ca	*Mackinneyella granulosa*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1 25,000
127160	B6a	B6ax	*Mackinneyella granulosa*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1 25,000
127161	B6a	B6ab	*Mackinneyella granulosa*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1:25,000
127162	M9	M9c	*Mackinneyella granulosa*	Counsel Creek Fm	Maria Island	Bernacchian	588550E	5284700N	Maria Is Nat. Pk. 1·50,000
127163	C10	C10c	*Mackinneyella granulosa*	Deep Bay Fm	Bruny Island	Lymingtonian	528750E	5214620N	Great Bay 1 25,000
127497	M14	M14d	*Rectifenestella sp A*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk 1.50,000
127498	M14	M14d2	*Rectifenestella sp A*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk 1·50,000
127499	H43	H43d	*Parapolypora ampla*	Bundella Formation	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1.25,000
127500	H43	H43s	*Parapolypora ampla*	Bundella Formation	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1 25,000
127501	H43	H43t	*Parapolypora ampla*	Bundella Formation	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1·25,000
127502	H41	H41a	*Parapolypora ampla*	Bundella Formation	Granton	Tamarian	514500E	5267200N	New Norfolk 1.25,000
127503	H41	H41y	*Parapolypora sp A*	Bundella Formation	Granton	Tamarian	514500E	5267200N	New Norfolk 1·25,000
127504	H46	H46c	*Parapolypora sp A*	Berriedale Limestone	Granton	Bernacchian	516400E	5269500N	New Norfolk 1.25,000
127505	H46	H46f	*Parapolypora sp A*	Berriedale Limestone	Granton	Bernacchian	516400E	5269500N	New Norfolk 1·25,000
127506	M10	M10c	*Parapolypora sp B*	Counsel Creek Fm.	Maria Island	Bernacchian	588600E	5285250N	Maria Is. Nat Pk. 1 50,000
127507	H43	H43b	*Polyporella internata*	Bundella Formation	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1 25,000
127508	H43	H43k	*Polyporella internata*	Bundella Formation	Lower Sandy Bay	Tamarian	529350E	5247550N	Taroona 1:25,000
127509	M8	M8xa	*Polyporella internata ?*	Darlington Limestone	Maria Island	Tamarian	588550E	5285900N	Maria Is Nat Pk 1.50,000
127510	M14	M14e	*Polyporella internata ?*	Skipping Ridge Fm.	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk 1.50,000
127511	M10	M10b	*Polyporella internata ?*	Counsel Creek Fm	Maria Island	Bernacchian	588600E	5285250N	Maria Is Nat. Pk 1·50,000
127512	B6b	B6bz	*Polyporella protuberans*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1 25,000
127513	M14	M14b	*Pseudopolypora banksi*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat Pk 1 50,000
127514	M14	M14w	*Pseudopolypora banksi*	Skipping Ridge Fm	Maria Island	Bernacchian	588500E	5285650N	Maria Is Nat. Pk 1 50,000
127515	H41	H41c	*Pseudopolypora bundellaensis*	Bundella Formation	Granton	Tamarian	514500E	5267200N	New Norfolk 1.25,000
127516	B6b	B6bx	*Pseudopolypora tamarensis*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1·25,000
127517	B6b	B6bw	*Pseudopolypora tamarensis*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1 25,000
127518	B5c	B5c2	*Pseudopolypora tamarensis*	West Arm Group	Beaconsfield	Lymingtonian	481300E	5445000N	Bell Bay 1 25,000
127519	B6b	B6bb	*Pseodopolypora versonoda*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1 25,000
127520	B6b	B6by	*Pseodopolypora versonoda*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1 25,000
127521	C9	C9a	*Shulgapora magnafenestrata*	Deep Bay Formation	Lymington	Lymingtonian	507360E	5214650N	Lymington 1.25,000
127522	B6a	B6ar	*Stenopora elongata*	West Arm Group	Beaconsfield	Lymingtonian	481325E	5444500N	Bell Bay 1 25,000
127523	DP2	DP2t	*Fenestella sp*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127524	DP2	DP2w	*Fenestella sp*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127525	DP2	DP2u	*Fenestella sp.*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127526	DP2	DP2r	*Laxifenestella exserta*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000

UTGD #	Locality #	Sample #	Species	Lithostratigraphy	Area	Stage	Easting	Northing	Map Title
127527	DP2	DP2s	*Laxifenestella exserta*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127528	DP2	DP2f	*Laxifenestella exserta*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127529	DP2	DP2p	*Laxifenestella exserta*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127530	DP2	DP2q	*Laxifenestella exserta*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127531	DP2	DP2h	*Laxifenestella exserta*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127532	DP2	DP2c	*Laxifenestella exserta*	Wandrawandian Siltstone	Dolphin Point, Ulladulla.	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127533	DP1	DP1t	*Laxifenestella exserta*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	267950E	6079050N	Ulladulla 1,100,000
127534	WH9	WH9z	*Laxifenestella exserta*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271950E	6083200N	Ulladulla 1,100,000
127535	WH9	WH9b	*Laxifenestella exserta*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271950E	6083200N	Ulladulla 1,100,000
127536	WH4	WH4e	*Laxifenestella exserta*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271950E	6083300N	Ulladulla 1,100,000
127537	WH4	WH4d	*Laxifenestella exserta*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271950E	6083300N	Ulladulla 1,100,000
127538	DP1	DP1z	*Laxifenestella oviferosa*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	267950E	6079050N	Ulladulla 1,100,000
127539	DP2	DP2y	*Laxifenestella oviferosa*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127540	DP2	DP2b	*Laxifenestella oviferosa*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127541	WH7	WH7a	*Levifenestella altacarinata*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271650E	6083850N	Ulladulla 1,100,000
127542	WH7	WH7b	*Levifenestella altacarinata*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271650E	6083850N	Ulladulla 1,100,000
127543	WH7	WH7c	*Levifenestella altacarinata*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271650E	6083850N	Ulladulla 1,100,000
127544	WH7	WH7f	*Levifenestella altacarinata*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271650E	6083850N	Ulladulla 1,100,000
127545	WH9	WH9a	*Levifenestella altacarinata*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271950E	6083200N	Ulladulla 1,100,000
127546	NH1	NH1p	*Levifenestella altacarinata*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127547	NH1	NH1z	*Levifenestella altacarinata*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127548	NH1	NH1l	*Levifenestella altacarinata*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127549	NH1	NH1xx	*Levifenestella altacarinata*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127550	NH1	NH1yy	*Levifenestella altacarinata*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127551	NH2	NH2x	*Minilya bituberculata*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127552	NH2	NH2s	*Minilya bituberculata*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127553	WH6	WH6v-	*Rectifenestella sparsa*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271450E	6083850N	Ulladulla 1,100,000
127554	NH1	NH1r	*Rectifenestella sparsa*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127555	DP2	DP2a	*Rectifenestella sparsa*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127556	DP2	DP2d	*Rectifenestella sparsa*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127557	DP2	DP2g	*Rectifenestella sparsa*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127558	DP2	DP2i	*Rectifenestella sparsa*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127559	DP2	DP2xx	*Rectifenestella sparsa*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127560	NH2	NH2o	*Rectifenestella sp B*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127561	NH2	NH2b	*Rectifenestella sp B*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000

UTGD #	Locality #	Sample #	Species	Lithostratigraphy	Area	Stage	Easting	Northing	Map Title
127562	DP2	DP2k	*Rectifenestella sp C*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127563	DP2	DP2z	*Rectifenestella sp C*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127564	DP1	DP1y'	*Shulgapora magnafenestrata*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	267950E	6079050N	Ulladulla 1,100,000
127565	NH2	NH2n	*Paucipora ulladullaensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127566	NH2	NH2w	*Paucipora ulladullaensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127567	NH2	NH2a	*Polypora dichotoma ?*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127568	NH2	NH2r	*Polypora dichotoma ?*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127569	NH1	NH1u	*Polyporella sp*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127570	NH1	NH1e	*Polyporella sp*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127571	DP2	DP2n	*Dyscritella espinensis*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127572	DP2	DP2m	*Dyscritella espinensis*	Wandrawandian Siltstone	Dolphin Point, Ulladulla	Kungurian	268000E	6078950N	Ulladulla 1,100,000
127573	NH3	NH3z	*Dyscritella espinensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127574	NH3	NH3x	*Dyscritella espinensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127575	NH3	NH3y	*Dyscritella espinensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127576	NH3	NH3v	*Dyscritella espinensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127577	WPH	WPH1	*Stenopora spiculata*	Wasp Head Formation	Wasp Head	Sakmarian	256200E	6049250N	Bateman's Bay 1,100,000
127578	PB	PB1	*Stenopora cf. spiculata*	Snapper Point Formation	Pretty Beach	Artinskian	261150E	6060200N	Bateman's Bay 1,100,000
127579	NH1	NH1j	*Stenopora seriatensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127580	NH1	NH1t	*Stenopora seriatensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127581	NH1	NH1s	*Stenopora seriatensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127582	NH1	NH1uu	*Stenopora seriatensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127583	NH2	NH2m	*Stenopora seriatensis*	Wandrawandian Siltstone	North Head, Ulladulla	Kungurian	271300E	6084750N	Ulladulla 1,100,000
127584	WH6	WH6u	*Stenopora seriatensis*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271450E	6083850N	Ulladulla 1,100,000
127585	WH6	WH6x	*Stenopora seriatensis*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271450E	6083850N	Ulladulla 1,100,000
127586	WH6	WH6z	*Stenopora seriatensis*	Wandrawandian Siltstone	Warden Head, Ulladulla	Kungurian	271450E	6083850N	Ulladulla 1,100,000
127587	TPPL2	TPPL2b	*Alternifenestella subquadratopora*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44'.7N	Thailand NB 47-2 1 250,000
127588	KPB	KPB17	*Fabifenestella carinata*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44'.5N	Thailand NB 47-2 1 250,000
127589	KPB	KPB17b	*Fabifenestella carinata*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127590	KPB	KPB32	*Fabifenestella subthaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o45'.8E	07o44' 5N	Thailand NB 47-2 1 250,000
127591	KPB	KPB28b	*Fabifenestella subthaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127592	KPB	KPB31	*Fabifenestella subthaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44'.5N	Thailand NB 47-2 1 250,000
127593	KPB	KPB30	*Flexifenestella hexaformis*	Ratburi Limestone	Ko Phi Phi Don		098o45'.8E	07o44' 5N	Thailand NB 47-2 1 250,000
127594	KPB	KPB30b	*Flexifenestella hexaformis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44'.5N	Thailand NB 47-2 1 250,000
127595	KPB	KPB19	*Minilya duplaris*	Ratburi Limestone	Ko Phi Phi Don		098o45'.8E	07o44' 5N	Thailand NB 47-2 1 250,000
127596	KPB	KPB19b	*Minilya duplaris*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000

UTGD #	Locality #	Sample #	Species	Lithostratigraphy	Area	Stage	Easting	Northing	Map Title
127597	KPB	KPB20	*Minilya duplaris*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127598	KPB	KPB25	*Minilya phiphiensis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127599	KPB	KPB33	*Rectifenestella pulchradorsalis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127600	KPB	KPB18	*Spinofenestella flanchea*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127601	KPB	KPB27	*Spinofenestella horologia*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1:250,000
127602	KPB	KPB26	*Spinofenestella lekformis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127603	KPB	KPB26b	*Spinofenestella lekformis*	Ratburi Limestone	Ko Phi Phi Don		098o45'.8E	07o44'.5N	Thailand NB 47-2 1·250,000
127604	KPB	KPB22	*Spinofenestella lekformis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1·250,000
127605	TPPL3	TPPL3k	*Spinofenestella pseudohorologia*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127606	TPPLL3	TPPL3j	*Spinofenestella pseudohorologia*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127607	KPB	KPB12	*Mackinneyella nodosa*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127608	KPB	KPB12b	*Mackinneyella nodosa*	Ratburi Limestone	Ko Phi Phi Don		098o45'.8E	07o44'.5N	Thailand NB 47-2 1 250,000
127609	KPB	KPB16	*Mackinneyella supraobesa*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127610	KPB	KPB16b	*Mackinneyella supraobesa*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44'.5N	Thailand NB 47-2 1·250,000
127611	KPB	KPB34	*Polypora canalis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127612	KPB	KPB34b	*Polypora canalis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127613	TPPL3	TPPL3g	*Polypora nodulifera*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127614	TPPL2	TPPL2d	*Polypora nodulifera*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44' 7N	Thailand NB 47-2 1 250,000
127615	TPPL2	TPPL2e	*Polypora nodulifera*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44' 7N	Thailand NB 47-2 1·250,000
127616	KPB	KPB11	*Shulgapora megacyclopora*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127617	KPB	KPB11b	*Shulgapora megacyclopora*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127618	KPB	KPB43p	*Shulgapora megacyclopora*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127619	TPPL3	TPPL3q	*Shulgapora reversa*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127620	TPPL3	TPPL3h	*Reteporidra yongkasemensis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127621	KPB	KPB7	*Septapora interformis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127622	KPA	KPA4	*Septapora interformis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127623	TPPL3	TPPL3a	*Synocladia irregularis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44'.5N	Thailand NB 47-2 1 250,000
127624	KPB	KPB8	*Penniretpora subtropica*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127625	KPB	KPB2	*Acanthocladia pseudothaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1.250,000
127626	KPB	KPB45	*Acanthocladia pseudothaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127627	KPB	KPB29	*Acanthocladia pseudothaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127628	KPB	KPB3	*Acanthocladia pseudothaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127629	KPB	KPB4	*Acanthocladia suprangularis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127630	KPB	KPB45b	*Acanthocladia suprangularis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127631	KPB	KPB1a	*Acanthocladia suprangularis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000

UTGD #	Locality #	Sample #	Species	Lithostratigraphy	Area	Stage	Easting	Northing	Map Title
127632	KPB	KPB1b	*Acanthocladia suprangularis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1 250,000
127633	TPPL3	TPPL3l	*Paralioclema phuketensis*	Ratburi Limestone	Ko Phi Phi Don		098o45'.8E	07o44'.5N	Thailand NB 47-2 1 250,000
127634	TPPL3	TPPL3n	*Paralioclema phuketensis*	Ratburi Limestone	Ko Phi Phi Don		098o45'.8E	07o44'.5N	Thailand NB 47-2 1 250,000
127635	KPB	KPB35	*Neoeridotrypella subpulchra*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1.250,000
127636	TPPL3	TPPL3d	*Ascopora robusta*	Ratburi Limestone	Ko Phi Phi Don		098o45'.8E	07o44' 5N	Thailand NB 47-2 1·250,000
127637	KPB	KPB37	*Ascopora variablis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44' 5N	Thailand NB 47-2 1.250,000
127638	KPB	KPB37b	*Ascopora variablis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44'.5N	Thailand NB 47-2 1·250,000
127639	KPB	KPB39	*Ascopora variablis*	Ratburi Limestone	Ko Phi Phi Don		098o45' 8E	07o44'.5N	Thailand NB 47-2 1 250,000
127640	TPPL2	TPPL2c	*Rhabdomeson monoformis*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44'.7N	Thailand NB 47-2 1.250,000
127641	KPB	KPB38	*Streblotrypa komukensis*	Ratburi Limestone	Ko Phi Phi Don		098o46'.1E	07o44' 7N	Thailand NB 47-2 1 250,000
127642	KPB	KPB38b	*Streblotrypa komukensis*	Ratburi Limestone	Ko Phi Phi Don		098o46'.1E	07o44' 7N	Thailand NB 47-2 1 250,000
127643	TPPL3	TPPL3o	*Cyclotrypa dendroides*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44' 7N	Thailand NB 47-2 1·250,000
127644	KPB	KPB43	*Eridopora thaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o46'.1E	07o44' 7N	Thailand NB 47-2 1 250,000
127645	KPB	KPB40	*Eridopora thaiensis*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44' 7N	Thailand NB 47-2 1.250,000
127646	TPPL3	TPPL3p	*Fistulipora horowitzi*	Ratburi Limestone	Ko Phi Phi Don		098o46'.1E	07o44' 7N	Thailand NB 47-2 1 250,000
127647	TPPL3	TPPL3f	*Fistulipora megapertura*	Ratburi Limestone	Ko Phi Phi Don		098o46'.1E	07o44' 7N	Thailand NB 47-2 1·250,000
127648	KPB	KPB43'	*Fistulipora satoi ?*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44' 7N	Thailand NB 47-2 1·250,000
127649	TPPL3	TPPL3b	*Coscinotrypa yaiformis*	Ratburi Limestone	Ko Phi Phi Don		098o46'.1E	07o44'.7N	Thailand NB 47-2 1 250,000
127650	TPPL3	TPPL3c	*Hexogonella khaophrikensis*	Ratburi Limestone	Ko Phi Phi Don		098o46'.1E	07o44' 7N	Thailand NB 47-2 1 250,000
127651	KPA	KPA2	*Goniocladia sp indet A*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44'.7N	Thailand NB 47-2 1 250,000
127652	KPA	KPA1	*Goniocladia sp indet B*	Ratburi Limestone	Ko Phi Phi Don		098o46' 1E	07o44'.7N	Thailand NB 47-2 1.250,000
127653	H26	H26xs	*Stenopora etheridgei*	Berriedale Limestone	Granton	Bernacchian	515400E	5266800N	New Norfolk 1·25,000

PLATES

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Plate 1 - *Laxifenestella exserta* (Laseron 1918)
all scale bars are 1 mm.

1. UTGD 127526 - oblique tangential section reverse to obverse surface.
2. UTGD 127531 - oblique tangential section reverse to obverse surface showing chamber outline near the reverse surface, A, at mid chamber level, B, and near the obverse surface, C. Note also hemisepta, D, and continuity of granular skeleton across the dissepiments, E.
3. UTGD 127528 - longitudinal section showing chamber outline, and hemisepta, A, and vestibule, B.
4. UTGD 127528 - transverse section showing the low rounded profile of the obverse surface.
5. UTGD 127528 - tangential section of the reverse surface showing fine dense microstylets and the absence of macrostylets.
6. UTGD 127534 - tangential section of the obverse surface showing the widely spaced circular apertures, A, small nodes, B, on the low keel.

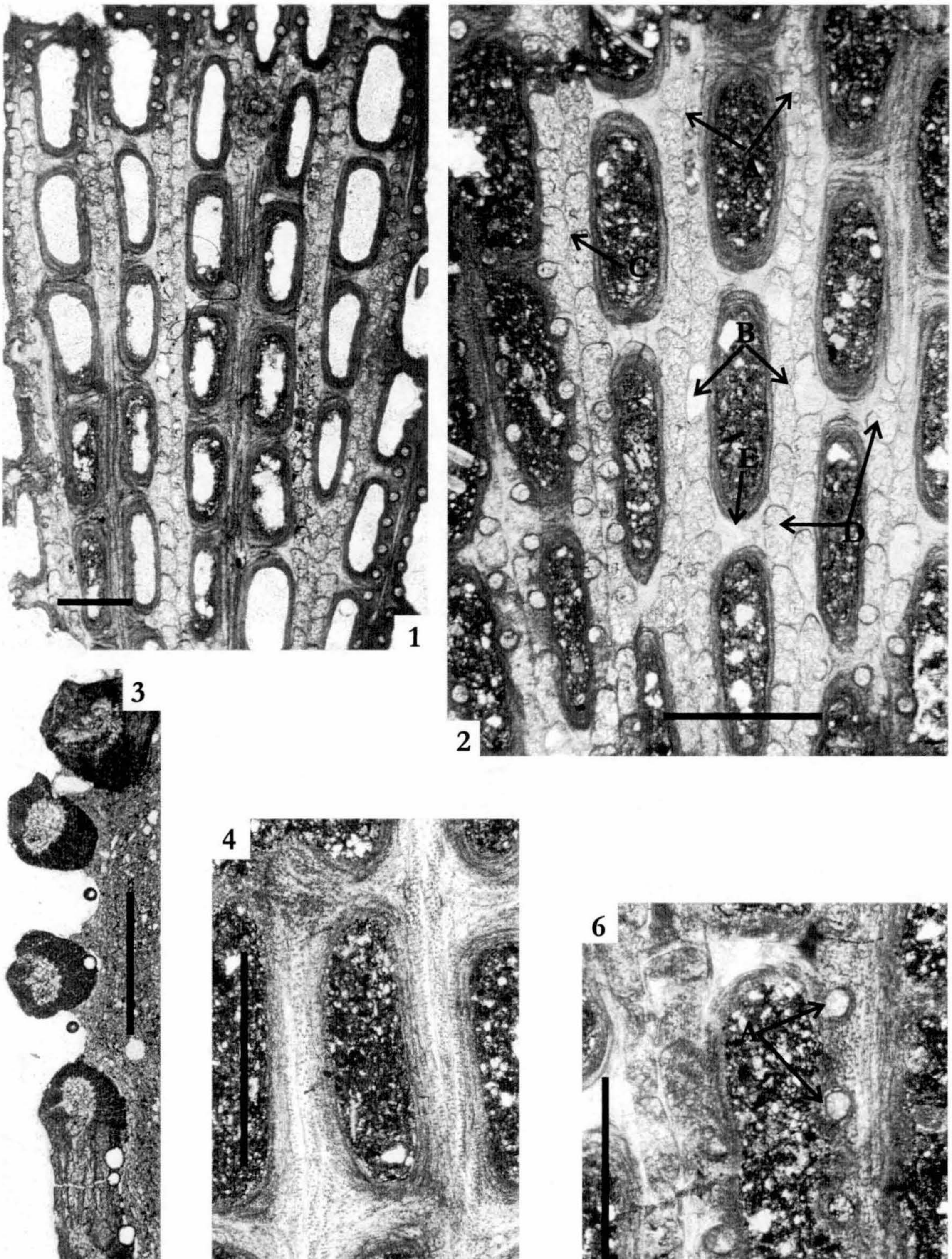

1
2
A
B
C
D
E
3
4
5
A
B
6
A
B

Plate 2 - *Laxifenestella oviferosa* n. sp.
all scale bars 1 mm.

1. UTGD 127538, holotype - oblique tangential section from reverse to obverse surface, showing chamber shape at mid chamber level, A, and near the obverse surface, B. Also shows the strong longitudinal striae, C, and circular upward facing apertures, D.
2. UTGD 127538, holotype - tangential section of the obverse surface near a bifurcation showing detail of ovicells, A, apertures, B, and nodes, C.
3. UTGD 127540, paratype - oblique tangential section with crushed chambers, but showing details of the obverse surface. Note ovicells, A, apertures, B, and nodes, C.
4. UTGD 127540, paratype - tangential section of the reverse surface showing densely packed reverse microstylets and absence of macrostylets.
5. UTGD 127540, paratype - longitudinal section.
6. UTGD 127540, paratype - transverse section, poorly preserved but showing ovicell, A, and upward facing vestibule, B.

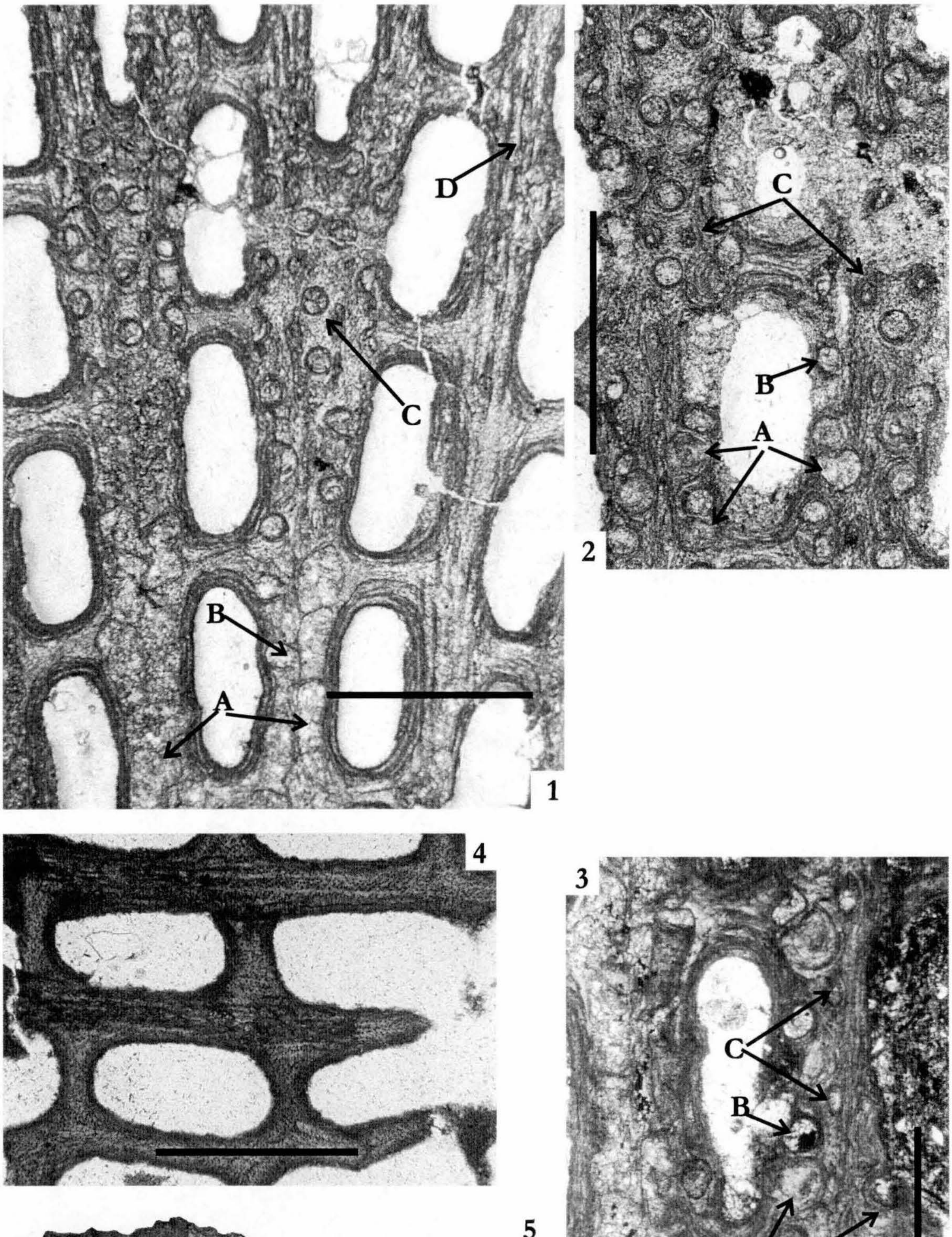
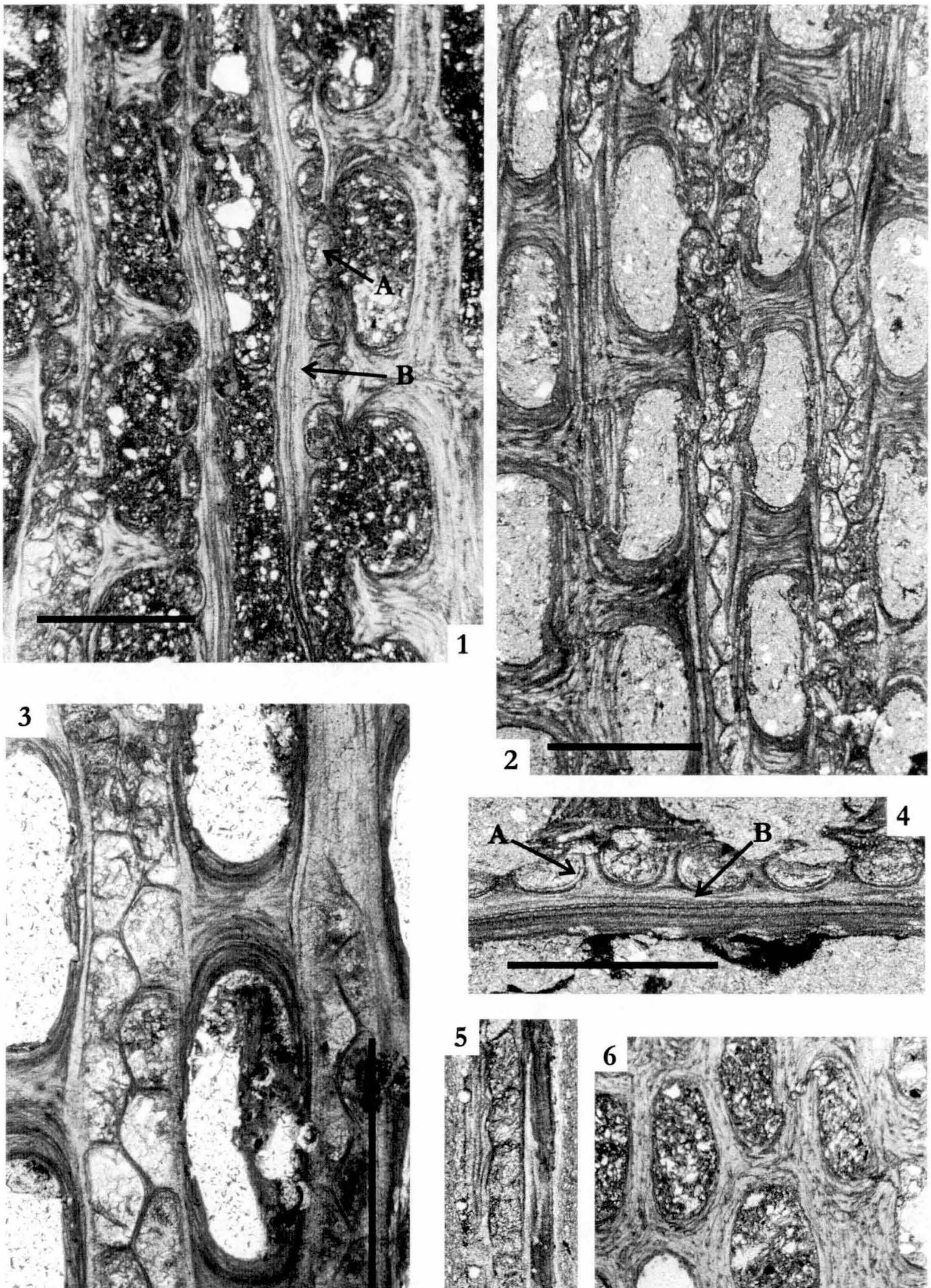

D
C
B
A
1
C
B
A
2
4
3
C
B
A
5
6
B
A

Plate 3 - *Levifenestella altacarinata* (Crockford 1941)
all scale bars 1 mm.

1. UTGD 127546 - tangential section of crushed specimen. Note large and closely spaced apertures, A, and the thick carina without nodes, B.
2. UTGD 127546 - tangential section.
3. UTGD 127547 - tangential section at mid chamber level showing zooecial chamber outline.
4. UTGD 127542 - longitudinal section showing the high reverse wall budding angle, and the thick frontal and reverse walls.
5. UTGD 127546 - tangential section of the reverse surface, showing the change in fenestrule and the reverse wall ornamentation.
6. UTGD 127546 - tangential section showing the detail of the obverse surface showing the large apertures with thin peristome, A, and the wide nodeless keel with central granular core visible, B.
7. UTGD 127542 - transverse section showing the continuity of the granular wall, and granular keel core, A, chamber shape, B, and high keel, C.



1
A
B
2
3
4
A
B
5
6
7
C
A
B

Plate 4 - *Levifenestella expansa* (Crockford 1946)

All scale bars 1 mm, except figure 5.5 where scale bar is 0.5 mm.

1. UTGD 127129 - oblique tangential thin section from reverse to obverse surface showing chamber shape, mesh character and prominent apparently nodeless carina.
2. UTGD 127130 - longitudinal thin section showing consistent reverse wall budding angle and long vestibule.
3. UTGD 127130 - transverse peel showing thick reverse and frontal walls.
4. UTGD 127129 - tangential thin section obverse surface, showing sinuous keel and possible node structure, A.
5. UTGD 127130 - tangential thin section obverse surface showing fine apertural stylets (A) and irregularities on keel, B.
6. UTGD 127130 - oblique tangential thin section, showing chamber shape near reverse surface, A, at mid chamber level, B, and near the obverse surface, C. Note variation in dissepiment width between this figure, UTGD 127130, and figure 5.1, UTGD 127129.

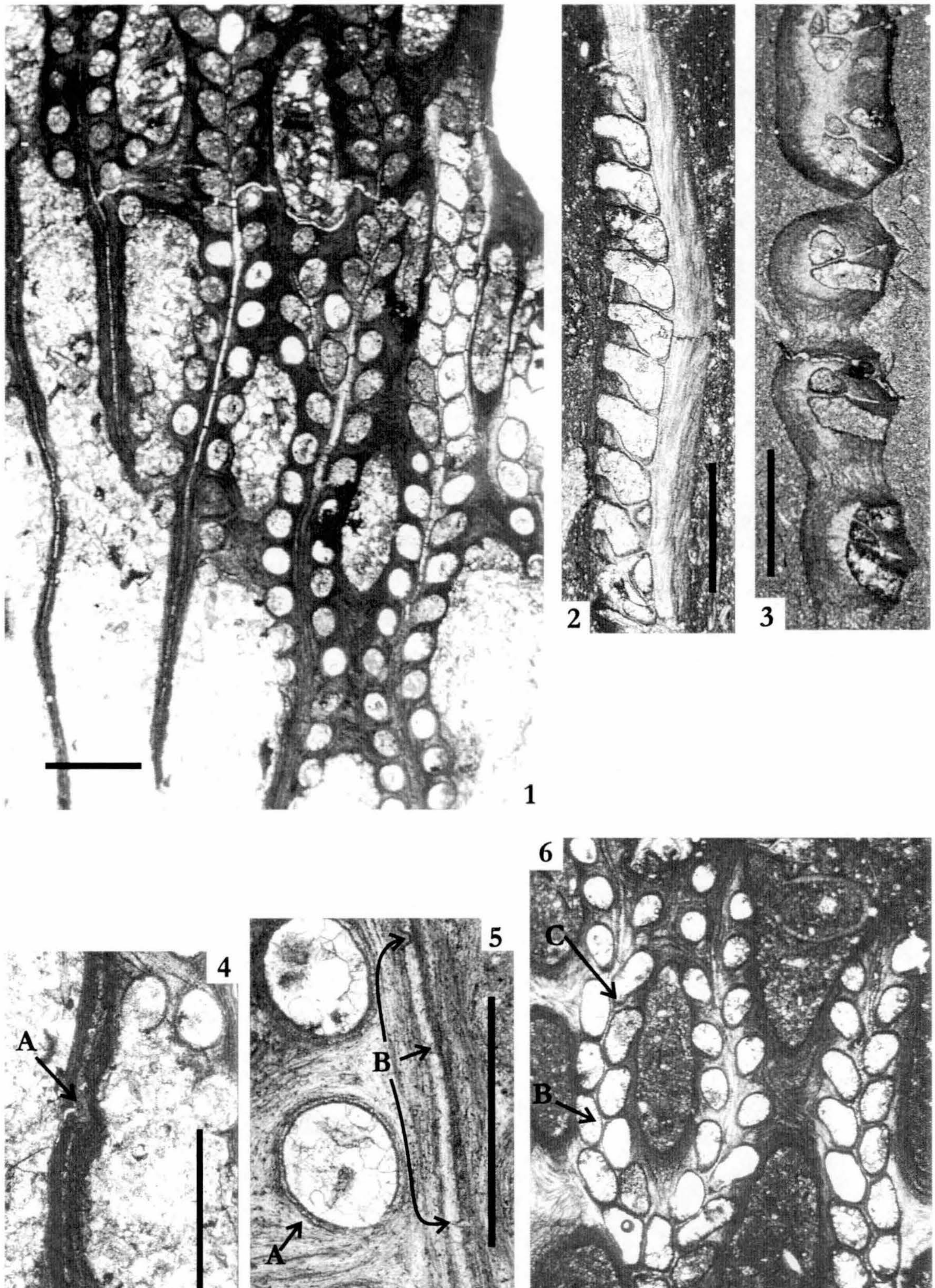

1
2
3
4
A
5
A
B
6
C
B
A

Plate 5 - *Minilya bituberculata* (Crockford 1941)
all scale bars 1mm, except figure 5.4 which is 0.5 mm.

1. UTGD 127551 - oblique tangential section from reverse to obverse surface, showing strong longitudinal striae, A, and chamber outline near reverse surface, B, at mid chamber, C, and near the obverse surface, D. Note also the double row of nodes, E.
2. UTGD 127551 - tangential section, showing apertural shape, A, and chamber outline at mid chamber level, B.
3. UTGD 127551 - transverse section showing development of nodes, arrow, and the rounded obverse surface profile.
4. UTGD 127551 - tangential section obverse surface showing detail of apertures and obverse stylets. Note also the small nodes, A, and small apertural stylets, B.
5. UTGD 127552 - tangential section at mid chamber level.
6. UTGD 127551 - longitudinal section showing the low reverse wall budding angle.

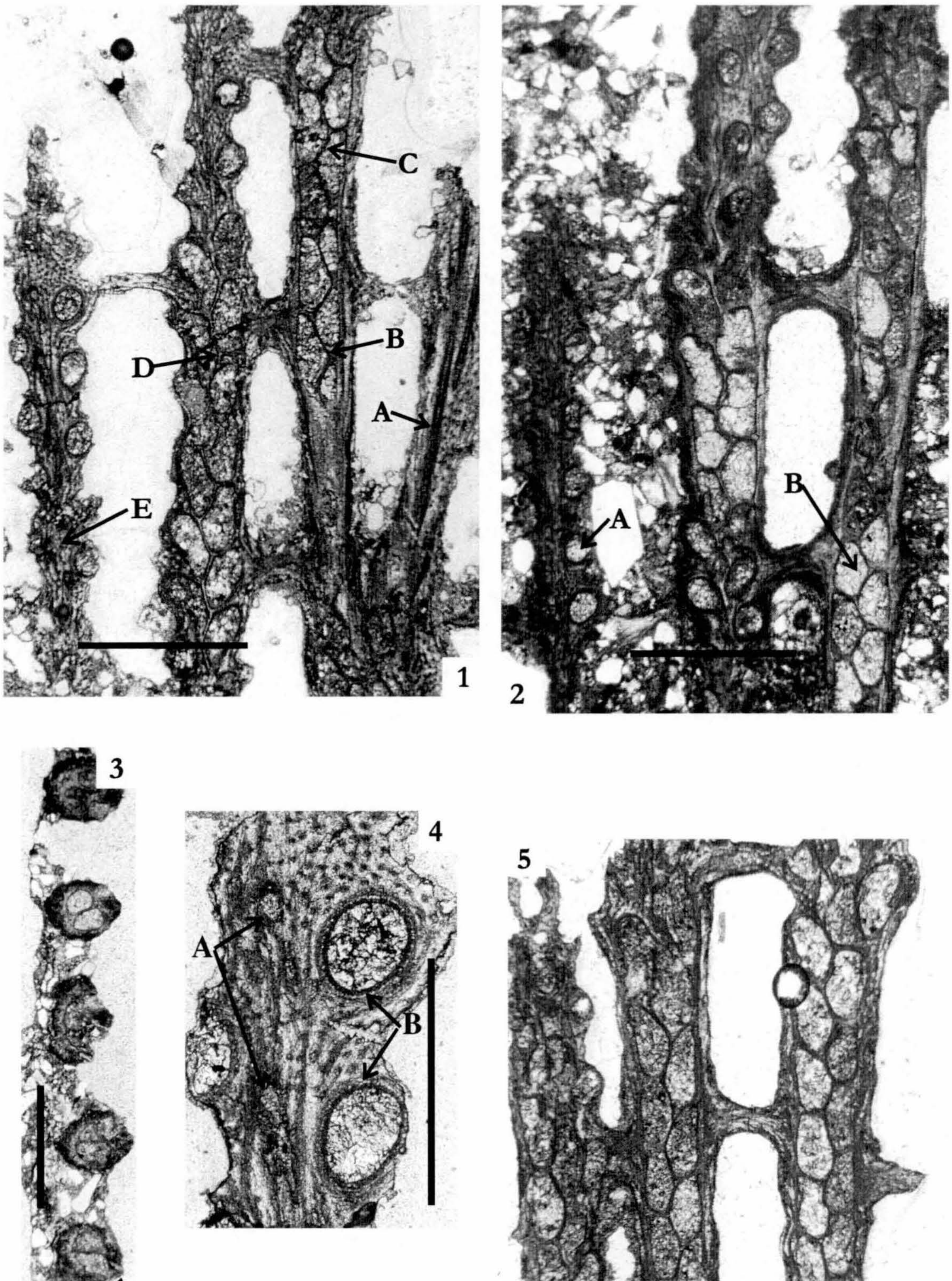

C
B
D
A
E
1
A
B
2
3
4
A
B
5
6

Plate 6 - *Rectifenestella counselensis* n. sp.
all scale bars 1 mm.

1. UTGD 127135, holotype - oblique tangential thin section reverse to obverse surface. Note large monoserial nodes, A, on wide keel , and indentation of apertures on fenestrules, B. Note also adaxial/abaxial apertural stylets, C, lower in frontal wall.
2. UTGD 127135, holotype - tangential peel mid chamber level showing consistent triangular pentagonal chamber shape and regularly ovate fenestrules. Third row of zooecia only inserted at point of branching, A.
3. UTGD 127135, holotype - tangential thin section reverse surface showing densely packed microstylets and shape of fenestrules at reverse surface.
4. UTGD 127135, holotype - tangential peel obverse surface showing detail of zooecial apertures with adaxial, A, and abaxial stylets, B. Monoserial row of keel nodes only seen as bases, C, at this level.
5. UTGD 127135, holotype - transverse thin section showing thick granular skeletal layer and ovate branch outline.
6. UTGD 127135, holotype - longitudinal peel showing continuity of granular skeleton in obverse nodes, A, and extension of reverse microstylets through reverse wall.

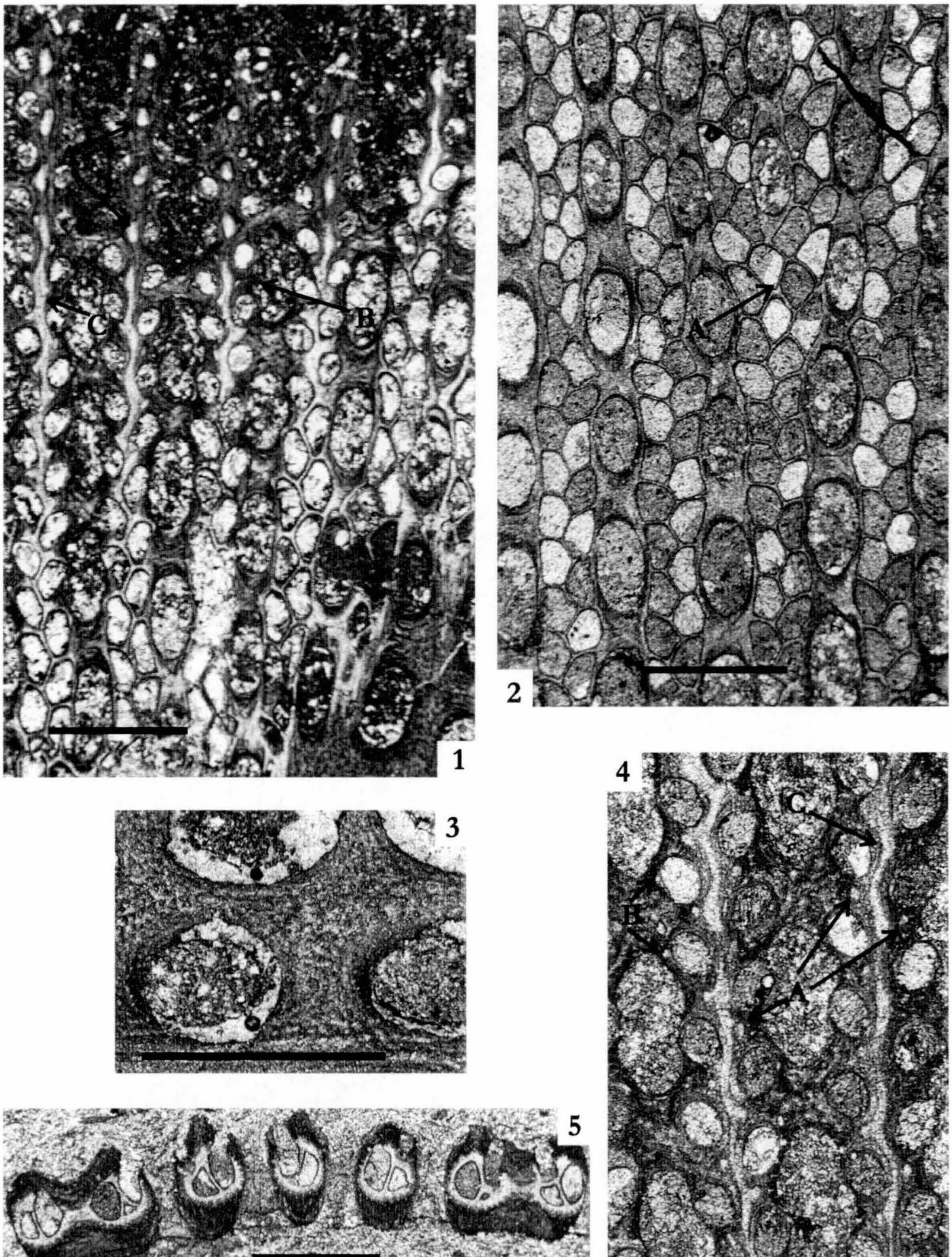
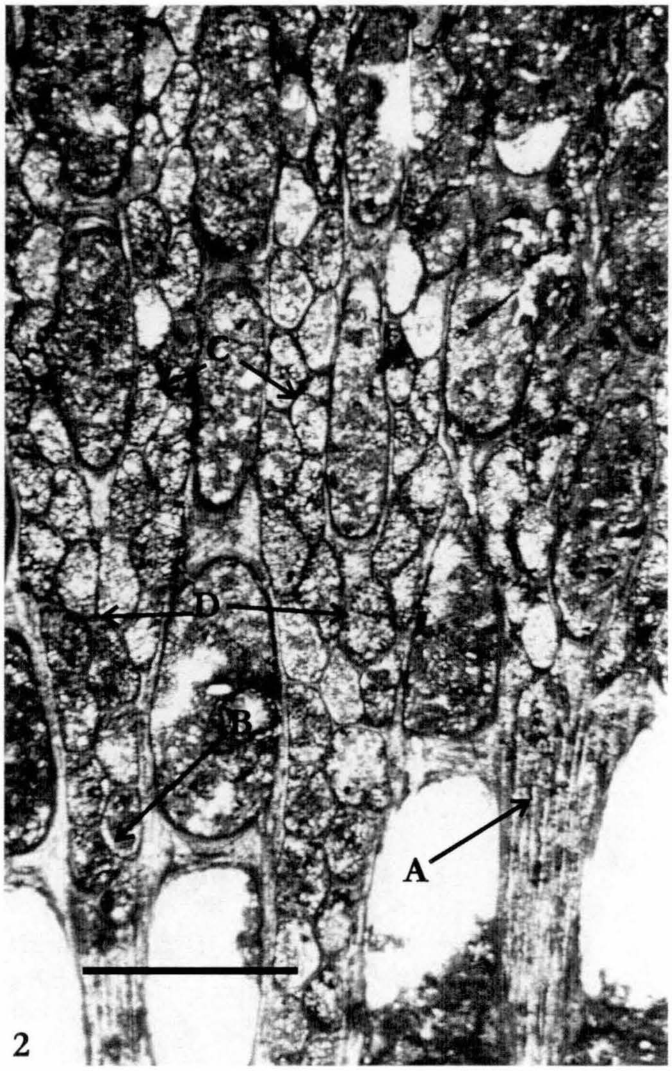
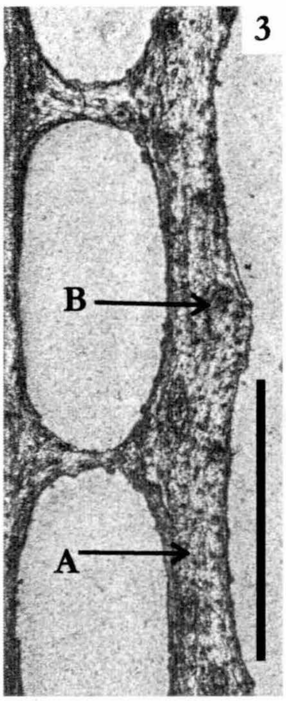

C
B
1
A
2
3
4
C
B
A
5
A
6

Plate 7 - *Rectifenestella granulifera* (Crockford 1941)
all scale bars 1mm.

1. UTGD 127123 - tangential thin section, obverse surface showing prominent keel, A, with large nodes, B, circular autozooecial apertures and insertion of third row of zooecia only at point, of bifurcation, C.
2. UTGD 127123 - oblique deep tangential thin. section. Note numerous longitudinal striae near reverse surface, A, and chamber shape at reverse surface, B, and evenly pentagonal shape at mid chamber level, C. Note also arrangement of chambers at point of bifurcation, D.
3. UTGD 127123 - tangential peel reverse surface showing numerous and evenly spread microstylets, A, and large macrostylets, B.
4. UTGD 127123 - transverse thin section showing angular obverse surface profile, angle of apertural opening, A, thin lamellar skeleton, B, and apparent continuity of granular skeleton, C.


C
A
B
1


C
D
B
A
2


3
B
A

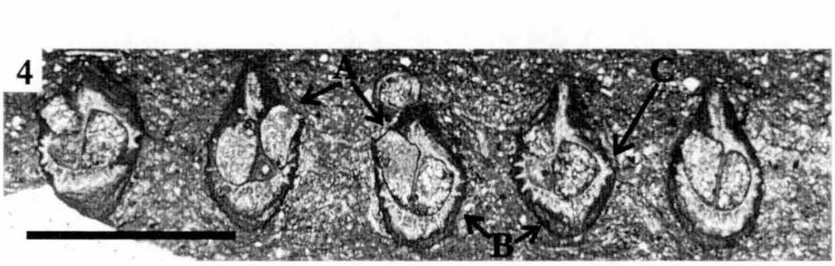

4
A
C
B

Plate 8 - *Rectifenestella smithae* n. sp.
all scale bars 1mm.

