Mémoires de Géologie (Lausanne) N° 11, 1993

Biochronology and Paleontology of uppermost Triassic (Rhaetian) radiolarians, Queen Charlotte Islands, British Columbia, Canada

par **Elizabeth S. Carter**

IMPRIMERIE CHABLOZ S.A., TOLOCHENAZ

ISSN 1015-3578

Université de Lausanne
Faculté des Sciences

Institut de Géologie
et de Paléontologie

Biochronology and Paleontology of uppermost Triassic (Rhaetian) radiolarians, Queen Charlotte Islands, British Columbia, Canada

thèse de doctorat
présentée à la Faculté des Sciences
de l'Université de Lausanne

par **Elizabeth S. Carter**

Jury de thèse :

Prof. J. Guex (Directeur)
Prof. C. Joseph (Président)
Prof. P.O. Baumgartner
Dr. A. Baud
Dr. P. Dumitrica, Bucarest
Dr. F. Hirsch, Jérusalem

Mémoires de Géologie (Lausanne) No.11, 1993

Cover photo
Totem poles silently keeping watch over the long-abandoned Haida village of Ninstins (Skang'Wai) on the east shore of Anthony Island, Queen Charlotte Islands, B.C. (J.W.Haggart/GSC Vancouver, photographer).

CONTENTS

BIOCHRONOLOGY AND PALEONTOLOGY OF UPPERMOST TRIASSIC (RHAETIAN) RADIOLARIANS QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA, CANADA

ABSTRACT

A rich radiolarian fauna of Rhaetian age has been recovered from limestone concretions in strata of the Sandilands Formation at localities on northwest Graham Island (Kennecott Point), Louise Island, Skidegate Inlet, and Kunga Island, Queen Charlotte Islands, British Columbia. Unusually thick stratigraphic sections at Kennecott Point and Kunga Island record continuous sedimentation through latest Triassic and earliest Jurassic time. Independent dating is provided by conodonts that co-occur in many radiolarian samples and rare ammonoids that are associated at several levels.

New radiolarian zonation for the Rhaetian defined by Unitary Associations (U.A.; Guex 1977, 1991) is presented. A database recording the appearance of 136 species in 69 superposed horizons or samples of 6 sections was used to establish 27 successive U.A., with each U.A. defined by the totality of its characteristic species. U.A. were grouped into 6 distinct assemblages (biochronozones) whose terminology follows Carter 1990.

The late Norian *Betraccium deweveri* Zone (Blome 1984) ranges into post-*Monotis* basal strata of the Sandilands Formation (late Norian or earliest Rhaetian). Immediately above this zone, three successive radiolarian assemblages occur whose age is correlated with Late Triassic ammonoid biochronology of Tozer (1979). Assemblage 1, the lower one, approximates the lower part of the Amoenum Zone; Assemblage 2 (with four subassemblages) approximates the middle and upper Amoenum Zone; and Assemblage 3 is correlated with the uppermost Triassic Crickmayi Zone.

Two formal zones are established which allow worldwide correlation of the Rhaetian using radiolarians. Their ages are correlative with the Late Triassic ammonoid biochronology of Tozer (1979). The *Proparvicingula moniliformis* Zone contains radiolarians of Assemblage 1 and Assemblage 2 (this study); it represents the lower Rhaetian and is approximately equivalent to the Amoenum Zone. The *Globolaxtorum tozeri* Zone contains radiolarians of Assemblage 3 (this study); it represents the upper Rhaetian and is equivalent to the Crickmayi Zone.

All radiolarian species used in the zonation are discussed along with a few others having more limited occurrence. Species previously described and/or figured in the literature are discussed in terms of their occurrence in Queen Charlotte Islands. One family, five genera and 63 species are described as new.

Biochronologie et paléontologie des radiolaires du Trias terminal (Rhétien) des Iles de la Reine Charlotte, Colombie Britanique, Canada

RESUME

Plusieurs gisements de la Formation de Sandilands des Iles de la Reine Charlotte ont livré une très riche faune de radiolaires d'âge triasique supérieur (Rhétien). Les niveaux fossilifères sont essentiellement représentés par des concrétions calcaires développées au nord-ouest de l'Ile de Graham (Kennecott Point), dans l'Ile Louise et dans l'ile de Kunga.

A Kennecott Point et dans l'Ile de Kunga, le Rhétien et le Jurassique inférieur sont compris dans une série stratigraphique continue et très épaisse. Cette série a également livré de nombreux conodontes et quelques ammonites qui permettent de raccorder les assemblages de radiolaires aux zones biochronologiques définies par ces deux groupes.

Nous présentons ici une zonation nouvelle du Rhétien basée sur les radiolaires. Cette zonation a été établie à l'aide de la méthode des association unitaires (Guex 1977). Les niveaux fossilifères étudiés nous ont livré 136 espèces réparties dans 69 échantillons provenant de 6 sections stratigraphiques distinctes. Le traitement de ces données biostratigraphiques met en évidence une séquence de 27 associations unitaires qui permettent de définir 6 zones significatives au plan chronologique. La terminologie utilisée pour ces zones est celle que nous avons introduite dans un travail précédent (Carter 1990).

Les radiolaires de la zone à *Betraccium deweveri* (Norien supérieur) définie par Blome (1984), persistent dans les premiers niveaux de la Formation de Sandilands: ces formes ont peut-être un âge Rhétien inférieur.

La zone à *B. dewereri* est suivie de 3 assemblages successifs principaux que l'on peut corréler avec la zonation standard de Tozer (1979): le premier (Assemblage 1) correspond approximativement à la partie inférieure de la zone à Amoenum; le deuxième (subidivisé ici en 4 sous-assemblages) est corrélable avec la partie moyenne et/ou supérieure de la zone à Amoenum; le troisième correspond à la zone à Crickmayi du Trias terminal.

Deux zones peuvent être établies formellement, permettant une corrélation mondiale du Rhétien à l'aide de faunes de radiolaires. Les zones proposées ici sont corrélées avec la biochronologie des ammonoïdés du Trias supérieur de Tozer (1979). La zone à *Proparvicingula moniliformis* représente le Rhétien inférieur, comprenant les strates des Assemblages 1 et 2, approximativement équivalente de la zone à Amoenum. La zone à *Globolaxtorum tozeri*, qui comprend l'Assemblage 3, est équivalente de la zone à Crickmayi du Trias terminal.

Tous les radiolaires utilisés dans la zonation présentée ici sont décrits en détail dans la partie systématique de ce travail (chapitre 2). Certaines formes plus rares sont également décrites ici. Une famille nouvelle, cinq genres nouveaux et 63 espèces nouvelles sont décrites dans le présent mémoire.

CHAPTER I

BIOCHRONOLOGY OF UPPERMOST TRIASSIC (RHAETIAN) RADIOLARIANS QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA, CANADA

INTRODUCTION

Radiolarians of suspected latest Triassic (Rhaetian) age were first discovered in isolated collections from Skidegate Inlet, Louise Island, and Kunga Island, Queen Charlotte Islands, British columbia, in 1985 and 1986 (Carter, 1988). Generic composition of these assemblages appeared similar to the *Betraccium deweveri* fauna of Blome (1984) but species differed, and faunas had slight Jurassic affinities as well. These rich collections were from limestone concretions in otherwise unfossiliferous siltstone so that precise age could not be determined. In 1987, field studies at Kennecott Point (northwest Graham Island) and Kunga Island confirmed the presence of uppermost Triassic radiolarians in post-*Monotis* strata of the Sandilands Formation (Cameron and Tipper, 1985; Orchard and Desrochers, 1991). At both localities limestone concretions in continuous sequences of strata yielded abundant radiolarians. At Kennecott Point ammonoids and conodonts are associated with radiolarians at several levels; at Kunga Island only conodonts are associated. Comparison of dated faunas with earlier collections from Skidegate Inlet and Louise Island indicates Rhaetian age for these collections as well. Field studies continued in 1988-1990 with the results (paleontologic database; Orchard et al., 1991) providing an excellent biostratigraphic framework for study of the biochronology, paleontology and evolution of latest Triassic radiolarians.

Radiolarians of Rhaetian age are rare (see 'Previous Work' herein). The Queen Charlotte Island faunas are abundant, well dated, well preserved and incredibly diverse even in topmost Triassic beds. This study deals only with the Rhaetian fauna from the Sandilands Formation. However, the Sandilands is continuous and radiolarian-bearing into the Lower Jurassic (Hettangian and Sinemurian) and contains possible Triassic-Jurassic Boundary sequences at both at Kennecott Point and Kunga Island (Tipper and Carter, 1990; Tipper et al., in press). Systematic collecting through Hettangian and Sinemurian strata has yielded rich radiolarian collections (Carter, 1988; Tipper et al., 1991) that will be studied at a later time. Study of the Rhaetian fauna is important not only in tracing radiolarian evolution through the very latest Triassic, but also in documenting a complete faunal assemblage just prior to the terminal Triassic extinction. In addition, a broad knowledge of Rhaetian faunas is essential to understanding the ancestry of earliest Jurassic radiolarians (Carter, in press).

In the first study of radiolarians from post-*Monotis* strata of the Sandilands Formation, three preliminary radiolarian assemblages were distinguished (Carter,1990). These assemblages were correlated with latest Triassic ammonoid zones of Tozer (1979): Assemblage 1 was tentatively correlated with the Cordilleranus Zone; Assemblage 2 approximated the Amoenum Zone; and Assemblage 3 was correlated with the Crickmayi Zone.

The purpose of this study is: (1) to develop zonation for Rhaetian radiolarians by more broadly defining preliminary assemblages established by Carter 1990; (2) to define radiolarian biochronology in terms of other fossil groups; and (3) to document the diverse uppermost Triassic (Rhaetian) radiolarian succession as completely as possible and describe new taxa.

Owing to the increased scope of the present study, a more quantitative approach to biochronology was sought in order to treat the vast quantity of data. In recent years the Unitary Association (U.A.) method developed by Jean Guex (1977) has been used effectively to integrate large amounts of data into a biochronologic framework. The Unitary Associations concept has been successfully applied to radiolarians (see Baumgartner 1984a, b, 1987, Baumgartner et al., 1991 etc.) and the zonation presented here is based on recent computations of U.A. using the computer program BioGraph (Savary and Guex,1991).

In terms of Upper Triassic stage terminology, this paper uses RHAETIAN as the uppermost stage of the Triassic. This follows the proposal of Dagys (1988) which was subsequently presented at the Symposium on Triassic Stratigraphy in Lausanne, Switzerland, October, 1991. This proposal has now been considered by the International Subcommission on Triassic Stratigraphy. Defined in the sense of Dagys, the RHAETIAN stage is approximately equivalent to the Amoenum and Crickmayi ammonoid zones of Tozer (1979) as used in North America. In the present study, the UPPER NORIAN substage is restricted to the Cordilleranus ammonoid zone of Tozer (1979). This terminology departs from Carter 1990 in which the term UPPER NORIAN included strata equivalent to the Cordilleranus, Amoenum, and Crickmayi ammonoid zones.

The information presented here is derived from 1985-1990 field studies in Queen Charlotte Islands sponsored by the Geological Survey of Canada. All radiolarian collections were processed at GSC facilities at the Cordilleran Division in Vancouver and the Pacific Geoscience Centre, Sidney, B.C. Scanning electron microscopy was undertaken at both the above facilities also.

Previous work

Despite the tremendous diversity observed among Upper Norian and Rhaetian radiolarians, relatively few taxa have been described. In North America, Pessagno and Blome (1980) studied the evolution of pantanelliid radiolarians and described species of *Betraccium*, *Gorgansium* and *Pantanellium* from the upper Norian *Monotis* beds (= Cordilleranus Ammonoid Zone) of the Peril Formation (middle black limestone member sensu Sutherland Brown, 1968) on Kunga Island, Queen Charlotte Islands. Blome (1984) further studied this fauna, described species of *Betraccium*, *Cantalum*, *Ferresium*, *Laxtorum* and *Pseudoheliodiscus* and proposed a preliminary radiolarian zonation for the Upper Triassic of western North America with the topmost Triassic subzone, the *Betraccium deweveri* Subzone, based on upper Norian faunas of *Monotis* age from Kunga Island.

Further investigations in the Queen Charlotte Islands were undertaken by Carter (1990) who studied the diverse Rhaetian fauna from the Sandilands Formation and proposed three prelimary radiolarian assemblages correlated approximately with the Amoenum and Crickmayi ammonoid zones of Tozer (1979). Subsequent studies have included documentation of the Triassic - Jurassic boundary in northern Queen Charlotte Islands (Tipper and Carter, 1990), evolutionary trends in latest Triassic and earliest Jurassic faunas (Carter, in press; Tipper et al., in press) and a phylogenetic study of the genus *Ferresium* Blome (Carter, 1992).

In the northern Cache Creek Terrane of southern Yukon, Canada, upper Norian radiolarians have been reported from a single chert sample by Cordey et al., (1991). These include taxa diagnostic of the *Betraccium deweveri* Subzone of Blome (1984), and others (e.g. *Livarella* sp., *Paratriassoastrum* sp., and *Squinabolella* sp.) similar to taxa reported by Carter (1990) from the Queen Charlotte Islands that may be somewhat younger.

Elsewhere in western North America, Blome, Reed and Tailleur (1989) found upper Norian radiolarians including *Betracium* Pessagno, *Cantalum* Pessagno, *Ferresium* Blome, *Laxtorum* Blome, *Livarella* Kozur and Mostler and *Pseudoheliodiscus* Kozur and Mostler in the Otuk Formation, northeastern Alaska. Yeh (1989) studied radiolarians in the upper part of the Fields Creek Formation, east-central Oregon. The fauna from sample FC35 is suggested to be Lower Jurassic, but it compares closely with radiolarians from the Sandilands Formation and is more likely Rhaetian.

In New Zealand, radiolarians from Kapiti Island (Torlesse Terrane) studied by Blome, Moore, Simes, and Watters (1987) are coeval with upper Norian faunas from the *Monotis* beds at Kunga Island. In the Waipapa terrane, Aita (in Spörli and Aita, 1988) figured a mixed fauna of Upper Triassic and Lower Jurassic Tethyan radiolarians from the red chert of Kawakawa Bay. Several forms from sample KA-8 are identical to taxa described herein from the upper Triassic part of the Sandilands formation. Further references to this fauna and its use in solving complexities of terrane accretion in New Zealand, are found in Spörli, Aita and Gibson (1989).

In their extensive study of Middle and Upper Triassic radiolarians, Kozur and Mostler (1981) described species of *Pentactinocarpus* Dumitrica, *Canoptum* Pessagno, *Syringocapsa* Neviani, *Triactoma* Rüst, and new genera *Neopaurinella*, *Norispongus*, and *Livarella* from the Pötschenkalk (Sevat) and Zlambach marls (Rhaetian) of Austria. Kozur subsequently described *Praecitriduma* from Zlambachgraben (1984a) and introduced the genus *Triassocrucella* (1984b) for four-rayed Triassic patulibracchiids with bulbous tips, formerly referred to by Kozur and Mostler (1978) and Pessagno (in Pessagno et al.,1979) as *Hagiastrum* Haeckel. Lahm (1984) figured Middle and Upper Triassic taxa from northern Italy and Austria; some of these range upward into the Sevat and Rhaetian.

Since the late 1970's a number of radiolarian zonal schemes for the Upper Triassic have been proposed by workers in Japan. Amongst these Yao, Matsuda, and Isozaki (1980a) established three successive radiolarian assemblages of Middle Triassic to Early Jurassic age from continuous sequences of chert in the Inuyama area, central Japan. The lower assemblage is Middle Triassic; the middle one, the *Dictyomitrella* sp. B Assemblage, is Late Triassic; and the upper one is Early Jurassic. The Late Triassic assemblage was later separated into three subassemblages (Yao et al.,1980b); the upper two of these, the *Paleosaturnalis gracilis* subassemblage and the *Poulpus* (?) sp. subassemblage were proposed for late Norian and Rhaetian forms, respectively. In 1982, Yao erected the *Canoptum triassicum* Assemblage to encompass the two upper subassemblages with *Canoptum triassicum* Yao designated as the nominal species; numerous undescribed taxa were also figured at this time.

In 1982, Kishida and Sugano established five assemblage zones for Triassic strata from the Chichibu Belt in the Kuchi and Oita Prefecture, Japan. Their upper two zones, the *Spongosaturnalis multidentatus* Zone and the *Pantanellium* sp. B - *Gorgansium* sp. A Zone, were believed to be "middle Norian to early Rhaetian?, and Rhaetian" in age, respectively. The former zone was characterized by species of *Spongosaturnalis* Campbell and Clark and *Paleosaturnalis* Donfrio and Mostler, the latter by undescribed species of *Pantanellium* Pessagno, *Gorgansium* Pessagno and Blome, *Paleosaturnalis* Donfrio and Mostler, and *Dictyomitra* Zittel. Kishida and Hisada (1986) renamed the *Spongosaturnalis multidentatus* Zone, the *Paleosaturnalis multidentatus* Assemblage, and divided it into two subassemblages: the lower *Canoptum* aff. *triassicum* Subassemblage, and the upper *Canoptum lubricum* Subassemblage. The *Paleosaturnalis multidentatus* Assemblage forms the uppermost Triassic unit in their zonal scheme. The overlying *Pantanellium* sp. B - *Gorgansium* sp. A Zone was revised to the *Bagotum psuedoerraticum* Assemblage becoming the lowest Jurassic unit.

Matsuoka figured upper Norian radiolarians from the southern subbelt of the Chichibu Belt, Kochi Prefecture (1983) and discussed faunas from the Togano Group (1984). Subsequently, Sato, Murata and Yoshida (1986) established the *Betraccium deweveri* Zone for upper Norian strata in the southern part of the Chichibu terrane in Kyushu. *Betraccium deweveri* Pessagno and Blome, *B. yakounense* Pessagno and Blome, and *Canoptum triassicum* Yao were included in this assemblage as well as species of *Sarla* Pessagno and *Pseudoheliodiscus* Kozur and Mostler. Yoshida (1986) examined a Late Triassic to Early Jurassic bedded chert sequence in Kagamigahara City, Gifu Prefecture, central Japan, and subdivided it into seven radiolarian zones. Based on comparison with radiolarian zonations of Yao (1982) and Blome (1984), Yoshida confined the *Betraccium deweveri* Zone to the upper Norian (as used in this study), established the *Livarella* - *Canoptum* Zone for strata believed to be early to middle Rhaetian in age, and the overlying *Justium* cf. *J. novum* Zone for strata presumably of late Rhaetian age. Three species of *Livarella* Kozur and Mostler were described from the *Livarella* - *Canoptum* Zone.

In initial studies of radiolarians from the Nadanhada Range, Northeast China, Kojima and Mizutani (1987) figured upper Norian and Rhaetian taxa (*Livarella validus* Yoshida and *Pseudoheliodiscus* sp.) from Triassic bedded chert (sample JMP 1299). Subsequently, Kojima (1989) discussed the accretionary history of terranes along the continental margin of East Asia during Mesozoic time using Middle and Upper Triassic radiolarian assemblages (including some upper Norian and Rhaetian taxa) to point out similarities between the Nadanhada-Western Sikhote-Alin terrane, and the Tamba-Mino-Ashio terrane of southwest Japan. Implications are that the Nadanhada Range is the northern extension of the Japanese terrane. The history of this Mesozoic superterrane is further discussed by Mizutani, Shao, and Zhang (1990) along with similar tectonostratigraphic terranes in the Ryukyu arc, the Philippines and probably Borneo. A recent paper by Yang and Mizutani (1991) outlines the geology and biostratigraphy of the Nadanhada Terrane, presents preliminary revision of parasaturnalids, and describes new parasaturnalid taxa of latest Triassic and early Jurassic age.

In the Phillipines, Cheng (1989) illustrated upper Norian radiolarians (*Betraccium deweveri* Assemblage) from bedded chert of Uson Island (sample USON-X). Further studies in this area by Yeh (1992) indicate that, in addition to faunas of late Ladinian and late Carnian age, two radiolarian assemblages dated as late Norian and early Rhaetian are present also. These were assigned to the *Betraccium deweveri* Assemblage and the *Livarella longus* Assemblage respectively.

In the eastern USSR (now eastern Russia), Triassic microfaunas in the Sikhote-Alin Terrane, Sakhalin Island, and the Koryak Upland were studied by Bragin (1986, 1990, 1991). Radiolarians and conodonts of mid Early Triassic to latest Triassic age (including late Norian and Rhaetian faunas) are present in chert sequences at Sikhote-Alin where seven radiolarian zones and seventeen conodont zones have been established. Forms such as *Betraccium deweveri* Pessagno and Blome, *Canoptum triassicum* Yao, *Kozurastrum multidentatus* (Kozur and Mostler) and *Livarella gifuensis*Yoshida occur in the uppermost radiolarian zone 7. These forms are discussed and illustrated and new taxa are described.

The foregoing synopsis illustrates that radiolarian workers around the world have been investigating upper Norian and Rhaetian faunas since 1980, and that the tempo of research has accelerated quite rapidly in the past five years. Despite this intensity, the vast majority of the Rhaetian fauna remains undescribed. The present study seeks to describe and illustrate as much of the Rhaetian fauna of the Queen Charlotte Islands as is possible at this time. Because the evolution of this diverse and unusually well preserved fauna can be followed so precisely and correlated from section to section, it is hoped that radiolarian zonation proposed will be able to stand alone wherever strata of Rhaetian age are found.

Acknowledgements

The work presented here is part of a joint biostratigraphic study of Upper Triassic and Lower Jurassic faunas of the Queen Charlotte Islands conducted by the Geological Survey of Canada. Discussions with M.J. Orchard, H.W. Tipper, and E.T. Tozer (other members of this group) have been stimulating, informative, and essential to the greater understanding of Late Triassic biostratigraphy. My special thanks go to Dr. Tipper for his enduring support and guidance towards the completion of this study.

I thank R.I. Thompson (and later J.W. Haggart) who headed the Queen Charlotte Frontier Geoscience Program, for providing logistic support. M.J. Johns (Pacific Geoscience Centre, Sidney, B.C.) and P. Krause (GSC, Vancouver, B.C.) photographed most the specimens; Tonia Oliveric carefully drafted the detailed figures; their help is greatly appreciated.

The database used for computation of Unitary associations (U.A.) was constructed during my visit to the Université de Lausanne in October 1991. I thank Spela Gorican and Pascale Mallan who helped with this task, ran the computer program BioGraph, and aided in the interpretation.

Two radiolarian samples from Triassic-Jurassic boundary localities in widely separate geographic areas of the world are also included in this study. The first, from a Triassic-Jurassic boundary section at

Wadi Musallah, Oman, was obtained from Alain Pillevuit, Université de Lausanne. The second sample, from the Utcubamba valley of northern Peru, was collected by Prof. Dr. A. von Hillebrandt of the Technische Universität, Berlin. Both collectors are kindly thanked for the samples and for permission to include the results in this study.

R.V. Best (Professor emeritus, University of British Columbia) carefully read the lengthy radiolarian systematics and contributed greatly towards improving the text. P. Dumitrica examined some Queen Charlotte radiolarian specimens in thin section; his meticulous study has contributed substantially to the detailed definition of the Family Ferresiidae and included genera. And finally, I thank J. Guex, A. Baud, P.O. Baumgartner, P. Dumitrica, and F. Hirsch for reviewing the manuscript; their comments and suggestions have been most helpful and are sincerely appreciated.

This work was completed for a PhD at the Université de Lausanne under the directorship of Prof. J.Guex. Publication was supported by the Université de Lausanne (Rectorat and Fondation Pierre Oguey) and the Geological Survey of Canada.

THE SANDILANDS FORMATION

Lithostratigraphy

The Sandilands Formation (Cameron and Tipper, 1985; Desrocher and Orchard, 1991) outcrops widely in Queen Charlotte Islands but exposures of the basal (Upper Triassic) part are rare. Reference sections for this interval designated by Desrocher and Orchard (1991) are located at Kennecott Point and Kunga Island; other very limited outcrops are exposed on the north side of Louise Island and the south shore of Skidegate Inlet east of South Bay (Fig. 1). The formation consists predominantly of thinly-bedded, dark grey siliceous siltstone, minor tuffaceous sandstone and shale, and rare limestone beds, lenses, and concretions. It conformably overlies the upper member (*Monotis* beds) of the Peril Formation (Desrochers and Orchard, 1991) and underlies the massive shale beds of the Ghost Creek Formation (Cameron and Tipper, 1985).

The Sandilands is Late Triassic (upper Norian? Rhaetian) to Early Jurassic (latest Sinemurian to earliest Pliensbachian) in age based on contained ammonoid, conodont and radiolarian faunas (Carter, Orchard and Tozer, 1989; Carter, 1990; Orchard, 1991; Tipper et al., 1991). The formation is believed to contain Triassic-Jurassic boundary strata at both Kennecott Point and Kunga Island (Tipper and Carter, 1990; Tipper et al., in press).

Cameron and Tipper (1985) suggested the Sandilands Formation was deposited in a relatively deep water backarc basin that was remote from volcanic centres receiving only fine volcanic detritus. The source of this volcanic material is problematic and there is no clear evidence for its location. They propose a volcanic terrane probably lying to the west or southwest of the basin.

Kennecott Point

The Sandilands Formation at Kennecott Point (northwest Graham Island) begins directly above the topmost *Monotis* coquina of the Peril Formation where the stratigraphic contact marks the change from carbonate to clastic sedimentation. It is composed of thinly-bedded siltstone with minor sandstone, limestone and shale, and abundant limestone lenses and concretions (Fig. 3a). In this area, the Sandilands is sandier and less tuffaceous than at localities further south in the Charlottes. The rocks are also lighter in colour and apparently have not undergone the extensive siliceous alteration more typical of the formation elsewhere. The main section at Kennecott Point (section KPA) and a shorter auxiliary section (section KPX; located parallel to, and seaward of, section KPA across a fault) have been measured and collected repeatedly over the years 1987-1990 by the author and M.J. Orchard. These sections are illustrated here as a composite section (section 1; Fig. 2). Several small faults displaying left lateral movement are present in the lower 30 m of section KPA but none have significant displacement. For this reason, the lower part of the composite section is based primarily on section KPX (where strata are less disrupted) whereas the middle and upper parts are from section KPA. Correlation between sections KPA and KPX is provided by prominent calcareous sandstone marker beds (some double leafed) (Fig. 3b). Other markers used to re-establish stratigraphic position from year to year include large concretions with painted numbers (Fig. 3c) and thin slabby siltstone beds whose surfaces are covered with flattened organic remains (subcircular in outline) possibly belonging to the hydrozoan *Heterastridium*. Trace fossils such as *Thalassinoides* are abundant on bedding planes throughout the sequence.

Well preserved radiolarians have been recovered from relatively large limestone concretions (maximum dimensions, 100 cm x 30 cm) in the lower 70 m of section (see Appendix for details). Above this level the beds become sandier and concretions are rare; those present are larger and coarser grained, and many have internal laminations of post-diagenetic origin. Over the years, radiolarian recovery in this interval has been poor but a few collections (90/23, 90/24 and 90/25) have yielded abundant but poorly preserved faunas. Other microfauna in section 1 include conodonts, icthyoliths, sponge spicules, and pyritized foraminifers.