1. UTGD 127125 - tangential peel, mid chamber level, showing the slightly variable pentagonal chamber shape at this level. Note also dissepiment width, further widened by thickening, A.
2. UTGD 127126 - oblique tangential thin section from reverse to obverse surfaces showing chamber shape near reverse wall, A, at mid chamber level, B, and near the obverse surface, C. Note also apertural arrangement and shape, and circular to ovate nodes, D.
3. UTGD 127125 - tangential peel obverse surface showing obverse stylets, A, and thin keel with prominent nodes, B.
4. UTGD 127125 - longitudinal peel clearly showing long vestibules and thickening of frontal wall, A, and reverse stylets in reverse wall laminated layer, B.
5. UTGD 127125 - transverse thin section showing low lateral wall angle and opening of apertures, and thickness of frontal and reverse walls.
6. UTGD 127125 - tangential thin section reverse surface, note densely packed microstylets.

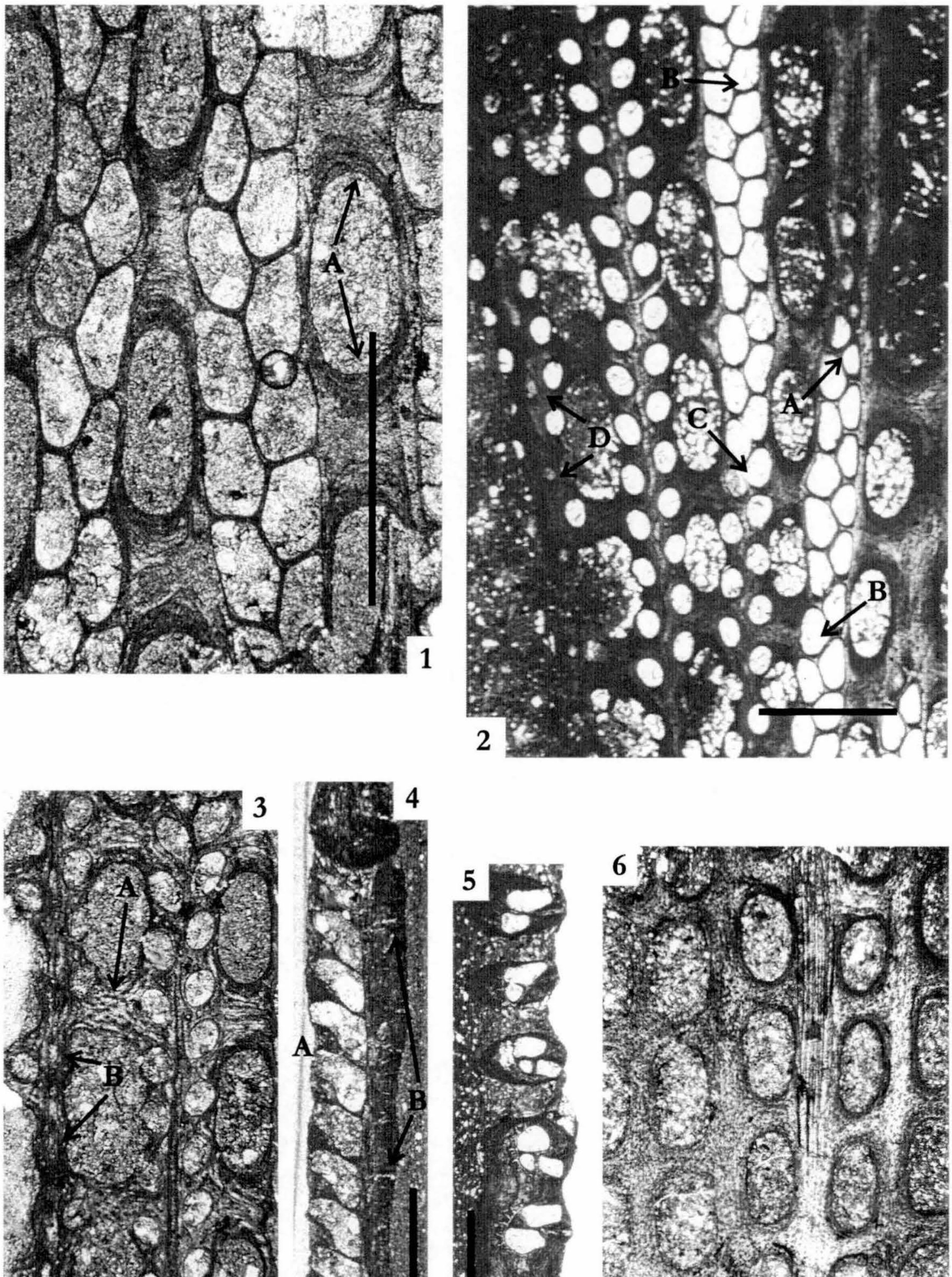

1
A
2
B
A
C
D
B
3
A
B
4
A
B
5
6

Plate 9 - *Rectifenestella sparsa* (Crockford 1945)
all scale bars 1 mm.

1. UTGD 127553 - oblique tangential section reverse to obverse surface showing the shape of the fenestrules, and the thin dissepiments. Note also the prominent nodes, A, on the carina and chamber shape, B.
2. UTGD 127556 - oblique tangential section reverse to obverse surface, showing the dense microstylets of the reverse surface, A, and the longitudinal striae within the reverse wall, B. Note also the obverse stylets and circular apertures, C, of the obverse surface.
3. UTGD 127556 - tangential section showing detail of the apertures, A, with peristomes, B, and obverse stylets, C.
4. UTGD 127554 - oblique tangential section reverse surface to mid branch level.
5. UTGD 127555 - transverse section, poorly preserved, showing the prominent carina and nodes, arrows. Note chambers are crushed.
6. UTGD 127555 - longitudinal section, showing the reverse wall budding angle and chamber shape, and the prominent nodes of the obverse surface, arrows.

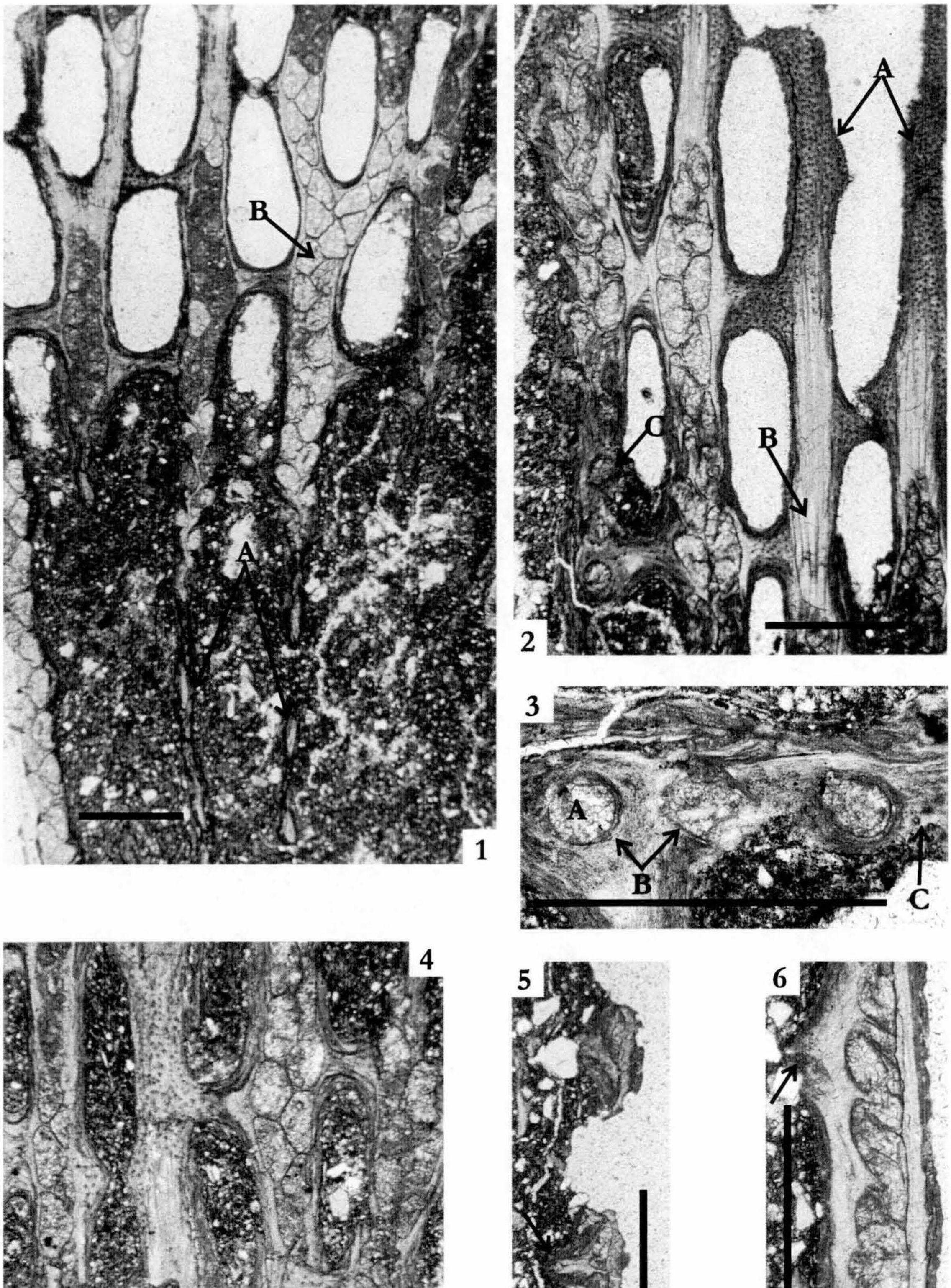

B
A
1
A
C
B
2
3
A
B
C
4
5
6

Plate 10 - *Rectifenestella* sp. A
all scale bars 1 mm.

1. UTGD 127498 - tangential view of unsectioned specimen showing the straight branches and characteristic shape of the fenestrules. Note also the longitudinal striae, A, and the increase to three rows of zooecia only at bifurcation, B.
2. UTGD 127498 - tangential section showing chamber shape.
3. UTGD 127498 - tangential section showing chamber shape near the reverse surface, A, at mid chamber level, B, and near the obverse surface, C. Note also the circular aperture, D, and thin keel, E.

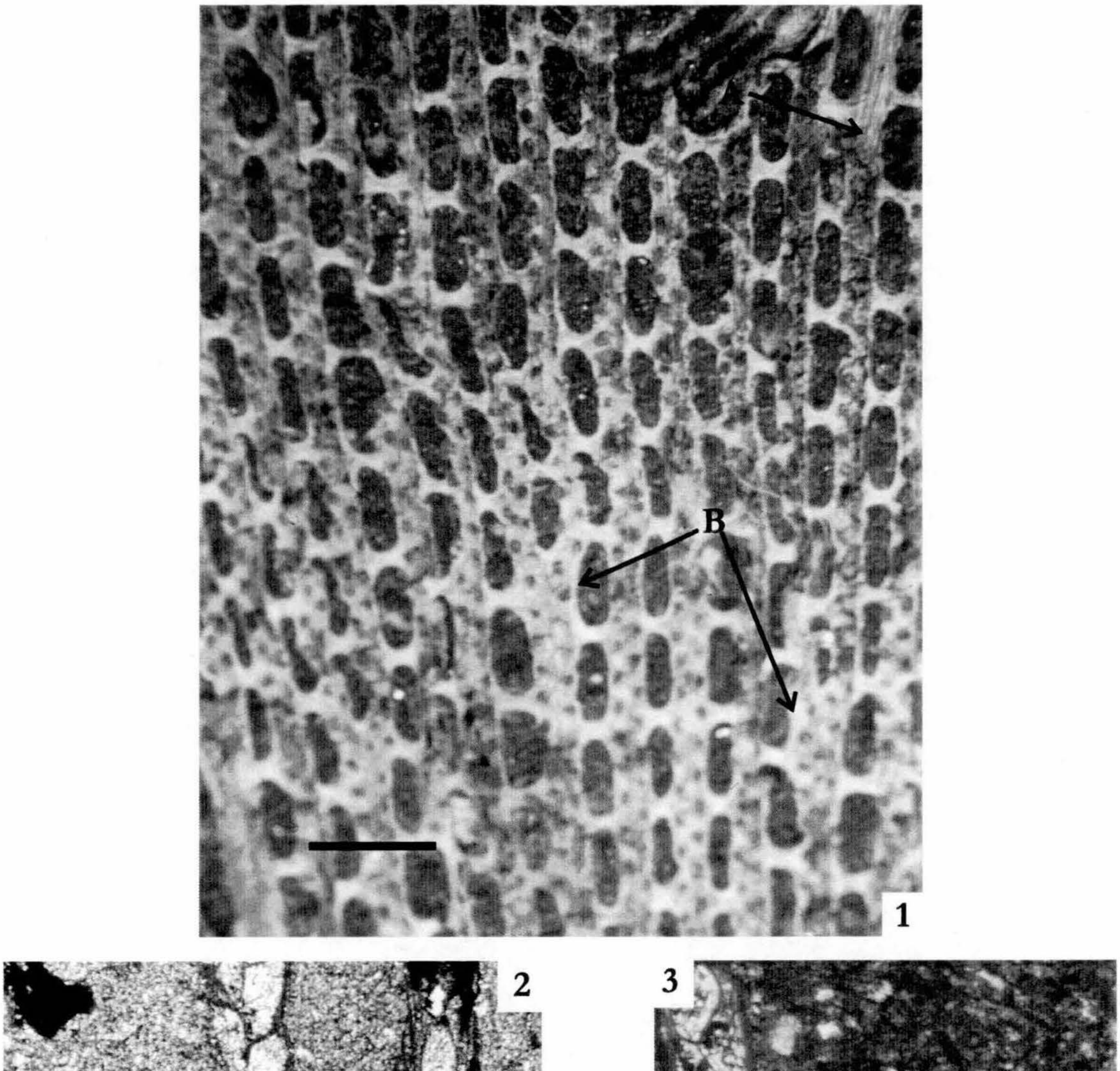

B
1
2
3
A
C
B
E
D

Plate 11 - *Rectifenestella* sp. B
all scale bars 1mm.

1. UTGD 127561 - oblique tangential section showing mesh form and the indentation of the apertures into the fenestrules. Note also chamber outline near the reverse wall , A, at mid chamber level, B, and near the obverse surface, C, small circular apertures, D, nodes, E, and obverse stylets, F.
2. UTGD 127561 - tangential section of the reverse surface showing the reverse microstylets, A, and macrostylets, B.
3. UTGD 127561 - tangential section showing detail of chambers and obverse surface.
4. UTGD 127560 - poorly preserved transverse section of two branches only. Note chamber outline, A, and keel, B.
5. UTGD 127560 - poorly preserved longitudinal section showing the reverse budding angle, A, and strong nodes, B. The reverse lamellar skeleton is weathered.

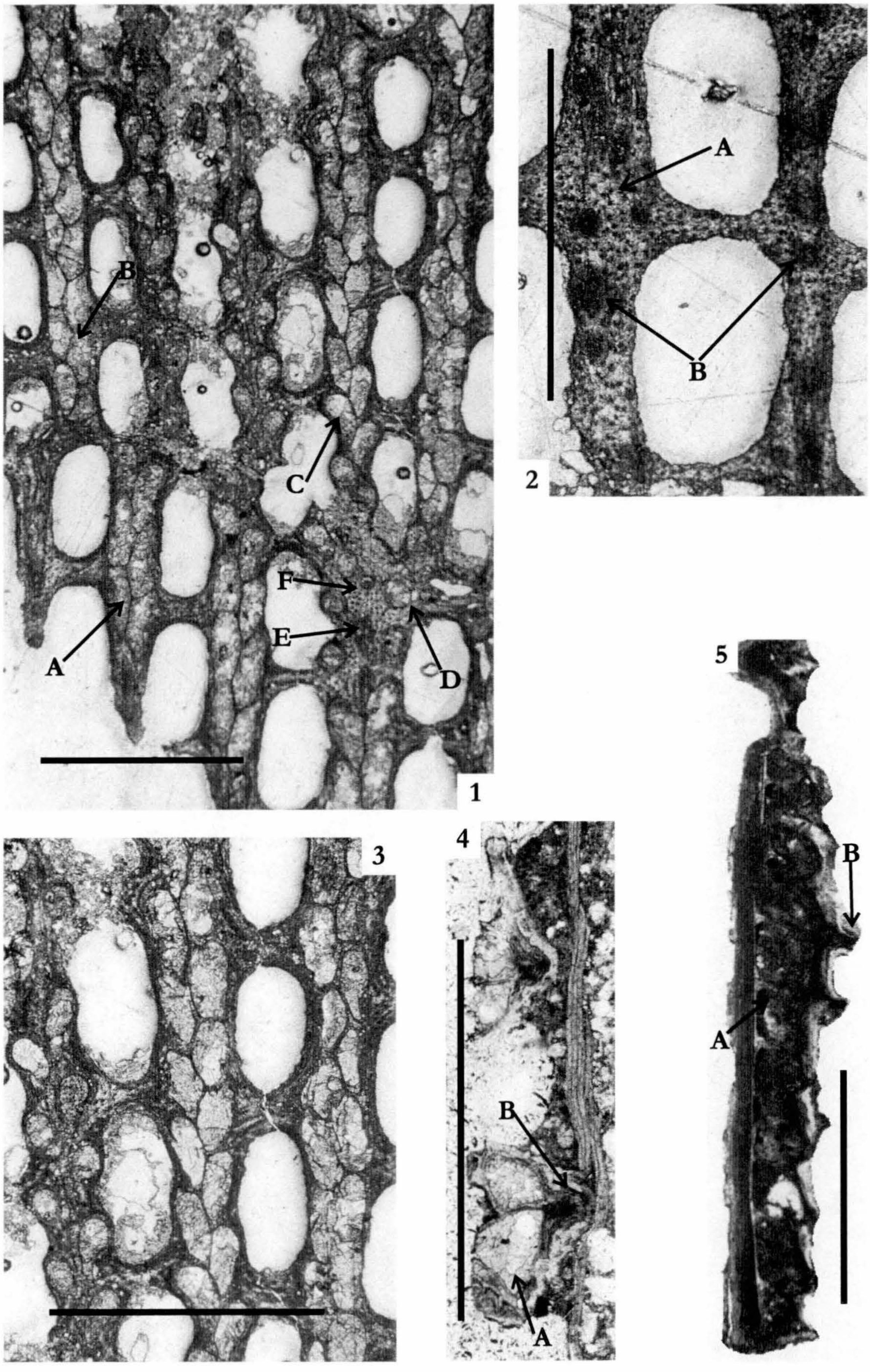
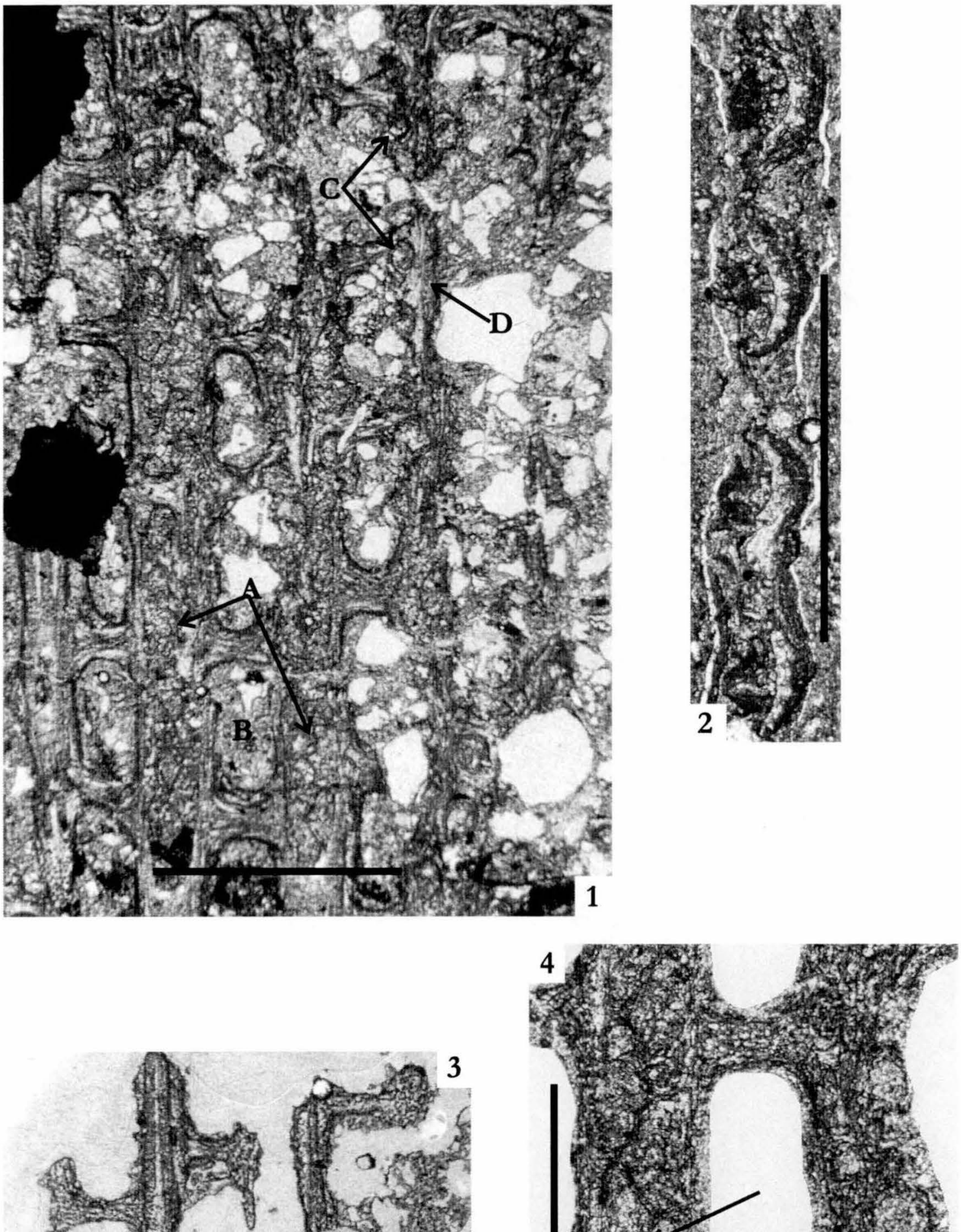

1
A
B
C
D
E
F
2
A
B
3
4
A
B
5
A
B

Plate 12 - *Rectifenestella* sp. C
all scale bars 1mm.

1. UTGD 127562 - tangential section of poorly preserved crushed specimen, showing mesh form with straight branches, A, subrectangular fenestrules, B, and thin dissepiments, C. Note also the small circular apertures, C, and keel, D.
2. UTGD 127562 - transverse section crushed specimen.
3. UTGD 127562 - tangential section reverse surface, showing strong longitudinal striae, A, and reverse microstylets, B, and the absence of macrostylets.
4. UTGD 127562 - tangential section showing zigzag axial wall trace, arrow.



C
D
A
B
1
2
3
B
A
4

Plate 13 - *Fenestella* sp.
all scale bars 1mm.

1. UTGD 127524 - oblique tangential section showing subrectangular shape of fenestrules, A, that become oval towards the reverse surface, B, and the straight axial wall trace, C.
2. UTGD 127525 - tangential section reverse surface showing fine longitudinal striae, A, and dense microstylets, B.
3. UTGD 127524 - deep tangential section showing the axial wall trace with quadrangular zooecial chambers. Chambers may be adjacent, A, or alternating, B.
4. UTGD 127523 - tangential section obverse surface showing circular aperture, A, and obverse microstylets, B.

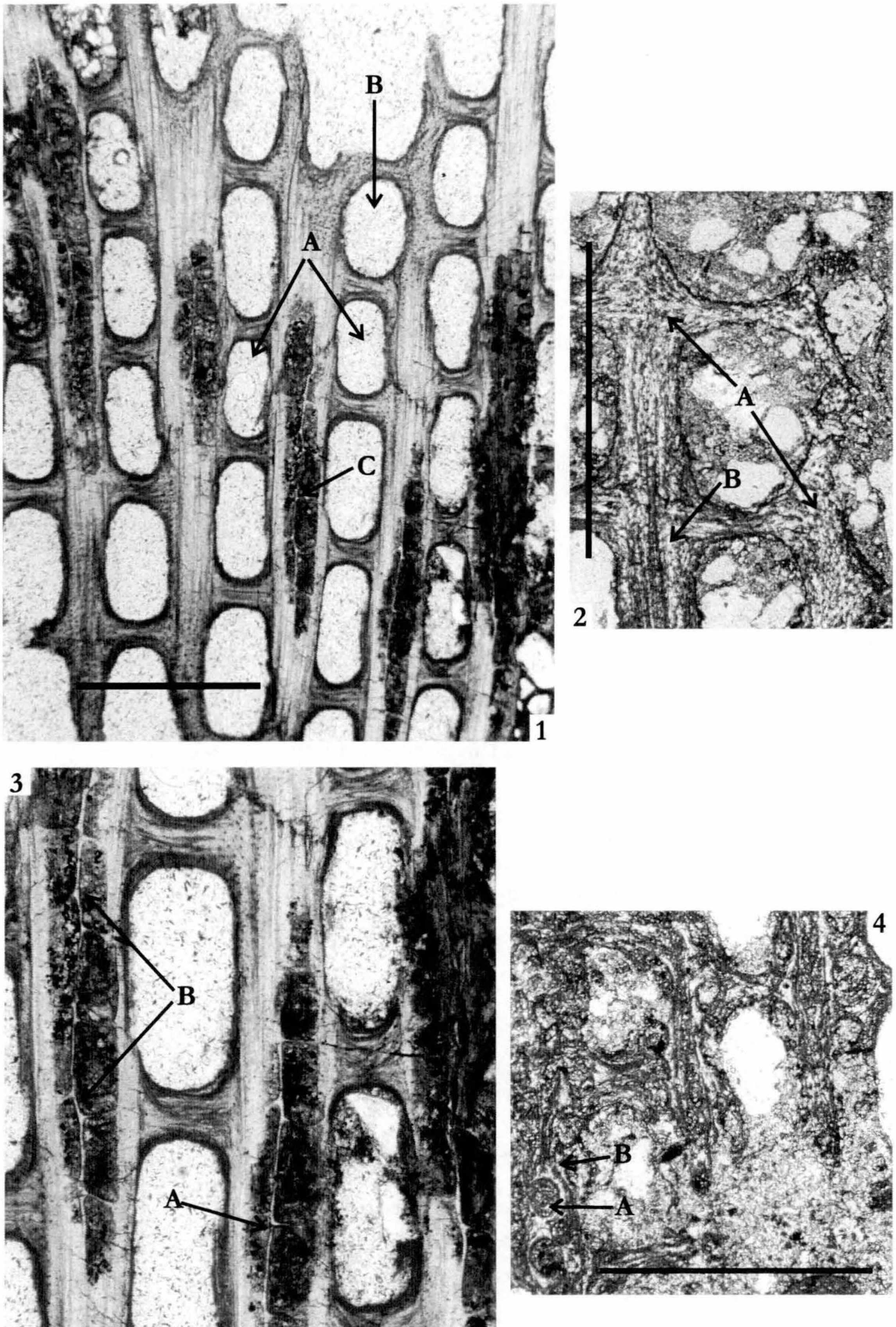

B
A
C
1
A
B
2
3
B
A
4
B
A

Plate 14 - *Mackinneyella granulosa* n. sp.
all scale bars 1mm except 29.4 which is 0.5 mm.

1. UTGD 127158, holotype - oblique tangential section reverse to obverse surface. Note fine longitudinal striae in reverse wall, A, and wide dissepiments with extra zooecia, B. Note chamber outline varies little from reverse to obverse surfaces with arrows C, D and E showing outline near reverse wall; mid chamber; and obverse surface respectively.
2. UTGD 127159, paratype - tangential section obverse surface. Note large closely spaced apertures providing good coverage of the available surface.
3. UTGD 127158, holotype - tangential section reverse surface showing increasingly circular fenestrules and the almost reticulate appearance of the lamellar wall.
4. UTGD 127158, holotype - tangential thin section showing detail of obverse surface. Note elliptical shaped Apertures with incomplete peristome, A, and densely packed obverse stylets, B.
5. UTGD 127158, holotype - longitudinal thin section. Note very thick reverse wall lamellar layer, and apparent partial erosion of reverse wall by zooecial chamber (arrow) and tubular nature of zooecial chambers.
6. UTGD 127158, holotype - transverse thin section showing very thick reverse and frontal walls and long vestibules.

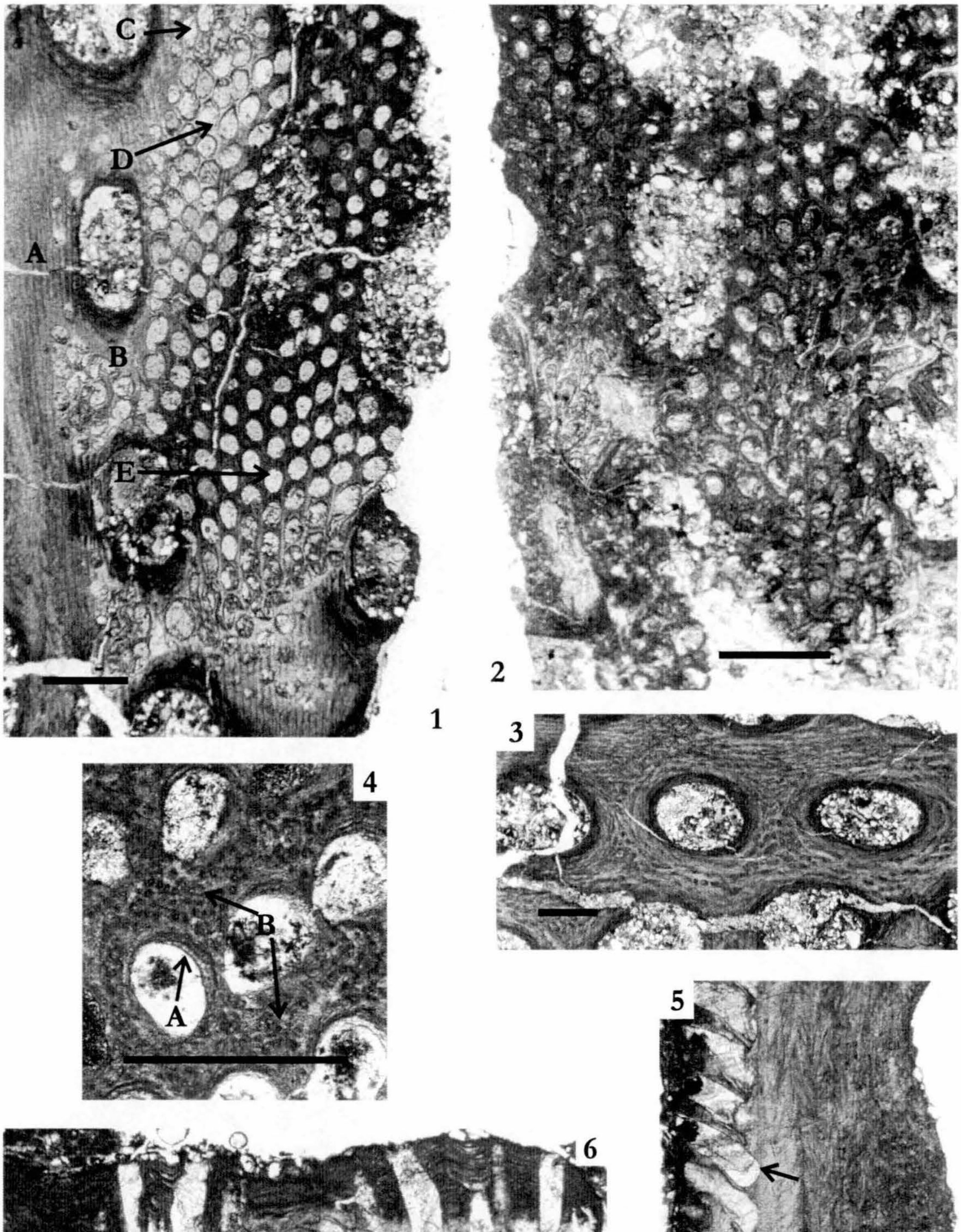

C
D
A
B
E
1
2
3
4
B
A
5
6

Plate 15 - *Parapolypora ampla* (Lonsdale 1844)
all scale bars 1mm, except 26.5 which is 0.5 mm.

1. UTGD 25080, neotype - oblique tangential section showing chamber outline at mid chamber level, A, and near the obverse surface, B, increased number of rows before bifurcation, C, and relative branch width and fenestrule size and shape.
2. UTGD 25080, neotype - oblique tangential section from reverse to obverse surface showing the fine longitudinal striae, A, chamber outline near the reverse surface, B, and apertural shape and spacing.
3. UTGD 25080, neotype - longitudinal section showing regular chamber outline and reverse wall budding angle, and long vestibule, arrow.
4. UTGD 25080, neotype - transverse section showing flattened branch outline, A, and more rounded shape where there are less rows, B. Note also the thin reverse wall and short numerous longitudinal striae, C.
5. UTGD 127500 - tangential section showing detail of the obverse surface. Note the incomplete peristome, arrow, and abundant coarse obverse stylets.

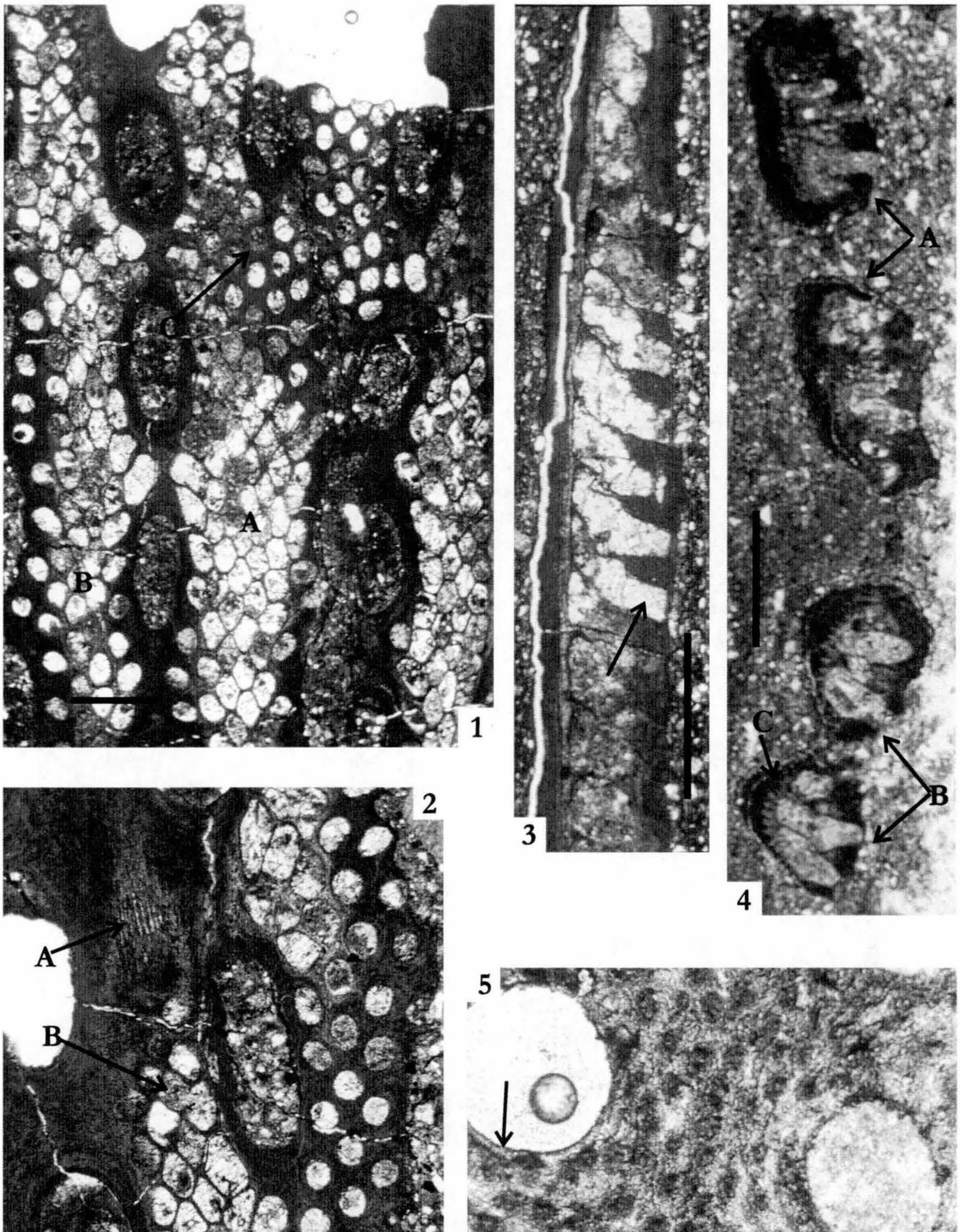

1
2
3
4
5
A
B
C

Plate 16 - *Parapolypora boraformis* n. sp.
all scale bars 1mm.

1. UTGD 127156, holotype - tangential thin section obverse surface, showing rows of zooecia and arrangement of large circular apertures, note also scattered large nodes, A, and shape of autozooecial chamber near obverse surface, B.
2. UTGD 127156, holotype - oblique tangential thin section reverse to obverse surface showing autozooecial chamber shape near reverse wall, A, and regular pentagonal shape at mid chamber level, B. Note also change in fenestrule shape from reverse to obverse surfaces and flatness of obverse surface.
3. UTGD 127156, holotype - tangential thin section showing detail of obverse surface, note peristome with apertural stylets, A, widely spaced obverse stylets, B, and large nodes, C.
4. UTGD 127156, holotype - longitudinal thin section showing thick frontal wall laminated layer giving rise to long vestibule, A. Note also granular node material extending through frontal wall, B.
5. UTGD 127156, holotype - transverse thin section showing the quite flat obverse surface profile, A, the varying depth of chambers according to their adaxial/abaxial position, B, and thickened granular skeleton, C.

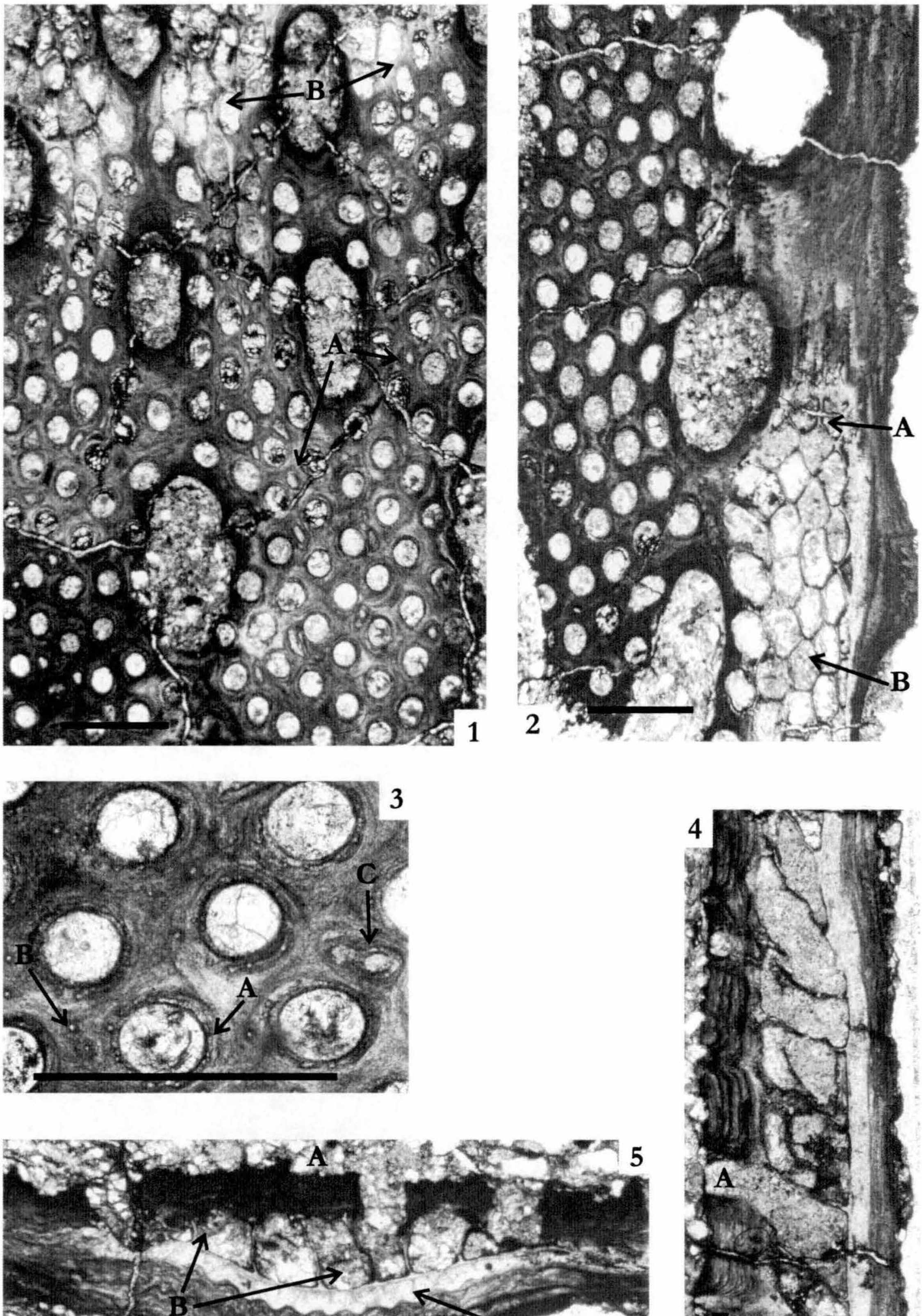

B
A
1
A
B
2
3
C
B
A
4
A
B
A
5
B
C

Plate 17
all scale bars 1mm.
Parapolypora sp. A

1. UTGD 127504 - oblique tangential section reverse to obverse surface showing branch and fenestrule arrangement and the thin dissepiments.
2. UTGD 127504 - oblique tangential section showing chamber outlines and apertural arrangement.
3. UTGD 127504 - transverse section.

Parapolypora sp. B

4. UTGD 127506 - tangential section of crushed specimen, lower left corner showing branches and growth direction indicated by arrow. Note also chamber outline, A, and fenestrule shape, B, and dissepiment, C.
5. UTGD 127506 - tangential section of the obverse surface of crushed specimen showing detail of apertures, A, and obverse stylets, B.

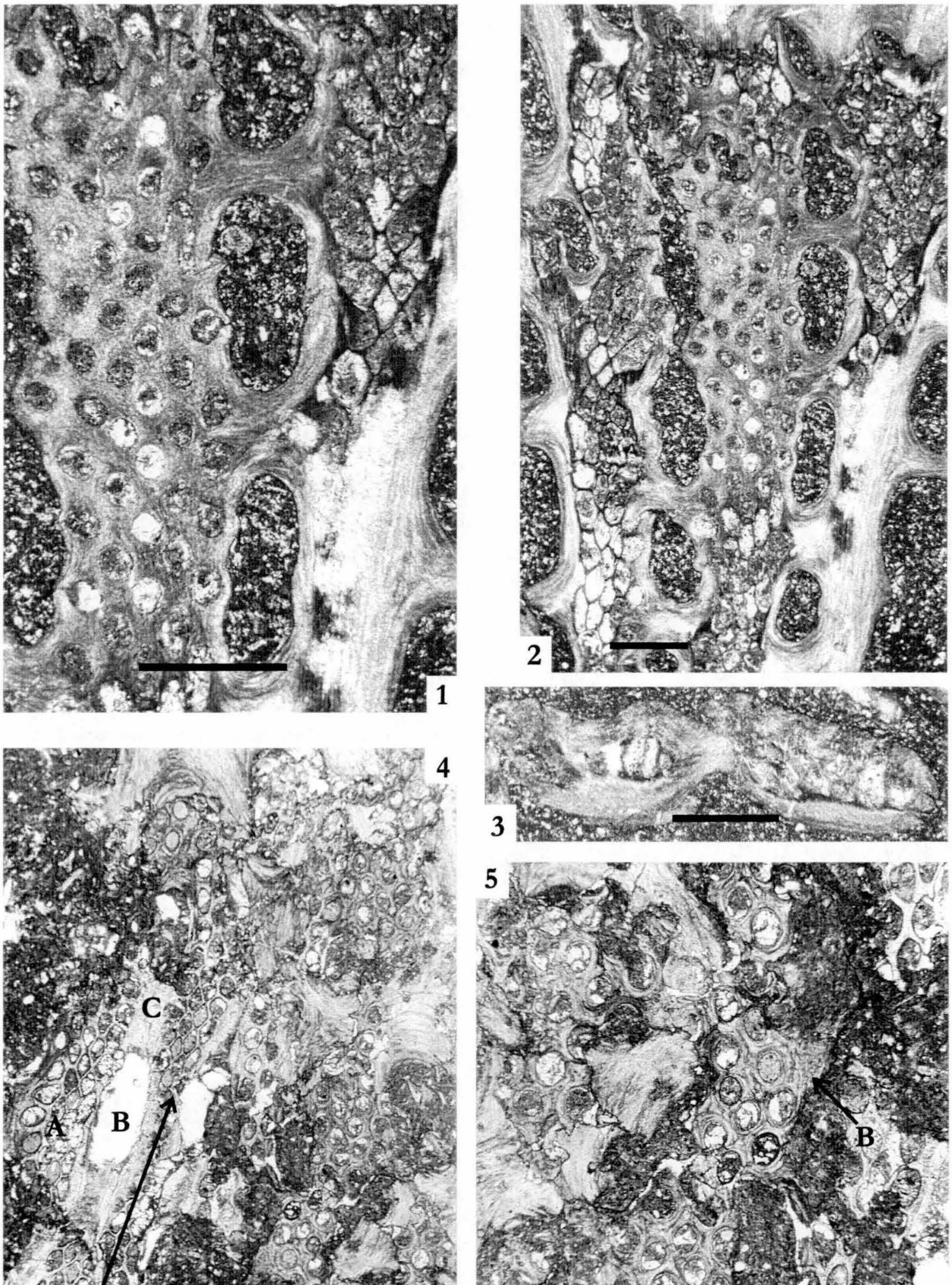

1
2
3
4
A
B
C
5
A
B

Plate 18 - *Paucipora ulladullaensis* n. sp.
all scale bars 1mm.

1. UTGD 127565, holotype - oblique tangential section showing form of the mesh and apertural arrangement. Note also apertures and tangential expression of the superior hemisepta, A, and the sinuous longitudinal ridges, B, between rows of zooecia, and the indistinct nodes, C.
2. UTGD 127566, paratype - tangential section of the reverse surface. Note the small dense reverse microstylets, coarse longitudinal striae and changing fenestrule shape.
3. UTGD 127565, holotype - tangential section showing the chamber outline at mid chamber level, with the tangential expression of the inferior hemisepta, arrows.
4. UTGD 127565, holotype - longitudinal section showing chamber shape, inferior, A, and superior, B, hemisepta and vestibule, C.
5. UTGD 127566, paratype - transverse section showing the branch outline and chamber arrangement.

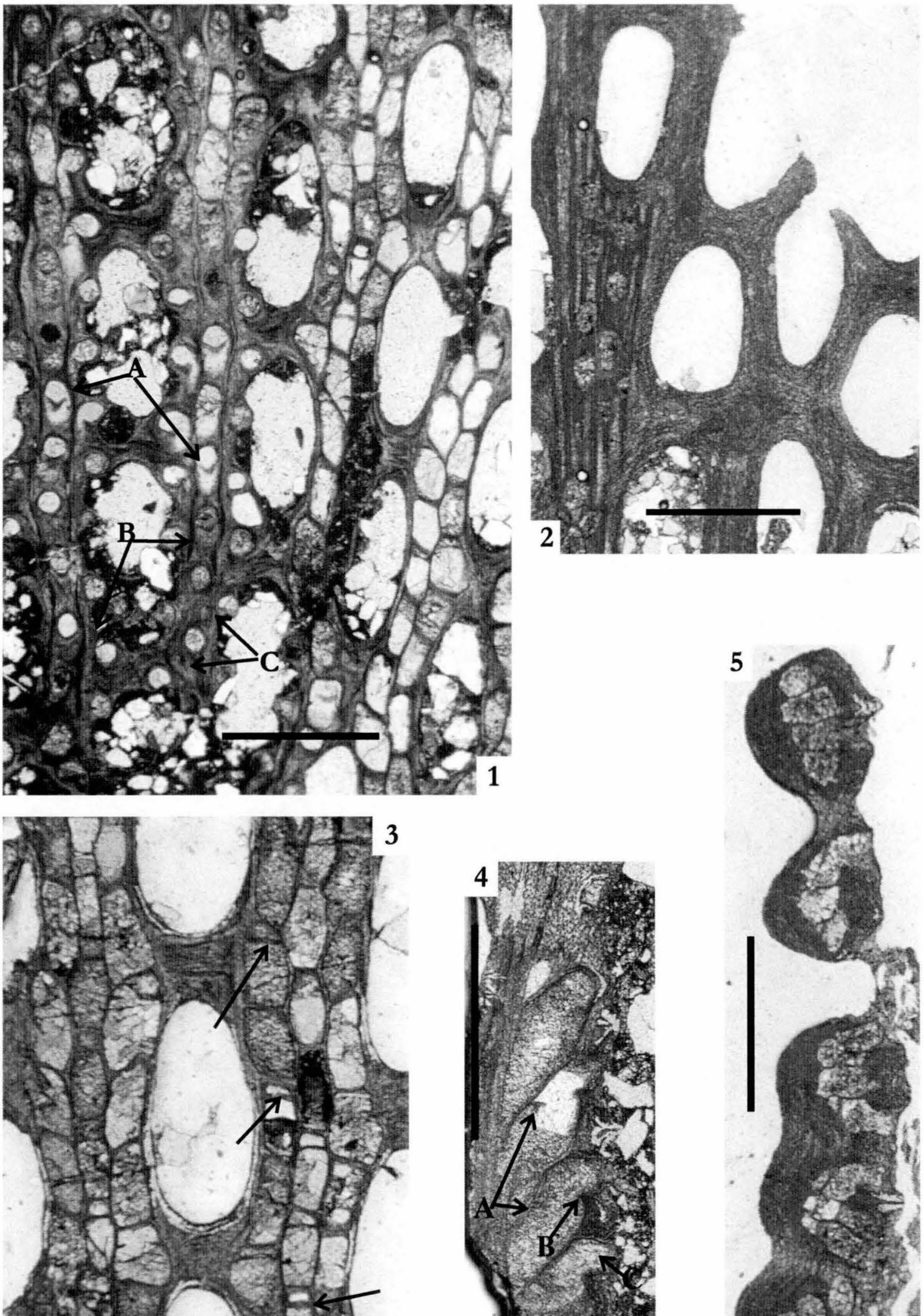

A
B
C
1
2
3
4
A
B
C
5

Plate 19 - *Polypora dichotoma* Crockford 1941

all scale bars 1mm, except for figure 19.3 which is 0.5 mm.