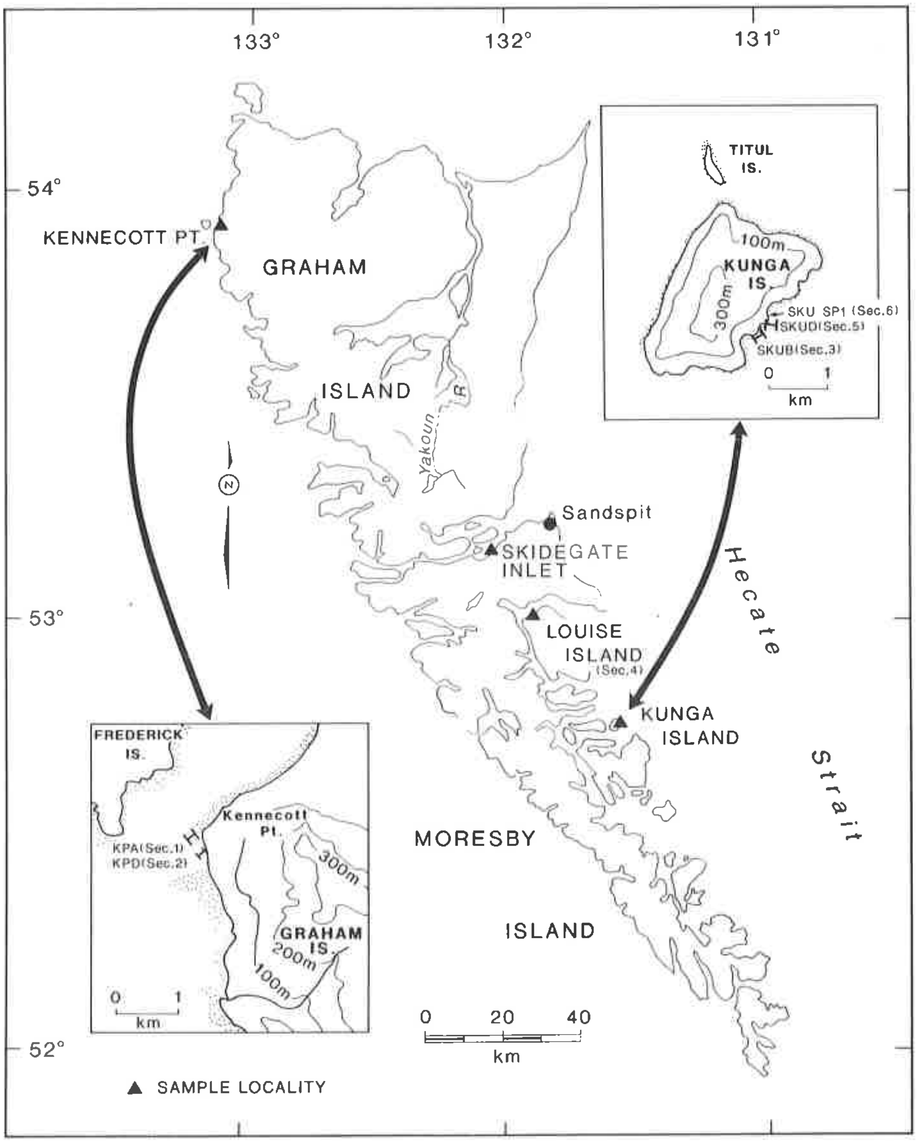


Figure 1. Map of Queen Charlotte Islands showing radiolarian-bearing localities of the Sandilands Formation. Insets show position of sections 1 and 2 at Kennecott Point, and sections 3, 5, and 6 at Kunga Island.

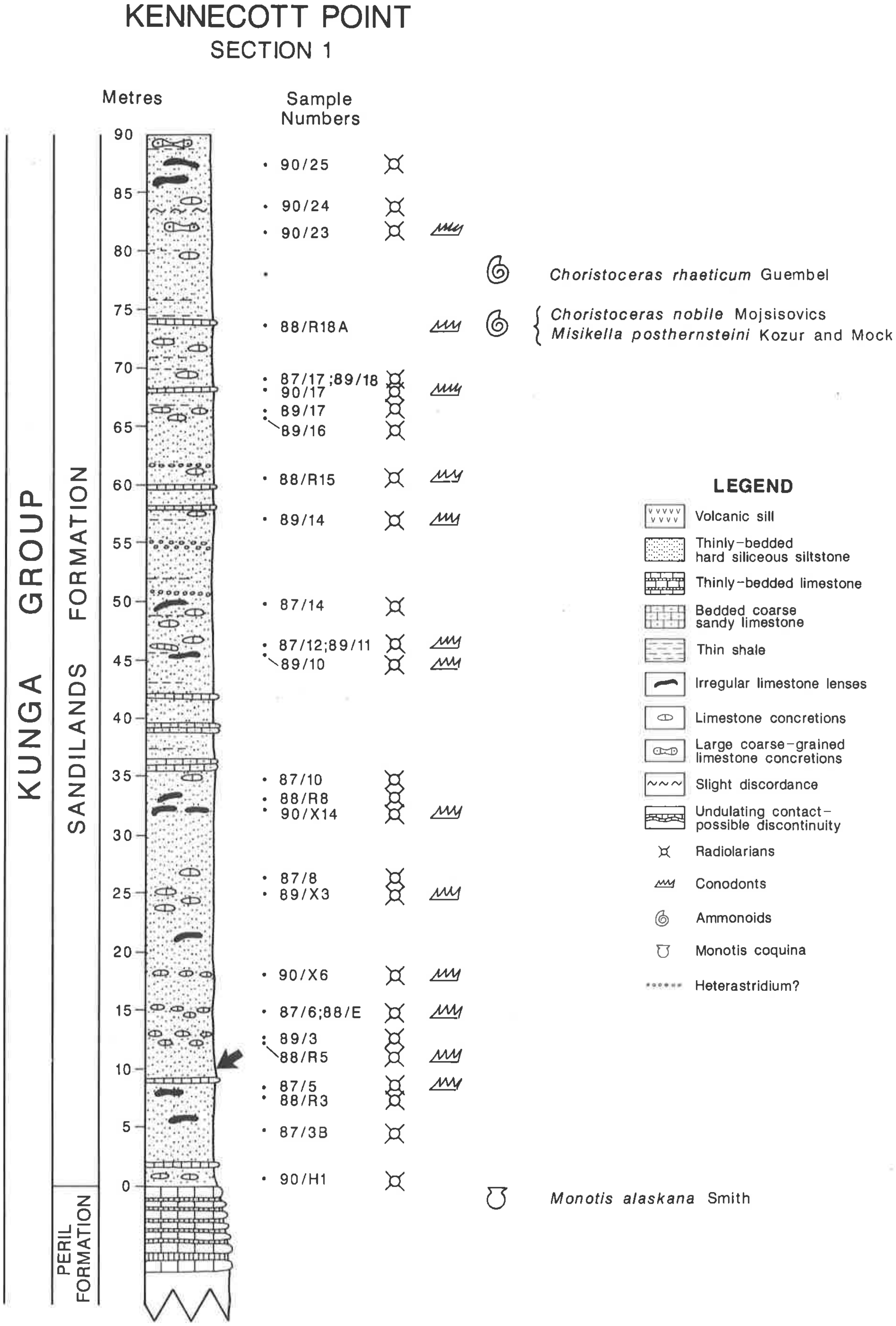


Figure 2. Section 1 (KPA), Kennecott Point; showing GSC sample localities yielding radiolarian and/or conodont collections and stratigraphic position of macrofossil collections. Arrow marks approximate position of Norian-Rhaetian boundary as defined by radiolarians. See Appendix 1 for other conodont identifications.

Kunga Island

Extensive exposures of the Sandilands Formation fringe the northern and southern shores of Kunga Island. These rocks were originally described by Sutherland Brown (1968) as the 'black argillite member' of the Kunga Formation with the type section for all three members of the formation located on the north shore of Kunga Island. Of all Sandilands localities examined by the Geological Survey of Canada since 1986, it is still likely that the most complete exposures of the formation are at Kunga Island. On the north side of the Island the topmost *Monotis* coquina of the Peril Formation is overlain (above an undulating contact) by a short sequence of calcite-veined argillaceous beds. These beds are possibly Sandilands Formation but no fossils have been recovered and age is uncertain. Upsection, beyond a covered interval, a lengthy exposure of faulted and disrupted (but probably complete) Sandilands strata is dated middle Hettangian to uppermost Sinemurian on ammonites (H.W. Tipper, pers. comm., 1991; Palfy, 1991). On the south side of Kunga Island the upper member (*Monotis* beds) of the Peril Formation and the overlying post-*Monotis* strata are exposed. These strata are conformably overlain by beds containing lowest Hettangian radiolarians (Carter, in press; Tipper et al., in press) and disconformably overlain by beds containing lower and middle Hettangian ammonites (H.W. Tipper, pers. comm., 1991). Across a small bay, and extending to the eastern tip of the island, the entire Sinemurian sequence is present (Palfy, 1991).

On the south side of Kunga Island the Triassic part of the Sandilands is exposed well above the rugged shoreline in steeply-dipping to nearly vertical overturned beds (Fig. 3d). It consists of a monotonous sequence of hard, black, frequently laminated, thinly-bedded siltstone, limestone concretions, a few sandy limestone beds and very minor limestone and shale (Fig. 3e). The rocks are heavily silicified and only the variably-sized concretions (Fig. 3f) appear to be unaltered. At this locality almost 50 m of calcite-veined argillaceous strata are exposed in the interval between the top of *Monotis* and the basal thinly-bedded, blocky, siliceous siltstone beds ("argillite") more typical of the Sandilands Formation. This sequence is cut by several volcanic dikes and sills and structural thickening is possible. Section 3 (Fig. 4) begins above the topmost sill and the lower part of the section illustrates part of the calcite-veined argillaceous package discussed above. At 16.5 m an undulating contact is observed and above this level thinly-bedded, blocky, siliceous siltstone typical of the Sandilands Formation predominates. On the north side of the Kunga Island a contact of similar kind is found in approximately the same stratigraphic position. The question of where to place the boundary between the Peril and Sandilands formations on the south side of Kunga Island is somewhat problematical as indicated on Fig. 4. According to definition, the base of the Sandilands Formation is drawn at the top of the *Monotis* coquina of the Peril Formation (Desrochers and Orchard, 1991). If the boundary is so placed then the immediately overlying strata differ considerably from the base of the Sandilands Formation at Kennecott Point, and the basal part of the formation is much thicker at Kunga Island. On the other hand, if the formational boundary is drawn where siliceous beds typical of the Sandilands Formation begin, then some basal beds at Kennecott Point may be missing or the sequence be simply much thinner in more northerly basins. In Fig. 4 this boundary is tentatively drawn where typical Sandilands beds begin. Regardless of where the base of the Sandilands is placed, the sequence illustrated in section 3 is continuous for at least 70 m above the possible contact shown at 16.5 m. Despite intensive search in 1989, no macrofossils have been found above *Monotis* in Triassic strata at Kunga Island. Section 3 is believed to be approximately equivalent to the Amoenum ammonoid zone based on comparision of the conodonts and radiolarians with better dated faunas at Kennecott Point.

Figure 3a. Section 1 (KPA), Kennecott Point; looking upsection from about 40 m level.

Figure 3b. Double-layered coarse calcarenite beds are a useful lithologic marker in correlating slightly displaced sequences of rock at Kennecott Point.

Figure 3c. Section 1 (84 m), Kennecott Point, large calcareous sandstone concretions provide minimal correlation between section 1 (Kennecott Point) and section 5 (Kunga Island).

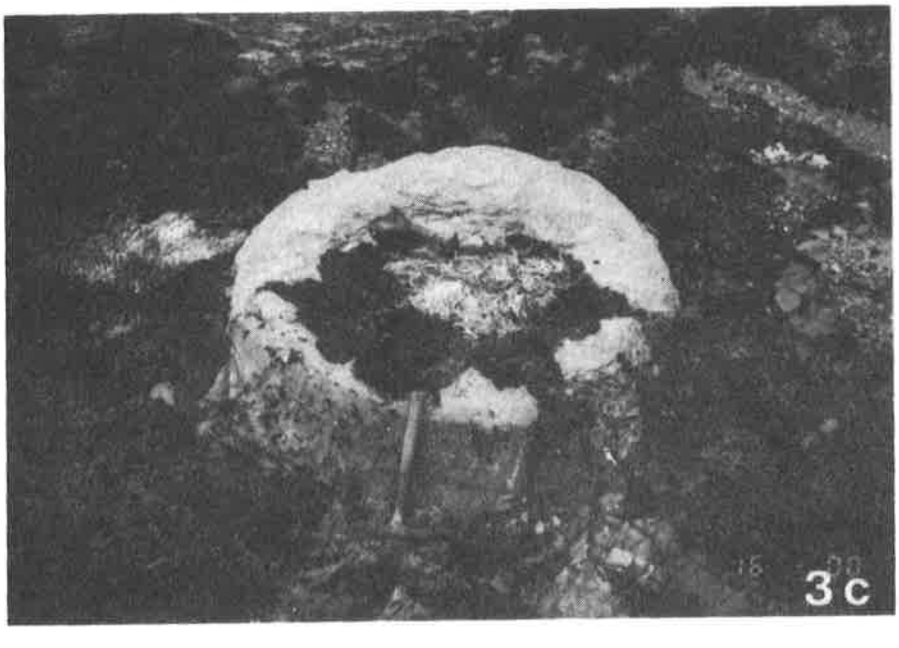
Figure 3d. Uppermost Triassic Sandilands Formation exposed high above shoreline on south side of Kunga Island (section 5); beds are steeply-dipping to vertical, and overturned. Photograph taken about 75 m level looking downsection.

Figure 3e. Partly laminated siliceous siltstone beds exposed in lower part of section 5, Kunga Island (from Carter and Galbrun, 1990).

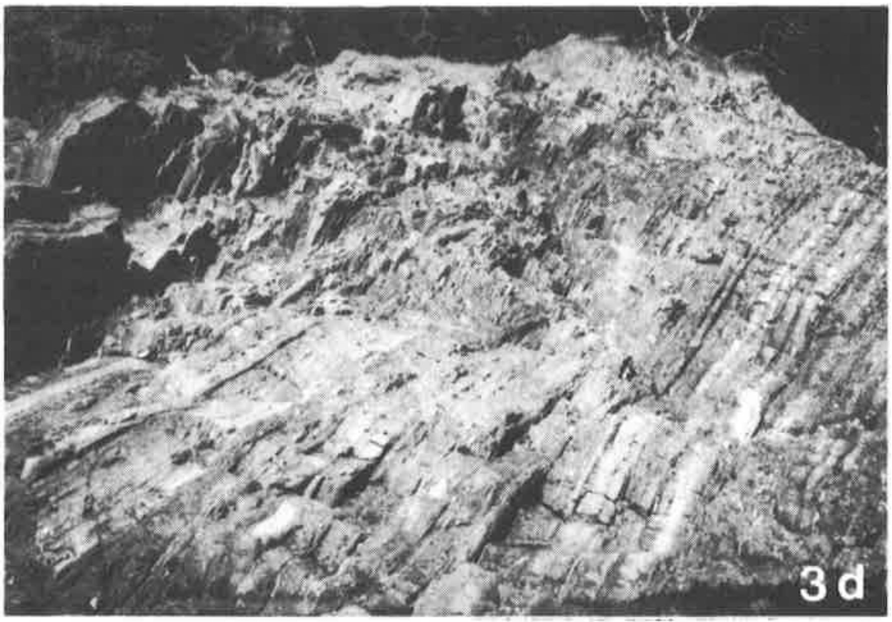
Figure 3f. Micrite concretions in thinly-bedded black siliceous siltstone about 28 m above base of section 5, Kunga Island. These concretions commonly contain well preserved radiolarians (from Carter and Galbrun, 1990).

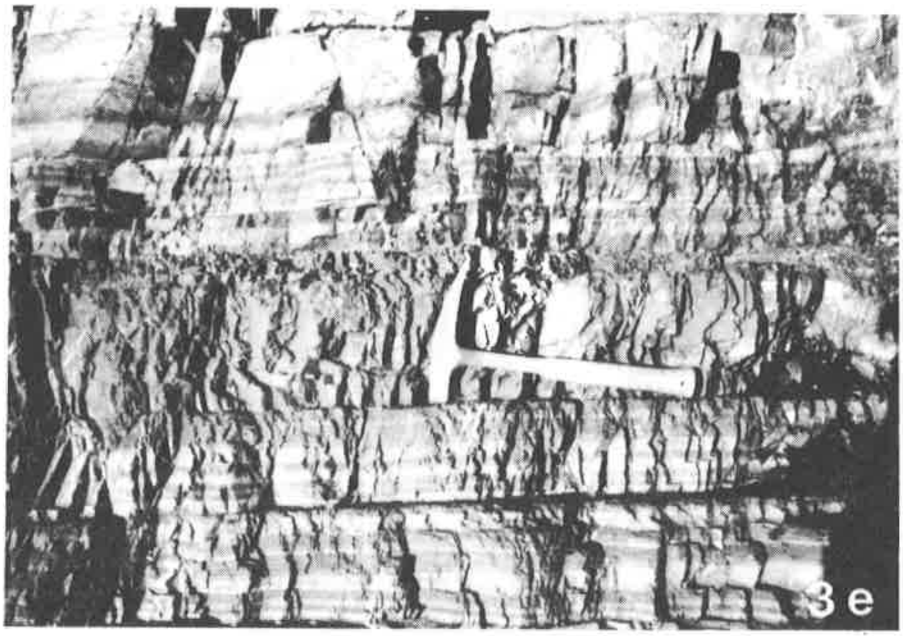
3a

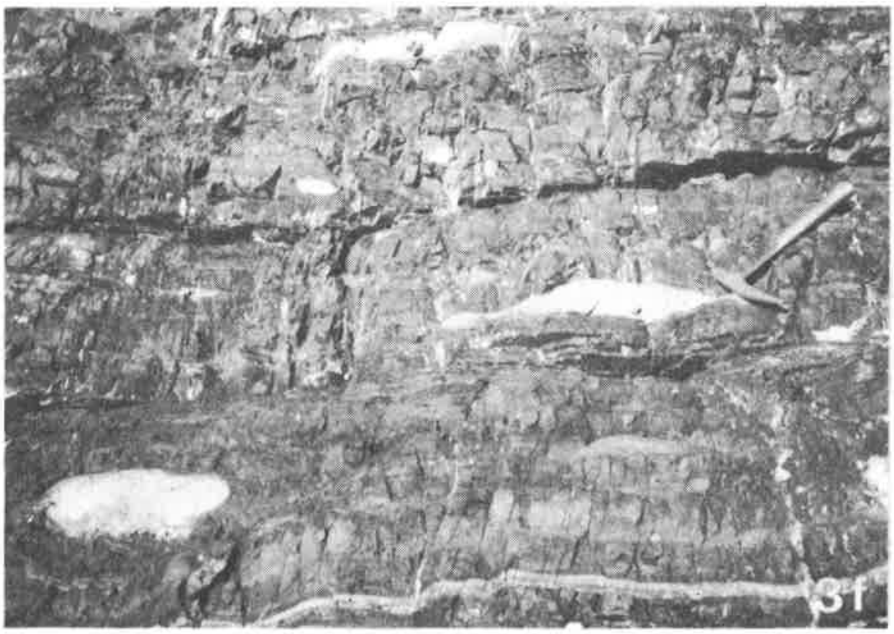
3b



3c


3d


3e


3f

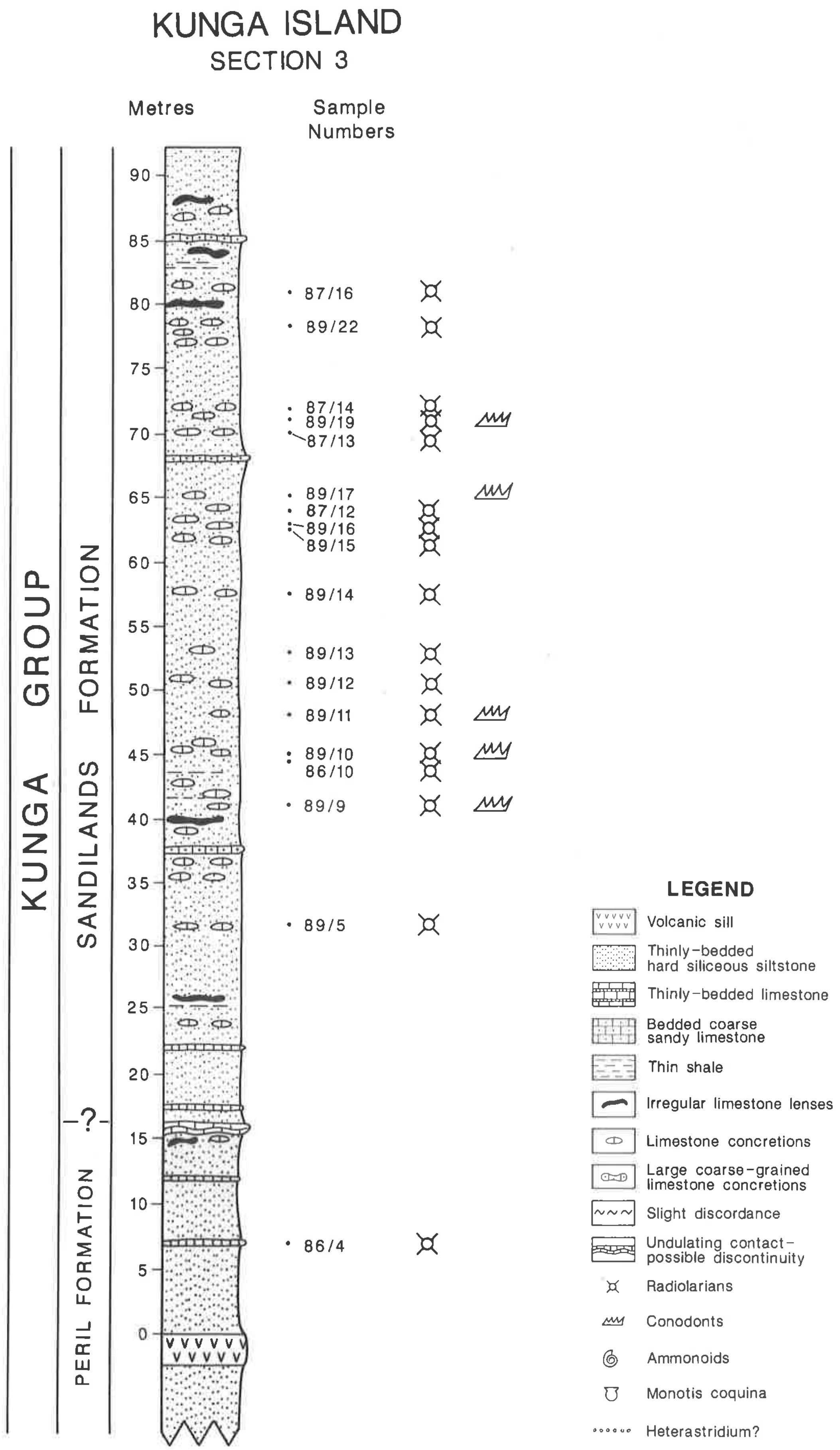


Figure 4. Section 3, Kunga Island; showing GSC sample localities yielding radiolarian and/or conodont collections. Boundary between Peril and Sandilands formations tentatively placed where typical Sandilands strata begin. See Appendix 1 for conodont identifications.

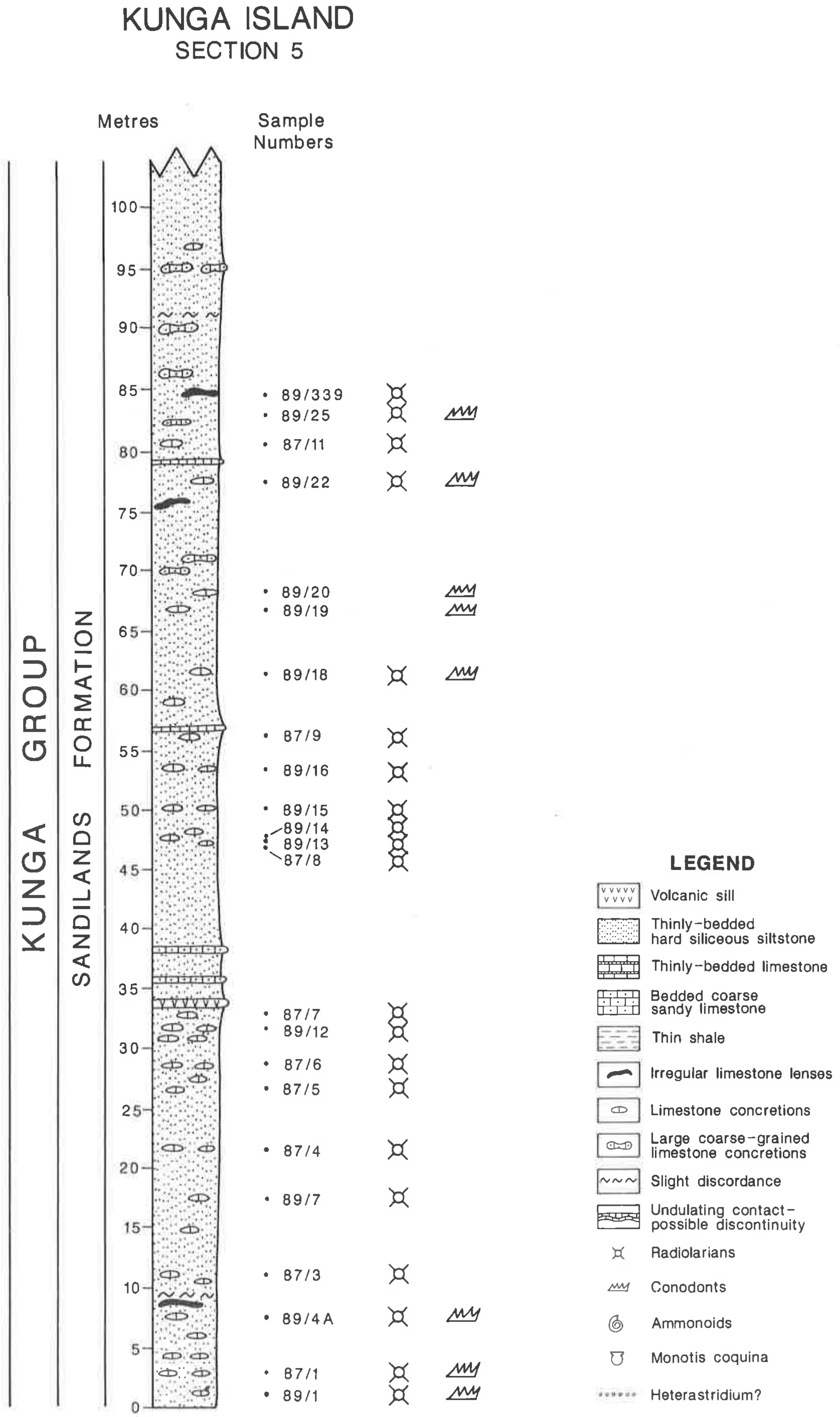


Figure 5. Section 5, Kunga Island; showing GSC sample localities yielding radiolarian and/or conodont collections. See Appendix 1 for conodont identifications.

Section 5 at Kunga Island (Fig. 5) lacks the base of the Sandilands Formation but probably contains the most complete sequence of uppermost Triassic strata in the Charlottes and possibly the Triassic-Jurassic boundary (Tipper et al., in press). The 0.5 m thick volcanic sill at 32.5 m is faulted and right-laterally displaced about 1 m causing some slight disruption in the overlying beds. As a result the section may be slightly thickened but evidence from the radiolarian faunal succession suggests none is missing. The lithology is almost identical to section 3, but in section 5 the uppermost beds tend to coarsen i.e. sandstone beds become more frequent, and limestone concretions larger (maximum diameter, 150 cm), coarser grained, and strongly laminated.

Triassic Sandilands sedimentary rock at Kunga Island is hard, black and barren. Microfaunas recovered from the limestone concretions apparently provide the only record of life at the time these rocks were deposited. Radiolarians are the most abundant well preserved fauna in these concretions and this emphasizes the fact stressed by Baumgartner (1984b) that "radiolarian abundance and preservation is extremely dependent on lithology reflecting sedimentary environment and diagenetic history." These Kunga Island faunas provide the most complete record of radiolarian evolution for the uppermost Triassic of the Queen Charlotte Islands. Conodonts are less frequent and diversity is lower than from samples of similar age at Kennecott Point. Other microfauna are very sparse.