1. UTGD 127568 - oblique tangential section. Note change of fenestrule shape from mid section, A, to reverse surface, B, and chamber outline near reverse, C, at mid chamber level, D, and near the obverse surface, E.
2. UTGD 127568 - tangential section of the reverse surface showing coarse longitudinal striae, arrow, and the dense reverse microstylets.
3. UTGD 127568 - tangential section of the obverse surface showing detail of apertures, A, stylets, B, small nodes, and large nodes, D.
4. UTGD 127568 - longitudinal section, showing the thick reverse wall and large nodes, arrow.
5. UTGD 127567 - transverse section, specimen with partly eroded reverse surface.

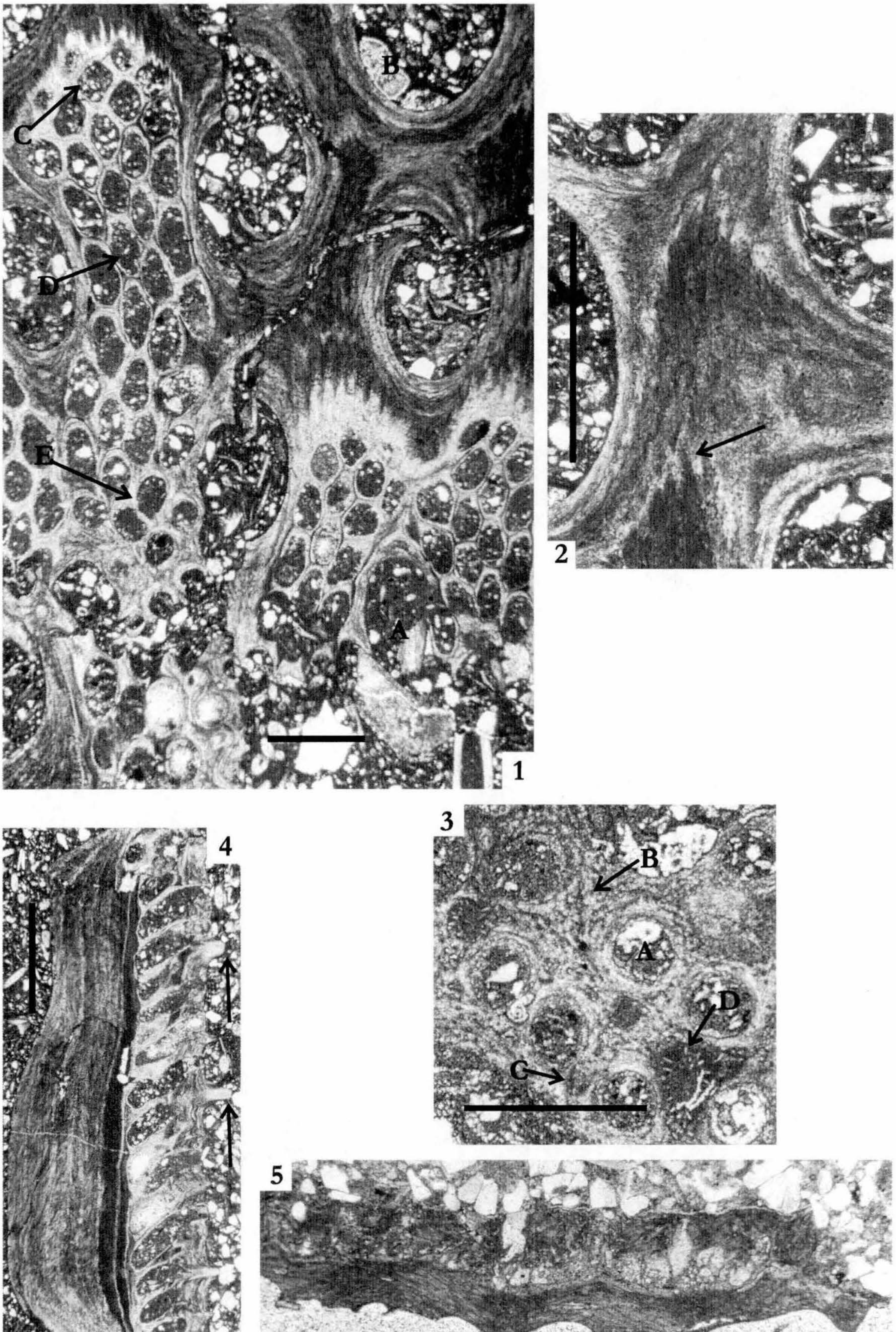
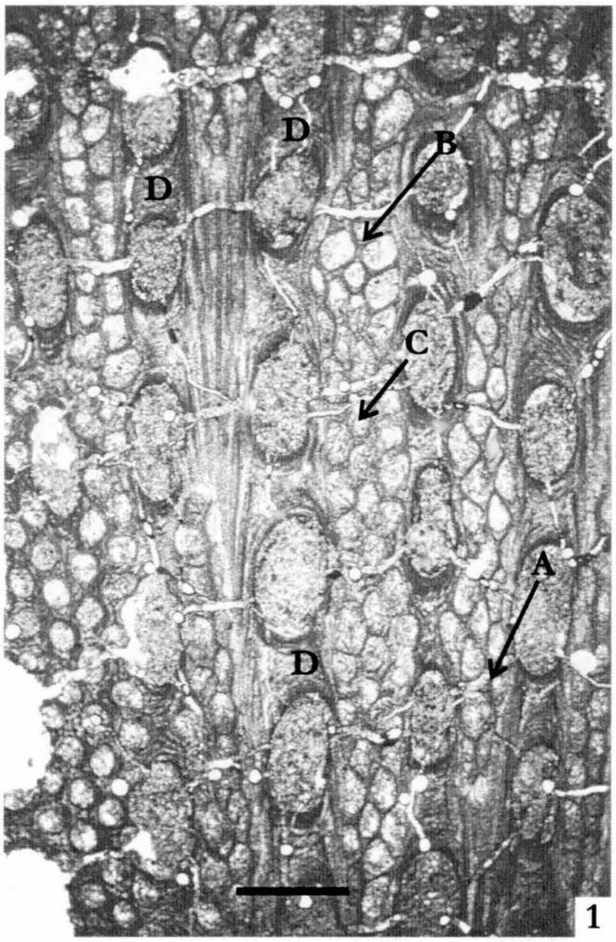
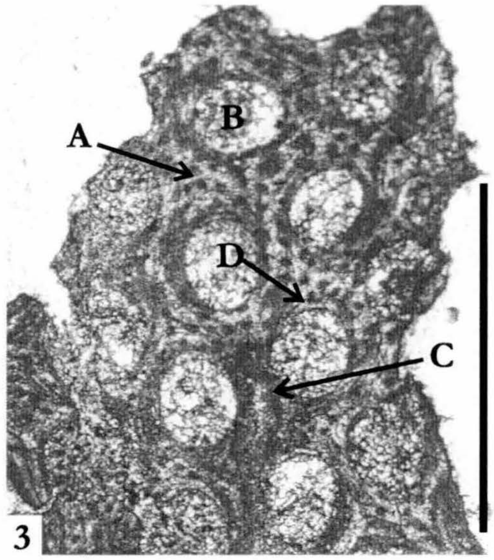
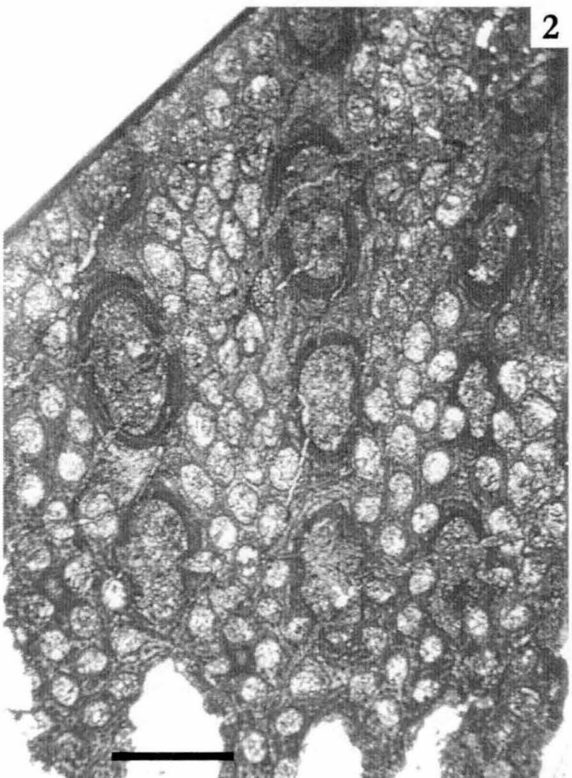

B
C
D
E
A
1
2
3
B
A
D
C
4
5

Plate 20 - *Polypora virga* Laseron
all scale bars 1mm.

1. UTGD 127136 - oblique tangential peel showing chamber shape near reverse surface, A, at mid chamber level, B, and near the obverse surface, C, and irregularity of fenestrules and dissepiments and tendency for dissepiments to be non-perpendicular to the branches, D.
2. UTGD 127136 - tangential thin section obverse surface, showing rows of zooecia and large size of apertures.
3. UTGD 127136 - tangential thin section obverse surface showing detail of obverse stylets, A, apertures, B, nodes, C. Note also incomplete peristomes, D.
4. UTGD 127136 - longitudinal thin section.
5. UTGD 127136 - transverse thin section showing thick reverse and frontal walls.


D
D
B
C
A
D
1


A
B
D
C
3


2


4


5

Plate 21 - *Polyporella internata* (Lonsdale 1844)
all scale bars 1mm.

1. UTGD 53637, neotype - oblique tangential section, specimen not well preserved but showing form of the mesh, and chamber shape. Note also the chambers swelling towards the dissepiments, arrow.
2. UTGD 127507, topotype - tangential section of the obverse surface, showing the arrangement of apertures, A, longitudinal ridges between rows of zooecia, B, and small nodes.
3. UTGD 127507, topotype - tangential section of the obverse surface, showing apertural arrangement, and increase from two to three rows, A. Note also longitudinal ridges, B and obverse stylets, C.
4. UTGD 127507, topotype - tangential section showing chamber outline in section, with two, A, and three, B, rows, and outline near the obverse surface, C.
5. UTGD 127507, topotype - longitudinal section showing chamber shape with regular reverse wall budding angle, and long vestibule, arrow.
6. UTGD 127507, topotype - transverse section showing the rounded outline of the branch with thick reverse and frontal wall lamellar layers. Note also the short strong longitudinal striae, A, and the stylets in the reverse wall, B.

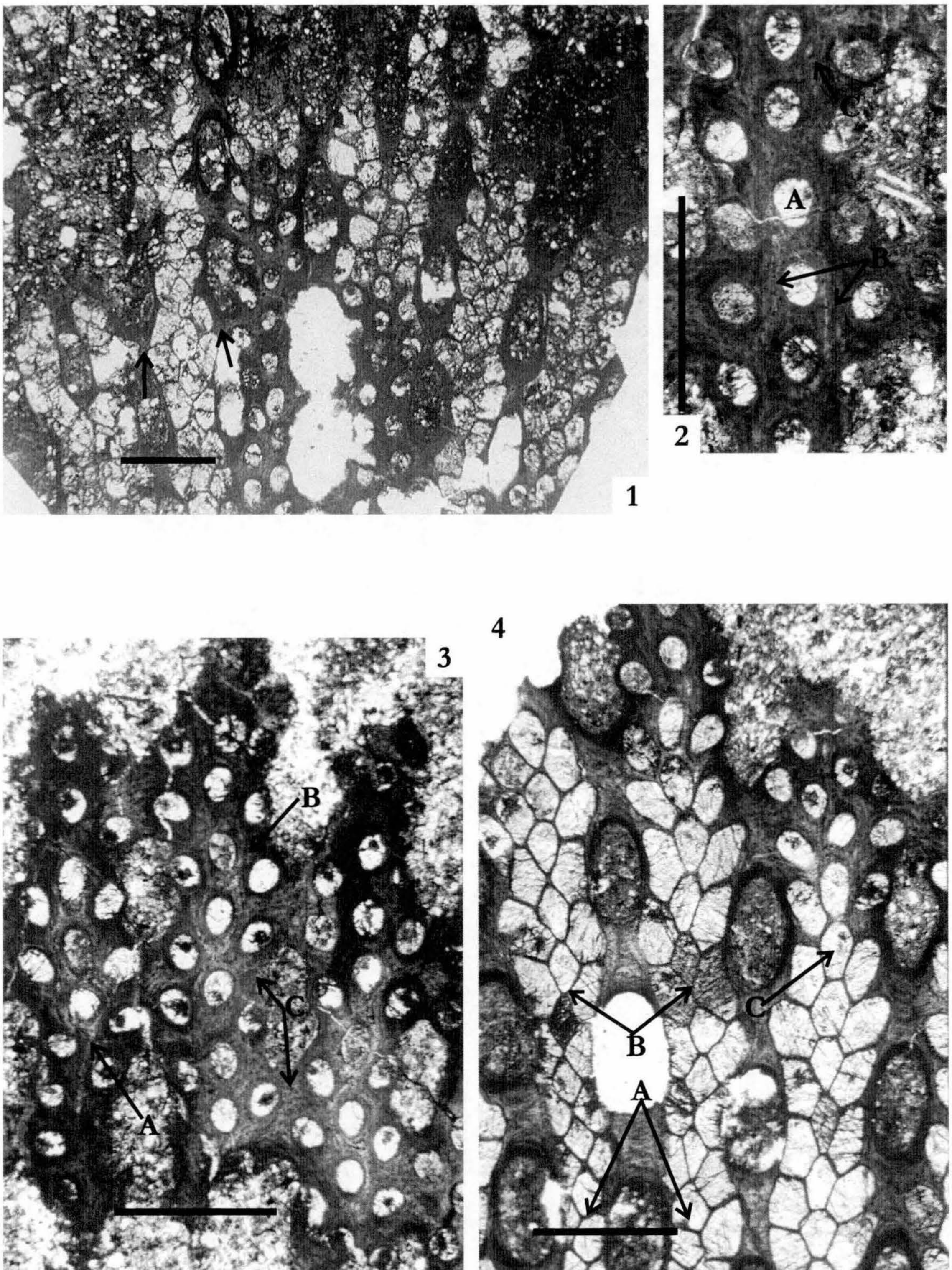

1
2
A
B
C
3
4
5
6

Plate 22 - *Polyporella protuberans* n. sp.
all scale bars 1mm.

1. UTGD 127512, holotype - tangential section showing fenestrule shape and swelling of lateral rows towards dissepiments. Note also the chamber outline near the reverse wall, A, at mid chamber level, B, and near the obverse surface, C, see also the chamber outline in mid section where there are only two rows of zooecia, D.
2. UTGD 127512, holotype - transverse section showing chamber outline.
3. UTGD 127512, holotype - longitudinal section showing chamber outline and reverse wall thickness. Note also short vestibule, A, and obverse nodes, B.
4. UTGD 127512, holotype - tangential section obverse to mid chamber showing the thickening of dissepiments, A, and arrangement of apertures and nodes on the obverse surface, B.
5. UTGD 127512, holotype - tangential section of obverse surface showing the distinct nodes, A, obverse stylets, B, and apertures without apertural stylets, C.
6. UTGD 127512, holotype - tangential section of the obverse surface showing coarse longitudinal striae, A, reverse microstylets, B, and macrostylets, C.

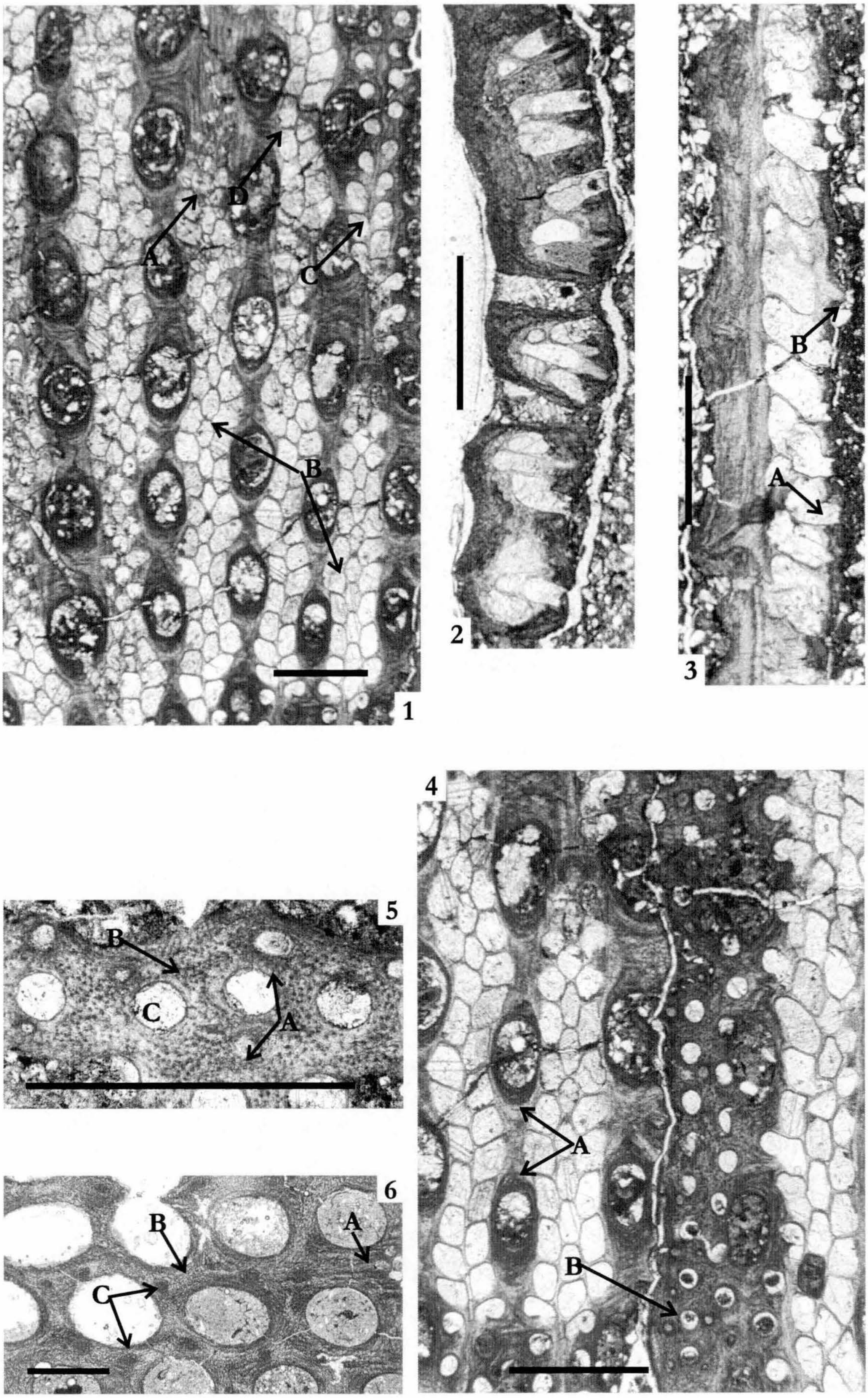

D
A
C
B
1
2
B
A
3
4
5
B
C
A
6
B
A
C
A
B

Plate 23 - *Polyporella subwoodsi* n. sp.
all scale bars 1mm, except for 23.5 which is 0.5 mm.

1. UTGD 127148, holotype - oblique tangential thin section, specimen slightly crushed.
2. UTGD 127148, holotype - tangential thin section obverse surface showing arrangement of apertures and nodes. Note nodes distinct high in frontal wall, A, but less distinct low in the frontal wall, B.
3. UTGD 127148, holotype - transverse thin section, showing ovate branch cross section.
4. UTGD 127148, holotype - longitudinal thin section.
5. UTGD 127148, holotype - tangential thin section showing detail of obverse surface. Note obverse stylets, A, nodes, B, and peristomes with distinct apertural stylets, C.
6. UTGD 127152 - oblique tangential thin section reverse to obverse surface. Note chamber outline near the reverse surface, A, at mid chamber level, B, and near the obverse surface, C. Zooecial rows are straight and do not bend onto dissepiments, D, which also show slight thickening near the reverse surface, E.

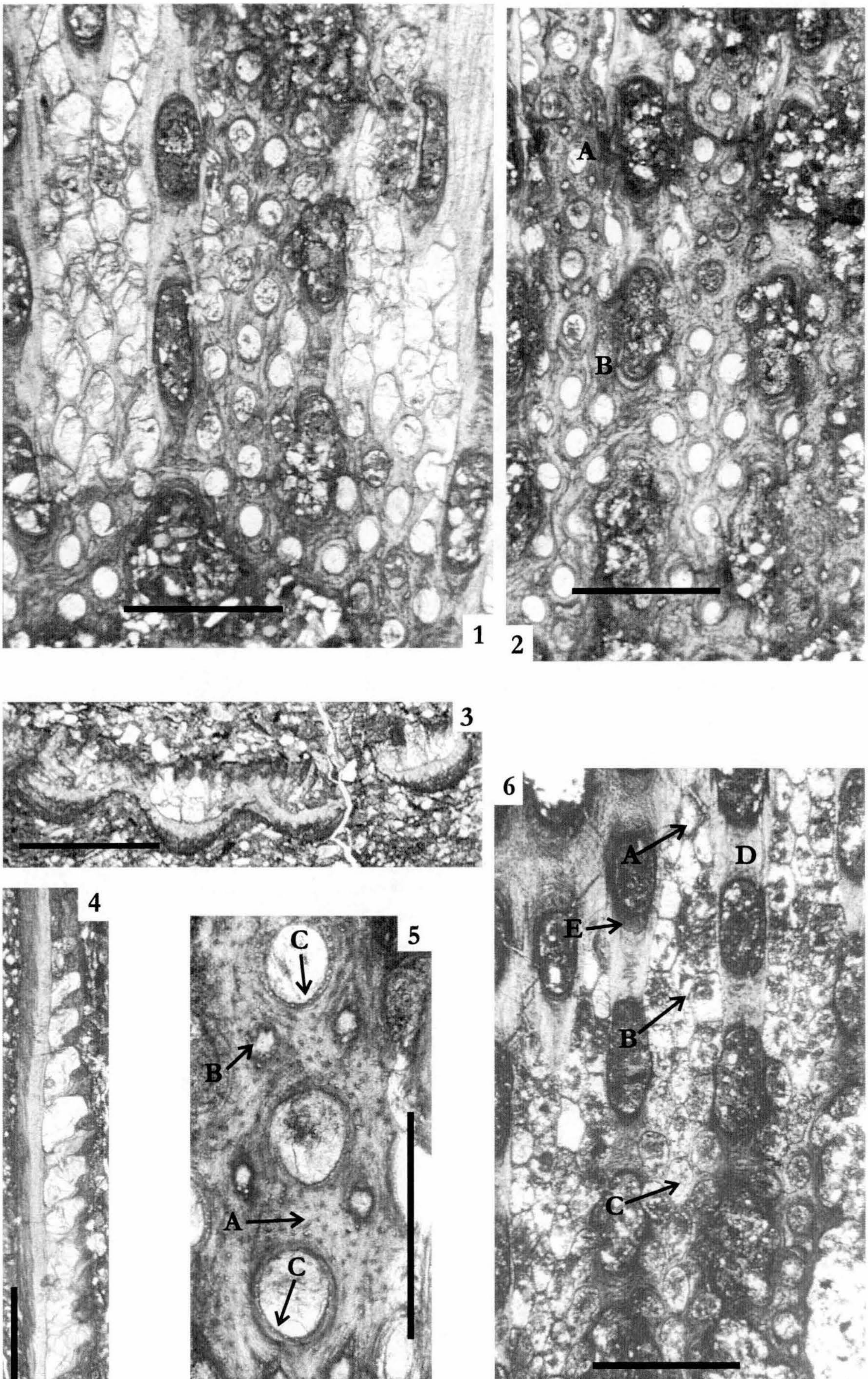

1
2
A
B
3
4
5
C
B
A
C
6
A
D
E
B
C

Plate 24 - *Polyporella westarmensis* n. sp.
all scale bars 1mm, except figure 24.5 where scale bar is 0.5 mm.

1. UTGD 127153, holotype - tangential section showing consistently hexagonal chamber shape near the reverse wall, A, at mid chamber level, B, and near the obverse surface, C. Note also zooecial rows do not bend onto dissepiments, and width and thickening of dissepiments, D.
2. UTGD 127153, holotype - oblique tangential section showing the form of the mesh near the obverse surface.
3. UTGD 127153, holotype - oblique tangential section showing mesh form and fenestrule shape near the reverse surface.
4. UTGD 127153, holotype - tangential section reverse surface showing circular shape of fenestrules at reverse.
5. UTGD 127153, holotype - tangential section showing detail of obverse surface, note large oval apertures, nodes about each aperture, A, and concentration of obverse stylets along ridge between central and lateral rows, B.
6. UTGD 127153, holotype - transverse thin section showing thick reverse wall.

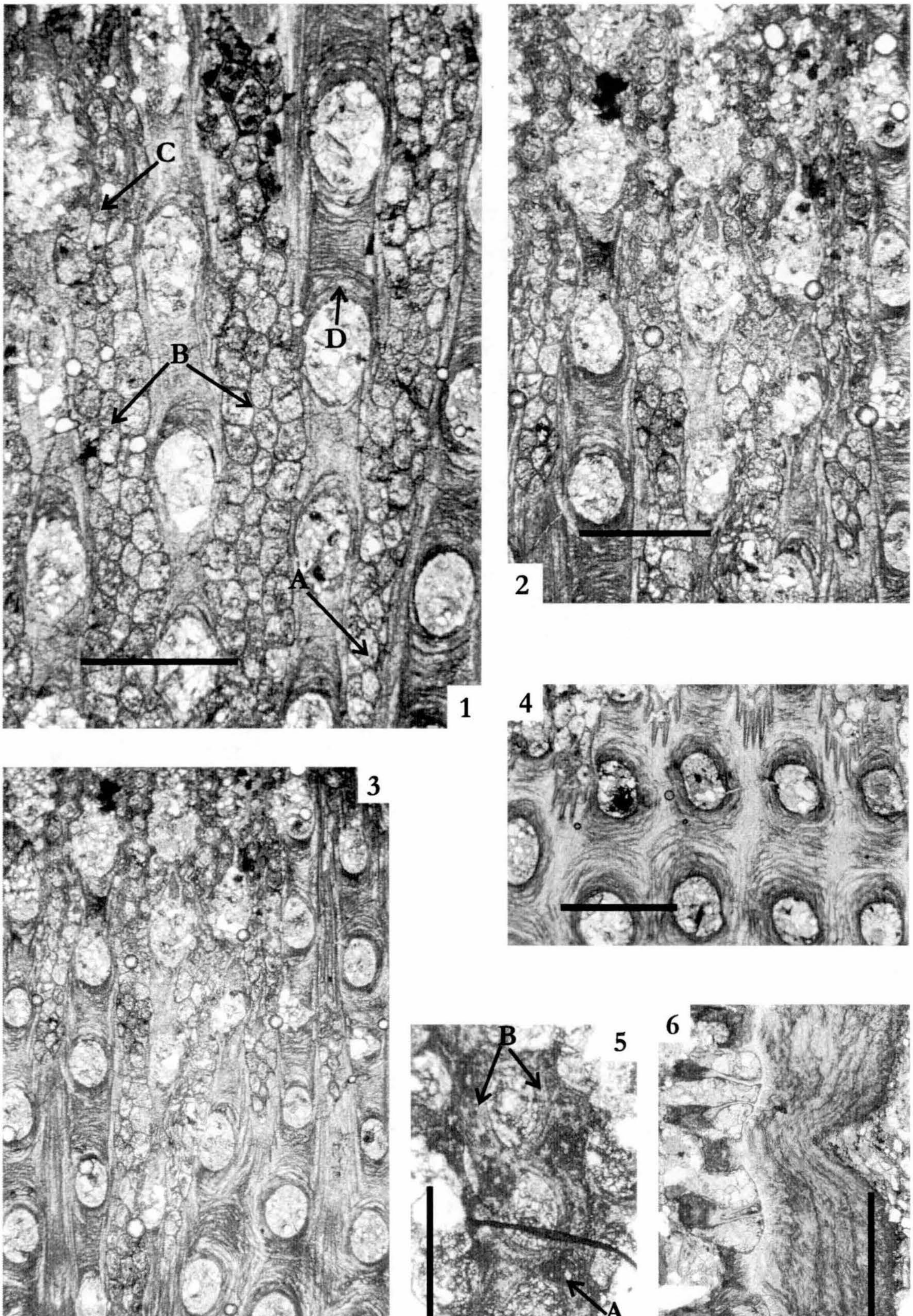

C
D
B
A
1
2
3
4
B
5
A
6

Plate 25 - *Polyporella* sp.
all scale bars 1mm.

1. UTGD 127569 - tangential section obverse to reverse surface of poorly preserved zoarium. Note straight branches, with rows straight and not swelling onto dissepiments.
2. UTGD 127569 - oblique tangential section showing coarse longitudinal striae, A, and chamber outline, B. Note also apertures, C, and nodes, D.
3. UTGD 127569 - tangential section of reverse surface showing the small reverse microstylets.
4. UTGD 127570 - longitudinal section with weathered reverse wall.
5. UTGD 127569 - transverse section of crushed specimen.

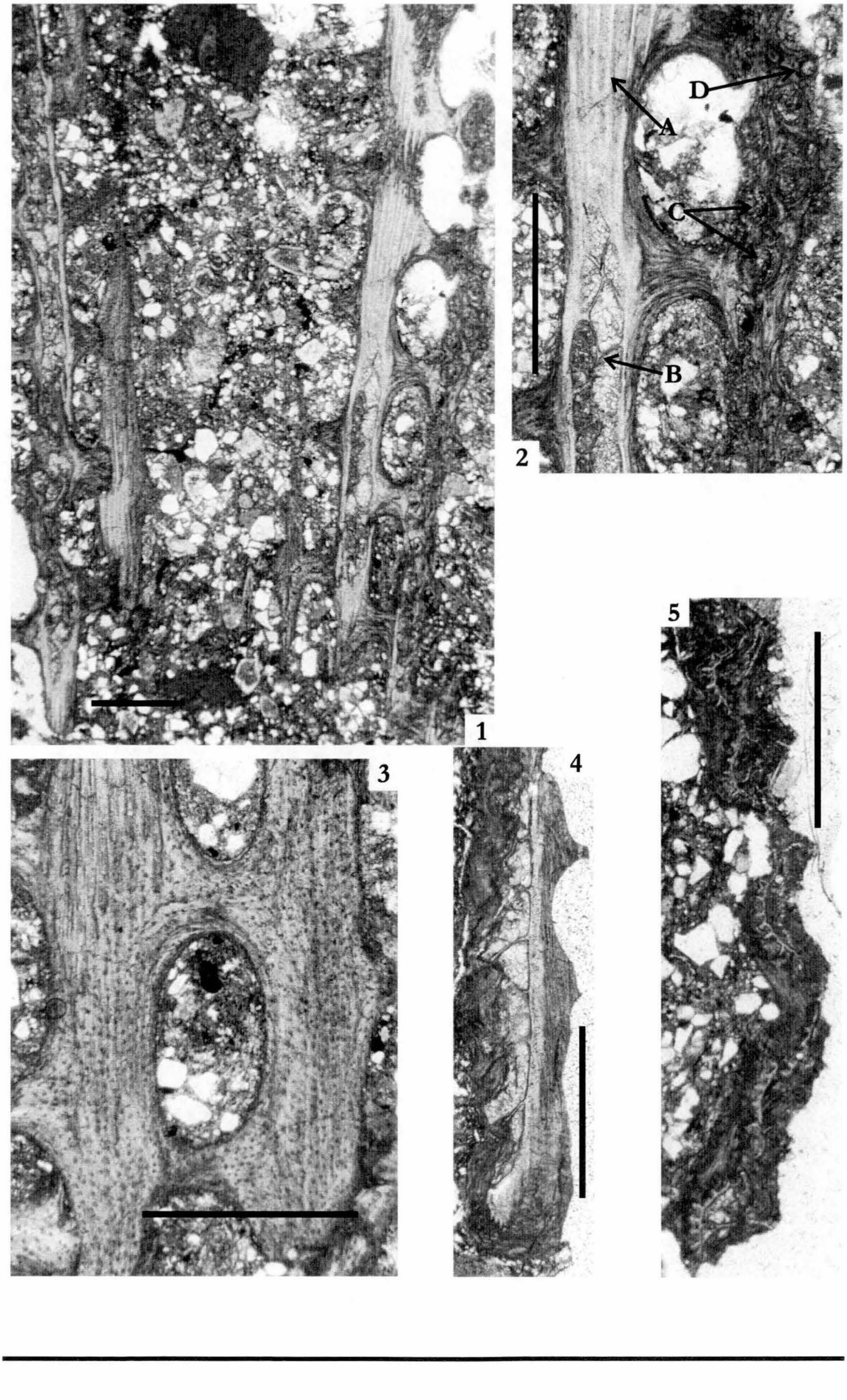

1
2
A
B
C
D
3
4
5

Plate 26 - *Pseudopolypora banksi* n. sp.
all scale bars 1mm.

1. UTGD 127514, holotype - oblique tangential section reverse to obverse surface, showing chamber outline at reverse, A, at mid chamber level, B, and near the obverse surface, C. Note also the prominent keel, D, brood chambers, E, and area with increasing and decreasing row number, F.
2. UTGD 127514, holotype - oblique tangential section showing longitudinal striae, A, and branch with only one row of zooecia, B, after a bifurcation.
3. UTGD 127514, holotype - longitudinal section showing high reverse wall budding angle and chamber outline. Specimen weathered.
4. UTGD 127514, holotype - tangential section showing large apertures, A, brood chamber outline at surface, B, and in mid chamber section, C.
5. UTGD 127514, holotype - transverse section.

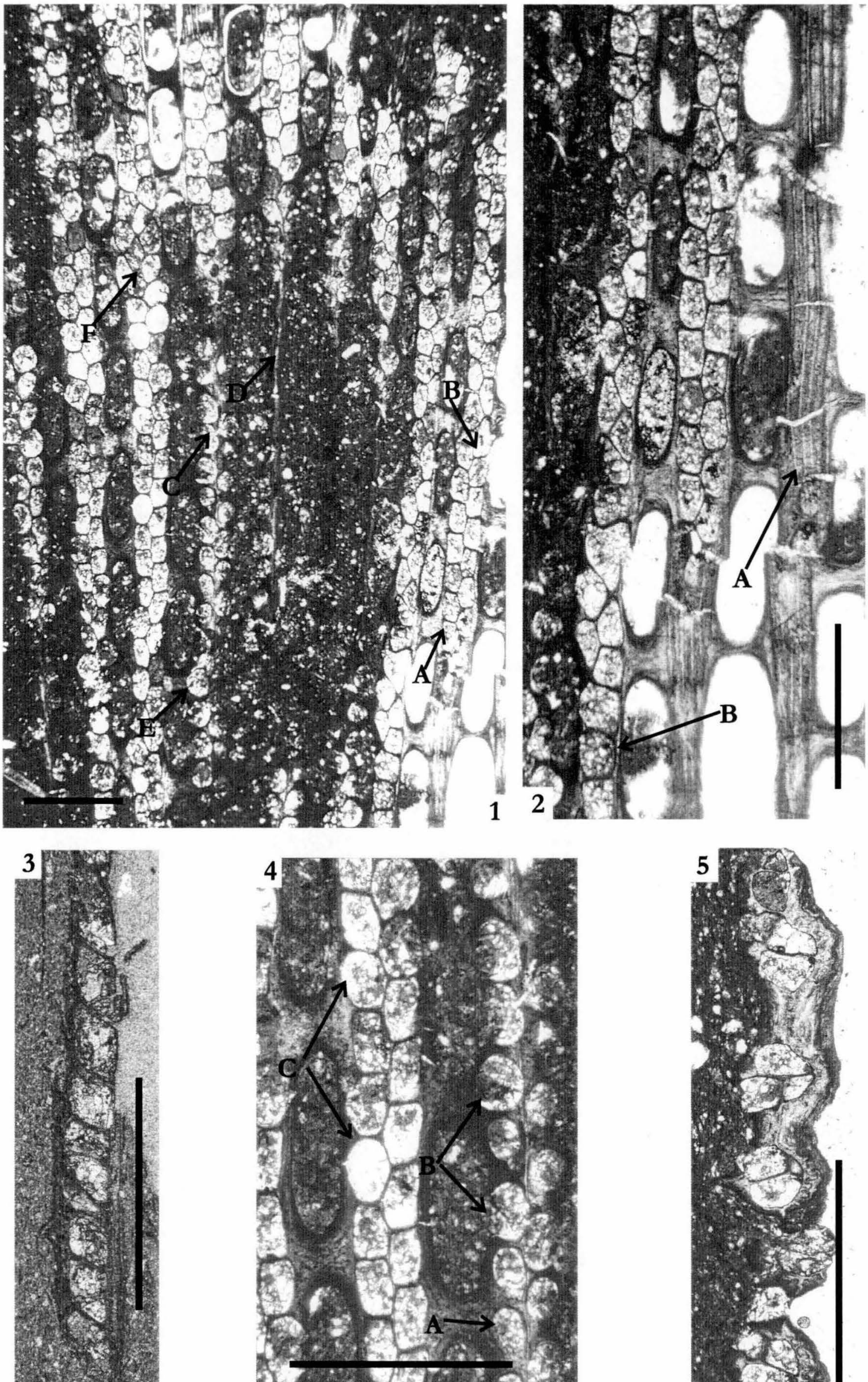

1
A
B
C
D
E
F
2
A
B
3
4
A
B
C
5

Plate 27 - *Pseudopolypora bundellaensis* n. sp.
all scale bars 1mm.

1. UTGD 127515, holotype - oblique tangential section obverse to reverse surface showing the form of the mesh. Note chamber outline near the reverse wall, A, at mid chamber level, B, and near the obverse surface, C, and where there are three rows, D. Note also the coarse longitudinal striae, E.
2. UTGD 127515, holotype - transverse section.
3. UTGD 127515, holotype - longitudinal section.
4. UTGD 127515, holotype - shallow tangential section of obverse surface showing the detail of the apertural shape, A, keel, B, and nodes, C.

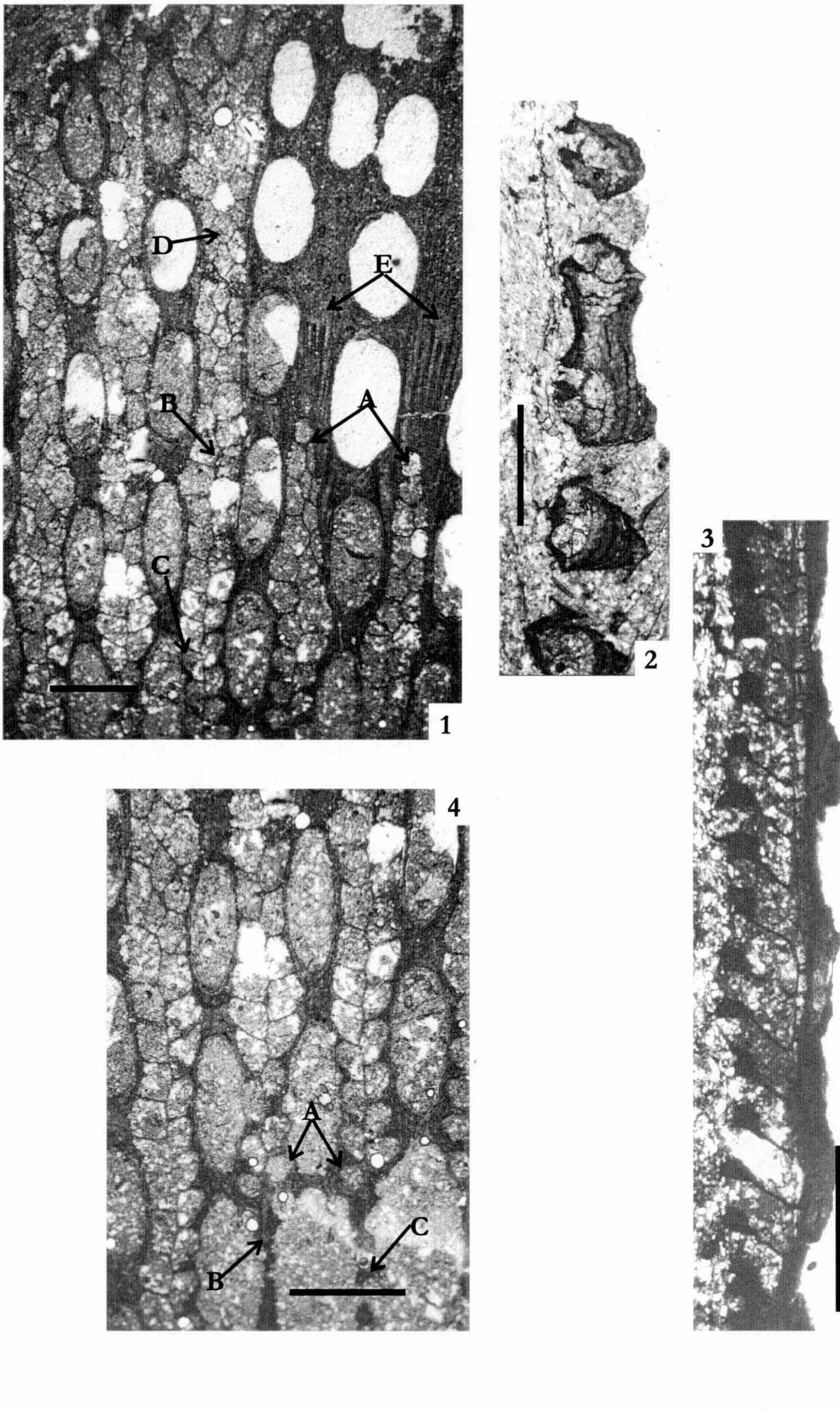

D
E
B
A
C
1
2
3
4
A
B
C

Plate 28 - *Pseudopolypora tamarensis* n. sp.
all scale bars 1mm.

1. UTGD 127516, holotype - oblique tangential section reverse to obverse surfaces showing mesh form with straight branches and variable fenestrule shape from reverse surface to mid zoarium. Note also the apertures, A, that open sideways and the strong keel, B, with large nodes, C.
2. UTGD 127516, holotype - oblique tangential section showing chamber outline near the reverse surface, A, at mid chamber level, B, and near the obverse surface, C.
3. UTGD 127518, paratype - tangential section reverse surface, showing the almost polygonal fenestrules formed by the branches and dissepiments, and the lack of macrostylets.
4. UTGD 127516, holotype - transverse section showing the very thick reverse wall, and thin frontal wall. Note the strong keel, A, with apertures, B, opening on the sloping branch sides, and the short longitudinal striae, C.
5. UTGD 127516, holotype - longitudinal section showing the high reverse wall budding angle and the regular chamber outline.

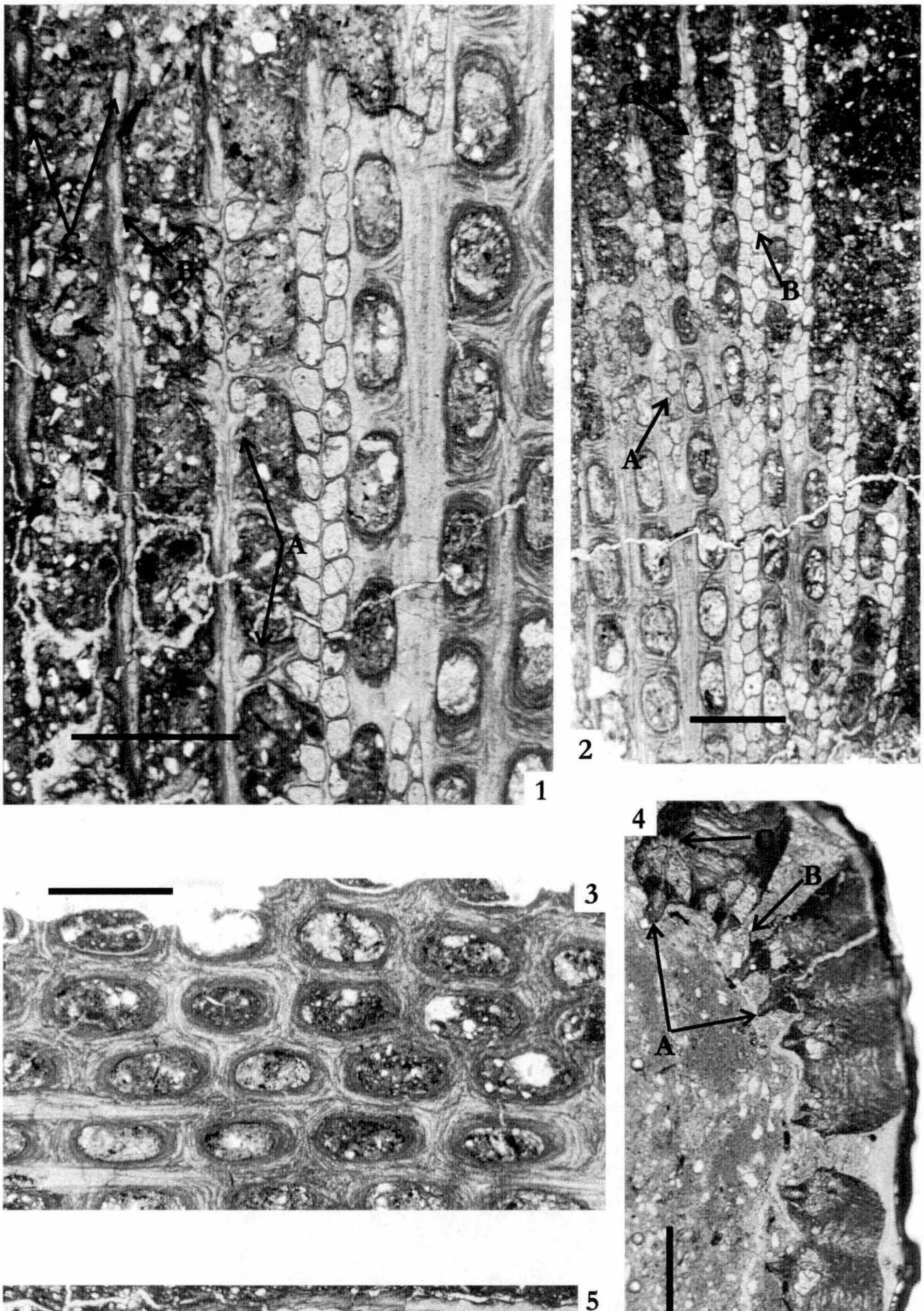

1
2
3
4
5
A
B

Plate 29 - *Pseudopolypora versonoda* n. sp.
all scale bars 1mm.

1. UTGD 127519, holotype - tangential section showing straightness of the rows and branches, and comparative width of dissepiments and length of fenestrules. Note also the thickening of dissepiments, A, and the chamber outline at mid chamber, B, and near the obverse surface, C.
2. UTGD 127519, holotype - tangential section showing three rows of zooecia with longitudinal ridges, A, between the rows of zooecia, with large apertures. Note in the left hand branch, row number reduces from three to two rows, B.
3. UTGD 127519, holotype - tangential section reverse surface, showing the differing fenestrule shape, and the large macrostylets, A, for which this species is named, and the small microstylets, C.
4. UTGD 127519, holotype - transverse section showing the flattened obverse surface, and flushness of the dissepiments with the obverse and reverse surfaces. Note also the strong longitudinal striae, A, and reverse macrostylets, B, in the very thick reverse wall.
5. UTGD 127519, holotype - longitudinal section, poorly preserved and not showing full branch depth, but showing clearly the chamber outline and reverse wall budding angle.