Louise Island

On the north side of Louise Island, just east of Beattie Anchorage, about 15 m of Sandilands strata are exposed in a vertical quarry face on the south side of the 'Louise Main' logging road (Fig. 1). Here the formation consists almost exclusively of hard, dense, thinly-bedded siltstone. Small micrite concretions (maximum dimensions, 30 cm x 5 cm) containing abundant, well preserved radiolarians occur at two horizons (approximately 2 m apart) near the base of the exposure (See Appendix 1). The quarry was first visited in 1985, and an intensive search was conducted for macrofossils during successive visits in 1986 and 1987 but none were found. Undifferentiated conodont ramiform elements have been recovered from the upper horizon at Louise Island (M.J. Orchard, pers. commun., 1989). Comparison of radiolarians with those from Kennecott Point and Kunga Island indicates the faunas belong to Assemblage 2 (Carter, 1990) and probably approximate the Amoenum Zone. The Louise Island samples comprise section 4 (see Radiolarian Biochronology); the distribution and abundance of radiolarians from these samples is shown on figures 7 and 8.

Skidegate Inlet

About 12 m of slightly dipping post-*Monotis* Sandilands strata are exposed on a narrow beach on the north shore of Moresby Island about 3.4 km east of south Bay (Fig.1). These beds are dark grey siliceous siltstone with a few concretionary limestone lenses. No ammonites or conodonts have been found at this locality but several well preserved radiolarian collections belong to Assemblage 3 of Carter 1990. A few radiolarians from GSC locality C-140377 (85 SP10/2) are illustrated on pl. 6 and 8, but the locality is not included on figures 7 and 8 nor in the computation of Unitary Associations.

Lithostratigraphic correlation

The Triassic Sandilands Formation is primarily a monotonous sequence of thinly-bedded, dark grey siltstone with common limestone concretions. There are very few distinctive lithologic markers. Correlation is not always possible within local areas and it is far more difficult at greater distance. The few markers utilized are discussed below together with an assessment of their value:

(1) The most distinctive and useful lithologic markers in Triassic Sandilands rock are large, sandy, frequently-laminated concretions (Fig. 3c) that occur in the upper parts of section 1 (Kennecott Point) and section 5 (Kunga Island) (see Fig. 6). These concretions correlate only the topmost beds of these sections but in both instances the underlying beds are believed to be continuous.

(2) The coarse calcarenite beds shown in section 1 at approximately 35.0 and 39.0 m (Fig. 2; Fig. 3b) are useful in correlating slightly displaced sequences of rock (e.g. sections KPA and KPX at Kennecott Point). However, beds of similar lithology cannot be correlated between section 3 and section 5 at Kunga Island, nor is correlation possible between Kennecott Point and Kunga Island.

(3) Bedding surfaces covered with flattened, subcircular organic remains (possibly *Heterastridium*) are useful in correlating closely spaced sections at Kennecott Point, but this marker is not present at Kunga Island.

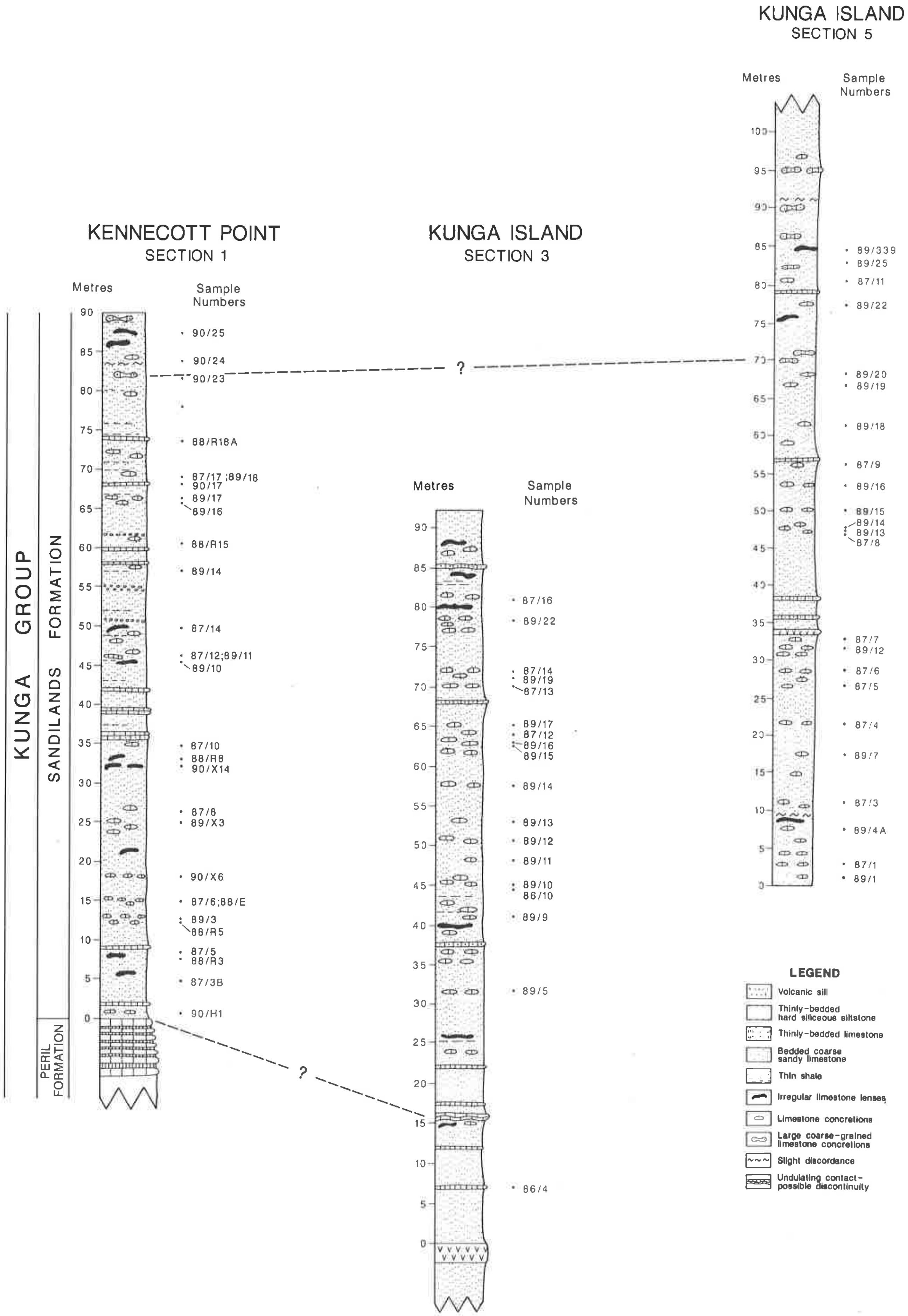


Figure 6. Lithologic correlation of sections at Kennecott Point and Kunga Island.

(4) In undeformed strata, the *Monotis* coquina is a distinctive marker. It is present directly beneath the base of Section 1 at Kennecott Point. However, at Kunga Island, structural complications in the interval between the top of *Monotis* and the beginning of "typical Sandilands beds" negate its value.

(5) Volcanic sills in sections 3 and 5 at Kunga Island cannot be correlated but do provide evidence that the two sections were separated before lava emplacement occurred. These sills are probably related to deformation associated with Middle to Late Jurassic plutonism (Anderson and Grieg, 1989). They have no correlative at Kennecott Point.

Lithostratigraphic correlation between sections at Kennecott Point and Kunga Island can be approximated only at two levels (see Fig. 6). The lower level is the Peril-Sandilands contact in section 1 (Kennecott Point) which can be correlated with the undulating contact marking the lowest siliceous beds "typical" of the Sandilands Formation in section 3 (Kunga Island). The upper level is characterized by the onset of beds containing large, coarse grained, calcareous sandstone concretions; this marker provides limited correlation between Kennecott Point (section 1) and Kunga Island (section 5).

Widespread correlation of Upper Triassic Sandilands strata is strongly hampered by the effects of thermal and hydrothermal alteration on geographically separated sequences exposed to differing plutonic or tectonic regimes. At Kennecott Point, Sandilands strata are light in colour, and individual beds can be easily differentiated. The overall appearance is strikingly different from the structurally-deformed and altered siliceous black rock at Kunga Island. These differences have been pointed out by Orchard and Forster (1991) in their studies of conodont colour and thermal maturity of the Late Triassic Kunga Group. Conodont colour is governed primarily by the effects of burial metamorphism, contact metamorphism, and hydrothermal alteration. It is calibrated against the colour alteration index (CAI) of Epstein et al. (1977), which ranges from 1 through 8 with increasing values implying greater post-depositional heating. Orchard and Forster found that conodonts from Sandilands strata at Kennecott Point have CAI values of 1.5 (rarely ranging to 2.0), whereas at Kunga Island CAI values are commonly 4.5 - 5.0. Thus, rocks at Kunga Island have presumably been exposed to a much higher heat regime than those at Kennecott Point. Orchard and Forster concluded that plutonism and associated hydrothermal activity strongly controlled the variation in conodont CAI values in Triassic Kunga Group strata.

INDEPENDENT FOSSIL DATING

In the following discussion of fossil dating, macrofossil determinations were made by E.T. Tozer and conodont identifications by M.J. Orchard both of the Geological Survey of Canada, Cordilleran Division, Vancouver, B.C. (See Appendix 1 for details).

Macrofossils

In Queen Charlotte Islands and other parts of North America the pelagic bivalve *Monotis* is equated with the Cordilleranus Zone which is "lower Upper Norian" according to Triassic ammonoid biochronology proposed by Tozer (1979). In the reference section for the Sandilands Formation at Kennecott Point (section 1, Fig. 2), lowest beds directly overlie the upper member (*Monotis* beds) of the Peril Formation. No macrofossils to indicate the Cordilleranus and/or Amoenum Zone have been found in the lower and middle parts of this section but the sequence appears to be continuous and contains *Choristoceras nobile* Mojsisovics and *C. rhaeticum* Gümbel (at 73.5 m and 78 m respectively) near the top. These ammonoids are characteristic of the uppermost Triassic Crickmayi Zone of Tozer (1979). No macrofossils have been found in Triassic Sandilands strata at Kunga Island.

Conodonts

Conodont collections are fairly common in lower and middle parts of the Triassic Sandilands Formation at Kennecott Point and Kunga Island but specimens are rare and the fauna is less diverse in the upper part. *Epigondolella* ex gr. *bidentata* [a broad group encompassing *E. bidentata* Mosher, *E. mosheri* (Kozur and Mostler 1971), *E. slovackensis* (Kozur 1972) and *E. humboldtensis* Meek 1971 (Orchard, 1991)] is characteristic of the *Epigondolella bidentata* Zone which in the Queen Charlotte Islands occurs in the upper member (*Monotis* beds) of the Peril Formation and in the overlying post-*Monotis* strata of the Sandilands Formation (Orchard, 1991, p. 180). In British Columbia and Nevada, *Epigondolella* ex gr. *bidentata* ranges from latest middle Norian to the lower part of the topmost Triassic Crickmayi Zone (see Orchard, in Carter, Orchard, and Tozer, 1989, p. 29). The age of the *bidentata* beds in the Sandilands is uncertain, but based on comparison with conodonts from other localities in British Columbia, they are probably equivalent to the Amoenum Zone (M.J. Orchard, pers. comm., 1991). Rare specimens of *Misikella posthernsteini* Kozur and Mock have been found in beds with *Choristoceras rhaeticum* in section 1 (KPA) at Kennecott Point. This confirms the presence of youngest Triassic conodonts in the Crickmayi Zone of North America.

Other conodonts in Triassic Sandilands strata include neogondolellid species, and undifferentated ramiform elements. These are the only conodonts found in the topmost beds of section 1 (Kennecott

Point) and section 5 (Kunga Island). At the former locality these faunas occur in beds above the single occurrence of *Misikella posthernsteini.*

RADIOLARIAN FAUNAS

Microfossil recovery and preservation

All radiolarians in this study have been extracted from limestone lenses or concretions. The faunas are very well preserved and contain many delicate and fragile skeletons. Most specimens are whole with intact spines, terminal tubes, velums etc. and the internal structure of many can be observed with the binocular microscope. This is consistent with Blome et al. (1987) who determined that microfaunas from limestone concretions are usually more abundant, diverse, and better preserved than those from the surrounding rocks. Most fossil radiolarians from the Sandilands Formation are siliceous but a few well preserved pyritized faunas have been found.

Microfossil recovery directly reflects the occurrence of fine grained limestone concretions in the sections sampled. Following an assessment of each years collections, sparsely productive or barren intervals in each section were identified and these were sampled more intensively during the next field season. Thus over the years 1987-1990 many excellently preserved collections have been assembled. Kennecott Point collections are well dated by co-occurring or associated fossil groups (ammonoids and conodonts); collections from Kunga Island are less precisely dated, but otherwise are more closely spaced, consistently better preserved, and likely provide the most complete record of radiolarian evolution through the Rhaetian. The stratigraphic position of the Louise Island collections has been identified both by comparison of faunas with those from Kennecott Point and Kunga Island, and by the computer program BioGraph (Savary and Guex, 1991) (see Figs. 11 and 12). These collections supplement radiolarian data for rock intervals of similar age that are less well recognized in other areas.

Radiolarian diversity and composition of the fauna

Radiolarian diversity is consistently high in Upper Carnian and Norian strata of the Queen Charlotte Islands (Carter, Orchard and Tozer, 1989; Carter, 1991) and is maintained through the Rhaetian to topmost beds. The Rhaetian fauna was evolving rapidly and many short-ranging taxa were introduced. Several broad taxonomic groups have been distinguished by Carter (in press): conservative forms such as the pantanelliids and canoptids; architecturally-complex forms like *Squinabolella*, *Haeckelicyrtium*, *Citriduma* etc.; and rapidly-radiating forms such as *Ferresium* and *Laxtorum* (see Carter 1992). Over 150 taxa, representing about 80 percent of the total fauna, comprise the biostratigraphic framework of this study. One family, five genera, and 63 species, are described as new and many other forms are informally discussed (see Chapter 2); with the exception of *Praecitriduma mostleri* Kozur, all forms are illustrated on plates 1-21. The distribution and abundance of taxa in sampled localities at Kennecott Point, Louise Island, and Kunga Island is shown on Figs. 7 and 8. Questionable occurrences (marked by a "?") indicate uncertain, but probable, identification.

Radiolarian diversity seems especially high when compared with that of ammonoids and conodonts, both of which experienced serious decline in the latest Triassic, with conodonts becoming extinct. This is not to say that radiolarians were not affected by the terminal Triassic extinction - they were, but theirs was an abrupt extinction rather than a gradual decline (Carter, in press). In all collections spumellarians outnumber nassellarians by a ratio of about two to one. The spumellarians are predominantly pantanelliids (*Betraccium* Pessagno, *Cantalum* Pessagno, and *Pantanellium* Pessagno), saturnalids (including *Kozurastrum* DeWever, *Mesosaturnalis* Kozur and Mostler, and *Pseudoacanthocircus* Kozur and Mostler) and other genera such as *Ferresium* Blome, *Paratriassoastrum* Kozur and Mostler, *Paronaella* Pessagno, and *Plafkerium* Pessagno. The nassellarian fauna is dominated by multicyrtid canoptids and laxtorids, by *Squinabolella* Pessagno, *Haeckelicyrtium* Kozur and Mostler, and by taxa having strong affinity to *Canutus* Pessagno and Whalen. *Livarella* Kozur and Mostler, of uncertain affinity, is common in most samples. Other commonly occurring genera include *Tetraporobrachia* Kozur and Mostler, *Triassocrucella* Kozur, *Citriduma* DeWever, *Deflandrecyrtium* Kozur and Mostler, *Pentactinocarpus* Dumitrica, *Praecitriduma* Kozur, and forms similar to *Bipedis* DeWever, *Droltus* Pessagno and Whalen, and *Eptingium* Dumitrica.

R-Rare 1-2 specimens
C-Common 3-6 specimens
A-Abundant 6-20 specimens
A-Very abundant >20 specimens

KENNECOTT POINT — SECTION 1; SEC. 2

Species Code	Unitary Association Sample Level	90JF KPH 1	87CNA KPA 3B	88CNA KPA R3	87CNA KPA 5	88CNA KPA R5	89CNA KPA 3	87CNA KPA 6; 88OF KPA E	90OF KPX 6	89CNA KPX 3	87CNA KPA 8	90OF KPX 14	88CNA KPA R8	87CNA KPA 10	89CNA KPA 10	87CNA KPA 12; 89CNA KPA 11	87CNA KPA 14	89CNA KPA 14	88CNA KPA R15	89CNA KPA 16	89CNA KPA 17	90OF KPA 17	87CNA KPA 17; 89CNA KPA 18	90OF KPA 23	90OF KPA 24	90OF KPA 25	88CNA KPD 1AA (Sec. 2)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	1
AMP01	*Bistarkum? cylindratum* n. sp.						R				R		C	C		C						A	A		A		
ARC01	*Archaeocenosphaera* sp. aff. *A. laseekensis*							C		A						R		R									
ARC02	*Archaeocenosphaera* sp. A	?		?				**A**	A	**A**	R					C											
ARC03	*Archaeocenosphaera* sp. B																										
BET01	*Betraccium deweveri*	R		C	R																						
BET02	*Betraccium inornatum*										R					R		R									
BET03	*Betraccium* sp. cf. *B. inornatum*																						R				
BET04	*Betraccium* sp. aff. *B. inornatum*										R				R	A											
BET05	*Betraccium kennecottense* n. sp.															**A**								R			R
BET06	*Betraccium maclearni*	C		R	C																						
BET07	*Betraccium nodulum* n. sp.																										
BET08	*Betraccium pariense* n. sp.	R		A				R	C	R																	
BET09	*Betraccium* sp. A																										
BET10	*Betraccium* sp. B																										
BET11	*Betraccium* sp. C																										
BET12	*Betraccium* sp. D																		R								
BET13	*Betraccium* sp. E																						R				
CTL01	*Cantalum tianense* n. sp.								R		R																
CTL02	*Cantalum gratum* n. sp.															C					R		A	R			C
CTL03	*Cantalum* sp. A															R											
CTL04	*Cantalum* sp. B																										
CRU01	*Crucella flowerpotensis* n. sp.							R			R																
CRU02	*Crucella?* sp. A															R			R				R				
CRU03	*Crucella* sp. B																										
CRU04	*Crucella* sp. C									R			R										R				
ENT01	*Entactinosphaera? amphilapes* n. sp.	C		R										C					A	R							
ENT02	*Entactinosphaera?* sp. aff. *E.? simoni*								C										R								
ENT03	*Entactinosphaera? spinulata* n. sp.													R					R								
FER01	*Ferresium conclusum* n. sp.																			R			**A**				
FER02	*Ferresium* sp. aff. *F. laseekense*										R					R											
FER03	*Ferresium teekwoonense* n. sp.															**A**			R				**A**				
FER04	*Ferresium triquetrum* n. sp.									R													C				
FER05	*Ferresium* sp. A																										
FER06	*Ferresium* sp. B															R											
FER07	*Ferresium* sp. C																		R	R	R		A				
FON01	*Fontinella clara* n. gen., n. sp.																		C				C				C
FON02	*Fontinella habros* n. gen., n. sp.	R							R		?												C				C
FON03	*Fontinella inflata* n. gen., n. sp.	A							A		A			R		A							A				A
FON04	*Fontinella louisensis* n. gen., n. sp.	C							R	C			R			A				R							
FON05	*Fontinella primitiva* n. gen., n. sp.	C						R	C																		
HAL01	*Haliomma ? sawaiense*										R			**A**		A		**A**	**A**	C			**A**				
ICR01	*Icrioma? cistella* n. sp.			?				?	R							C											
ICR02	*Icrioma?* sp. A									R	R					C			R				C				
KAH01	*Kahlerosphaera* sp. A																										
KOZ01	*Kozurastrum beattiense* n. sp.																										
KOZ02	*Kozurastrum decibulum* n. sp.	C		C					C		R																
KOZ03	*Kozurastrum gracile*	A	C																								
KOZ04	*Kozurastrum huxleyense* n. sp.								R							R											
KOZ05	*Kozurastrum sandspitense*																										
KOZ06	*Kozurastrum* sp. aff. *K. sandspitense*																										
KOZ07	*Kozurastrum* sp. A	R																									
KOZ08	*Kozurastrum* sp. B																		C								
LOU01	*Loupanus thompsoni* n. gen., n. sp.								R										R		R						
	Radiolarian Assemblages	Bd				1					2a		2b				2c		2d		3						3

KUNGA ISLAND — SECTION 3; LOUISE ISLAND — SEC. 4

Species Code	Unitary Association Sample Level	88OF SKU B4	89CNA SKU B5	89CNA SKU B9	88OF SKU B10	89CNA SKU B10	89CNA SKU B11	89CNA SKU B12	89CNA SKU B13	89CNA SKU B14	89CNA SKU B15	89CNA SKU B16	87CNA SKU B12	87CNA SKU B13	89CNA SKU B19	87CNA SKU B14	89CNA SKU B22	87CNA SKU B16	85CNA SP 9/1	86CNA SP 1/1	87CNA SP 3/1	88OF LI 1
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	1	2	3	4
AMP01	*Bistarkum? cylindratum* n. sp.																R					
ARC01	*Archaeocenosphaera* sp. aff. *A. laseekensis*				A		R	R		R	R	C			R	R				R		
ARC02	*Archaeocenosphaera* sp. A				A			A		R		R	?	R			A			R	C	R
ARC03	*Archaeocenosphaera* sp. B																					
BET01	*Betraccium deweveri*																					
BET02	*Betraccium inornatum*		R		C		R	R		R		C					R			R	R	
BET03	*Betraccium* sp. cf. *B. inornatum*																					
BET04	*Betraccium* sp. aff. *B. inornatum*						R								C	R				R	R	
BET05	*Betraccium kennecottense* n. sp.															R	R	R		R		R
BET06	*Betraccium maclearni*																					
BET07	*Betraccium nodulum* n. sp.																					
BET08	*Betraccium pariense* n. sp.				C	R		A														
BET09	*Betraccium* sp. A				A			A								R				C	R	
BET10	*Betraccium* sp. B				A																	
BET11	*Betraccium* sp. C				R			A			R	C			**A**	R					R	R
BET12	*Betraccium* sp. D								?	R	R	A	R				C	R		R		
BET13	*Betraccium* sp. E																C					
CTL01	*Cantalum tianense* n. sp.									**A**	R	**A**	A							R		
CTL02	*Cantalum gratum* n. sp.														A			R	R	C	R	R
CTL03	*Cantalum* sp. A												R		R		A			R	R	
CTL04	*Cantalum* sp. B										C	A	A		R					R		
CRU01	*Crucella flowerpotensis* n. sp.				R			R						R	C					R		
CRU02	*Crucella?* sp. A														R							
CRU03	*Crucella* sp. B																					
CRU04	*Crucella* sp. C						C	R							C							
ENT01	*Entactinosphaera? amphilapes* n. sp.				C		A	A	R	A	C	A	R		A		C			R	R	
ENT02	*Entactinosphaera?* sp. aff. *E.? simoni*				R															C		R
ENT03	*Entactinosphaera? spinulata* n. sp.											R			A	R	R		C	A		R
FER01	*Ferresium conclusum* n. sp.																C					
FER02	*Ferresium* sp. aff. *F. laseekense*								R										R	R		
FER03	*Ferresium teekwoonense* n. sp.															R	**A**			C	R	
FER04	*Ferresium triquetrum* n. sp.				C		A										A			R	R	
FER05	*Ferresium* sp. A				C											R				R		
FER06	*Ferresium* sp. B												R			R			C	A	R	
FER07	*Ferresium* sp. C																					
FON01	*Fontinella clara* n. gen., n. sp.																					
FON02	*Fontinella habros* n. gen., n. sp.				A		A	A		A		C	A		A	C	R		C	C	C	C
FON03	*Fontinella inflata* n. gen., n. sp.				R			**A**		A		**A**	A		A	C	A		A	**A**	C	**A**
FON04	*Fontinella louisensis* n. gen., n. sp.		R		A		R	A			C		R	C	A	A	A		A	**A**	R	A
FON05	*Fontinella primitiva* n. gen., n. sp.				C	R		C			R											
HAL01	*Haliomma ? sawaiense*				R		R	A			C	**A**			**A**	**A**	**A**			A	C	A
ICR01	*Icrioma? cistella* n. sp.		R		C	R	C	R								?						
ICR02	*Icrioma?* sp. A				R											R			R	R		
KAH01	*Kahlerosphaera* sp. A						R	C								R				R		
KOZ01	*Kozurastrum beattiense* n. sp.												R		R	R			A	A		R
KOZ02	*Kozurastrum decibulum* n. sp.		C																			
KOZ03	*Kozurastrum gracile*		C				?															
KOZ04	*Kozurastrum huxleyense* n. sp.		C		C	R	C	A	C	C		R			A	A					R	
KOZ05	*Kozurastrum sandspitense*		?		C		?	R	C			A	R		R	R						
KOZ06	*Kozurastrum* sp. aff. *K. sandspitense*											C				R				R		
KOZ07	*Kozurastrum* sp. A																					
KOZ08	*Kozurastrum* sp. B								R							C	R			R		R
LOU01	*Loupanus thompsoni* n. gen., n. sp.				A		C	R		**A**		A		A	**A**	A	R		A	**A**	R	**A**
	Radiolarian Assemblages	Bd	1					2a				2b					2c		2b			2d

KUNGA ISLAND — SECTION 5; SEC. 6

Species Code	Unitary Association Sample Level	89CNA SKU D1	87CNA SKU D1	89CNA SKU D4A	87CNA SKU D3	89CNA SKU D7	87CNA SKU D4	87CNA SKU D5	87CNA SKU D6	89CNA SKU D12	87CNA SKU D7	87CNA SKU D8	89CNA SKU D13	89CNA SKU D14	89CNA SKU D15	89CNA SKU D16	87CNA SKU D9	89CNA SKU D18	89CNA SKU D22	87CNA SKU D11	89CNA SKU D25	87CNA SKU SP1 (Sec. 6)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1
AMP01	*Bistarkum? cylindratum* n. sp.						R				R	R	C			R	R		R	C	R	C
ARC01	*Archaeocenosphaera* sp. aff. *A. laseekensis*	R	R		R		R				A		A	C	R	C						
ARC02	*Archaeocenosphaera* sp. A	C	A	R	C	R		C	**A**			A	A	R	C	R		R			R	
ARC03	*Archaeocenosphaera* sp. B																R			R	**A**	
BET01	*Betraccium deweveri*																					
BET02	*Betraccium inornatum*	R			C												R					R
BET03	*Betraccium* sp. cf. *B. inornatum*																R					
BET04	*Betraccium* sp. aff. *B. inornatum*								R		R						R	R				
BET05	*Betraccium kennecottense* n. sp.										**A**	R	**A**	R			R	R	R	C	A	
BET06	*Betraccium maclearni*																					
BET07	*Betraccium nodulum* n. sp.																**A**	A	R		C	**A**
BET08	*Betraccium pariense* n. sp.			R	C		R															
BET09	*Betraccium* sp. A	R			A																	
BET10	*Betraccium* sp. B																					
BET11	*Betraccium* sp. C	R			A				R		R	R				C	C					C
BET12	*Betraccium* sp. D																					
BET13	*Betraccium* sp. E													R	R		C	C	R	C	A	R
CTL01	*Cantalum tianense* n. sp.				R	A	?															
CTL02	*Cantalum gratum* n. sp.										C	R	A			C	R	R			R	
CTL03	*Cantalum* sp. A				R				R													
CTL04	*Cantalum* sp. B												R									
CRU01	*Crucella flowerpotensis* n. sp.								R				R									
CRU02	*Crucella?* sp. A										R						C	R		?	R	R
CRU03	*Crucella* sp. B				R																	
CRU04	*Crucella* sp. C				R												?					C
ENT01	*Entactinosphaera? amphilapes* n. sp.	?		?	A	C	R				A		A	C			C	A				C
ENT02	*Entactinosphaera?* sp. aff. *E.? simoni*										C		C	C			C	C			A	R
ENT03	*Entactinosphaera? spinulata* n. sp.								C		A			R				C			R	
FER01	*Ferresium conclusum* n. sp.										R		R	R			A			R		C
FER02	*Ferresium* sp. aff. *F. laseekense*			R																		
FER03	*Ferresium teekwoonense* n. sp.								R				C				A	A		R		C
FER04	*Ferresium triquetrum* n. sp.																					
FER05	*Ferresium* sp. A																					
FER06	*Ferresium* sp. B				R				R													
FER07	*Ferresium* sp. C															R	A	A				C
FON01	*Fontinella clara* n. gen., n. sp.				R						R	R				R	R	R				
FON02	*Fontinella habros* n. gen., n. sp.		R		A	R	R	R	R		C	A	C	R		A	C	R		R	R	R
FON03	*Fontinella inflata* n. gen., n. sp.		A		**A**	A	R	R	C		**A**	A	**A**	C		A	A	R	R	C	A	C
FON04	*Fontinella louisensis* n. gen., n. sp.		R		A			R	R		A		A			R	A	R		?		R
FON05	*Fontinella primitiva* n. gen., n. sp.																					
HAL01	*Haliomma ? sawaiense*	A	R		A	R	A		**A**		**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**		C	**A**	**A**
ICR01	*Icrioma? cistella* n. sp.	R																				
ICR02	*Icrioma?* sp. A			R	R						C		R				?	C		R	**A**	R
KAH01	*Kahlerosphaera* sp. A				R				R													
KOZ01	*Kozurastrum beattiense* n. sp.						R															
KOZ02	*Kozurastrum decibulum* n. sp.			R																		
KOZ03	*Kozurastrum gracile*			R									?									
KOZ04	*Kozurastrum huxleyense* n. sp.				A	C							C									
KOZ05	*Kozurastrum sandspitense*	C			C																	
KOZ06	*Kozurastrum* sp. aff. *K. sandspitense*										R		R	R							R	
KOZ07	*Kozurastrum* sp. A																					
KOZ08	*Kozurastrum* sp. B										R	R	R									
LOU01	*Loupanus thompsoni* n. gen., n. sp.				A	C		R	**A**		**A**	A	**A**	C	R	**A**	**A**	**A**		C	**A**	**A**
	Radiolarian Assemblages	1			2a			2b		2c					2d		3					3

Figure 7a. Distribution and relative abundance of spumellarians in sections of Kennecott Point, Louise Island, and Kunga Island, Queen Charlotte Islands.

R Rare 1-2 specimens
C Common 3-6 specimens
A Abundant 6-20 specimens
A Very abundant >20 specimens

KENNECOTT POINT — SECTION 1; Sec 2

Species Code	Unitary Association Sample Level	90JF KPH 1	87CNA KPA 3B	88CNA KPA R3	87CNA KPA 5	88CNA KPA R5	89CNA KPA 3	87CNA KPA 6; 88OF KPA E	90OF KPX 6	89CNA KPX 3	87CNA KPA 8	90OF KPX 14	88CNA KPA R8	87CNA KPA 10	89CNA KPA 10	87CNA KPA 12; 89CNA KPA 11	87CNA KPA 14	89CNA KPA 14	88CNA KPA R15	89CNA KPA 16	89CNA KPA 17	90OF KPA 17	87CNA KPA 17; 89CNA KPA 18	90OF KPA 23	90OF KPA 24	90OF KPA 25	88CNA KPD 1AA (Sec 2)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	1
LOU02	Loupanus sp. A															R											
MES01	Mesosaturnalis acuminatus n. sp.																										
MES02	Pseudoacanthocircus troegeri																						C				
MES03	Mesosaturnalis sp. A																										
MES04	Mesosaturnalis sp. B																			R							
ORB01	Orbiculiforma multibrachiata n. sp.																		?	R	?	?	**A**				
PAL01	Liassosaturnalis sp. aff. L. parvus																										
PAN01	Pantanellium fosteri																										
PAN02	Pantanellium sp. aff. P. fosteri							C	A																		
PAN03	Pantanellium sp. aff. P. kungaense																										
PAN04	Pantanellium newilduense n. sp.													R									R				
PAN05	Pantanellium sp. aff. P. skidegatense var. A										R																
PAN06	Pantanellium sp. aff. P. skidegatense var. B										A			R	?												
PAN07	Pantanellium sp. A															R											
PTR01	Paratriassoastrum crassum n. sp.																										
PTR02	Paratriassoastrum sp. aff. P. crassum n. sp.						A																				
PTR03	Paratriassoastrum omegaense n. sp.																				C	C	A		R		
PTR04	Paratriassoastrum sp. A													A									R	R			
PTR05	Paratriassoastrum sp. B																										
PAR01	Paronaella? beatrica n. sp.			R					R		?	R		A	C			?				R					
PAR02	Paronaella bifida n. sp.					A	R	**A**		R	A			R		A		C									
PAR03	Paronaella pacofiensis n. sp.								R	R				R													
PAR04	Paronaella ultrabifida n. sp.							C			**A**			**A**		C	R		R								
PAR05	Paronaella yaoguensis n. sp.							C			C			A		A				R			R				
PTC01	Pentactinocarpus sp. cf. P. sevaticus	R		R					C																		
PSD01	Pentaspongodiscus? dihexacanthus n. sp.												R	C		A							R				
PLF01	Plafkerium fidiculanum n. sp.															C											
PLF02	Plafkerium kaloense n. sp.																			R	R	A	A				**A**
PLF03	Plafkerium gadoense n. sp.								R							A			R	C		R	C				
PLF04	Plafkerium sp. A			?					R		?			?		C		?									
PLF05	Plafkerium sp. B															A											
PSH01	Pseudohagiastrum sp. cf. P. monstruosum																										
PSH02	Pseudohagiastrum? tasuense n. sp.	A		C				R	A	**A**				A		R											
PSH03	Pseudohagiastrum? sp. A								R					?		?											
RIS01	Risella ellisensis n. gen., n. sp.															R				C			A				
RIS02	Risella stalkungensis n. gen., n. sp.															R				C							
RIS03	Risella tanglensis n. gen., n. sp.																										
RIS04	Risella tledoensis n. gen., n. sp.																	R	C				C				R
RIS05	Risella sp. A																			R			R				
RIS06	Risella sp. B																										
TET01	Tetraporobrachia composita n. sp.																										
TET03	Tetraporobrachia sp. A																										
TET04	Tetraporobrachia? sp. B																										
TET05	Tetraporobrachia sp. C						A		C					A													
TET06	Tetraporobrachia sp. D																										
TBS01	Tetratrabs? noricus n. sp.	**A**	A	A		R			C	C																	
TCR01	Triassocrucella sp. aff. T. triassicum						R	C					R			R							C				
TCR02	Triassocrucella sp. A						R																R				
SIN01	Spumellaria gen. and sp. indet. A										C			?		R											
SIN02	Spumellaria gen. and sp. indet. B										C								R				R				
SIN03	Spumellaria gen. and sp. indet. C																										
SIN04	Spumellaria gen. and sp. indet. E								R										R				A				
SIN05	Entactinid gen. and sp. indet.										R			R					C								
	Radiolarian Assemblages	Bd				1					2a		2b				2c		2d		3						3

KUNGA ISLAND — SECTION 3; **LOUISE ISLAND** — SEC. 4

Species Code	Unitary Association Sample Level	86OF SKU B4	89CNA SKU B5	89CNA SKU B9	J6OF SKU B10	89CNA SKU B10	89CNA SKU B11	89CNA SKU B12	89CNA SKU B13	89CNA SKU B14	89CNA SKU B15	89CNA SKU B16	87CNA SKU B12	87CNA SKU B13	89CNA SKU B19	87CNA SKU B14	89CNA SKU B22	87CNA SKU B16	85CNA SP 9/1	86CNA SP I/I	87CNA SP 3/1	88OF LI I
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	1	2	3	4
LOU02	Loupanus sp. A														C	?	R			A		R
MES01	Mesosaturnalis acuminatus n. sp.																					
MES02	Pseudoacanthocircus troegeri														R					C		
MES03	Mesosaturnalis sp. A														R					C		
MES04	Mesosaturnalis sp. B														R							
ORB01	Orbiculiforma multibrachiata n. sp.																					R
PAL01	Liassosaturnalis sp. aff. L. parvus							C									R		R			
PAN01	Pantanellium fosteri									A												
PAN02	Pantanellium sp. aff. P. fosteri									A					C							
PAN03	Pantanellium sp. aff. P. kungaense														R							
PAN04	Pantanellium newilduense n. sp.							A			R	A			**A**		A		R	C	R	
PAN05	Pantanellium sp. aff. P. skidegatense var. A							A							C					R	R	
PAN06	Pantanellium sp. aff. P. skidegatense var. B										R				R		**A**		C	A		A
PAN07	Pantanellium sp. A																					
PTR01	Paratriassoastrum crassum n. sp.																					
PTR02	Paratriassoastrum sp. aff. P. crassum n. sp.								C										R	C		
PTR03	Paratriassoastrum omegaense n. sp.																					R
PTR04	Paratriassoastrum sp. A									R							C		R			R
PTR05	Paratriassoastrum sp. B																					
PAR01	Paronaella? beatrica n. sp.				C				R	C		A		R	A	?	R	R		A	R	
PAR02	Paronaella bifida n. sp.						R	A	A	A	R	A	R	C	A	R		C		R	R	
PAR03	Paronaella pacofiensis n. sp.				R					R						A			C	A	R	R
PAR04	Paronaella ultrabifida n. sp.						R			A	C	A	C	R	A	C	**A**		A	C		A
PAR05	Paronaella yaoguensis n. sp.									R		A	C	R	A	C	R		A	**A**	C	A
PTC01	Pentactinocarpus sp. cf. P. sevaticus				R		A	R		R		C			A	R			R	C	R	
PSD01	Pentaspongodiscus? dihexacanthus n. sp.							C		R					C	R		R	C	C		R
PLF01	Plafkerium fidiculanum n. sp.																R	R				
PLF02	Plafkerium kaloense n. sp.							?				?										
PLF03	Plafkerium gadoense n. sp.		R		A	R	**A**	R	R	A		A	R		A	R	C			R		
PLF04	Plafkerium sp. A				R			R								R			R	R		R
PLF05	Plafkerium sp. B											R	?		A				R		R	
PSH01	Pseudohagiastrum sp. cf. P. monstruosum																					
PSH02	Pseudohagiastrum? tasuense n. sp.	?	A		**A**	C	**A**	**A**	R	A	C											
PSH03	Pseudohagiastrum? sp. A									C				R		R	C					
RIS01	Risella ellisensis n. gen., n. sp.						?				R	R										
RIS02	Risella stalkungensis n. gen., n. sp.																					
RIS03	Risella tanglensis n. gen., n. sp.																					
RIS04	Risella tledoensis n. gen., n. sp.																					
RIS05	Risella sp. A																					
RIS06	Risella sp. B																					
TET01	Tetraporobrachia composita n. sp.	C			C		R															
TET03	Tetraporobrachia sp. A																					
TET04	Tetraporobrachia? sp. B																					
TET05	Tetraporobrachia sp. C						R								R	C						
TET06	Tetraporobrachia sp. D																					
TBS01	Tetratrabs? noricus n. sp.	?	C				R															
TCR01	Triassocrucella sp. aff. T. triassicum				R		R	R		R		R	R		A	C	R					
TCR02	Triassocrucella sp. A				R	R	R	R							C							
SIN01	Spumellaria gen. and sp. indet. A											R			A		R		C	A	R	A
SIN02	Spumellaria gen. and sp. indet. B		C		R			C		R	R	C		R	R	A	C		C	A	R	C
SIN03	Spumellaria gen. and sp. indet. C														R		R		R	R		
SIN04	Spumellaria gen. and sp. indet. E				R			C		R										R		
SIN05	Entactinid gen. and sp. indet.				C	R	A					A			**A**				A	A	R	C
	Radiolarian Assemblages	Bd	1					2a				2b					2c		2b			2d

KUNGA ISLAND — SECTION 5; SEC. 6

Species Code	Unitary Association Sample Level	89CNA SKU D1	87CNA SKU D1	89CNA SKU D4A	87CNA SKU D3	89CNA SKU D7	87CNA SKU D4	89CNA SKU D5	87CNA SKU D6	89CNA SKU D12	87CNA SKU D7	87CNA SKU D8	89CNA SKU D13	87CNA SKU D14	89CNA SKU D15	89CNA SKU D16	87CNA SKU D9	89CNA SKU D18	89CNA SKU D22	87CNA SKU D11	89CNA SKU D25	87CNA SKU SP1 (Sec. 6)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1
LOU02	Loupanus sp. A										R	R	R			C						
MES01	Mesosaturnalis acuminatus n. sp.																				**A**	
MES02	Pseudoacanthocircus troegeri											R			R	R	A	C				C
MES03	Mesosaturnalis sp. A																				C	
MES04	Mesosaturnalis sp. B										R											
ORB01	Orbiculiforma multibrachiata n. sp.															R	R	A	R	A	**A**	A
PAL01	Liassosaturnalis sp. aff. L. parvus											R			?		R	R	R	C		R
PAN01	Pantanellium fosteri																					
PAN02	Pantanellium sp. aff. P. fosteri	R			C	R			R													
PAN03	Pantanellium sp. aff. P. kungaense				R																	
PAN04	Pantanellium newilduense n. sp.				C			R	A		C									A		
PAN05	Pantanellium sp. aff. P. skidegatense var. A				A						C											
PAN06	Pantanellium sp. aff. P. skidegatense var. B								**A**			R			R	R						R
PAN07	Pantanellium sp. A																					
PTR01	Paratriassoastrum crassum n. sp.												R			R	R	C				C
PTR02	Paratriassoastrum sp. aff. P. crassum n. sp.			R																		
PTR03	Paratriassoastrum omegaense n. sp.																R				R	A
PTR04	Paratriassoastrum sp. A								R		C		R			R	R			R	A	
PTR05	Paratriassoastrum sp. B												C	C					C		C	C
PAR01	Paronaella? beatrica n. sp.								R		**A**	?	**A**	A	C	A					C	?
PAR02	Paronaella bifida n. sp.					C	A		?		?	A			C							
PAR03	Paronaella pacofiensis n. sp.				R			R	R	R	R											
PAR04	Paronaella ultrabifida n. sp.					C	R	R	**A**	R	A	R	A	A		R						
PAR05	Paronaella yaoguensis n. sp.					A	R		A	C	C		C	C								
PTC01	Pentactinocarpus sp. cf. P. sevaticus				C				C		R		R			R		R		R		R
PSD01	Pentaspongodiscus? dihexacanthus n. sp.				R				C		R	R		R		C	R	R				C
PLF01	Plafkerium fidiculanum n. sp.				R						A	C	**A**	R		C	R					
PLF02	Plafkerium kaloense n. sp.										R					C	A	A				C
PLF03	Plafkerium gadoense n. sp.		?	R	C	R			R		R		R			R	A	C		R	A	R
PLF04	Plafkerium sp. A				R				R			C					C					?
PLF05	Plafkerium sp. B				R											R		R				
PSH01	Pseudohagiastrum sp. cf. P. monstruosum										R											
PSH02	Pseudohagiastrum? tasuense n. sp.	A			**A**	R	R				C		C									
PSH03	Pseudohagiastrum? sp. A										R		C	R								
RIS01	Risella ellisensis n. gen., n. sp.									R	R	R	R		C	A	A	A				C
RIS02	Risella stalkungensis n. gen., n. sp.									R	C						R	C		R		A
RIS03	Risella tanglensis n. gen., n. sp.																C	C				R
RIS04	Risella tledoensis n. gen., n. sp.										R	R	R			C	A	A		R	A	A
RIS05	Risella sp. A																R	R		R	C	
RIS06	Risella sp. B																				C	
TET01	Tetraporobrachia composita n. sp.	?																				
TET03	Tetraporobrachia sp. A																					
TET04	Tetraporobrachia? sp. B																					
TET05	Tetraporobrachia sp. C																					
TET06	Tetraporobrachia sp. D						R		R							R	R					
TBS01	Tetratrabs? noricus n. sp.		R																			
TCR01	Triassocrucella sp. aff. T. triassicum								A		R		R						R			C
TCR02	Triassocrucella sp. A																					
SIN01	Spumellaria gen. and sp. indet. A															R						
SIN02	Spumellaria gen. and sp. indet. B								R		C	C	A	R	R			C	R	C	A	R
SIN03	Spumellaria gen. and sp. indet. C										**A**		**A**	C					?	C		
SIN04	Spumellaria gen. and sp. indet. E	R				R					R									C		R
SIN05	Entactinid gen. and sp. indet.	R		R	C		R	R	C		**A**	A	**A**	A	C	A	A	A		R	**A**	C
	Radiolarian Assemblages	1			2a			2b		2c					2d		3					3

Figure 7b. Distribution and relative abundance of spumellarians in sections of Kennecott Point, Louise Island, and Kunga Island, Queen Charlotte Islands.

R-Rare 1-2 specimens
C-Common 3-6 specimens
A-Abundant 6-20 specimens
A-Very abundant >20 specimens

KENNECOTT POINT — SECTION 1 (levels 1–25); SEC. 2 (level 1)

Species Code	Unitary Association Sample Level	90JF KPH 1	87CNA KPA 3B	88CNA KPA R3	87CNA KPA 5	88CNA KPA R5	89CNA KPA 3	87CNA KPA 6; 88OF KPA E	90OF KPX 6	89CNA KPX 3	87CNA KPA 8·	90OF KPX 14	88CNA KPA R8	87CNA KPA 10	89CNA KPA 10	87CNA KPA 12; 89CNA KPA 11	87CNA KPA 14	89CNA KPA 14	88CNA KPA R15	89CNA KPA 16	89CNA KPA 17	90OF KPA 17	87CNA KPA 17; 89CNA KPA 18	90OF KPA 23	90OF KPA 24	90OF KPA 25	88CNA KPD 1AA
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	1
BPD01	*Bipedis?* sp. A	R																										
BPD02	*Bipedis acrostylus*	C															R										R	R
CAN01	*Canoptum* sp. aff. *C. dixoni*	C						**A**	A	**A**	C		A	**A**		**A**	A	A	C	A		C	**A**				
CAN02	*Canoptum* sp. cf. *C. triassicum*	C											C			**A**		C		C		C	A				
CAN03	*Canoptum* sp. aff. *C. unicum*																					R	R	**A**				
CAN04	*Canoptum* sp. A													A		A				C			R				
CAN05	*Canoptum* sp. B												R			R							A				
CTS01	*Canutus? beehivensis* n. sp.	R							C	**A**	R		R	?		A		R	C	R		A	A				
CTS02	*Canutus? ingrahamensis* n. sp.								R	?						A		R										
CIT01	*Citriduma asteroides* n. sp.																		R								
CIT02	*Citriduma* sp. A																										
CIT03	*Citriduma* sp. B	A								R																	
CIT04	*Citriduma* sp. C									C				C												
DEF01	*Deflandrecyrtium nobense* n. sp.									C									R							
DEF02	*Deflandrecyrtium* sp. A							R		R																
DEF03	*Deflandrecyrtium* sp. B							C																		
DRO01	*Droltus orchardi* n. sp.							?	C	**A**			R													
CTS03	*Canutus* ? sp. A																										
EPT01	*Eptingium? amoenum* n. sp.								A		R			C												
EPT02	*Eptingium? onesimos* n. sp.															A		R		C			**A**				R
EUC01	Eucyrtid gen. and sp. indet.							A		A	R		A	**A**		A	A	R		C	C	A	A				
GLO01	*Globolaxtorum christatum* n. gen., n. sp.												C	?		C			?	C	R							
GLO02	*Globolaxtorum tozeri* n. gen., n. sp.													?								A	**A**		C		**A**
GLO03	*Globolaxtorum?* sp. A																					R					
HCK01	*Haeckelicyrtium karcharos* n. sp.													R		A												
HCK02	*Haeckelicyrtium* sp. aff. *H. karcharos* n. sp.																										
LAX02	*Laxtorum capitaneum* n. sp.																		A	C	C	A	**A**				
LAX03	*Laxtorum* sp. aff. *L. kuluense*							R	R																		
LAX04	*Laxtorum perfectum* n. sp.																				?	?	A		R		
LAX05	*Laxtorum porterheadense* n. sp.												?						R				A				
LIV01	*Livarella densiporata*	C		R				C	C	**A**	R					R	C		R			R	A				
LIV02	*Livarella* sp. aff. *L. gifuensis*																										
LIV03	*Livarella validus*								C								R						R	A				R
PCD01	*Praecitriduma apexensis* n. sp.	R								C				R								?					
PCD02	*Praecitriduma cantholistula* n. sp.																										
PCD03	*Praecitriduma mostleri*								?																			
PRP01	*Praeparvicingula moniliformis* n. gen., n. sp.						R	A			A			C		A	R	A	R								
SQN01	*Squinabolella causia* n. sp.																						C				
SQN02	*Squinabolella* sp. aff. *S. causia* n. sp.																						R				
SQN03	*Squinabolella desrochersi* n. sp.															C	R						R				
SQN04	*Squinabolella* sp. aff. *S. desrochersi* n. sp.															R						R				
SQN05	*Squinabolella? trispinosa* n. sp.										R			R		R										
SQN06	*Squinabolella* sp. A							C																		
SQN07	*Squinabolella?* sp. B																										
SQN08	*Squinabolella* sp. C							R								C										
SQN09	*Squinabolella* sp. D																										
NIN01	Nassellaria gen. and sp. indet. A								C		R															
NIN02	Nassellaria gen. and sp. indet. B			R												R										
	Radiolarian Assemblages	Bd				1					2a		2b				2c		2d		3						3

KUNGA ISLAND — SECTION 3 (levels 2–18)

Species Code	86OF SKU B4	89CNA SKU B5	89CNA SKU B9	86OF SKU B10	89CNA SKU B10	89CNA SKU B11	89CNA SKU B12	89CNA SKU B13	89CNA SKU B14	89CNA SKU B15	89CNA SKU B16	87CNA SKU B12	87CNA SKU B13	89CNA SKU B19	87CNA SKU B14	89CNA SKU B22	87CNA SKU B18
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
BPD01				R	R													
BPD02		C				R		R	R	R				C	R	C	
CAN01			R	A	R	R	R	C	**A**	A	A	A	**A**	**A**	**A**	**A**	
CAN02						R	R			C			C	A	C		
CAN03																	
CAN04																	
CAN05														?			
CTS01		R		A	C	**A**	R	R	R	R			R	C		A	
CTS02					R	C	R		R		R			R	R		
CIT01																	
CIT02																	
CIT03				R	R													
CIT04														R		C	
DEF01				R		R	?		R		R						R	
DEF02				C	R	C			R		R			R			
DEF03						R	C	R	R					C		C	
DRO01		C	R			**A**					?				?	?	
CTS03																	
EPT01						R					A	R	R		R	R	
EPT02																	
EUC01				C					R		R			C		C	
GLO01																	
GLO02																	
GLO03																	
HCK01											A			C	**A**		
HCK02															R		
LAX02																	
LAX03		R	R	A		A	R		R								
LAX04																	
LAX05																	
LIV01			R	**A**	R	C	C		R		R						R	
LIV02																	
LIV03			R	C	R	C											
PCD01						R											
PCD02						R								R	R		
PCD03											R				R	R	
PRP01		?		C		?	A		A	R	A	R	C	**A**	C	**A**	
SQN01											?			R			
SQN02														R			
SQN03														A	R		
SQN04																C	
SQN05		R		R		A					A	R		R			
SQN06															R		
SQN07																	
SQN08						?					R			R			
SQN09																	
NIN01														A		R	
NIN02							A								R	R	
Radiolarian Assemblages	Bd	1					2a				2b					2c	

LOUISE ISLAND — SEC. 4 (levels 1–4); KUNGA ISLAND — SECTION 5 (levels 1–20); SEC. 6 (level 1)

Species Code	85CNA SP 9/1	88CNA SP 1/1	87CNA SP 3/1	88OF LI 1	89CNA SKU D1	87CNA SKU D1	89CNA SKU D4A	87CNA SKU D3	89CNA SKU D7	89CNA SKU D4	87CNA SKU D5	87CNA SKU D6	89CNA SKU D12	87CNA SKU D7	87CNA SKU D8	89CNA SKU D13	89CNA SKU D14	89CNA SKU D15	89CNA SKU D16	87CNA SKU D9	89CNA SKU D18	89CNA SKU D22	87CNA SKU D11	89CNA SKU D25	87CNA SKU SP1
	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1
BPD01																									
BPD02		R			?			R											A			R			R	R
CAN01	**A**	**A**	**A**	**A**	A		C	A	C	A	A	**A**		**A**	**A**	**A**	R		**A**	A	**A**		?	A	A
CAN02	C	C	R	C				R		C		C		C	A	R	R		**A**	A	A		C		A
CAN03																								R	?	C
CAN04		?										?		C	A	C	R	R	R	C					A
CAN05				R							?	R		R	R	R				C			C	A	R
CTS01	C	C	R	R	R		R		R			A		**A**	C	**A**	R	C	**A**	**A**	**A**		R	C	**A**
CTS02					R							R		R	C	R								
CIT01																		**A**			**A**				**A**
CIT02																									
CIT03																									
CIT04														A		C		C			C				
DEF01	R	R		R				C			?	C		A	C	C	R	R	A		?		C	C	R
DEF02					R		R																		
DEF03	R	R			R			A																
DRO01	?	R			C			R						R			?								
CTS03	R																R				R				
EPT01	A	**A**	C	C	?			?	C				R			C								
EPT02			R	C							C	C	**A**	A	**A**	A	A	**A**		A		R	**A**	C
EUC01	R										C		R		A	R	A				A	R	A	R		
GLO01														C	A	A	R		R	**A**	**A**				A
GLO02																				R		A	A	A	
GLO03																								R	R
HCK01		A	R												R		R			R			R	
HCK02			R																						
LAX02																			**A**	**A**	**A**		A		**A**
LAX03					R																			
LAX04																			C	R	R				C
LAX05														?		R			R	A	A		C	C	**A**
LIV01					C			C						C	A	C			C	C	C		C	R	C
LIV02								R																	
LIV03														R								R	R	R
PCD01			R											A	R	A			R	R					
PCD02		R	C	R										C										
PCD03			R											C		R								
PRP01	C	**A**	A	A			R	R	A		R	**A**		C		A								
SQN01															R					C	A				C
SQN02																				R	R				A
SQN03	**A**	**A**		A							A		A	R	R					R				
SQN04															R				C	C					C
SQN05					A	?		A		R		R													
SQN06																									
SQN07												C													
SQN08	A	C		R							C		R						R				R	R
SQN09																									R
NIN01	C	R		R											?									
NIN02	C	R		R				R						R		C				?					
Radiolarian Assemblages	2b			2d	1			2a			2b		2c					2d		3					3

Figure 8. Distribution and relative abundance of nassellarians in sections at Kennecott Point, Louise Island, and Kunga Island, Queen Charlotte Islands.

The Sandilands fauna and radiolarian dating

In addition to the abundance of new forms, the radiolarian fauna studied here contains a few described species and some undescribed but previously figured taxa as well. These taxa and their ages are discussed below. *Betraccium deweveri* Pessagno and Blome, *B. inornatum* Blome, *B. maclearni* Pessagno and Blome, *Pantanellium fosteri* Pessagno and Blome, and *Pseudoheliodiscus sandspitense* Blome were described from the *Monotis* beds at Kunga Island; they are characteristic of the *Betraccium deweveri* Subzone of Blome 1984, and are late Norian in age (see Fig. 13 herein). *Livarella densiporata* Kozur and Mostler, and *Praecitriduma mostleri* Kozur were described from sample ZL 6/1 Zlambachgraben, Austria. The precise age of these taxa is difficult to determine because stratigraphic information is not directly mentioned in the original papers. However, L. Krystyn (written communication, 1989) indicates this is "top upper Norian most probably" which in terms of Krystyn's zonation (1980, 1988) would be approximately equivalent to the upper part of the Amoenum Zone of Tozer (1979). *Livarella validus* was described by Yoshida (1986) from bedded chert in Central Japan. Dating is imprecise because no diagnostic fossils other than radiolarians were obtained, however, Yoshida suggests the age is probably "early to middle Rhaetian" (see Fig. 13, herein). And finally, *Bipedis acrostylus* Bragin was described from the upper Norian (sensu Tozer, 1979) succession in Sikhote-Alin, southeastern Russia.