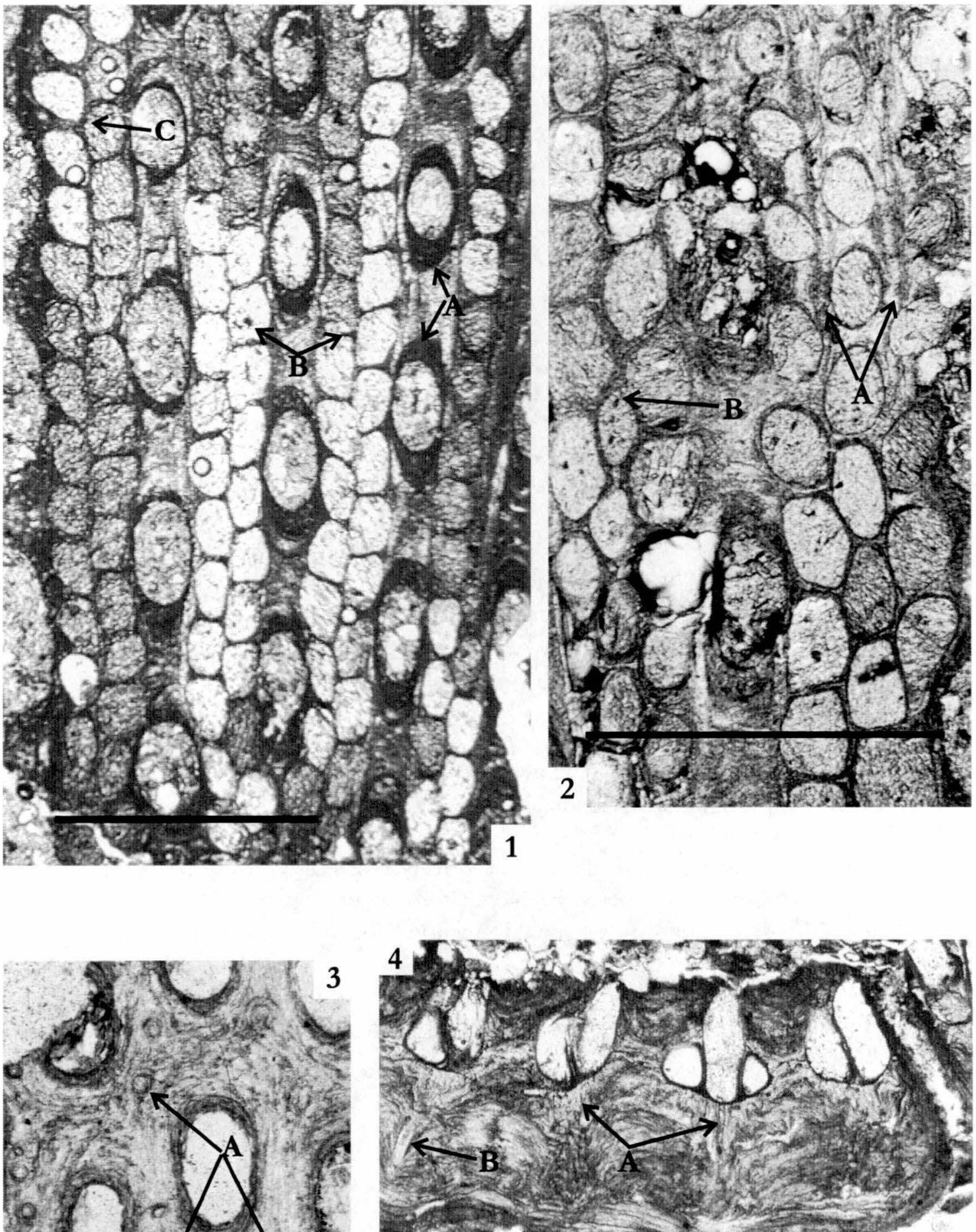

C
A
B
1
B
A
2
3
A
B
4
B
A
5

Plate 30 - *Shulgapora magnafenestrata* (Crockford 1941)
all scale bars 1mm.

1. UTGD 127564 - oblique tangential section reverse to obverse surface showing the longitudinal striae in the reverse wall, A, the thin dissepiments and the coverage of the obverse surface by the apertures, B.
2. UTGD 127564 - oblique tangential section showing chamber outline near the reverse wall, A, at mid chamber level, B, and near the obverse surface, C.
3. UTGD 127564 - longitudinal section showing chamber outline and the high reverse wall budding angle, arrow.
4. UTGD 127564 - tangential section of the obverse surface showing detail of the large apertures, A, and the cyclozooecia, B. Note also how the rows of apertures overlap.
5. UTGD 127564 - oblique tangential section showing zooecial chambers and cyclozooecia, arrow.
6. UTGD 127564 - transverse section showing the flattened obverse surface and thickened reverse wall. Note also the cyclozooecium beneath the granular skeleton within the dissepiment, arrow.

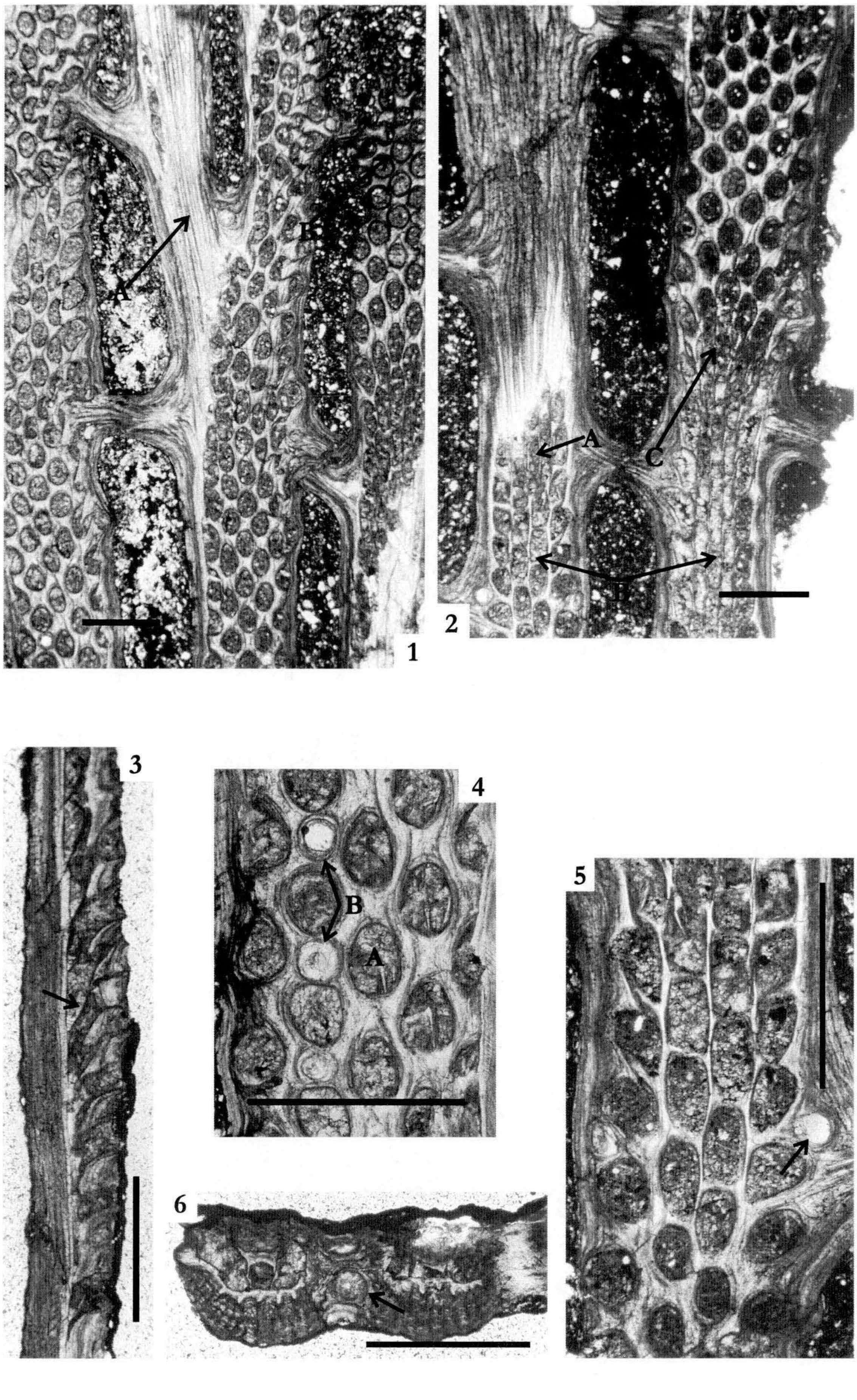

A
B
1
A
C
D
2
3
4
B
A
5
6

Plate 31 - *Dyscritella espinensis* n. sp.
all scale bars 1mm.

1. UTGD 127571, holotype - oblique tangential section showing thin zooecial wall in endozone and thick-walled exozone. Note also acanthostyle spines, A, in longitudinal view and B, in tangential view.
2. UTGD 127572, paratype - tangential section showing abundant acanthostyles, A, and small, B, and larger, C, exilazooecia.
3. UTGD 127571, holotype - longitudinal section showing gentle curve of zooecial tube from endozone to exozone. Acanthostyle spines worn in this portion of the holotype.
4. UTGD 127571, holotype - transverse section with slightly crushed endozone.
5. UTGD 127573, paratype - tangential section showing detail of acanthostyles, A, and exilazooecia, B.
6. UTGD 127572, paratype - longitudinal section showing detail of acanthostyle spines, arrows.

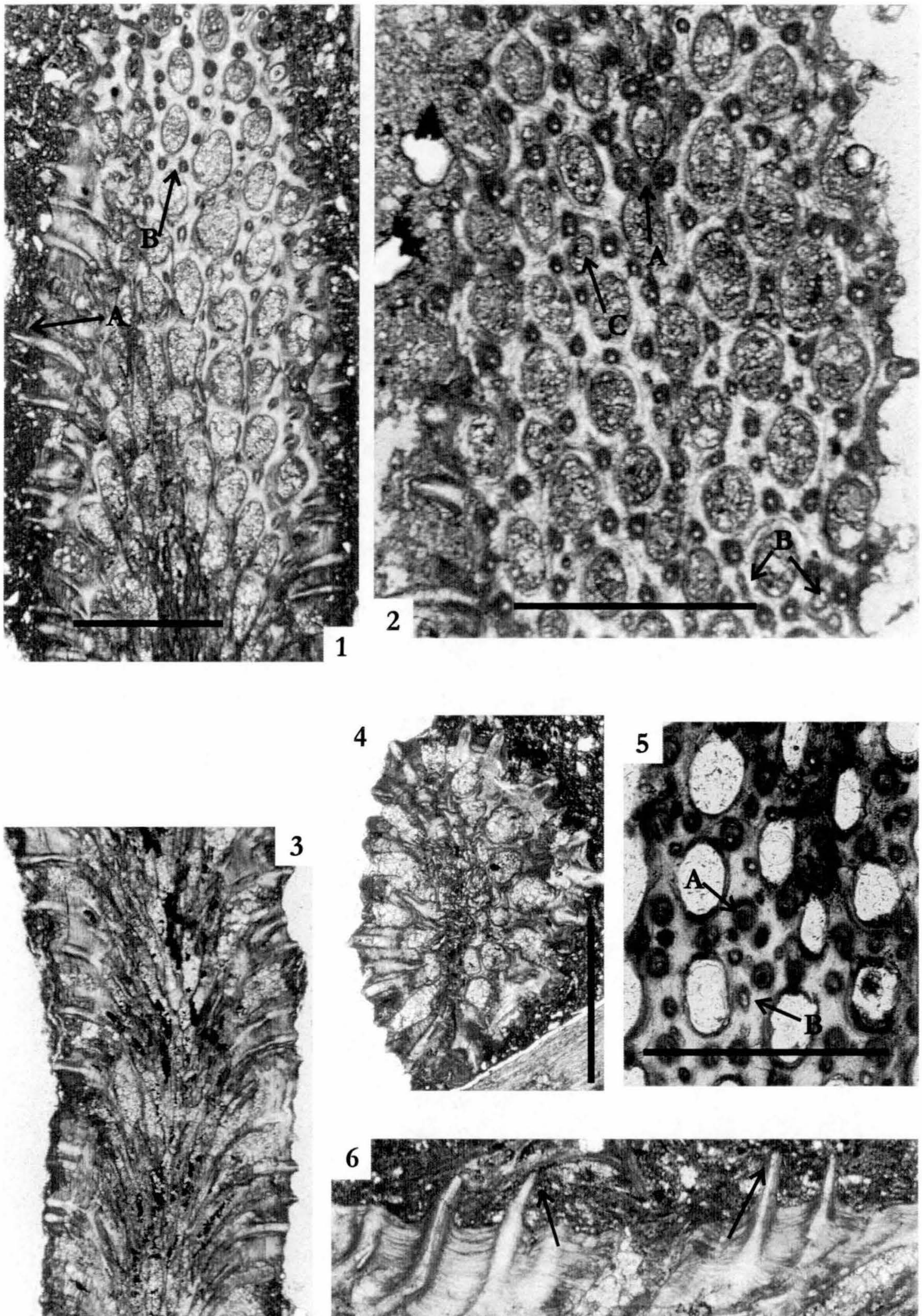

1
B
A
2
A
C
B
3
4
5
A
B
6

Plate 32 - *Dyscritella inversa* n. sp.
all scale bars 1mm

1. UTGD 126949, holotype - tangential section of intermonticular area, exilazooecia more abundant than acanthostyles.
2. UTGD 126950, paratype - tangential section through monticule (at base of picture) showing thickened autozooecial walls, circular autozooecia and clustered abundant exilazooecia.
3. UTGD 126951 - longitudinal section.
4. UTGD 126949, holotype - transverse section showing evenly thickened walls in exozone.

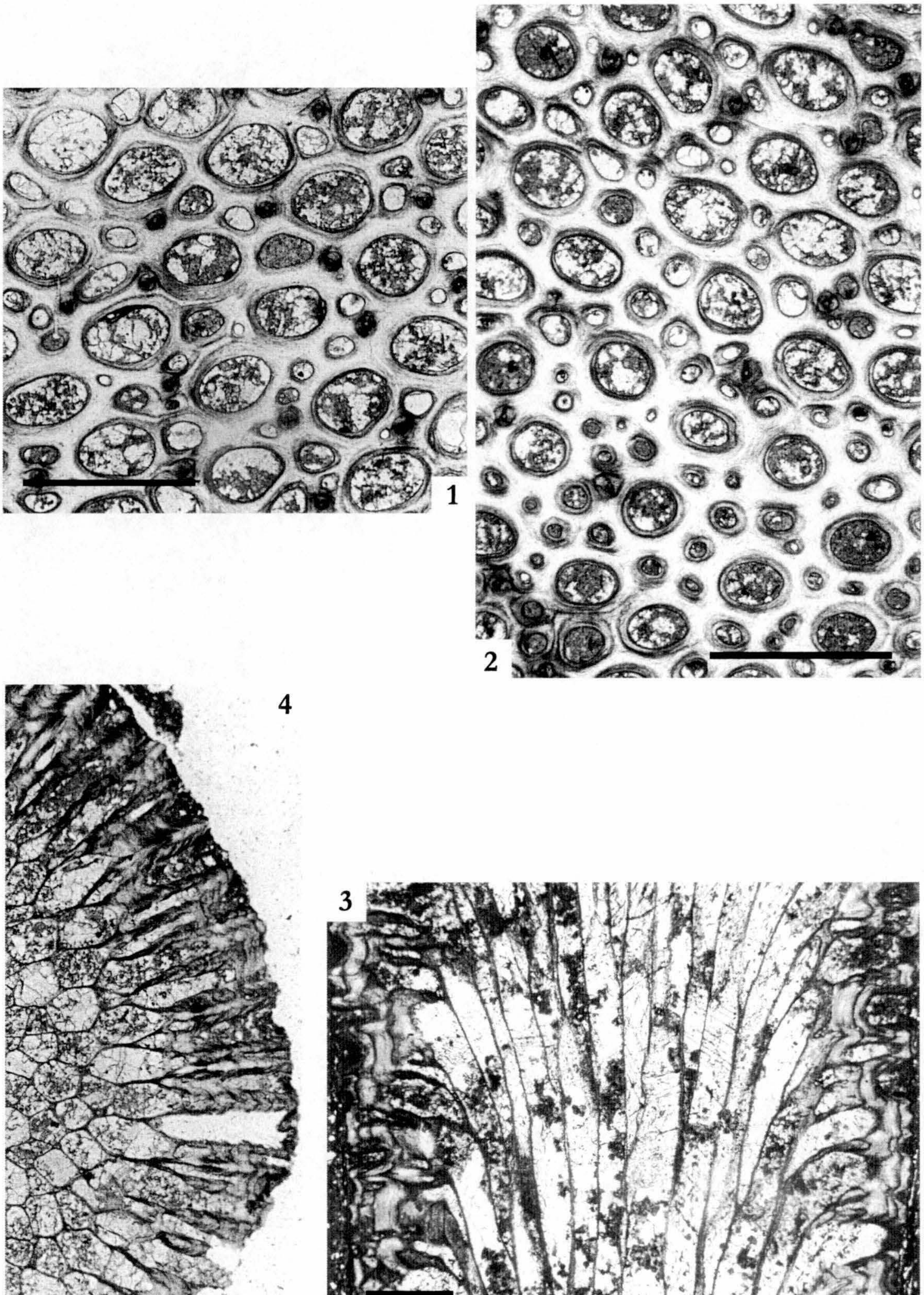
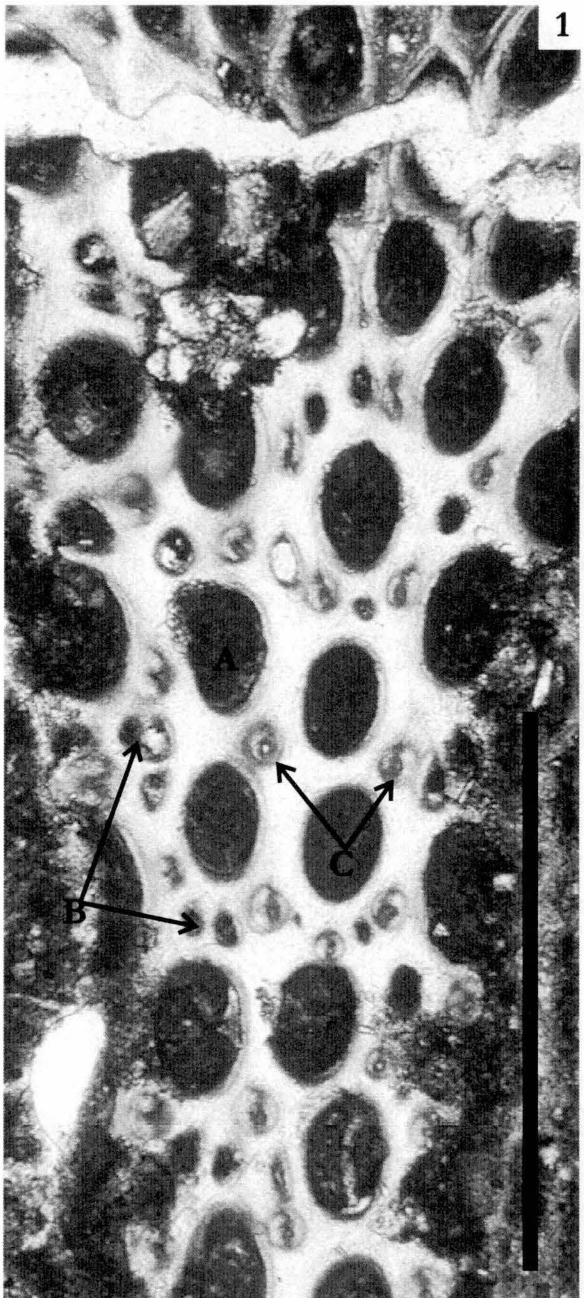


Plate 33 - *Dyscritella restis* Crockford 1943
all scale bars 1mm.

1. UTGD 126923 - tangential section through exozone showing rounded apertures, A, exilazooecia, B, and acanthostyles, C.
2. UTGD 126923 - longitudinal section showing curvature of zooecial tubes from endozone to exozone, A, and acanthostyles developed deep in exozone and expressed at the surface as short spines, B.


1
A
B
C

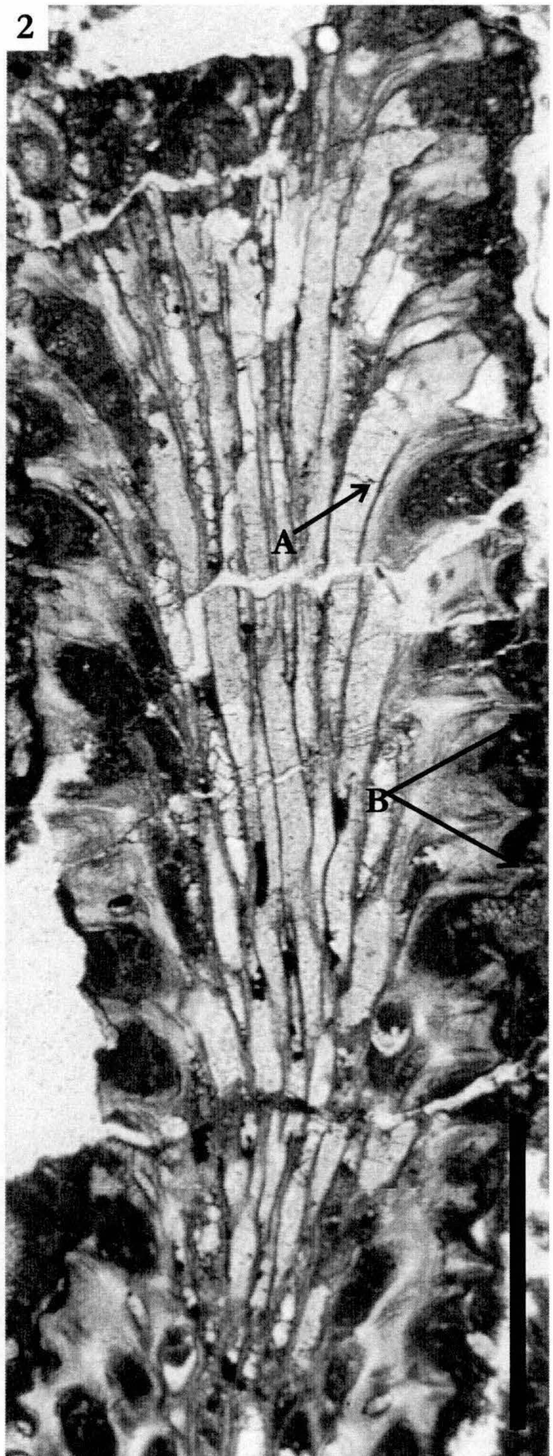

2
A
B

Plate 34 - *Dyscritellina megacanthi* n. sp.
all scale bars 1mm.

1. UTGD 127061, paratype - tangential section through exozone.
2. UTGD 126948, holotype - tangential section through exozone showing autozooecial apertures, A, exilazooecia, B, micracanthostyles, C, and megacanthostyles, D.
3. UTGD 126948, holotype - tangential section deep exozone, showing the thinner zooecial walls, A, in the deeper part of the exozone without monilae, plus micracanthostyles, B, and megacanthostyles, C.
4. UTGD 126948, holotype - longitudinal section through endo and exozones, showing a row of monilae, arrow, crossing the endozone.
5. UTGD 126948, holotype - transverse section showing the relative width of the endo and exozones, and the development of acanthostyles with the endozone, A. Note also the variable apparent thickness of the zooecial walls in the exozone, monilae long and thin where no acanthostyles, B, and wide and rounded where acanthostyles are in section, C.

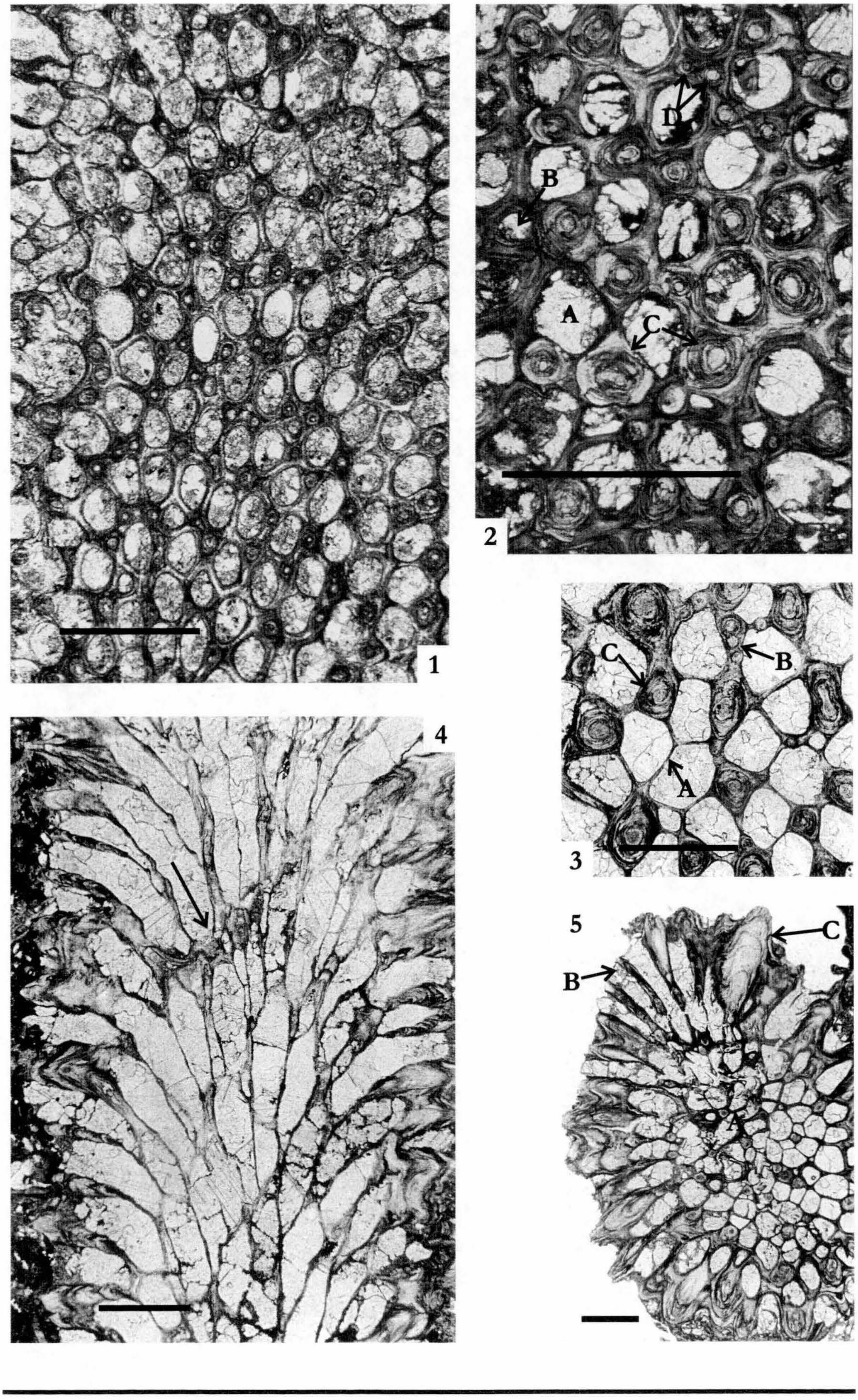
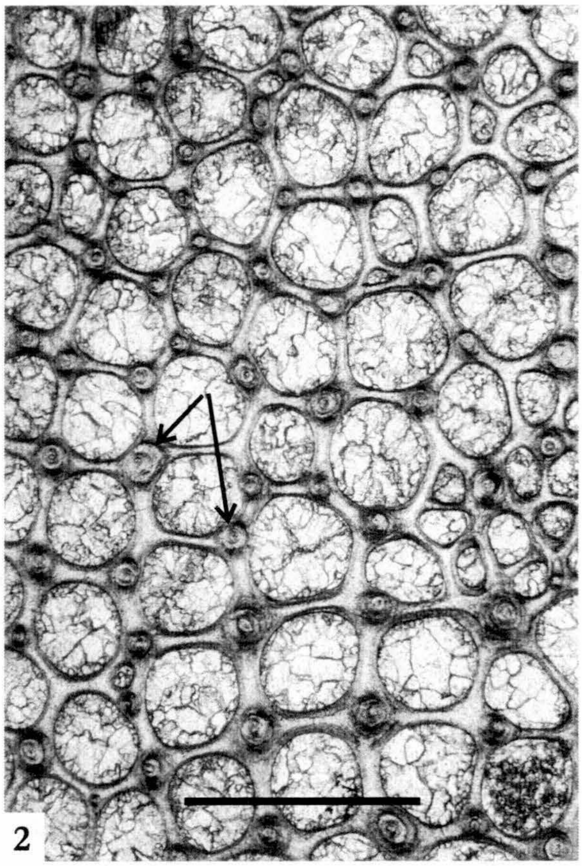
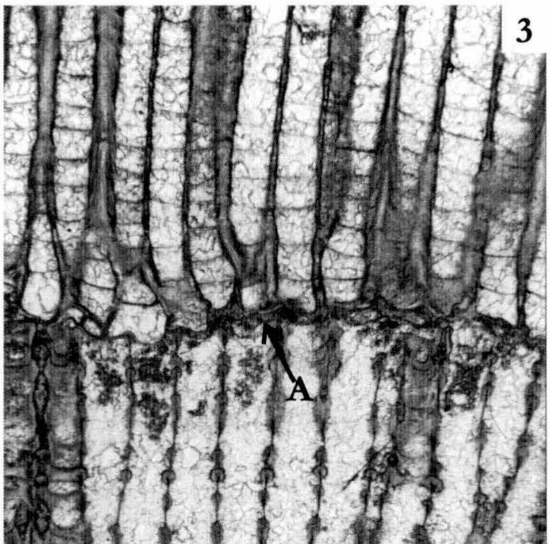

1
2
A
B
C
D
3
A
B
C
4
5
A
B
C

Plate 35 - *Paralioclema wassi* n. sp.
all scale bars 1mm.

1. UTGD 126936, holotype - *P. wassi* encrusting about a pectin shell, lens cap for scale 58mm diameter.
2. UTGD 126936, holotype - tangential section showing variable size of acanthostyles (arrows)
3. UTGD 126936, holotype - transverse section, *P. wassi* overgrowing *Stenopora sp.,* A, on pectin shell, B.
4. UTGD 126936, holotype - transverse section showing thin unbeaded walls, except where section cuts acanthostyles, and abundant straight to curved diaphragms


1


2


3
A
B

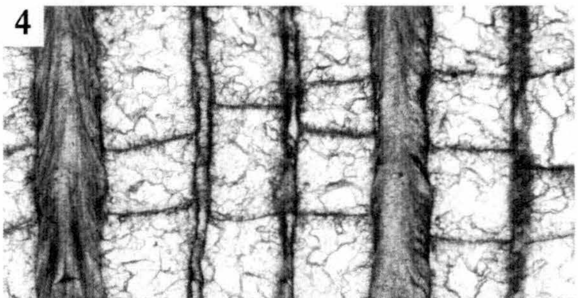
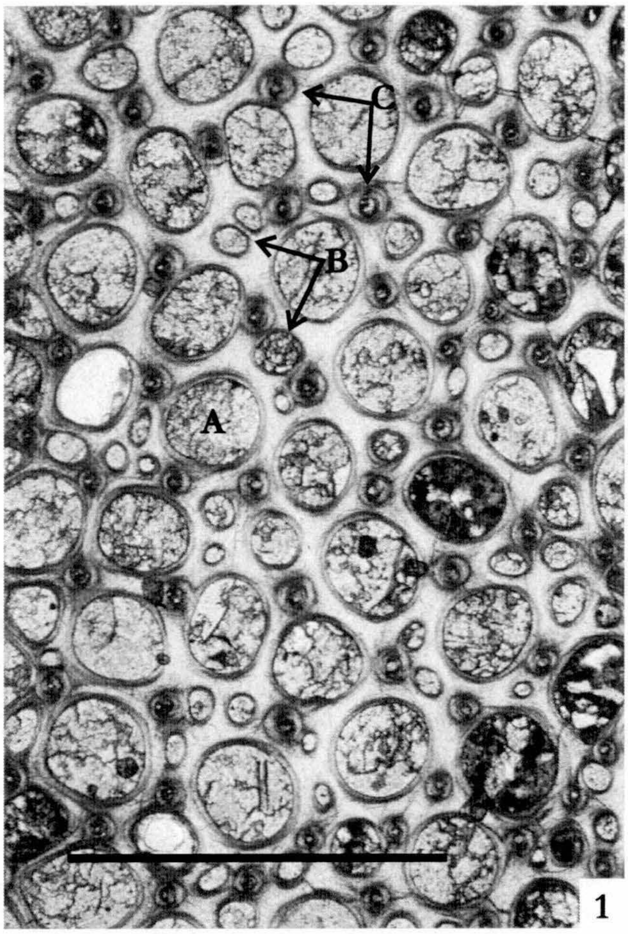
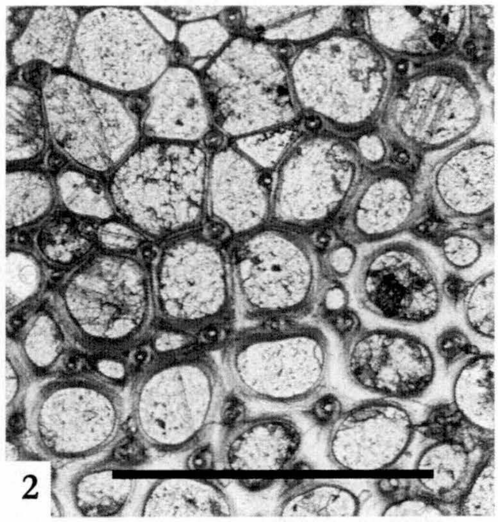
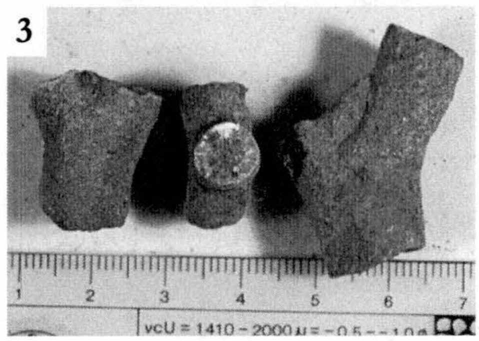

4

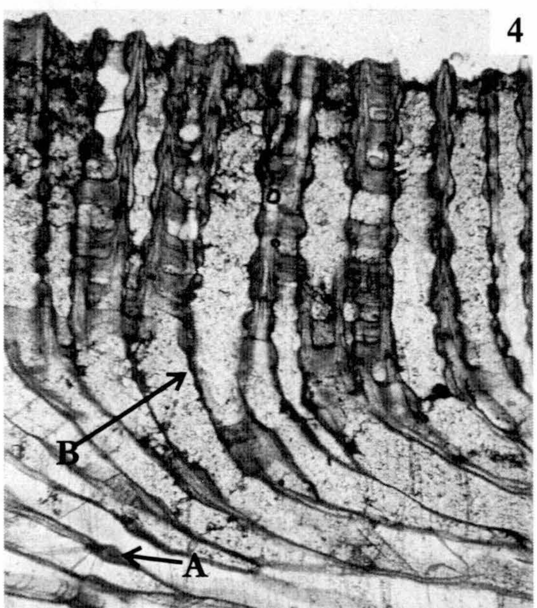
Plate 36 - *Stenopora aequalis* n. sp.
all scale bars 1mm except where otherwise stated.

1. UTGD 126932, paratype - tangential section through the outer exozone showing the rounded apertures, A, exilazooecia, B, and acanthostyles, C.
2. UTGD 126933, holotype - oblique tangential section through exozone. Note zooecial walls thinner in the upper picture where zooecial wall is without monilae.
3. UTGD 126933, holotype - zoarial fragments. Scale is in centimetres.
4. UTGD 126933, holotype - longitudinal section, with large arrow denoting the growth direction of the branch. Note the row of monilae in the endozone, A, and the smooth curvature of the zooecial tubes from the endo to exozone.
5. UTGD 126933, holotype - transverse section showing shape of the zooecial tube in the endozone at bottom of picture, and the separated rows of monilae in the exozone at the top of the picture.


C
B
A
1


2


3
1
2
3
4
5
6
7


4
B
A

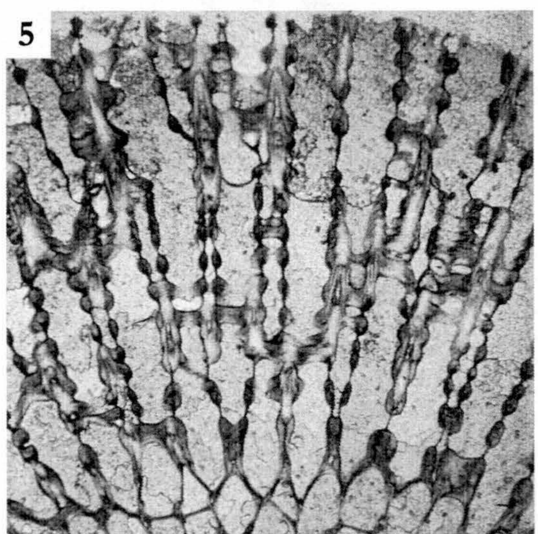

5

Plate 37 - *Stenopora berriedalensis* n. sp.
all scale bars 1mm.

1. UTGD 126920, holotype - tangential section showing large acanthostyles, A, and small exilazooecia, B.
2. UTGD 126920, holotype - transverse section with almost confluent monilae in a narrow exozone, and showing the acanthostyles developed deep in the exozone, arrow.
3. UTGD 126920, holotype - transverse section showing endozone and exozone, and the almost confluent monilae in the exozone, with some not quite overlapping, arrow.
4. UTGD 126920, holotype - longitudinal section showing gradual bend of zooecial tube from endozone to exozone, opening at 55 to 75 degrees to external surface, arrow denotes growth direction of the branch.

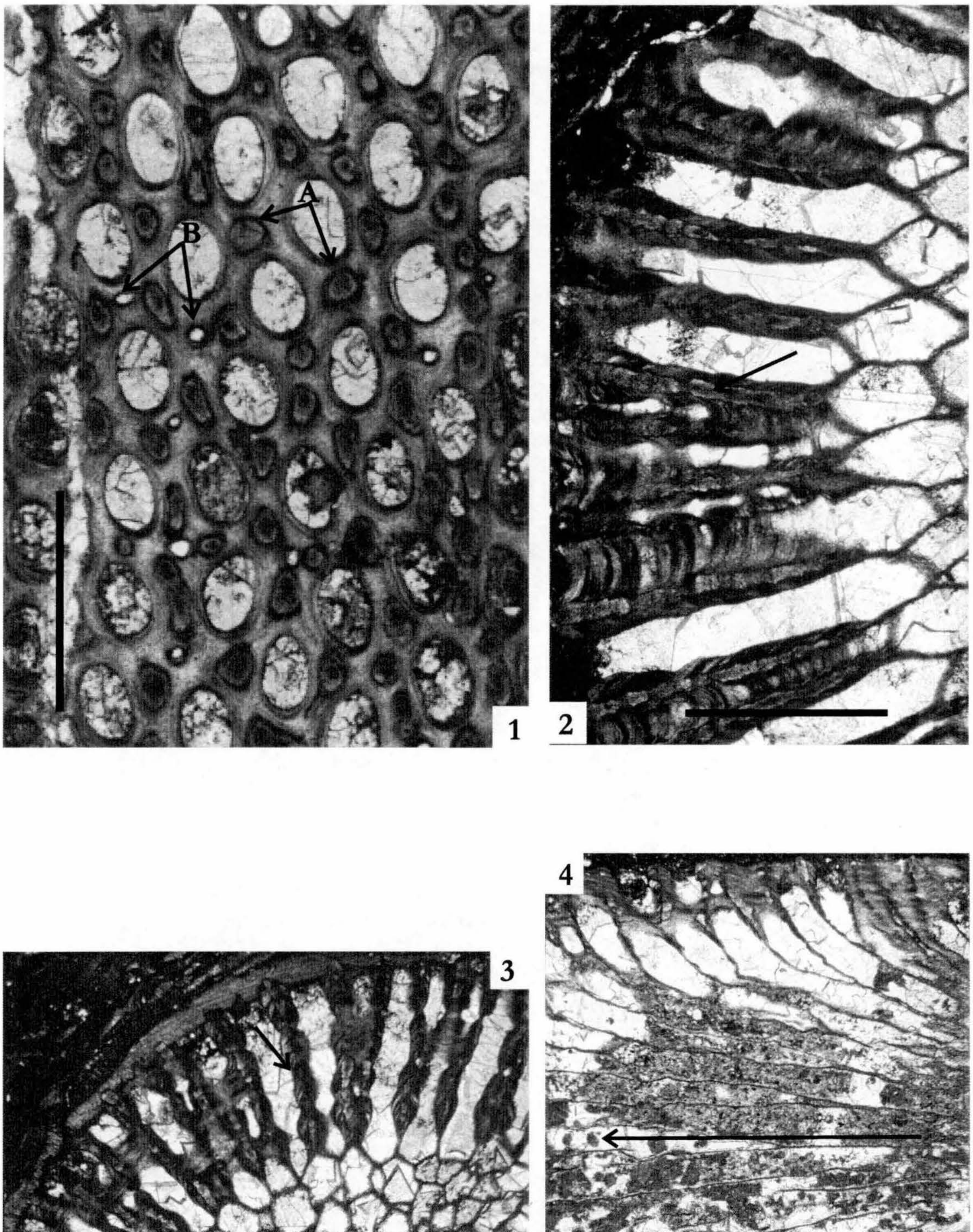

A
B
1
2
3
4

Plate 38 - *Stenopora crinita* Lonsdale 1845
all scale bars 1mm.

1. UTGD 126925 - tangential section through the outer exozone, showing the large subpolygonal autozooecial apertures, with small acanthostyles, A, at wall junctions. Note wall thins where section at level of non-moniliform portion of the exozone, B.
2. UTGD 126925 - transverse section, showing outer endozone and bottome of picture and widely spaced monilae of exozone towards top of picture.
3. UTGD 126925 - transverse section, with endozone to bottom and outer exozone to top of picture. Note how the small beadlike monilae, arrows, become more closely spaced towards the outer exozone.
4. UTGD 126925 - transverse section, showing detail of monilae.
5. UTGD 126924 - tangential section through outer exozone.

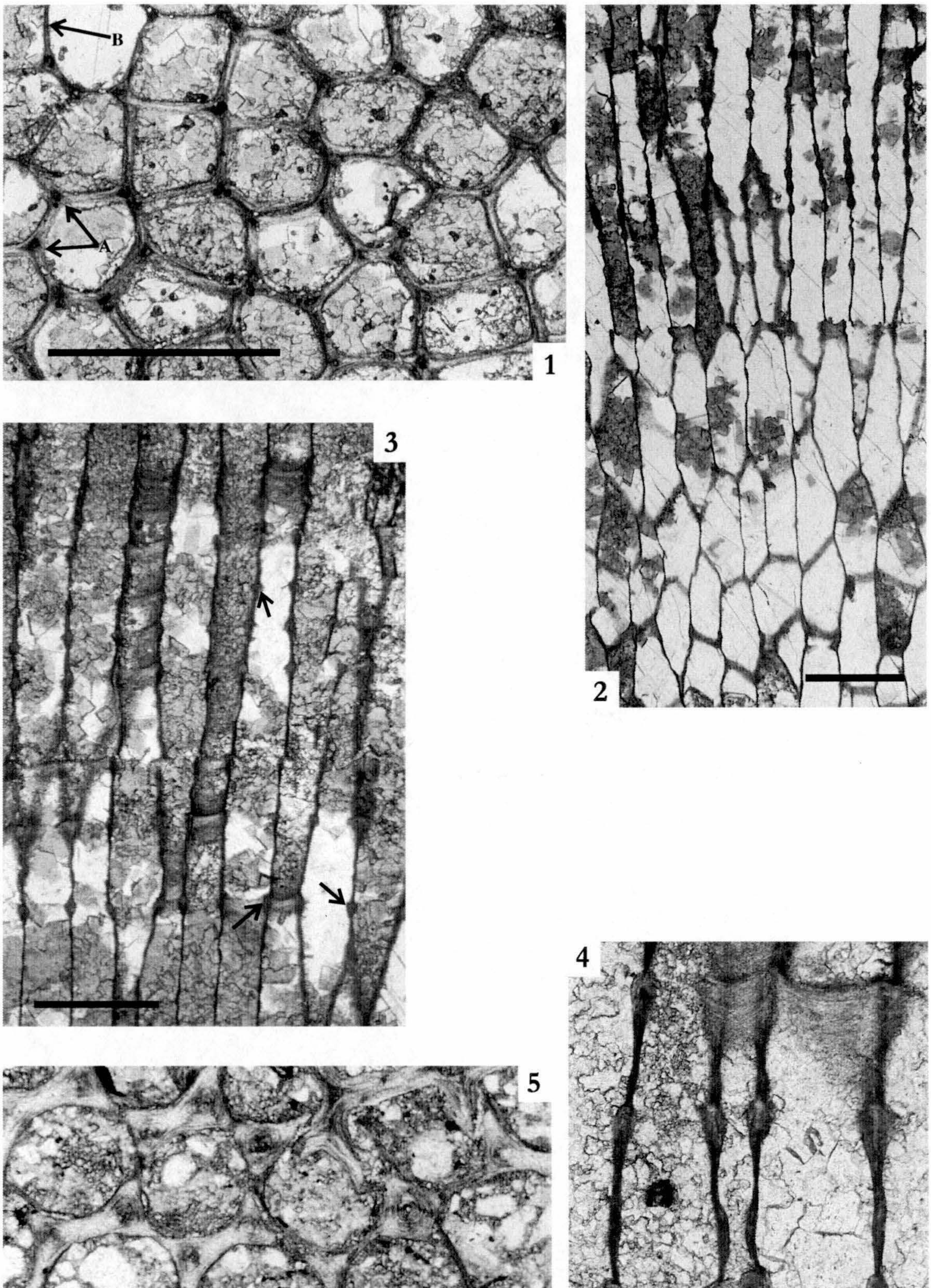
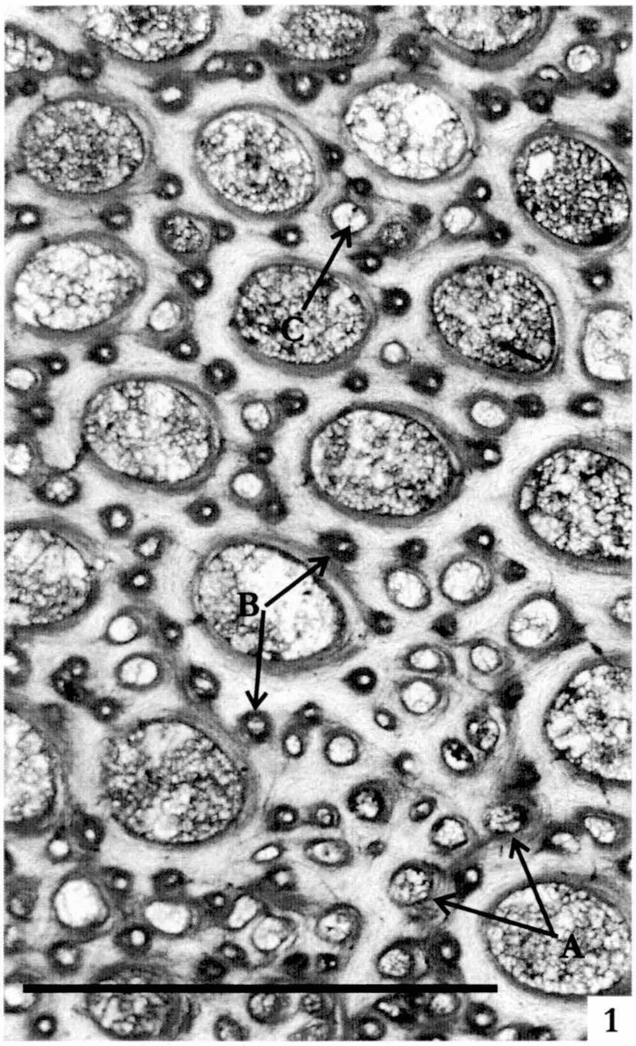
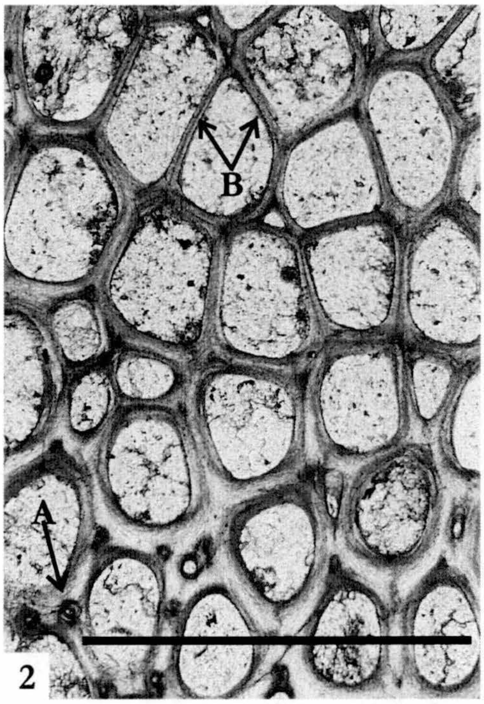
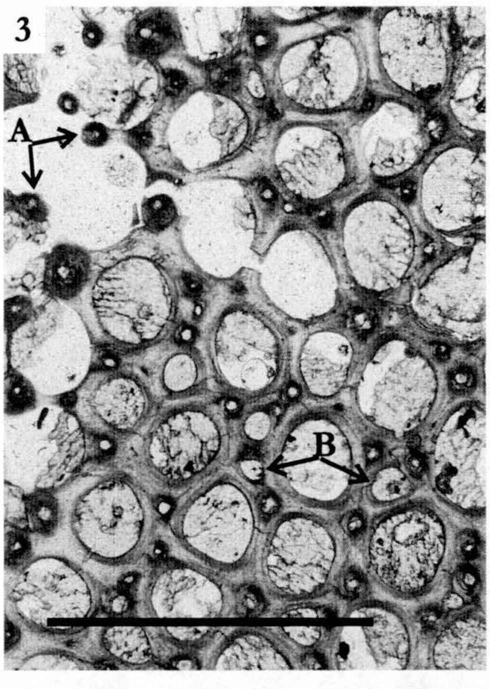

B
A
1
2
3
4
5

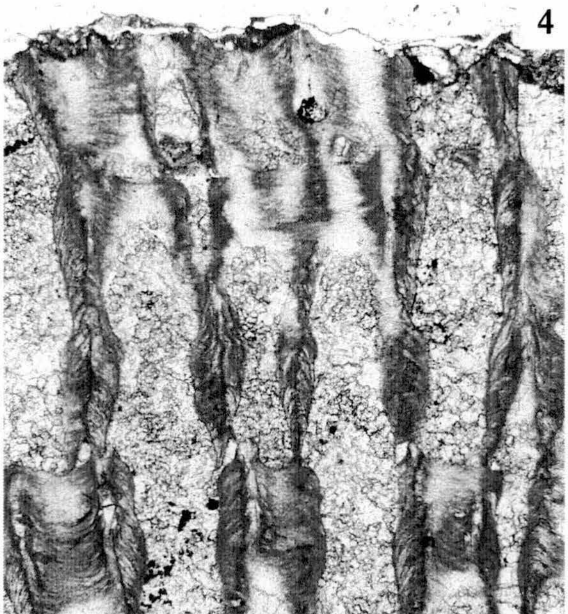
Plate 39 - *Stenopora elongata* n. sp.
all scale bars 1mm.

1. UTGD 127522, holotype - tangential section through outer exozone, showing monticule in lower right with abundant exilazooecia, A. Upper portion of picture between monticules showing acanthostyles, B, and exiliazooecial, C, distribution.
2. UTGD 126931, paratype - oblique tangential section through exozone, showing thick zooecial walls and acanthostyles, A, and thin zooecial walls lower in exozone, B.
3. UTGD 126931, paratype - oblique tangential section showing acanthostyles raised above zooarial surface, A. Note also number of exilazooecia, B, in intermonticular area.
4. UTGD 127522, holotype - transverse section through the exozone, showing the elongate robust monilae arranged laterally into rows.
5. UTGD 127522, holotype - transverse section through entire zoarium, showing width of exozone. Note however endozone is somewhat crushed.


C
B
A
1


B
A
2


3
A
B


4

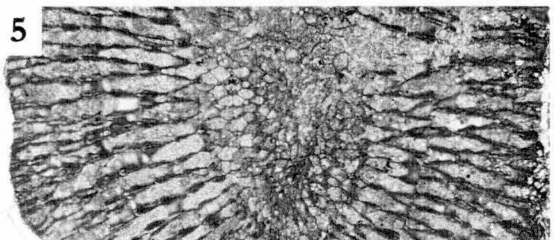
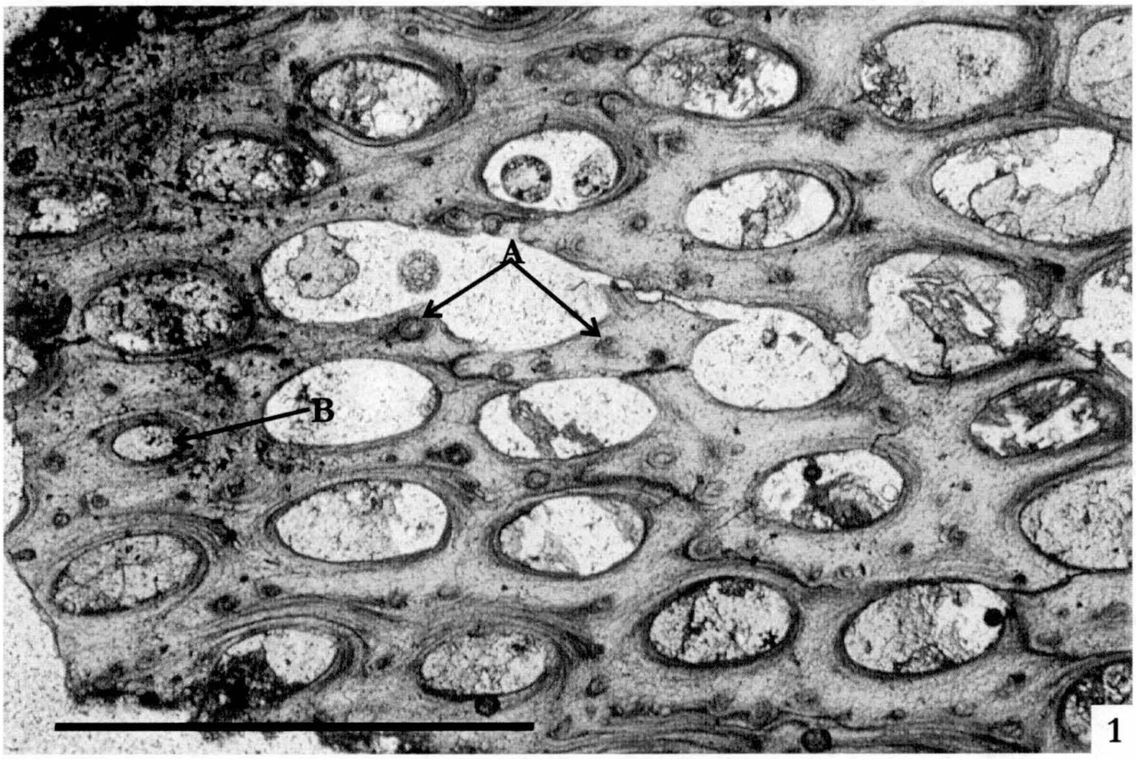
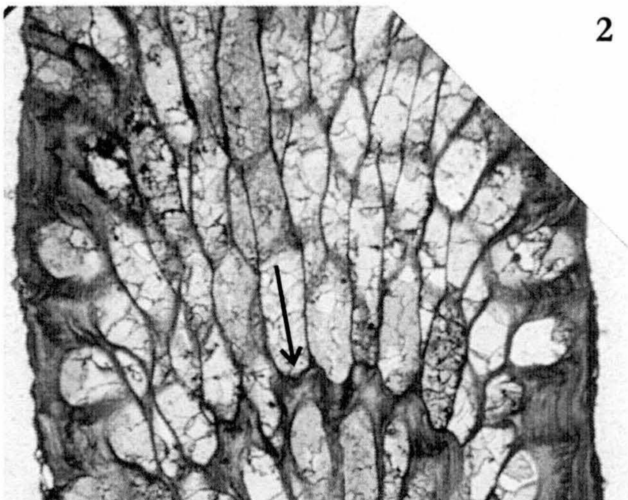

5

Plate 40 - *Stenopora etheridgei* Crockford 1945
all scale bars 1mm.

1. UTGD 126928 - tangential section through outer exozone, showing the oval autozooecial apertures in rough longitudinal rows. Note also the small acanthostyles, A, and rare exilazooecia, B.
2. UTGD 126928 - longitudinal section showing the relative widths of endo and exozone, and the arcuate row of monilae across the endozone, arrow.
3. UTGD 126928 - transverse section.


A
B
1


2

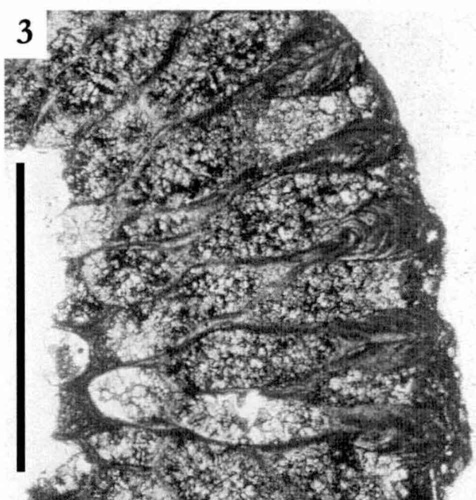
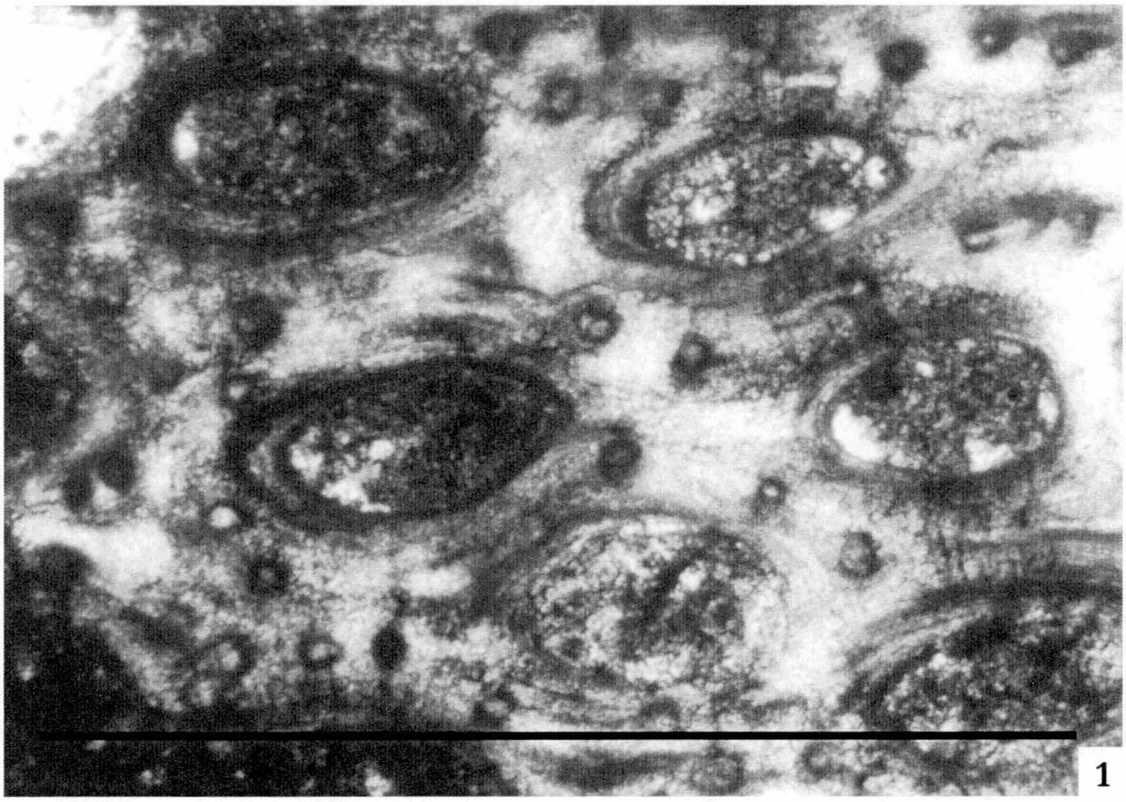

3

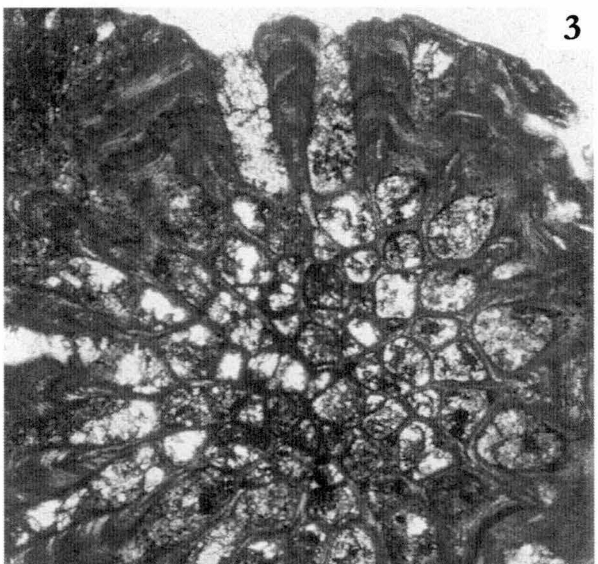
Plate 41 - *Stenopora grantonensis* Crockford 1943
all scale bars 1mm.

1. UTGD 126929 - tangential section through the outer exozone, showing the oval apertures and abundant acanthostyles.
2. UTGD 126930 - longitudinal section showing the zooecial tubes curving gently from the endozone to the exozone, and the abundant small acanthostyles seen immediately beneath the surface, arrows.
3. UTGD 126930 - transverse section showing the relative width of the endo and exozones, and larger acanthostyles developed deep in the exozone, arrow.



1

2



3

Plate 42 - *Stenopora ovata* Lonsdale 1844
all scale bars 1mm.

1. UTGD 53856 - tangential section through middle exozone, showing shape and arrangement of autozooecial apertures.
2. UTGD 53856 - tangential section through outer exozone, showing acanthostyles, A, and few exiliazooecia, B.
3. UTGD 53856 - tangential section through middle exozone, showing thickened zooecial wall at level of monilae, A, and wall thickness between monilae, B. Note also smaller acanthostyles, C, deeper in exozone in comparison to shallow acanthostyles of figure 2.
4. UTGD 53856 - transverse section through encrusting zoarium.
5. UTGD 53856 - transverse section showing detail of zooecial wall with closely spaced pyriform monilae, arrows.

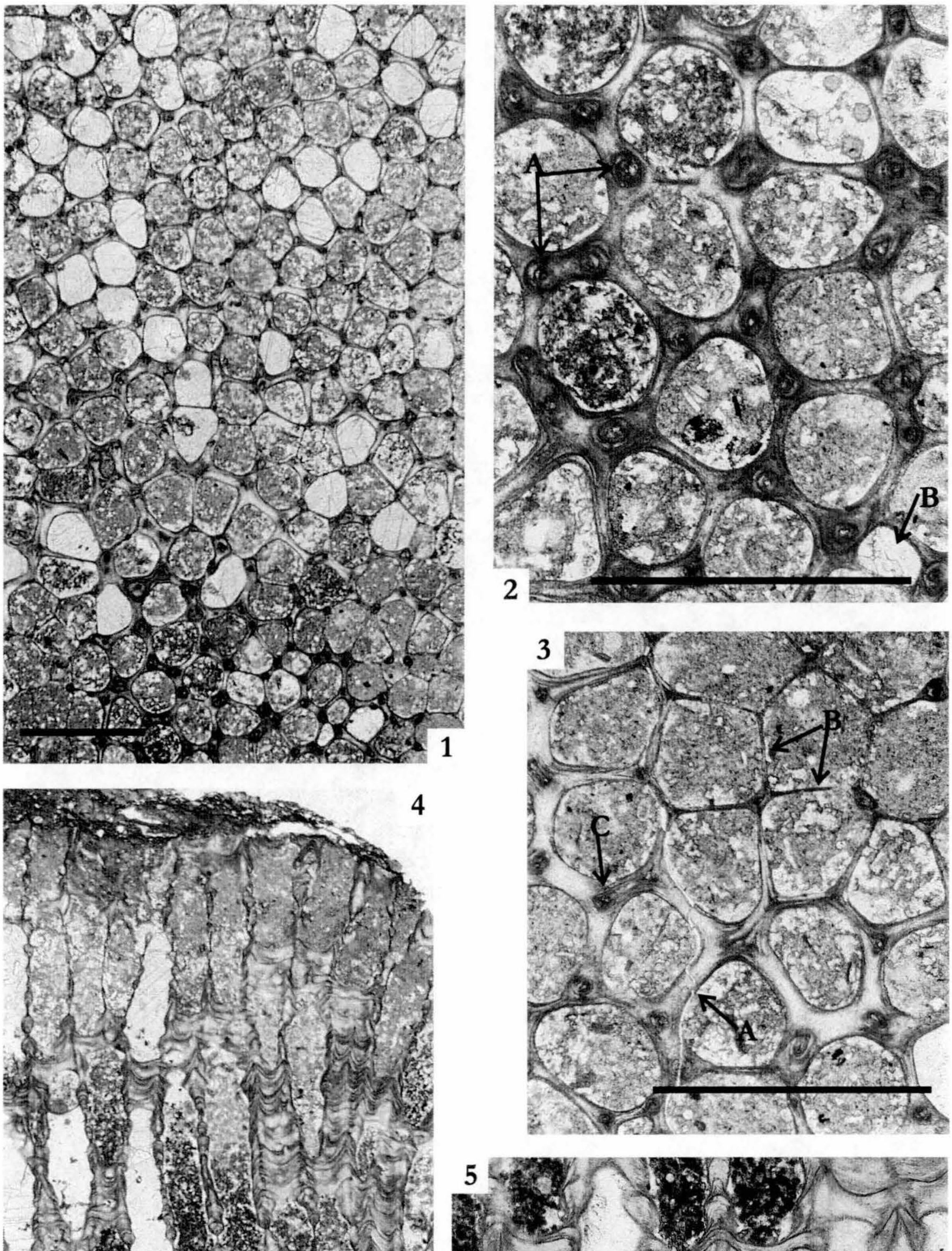

1
2
A
B
3
B
C
A
4
5

Plate 43 - *Stenopora seriatensis* n sp.
all scale bars 1mm.

1. UTGD 127579, holotype - tangential section in outer exozone, showing the oval autozooecial apertures and the numerous acanthostyles, A, and exilazooecia, B, both of variable size.
2. UTGD 127586 - tangential section showing large, A, and small, B, exilazooecia.
3. UTGD 127584 - longitudinal section showing zooecial tubes in endozone, A, and their sharp curve into the base of the exozone, B. Note also acanthostyles forming short spines, C.
4. UTGD 127584 - transverse section showing relative width of endozone, A, and exozone, B.
5. UTGD 127580, paratype - tangential section.

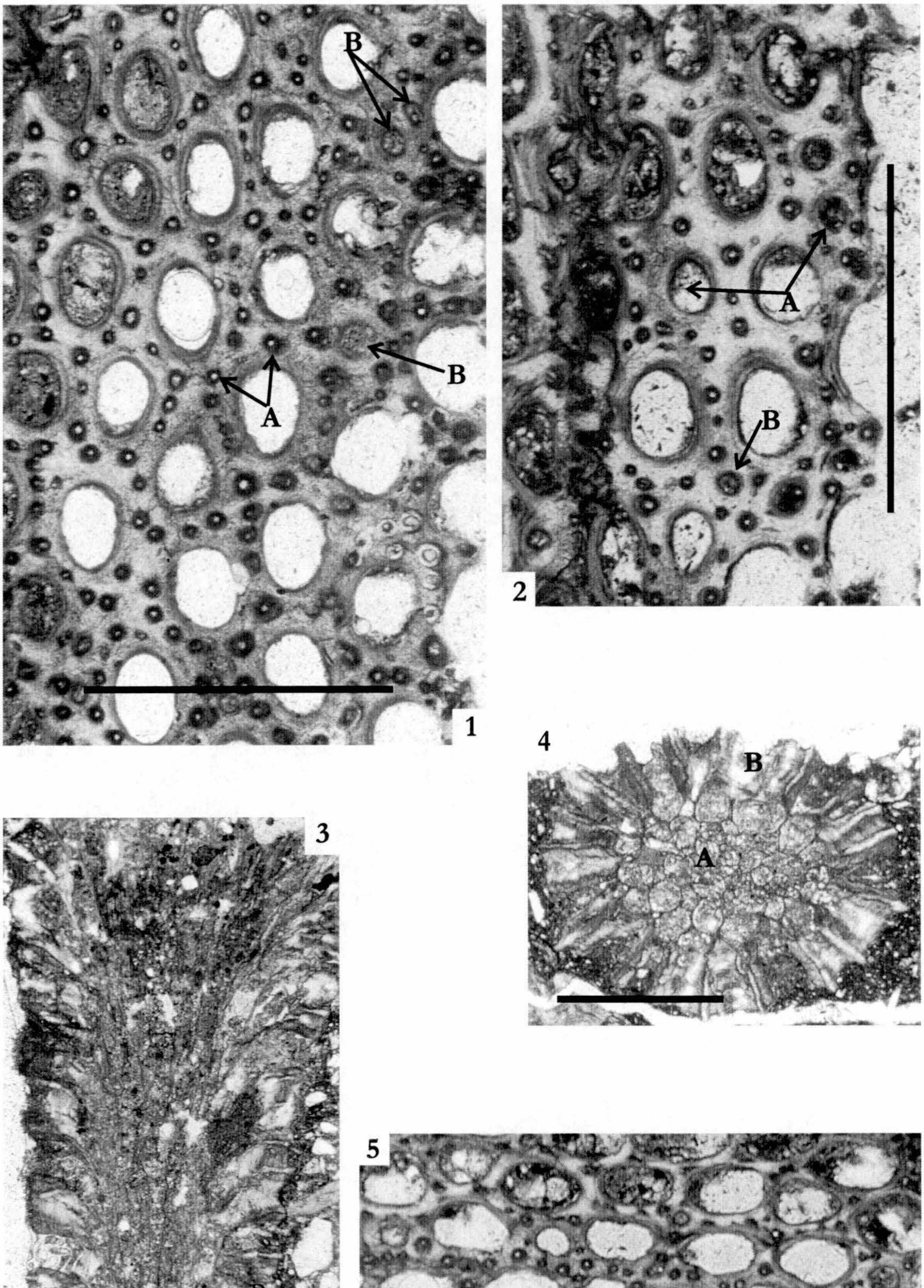

1
B
A
B
2
A
B
3
A
B
C
4
A
B
5

Plate 44 - *Stenopora spiculata* Crockford 1945
all scale bars 1mm.

1. UTGD 127577 - tangential section showing the subpolygonal to subcircular apertural shape and zooecial wall thickness at the level of the monilae, A, and between monilae, B.
2. UTGD 127577 - tangential section showing area of abundant acanthostyles.
3. UTGD 127577 - tangential section showing abundant acanthostyles, upper picture, and reduced number of acanthostyles, lower picture.
4. UTGD 127577 - transverse section of bilamellar frondescent zoarium, showing slightly crushed endozone, and the base of the exozone with monilae.
5. UTGD 127577 - transverse section of exozone, showing separated monilae in lower picture becoming slightly more closely spaced in upper picture.

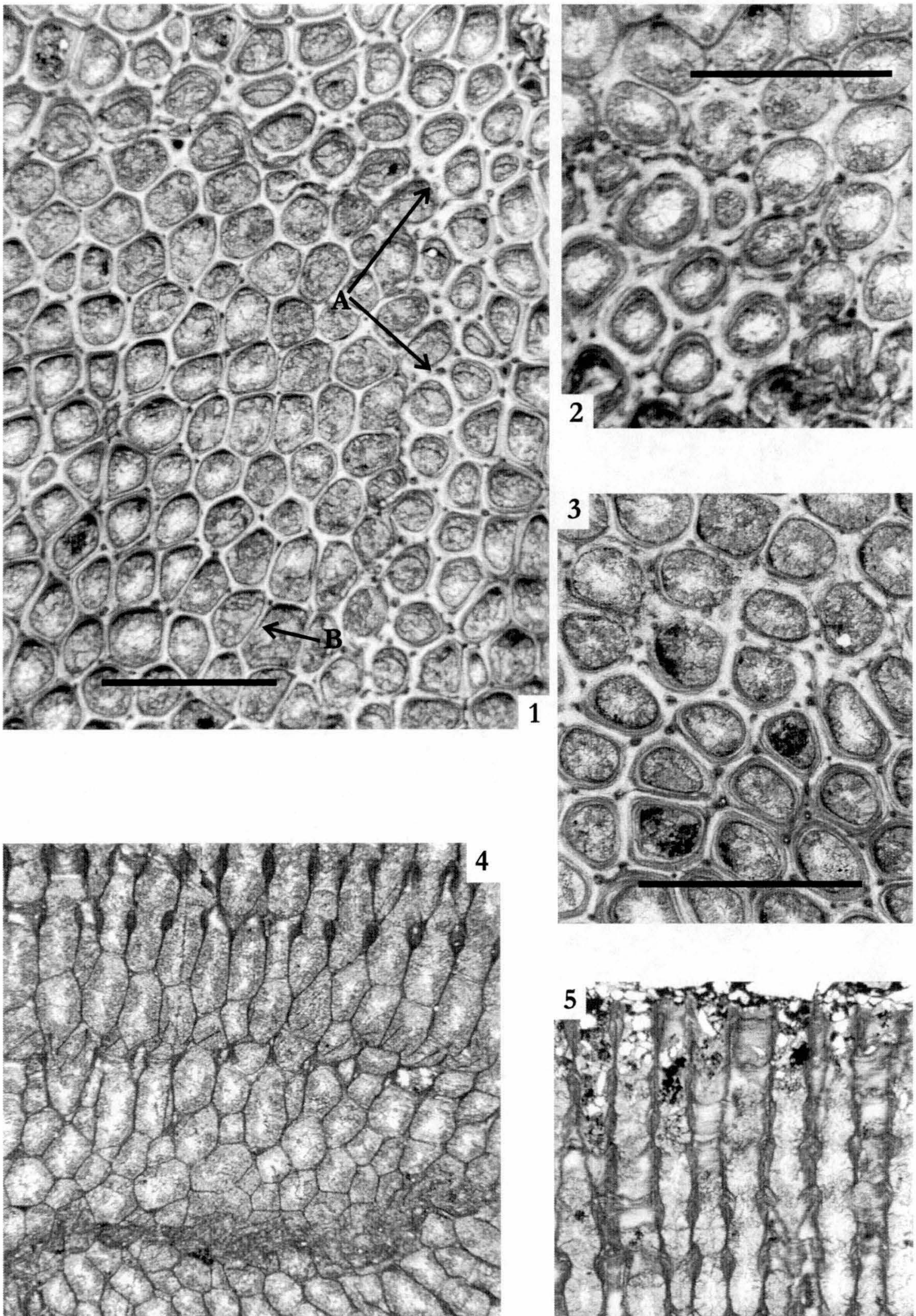

A
B
1
2
3
4
5

Plate 45 - *Stenopora* cf. *spiculata* Crockford 1945
all scale bars 1mm.

1. UTGD 127578 - tangential section showing wall thickness at level of monilae, A, and between monilae, B, and monticular area with abundant exilazooecia, C.
2. UTGD 127578 - transverse section showing shape of zooecial tube in transverse section of endozone in lower picture and the separated rows of monilae in exozone in upper picture.
3. UTGD 127578 - tangential section showing acanthostyle arrangement.
4. UTGD 127578 - longitudinal section showing zooecial tubes in endozone, upper picture, curving gently into exozone with separated monilae, lower picture.

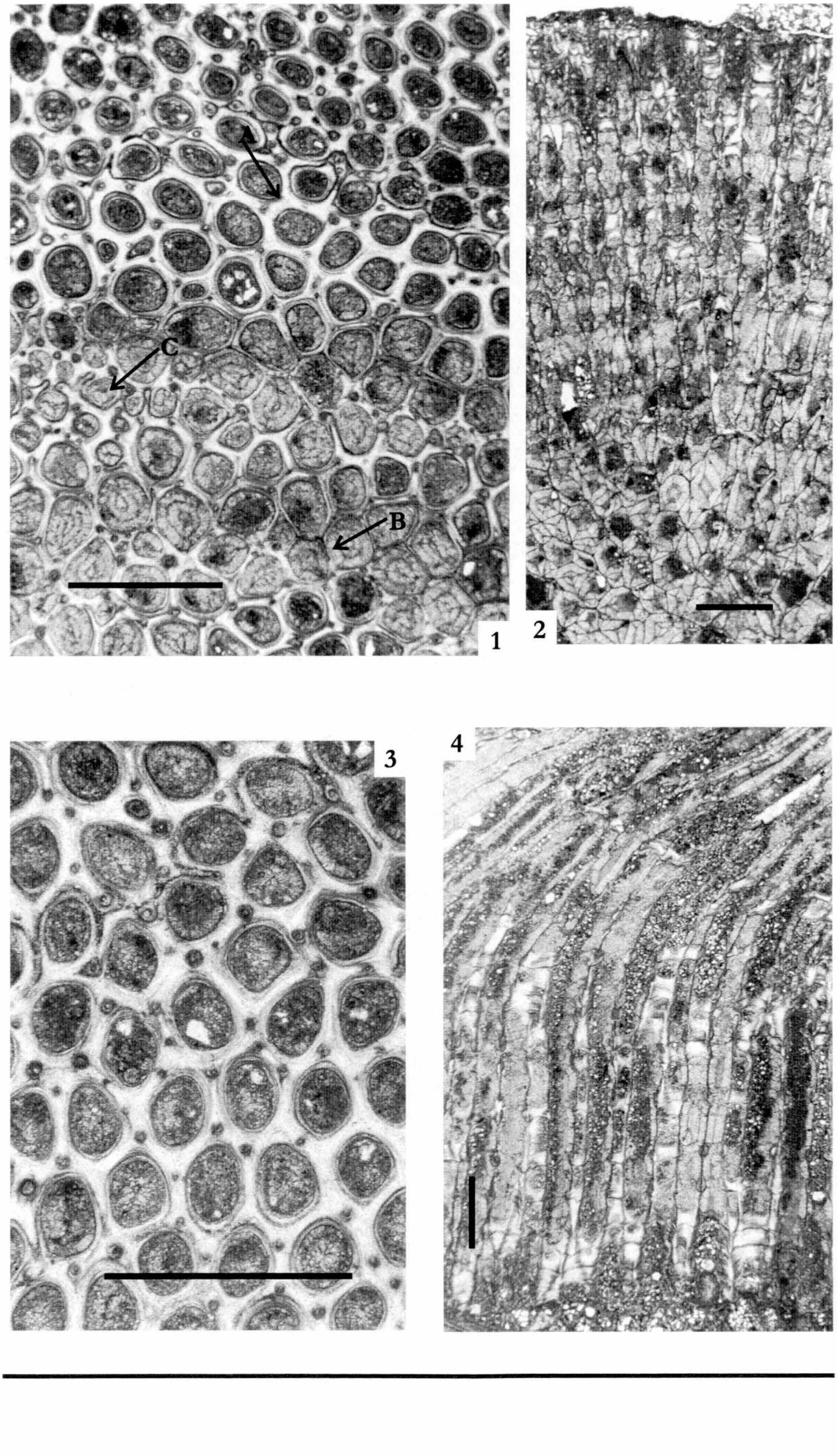

C
B
1
2
3
4

Plate 46 - *Stenopora tasmaniensis* Lonsdale 1844
all scale bars 1mm except where indicated.

1. large foliose colony from the basal beds, Maria Island. Specimen overturned in loose boulder. Base of colony is at A, with fronds shown with arrows. Hammer for scale, length 33 centimetres. UTGD 126943 samples taken from this colony.
2. UTGD 126942 - bilaminar fragment from the basal beds, Maria Island, showing area of large sharp closely packed monticules, A, with area free of monticules, B. Coin for scale 188mm in diameter.
3. UTGD 126941 - tangential section through exozone showing abundant acanthostyles and few exilazooecia. Note in areas denoted by arrows, that in deeper section zooecial walls are thinner and acanthostyles smaller and less frequent.
4. UTGD 126944 - tangential section through exozone, showing very large zooecia, A, surrounded by thick walled zoarium with abundant acanthostyles, B, and exilazooecia, C.
5. UTGD 126943 - transverse section through exozone of large frondescent zoarium shown in figure 44.1, showing the slightly separated monilae in lower picture, with closely spaced monilae in upper picture.
6. UTGD 126942 - transverse section through bilaminar zoarium with crushed endozone, A, showing the closely spaced monilae of the exozone, B.

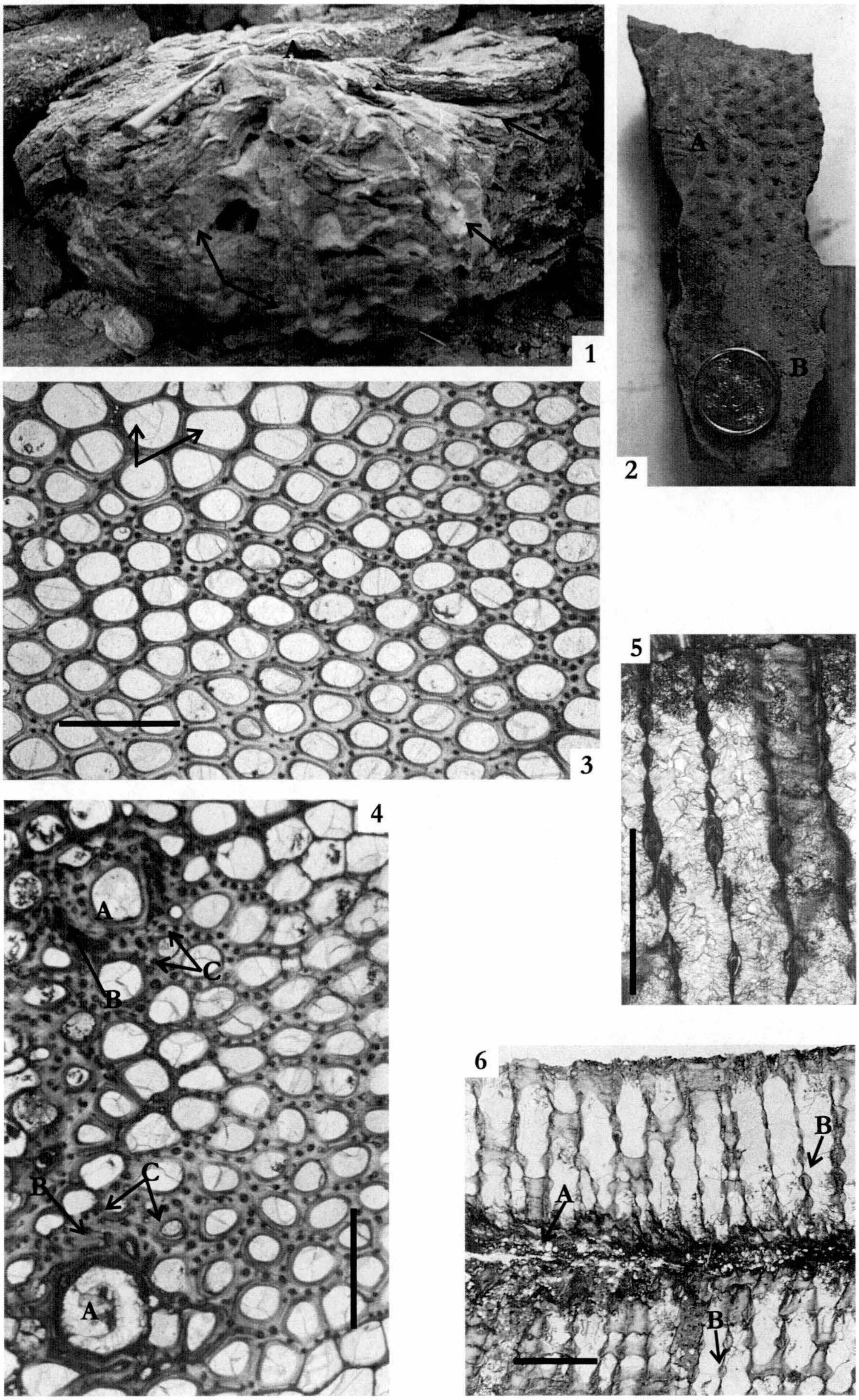

1
A
B
2
3
4
A
C
B
C
B
A
5
6
B
A
B

Plate 47 - *Alternifenestella subquadratopora* (Shulga-Nesterenko, 1952)
All scale bars 1 mm.

1. UTGD 127587 - oblique tangential section showing chamber outline near reverse, A, at mid chamber, B, and near obverse, C. Note also the thin dissepiments and hourglass shaped fenestrules.
2. UTGD 127587 - transverse section showing the thin frontal and reverse walls, and the sharp nodes, arrow.
3. UTGD 127587 - longitudinal section.
4. UTGD 127587 - tangential section reverse surface, showing the strong longitudinal striae, A, the reverse microstylets, B, and the base of the zooecial chambers, C.
5. UTGD 127587 - oblique tangential section showing the chamber outline near the obverse, A, the circular apertures, B, and the thin carina and nodes, C.

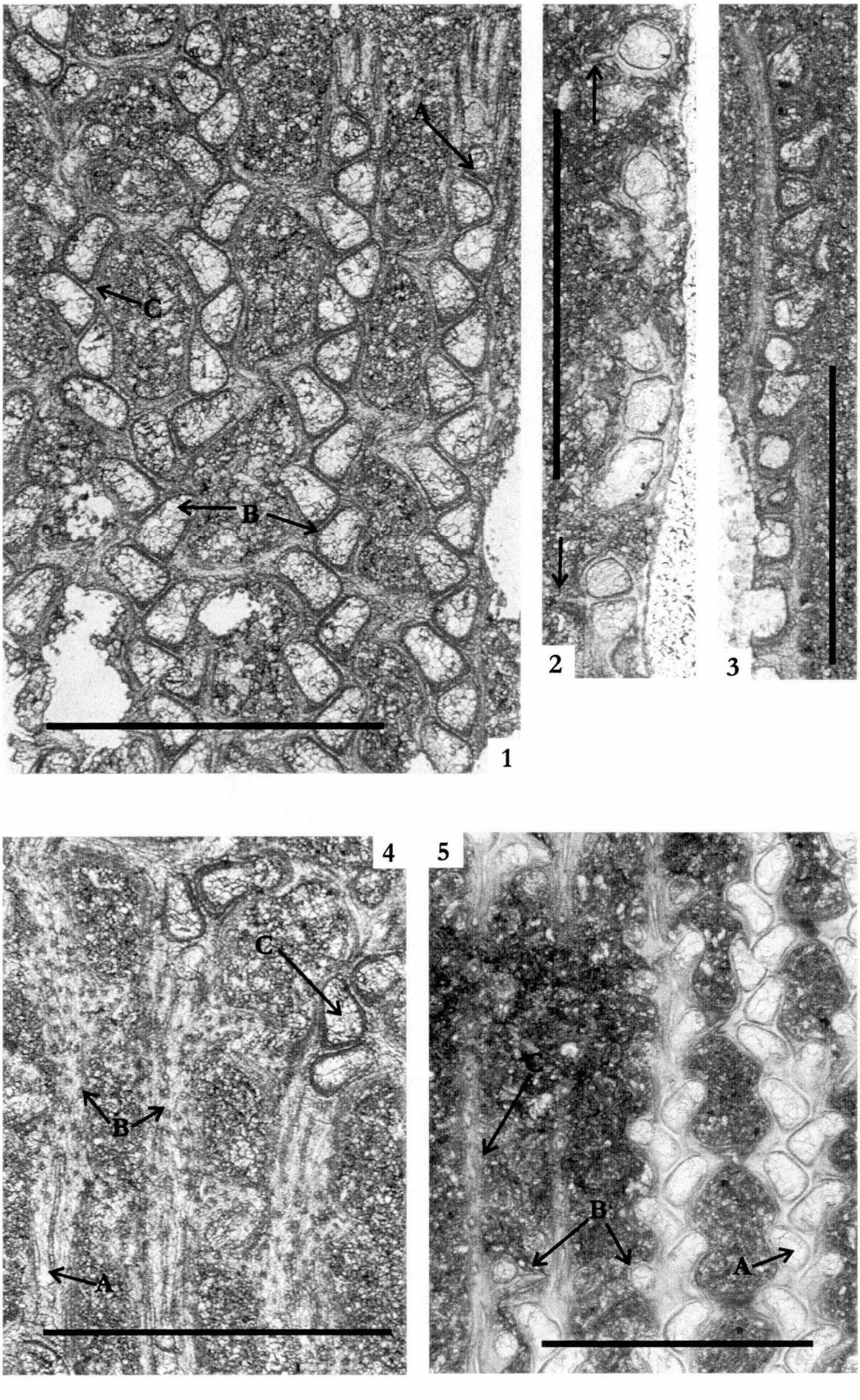
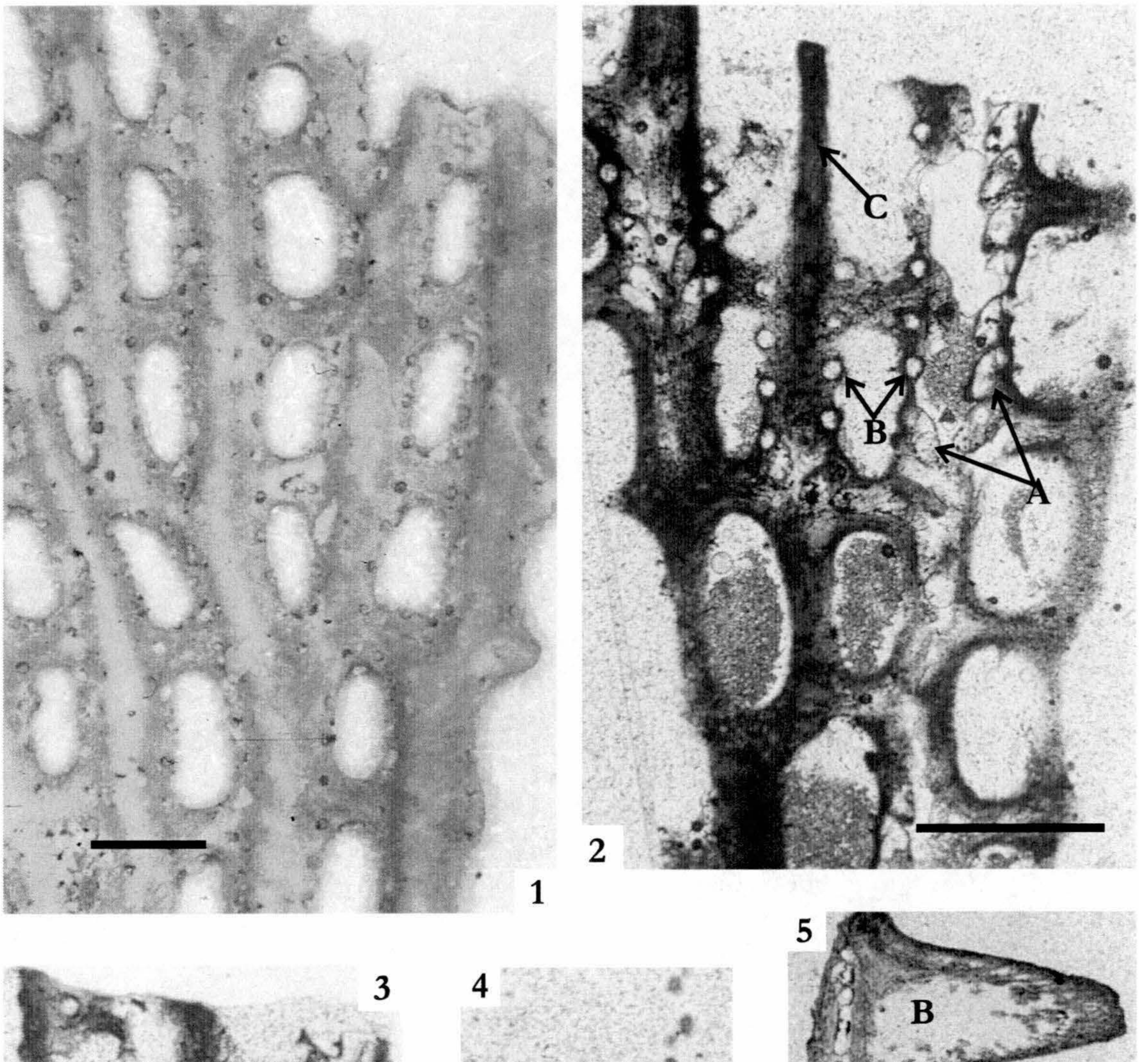

A
C
B
1
2
3
4
C
B
A
5
C
B
A

Plate 48 - *Fabifenestella carinata* n. sp.
All scale bars 1 mm.

1. UTGD 127588, holotype - obverse surface of the zoarium, note the prominent keel, and wide spacing of the apertures across the branch.
2. UTGD 127589, paratype - oblique tangential section showing the fabiform chamber outline, A, the circular apertures, B, and the strong keel, C.
3. UTGD 127589, paratype - tangential section obverse surface the fabiform chamber outline, arrow.
4. UTGD 127589, paratype - detail of the string keel and biserial nodes, arrows.
5. UTGD 127588, holotype - longitudinal section showing the low chamber height, A, and a strong zoarial support, B, developed from the reverse surface.
6. UTGD 127588, holotype - transverse section.



1
2
C
B
A
3
4
5
B
A
6

Plate 49 - *Fabifenestella subthaiensis* n. sp.
All scale bars 1 mm.

1. UTGD 127592, paratype - obverse surface of the zoarium.
2. UTGD 127592, paratype - oblique tangential section showing chamber outline near reverse surface, A, at mid chamber level, B, and near the obverse surface, C. Note also the biserial row of nodes, D.
3. UTGD 127590, holotype - oblique tangential section reverse to obverse surface.
4. UTGD 127592, paratype - tangential section showing detail of upper chamber, apertures, A and biserial nodes, B.
5. UTGD 127590, holotype - transverse section.
6. UTGD 127591, paratype - longitudinal section.

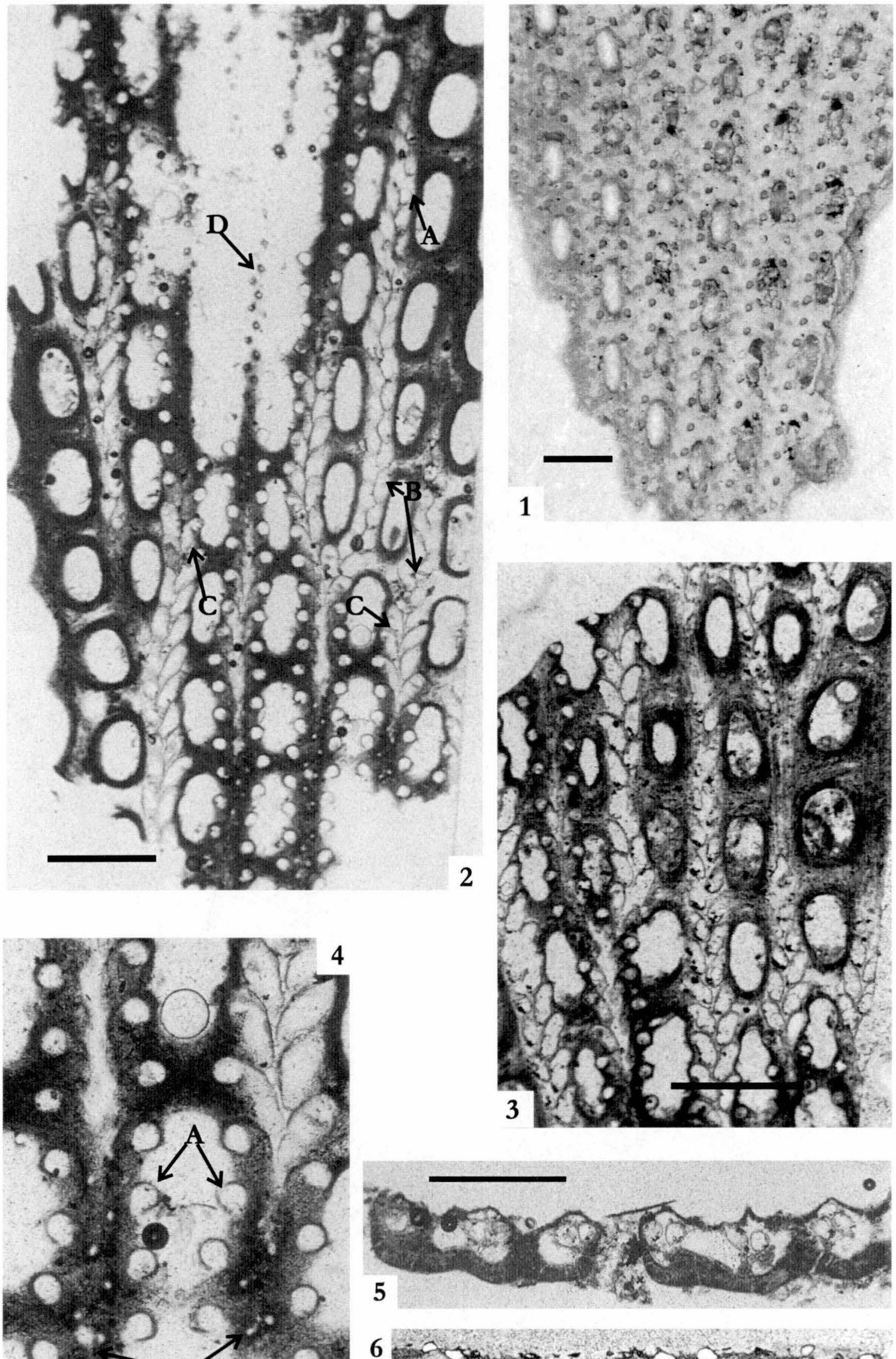

D
A
B
C
C
1
2
3
4
A
B
5
6

Plate 50 - *Flexifenestella hexaformis* n. sp.
All scale bars 1 mm.

1. UTGD 127593, holotype - oblique tangential section reverse to obverse surface, showing the strongly flexuous branches and the tetragonal chamber shape. Note also the longitudinal striae within the reverse wall, arrow.
2. UTGD 127593, holotype - obverse surface of zoarium. Note the interconnected keels of both the branches and dissepiments, and the broad low nodes at their junction, arrow.
3. UTGD 127594, paratype - longitudinal section, showing reverse wall budding angle and hemisepta, arrow.
4. UTGD 127593, holotype - reverse surface of zoarium.
5. UTGD 127594, paratype - oblique tangential section showing the hemisepta, A, circular apertures, B. keel, C, and nodes, D.
6. UTGD 127593, holotype - transverse section showing flattened obverse surface, and corrugated reverse surface, arrow.
7. UTGD 127594, paratype - oblique tangential section.