Other taxa in the collections have affinity to the upper Norian/Sevatian species *Ferresium laseekense* Blome, *Laxtorum atliense* Blome, *L. kulense* Blome, *Pantanellium skidegatense* Pessagno and Blome, *Pseudohagiastrum monstruosum* Pessagno, *Pentactinocarpus sevaticus* Kozur and Mostler, *Triassocrucella triassicum* Kozur and Mostler, and *Canoptum triassicum* Yao (of late Norian/Rhaetian age). Additional forms have affinity with the Lower Jurassic species *Archaeocenosphaera laseekensis* Pessagno and Yang, *Canoptum dixoni* Pessagno and Whalen, and *Canoptum unicum* Pessagno and Whalen.

Undescribed taxa previously figured by other authors include: *Poulpus* ? sp. (cf. *Livarella densiporata* Kozur and Mostler) in Yao et al. (1980a, pl. 2, fig. 6); *Dreyericyrtium* sp. A, *Poulpus* (?) sp. A (= *Livarella* Kozur and Mostler) and Nassellaria gen. and sp. indet A (similar to *Bipedis* DeWever) in Yao (1982, pl. 3, fig. 7, 13, 14; 1983, fig 2, no. 14), Yao, Matsuoka and Nakatani (1982, pl. 2, fig. 2, 6, 8) and Matsuoka (1983, fig. 4, no. 3); all characteristic of the *Canoptum triassicum* Zone which has a combined range of upper Norian and Rhaetian (see Fig. 13, herein). *Paleosaturnalis* sp. C in Kishida and Hisada (1986, fig. 4, no. 3) is included in the *Paleosaturnalis multidentatus* Assemblage (upper Norian and Rhaetian; see Fig 13, herein); this species is described as *Kozurastrum beattiense* n. sp. herein. *Sarla* spp. and *Livarella* sp., figured by Aita (in Spörli and Aita, 1988, p. 21, fig. 3, 9, 10, 16) are from a mixed assemblage of Late Triassic and Early Jurassic age.

From the above discussion, it seems evident that radiolarian dating for faunas younger than the *Betraccium deweveri* fauna is too sparse and imprecise to be of much value.

BIOSTRATIGRAPHY

Summary of faunal evidence for dating the Sandilands formation

At Kennecott Point, basal beds of the Triassic Sandilands Formation directly overlie upper Norian *Monotis* beds of the Peril Formation that are equivalent in age to the Cordilleranus Ammonoid Zone of Tozer (1979). Younger beds of this same succession contain ammonoids of the topmost Triassic Crickmayi Zone of Tozer (1979). Between these two points of reference independent age dating is unavailable, but the section is most probably complete and contains throughout an abundant and diverse radiolarian fauna. When considering the paucity of both ammonoids and conodonts in these rocks as against the wealth of radiolarians, it is clear that radiolarians are the most useful tool for dating this interval of time.

Although the contact between the Peril and Sandilands formations appears to be conformable at Kennecott Point there is no independent dating to confirm the age of lowest Sandilands beds. Radiolarian taxa characteristic of the upper Norian *Betraccium deweveri* Zone are common in the basal 10 m of the Sandilands Formation, but immediately above this level radiolarians of Assemblage 1 (Carter, 1990 and herein) dominate. Because the radiolarian succession is continuous from the *Monotis* beds of the Peril Formation through topmost Triassic beds of the Sandilands, it is suggested here (with no other confirming evidence) that the lowest 10 m of the Sandilands Formation is probably upper Norian and, above this level it is Rhaetian. This statement is important and may prove to be of great value in defining the Norian-Rhaetian boundary.

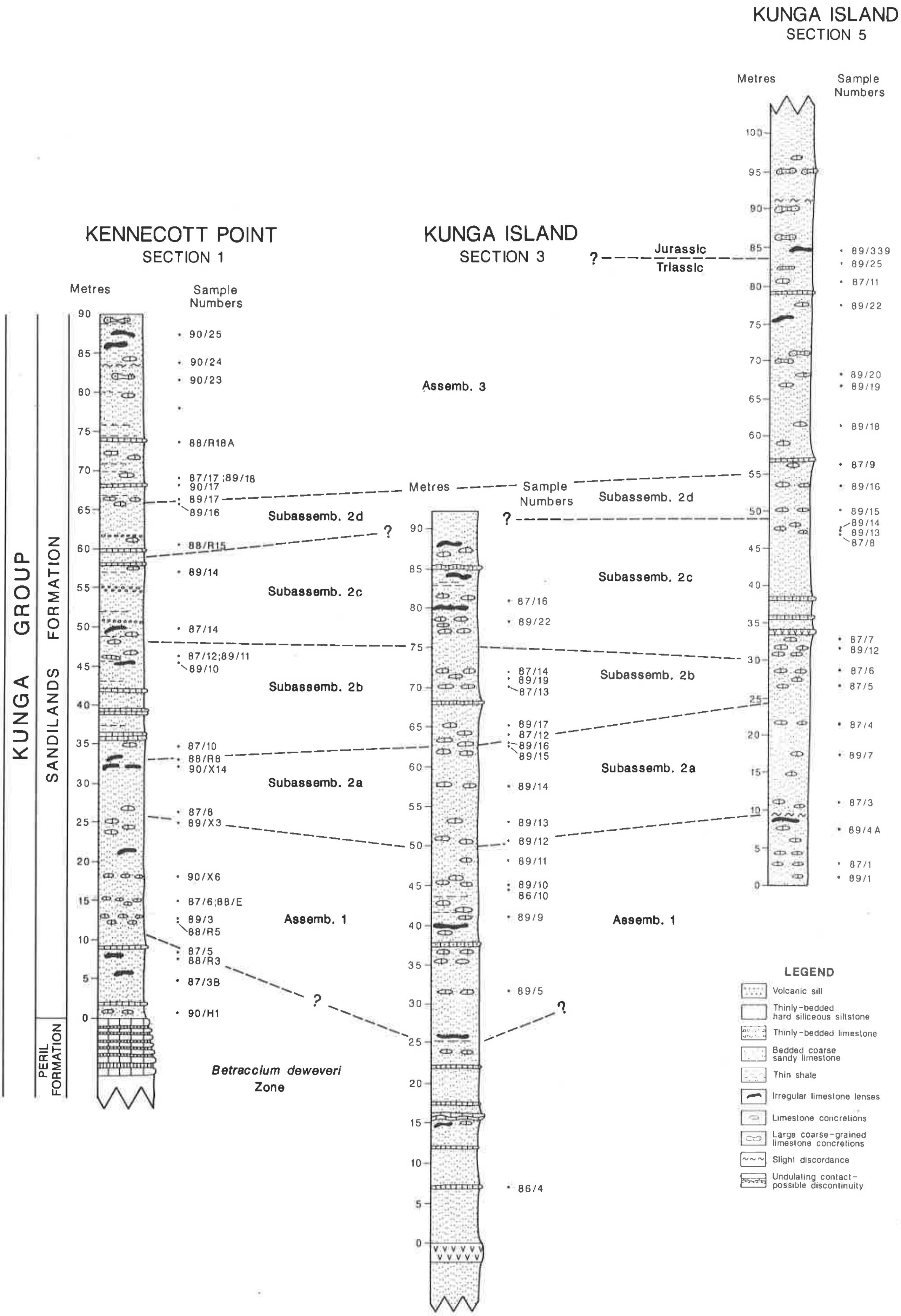


Figure 9. Biostratigraphic correlation of sections at Kennecott Point and Kunga Island showing radiolarian assemblages and subassemblages, and the position of the Triassic-Jurassic boundary at Kunga Island.

Biostratigraphic correlation

Precise correlation of the Triassic part of the Sandilands Formation can be achieved only with radiolarians. In 1990, three preliminary radiolarian assemblages were established for post-*Monotis* strata of the Sandilands Formation and these were used to correlate sequences at Kennecott Point and Kunga Island (Carter, 1990; Fig. 2). These assemblages have undergone further intensive investigation and with a few minor boundary changes, they remain intact. The present study utilizes the Unitary Associations method of Guex (1977) to distinguish assemblages and plot assemblage boundaries (see Radiolarian Biochronology below). The only major difference between the preliminary study (1990) and the work reported herein is that Assemblage 2 is now subdivided into four subassemblages; the lower and upper boundaries of the assemblage are essentially the same. Biostratigraphic correlation of section 1 at Kennecott Point with sections 3 and 5 at Kunga Island, is illustrated in Fig. 9. (see also Fig. 12 for delineation of assemblage boundaries as determined by the computer program BioGraph).

RADIOLARIAN BIOCHRONOLOGY

Introduction

Biostratigraphic study of radiolarians from uppermost Triassic strata of the Sandilands Formation was begun in 1987. The initial study (Carter, 1990) was based on a total of 27 samples from stratigraphic sections at Kennecott Point (section 1, KPA) and Kunga Island (section 3, SKU-B and section 5, SKU-D), and from two levels 2 m apart at Louise Island. This study utilized 27 'informally-defined' morphotypes (Fig. 3, Carter, 1990) in addition to other previously described or figured species from the literature, in order to establish three preliminary radiolarian assemblages (Assemblages 1-3). Zonation was approached from the assemblage concept i.e. several characteristic species were used as the criterion for recognizing an 'Assemblage'. Assemblage zones have been utilized by many Japanese workers in their biostratigraphic work (see summary in Yao, 1991).

In order to document the latest Triassic radiolarian succession as completely as possible, and to define more precisely the earlier established assemblages, a much greater volume of biostratigraphic data has been gathered since 1987. Although the number of sections and geographic areas is still limited (six sections; three separate geographic areas), this study now utilizes over 70 well preserved radiolarian collections from continuous uppermost Triassic sequences at Kennecott Point, Kunga Island, and Louise Island (plus additional information from Skidegate Inlet and an upper Norian locality at Shields Bay). All rock sequences were sampled intensively and only the best collections are included here. Owing to the increased scope of this study, a more quantitative biostratigraphic approach has been used in treating the data.

Unitary Associations

In recent years the Unitary Association (U.A.) method developed by Guex (1977) has been used effectively to integrate a large amount of data into a biochronologic framework. This method analyses the first and final occurrences of species in all available sections and defines maximal sets of mutually coexisting species (U.A.). It also produces maximum ranges of the taxa relative to each other by stacking co-occurrence data from all sections to compensate for local dissolution effects (poor preservation). Procedures developed by Guex and Davaud (1984) were used by Baumgartner and associates in establishing radiolarian zonation for Tethyan radiolarites of Middle Jurassic to Early Cretaceous age (Baumgartner et al.,1980, Baumgartner, 1984a, b, 1987 etc.). These procedures are thoroughly discussed in Baumgartner 1984a, summarized in Baumgartner 1984b, and are not presented here. More recently, Savary and Guex (1991) developed the computer program BioGraph to deal more efficiently with a large volume of data. This program was used by Jud (1991) in zoning Lower Cretaceous radiolarians from western Tethys, and is currently being employed by the multi-worker JURASSIC-CRETACEOUS WORKING GROUP in constructing worldwide zonation for low-latitude radiolarians of Middle Jurassic to Cretaceous age. BioGraph (Savary and Guex, 1991) has been used in the computer treatment of biostratigraphic data from the Queen Charlotte Islands.

<u>Procedures - Database</u>

A database (Appendix II) has been constructed consisting of 136 species in 69 stratigraphic horizons from six localities in three areas of the Queen Charlotte Islands (Kennecott Point, Kunga Island and Louise Island). Section 1 (Kennecott Point), and sections 3 and 5 (Kunga Island) are stratigraphic sections containing many superposed samples (or horizons); sections 2 and 6 are single sample localities at Kennecott Point and Kunga Island respectively; and section 4 consists of four samples from Louise Island. The morphotypes selected were carefully compared with SEM photos of 'newly-defined types' and only those having sharply defined limits of variation were utilized.

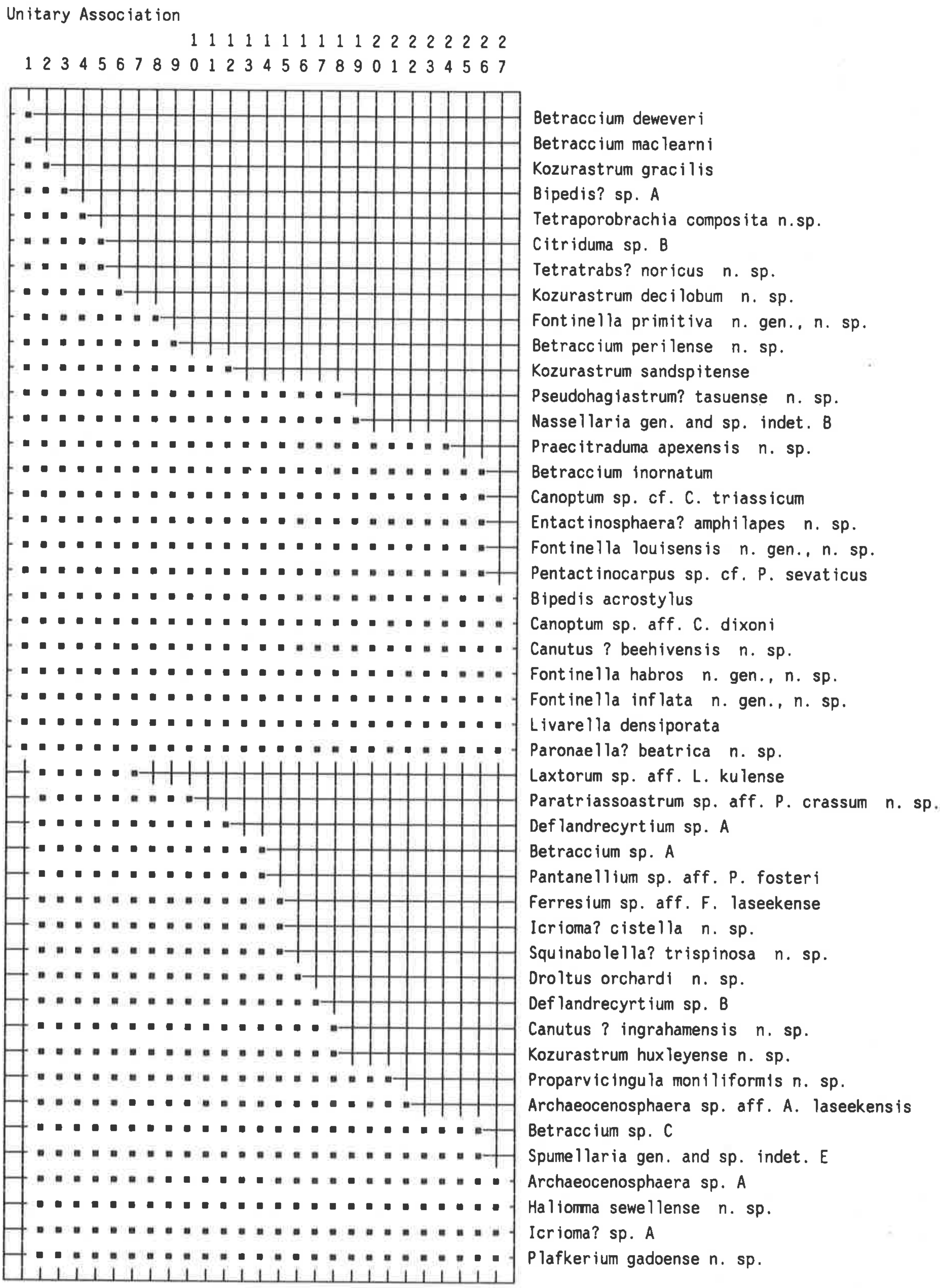


Figure 10a. Rhaetian radiolarian protoreferential based on Unitary Associations (output of BioGraph program, Savary and Guex, 1991).

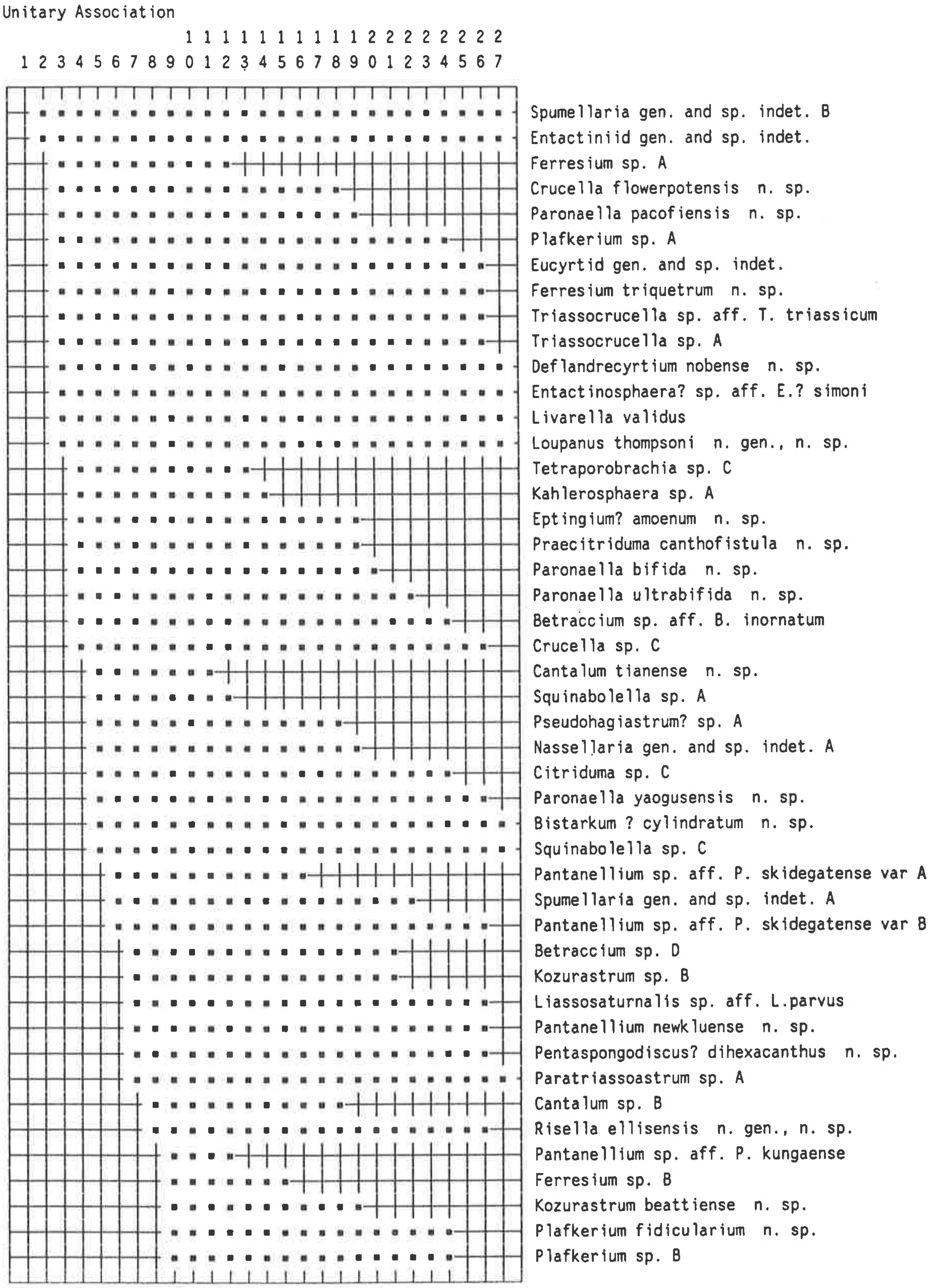


Figure 10b. Rhaetian radiolarian protoreferential based on Unitary Associations (output of BioGraph program, Savary and Guex, 1991).

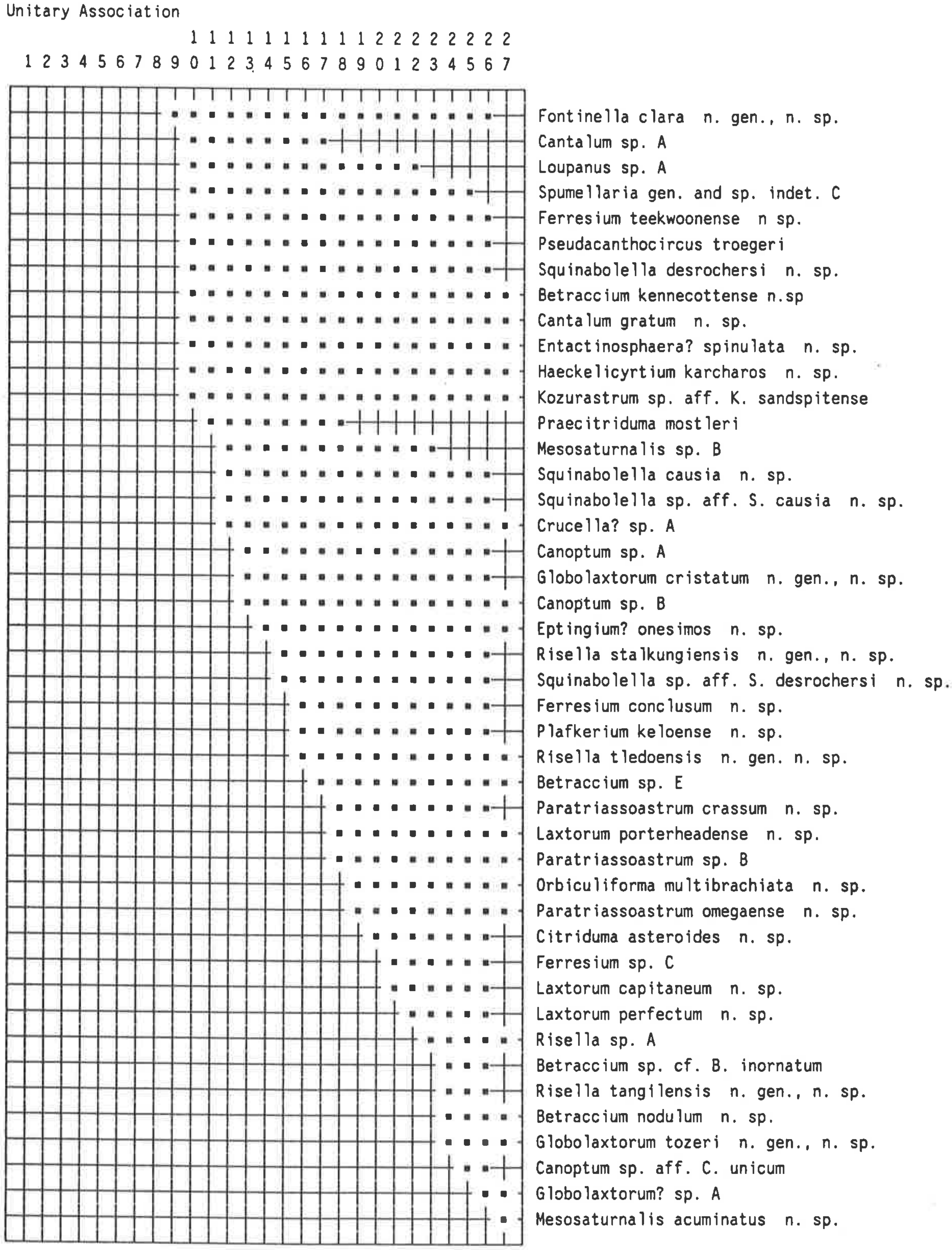


Figure 10c. Rhaetian radiolarian protoreferential based on Unitary Associations (output of BioGraph program, Savary and Guex, 1991).

Very rare species were generally excluded. Morphotypes were given codes consisting of five characters: three letters (an abbreviation of genus) and two numbers. Species indicated as having questionable occurrence in Fig. 7 and 8 (indicated by "?") were treated as absences in the database prepared for Unitary Associations. The database lists each section and records the appearance of all morphotypes present in each stratigraphic horizon.

Each U.A. is defined by the totality of its characteristic species, not only by coexisiting species pairs. This defines assemblage (biochronozone) boundaries less precisely but allows for the expansion of species range if and when additional data become available. The protoreferential for Rhaetian species is shown in Figs.10a-c.

Definition of assemblages

Radiolarian zonation consisting of 27 vertically ordered U.A. are distinguished in Upper Triassic strata of the Sandilands Formation; these are shown on the vertical graph in Fig 11. Because of strong similarites between the preliminary assemblages of Carter 1990 and results of this study, it was decided to retain the original assemblages but broaden their definition in terms of U.A. Each assemblage is defined by one or more U.A., and each U.A. is defined by the totality of its co-occurring species. Thus a sample can be assigned to an assemblage if one or more of its U.A. can be identified. Because radiolarians are dissolution controlled, morphotypes sparsely represented in one section are sometimes better represented in other sections. The U.A. method considers the combined occurrence (in all sections) of each species and plots its maximum range. Thus the more species are included in an assemblage, the broader the assemblage definition and the easier it can be recognized in poorly preserved material.

The *Betraccium deweveri* Zone (U.A. 1). This zone was established as the *Betraccium deweveri* subzone by Blome 1984, and is retained here at the base of the sequence. It is defined on the range of the nominal species *B. deweveri*. Morphotypes belonging to this zone range through the upper member (*Monotis* beds) of the Peril Formation (Blome, 1984) and lowest beds of the Sandilands Formation. The upper limit of this zone is defined by the Last Appearance Datum (LAD) of *Betraccium deweveri* and this sets the base for the post-Norian zonation to follow. U.A. 1 is recognized in section1 (Kennecott Point) and section 3 (Kunga Island).

For each new assemblage described below a few representative taxa are listed. In addition to these, the following taxa are abundant in all Rhaetian assemblages: *Fontinella inflata* n. sp., *F. louisensis* n. sp., *Haliomma ? sewellense* n. sp., *Loupanus thompsoni* n. sp., *Canotpum* sp. aff. *C. dixoni* Pessagno and Whalen, and *Canutus ? beehivensis* n. sp.. Of the above, *F. inflata* , *F. louisensis*, and *C.*sp. aff. *C. dixoni* are known from the upper part of the *Betraccium deweveri* Zone but are much less common.

Assemblage 1 (U.A. 2-5). The lower and middle parts of this assemblage (U.A. 2-4) are best defined in section 3 (Kunga Island) with U.A. 2 further represented at the base of section 5 (Kunga Island). The upper part of the assemblage (U.A. 5) is best represented in section 1 (Kennecott Point). Most representative taxa include *Archaeocenosphaera* sp. A, *Paronaella bifida* n. sp., *Pseudohagiastrum ? tasuense* n. sp., *Droltus orchardi* n. sp., *Squinabolella ? trispinosa* n. sp. and *Livarella densiporata* Kozur and Mostler.

Assemblage 2 (U.A. 6-23). This assemblage contains the most diverse fauna and the greatest number of U.A. (18). Intraspecific variation is moderately high but generic composition of the fauna is relatively stable. For this reason Assemblage 2 is divided into four subassemblages (2a-2d) rather than into separate assemblages. Well represented taxa found in all subassemblages include *Fontinella habros* n. sp., *Entactinosphaera ? amphilapes* n. sp., *Paronaella ultrabifida* n. sp. and *Proparvicingula moniliformis* n. sp..

Subassemblage 2a (U.A. 6-9). U.A. 6 defined in section 1 (Kennecott Point); U.A. 7-8 are well defined in section 3 (Kunga Island), U.A. 9 is strictly defined in section 5 (Kunga Island). Most abundant and representative taxa include *Fontinella habros* n. sp., *F. inflata* n. sp., *Entactinosphaera ? amphilapes* n. sp., *Paronaella bifida* n. sp., *Pseudohagiastrum ? tasuense* n. sp. and *Proparvicingula moniliformis* n. sp.