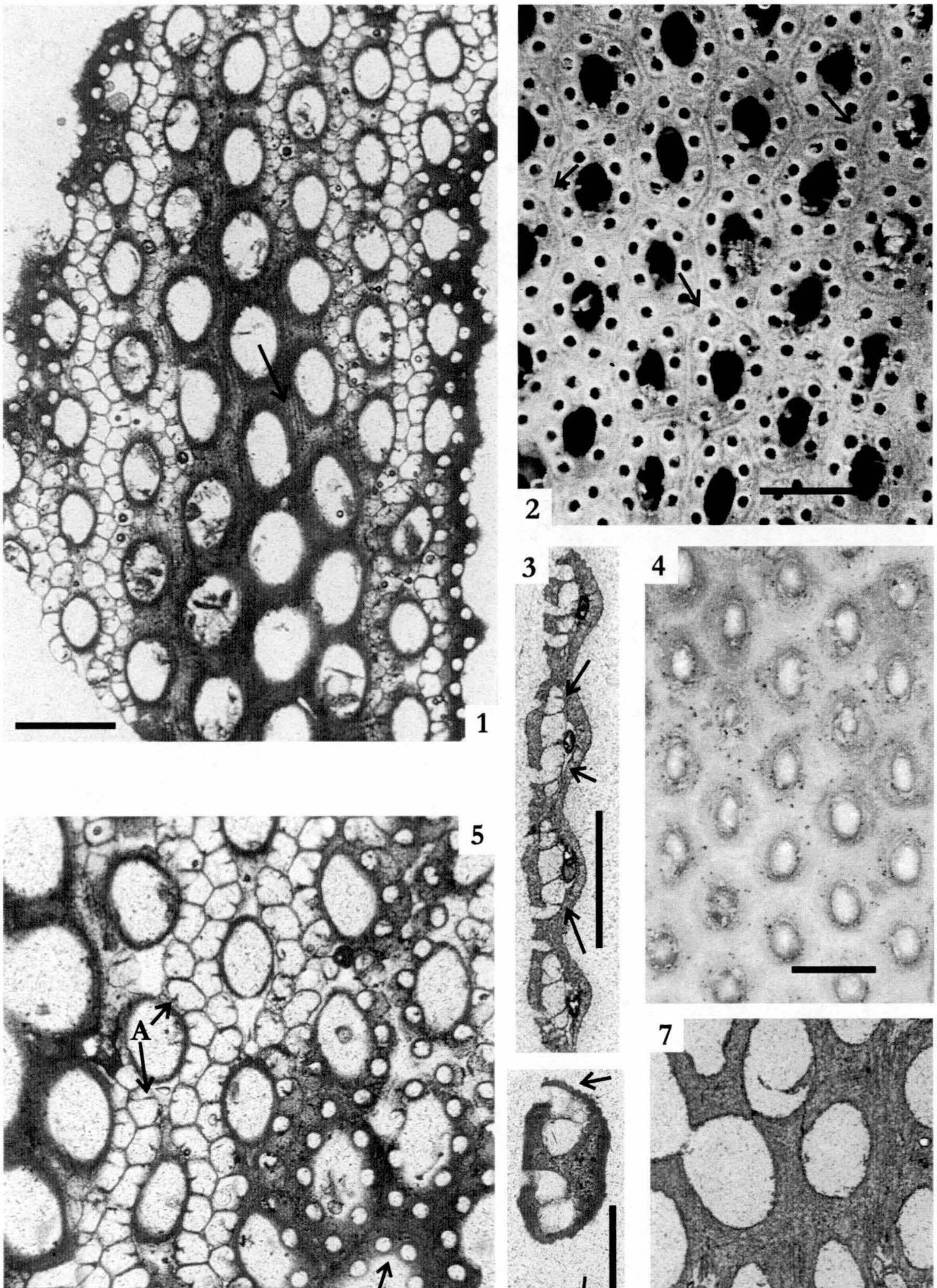

1
2
3
4
5
A
B
C
D
6
7

Plate 51 - *Minilya duplaris* Crockford, 1944
All scale bars 1 mm.

1. UTGD 127597 - oblique tangential section showing fenestrule shape on reverse surface, chamber outline near reverse, A, and at mid chamber, B.
2. UTGD 127595 - oblique tangential section, showing the hourglass shape of the fenestrules on obverse, chamber outline near obverse surface, A, and at mid chamber, B, and the arrangement of the apertures.
3. UTGD 127595 - oblique tangential section, showing the biserial nodes, arrow.
4. UTGD 127597 - tangential section reverse surface, showing the reverse surface macrostylets, arrows.
5. UTGD 127595 - longitudinal section.
6. UTGD 127597 - transverse section.

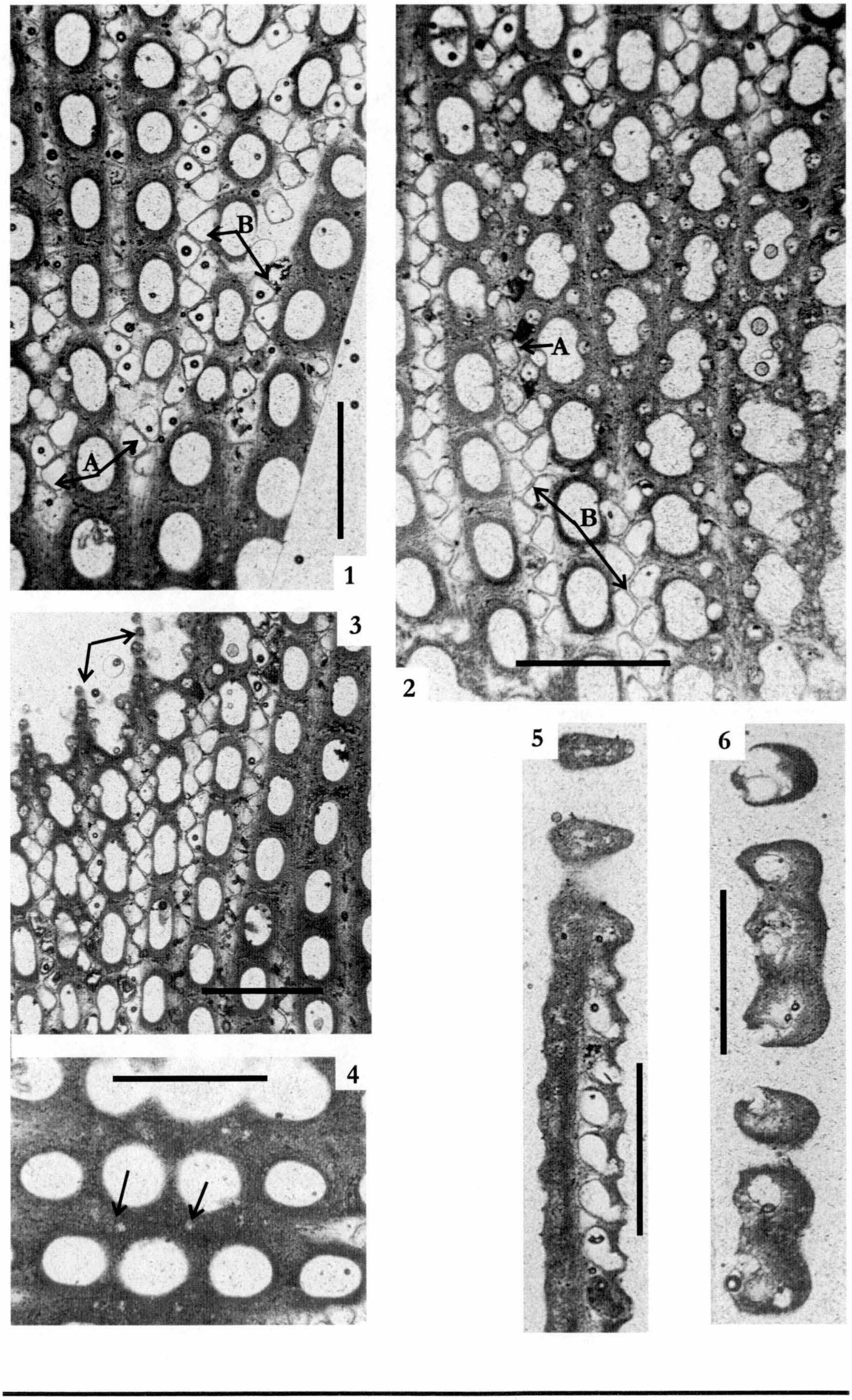

B
A
1
A
B
2
3
4
5
6

Plate 52 - *Minilya phiphiensis* n. sp.
All scale bars 1 mm.

1. UTGD 127598, holotype - obverse surface of the zoarium, showing the hourglass shaped fenestrules, thin dissepiments and form of the mesh.
2. UTGD 127598, holotype - oblique tangential section, showing chamber outline at reverse, A, mid chamber, B, and near obverse, C.
3. UTGD 127598, holotype - tangential section obverse surface, showing circular apertures, A, and biserial nodes, B.
4. UTGD 127598, holotype - transverse section.
5. UTGD 127598, holotype - longitudinal section.

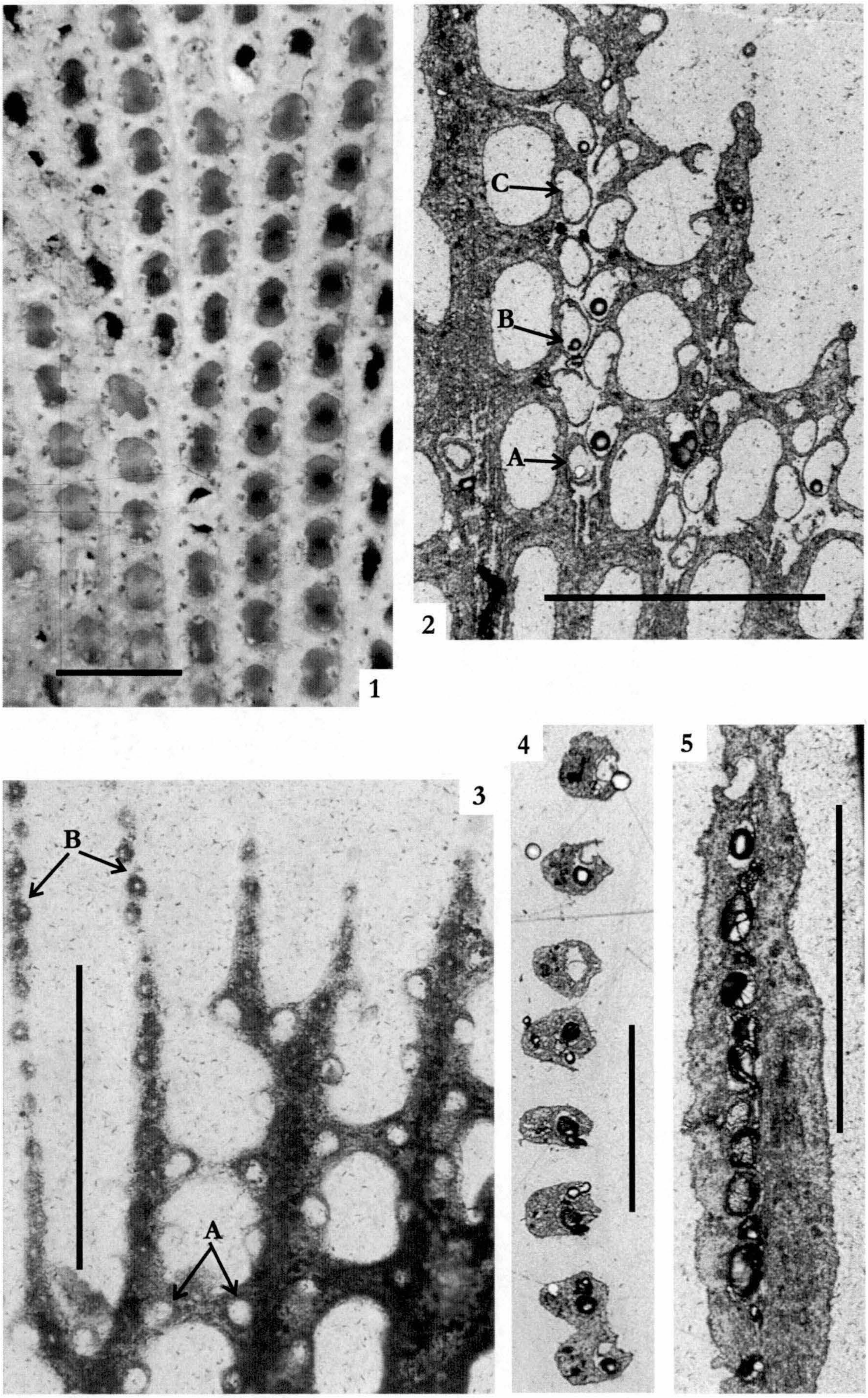

1
C
B
A
2
B
A
3
4
5

Plate 53 - *Rectifenestella pulchradorsalis* (Bassler, 1929).
All scale bars 1 mm.

1. UTGD 127599 - obverse surface of the zoarium.
2. UTGD 127599 - oblique tangential peel showing chamber outline at mid chamber level, A, and near the obverse surface, B.
3. UTGD 127599 - oblique tangential section.
4. UTGD 127599 - tangential section obverse surface, showing apertural shape and orientation, A, and the widely spaced nodes, B.
5. UTGD 127599 - longitudinal section.
6. UTGD 127599 - transverse section.

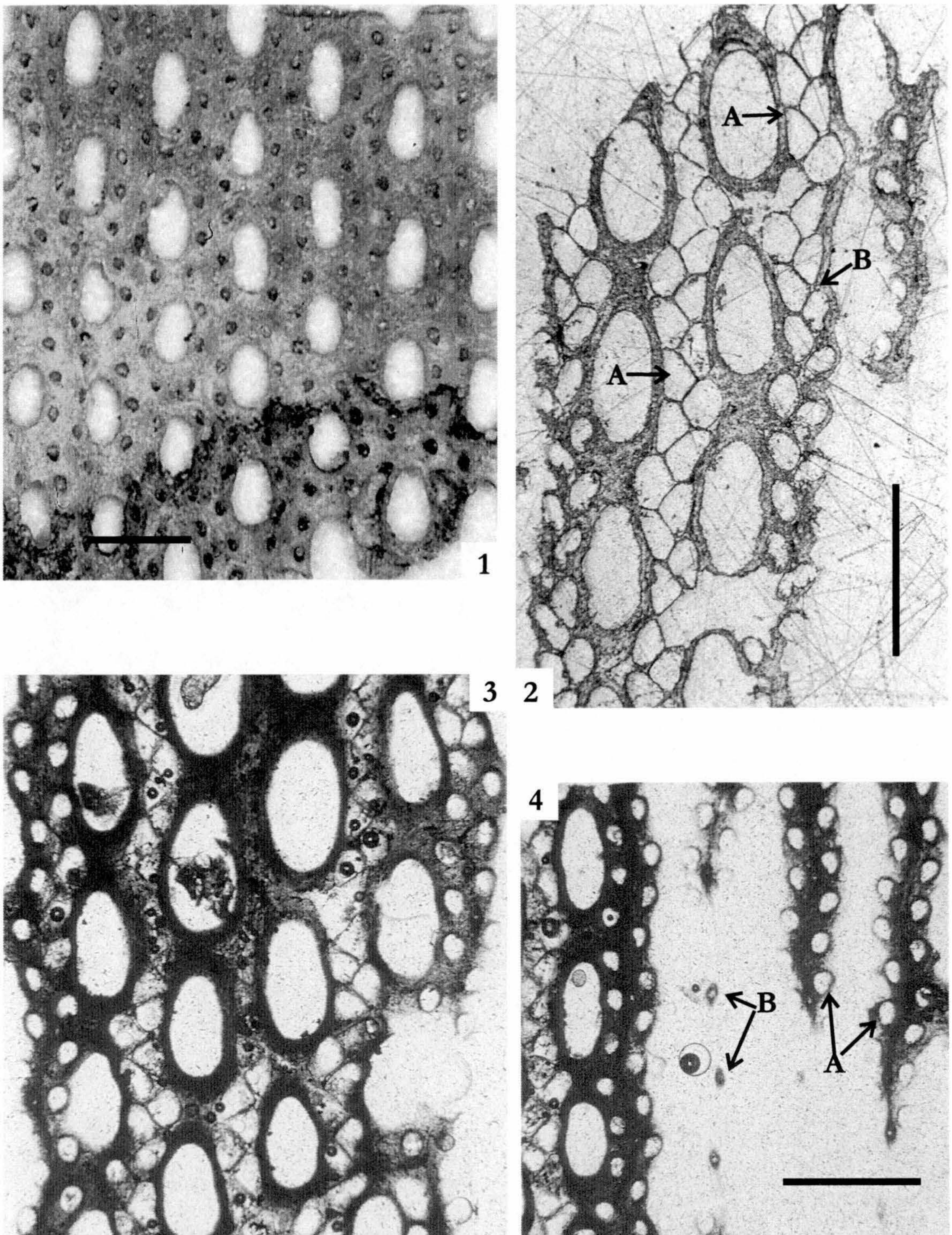

1
A
A
B
2
3
4
B
A
5
6

Plate 54 - *Spinofenestella flanchea* n. sp.
All scale bars 1 mm.

1. UTGD 127600, holotype - obverse surface of the zoarium, showing the prominent apertural peristomes for this species is named.
2. UTGD 127600, holotype - reverse tangential section showing fenestrule shape at reverse and macrostylets, arrows.
3. UTGD 127600, holotype - oblique tangential section showing the triangular chambers, A, the strong longitudinal striae in the reverse wall, B, and the large nodes, C.
4. UTGD 127600, holotype - oblique tangential section obverse to reverse surface, showing the skeletal structures associated with the branches and dissepiments, arrows.
5. UTGD 127600, holotype - transverse section.
6. UTGD 127600, holotype - longitudinal section.

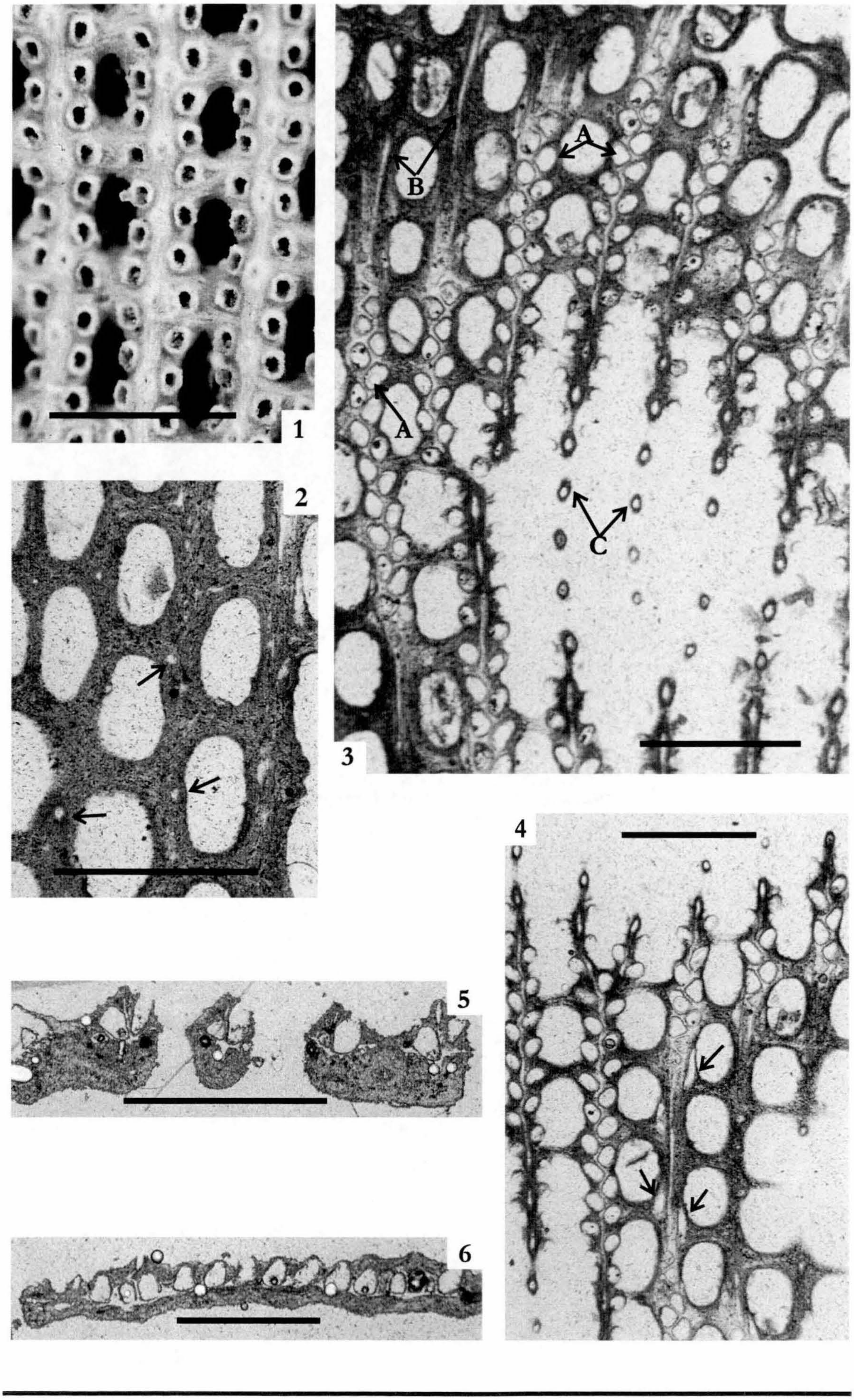

1
2
3
A
B
A
C
4
5
6

Plate 55 - *Spinofenestella horologia* (Bretnall, 1926)
All scale bars 1 mm.

1. UTGD 127601 - obverse surface of zoarium.
2. UTGD 127601 - oblique tangential section reverse to obverse surface , showing the triangular chamber outline, arrows.
3. UTGD 127601 - tangential section showing chamber outline, A, circular apertures, B, and monoserial nodes, C.
4. UTGD 127601 - oblique tangential section.
5. UTGD 127601 - transverse section.
6. UTGD 127601 - longitudinal section showing high reverse wall budding angle.

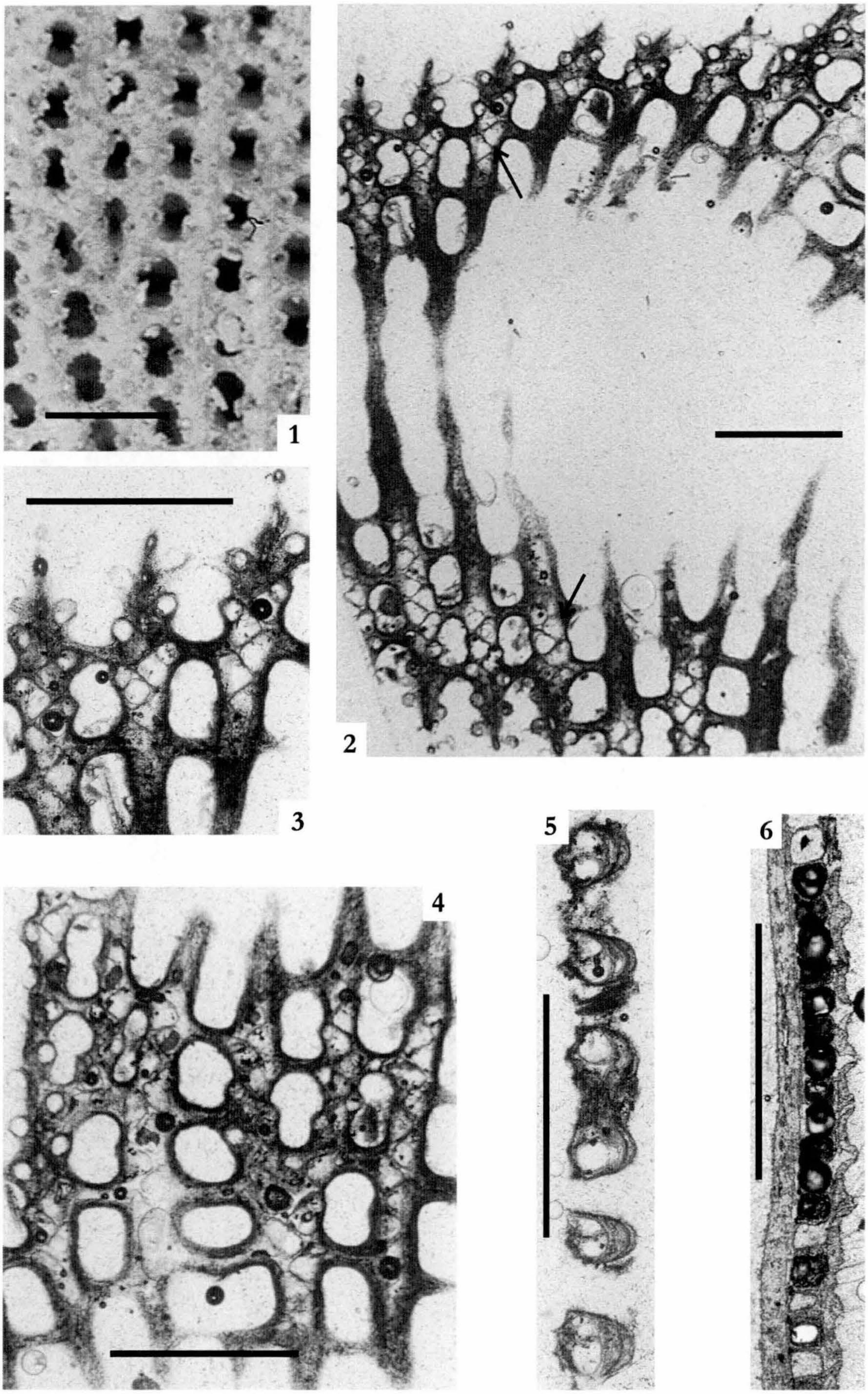

1
2
3
4
5
6

Plate 56 - *Spinofenestella lekformis* n. sp.
All scale bars 1 mm.

1. UTGD 127602, holotype - obverse surface of the zoarium, showing the wide branches and narrow fenestrules.
2. UTGD 127602, holotype - reverse surface of the zoarium.
3. UTGD 127604, paratype - oblique tangential section reverse to obverse surface, showing the triangular chamber outline, A, the circular apertures, B. and the monoserial nodes, C.
4. UTGD 127604, paratype - transverse section.
5. UTGD 127603, paratype - longitudinal section.

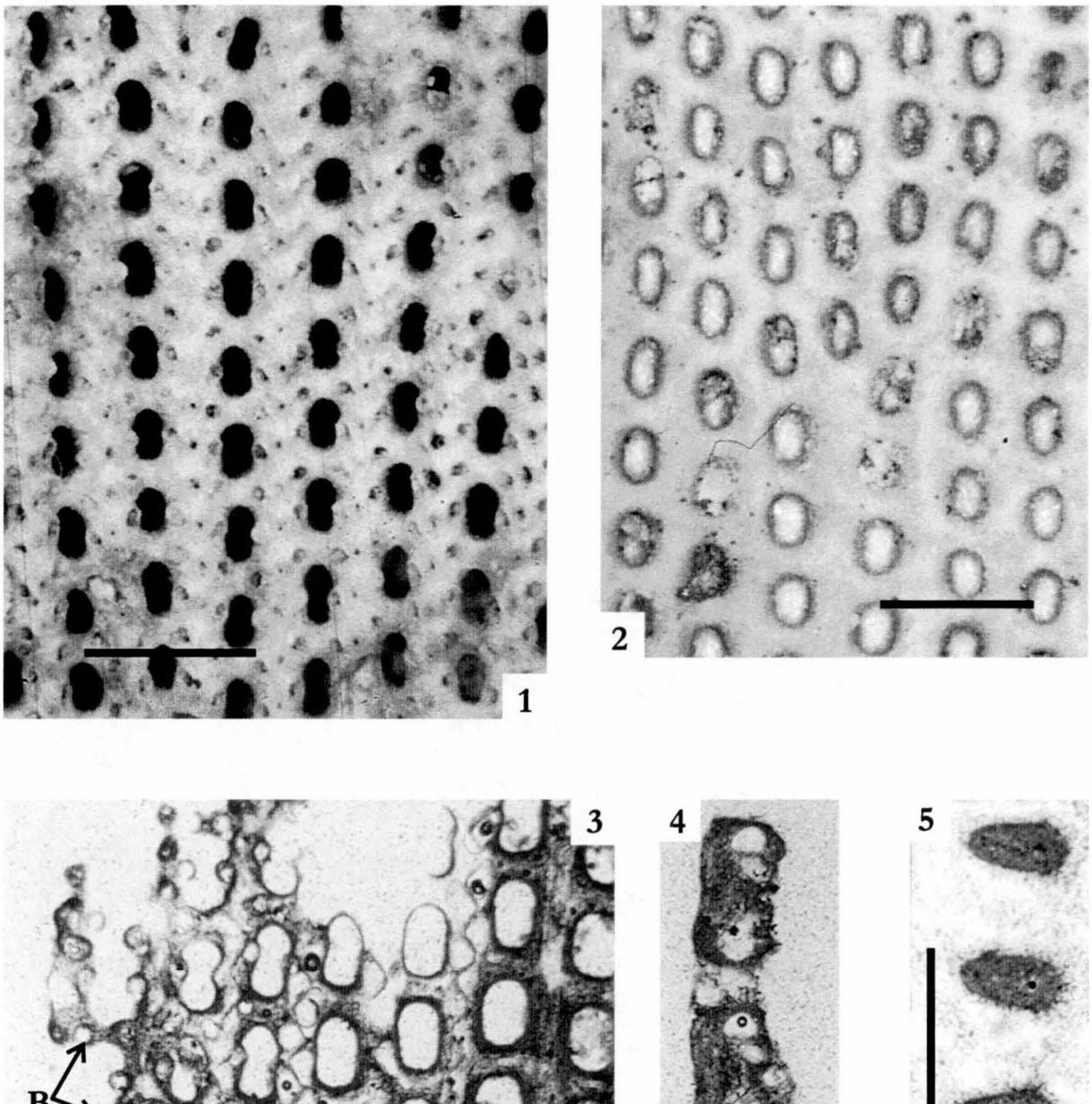

1
2
3
4
5
A
B
C

Plate 57 - *Spinofenestella pseudohorologia* n. sp.
All scale bars 1 mm.

1. UTGD 127606, paratype - tangential section showing triangular chamber outline, A, the circular apertures, B, monoserial nodes, C, and large apertural stylets, D.
2. UTGD 127605, holotype - tangential section.
3. UTGD 127605, holotype - tangential section. Note the strong longitudinal striae, arrow.
4. UTGD 127605, holotype - transverse section showing the sharp nodes, A, and recessed dissepiments, B.
5. UTGD 127605, holotype - oblique tangential section showing the sometimes thick wall between chambers at the reverse surface, arrows.

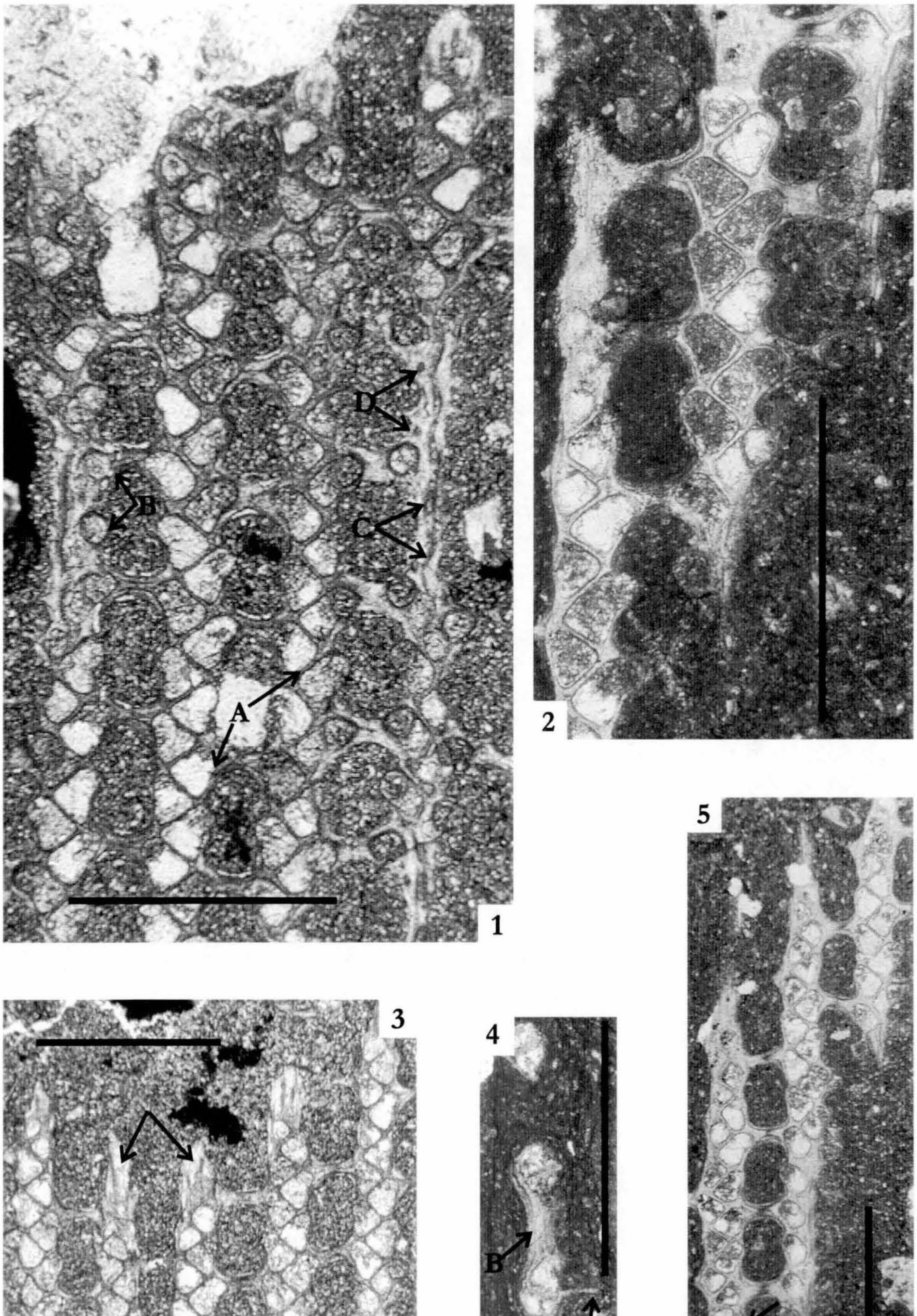

1
A
B
C
D
2
3
4
A
B
5

Plate 58 - *Mackinneyella nodosa* n. sp.
All scale bars 1 mm.

1. UTGD 127608, paratype - obverse surface of whole zoarium. Note the zoarial base.
2. UTGD 127608, paratype - oblique tangential section, showing macrostylets of the reverse surface, A, chamber outline, B, and apertural arrangement, C.
3. UTGD 127608, paratype - tangential section showing chamber outline near the reverse surface, A, at mid chamber, B, and near obverse, C.
4. UTGD 127607, holotype - tangential section obverse surface, showing the arrangement of the apertures, A, and the large nodes, B.
5. UTGD 127607, holotype - longitudinal section, showing chamber outline and high reverse wall budding angle. Note also the prominence of the nodes, arrow, on the obverse.
6. UTGD 127607, holotype - transverse section.

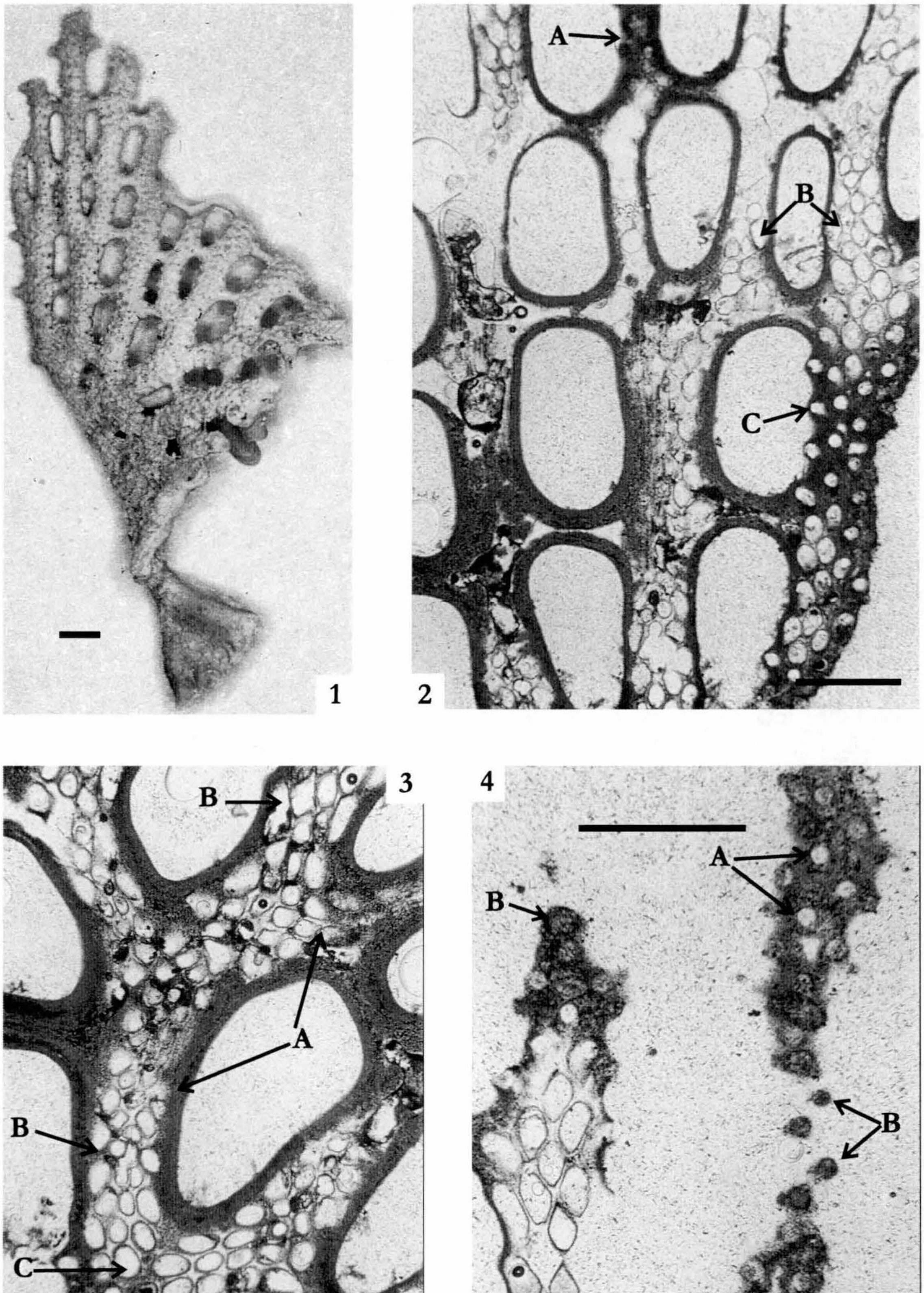
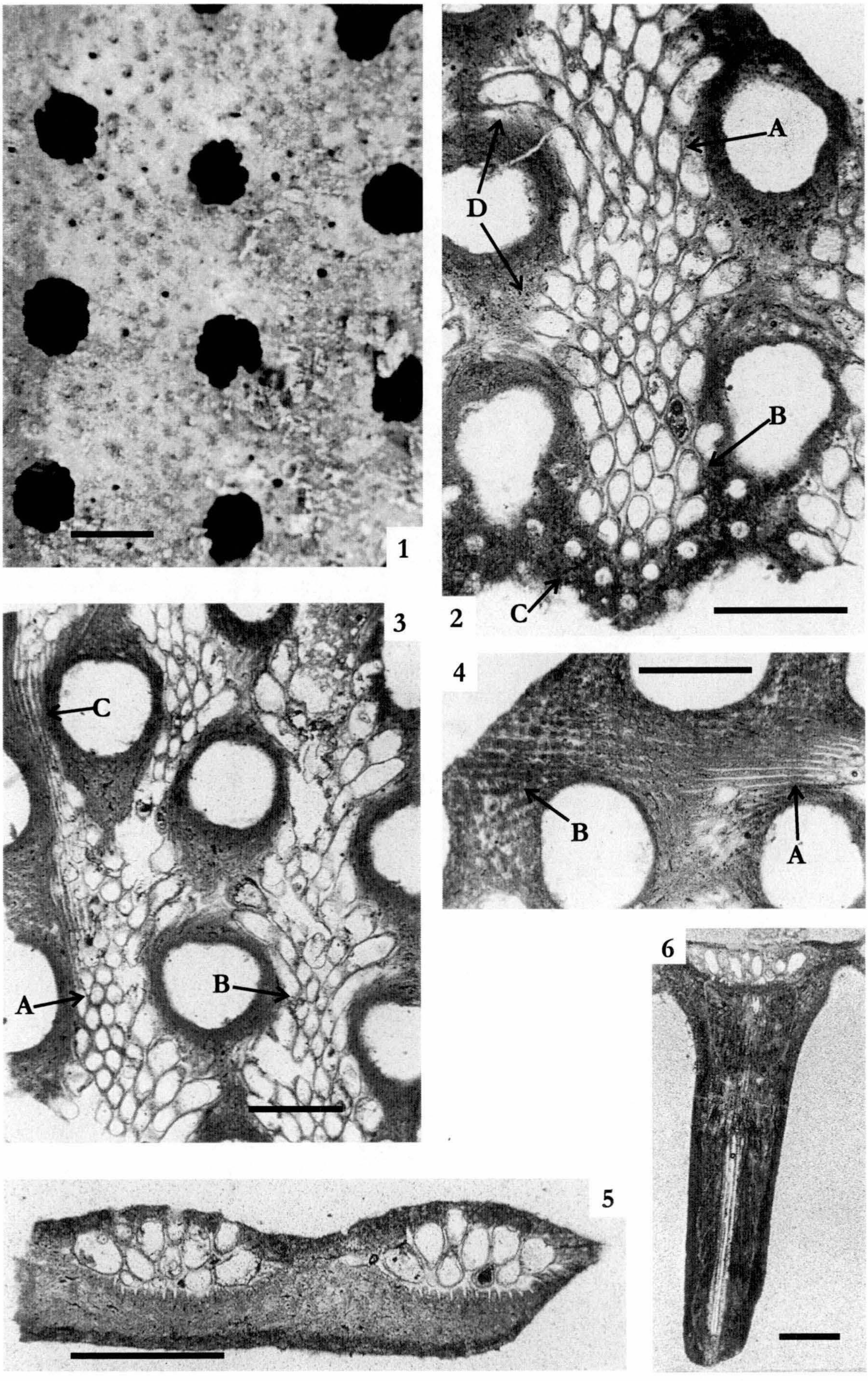

1
2
A
B
C
3
4
A
B
C
A
B
B
5
6

Plate 59 - *Mackinneyella supraobesa* n. sp.
All scale bars 1 mm.

1. UTGD 127609, holotype - obverse surface of the zoarium.
2. UTGD 127609, holotype - oblique tangential section, showing chamber outline at mid chamber level, A, and near obverse, B. Note also the arrangement of the apertures, C, and the lateral rows of zooecia bending onto the dissepiments, D.
3. UTGD 127609, holotype - oblique tangential section, showing chamber outline near the reverse surface, A, and at mid chamber level, B. Note also the fine and numerous longitudinal striae, C.
4. UTGD 127609, holotype - tangential section of the reverse surface, showing the fine longitudinal striae, A, and reverse macrostylets, B.
5. UTGD 127609, holotype - transverse section.
6. UTGD 127610, paratype - transverse section showing strong zoarial support developed from the reverse surface.



1
D
A
B
C
2
3
C
A
B
4
B
A
5
6

Plate 60 - *Polypora canalis* n. sp.
All scale bars 1 mm.

1. UTGD 127611, holotype - reverse surface of the zoarium, showing the groove in the reverse wall of the branches and dissepiments, arrows.
2. UTGD 127611, holotype - obverse surface of the zoarium.
3. UTGD 127611, holotype - oblique tangential section, showing chamber outline near reverse, A, at mid chamber, B, and near the obverse surface, C.
4. UTGD 127612, paratype - oblique tangential section obverse to reverse, showing the hexagonal chamber outline, A, circular apertures, B, and nodes, C.
5. UTGD 127612, paratype - tangential section reverse surface, showing the groove in the reverse wall of the branches and dissepiments, arrows.
6. UTGD 127612, paratype - longitudinal section.
7. UTGD 127612, paratype - transverse section, showing the outline of the groove on the reverse surface, arrows.

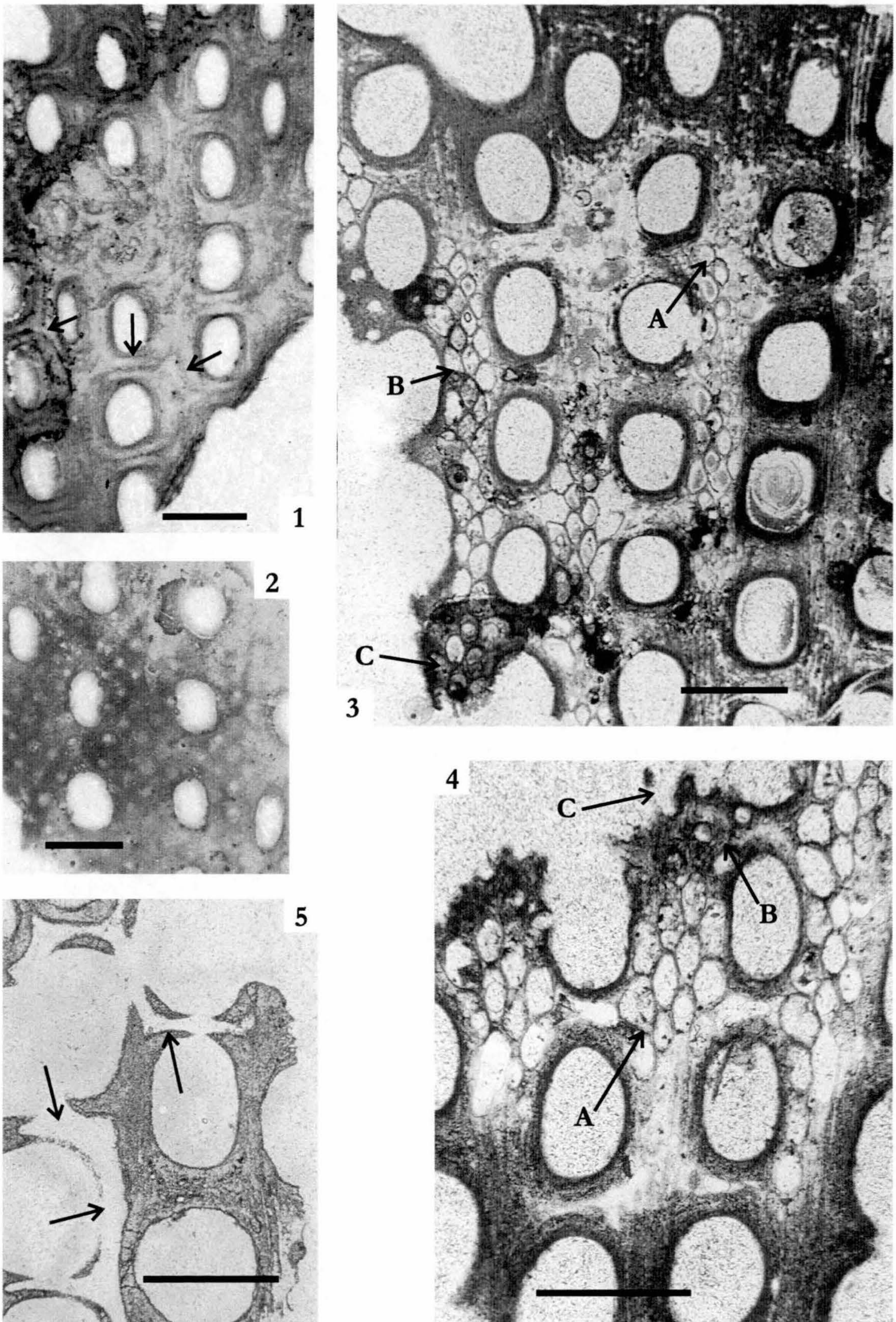

1
2
3
A
B
C
4
C
B
A
5
6
7

Plate 61 - *Polypora nodulifera* n. sp.
All scale bars 1 mm.

1. UTGD 1217613, holotype - oblique tangential section reverse to obverse surface.
2. UTGD 1217613, holotype - tangential section showing the rhombic chamber outline and the thin dissepiments, arrow.
3. UTGD 127614, paratype - tangential section obverse to reverse, showing large macrostylets of the reverse surface, A, and the nodes and Apertures of the obverse surface, B.
4. UTGD 127615, paratype - tangential section obverse, showing the circular apertures, A, the large nodes, B, and the fine evenly spaced obverse stylets, C.
5. UTGD 1217613, holotype - transverse section showing the height of the nodes, arrows, and their effect on the obverse surface profile.
6. UTGD 1217613, holotype - longitudinal section.