Subassemblage 2b (U.A. 10-15). The lower part of this subassemblage (U.A. 10) is defined in section 4 (Louise Island); U.A. 11-12 are defined in section 3 (Kunga Island); U.A. 13 is defined in section 1 (Kennecott Point); U.A.14 is clearly defined in both sections 4 (Louise Island) and 5 (Kunga Island); and the uppermost part of the assemblage (U.A. 15) is defined in section 1 (Kennecott Point). Most representative taxa include Entactiniid gen. and sp. indet., *Ferresium teekwoonense* n. sp.,

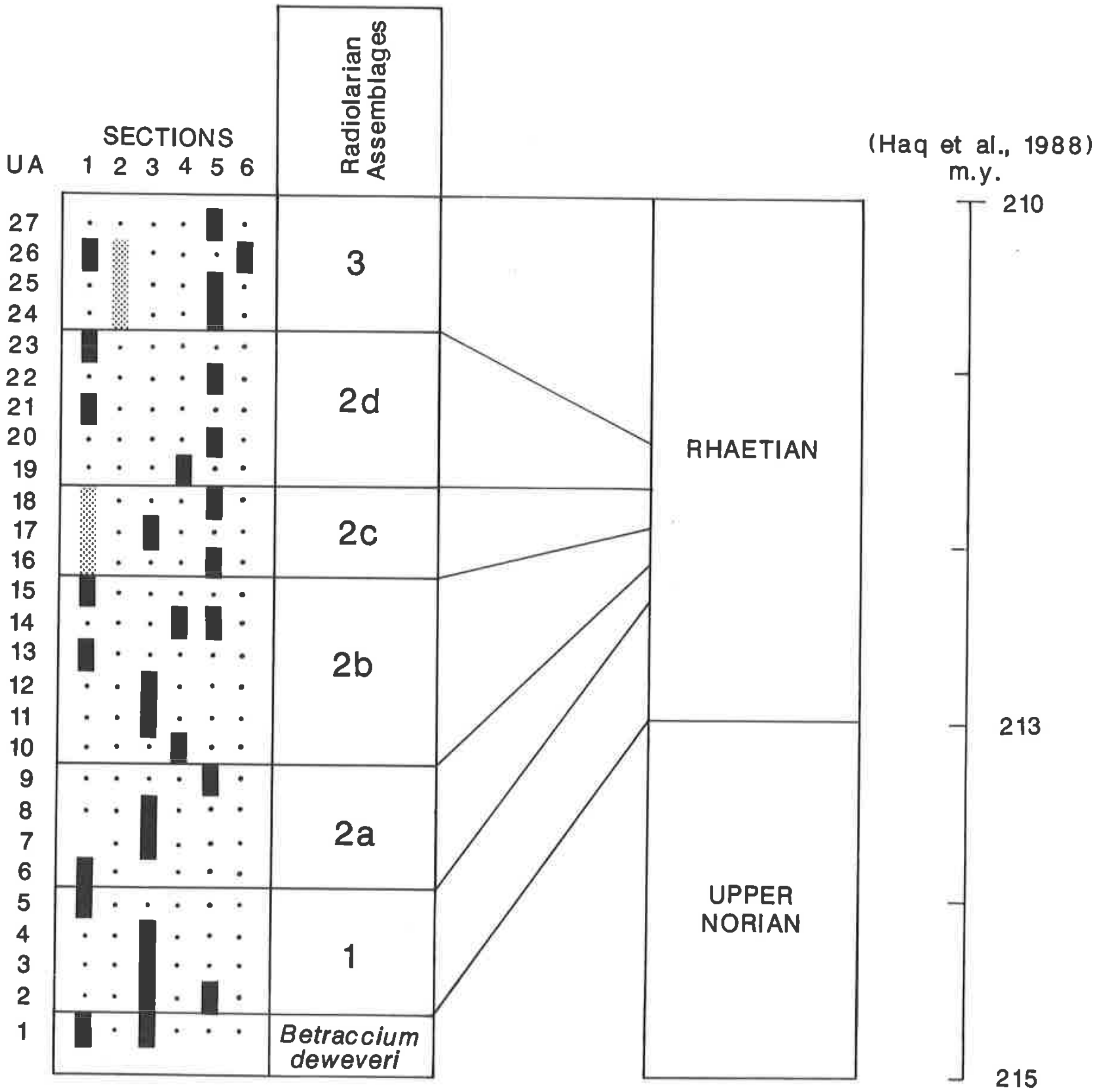


Figure 11. Reproducibility of 27 Unitary Associations from data of investigated sections at Kennecott Point, Louise Island, and Kunga Island, Queen Charlotte Islands and correlation to chronostratigraphy (output of BioGraph program v. 2.02, Savary and Guex, 1990). Solid bars indicate Unitary Associations identified in the sections. Stippled bars indicate adjacent unions of Unitary Associations which are not individually reproducible.

Fontinella inflata n. sp., *F. louisensis* n. sp., *Kozurastrum beattiense* n. sp., *Pantanellium* sp. aff. *P. skidegatense* Pessagno and Blome var. B, *Paronaella ? beatricia* n. sp., *P. ultrabifida* n. sp., *Eptingium*? *amoenum* n. sp., *Haeckelicyrtium karcharos* n. sp., *Proparvicingula moniliformis* n. sp. and *Squinabolella desrochersi* n. sp..

Subassemblage 2c (U.A. 16-18). U.A. 16 and 18 are well defined in section 5, (Kunga Island) whereas U.A. 17 is defined in section 3 (Kunga Island). Subassemblage 2c is moderately defined in section 1 (Kennecott Point). Most representative taxa include *Betraccium kennecottense* n. sp., *Paronaella*? *beatricia* n. sp., *P. ultrabifida* n. sp., Entactiniid gen. and sp. indet., *Citriduma asteroides* n. sp., *Eptingium*? *onesimos* n. sp. and *Plafkerium fidicularium* n. sp..

Subassemblage 2d (U.A. 19-23). The base of subassemblage 2d (U.A. 19) is clearly defined at section 4 (Louise Island). U.A. 20 and 22 are defined in section 5 (Kunga Island) whereas U.A. 21 and 23 are defined in section 1 (Kennecott Point). Most representative taxa include *Bipedis acrostylus* Bragin, *Citriduma asteroides* n. sp., *Eptingium ? onesimos* n.sp. and *Laxtorum capitaneum* n. sp..

Assemblage 3 (U.A. 24-27). U.A. 24-25 are defined in section 5, (Kunga Island); U.A. 26 is defined in section 1 (Kennecott Point) and section 6 (Kunga Island); and U.A. 27 (the highest U.A.) is defined only in section 5 ((Kunga Island). U.A. 24-26 are moderately well defined in section 2 (Kennecott Point). Most representative taxa include *Betraccium nodulum* n. sp., *Bistarkum ? cylindratum* n. sp., *Ferresium conclusum* n. sp., *F. teekwoonense* n. sp., *Fontinella clara* n. sp., Entactiniid gen. and sp. indet., *Citriduma asteroides* n. sp., *Eptingium ? onesimos* n. sp., *Globolaxtorum cristatum* n. sp., *G. tozeri* n. sp., *Laxtorum capitaneum* n. sp., *L. porterheadense* n. sp., *Mesosaturnalis acuminatus* n. sp., *Orbiculiforma multibrachiata* n. sp., *Plafkerium keloense* n. sp., *Risella ellisensis* n. sp. and *R. tledoensis* n. sp.

The radiolarian assemblages described here are for local use in Queen Charlotte Islands and nearby areas. Their use in correlating Rhaetian strata at Kennecott Point with those at Louise Island and Kunga Island is illustrated in Fig. 12. Further testing of this zonation is necessary in order to determine its wider applicability.

Previously described species observed in the Sandilands succession are mentioned below, together with an approximation of their stratigraphic position as related to radiolarian zonation presented here. *Betraccium deweveri* Pessagno and Blome and *B. macleami* Pessagno and Blome are present in the lower 10 m of the Sandilands Formation and belong to the *B. deweveri* Zone as restricted herein; *Pantanellium fosteri* Pessagno and Blome and *Pseudoheliodiscus sandspitensis* Blome [*Kozurastrum sandspitense* (Blome) herein] range into the lower part of Assemblage 2 (Carter, 1990). *Livarella densiporata* Kozur and Mostler is present in some uppermost Norian collections and ranges through the entire Rhaetian sequence of the Sandilands Formation; *Praecitriduma mostleri* Kozur occurs in Subassemblages 2b and 2c but is quite rare. The *Betraccium inornatum* Group ranges throughout the Sandilands sequence. The presence of *B. inornatum* s.s. in assemblages 1 and 3 is confirmed but, in Assemblage 2, this species is usually larger with more variable pore frames, spines etc. *Bipedis acrostylus* Bragin ranges throughout upper Norian and Rhaetian strata of the Queen Charlotte Islands.

Chronostratigraphic correlation of radiolarian assemblages

The preliminary radiolarian assemblages established by Carter 1990 and the more detailed assemblages proposed here are correlated as closely as possible with the Upper Triassic ammonoid zones of Tozer (1979). In the initial study, Assemblage 1 was tentatively correlated with the upper part of the Cordilleranus Zone; Assemblage 2 approximated the Amoenum Zone; and Assemblage 3 was correlated with the Crickmayi Zone.

Lowest beds of the Sandilands Formation are now known to contain rare specimens of *Betraccium deweveri* Pessagno and Blome which is the primary indicator of the *Betraccium deweveri* Subzone of Blome,1984 (raised herein to zone). Analysis of the published literature indicates that in the circum-Pacific region *B. deweveri* and other species characteristic of this fauna are widely distributed in upper Norian beds that commonly contain the pelagic bivalve *Monotis* (= Cordilleranus Zone equivalent). Basal Sandilands beds lack other diagnostic fossils and precise age is uncertain, however, the presence of the *B. deweveri* fauna suggests these beds may be upper Norian also. In overlying strata *B. deweveri* is absent, very few other representatives of the *B. deweveri* fauna remain, and the radiolarian assemblage is distinctly different. Because the Sandilands succession is believed continuous and complete, Assemblage 1 is probably equivalent to the lower part of the Amoenum Zone. Assemblage 2, the largest assemblage (now subdivided into four subassemblages), approximates the middle and upper parts of the Amoenum Zone.

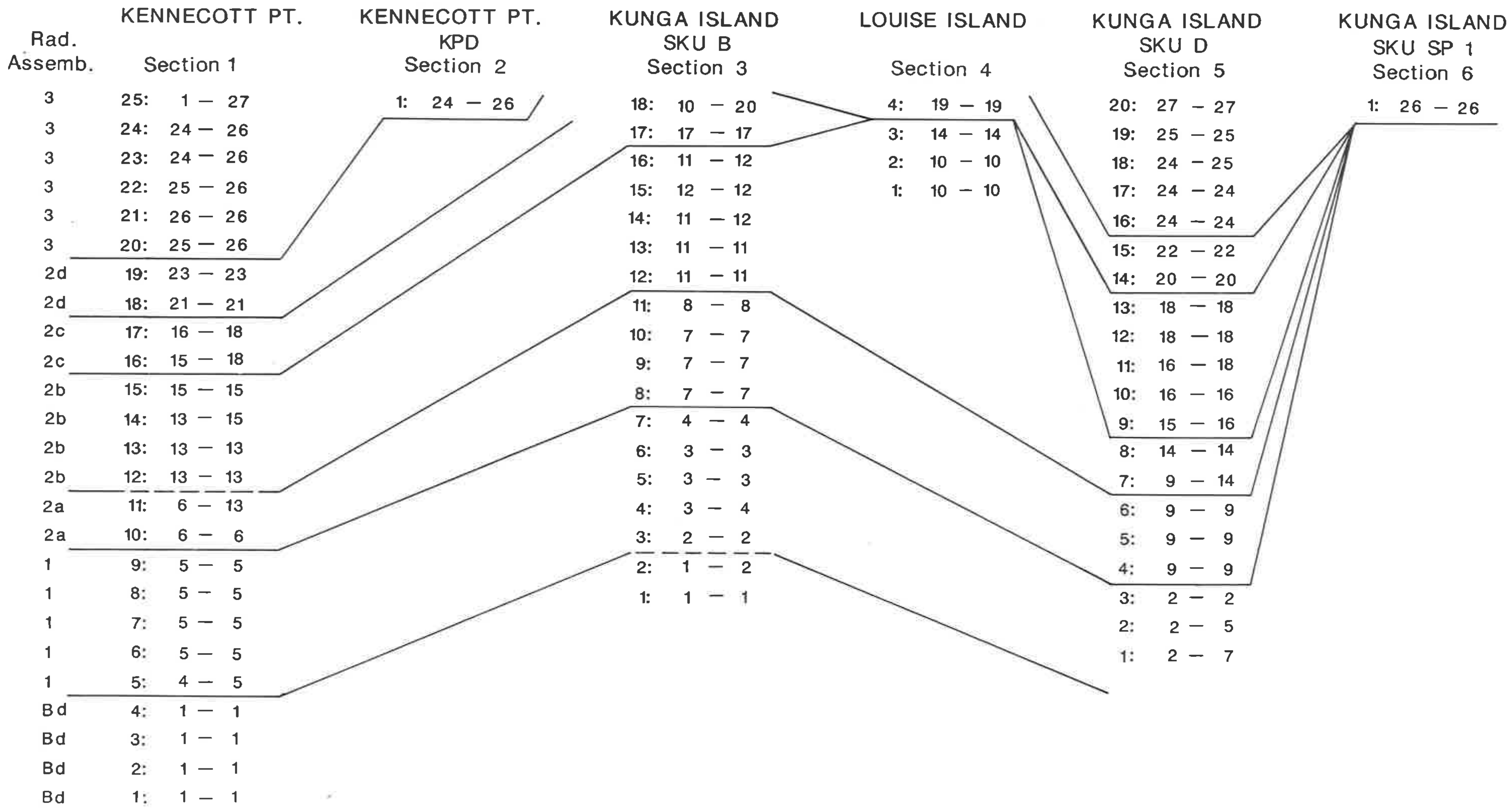


Figure 12. Correlation Table. Solid lines are zonal correlations; dashed lines are uncertain correlations (output of BioGraph program v. 2.02, Savary and Guex, 1990).

Assemblage 3 is correlated with the uppermost Triassic Crickmayi Zone (as in Carter, 1990). All three assemblages are Rhaetian in age.

Correlation with other zonations

Correlation with upper Norian and Rhaetian zonal schemes proposed for North America, Japan, eastern Russia and the Philippines is imprecise because very few Rhaetian taxa have been described from these areas. This study presents the first comphrehensive taxonomic and biochronologic examination of the diverse Rhaetian radiolarian fauna and most of these forms either do not exist or have not yet been discovered elsewhere. Nevertheless, other zonal schemes are reviewed below and comparison and/or disagreement with new Queen Charlotte Island zonation is discussed (Fig. 13).

Comparison with North American zonation

Upper Triassic zonal schemes for western North America have been proposed by Pessagno (1979) and Blome (1984). The uppermost unit in Pessagno's zonation is the *Pantanellium silberlingi* Zone, the top of which was tentatively interpreted by Pessagno to be late Norian in age. None of the taxa from this zone (which in addition to species of *Pantanellium* Pessagno and *Betraccium* Pessagno and Blome also include species of *Capnuchosphaera* DeWever and *Sarla* Pessagno) have been recognized even in the lowest radiolarian collections from the Sandilands Formation, nor are they found in this author's collections from the *Monotis* beds on the north side of Kunga Island or from just below the *Monotis* beds at Shields Bay. This suggests the *Pantanellium silberlingi* Zone does not range into the upper Norian but instead is more probably restricted to the upper part of the middle Norian.

In Blome's zonal scheme, the uppermost unit, the *Betraccium* Zone, was proposed for strata of middle and late Norian age. This zone was divided into the lower *Pantanellium silberlingi* Subzone and the upper *Betraccium deweveri* Subzone, with the latter ranging to the top of the Triassic. All taxa characteristic of the *Betraccium deweveri* Subzone were described by Pessagno and Blome (1980) and Blome (1984) from the upper Norian *Monotis* beds on the north side of Kunga Island. These authors did not report on samples from younger upper Norian/Rhaetian strata of the Queen Charlotte Islands or elsewhere. Although some genera range through both the above subzones e.g. *Acanthocircus*, *Betraccium*, *Canoptum*, *Cantalum*, *Pantanellium*, and *Pseudoheliodiscus* (see Blome, 1984, fig. 6), the species in each subzone appear to be mutually exclusive.

The present study confirms genus *Betraccium* ranges to the top of the Triassic, but that the range of *B.deweveri* is much more restricted. In Queen Charlotte Islands, this species occurs only in the upper Norian *Monotis* beds of the Peril Formation and in the basal 10 m of the Sandilands Formation which are also believed to be upper Norian. Evidence from Japan, eastern Russia, and the Philippines further suggest the *B. deweveri* Zone is confined to strata that is probably equivalent to the upper Norian Cordilleranus Ammonoid Zone (see Yosida, 1986; Bragin 1991; and Yeh, 1992 below). Thus in zonation proposed here, the *B. deweveri* Zone is restricted essentially to the upper Norian; it does not range through the Rhaetian.

Comparison with zonation from Japan

Correlation with Yao, Matsuda and Isozaki (1980a, b) and Yao (1982)

Zonations proposed by these authors are closely related and are grouped together for discussion because the taxa involved are common to all three zonations. In 1980a, Yao, Matsuda and Isozaki established the *Dictyomitrella* sp. Assemblage for upper Carnian and Norian radiolarians from a continuous sequence of chert in the Inuyama area of Central Japan. Soon after, the same authors (1980b) divided the upper part of this assemblage into the lower *Paleosaturnalis gracilis* Subassemblage and the upper *Poulpus* (?) sp. Subassemblage of upper Norian and Rhaetian age respectively. In 1982 Yao reeaxamined this material and established the *Canoptum triassicum* Assemblage to encompass these two subassemblages. The following species described or figured from the *Canoptum triassicum* Assemblage are present in Upper Triassic strata of the Sandilands Formation. The oldest representative is *Paleosaturnalis gracilis* (Kozur and Mostler) [herein referred to as *Kozurastrum gracilis* (Kozur and Mostler)] which occurs in the upper Norian *Monotis* beds of the Peril Formation and U.A. 1-2 of the Sandilands Formation; in Queen Charlotte Islands this species is restricted to the *Betraccium deweveri* Zone and the basal assemblage of Assemblage 1. Younger forms include *Dreyericyrtium* sp. A (herein *Deflandrecyrtium* sp. A) found in U.A. 2-12 (Assemblage 1 - Subassemblage 2b); *Poulpus* ? sp. A (herein *Livarella validus* Yoshida) found in U.A. 3-27 (Assemblages 1-3); a form very similar to *Canoptum triassicum* Yao found in U.A. 1-26 (uppermost *B. deweveri* Zone - Assemblage 3); Nassellaria gen. and sp. indet. A (*Bipedis acrostylus* Bragin herein) found in U.A. 1- 27 (uppermost *B. deweveri* Zone - Assemblage 3); and *Squinabolella* (?) sp. C (*Squinabolella* sp. D herein) is found only in Assemblage 3 (not included in computation of U.A. because of rare occurrence. Based on the above information, the *Canoptum triassicum* Assemblage is correlated with the *Betraccium deweveri* Zone plus Assemblages 1-3 defined in this study.

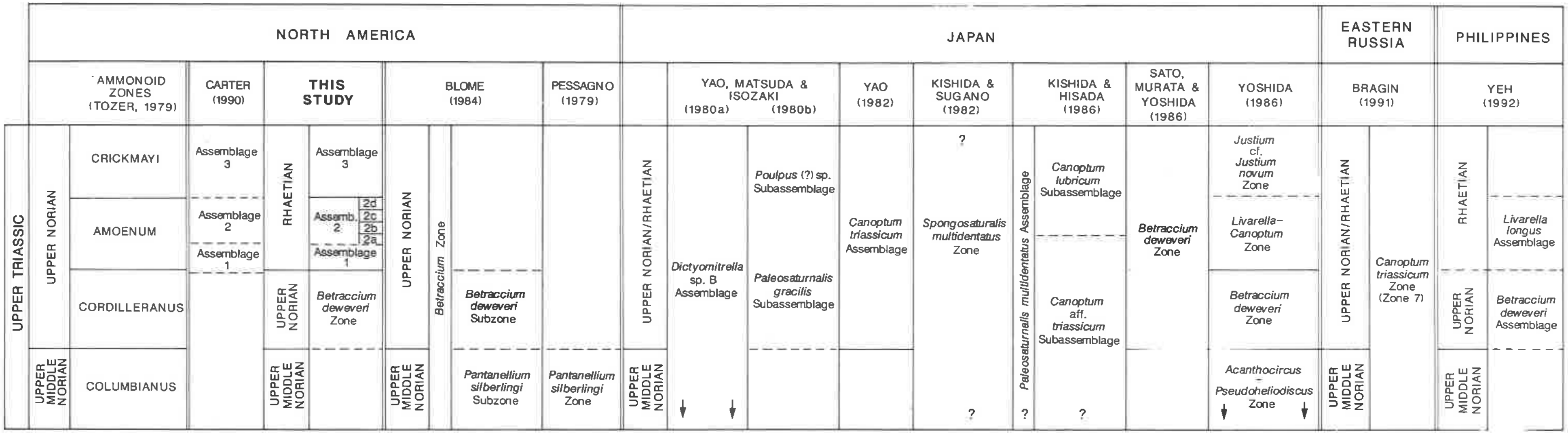


Figure 13. Correlation of newly proposed radiolarian zonation (and assemblages of Carter, 1990) with ammonoid zones of Tozer (1979), and further correlation with radiolarian zonation in North America, Japan, eastern Russia, and the Philippines.

Correlation with Kishida and Sugano (1982)

Kishida and Sugano (1982) established five assemblage zones for Triassic strata from the Chichibu Belt in the Kuchi and Oita Prefecture, Japan. Their upper two zones, the *Spongosaturnalis multidentatus* Zone and the *Pantanellium* sp. B - *Gorgansium* sp. A Zone, were believed to be "middle Norian to early Rhaetian?, and Rhaetian" in age, respectively. The lower zone was characterized by species of *Spongosaturnalis* Campbell and Clark, and *Paleosaturnalis* Donfrio and Mostler, and the upper zone by undescribed species of *Pantanellium* (sp. A), *Gorgansium* (sp. A), *Paleosaturnalis* (sp. L), and *Dictyomitra* (?) (sp. F). The *Pantanellium* sp. B - *Gorgansium* sp. A Zone was subsequently revised by Kishida and Hisada (1986) to the *Bagotum pseudoerraticum* Assemblage becoming the lowest Jurassic unit. The *S. multidentatus* Zone in now the uppermost Triassic unit.

With regard to the *Spongosaturnalis multidentatus* Assemblage, the only form typifying this assemblage that is present in Queen Charlotte Islands is *Paleosaturnalis* sp. D which is very similar to *Kozurastrum gracilis* (Kozur and Mostler), discussed and figured in this study. *K. gracilis* occurs in the *Betraccium deweveri* Zone and in lower Assemblage 1 (U.A. 2 only). The *S. multidentatus* Assemblage also contains *Sarla natividadensis* Pessagno, a species characteristic of the *Pantanellium silberlingi* Zone of Pessagno (1979). This zone is probably middle to upper Norian but not likely younger.

Correlation with Kishida and Hisada (1986)

Kishida and Hisada (1986) renamed the *Spongosaturnalis multidentatus* Zone the *Paleosaturnalis multidentatus* Assemblage, and divided it into two subassemblages: the lower *Canoptum* aff. *triassicum* Subassemblage and the upper *Canoptum lubricum* Subassemblage. Component species of these subassemblages include: *Canoptum* aff. *triassicum* Yao, *C. lubricum*, *Gorgansium gongyloideum*, *G. crassum*, and *Paleosaturnalis* sp. C (*Kozurastrum beattiense* n. sp. herein). In Queen Charlotte Islands, *Canoptum* cf. *triassicum* is found in U.A. 1-26 and *Kozurastrum beattiense* in U.A. 9-19 (Assemblage 2), whereas *C. lubricum*, *G. gongyloideum*, and *G. crassum* do not occur in Sandilands assemblages. This very limited evidence suggests the *Paleosaturnalis multidentatus* Assemblage is correlative with the *Betraccium deweveri* Zone and possibly Assemblages 1 and 2, and is late Norian to ?middle Rhaetian in age.

Correlation with Sato, Murata and Yoshida (1986)

Sato, Murata and Yoshida (1986) established the *Betraccium deweveri* Zone for upper Norian strata in the southern part of the Chichibu terrane in Kyushu. *Betraccium deweveri* Pessagno and Blome, *B. yakounense* Pessagno and Blome, and *Canoptum triassicum* Yao were included in this assemblage as well as species of *Sarla* Pessagno and *Pseudoheliodiscus* Kozur and Mostler. This zone correlates with the *Betraccium deweveri* Zone(as restricted herein) and apparently ranges no higher.

Correlation with Yoshida (1986)

Yoshida confined the *Betraccium deweveri* Zone to the upper Norian (as restricted here) and established the *Livarella* - *Canoptum* Zone for strata believed to be early to middle Rhaetian in age, and the *Justium* cf. *J. novum* Zone for strata of presumed late Rhaetian age. Of the many taxa designated by Yoshida as characteristic of the *Livarella* - *Canoptum* Zone, only the following species occur in Queen Charlotte Islands: *Livarella densiporata* Kozur and Mostler (U.A. 1-27), *L. validus* Yoshida (U.A. 3-27), *Canoptum triassicum* Yao (*Canoptum* cf. *triassicum* Yao herein, U.A. 1-26), *Dreyericyrtium* (?) sp. B (*Squinabolella desrochersi* n. sp. herein, U.A. 10-26), *Ferresium* sp. A (*Ferresium conclusum* n. sp. herein, U.A. 16-26), and Nassellaria B (*Bipedis acrostylus* Bragin herein, U.A. 1-27). *Livarella densiporata* Kozur and Mostler and *Canoptum triassicum* Yao (*Canoptum* cf. *triassicum* Yao herein) are the only recognized species from the *Justium* cf. *J. novum* Zone. Both the *Livarella* - *Canoptum* Zone and the *Justium* cf. *J. novum* Zone correlate with Rhaetian assemblages 1-3 described herein, but no age distinction can be made between the two.

<u>Correlation with zonation from eastern Russia</u>

In the eastern part of the former USSR, Bragin (1991) described seven radiolarian zones for strata of mid Early Triassic to latest Triassic age. The uppermost zone, the *Canoptum triassicum* Zone (Zone 7), is upper Norian and Rhaetian. Taxa from this zone include *Betraccium deweveri* Pessagno and Blome (in lower part of zone only), *Canoptum triassicum* Yao, *Kozurastrum multidentatus* (Kozur and Mostler), *Livarella gifuensis* Yoshida, *Bipedis acrosltylus* Bragin, *Hagiastrum* (?) sp. (?*Risella tledoensis* n. sp. herein, U.A. 16-27), and *Triassocampe* sp. (*Proparvicingula moniliformis* n. sp. herein, U.A. 2-21). This zone correlates with the *Betraccium deweveri* Zone, Assemblages 1 and 2, and possibly Assemblage 3 as well.

Comparison with assemblages in the Philippines

In the Philippines, Yeh (1992) discussed two radiolarian assemblages: the *Betraccium deweveri* Assemblage and the *Livarella longus* Assemblage. The former assemblage is dated late Norian and includes *Betraccium chengi* Yeh (*Betraccium* aff. *inornatum* Blome herein, U. A. 4-24), *B. deweveri* Pessagno and Blome, *Pantanellium inornatum* Pessagno and Poisson, *Pantanellium ultrasincerum* Pessagno and Blome (=*Pantanellium* sp. aff.*P.fosteri* Pessagno and Blome herein, U. A. 2-14), and *Canoptum laxum* Blome. Diagnostic taxa of the *Livarella longus* Assemblage, dated early Rhaetian, include *L. densiporata* Kozur and Mostler, *L. gifuensis* Yoshida, *L. inflata* Yeh, *L. longus* Yoshida, and *L. usonensis* Yeh. Other taxa in this assemblage include Nassellaria indet. gen. A sp. A/Nassellaria indet. gen. B sp. A (*Bipedis acrostylus* Bragin), several species of *Deflandrecyrtium* (Nassellaria indet. gen. C sp. A, in Yeh), *Paronaella* sp. B (probably a species of *Risella* i.e. *R. tledoensis* n. sp. herein), and *Katroma* sp. A (?*Globolaxtorum* n. gen., herein). This assemblage probably correlates with at least Assemblages 1 and 2 in the Queen Charlotte Islands and possesses some taxa more commonly found in Assemblage 3. The age of the *Livarella longus* Assemblage was determined by the absence of *Betraccium* spp. and the presence of *Livarella* forms. In the Queen Charlotte Islands both genera occur together throughout the entire Rhaetian sequence.