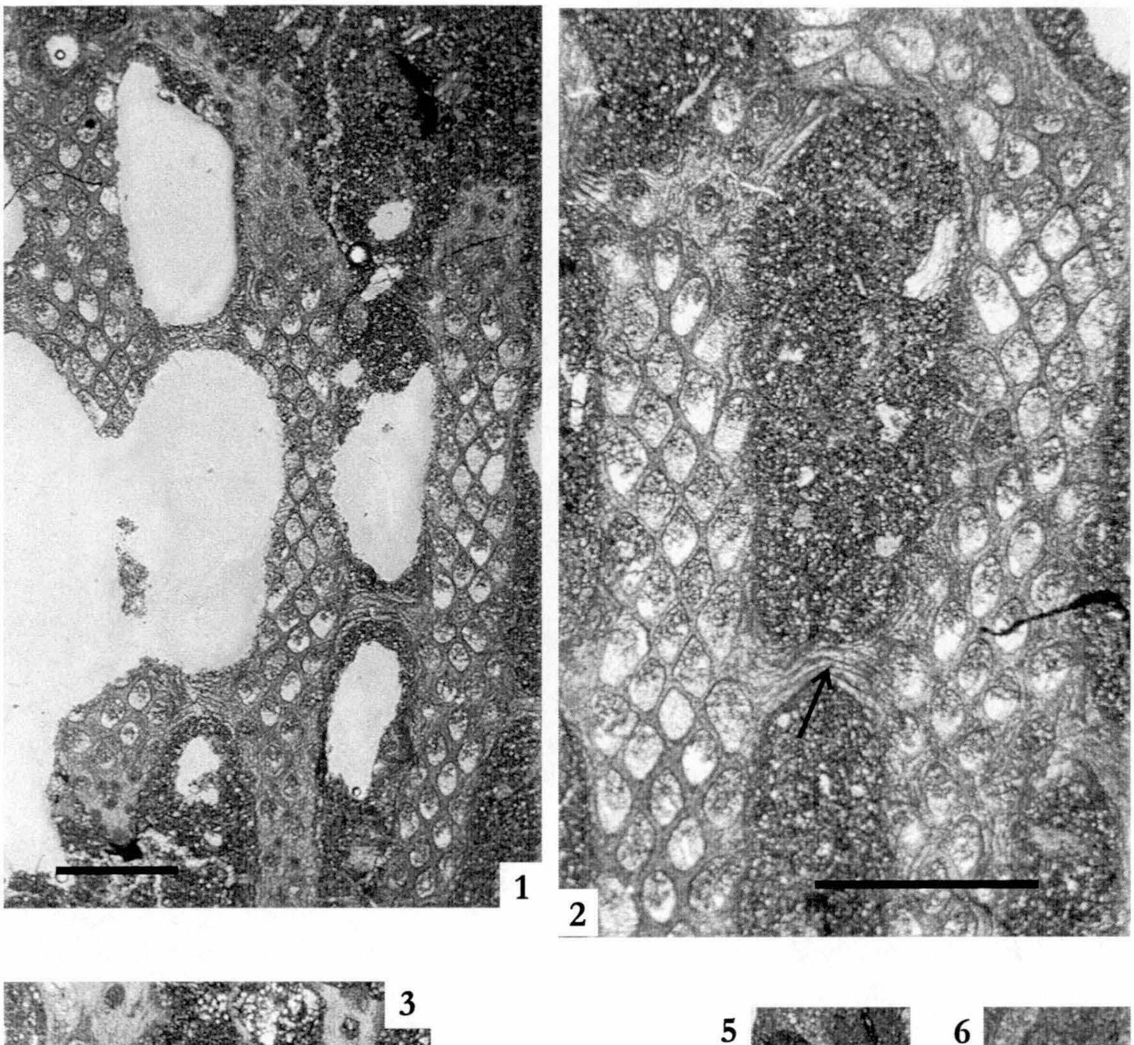

1
2
3
B
A
4
A
B
5
6

Plate 62 - *Shulgapora megacyclopora* n. sp.
All scale bars 1 mm.

1. UTGD 127616, holotype - reverse surface of the zoarium.
2. UTGD 127616, holotype - oblique tangential section showing the macrostylets, arrow, on the reverse surface.
3. UTGD 127616, holotype - oblique tangential section showing the chamber outline near reverse, A, at mid chamber, B, and near obverse, C. Note also how zooecia of lateral rows indent zooecia.
4. UTGD 127618, paratype - tangential section reverse surface, showing the numerous fine longitudinal striae.
5. UTGD 127616, holotype - tangential section obverse surface, showing the apertures, A, and large cyclozooecia, B.
6. UTGD 127617, paratype - longitudinal section, showing cyclozooecia within the frontal wall, arrows.
7. UTGD 127616, holotype - transverse section showing the rounded triangular outline of the branches.

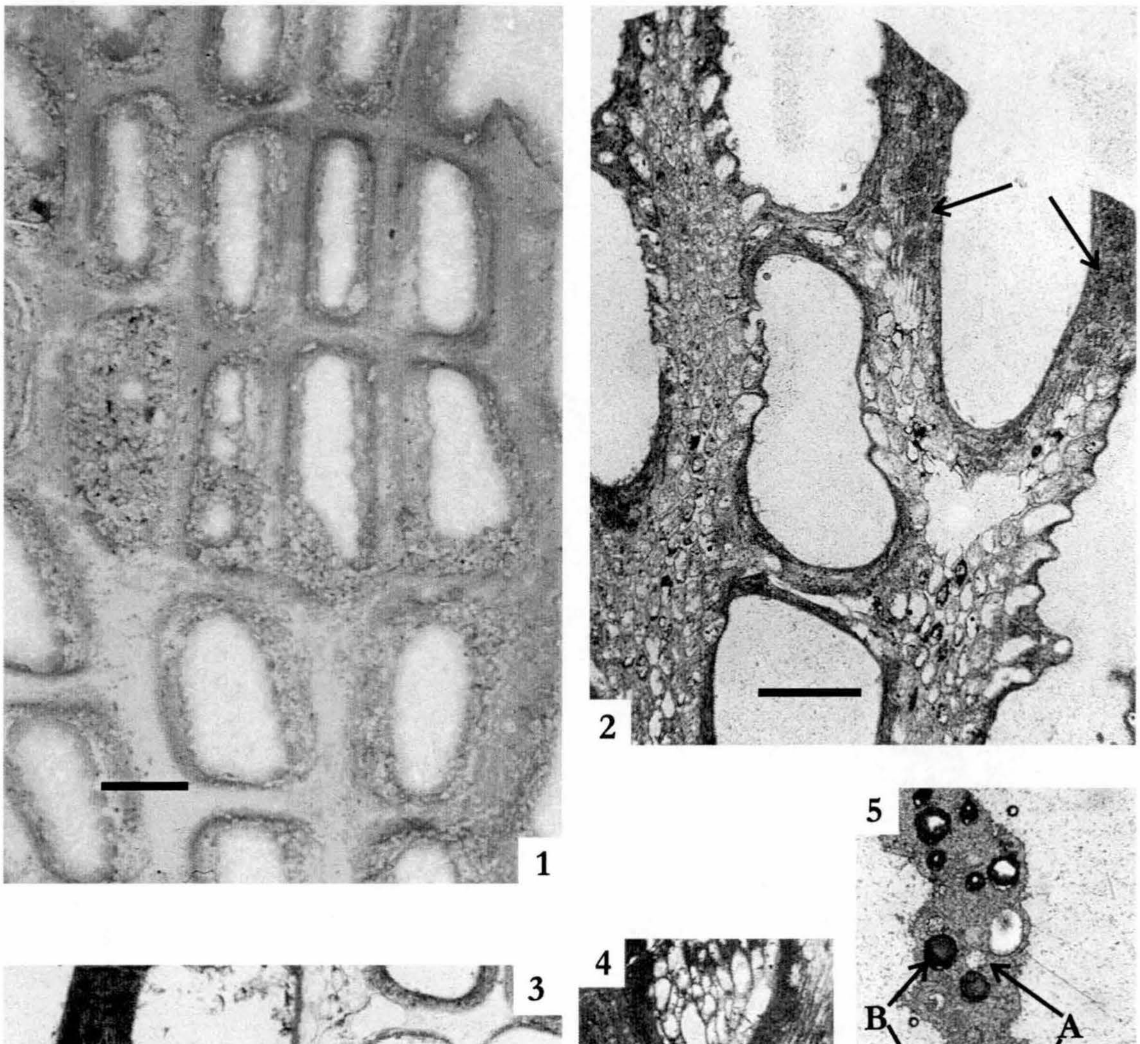

1
2
3
A
B
C
4
5
B
A
6
7

Plate 63 - *Shulgapora reversa* n. sp.
All scale bars 1 mm.

1. UTGD 127619, holotype - oblique tangential section, showing the large apertures on the obverse surface, A, and the cyclozooecia, B, on the reverse.
2. UTGD 127619, holotype - tangential section obverse surface, showing large apertures and absence of stylets or cyclozooecia.
3. UTGD 127619, holotype - oblique tangential section.
4. UTGD 127619, holotype - transverse section.
5. UTGD 127619, holotype - longitudinal section.

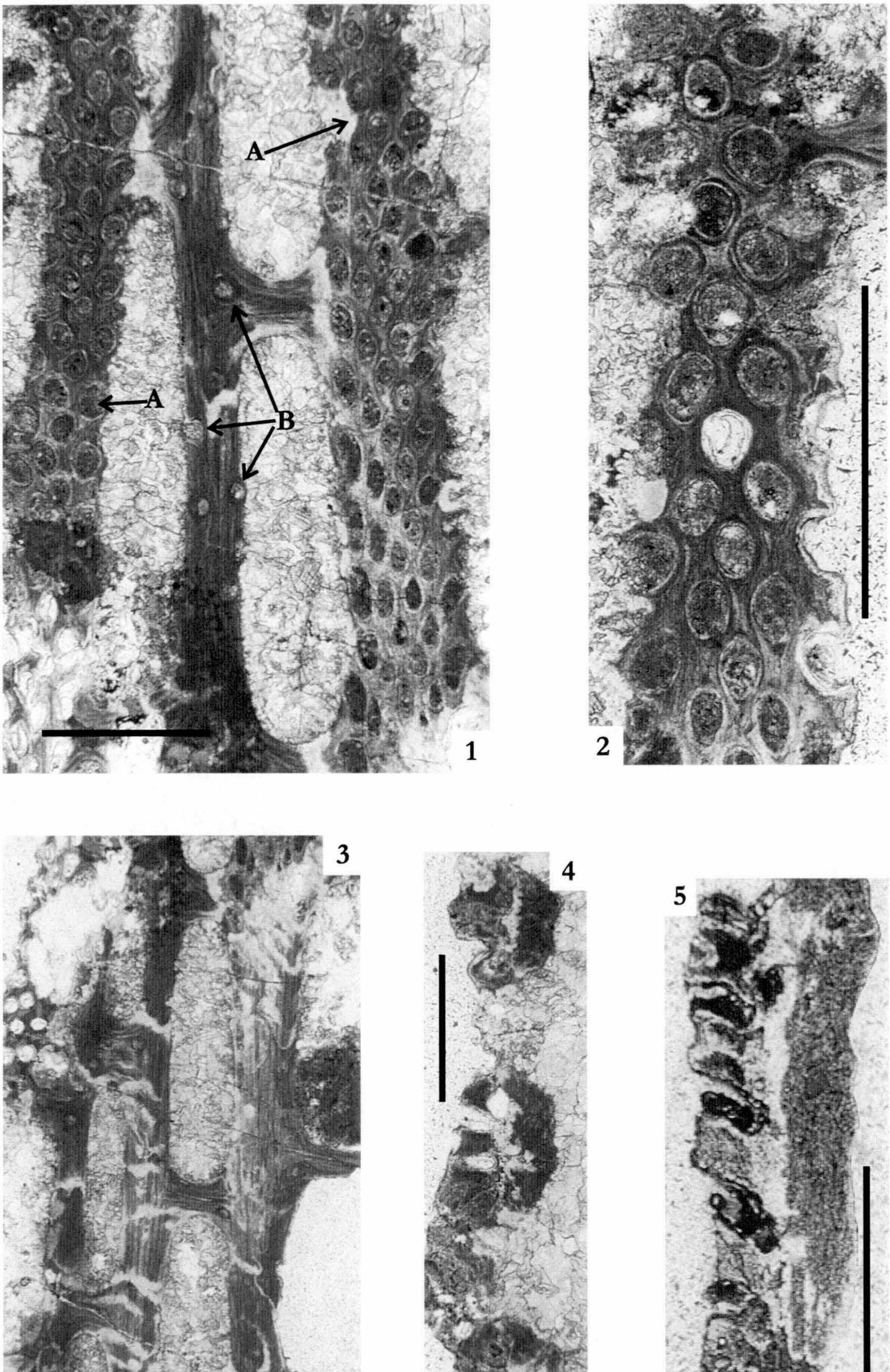

A
A
B
1
2
3
4
5

Plate 64 - *Reteporidra yongkasemensis* n. sp.
All scale bars 1 mm.

1. UTGD 127620, holotype - tangential section showing chamber outline and anastomosing branches, arrows.
2. UTGD 127620, holotype - tangential section obverse surface, showing the large circular apertures, A, nodes on apertural rim, B, and the obverse stylets, C.
3. UTGD 127620, holotype - tangential section reverse surface, showing microstylets clustered to form macrostylets.
4. UTGD 127620, holotype - tangential section.
5. UTGD 127620, holotype - transverse section.
6. UTGD 127620, holotype - longitudinal section.

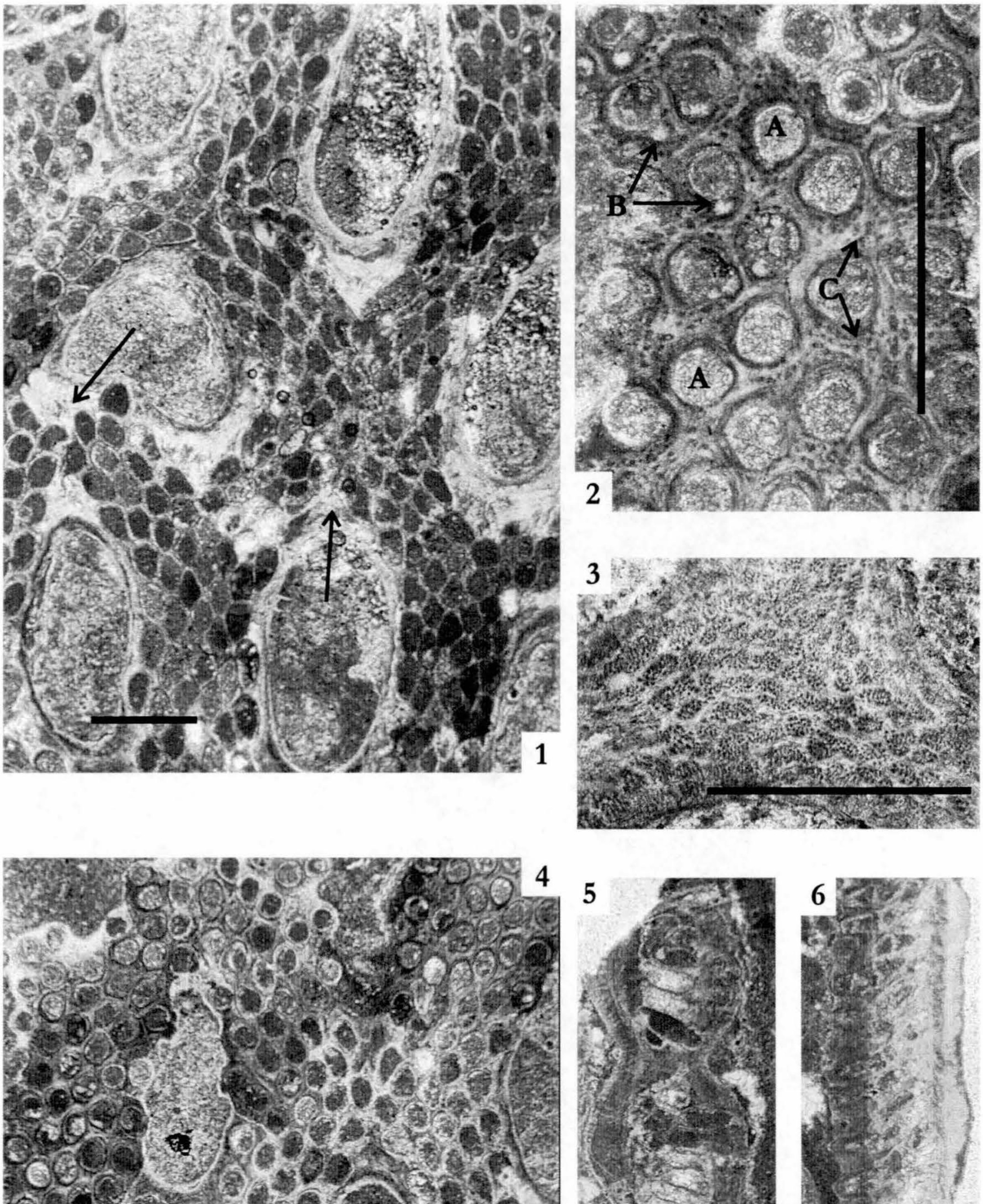

1
2
A
A
B
C
3
4
5
6

Plate 65 - *Septopora interformis* n. sp.
All scale bars 1 mm.

1. UTGD 127621, holotype - obverse surface of the zoarium.
2. UTGD 127621, holotype - tangential section obverse surface, showing the double row of zooecia on both the primary and lateral branches.
3. UTGD 127621, holotype - tangential section reverse to obverse surface.
4. UTGD 127621, holotype - tangential section obverse surface, showing the large apertures, A, small cyclozooecia, B, and the stellate nodes, C.
5. UTGD 127621, holotype - tangential section showing detail of cyclozooecia, A, and nodes, B.

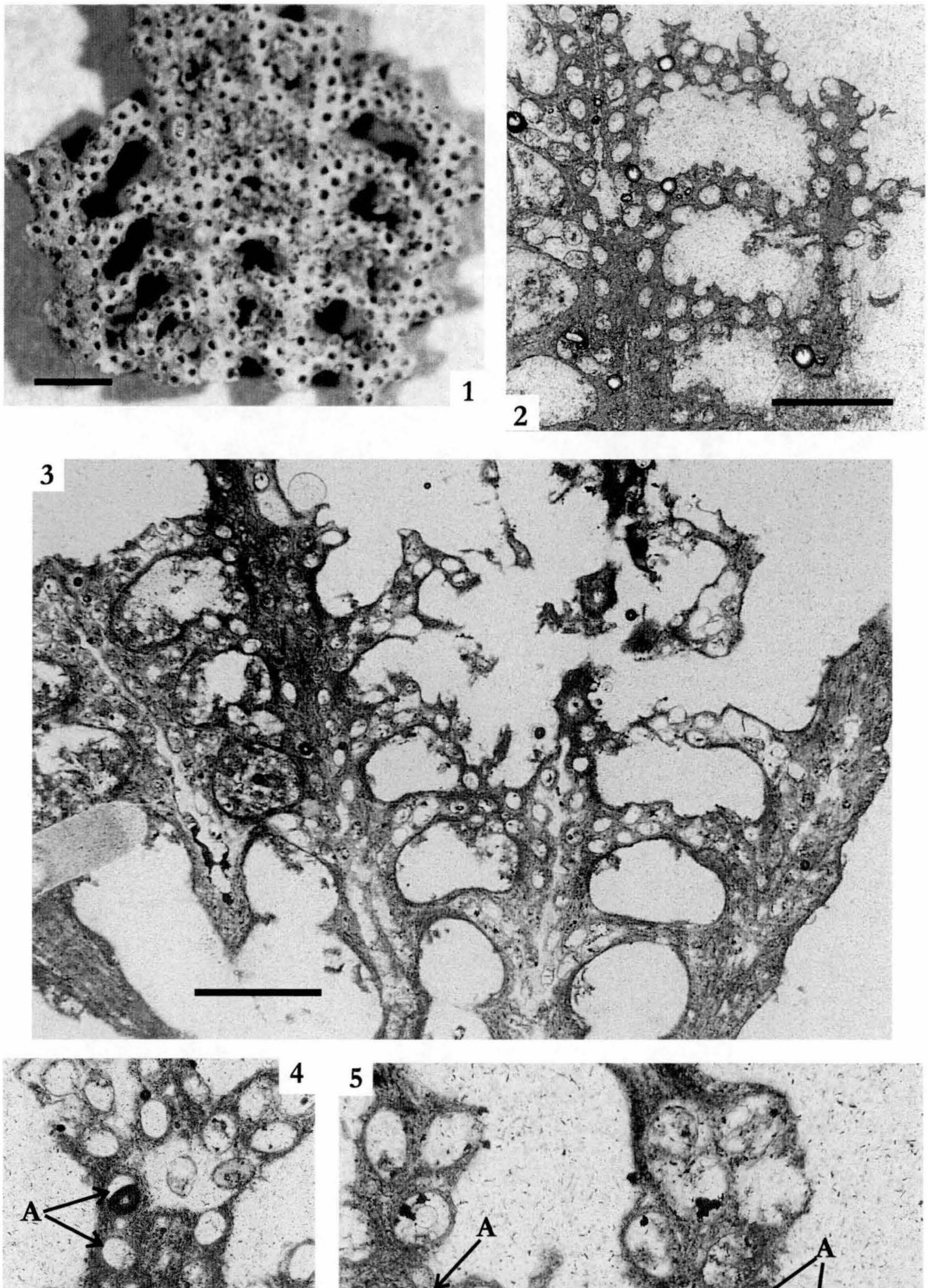

1
2
3
4
A
B
C
5
A
A
B

Plate 66 - *Synocladia irregularis* n. sp.
All scale bars 1 mm.

1. UTGD 127623, holotype - oblique tangential section showing the primary, A, and lateral branches, B.
2. UTGD 127623, holotype - tangential section reverse surface, showing the chamber outline near the reverse wall, A, cyclozooecia, B, and reverse wall ornamentation, C.
3. UTGD 127623, holotype - tangential section obverse surface, showing the large apertures, A, cyclozooecia, B, and nodes, C.
4. UTGD 127623, holotype - tangential section.
5. UTGD 127623, holotype - transverse section.
6. UTGD 127623, holotype - longitudinal section.

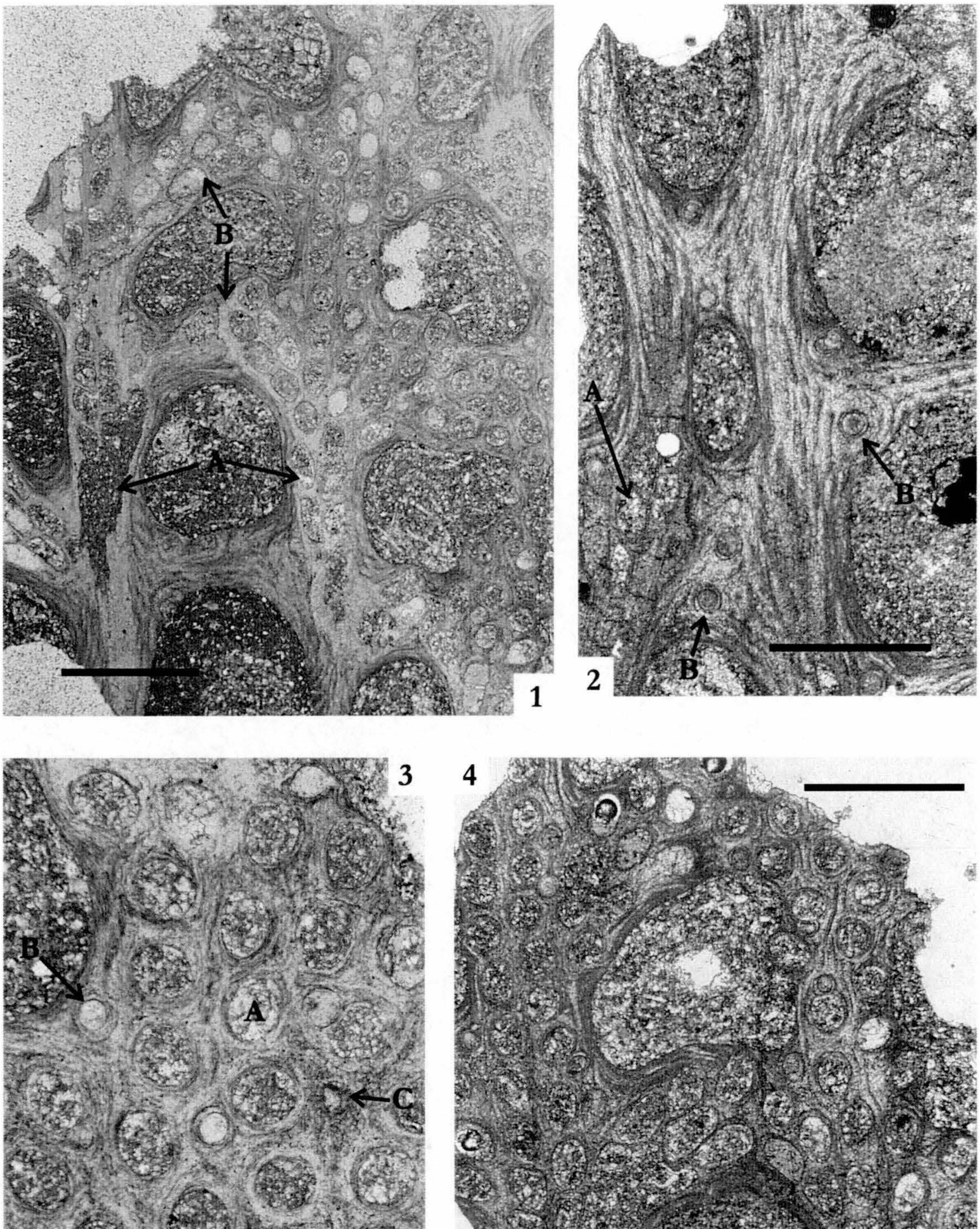

B
B
A
1
A
B
B
2
3
B
A
C
A
4
5
6

Plate 67 - *Penniretepora subtropica* n. sp.
All scale bars 1 mm.

1. UTGD 127624, holotype - obverse surface of the zoarium.
2. UTGD 127624, holotype - tangential section, showing chamber outline on main branch, A, and lateral branches, B. Note also the wide space between the chambers, C.
3. UTGD 127624, holotype - tangential section.
4. UTGD 127624, holotype - longitudinal section.
5. UTGD 127624, holotype - tangential section, showing chamber outline near obverse, A, and apertures, B.
6. UTGD 127624, holotype - transverse section main branch, at level of bifurcation of two lateral branches.

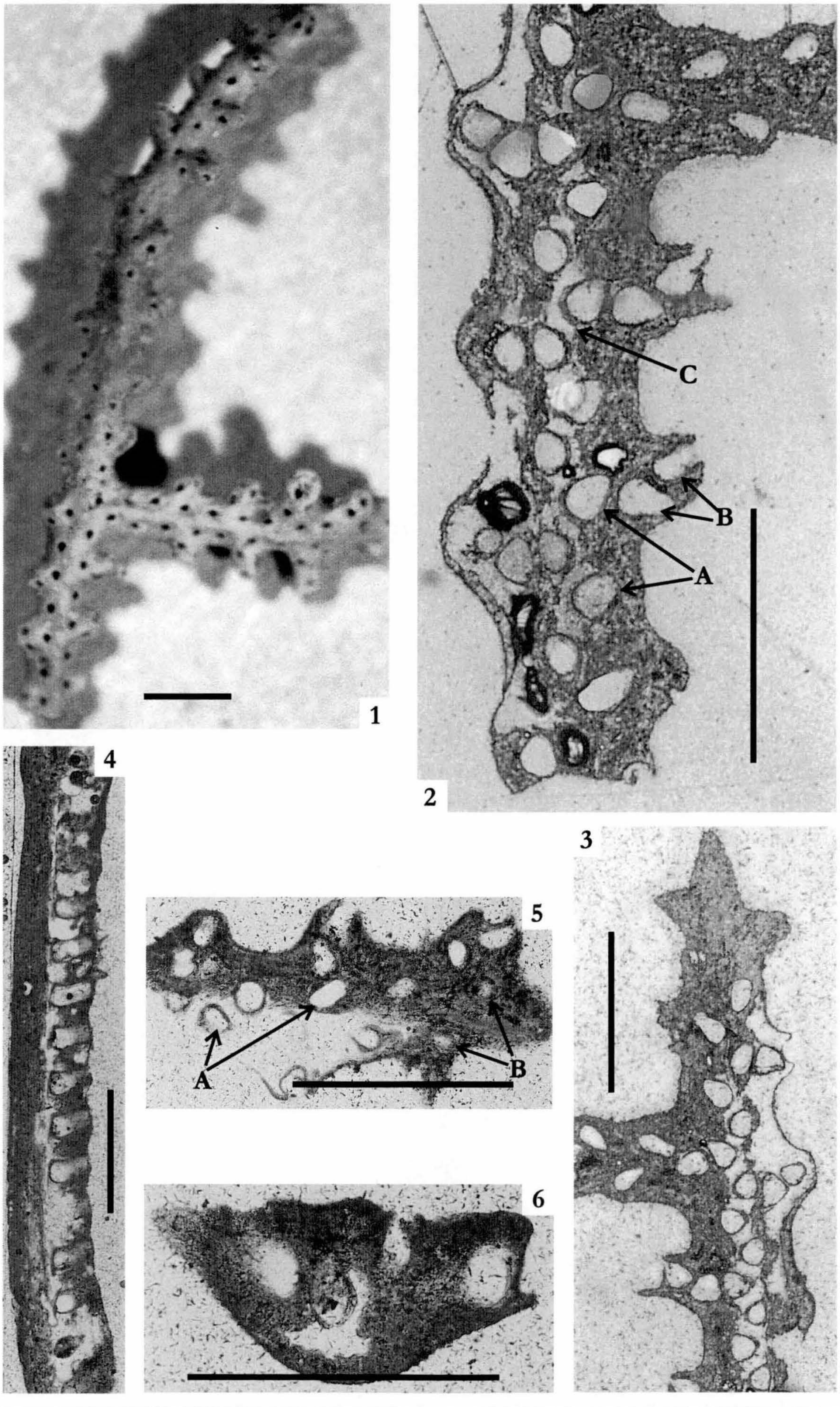

1
2
C
B
A
3
4
5
A
B
6

Plate 68 - *Acanthocladia pseudothaiensis* n. sp.
All scale bars 1 mm, except Figure 3 which is 0.5 mm.

1. UTGD 127626, paratype - tangential section showing chamber outline on the main branch, A, and on lateral branches, B.
2. UTGD 127627, paratype - tangential section.
3. UTGD 127625, holotype - tangential section obverse surface, showing the circular apertures, A, nodes, B, and obverse stylets, C.
4. UTGD 127625, holotype - longitudinal section.
5. UTGD 127625, holotype - tangential section reverse surface, showing the reverse macrostylets, arrows.
6. UTGD 127626, paratype - tangential section of lateral branches.
7. UTGD 127627, paratype - transverse section.

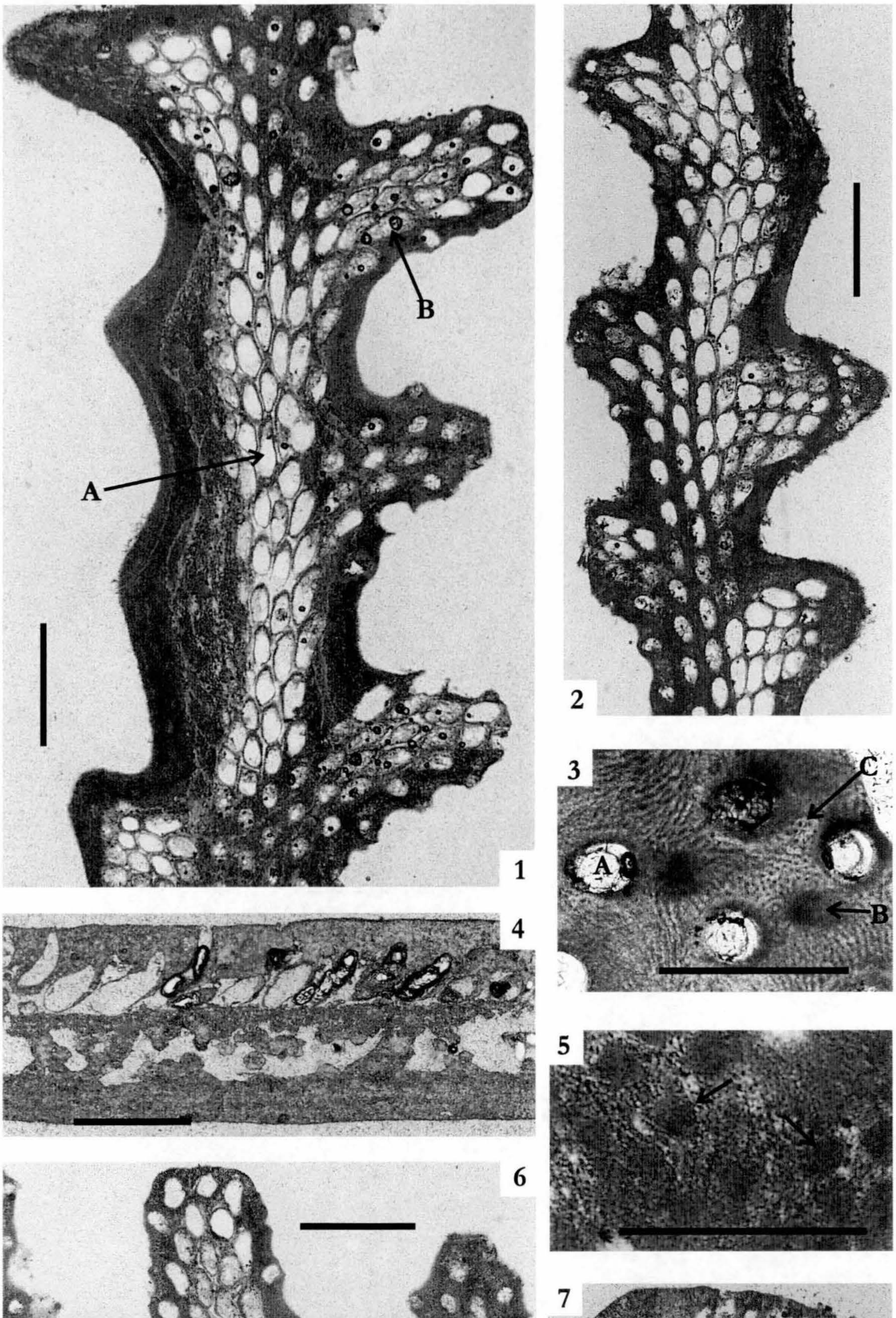

B
A
1
2
3
C
A
B
4
5
6
7

Plate 69 - *Acanthocladia suprangularis* n. sp.
All scale bars 1 mm.

1. UTGD 127629, holotype - reverse surface of the zoarium.
2. UTGD 127629, holotype - obverse surface of the zoarium.
3. UTGD 127629, holotype - tangential section.
4. UTGD 127629, holotype - transverse section of main branch with partial longitudinal section of lateral branches.
5. UTGD 127632, paratype - tangential section showing chamber outline on main and lateral branches.
6. UTGD 127630, paratype - tangential section showing arrangement of the apertures, and bifurcation of main branch, arrow.
7. UTGD 127631, paratype - longitudinal section, main branch.
8. UTGD 127631, paratype - transverse section, main branch.

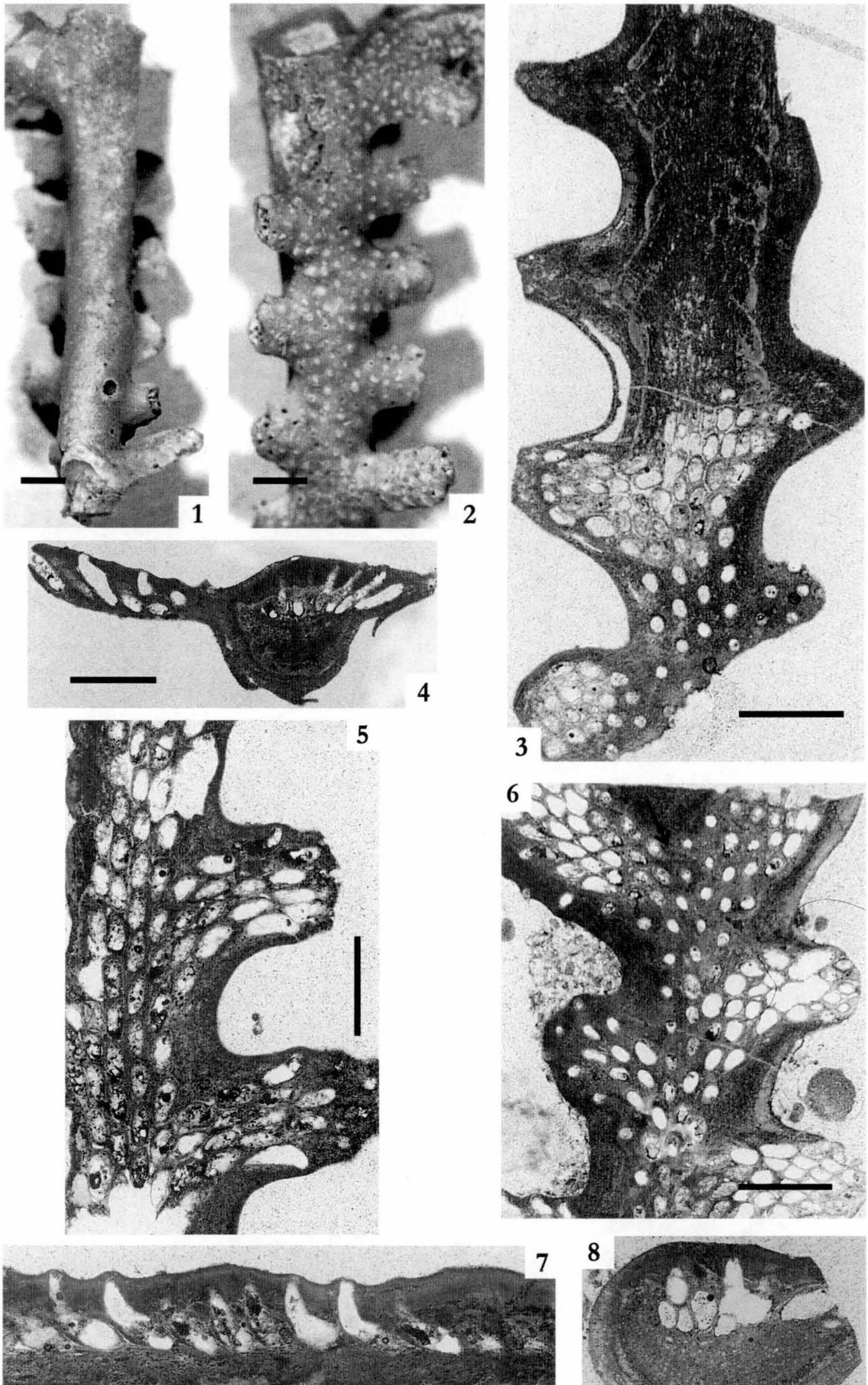

1
2
3
4
5
6
7
8

Plate 70 - *Paralioclema phuketensis* n. sp.
All scale bars 1 mm.

1. UTGD 127633, holotype - oblique tangential section through endozone, lower picture, to exozone, upper picture.
2. UTGD 127634, paratype - tangential section exozone, showing the oval to rounded polygonal autozooecial apertures, A, exilazooecia, B, and acanthostyles, C.
3. UTGD 127633, holotype - longitudinal section, showing the thickened walls of the exozone, A, and diaphragms, widely spaced in endozone, B, and closely spaced in exozone, C.
4. UTGD 127633, holotype - transverse section.
5. UTGD 127633, holotype - longitudinal section, showing endozone and exozone, and overgrowths in exozone, arrows.

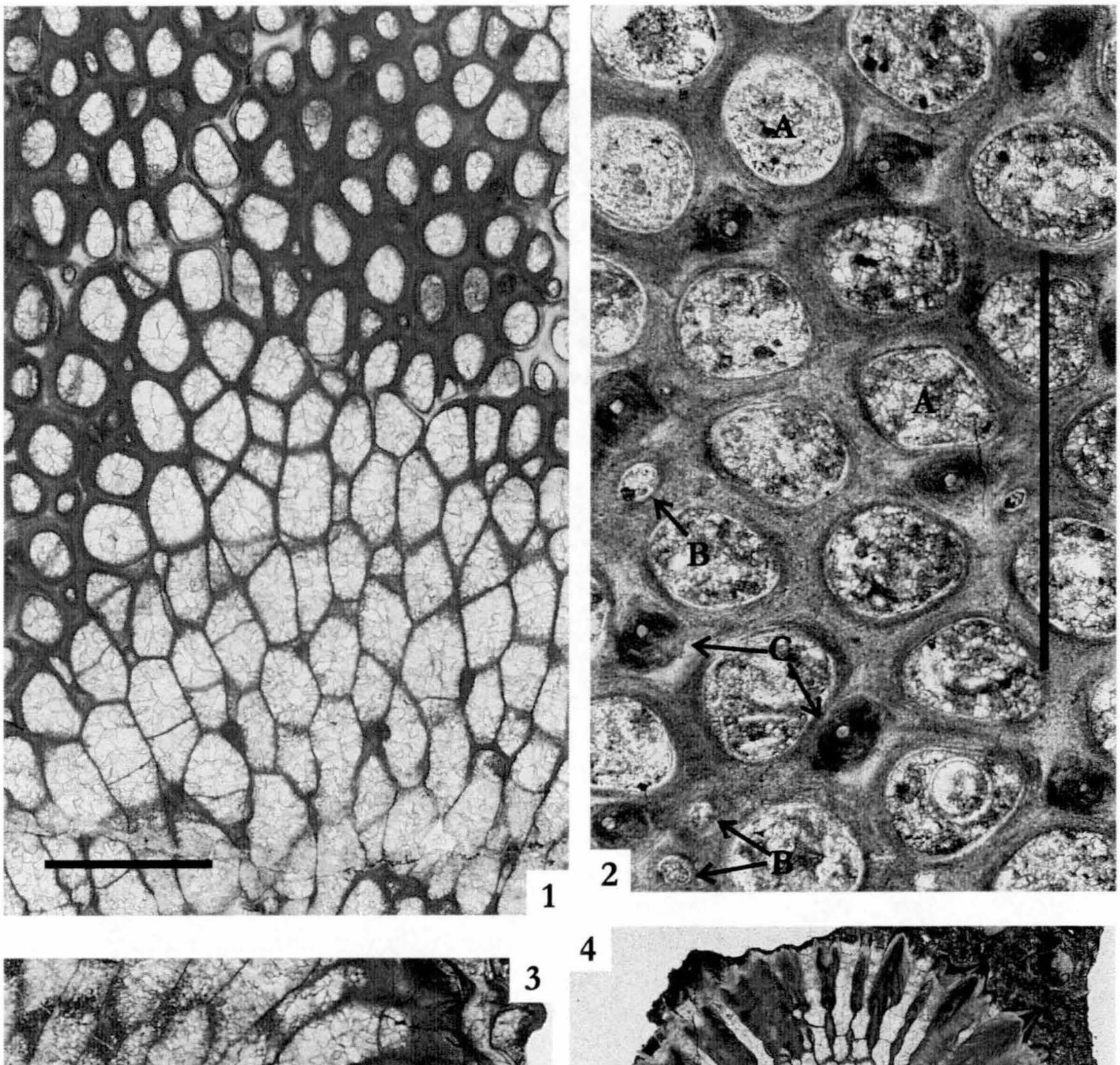

1
2
A
A
B
C
B
3
C
A
B
4
5

Plate 71 - *Neoeridotrypella subpulchra* n. sp.
All scale bars 1 mm.

1. UTGD 127635, holotype - longitudinal section, showing base of zoarium encrusting cylindrical object, and developing dendroid zoarium.
2. UTGD 127635, holotype - tangential section, showing the thin walls if the exozone, the autozooecial apertures, A, and the exilazooecia, B.
3. UTGD 127635, holotype - transverse section, showing the acanthostyles and paurostyles, arrows.
4. UTGD 127635, holotype - longitudinal section.
5. UTGD 127635, holotype - tangential peel, showing the paurostyles, arrows.

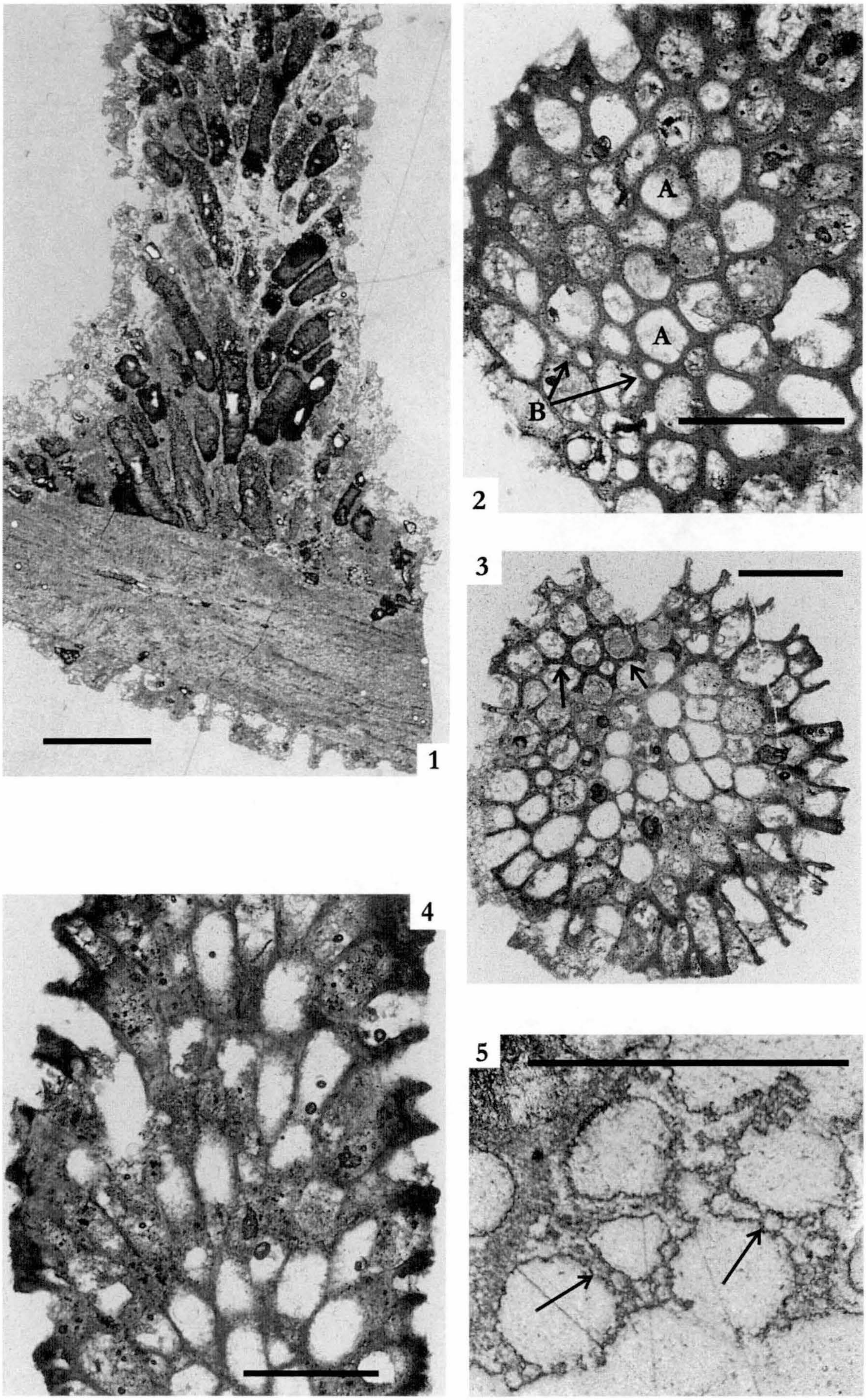

1
2
A
A
B
3
4
5

Plate 72 - *Ascopora robusta* n. sp.
All scale bars 1 mm.

1. UTGD 127636, holotype - tangential section through exozone, showing the longitudinal rows of zooecia, and the irregularly placed acanthostyles, arrows.
2. UTGD 127636, holotype - tangential section.
3. UTGD 127636, holotype - transverse section, showing the wide exozone and the central bundle.
4. UTGD 127636, holotype - tangential section through exozone, showing the large acanthostyles, A, and the numerous paurostyles, B.
5. UTGD 127636, holotype - longitudinal section, showing clearly the axial bundle of zooecia, the divergence angle, and the wide exozone.

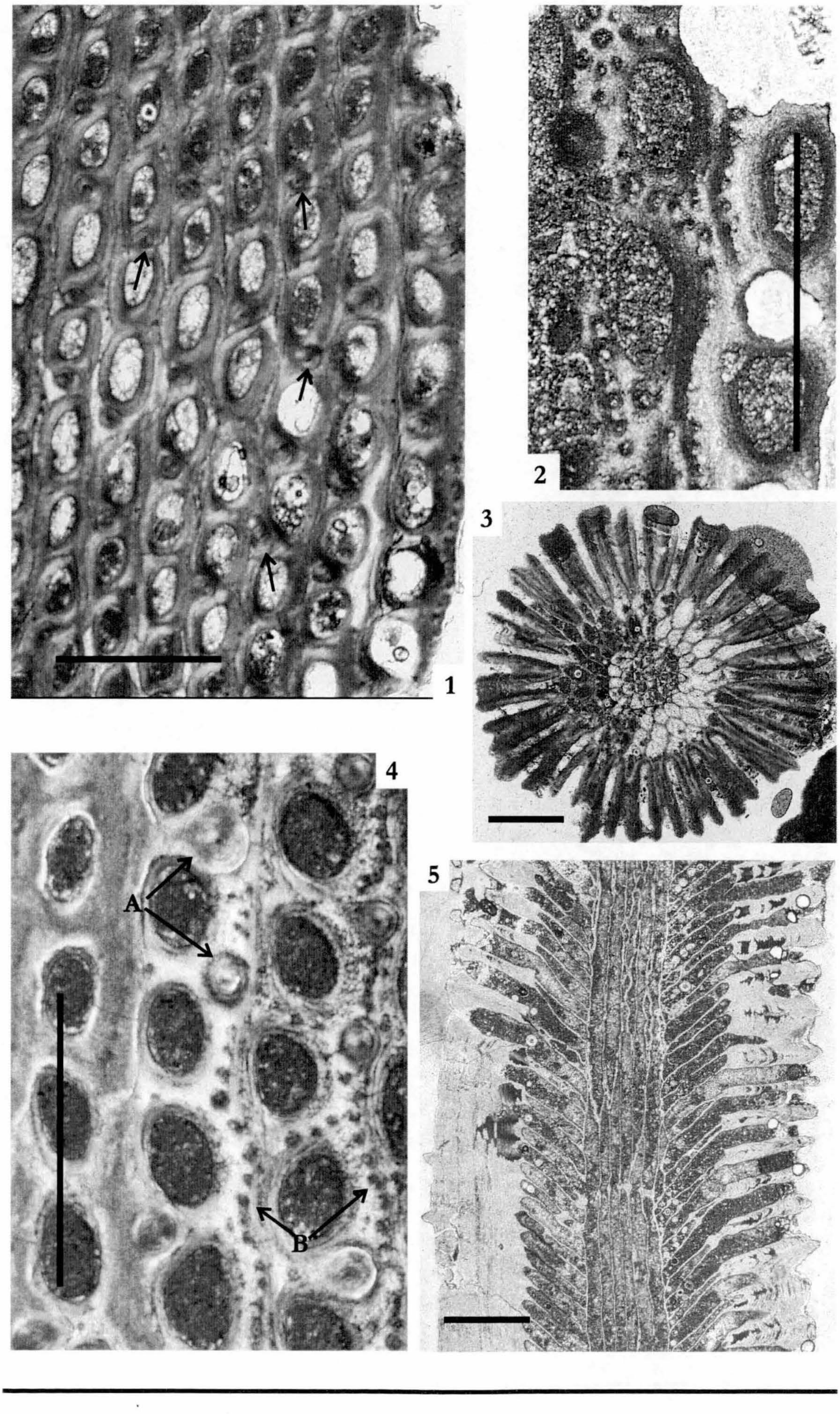

1
2
3
4
A
B
5

Plate 73 - *Ascopora variablis* n. sp.
All scale bars 1 mm.

1. UTGD 127638, holotype - external view of the zoarium.
2. UTGD 127638, holotype - tangential section through the exozone, showing the autozooecial apertures and acanthostyles, arrows.
3. UTGD 127638, holotype - tangential section, endozone to exozone, showing the rhombic arrangement of the zooecia in the central picture.
4. UTGD 127638, holotype - transverse section, showing the thick exozone and rapid thickening of the zooecial wall at the base of the exozone, arrows.
5. UTGD 127638, holotype - longitudinal section.
6. UTGD 127639, paratype - tangential section through the exozone.

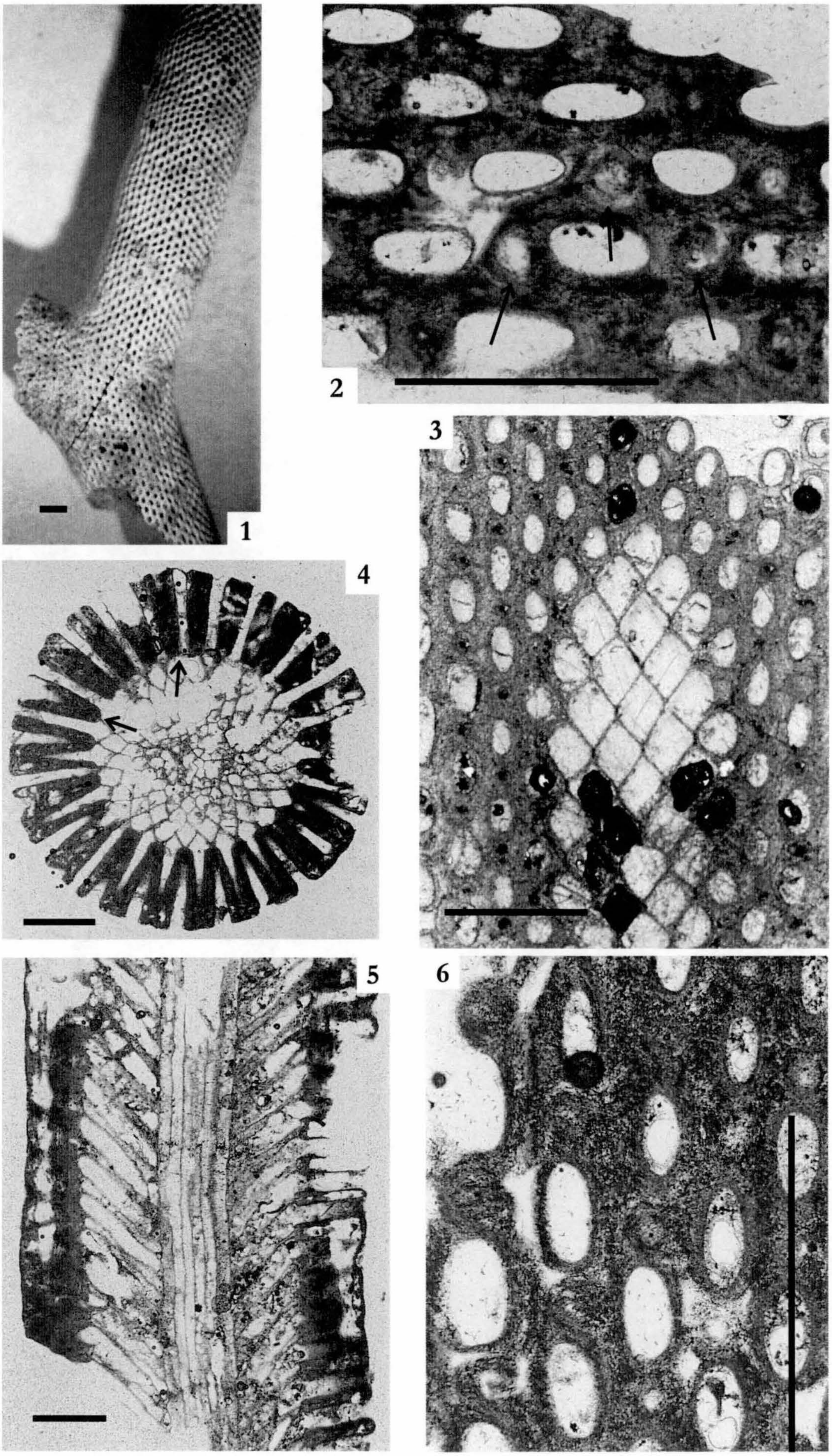

1
2
3
4
5
6

Plate 74 - *Rhabdomeson monoformis* n. sp.
All scale bars 1 mm.

1. UTGD 127640, holotype - tangential section through the exozone.
2. UTGD 127640, holotype - longitudinal section showing the wide central zooecial tube, with walls thickening gradually from endozone to exozone. Note also the prominent acanthostyles, arrows.
3. UTGD 127640, holotype - tangential section through exozone, showing the numerous acanthostyles of one size.
4. UTGD 127640, holotype - longitudinal section, showing the detail of the wall thickening and acanthostyles, arrows.
5. UTGD 127640, holotype - transverse section.

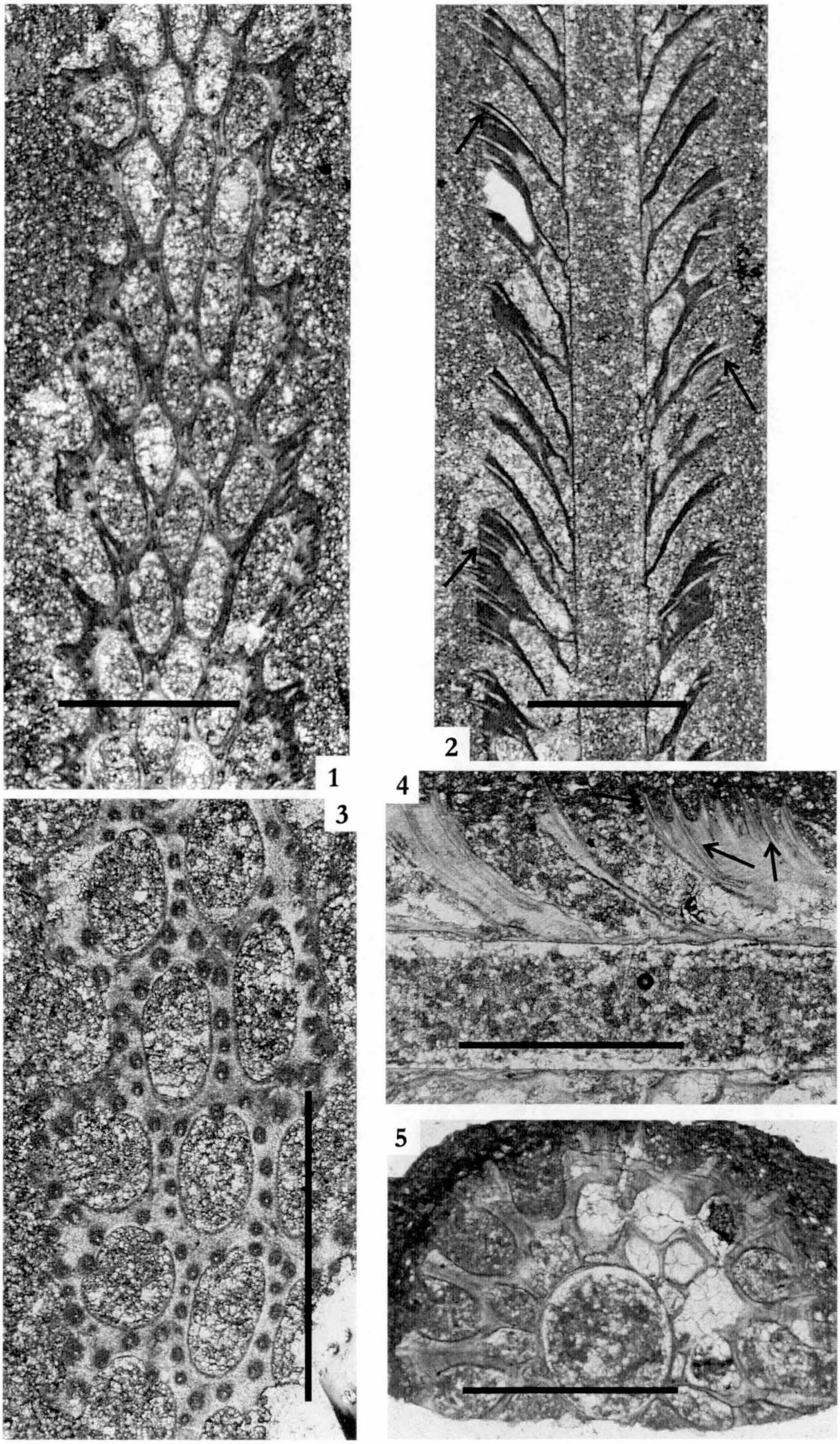

1
2
3
4
5

Plate 75 - *Streblotrypa (Streblascopora) komukensis* (Sakagami, 1970)
All scale bars 1 mm.

1. UTGD 127642 - external zoarial surface.
2. UTGD 127641 - tangential section through exozone, showing the autozooecial apertures, A, metapores, B, and longitudinal ridges, C.
3. UTGD 127641 - longitudinal section showing rare hemiphragms, arrows.
4. UTGD 127642 - tangential section exozone.
5. UTGD 127642 - transverse section.

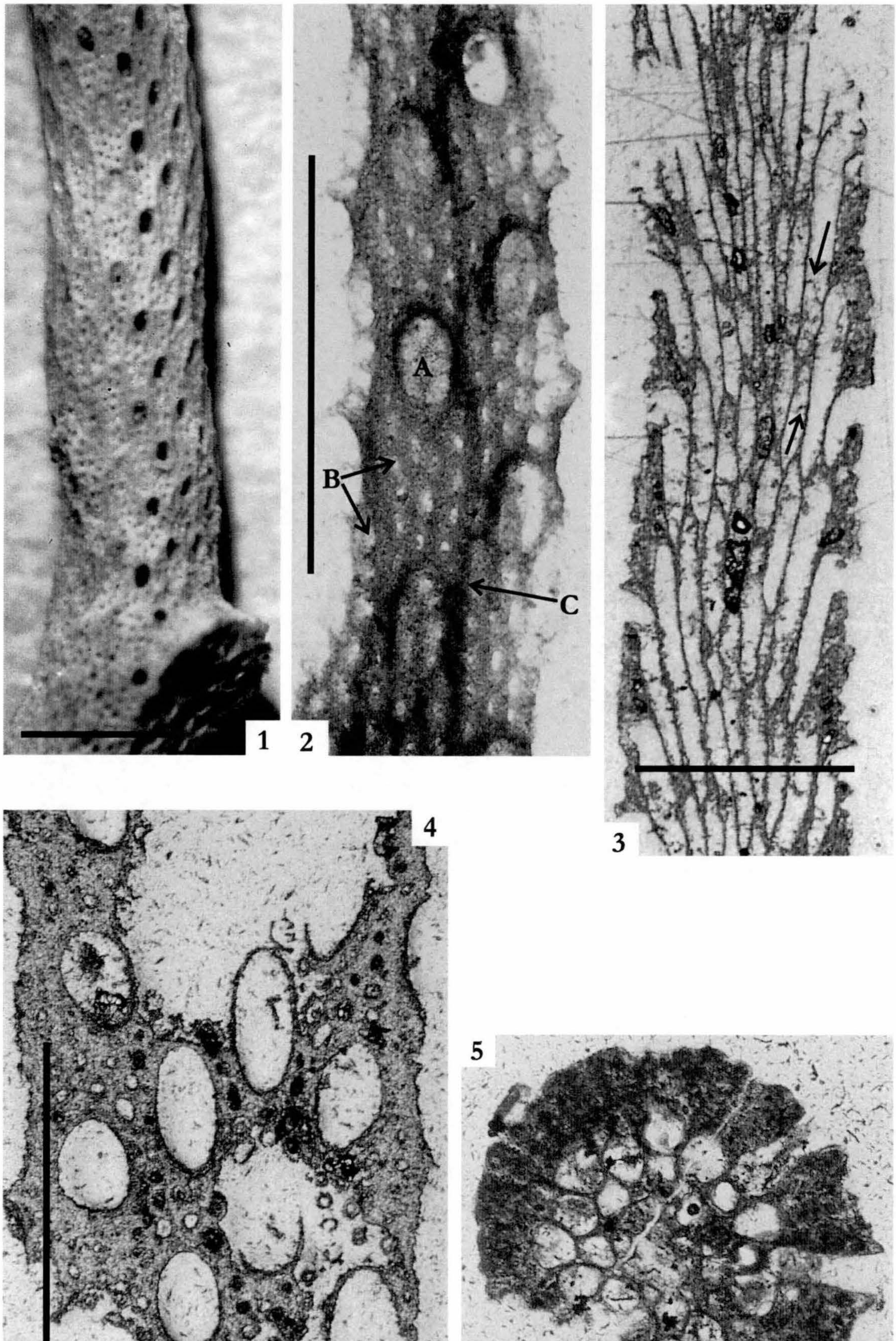

A
B
C
1
2
3
4
5

Plate 76 - *Cyclotrypa dendroides* n. sp.
All scale bars 1 mm.

1. UTGD 127643, holotype - tangential section through exozone, showing the circular apertures, A, with thin peristomes, B, but no apparent lunarium.
2. UTGD 127643, holotype - tangential section through lower exozone, showing monticular area with central vesicular tissue.
3. UTGD 127643, holotype - tangential section through exozone, showing single large zooecial tube, A, in centre of monticule, and radially arranged larger tubes, B, and regular zooecial tubes. C.
4. UTGD 127643, holotype - transverse section, showing zooecial tubes in endozone separated by vesicular tissue in lower picture, and exozone of stereom in upper picture.
5. UTGD 127643, holotype - longitudinal section showing the gentle curvature of zooecial tubes from endozone to exozone.
6. UTGD 127643, holotype - longitudinal section through outer exozone, showing structures that may represent lunaria, arrows.

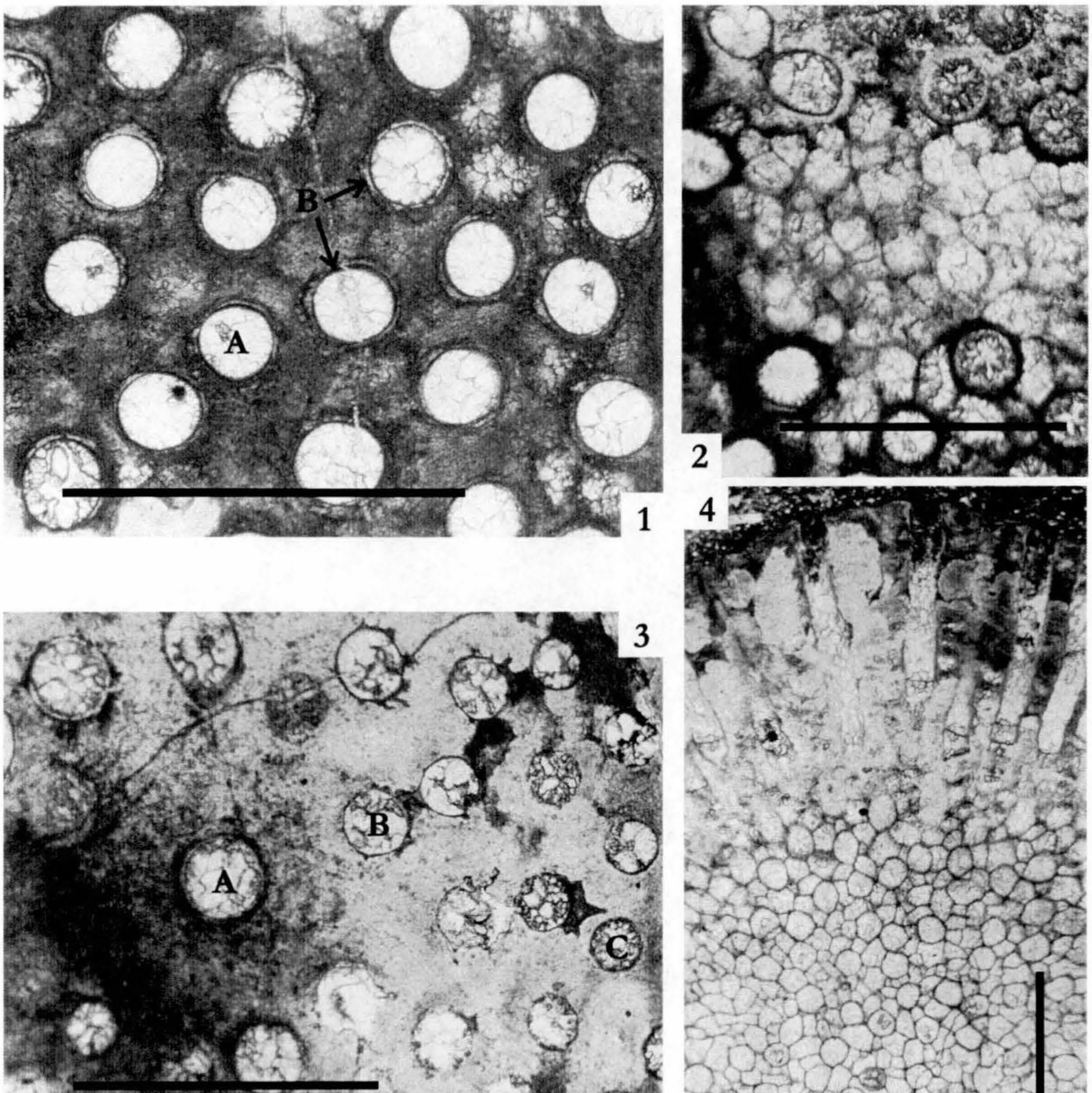

A
B
1
2
4
A
B
C
3
5
6

Plate 77 - *Eridopora thaiensis* n. sp.
All scale bars 1 mm.

1. UTGD 127644, holotype - tangential section, showing large triangular zooecial tubes at monticule centres, A, and the regular rounded triangular zooecial tubes, B.
2. UTGD 127645, paratype - Tangential section showing the large lunaria, arrows, that is this specimen indent the zooecia.
3. UTGD 127644, holotype - tangential section.
4. UTGD 127644, holotype - longitudinal section showing the angle of the zooecial tubes, arrows.

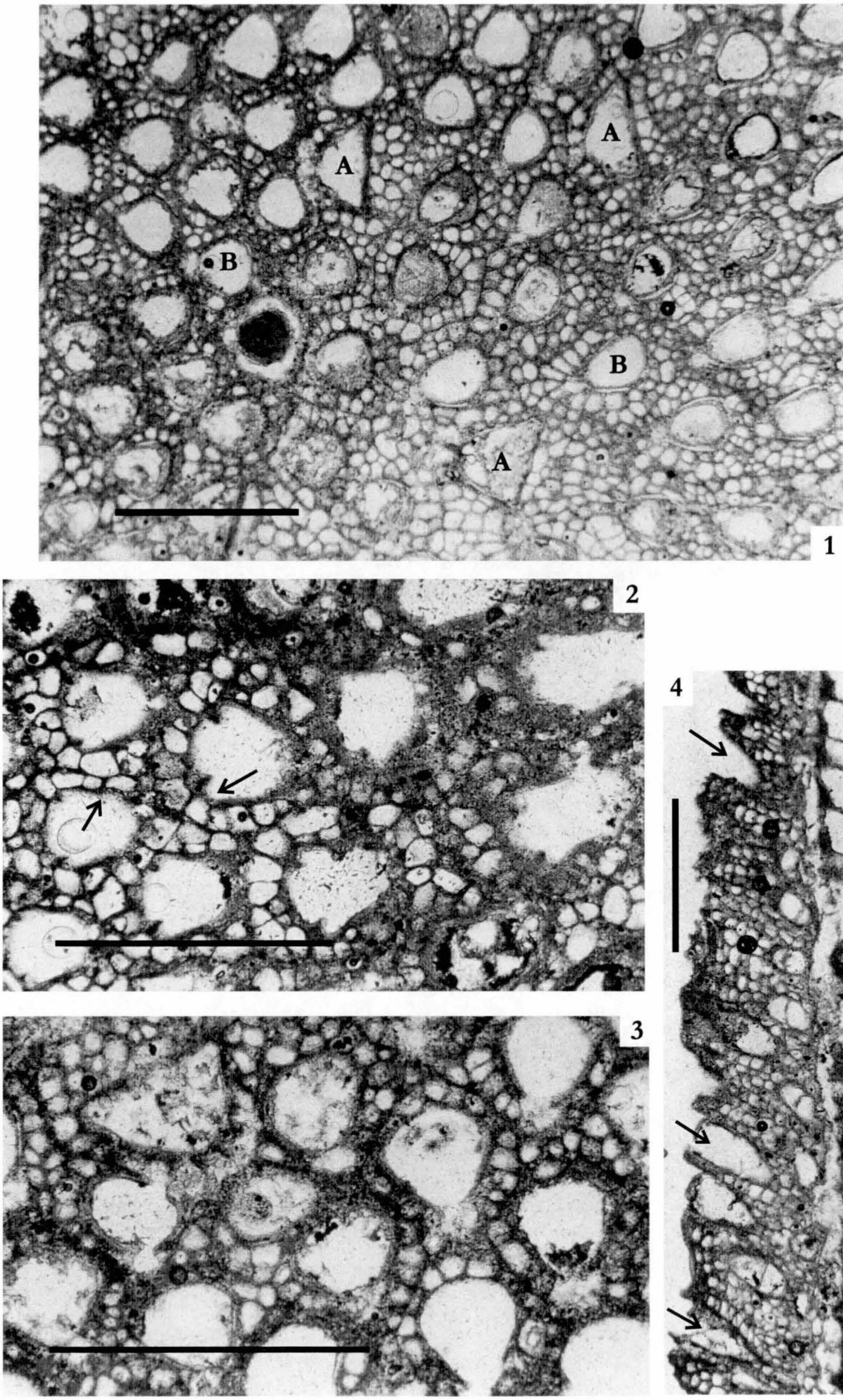

A
A
B
B
A
1
2
3
4

Plate 78 - *Fistulopora horowitzi* Sakagami, 1970
All scale bars 1 mm.

1. UTGD 127646 - tangential section, upper exozone with stereom on left of picture, lower exozone with vesicular material on right.
2. UTGD 127646 - Tangential section through endozone, showing zooecial tubes, A, separated by 2 to 3 rows of vesicular material, B.
3. UTGD 127646 - tangential section through exozone, showing the oval zooecial apertures, A, and large lunaria, B, that indent the zooecial tubes. Note also the stylets in the stereom, C.
4. UTGD 127646 - transverse section endozone to exozone. Note the shape and spacing of zooecial tubes in the endozone, A, and the vesicular material in the base of the exozone, B, with a thin layer of stereom, C.
5. UTGD 127646 - longitudinal section endozone to exozone. Note the vertical trend of the zooecial tubes in the inner endozone, A, curving gently to the exozone, B, and the reduction in height of the vesicles from endozone to exozone.

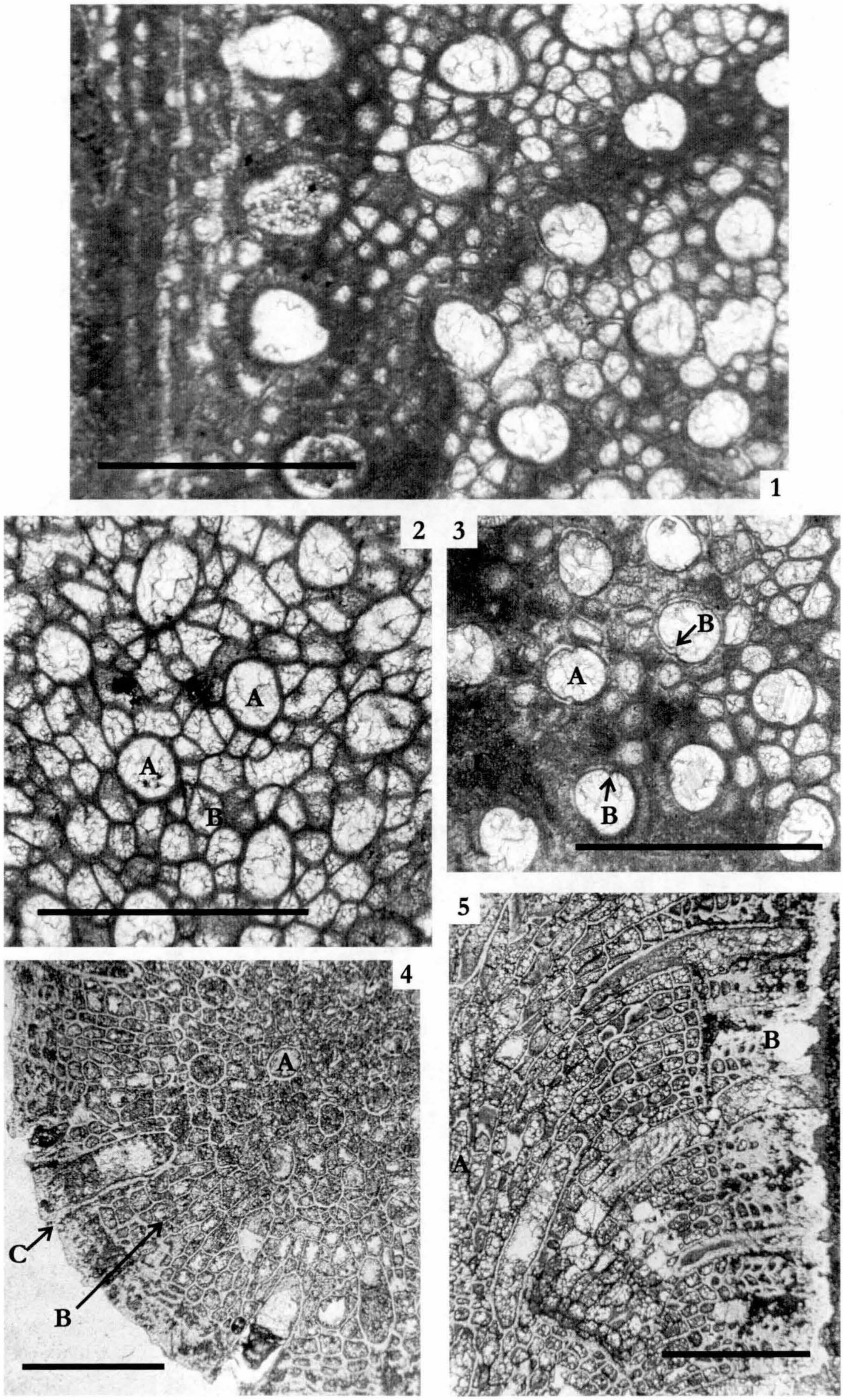

1
2
A
A
B
3
B
A
B
4
A
C
B
5
B
A

Plate 79 - *Fistulopra megapertura* n. sp.
All scale bars 1 mm.

1. UTGD 127647, holotype - tangential section through exozone, showing the elliptical zooecial apertures, A, separated by vesicular tissue, B, with only a thin layer of stereom, C.
2. UTGD 127647, holotype - tangential peel through inner exozone, showing the large lunaria, arrows.
3. UTGD 127647, holotype - transverse section showing the zooecial tubes, A, separated by blisterlike vesicles, B, with rare diaphragms.
4. UTGD 127647, holotype - tangential section exozone.

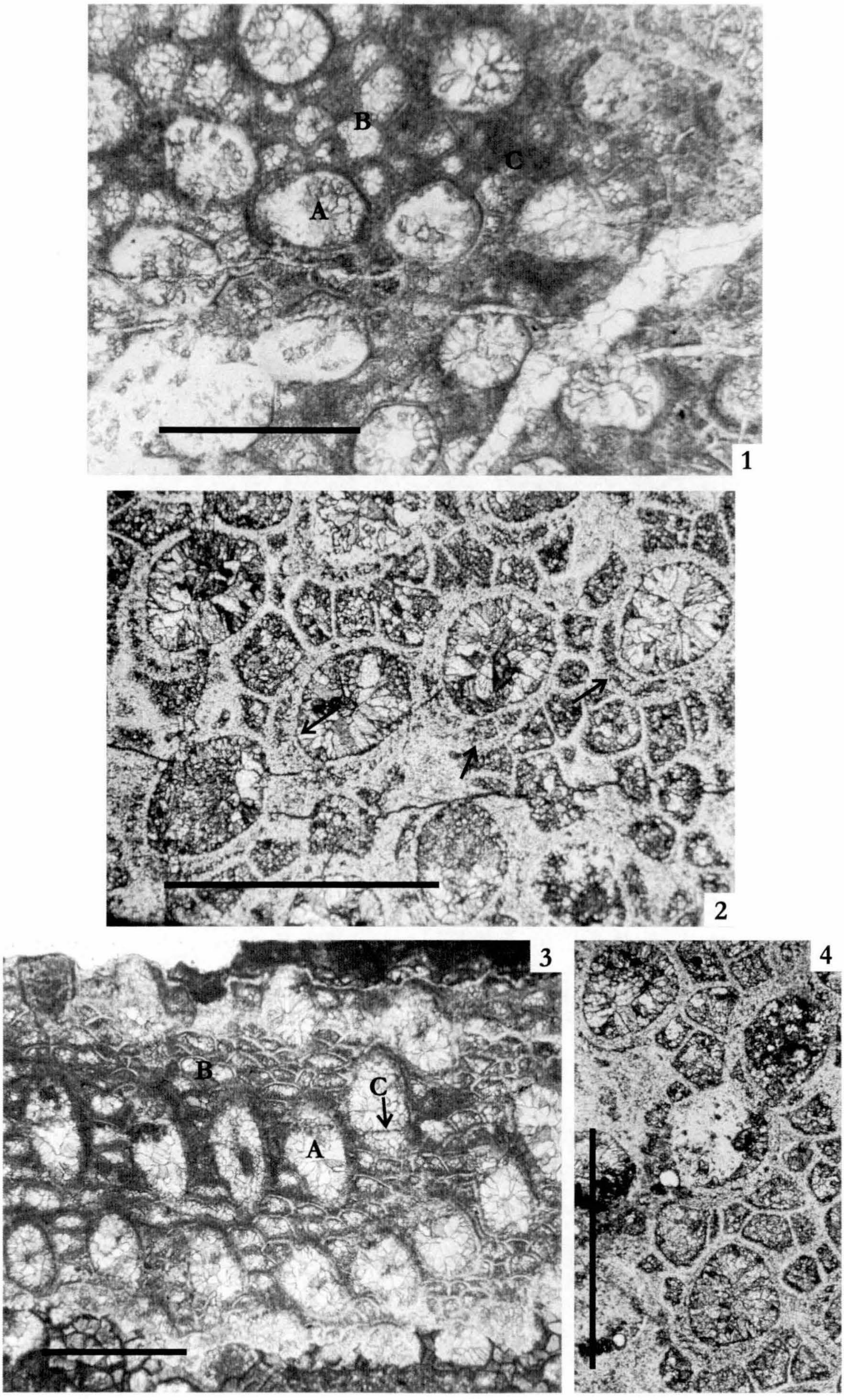

B
C
A
1
2
3
B
C
A
4

Plate 80 - *Fistulopora satoi*? Sakagami, 1966
All scale bars 1 mm.

1. UTGD 127648 - tangential section outer exozone.
2. UTGD 127648 - tangential section outer exozone, showing the oval zooecial apertures, A, indented by lunaria, B, and surrounded by stereom, C.
3. UTGD 127648 - transverse section, showing the repeated encrusting layers, arrows, and boxlike vesicles.
4. UTGD 127648 - transverse section showing the boxlike vesicles and stereom.
5. UTGD 127648 - tangential section exozone showing stereom between zooecial tubes and vesicular tissue, arrows.

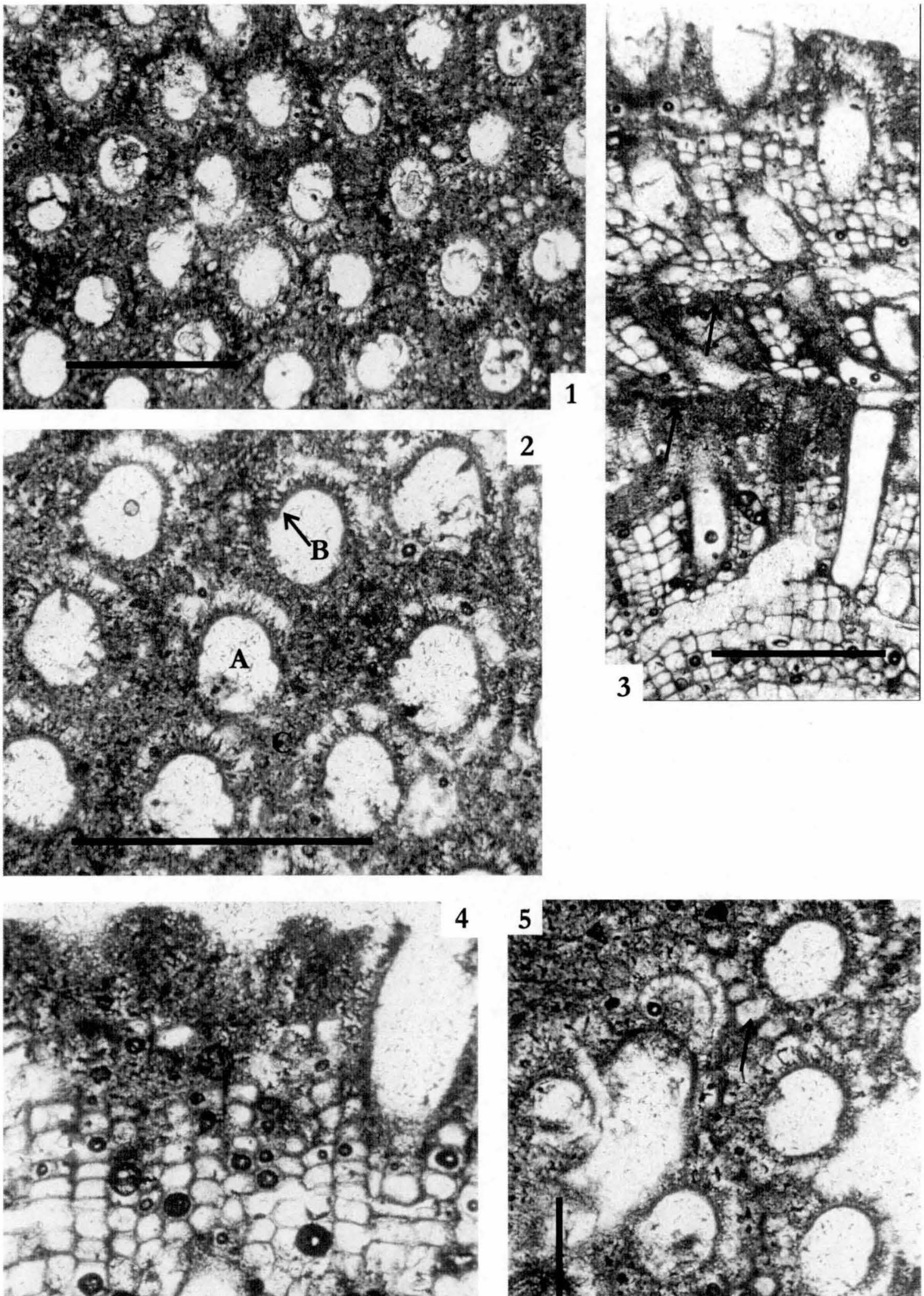

1
2
B
A
C
3
4
5

Plate 81 - *Coscinotrypa yaiformis* n. sp.

All scale bars 1 mm., except where indicated.

1. UTGD 127649, holotype - zoarium in outcrop view. Lens cap for scale, diameter
2. UTGD 127649, holotype - tangential section endozone, A, to exozone, B, and showing fenestrule margins, C.
3. UTGD 127649, holotype - oblique longitudinal section showing the mesotheca, A, and straight zooecial tubes, B, surrounded by stereom.
4. UTGD 127649, holotype - tangential section endozone to exozone.
5. UTGD 127649, holotype - tangential section through exozone, showing detail of oval apertures, A, with no lunarium, but thin complete peristomes.
6. UTGD 127649, holotype - transverse section showing single layer of vesicles in endozone, arrow.

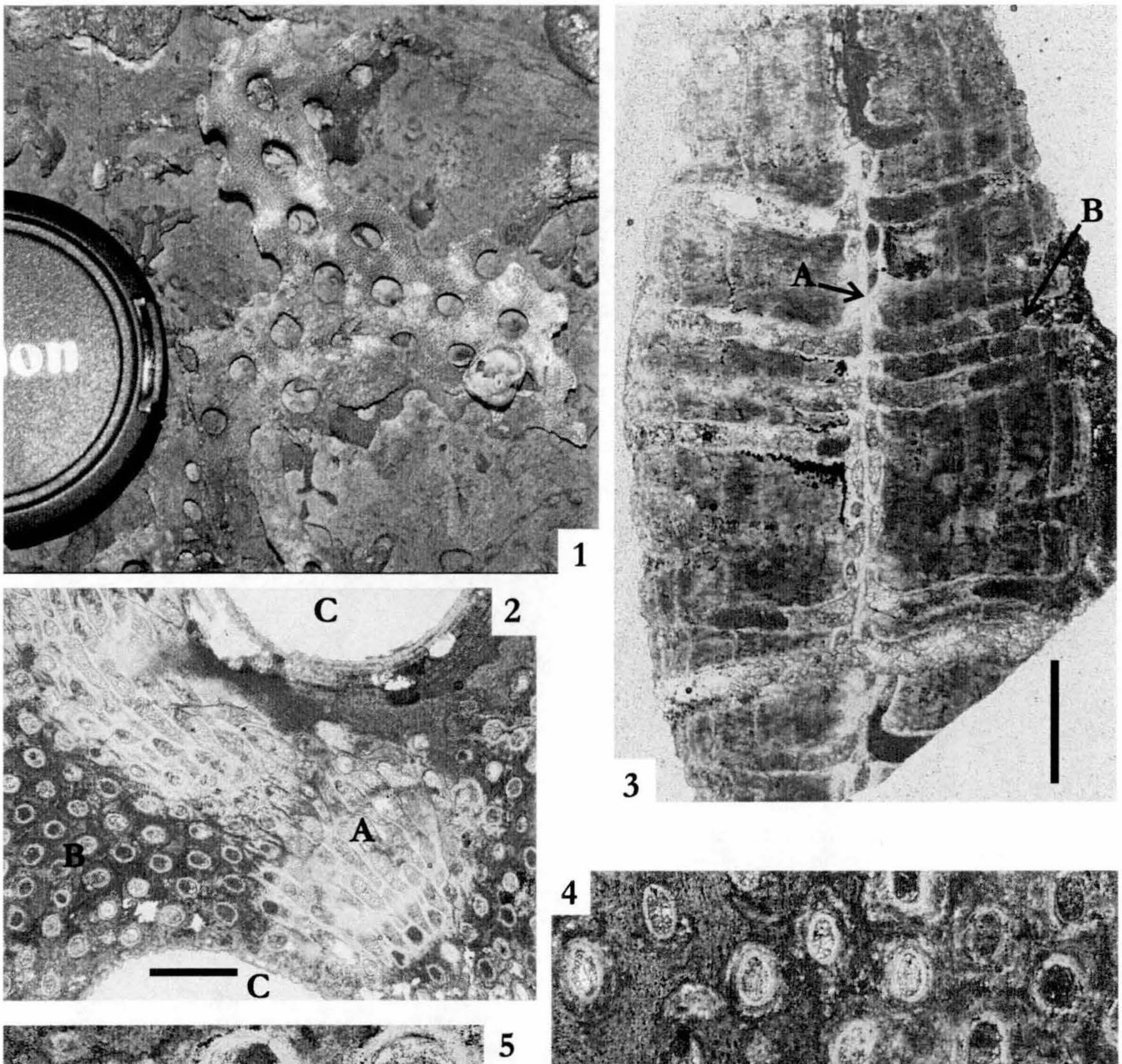

1
2
C
A
B
C
3
A
B
4
5
B
A
6

Plate 82 - *Hexagonella khaophrikensis* Sakagami, 1968
All scale bars 1 mm.

1. UTGD 127650 - tangential section showing the zooecial tubes surrounded by vesicular tissue.
2. UTGD 127650 - transverse section.
3. UTGD 127650 - transverse section showing straight mesotheca, A, straight zooecial tubes, B, and vesicles, C, decreasing in height towards stereom, D.
4. UTGD 127650 - tangential section showing zooecial tubes surrounded by vesicular tissue.

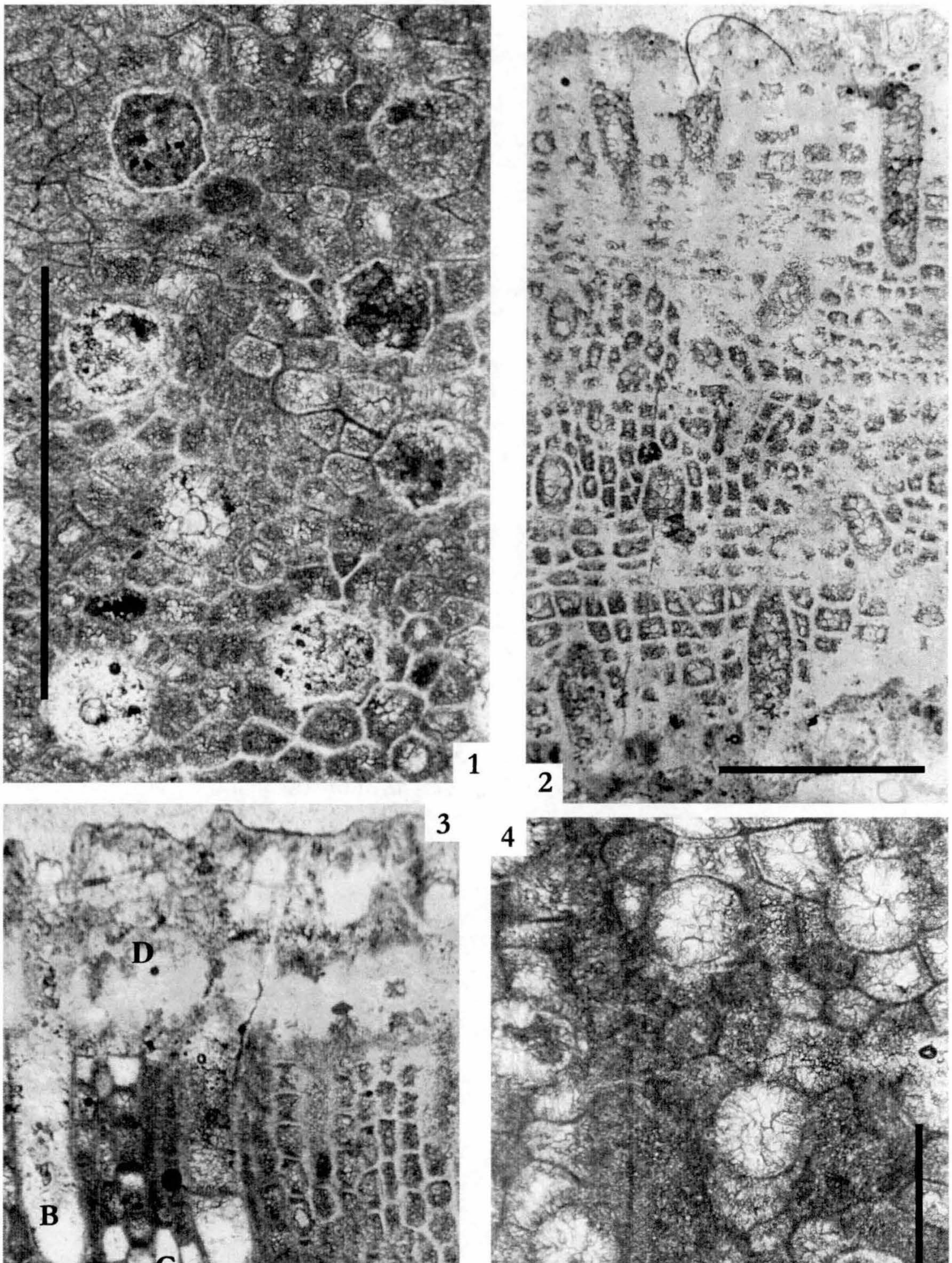

1
2
3
4
D
B
C
A

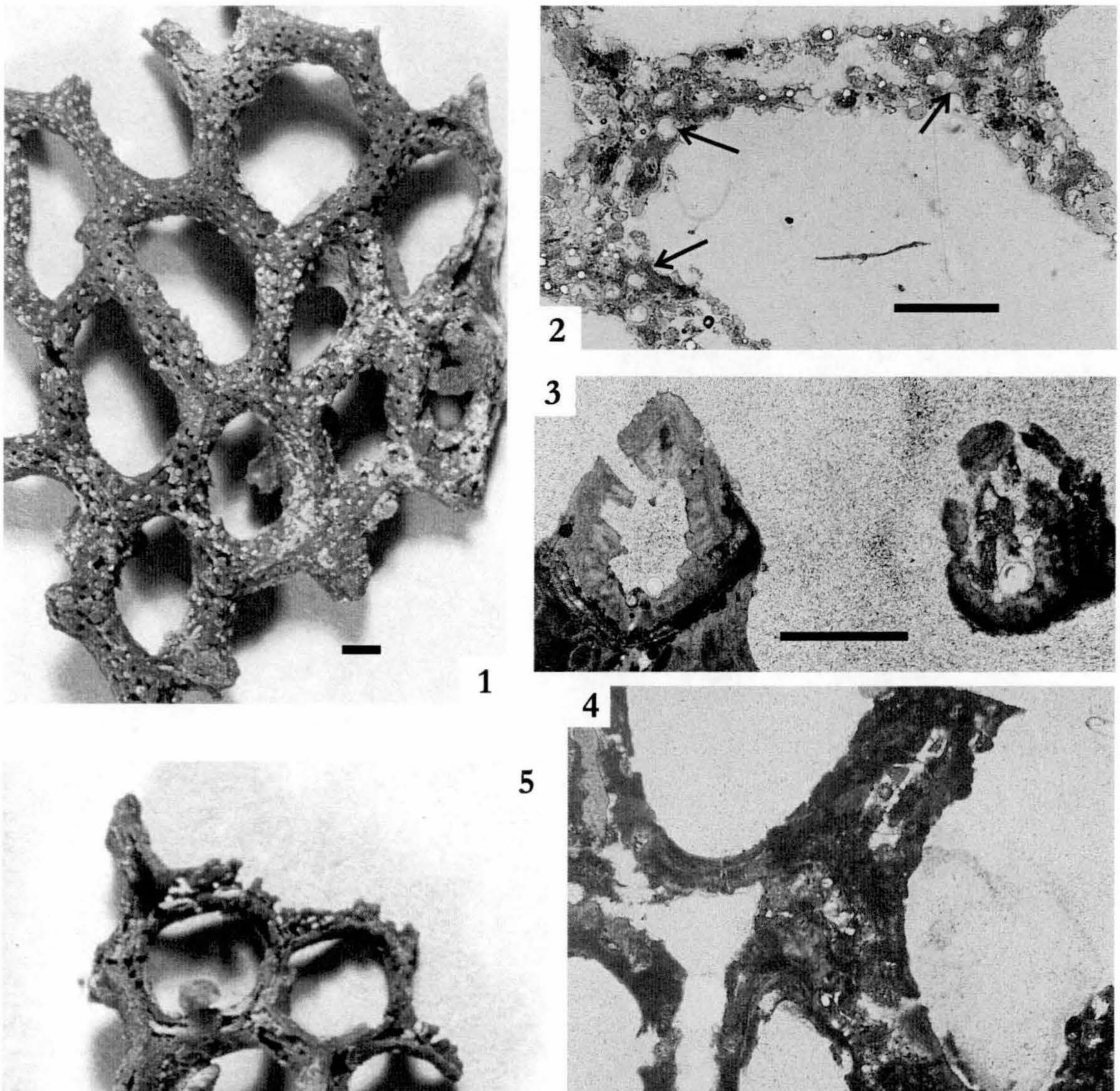
Plate 83
All scale bars 1 mm.

Goniacladia sp. indet.

1. UTGD 127652 - external obverse zoarial surface, showing the mesh form.
2. UTGD 127652 - tangential section showing the zooecial apertures, arrows.
3. UTGD 127652 - transverse section showing outline of the branches.
4. UTGD 127652 - tangential section.

Goniacladia sp. indet.

5. UTGD 127651 - external zoarial surface showing the regularly hexagonal mesh form.
6. UTGD 127651 - tangential section showing the zooecial apertures, A, and keel?, B.


1
2
3
4
5
6
A
B