Corroborating evidence from other areas

Two miscellaneous samples of Rhaetian age have been made available to the author; one from Oman and the other from northern Peru. These samples were examined to see (1) if new taxa from the Queen Charlotte Islands are present; (2) how the assemblage as a whole differs from Queen Charlotte assemblages; and (3) if the contained radiolarian assemblage provides supporting evidence for zonation presented in this study.

Oman

Sample 1197 was collected by Alain Pillevuit, Université de Lausanne, from a Triassic-Jurassic boundary section at Wadi Musallah, Oman. At this locality Lower Jurassic strata are underlain by several metres of radiolarite of probable Rhaetian age. *Halobia* -like bivalves are present in cherty limestone beneath the radiolarite but the precise age is not known, whereas overlying calcareous sediments are believed to be Lower Jurassic based on lithological correlation with other units in the area (S. Gorican, written comminication, 1992). Sample 1197 was collected about 2 m below the top of the radiolarite (A. Pillevuit, written communication 1992); it contains abundant radiolarians.

The assemblage from Oman contains *Globolaxtorum tozeri* n. sp. and *Pseudoacanthocircis troegeri* Kozur and Mostler, taxa strongly indicative of Assemblage 3 in Queen Charlotte Islands (*P. troegeri* further ranges into the Hettangian as presently known). Another form has affinity to *Mesosaturnalis acuminatus* n. sp., also confined to Assemblage 3 in the Charlottes. The remaining fauna consist of (1) *Livarella densiporata* Kozur and Mostler, *L. validus* Yoshida, and Eucyrtid gen. and sp. indet., species common to Assemblages 1-3; (2) species with affinities to *Kozurastrum sandspitense* (Blome) and *Paleosaturnalis vigrassi* Blome; (3) *L. gifuensis* Yoshida and *L. longus* Yoshida, forms not found in Queen Charlotte Islands; and (4) species of *Ferresium*, *Paratriassoastrum*, *Plafkerium*, and a particularly abundant form of *Sarla* ? having massive, highly twisted spines.

Generic composition of the Oman fauna is similar to that found in middle and upper Rhaetian faunas of the Queen Charlotte Islands. Some species are identical to new species described here while others are strongly similar. A few Rhaetian species from other parts of the world are also present but others are entirely different from all the foregoing. The Oman assemblage correlates best with Queen Charlotte faunas belonging to the upper part of Assemblage 2, and Assemblage 3. It provides useful evidence that while variation was rampant, some radiolarian species had wide latitudinal distrubution in the very latest Triassic. The Oman fauna further provides a good base for the establishment of a worldwide Rhaetian Radiolarian Zonation.

Northern Peru

Sample 900928/0 from the Utcubamba valley of Northern Peru was obtained courtesy of Prof. Dr. A. Von Hillebrandt of the Technische Universität, Berlin. In Chilingote, in the southern part of this region, upper Rhaetian strata are directly overlain by ammonite-bearing beds of LowerJurassic (Hettangian) age (v. Hillebrandt, in press, see text-fig. 2). No other microfaunas or ammonoids were present in this sample (a calcareous concretion), but 1 m above the first lowermost Hettangian ammonites (*Psiloceras tilmanni*) appear (A. v. Hillebrandt, written communication, 1992).

The sample contains abundant, well preserved radiolarians. The majority are simple, spherical forms with either latticed or spongy meshwork and randomly oriented radial spines. These have no counterpart in the Queen Charlotte Islands Rhaetian fauna but have strong affinity to earliest Hettangian radiolarians from Kennecott Point (Carter, in press). These forms constitute the lowest Jurassic fauna (R3) of section KPD in Tipper et al. (in press, see fig. 2). Of greater interest to this study are rare specimens of *Entactinosphaera* ? *spinulata* n. sp., *Haeckelicyrtium karcharos* n. sp., *Squinabolella* sp. aff. *S.*

desrochersi n. sp. (very similar to the species of the same name herein), *Canoptum* sp. cf. *C. triassicum* Yao, *Betraccium* sp., and *Deflandricyrtium* spp. These forms are decidedly latest Triassic and do not range into the Hettangian. In Queen Charlotte Islands, *E.* ? *spinulata* and *H. karcharos* are found in U.A. 10-27, whereas *S.* sp. aff. *S. desrochersi* is found in U.A. 15-26. Thus all three range from the lower part of Assemblage 2 through Assemblage 3. Forms similar to *C. triassicum* range throughout the Queen Charlotte Rhaetian fauna as do a variety of species of *Betraccium* and *Deflandrecyrtium*.

Generic composition of the late Rhaetian Peruvian fauna as compared to Queen Charlotte faunas discussed herein is similar, and some species are identical. Of identical species, age is consistent with Queen Charlotte forms that occur in topmost beds of the Triassic (Assemblage 3). Information from this sample further indicates that radiolarian genera and even some species had wide distribution (latitudinal and longitudinal) in the Late Triassic Tethys ocean.

The occurrence of forms similar to those found in Triassic-Jurassic transitional beds at Kennecott Point (Tipper et al., in press) is more problematical because in Queen Charlotte Islands, latest Triassic and earliest Jurassic radiolarian faunas are completely separate and distinct [of over 40 genera discussed in this study, less than 40 percent survive the Triassic-Jurassic boundary and, with the exception of *Pseudoacanthocircus troegeri* Kozur and Mostler, all species go extinct as well; furthermore, many surviving genera are not found in the low diversity early Hettangian radiolarian fauna of Queen Charlotte Islands (Carter, in press)]. The exact cause of the terminal Triassic extinction is unknown and not discussed here, but it is likely that many environmental factors were involved in the deterioration of the marine faunas, and undoubtedly, some of these impacted the radiolarians. In Queen Charlotte Islands it seems apparent from present data available that the equivalent of this transitional fauna from Peru was either absent initially or not preserved. On the other hand, the presence of this fauna in Peru suggests the possibility that the faunal transition from Triassic to Jurassic could have been more gradual in southerly oceans.

RADIOLARIAN ZONATION FOR THE RHAETIAN

The radiolarian assemblages proposed in this study are for local correlation of the exceedingly rich and well preserved fauna of Queen Charlotte Islands. This fauna illustrates the optimal development of radiolarians during the Rhaetian. The assemblages are easily recognized locally and are expected to be useful for precise correlation wherever such a wealth of material is found. However, information provided by Rhaetian radiolarians in most other parts of the world reveals that such wealthy faunas are indeed rare and that most workers have only a limited number of genera/species upon which to base their correlations. For this reason, a system of radiolarian zones having worldwide distribution (Pacific-Tethys) during the Rhaetian is also proposed (Fig. 14).

The essential requirements for a reliable zonal indicator are short range, abundance, and worldwide distribution. The genera most frequently recognized and characteristic of Rhaetian assemblages around the world are *Betraccium* and *Livarella*. In Queen Charlotte Islands, *Betraccium* is the most diverse genus in Rhaetian strata equivalent to the Amoenum and Crickmayi (ammonoid) Zones, but it is not exceptionally abundant nor does the range of most species coincide directly with assemblage boundaries established here. Among the Livarellidae, *Livarella densiporata* Kozur and Mostler is recognized worldwide in Rhaetian assemblages, but the range of this form is lengthy and spans at least the uppermost Norian, and the entire Rhaetian. Other described species of *Livarella* are either absent in Queen Charlotte Islands, or have discontinuous distribution making them inappropriate as zonal indicators. Thus it has been necessary to choose other indicators from among the new Rhaetian fauna described here.

The *Betraccium deweveri* Zone is retained at the base of the new zonal scheme. This zone is late Norian in age and is biochronologically equivalent to the Cordilleranus (ammonoid) Zone of Tozer (1979). The *B. deweveri* Zone is confirmed worldwide and provides an excellent base for the post-Norian zonation developed here. New radiolarian zones for the Rhaetian are the *Proparvicingula moniliformis* Zone and the *Globolaxtorum tozeri* Zone.

Proparvicingula moniliformis **Zone**

The *Proparvicingula moniliformis* Zone is proposed for strata containing radiolarians of Assemblages 1 and 2 (including Subassemblages 2a-2d) combined (this study). Although these assemblages are easily recognized in Queen Charlotte Islands, recognition may prove difficult in localities where only a few species are found. This zone is approximately equivalent biochronologically to the Amoenum (ammonoid) Zone of Tozer (1979). *P. moniliformis* n. sp. is the chosen indicator for this zone because its First Appearance Datum (FAD) at the base of Assemblage 1 coincides perfectly with base Rhaetian as defined in this study. The Last Appearance Datum (LAD) of *P. moniliformis* occurs in the upper part of Assemblage 2 (Subassemblage 2d). This species has not been found in either the underlying *Betraccium deweveri* Zone or the overlying *Globolaxtorum tozeri* Zone. *P. moniliformis* has a short range and is common to very abundant throughout this zone. *P. moniliformis* is cospecific with a form illustrated by Bragin (1992) from eastern Russia, but it has not been found in other Rhaetian faunas. In poor to moderately preserved material it is quite possible this large multicyrtid form could be mistaken for *Canoptum* Pessagno, and this may account for its unreported occurrence thus far in other parts of the world.

Globolaxtorum tozeri **Zone**

The *Globolaxtorum tozeri* Zone is proposed for strata containing radiolarians of Assemblage 3 (this study) and is biochronologically equivalent to the Crickmayi (ammonoid) Zone of Tozer (1979). The First Appearance Datum (FAD) of *Globolaxtorum tozeri* n. sp. occurs at the base of Assemblage 3. This species is plentiful throughout the assemblage and apparently dies out at the very end of the Triassic. There is no evidence of this species (or genus) in the overlying Hettangian sequence of Queen Charlotte Islands which is also judged to be complete (Carter, in press; unpublished data). *G. tozeri* is considered an excellent indicator for this zone because it has a short range, is abundant in all sample horizons, and is distributed worldwide as now evidenced by its occurrence in the Pacific and Tethyan localities of the Philippines and Oman respectively.

As with the assemblages described earlier in this study, these formal zones can be correlated with zonations from Japan, eastern Russia, the Philippines, and with radiolarian assemblages from North America, China, New Zealand, Oman, and Peru.

<table>
<tr><th rowspan="2">STAGES</th><th rowspan="2">AMMONOID ZONATION (TOZER, 1979)</th><th colspan="3">RADIOLARIAN ZONATION</th></tr>
<tr><th colspan="2">Assemblages</th><th>ZONES</th></tr>
<tr><td rowspan="6">RHAETIAN</td><td>CRICKMAYI</td><td colspan="2">Assemb. 3</td><td>Globolaxtorum tozeri Zone</td></tr>
<tr><td rowspan="5">AMOENUM</td><td rowspan="4">Asmb. 2</td><td>2d</td><td rowspan="5">Proparvicingula moniliformis Zone</td></tr>
<tr><td>2c</td></tr>
<tr><td>2b</td></tr>
<tr><td>2a</td></tr>
<tr><td colspan="2">Assemb.1</td></tr>
<tr><td>UPPER NORIAN</td><td>CORDILLERANUS</td><td colspan="3">Betraccium deweveri Zone</td></tr>
</table>

Figure 14. Proposed radiolarian zonation. Position of new radiolarian assemblages and zones shown against ammonoid zonation for the uppermost Triassic.

CHAPTER II - SYSTEMATIC PALEONTOLOGY

Introduction

Radiolarian taxonomy follows chiefly the polycystine systematic classification of Riedel (1967, 1971) with modifications by Baumgartner (1980), Deflandre (1953), De Wever (1979, 1984), Dumitrica (1978a, b), Kozur and Mostler (1979, 1981), Pessagno (1969, 1971, 1973, 1977b, 1979), Pessagno and Whalen (1982), and Yeh (1987). Two groups of Radiolaria follow the primitive classification schemes of Haeckel (1881) and Vinassa de Regny (1898). Radiolarians are classified to family where possible; genera and species are arranged alphabetically within each family.

<u>Basis for description of new taxa</u>

Definitions of new taxa are based if possible on elements of internal structure as well as external diagnostic features of the cortical shell that are visible with the binocular or scanning electron microscope. Specimens were not photographed in transmitted light, but internal features of the ferrisiids were observed by this method. Less certainly identifiable forms: for example, those poorly preserved, those with nondiagnostic or incompletely understood morphology, or those represented by insufficient numbers for variation to be documented, are recorded in open nomenclature. These taxa are used for correlation purposes but are not included on the range chart (Fig. 10a-c).

The term "cf." is used here to indicate uncertainty i.e. the taxon is probably the same as the attributed species but factors such as poor preservation, rarity of specimens, or minor (but consistent) morphological differences leave identification uncertain. In the latter category, *Canoptum* sp. cf. *C. triassicum* Yao is the most notable example. It is similar but not identical to *Canoptum triassicum* but is not different enough to warrant description as a new species. The term "aff." indicates the taxon could be a new species but differences are not distinctive enough to allow description at this time. Sometimes "aff." is used to compare late Norian species with their descendent forms e.g. *Pantanellium fosteri* Pessagno and Blome (upper Norian) with *Pantanellium* sp. aff. *P. fosteri* Pessagno and Blome (Rhaetian); in these instances vertical distribution of the two compared taxa is most always different. At other times "aff." is used for forms that are probably ancestral to Lower Jurassic species such as *Canoptum* sp. aff. *C. dixoni* Pessagno and Whalen and *Archaeocenosphaera* sp. aff. *A. laseekensis* Pessagno and Yang. Sometimes forms having affinity to described species are very abundant, other times they are rare.

Measurements of the Pantanellidae follow a system of measurements proposed by Pessagno and Blome (1980, p. 241); those of the Hagiastridae and Patulibracchiidae follow Pessagno (1971, p. 18). Among the Nassellariina, both the length and maximum width of the test are measured. Length of horn is measured separately and is not included in total test length. For other supraspecific taxa, measurements are normally self explanatory.

<u>Taxonomic Notes</u>

(1) Morphologic variation is high amongst radiolarian species of Rhaetian age, and the number of aberrant specimens seems inordinantly high also when compared with older faunas of late Carnian and early to middle Norian age. Morphological irregularities are observed most often in the Spumellariina where they are expressed by an abnormal number of arms and/or spines per specimen. For example, in spumellarians composed of a cortical shell with three radial spines (e.g. *Fontinella* n. gen.), specimens bearing four, five, or even six spines have been found. Genera most commonly affected include *Betraccium* Pessagno, *Cantalum* Pessagno, *Fontinella* n. gen., *Icrioma* De Wever, *Paratriassoastrum* Kozur and Mostler, and *Pentaspongodiscus* Kozur and Mostler. Aberrant specimens are much less common in the Nassellariina. The cause of this phenomenon is not known, but it is suspected that changing environmental conditions in latest Triassic time may have imposed stresses on the fauna sufficient to cause these irregularities.

(2) There is a great abundance of tetrahedrally-shaped spongy forms having four spines (either simple or twisted) in the Rhaetian fauna. A diverse assortment of specimens is present in all samples, and they are recognizable even when poorly preserved; two are illustrated here (see Spumellaria gen. and sp. indet D, pl. 13, figs. 12, 13). These forms are not treated in depth because their morphology is simple, quite variable, and lacks diagnostic criteria. They are present also in the lowest Jurassic (Hettangian) fauna and apparently survived the Triassic extinction relatively unscathed. The only consistent difference between Rhaetian and Hettangian forms is that the latter almost always have straight rather than twisted spines.

(3) The Deflandrecyrtiidae Kozur and Mostler (including *Deflandrecyrtium* Kozur and Mostler and *Haeckelicyrtium* Kozur and Mostler) are particularly abundant in Assemblages 1 and 2. These forms together with the genus *Squinabolella* Pessagno (which is common to abundant in Assemblage 3) are common in the upper Carnian but rare in lower and middle Norian strata of the Queen Charlotte Islands. Evidence presented here suggests they may have reached their acme in the Rhaetian, just prior to extinction of the Deflandricyrtiidae and most Squinabolellids at the end of the Triassic.

(4) The vast majority of ringed saturnalids in upper Norian and Rhaetian strata belong to the Family Saturnalidae. They possess well developed peripolar spines, polar rays and auxiliary rays (terminology after De Wever, 1984). This is in marked contrast to lower and middle Norian saturnalid forms illustrated by Blome (1984) almost all of which possess well developed polar spines (i.e. aligned with polar rays). *Kozurastrum sandspitense* (Blome), the only form with peripolar spines described by Blome, is upper Norian.

Repository
Type specimens and some paratypes, illustrating specific morphological features, were mounted on standard aluminium SEM stubs, coated with gold/palladium and photographed with the scanning electron microscope. Holotypes and all illustrated material are catalogued and deposited with the Geological Survey of Canada, Ottawa, under numbers GSC 85910 to GSC 85935 and GSC 101857 to GSC 102126.

Phylum PROTOZOA
Subclass RADIOLARIA Müller 1858
Order POLYCYSTINA Ehrenberg 1838
emend. Riedel 1967b
Suborder SPUMELLARIINA Ehrenberg 1875

Family ENTACTINIIDAE Riedel 1967a

Subfamily ENTACTINIINAE Riedel 1967

Genus *Entactinosphaera* Foreman 1963

Type species. Entactinosphaera esostrongyla Foreman 1963.

Remarks. All species discussed below have two spherical or subspherical shells and appear to have an internal spicule. The spicule is very small and its detailed structure has not been studied.

Entactinosphaera ? amphilaphes n. sp.
Plate 1, figures 3, 4, and 8
Species code ENT01

Diagnosis. Large, suboctahedral shell with thin, irregular meshwork and 6 extremely long, bladed spines.

Description. Two suboctahedral lattice shells, a probable internal spicule, and six very long, tapering, strongly bladed spines. Outer shell large, composed of a single layer of thin, irregularly arranged and shaped pore frames. Pores subcircular, elliptical or polygonal; three larger pores at base of each spine. Surface of shell has some very short, fine spinules at vertices of pore frames. Inner shell very small, composed of thin, irregular pore frames; contains an internal spicule. Fine triradiate beams connect inner shell to outer shell. Primary spines composed of three slim blades whose outer edges are rounded. Spines markedly triradiate in cross section.

Remarks. Differs from *E.* sp. aff. *E.* ? *simoni* Kozur and Mostler in having a suboctahedral shell with larger, more irregular pore frames. The test of this new species is very large and seldom entire; it frequently is represented only by spines.

Etymology. amphilaphes (Greek, adj.) meaning enormous, large, vast.

Measurements (microns).

	Holotype	Average of 12 specimens	Max.	Min.
Diameter of cortical shell	260	281	300	234
Length of spines	-	*661	788	630

*Spines seldom entire, only 5 measured.

Type locality. GSC locality C-164696/7 (87 SKU D7), Kunga Island. See Appendix 1.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimens GSC 101860 (holotype) and GSC 101861 (paratype) from type locality.

Entactinosphaera ? sp. aff. *E.* ? *simoni* Kozur and Mostler
Plate 1, figures 1, 2, 5 and 17
Species code ENT02

aff. *Entactinosphaera* ? *simoni* Kozur and Mostler, 1979, pl. 4, fig. 5; pl. 7, fig. 2; pl. 8, fig. 1. Lahm, 1984, p. 17, pl. 1, fig. 10.

Remarks. This species is larger than *E.* ? *simoni* and has correspondingly larger pore frames on the external shell. Diameter of shell 227-319 microns; spines seldom complete, but lengths up to 788 microns have been measured.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimens GSC 101857 from GSC locality C-164696/7 (87 SKU D7) Kunga Island; GSC 101858 and GSC 101859 from GSC locality C-158510 (88 SHB 3) Shields Bay, Graham Island.

Entactinosphaera ? *spinulata* n. sp.
Plate 1, figures 6 and 7
Species code ENT03

Diagnosis. Moderately sized, spinulate shell with 6 very long, bladed spines.

Description. Two subspherical lattice shells, a probable internal spicule and six very long, strongly bladed spines. Outer shell moderate in size, composed of a single layer of thin, very irregular pore frames. Surface of shell with sharp, fine spinules extending from vertices of all pore frames. Internal shell very small, composed of relatively large, thin pore frames. Primary radial beams connect inner and outer shells. Primary spines very long and maintain equal width for most of length. Spines composed of three thin, but wide, blades; spines strongly triradiate in cross section.

Remarks. This species differs from *E.* ? *amphilaphes* n. sp. in having a smaller, more spinose shell that is subspherical, rather than octahedral. Differs from *E.* ? *zapfei* Kozur and Mostler in being larger overall, and by having larger pore frames and wider spines.

Etymology. From the latin *spinulatus-a-um* = having small spines or thorns..

Measurements (microns).

	Holotype	Average of 16 specimens	Max.	Min.
Diameter of cortical shell	210	197	215	169
Length of spines	-	*660	768	562

*7 measured and some of these not entire.

Type locality. GSC locality C-140373 (85 SP 9/1), Louise Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101862 (holotype) from type locality, GSC 101863 (paratype) from GSC locality C-127798 (86 SP 1/1), Louise Island.

Entactiniid gen. and sp. indet.
Plate 13, figures 16 and 19
Species code SIN05

Remarks. This entactinniid form is comprised of two concentric shells each having large, irregularly-shaped pore frames. The inner shell encloses a 6-spined spicule. Several specimens of this taxon were sent to Paulian Dumitrica, whose very detailed observations indicate this is a new entactinniid genus (written communication to E.S. Carter, September, 1992). Further description will be presented at a latter time. This report seeks only to present the distribution of this form in the uppermost Triassic strata Sandilands Formation, and to give an indication of taxon abundance.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102034 from GSC loc. C-164696/7 (87 SKU D7), Kunga Island.

Family PALEOSCENIDIIDAE Riedel, 1967,
emend. Holdsworth, 1977

Subfamily PENTACTINOCARPINAE Dumitrica, 1978

Genus *Pentactinocarpus* Dumitrica, 1978

Type species. Pentactinocarpus fusiformis Dumitrica, 1978

Pentactinocarpus sp. cf. *P. sevaticus* Kozur and Mostler
Plate 1, figures 11 and 15; Plate 21, figures 15 and 17
Species code PTC01

cf. *Pentactinocarpus sevaticus* Kozur and Mostler 1981, p. 21-22, pl. 52, fig 3; pl. 53, fig. 5; pl. 55, fig. 1.

Remarks. Very similar to *P. sevaticus* in overall size and shape. Queen Charlotte specimens differ only in that the pores comprising the shell wall are somewhat smaller in size.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimens GSC 101867 and GSC 101868 from GSC localities GSC C-127798 (86 sp 1/1), Louise Island and C-164674 (87 SKU SP 1), Kunga Island, respectively. *P. sevaticus* was described from upper Norian beds of Pötschenkalk, Austria (see Kozur and Mostler, 1981).

Family ORBICULIFORMIDAE Pessagno 1973

Genus *Orbiculiforma* Pessagno,1973

Type species. Orbiculiforma quadrata Pessagno 1973

Orbiculiforma multibrachiata n. sp.
Plate 5, figures 11 and 12
Species code ORB01

Diagnosis. Very large test with five to seven short, spongy, spine-tipped arms radiating from outer rim of disc. Central cavity of test wide and deep.

Description. Test very large and thick with six (less commonly five or seven) short, spongy arms radiating in the same plane from periphery of central disc. Some arms apparently bifurcated, giving the appearance of additional arms. Upper and lower surfaces of test planiform. Outer rim of disc and arms composed of fine spongy meshwork with polygonal pore frames. Central cavity well defined and wide occupying at least one-half diameter of disc-portion of test. Meshwork of central cavity finer than that of surrounding rim. Inner part of central cavity thicker, more densely porate and biconvex. Arms taper distally and terminate in short, circular spines.

Remarks. *O. multibrachiata* n. sp. differs from all other species of *Orbiculiforma* in having short, spongy arms that radiate from the perimeter of the disc. Test very large when complete, but rarely found whole. Most commonly the central cavity is missing and the arms are broken off giving the disc a five or six-sided outline. When specimens are even less poorly preserved, this angular feature too is eroded and the test outline is smooth. Central cavity missing in holotype, but an additional specimen (from lower in section D) (pl. 5, fig. 11) illustrates this feature. It is emphasized, however, that the outer rim of this secimen is eroded and one cannot be positively certain it is *O. multibrachiata* n. sp..

Etymology. Name from the Latin, *multus* = much, large number and *brachiatus* = with arms or branches.

Measurements (microns).

	Holotype	Average of 9 specimens	Max.	Min.
Diameter of disc-portion of test	300	275	300	244
Diameter of central cavity	169	145	169	131
Average length of arms	131	150	169	131

Type locality. GSC locality C-173287 (89 SKU D25), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101918 (holotype) and GSC 101917 from type locality and GSC locality C-164696/6 (87 SKU D6), Kunga Island respectively.

Family ACTINOMMIDAE Haeckel 1862
emend. Riedel 1967b

Genus *Haliomma* Ehrenberg 1838

Type species. Haliomma aequoreum Ehrenberg 1844.

Remarks. Campbell (1954, p. D60) placed genus *Haliomma* in Family ASTROSPHAERIDAE Haeckel, 1882, defined as "Lattice shell single or concentrically multiple, with 8 or more (commonly 20 to 60) radial spines", Subfamily ASTROSPHAERINAE Haeckel, 1882, defined as having "two concentric shells". Paraphrased from Campbell (1954, p. D62), *Haliomma* may be defined as "a cortical shell and a medullary shell; outer shell covered by unbranched radial spines).

Haliomma? *sewellense* n. sp.
Plate 1, fugires 9, 10 and 13
Species code HAL01

Diagnosis. Spherical to subspherical cortical shell usually with 6 to 9 short triradiate spines. Meshwork fairly symmetrical and consisting of variably sized small pores.

Description. Outer shell spherical to subspherical with 6 to 9 (or more) short main spines; spines about one-fourth to one-fifth diameter of shell. When 6 spines are present they intersect in two planes at right angles; when 7 or more spines present, they are more randomly arranged. Pore frames of meshwork generally small but variable in size with groups of small pore frames interspersed among larger ones. Pore frames mostly hexagonal and pentagonal with small raised nodes at vertices of bars. Pores subcircular to elliptical. Inner shell small, composed of relatively large, pentagonal and hexagonal poreframes and connected to outer shell by slim triradiate beams. Beams project beyond outer wall of test as short, tapering main spines whose wide base arises from the intersection of 3 pore frames. Spines composed of ridges and grooves, triradiate in cross section.

Remarks. Genus assignment queried until investigation of the inner structure in optical microscopy can verify whether or not this form is conspecific with the Tertiary *Haliomma*. Other than possessing a variable number of spines, the forms described above are identical.

Etymology. This species named for Sewell Inlet southwest of type locality.

Measurements (microns).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of test	216	212	219	20
Length of spines	40	52	66	40

Type locality. GSC locality C-127798 (86 SP 1/1), Louise Island. See Appendix 1.

Range. Upper Triassic ; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101864 (holotype), GSC 101865 and GSC 101866 (paratypes) from type locality.

Genus *Kahlerosphaera* Kozur and Mostler 1979

Type species. Kahlerosphaera parvispinosa Kozur and Mostler 1979.

Kahlerosphaera sp. A
Plate 2, figures 12 and 15
Species code KAH01

Remarks. This species has some affinity with *Kahlerosphaera parvispinosa* Kozur and Mostler (1979) but differs in having larger pores on surface of cortical shell, and by lacking thorns that branch from the secondary spines. No internal (medullary) shell has been observed. Diameter of cortical shell 94 microns; length of spines 94 microns. This is the only species of *Kahlerosphaera* found thus far in the Sandilands Formation, and may represent the terminal species of this genus.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101884 from GSC locality C-164696/3 (87 SKU D3) Kunga Island.

Family TRIPOSPHAERIDAE Vinassa de Regny 1898

Diagnosis. Single or multiple concentric spongy or latticed shells with 3 to 4 equidistant main radial spines (Treatise on Invertebrate Paleontology, Part D, Protista 3, Campbell, 1954, p. 56).

Genus *Fontinella* n. gen.

Type species. Fontinella louisensis n. sp..

Diagnosis. Small, hollow, single layered, latticed shell with three triradiate coplanar spines.

Description. Shell small and spherical with three radially arranged coplanar primary spines. Shell composed of a single layer of small polygonal pore frames with nodes at vertices; pores circular. Primary spines bladed, composed of three alternating ridges and grooves; ridges usually perforated at their base by a single pore. No internal structures are visible.

Remarks. This enigmatic radiolarian has a single shell lacking internal structures. Thorny remnants on the spines close to the shell suggest original peripheral continuity. However, of hundreds of well preserved specimens of the species that have been observed, none possesses any type of outer structure or anything but a single, hollow shell. This remnant evidence, most prominently displayed on *F. louisensis* n. sp. (pl. 2, fig. 4 and 14) and *F. habros* n. sp. (pl. 2, fig. 13 and 16), is common but not always present, and is rarer in some species than others. It is believed *Fontinella* n. gen. is either the inner cortical shell of a form (lacking a medullary shell) whose extremely fragile outer shell or velum is completely missing, or a form consisting of a medullary shell alone whose cortical shell is either missing or perhaps never developed. For these reasons *Fontinella* is described here as a separate genus and one that, because of its abundance in the upper Norian and Rhaetian and absence in the Lower Jurassic, is biostratigraphically significant.

Fontinella n. gen. differs from *Betraccium* Pessagno in possessing a single shell and in having much smaller, more numerous, and less regularly shaped pore frames. It differs from single shelled genera such as *Kahlerosphaera* Kozur and Mostler, *Sarla* Pessagno, and *Triactoma* Haeckel (emend. Pessagno and Yang, 1989) in possessing a shell with a single, rather than double, layer of polygonal pore frames. Furthermore, *Fontinella* differs from all above genera in that each spine ridge is usually perforated at the base by a single pore thus creating an open lattice at the base of each spine.

Fontinella n. gen. could be derived from either *Kahlerosphaera* Kozur and Mostler or *Sarla* Pessagno but the former is considered more likely because of the morphology of the spines. *Kahlerosphaera* is diverse and very abundant in upper Carnian to middle Norian strata of the Peril Formation, and rare in the Triassic Sandilands Formation (see *Kahlerosphaera* sp. A, pl. 2 fig. 12 and 15 herein). *Sarla* s.s. has not been found in the Sandilands Formation.

It is possible that *Fontinella* n. gen. may be the direct ancestor of *Triactoma* Haeckel as both possess a single shell with similar pore frame configuration. The shell of *Fontinella* is composed of a single thin lattice layer whereas the shell wall of *Triactoma* is two fused layers and consequently much thicker. Other than the shell wall, the main differentiating characteristic between *Fontinella* and *Triactoma* is that the former has perforations at the base of each spine ridges, whereas the latter does not.

Fontinella n. gen. is not related to *Betraccium* Pessagno but both genera occur together in upper Norian and Rhaetian strata of the Queen Charlotte Islands. *Fontinella* first appears in the upper Peril Formation in beds immediately below those containing *Monotis* (equated with Cordilleranus Ammonoid Zone), however it becomes abundant only in strata of the overlying Sandilands Formation.

Etymology. *Fontinella* is a name formed by an arbitrary combination of letters (ICZN, 1985, p. 201, Appendix D, pt. VI, Recommendation 40).

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands; Waipapa Terrane, Kawakawa Bay, New Zealand; Uson Island, Philippines.

Fontinella clara n. sp.
Plate 2, figures 7 and 8
Species code FON01

Diagnosis. Very small cortical shell with regularly shaped pore frames and three straight, strongly tapering, coplanar spines. Each spine ridge has a prominent rounded pore at the base, and a single sharp lateral thorn near tip.
Description. Test as with genus. Cortical shell very small with three spines in the same plane. Surface of cortical shell composed of small equal-sized pore frames (mostly hexagonal); pores circular. Small pointed nodes located at vertices of pore frames. Primary spines long, straight and tapering, composed of three alternating ridges and grooves; ridges narrow, grooves wide (3 to 4 times width of ridges). Single prominent round pore pierces base of each ridge very close to shell. Each primary spine has three sharply pointed lateral spines which radiate from ridges near distal end of spine. Tips of spines slim and pointed.

Remarks. *F. clara* n. sp. differs from all other species of this genus by having a smaller cortical shell, more regularly sized and shaped pore frames, longer, straighter spines and more prominent pores at the base of each spine ridge. *F. clara* n. sp. shows no evidence of having had any type of outer shell or other structure. It is apparently the final end member in the *Fontinella* lineage. Throughout the succession from oldest (*F. primitiva*) to youngest (*F. clara*) there is steady reduction in the number of pores per surface area of the cortical shell accompanied by increasing regularity in the size and shape of these pores. Progressive changes are also observed in the primary spines: *F. primitiva* has simple spines that lack pores at their base; *F. habros* , *F. inflata* , and *F. louisenesis* all possess some type of open structure near the base of spines; *F. clara* lacks any open structure but has very large, prominent pores at the base of each spine ridge. Finally, some degree of spinal torsion is apparent in all species but *F. clara* n. sp..

Etymology. Latin *clara* (adj.), bright, plain, distinct.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Diameter of cortical shell	69	75	84	58
Length of spines	120	124	133	96

Type locality. GSC C-140489 (87 KPA 17), Kennecott Point: see Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen (holotype) GSC 101880 from type locality.

Fontinella habros n. sp.
Plate 2, figures 13 and 16
Species code FON02

Diagnosis. Very small, cortical shell with three, slightly twisted, coplanar spines. Distal ends of spine ridges have single sharp lateral thorns.

Description. Test as with genus. Small spherical cortical shell with three coplanar spines. Meshwork of shell composed of small, irregularly shaped, polygonal pore frames of variable size; pores circular. Low spinose nodes present at vertices of pore frames. Primary spines bladed, strongly tapering, composed of three longitudinal ridges and grooves; ridges wide and rounded, grooves narrow and deep proximally becoming shallow and wide distally. Near tip of spine each ridge extends laterally to form a sharp pointed thorn; central tip of spine pointed. Spines very slightly twisted. Small thorny remnants of possible missing outer structure surround each spine near base. A latticed partly open area at the base of each spine is formed by (1) three large ovoid relict pores (one on the upper surface of each spine ridge), (2) the spine groove, and (3) rounded pores (one per ridge) that pierce each ridge perpendicular to the axis of the spine.

Remarks. Differs from *F. louisensis* n. sp. by having (1) spines that are less twisted, (2) a pronounced open area at base of each spine, (3) thorny remnants that are closer to base of each spine and more confluent with open area, and (4) lateral thorns on ridges near tip of spine.

Etymology. Greek, *habros* (adj.), delicate, dainty, graceful.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Diameter of cortical shell	94	93	97	86
Overall length of spines	112	99	112	92

Type locality. GSC locality C-127798 (86 SP 1/1), Louise Island: see Appendix 1.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Holotype GSC 101883 from type locality.

Fontinella inflata n. sp.
Plate 2, figures 5, 6 and 17.
Species code FON03

Sarla sp. Spörli and Aita 1988, p. 21, no. 9.

Diagnosis. Test as with genus. Cortical shell inflated perpendicular to plane of spines. Spines strongly tapering and slightly twisted; distal ends of ridges have two pointed lateral thorns.

Description. Cortical shell subspherical with three coplanar spines. Cortical shell inflated in direction perpendicular to plane of spines; surface of shell composed of small, irregularly sized, polygonal pore frames (mostly pentagonal) with circular pores. Pore frame walls thin but deep. Nodes at pore frame vertices sharp with moderate relief. Primary spines bladed, strongly tapering, composed of three alternating ridges and grooves; ridges wide and rounded, grooves wide and deep proximally, becoming narrow and shallow distally. Spines approximately equal in length to diameter of cortical shell. Large rounded pores pierce the base of each spine ridge in direction perpendicular to axis of spine. Near pointed tip of spine each ridge extends laterally to form two small pointed thorns.

Remarks. Differs from *F. habros* n. sp in having a larger shell that is inflated and subspherical, and spine ridges with two lateral thorns at distal end rather than one. *F. inflata* n. sp. generally shows little evidence of a missing outer structure but, similar to *F. habros* n. sp., a few specimens do have a partly open structure at the junction between shell and spines.

Etymology. Latin, *inflata* (adj.), puffed up, swollen.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Diameter of cortical shell	101	103	114	94
Overall length of spines	105	108	116	90

Type locality. GSC C-140489 (87 KPA 17), Kennecott Point: see Appendix 1.
Range. Upper Triassic; upper Norian? Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101878 (holotype) and GSC 101879 (paratype) from type locality and GSC locality C- 164693/14 (87 SKU B14), Kunga Island respectively. Also Waipapa Terrane, Kawakawa Bay, New Zealand (see Spörli and Aita,1988).

Fontinella louisensis n. sp.
Plate 2, figures 1, 2, 3, 4 and 14
Species code FON04

Sarla sp. Spörli and Aita, 1988, p. 21, no. 3, 10.
Gen. nov. A sp. 1 Carter, 1990, pl. 1, fig. 1.
Triactoma (?) sp. A, in Yeh, 1992, p. 62, pl. 1, fig. 10.

Diagnosis. Small, cortical shell with three coplanar twisted spines. A single pore penetrates each spine ridge adjacent to the shell.

Description. Test as with genus. Small, spherical cortical shell with three coplanar spines. Surface of cortical shell composed of small polygonal pore frames (many pentagonal) with circular pores; walls of pore frames thin but deep. Short spinose nodes present at vertices of pore frames. Primary spines coplanar, equal to subequal in length, composed of three alternating ridges and grooves. Ridges wide and rounded; grooves narrow and deep proximally becoming wide and shallow distally. Spines twisted dextrally. A single large rounded pore passes perpendicularly through the base of each spine ridge.

Remarks. The holotype of *Fontinella louisensis* n. sp. has been chosen among specimens that lack strong evidence of an outer structure. However, more commonly than not, thorny remnants are present near the base of spines (see pl. 2 fig. 4 and 14) and are quite diagnostic for this species. *Fontinella louisensis* n. sp. is compared to *F. habros* n. sp. under the latter.

Etymology. Named for Louise Island on the east coast of Moresby Island, type locality for the new genus *Fontinella*.

Measurements (microns).

	Holotype	Average of 13 specimens	Max.	Min.
Diameter of cortical shell	97	100	112	94
Overall length of spines	131	126	150	105

Type locality. GSC locality C-127798 (86 SP 1/1), Louise Island: see Appendix 1.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimens GSC 101874 (holotype) and GSC 101876 and GSC 85910 (paratypes) from type locality; GSC 101875 from GSC locality C-164674 (87 SKU SP 1), Kunga Island. Waipapa Terrane, Kawakawa Bay, New Zealand (see Spörli and Aita,1988); Uson Island, Philippines (see Yeh,1992).

Fontinella primitiva n. sp.
Plate 2, figures 9, 10 and 11
Species code FON05

Diagnosis. Cortical shell densely and irregularly porate with three straight, coplanar spines. Spines solid at base; distal end of each ridge has a single small lateral thorn.

Description. Test as with genus. Cortical shell spherical, surface composed of numerous small, irregularly-sized polygonal pore frames; pores circular. Walls of pore frames thin and deep; small rounded nodes at vertices of pore frames. Primary spines bladed, straight, composed of three alternating ridges and grooves; ridges very wide and rounded, grooves relatively wide and deep proximally becoming narrow and shallow distally. Near tip of spine each ridge extends laterally to form a small pointed thorn.

Remarks. F. primitiva n. sp. appears to be the simplest form of *Fontinella* and may be linked more closely to *Kahlerosphaera* Kozur and Mostler than other species of this genus described herein. It differs from *F. habros* n. sp. in lacking any type of open lattice structure at base of the primary spines; it differs from *F. inflata* n. sp. in having a simple spherical shell that is not inflated, and by having only one thorn per ridge (rather than two) at the ends of the primary spines. *F. primitiva* n. sp is apparently the oldest species in the *Fontinella* lineage. It occurs primarily in strata containing the bivalve *Monotis* (i.e. Cordilleranus Ammonoid Zone) in the uppermost part of the Peril Formation. Very few specimens have been found in the Sandilands Formation, and these only in basal beds.

Etymology. Latin *primitiva* (adj.), first, early.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Diameter of cortical shell	103	93	103	84
Overall length of spines	103	93	103	82

Type locality. GSC C-140478 (87 KPA 6), Kennecott Point: see Appendix 1.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimens GSC 101881 (holotype) from type locality; GSC 101882 (paratype) from GSC locality C-158510 (88 SHB 3), Shields Bay.

Family CAPNUCHOSPHAERIDAE De Wever 1979
emend. Pessagno et al. 1979, emend. Blome 1983

Genus *Icrioma* De Wever 1979
emend. Blome 1983

Type species. Icrioma tetrancistrum De Wever 1979.

Icrioma ? cistella n. sp.
Plate 3, figures 13 and 14
Species code ICR01

Diagnosis. Cortical shell square and box-like, upper and lower surfaces having regularly arranged pore frames with strong nodes at vertices. Spinal tunnels of tumidispinae irregularly porous and subtriradiate in axial section.

Description. Cortical shell large, square and box-like with four tumidispinae in the same plane. Upper and lower surfaces of cortical shell planiform to very slightly convex; sides vertical. Outer layer of meshwork consisting of regularly arranged, mostly triangular and tetragonal pore frames; pores subcircular. Large massive nodes superimposed at vertices of pore frames. Inner layer consisting of coarse polygonal pore frames with subcircular pores. Tumidaspinae moderately long: spinal tunnels long, hollow, irregularly porous and subtriradiate in axial section; spinal tumors moderately developed, triradiate in axial section with three well developed tumidapores; spinal shafts long, solid, circular in axial section.

Remarks. Differs from all described species of *Icrioma* in having a box-shaped cortical shell and regularly arranged pore frames on the outer shell layer. The shape of the cortical shell of this form resembles *Plafkerium* Pessagno but because of the presence of tumidaspinae it cannot be assigned to this genus.

Etymology. Latin *cistella* (n. dim.) box, chest.

Measurements (microns).

	Holotype	Average of 6 specimens	Max.	Min.
Diameter of test	152	144	159	122
Overall length of spines	141	113	141	94

Type locality. GSC locality C-150179 (86 SKU B10), Kunga Island: see Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101894 (holotype) from type locality.

Icrioma ? sp. A
Plate 3, figures 3, 5, 8, 12, 15
Species code ICR02

Remarks. Differs from *Icrioma ? cistella* n. sp. in having (1) a modified 4- armed shape with convex upper and lower surfaces, (2) finer pore frames on the outer layer of the cortical shell, and (3) shorter tumidispinae with more strongly developed spinal tumors. An aberrant 5-armed form (pl. 3 fig. 5) is also figured.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101887 from GSC locality C-140373 (85 SP 9/1), Louise Island; GSC 101888 and GSC 101889 from GSC localities C-164674 (87 SKU SP 1) and C-164696/7 (87 SKU D7), Kunga Island respectively.

Genus *Plafkerium* Pessagno 1979

Type species. Plafkerium abbotti Pessagno 1979.

Remarks. All upper Norian and Rhaetian species described and illustrated in this report differ from *Plafkerium* s.s. in having a cortical shell composed of more regularly defined pore frames with strong individual nodes that do not coalesce. The shape of the shell is generally box-like but some forms develop more or less concave edges to the square planar shape producing a modified 4-armed effect. As with so many other uppermost Norian taxa, these forms may comprise an intermediate link between the Middle and Late Triassic genus *Plafkerium* , and the 4-spined *Emiluvia* -like forms common in the Hettangian and Sinemurian. The Jurassic forms all have long, straight, tapering spines.

Plafkerium fidicularium n. sp.
Plate 3, figures 1 and 6
Species code PLF01

Diagnosis. Walls of cortical shell composed of regularly arranged pore frames with strong nodes. Three spines strong and highly twisted; fourth spine slightly reduced in size and less twisted.

Description. Cortical shell subspherical to square in outline with four primary spines in the same plane. Upper and lower surfaces of cortical shell convex, sides vertical. Shell composed of medium-sized triangular and tetragonal pore frames with strong rounded nodes of moderate relief at vertices of bars. Primary spines approximately equal in length, triradiate, composed of three alternating ridges and grooves. Three spines have strong narrow ridges with wide grooves and are highly twisted; fourth spine is generally slightly reduced in length and width, and less twisted.

Remarks. Differs from *Plafkerium abbotti* Pessagno in having (1) larger, more regularly defined pore frames with strong individual nodes, and (2) spines that are approximately equal in length, triradiate throughout, and more strongly twisted.

Etmology. Latin *fidicularium* (adj.) like a cord, twisted.

Measurements (microns).

	Holotype	Average of 14 specimens	Max.	Min.
Diameter of test	135	120	135	108
Length of longest spine	118	109	129	94

Type locality. GSC locality C-164696/7 (87 SKU D7), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated holotype GSC 101885 from type locality.

Plafkerium gadoense n. sp.
Plate 3, figures 2 and 16
Species code PLF03

Diagnosis. Cortical shell moderate in size, almost 4-armed in outline, with walls composed of strong, regularly arranged pore frames. Primary spines long, tapering, and moderately twisted.

Description. Cortical shell of moderate size, square to almost 4-armed in outline, with 4 primary spines in the same plane. Upper and lower surfaces of test moderately convex, sides vertical. Walls of cortical shell composed of strong triangular and tetragonal pore frames; raised polygonal nodes at vertices of bars. Primary spines equal in length, triradiate, composed of three alternating ridges and grooves. Ridges rounded and near equal in width to grooves. Distal portions of spines, when well preserved, much narrower and becoming circular in axial section. Spines are slightly to moderately twisted.

Remarks. Differs from *Plafkerium keloense* n. sp in having a more box-like shape, more massive pore frames and nodes, and shorter spines. Size variability in this species may possibly be age related: younger specimens frequently have a slightly larger cortical shell and longer, slimmer spines (see holotype).

Etymology. Named for Gado village on the east coast of Lyell Island.

Measurements (microns).

	Holotype	Average of 12 specimens	Max.	Min.
Diameter of test	191	181	215	169
Length of spines	103	81	103	62

Type locality. GSC locality C-164674 (87 SKU SP 1), Kunga Island: see Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101886 (holotype) from type locality.

Plafkerium keloense n. sp.
Plate 3, figures 4 and 11
Species code PLF02

Diagnosis. Cortical shell large, square to almost 4-armed in outline, with thick wall composed of small, regularly arranged pore frames. Primary spines short and slightly twisted.

Description. Cortical shell large, square to almost 4-armed in outline, with four spines in the same plane. Upper and lower surfaces of shell convex, sides vertical. Walls of cortical shell thick, composed of at least two layers of pore frames. Inner layer of polygonal pore frames relatively thin, outer layer composed of deep triangular to tetragonal pore frames with polygonal nodes superimposed at vertices of bars; nodes moderate in relief. Primary spines short and tapering, composed of three alternating ridges and grooves; ridges narrow and rounded, grooves 3 to 4 times width of ridges. Distal portions of spines narrow, becoming circular in axial section. Spines display only slight torsion.

Remarks. Differs from all other described species of *Plafkerium* Pessagno in having a much larger shell and shorter spines.

Etymology. Kelo Rocks, off the southeast point of Kunga Island, were named by the Hydrographic Service in 1957 after the Haida word for shag or cormorant.

Measurements (microns).

	Holotype	Average of 9 specimens	Max.	Min.
Diameter of test	193	197	208	188
Length of longest spine	56	57	64	53

Type locality. GSC locality C-164696/9 (87 SKU D9), Kunga Island: see Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101890 (holotype) and GSC 101891 from type locality.

Plafkerium sp. A
Plate 3, figures 7 and 10
Species code PLF04

Remarks. The cortical shell of this square box-like form has convex upper and lower surfaces and vertical sides. The outer layer of pore frames are regular (mostly triangular) with large rounded nodes at vertices of bars. The four primary spines are short, triradiate, and strongly twisted. Diameter of cortical shell 180 microns; length of spines 77 microns (extreme tips of spines broken) on illustrated specimen.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101892from GSC locality C-158569 (88 LI 1), Louise Island.

Plafkerium sp. B
Plate 3, figure 9
Species code PLF05

Remarks. Cortical shell small and square; outer wall composed of irregular pore frames (mostly triangular and tetragonal) with low rounded nodes at vertices of bars. Primary spines short, sturdy, triradiate, and almost straight. Diameter of cortical shell 139 microns; length of spines 77 microns on illustrated specimen.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101893 from GSC locality C-164696/3 (87 SKU D3), Kunga Island.

Family HAGIASTRIDAE Riedel 1971
emend. Baumgartner 1980
Subfamily TRITRABINAE Baumgartner 1980

Genus *Tetratrabs* Baumgartner 1980

Type species. Tetratrabs gratiosa Baumgartner 1980.

Tetratrabs ? *noricus* n. sp.
Plate 11, figures 9, 10 and 17
Species code TBS01

?*Tetratrabs* sp. A, in Yeh, 1989, p. 62, pl. 14, fig. 10.

Diagnosis. Large test with long rays each having 6 external beams equally distributed around ray; rays terminate with short, grooved spines.

Description. Test large with four rays of equal length at right angles. Central area small and strongly nodose. Rays long, composed of six well developed, nodose, external beams distributed equally around circumference of ray. Two rows of alternating circular to subcircular pores lie in narrow depression between adjacent external beams. Cross section of rays subhexagonal. Ray tips taper to short, stout, deeply grooved central spines.

Remarks. Both externally and internally this species is obviously related to the genus *Tetratrabs* but differs slightly in having the six external beams disposed equally around the circumference of the ray rather than confined to the upper and lower surfaces. In addition, *Tetratrabs* s.s. has thin diagonal bars separating the double row of pores between external beams; this form has stronger, more irregular bars separating the pores. In Baumgartner's revision of the Hagiastridae, the Tritrabinae Baumgartner is the only subfamily possessing two rows of alternating pore frames between external beams. Apart from this feature and the fact *T.* ? *noricus* n. sp. possesses only 6 longitudinal beams (rather than 8-12) it could be included in *Hagiastrum*. In any case, *T.* ? *noricus* n. sp. appears to represent one of the earliest hagiastrid forms. Specimens from very basal beds of Sandilands Formation (see pl. 11 fig. 10) have less organized meshwork than holotype.

Etymology. This species is named for its occurrence in the Norian stage.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Length of rays	244-263	207	263	172
Width of rays	50	51	56	47
Length of longest spine	37	57	79	37

Type locality. GSC locality C-156789 (88 KPA R3), Kennecott Point. See Appendix 1.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102000 (holotype) from type locality; GSC 102001 (paratype) from GSC locality C-173404 (90 KPH 1), Kennecott Point. ?Fields Creek Formation, east-central Oregon (see Yeh, 1989).

Family SATURNALIDAE Deflandre 1953
emend. De Wever 1984, emend. Dumitrica 1985

Type Genus. Saturnalis Haeckel 1882.

Remarks. The saturnalid classification of De Wever (1984) is followed in this study because the possession of polar versus peripolar spines seems to be important stratigraphically. Based on the study of extensive Upper Triassic collections from the Queen Charlotte Islands (Orchard et al., 1990), it is apparent that lower and middle Norian saturnalids almost all have polar spines, but beginning in the uppermost middle to upper Norian, forms with peripolar spines become common to dominant.

Subfamily PALEOSATURNALINAE Kozur and Mostler 1981
emend. De Wever 1984

Type genus. Paleosaturnalis Donfrio and Mostler 1978.

Genus *Liassosaturnalis* Kozur and Mostler 1990

Type species. Liassosaturnalis parvus Kozur and Mostler 1990.

Liassosaturnalis sp. aff. *L. parvus* Kozur and Mostler
Plate 5, figure 8
Species code PAL01

Liassosaturnalis parvus Kozur and Mostler 1990, p. 203, pl. 4, figs. 3, 7, 12; pl. 6, fig. 6.

Remarks. This form differs from *L. parvus* in that the ring is truly circular in outline rather than subcircular to elliptical, and the polar spines are long and slender rather than short and robust. This form is also much larger that *L. parvus* (length of ring along polar axis is 310microns, width of ring 328 microns on illustrated specimen) and may be the immediate ancestor.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101914 from GSC locality C-164696/8 (87 SKU D8), Kunga Island.

Subfamily SATURNALINAE Deflandre 1953
emend. De Wever1984

Type genus. Saturnalis Haeckel 1882.

Remarks. Of the hundreds of late Norian and Rhaetian saturnalids examined in this study, almost all have peripolar spines. These specimens are herein assigned either to *Kozurastrum* De Wever, 1984, or *Mesosaturnalis* Kozur and Mostler 1981, emend. De Wever 1984, depending upon the presence/absence of auxiliary and secondary rays.

Genus *Kozurastrum* De Wever 1984

Type species. Spongosaturnalis minoensis Yao 1972.

Remarks. In 1984, De Wever assigned many described saturnalid species to a new genus *Kozurastrum*. Some of these had previously been assigned to *Praemesosaturnalis* Kozur and Mostler 1981, by Kozur and Mostler in their saturnalid classification of 1983. The two genera are very similar, if not synonymous, and differ only in that *Praemesosaturnalis* is described as having "two polar spines, one of these or both opposite to interspine spaces on the outer margin of the ring", whereas *Kozurastrum* by definition of the Subfamily Saturnalinae Deflandre, emend. De Wever 1984, includes "Saturnalide possédant des éspines péripolaires". The genus *Kozurastrum* De Wever is used in this report because the type species is more closely related to new forms described below than is *Spongosaturnalis bifidus* Kozur and Mostler 1972, the type species of *Praemesosaturnalis* Kozur and Mostler 1981.

Kozurastrum beattiense n. sp.
Plate 4, figures 7 and 8
Species code KOZ01

Paleosaturnalis sp. C, in Kishida and Hisada, 1986, fig. 4, no. 3.
Saturnosphaera sp. 1, in Carter, 1990, pl. 1, fig. 6.

Diagnosis. Wide, flat, circular ring with approximately 20 short peripheral spines and 6 internal rays of near equal size.

Description. Test with relatively wide, flat ring, circular to subcircular in outline. Twenty short tapering spines normally surround periphery of ring (number observed to vary from 17 to 22). Polar rays long and narrow; auxiliary rays (2 to either side of polar axis) frequently almost equal in size to polar rays. Ring cavity circular to subcircular in outline.

Remarks. This species is similar to *Kozurastrum sandspitensis* (Blome, 1984) but is smaller in size and has a greater number of peripheral spines. It was originally assigned to *Saturnosphaera* (Carter, 1990) but examination of additional specimens has revealed that some specimens have more prominent polar rays than originally observed, suggesting greater affinity to the genus *Kozurastrum*.

Etymology. Named for Beattie Anchorage, a harbour very close to the type locality.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Maximum diameter of ring and cavity (w/o spines)	266	276	294	263
Maximum length peripheral spines	24	30	37	19

Type locality. GSC locality C-127798 (86 SP 1/1), Louise Island: see Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85915 (holotype) from type locality; GSC 101902 (paratype) from GSC locality C-140373 (85 SP 9/1), Louise Island. Japan (see, Kishida and Hisada, 1986).

Kozurastrum decilobum n. sp.
Plate 4, figure 1
Species code KOZ02

Diagnosis. Moderately wide, flat circular ring with ten lobate peripheral spines. Outer periphery of ring and spines has narrow carina.

Description. Test with relatively wide, flat ring, circular in outline. Ten broad spines with spatulate tips surround periphery of ring, five either side of polar axis. Outer edges of ring and spines defined by narrow carina. Polar rays long and narrow; auxiliary rays (normally two either side of polar axis) moderately long. Ring cavity circular to slightly elliptical in outline.

Remarks. This distinctive saturnalid has no closely comparable forms in the described literature. Most importantly, it is apparently confined to a narrow stratigraphic interval at the base of the Sandilands Formation.

Etymology. Latin, from *deci* = ten, plus *lobum* = a rounded projection or protuberance; *decilobum* = ten lobes.

Measurements (microns).

	Holotype	Average of 7 specimens	Max.	Min.
Maximum diameter of ring and cavity (w/o spines)	272	273	300	261
Maximum length peripheral spines	107	106	112	90

Type locality. GSC locality C-156789 (88 KPA R3), Kennecott Point: see Appendix 1.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Holotype GSC 101895 from type locality.

Kozurastrum gracilis (Kozur and Mostler)
Plate 4, figures 10 and 11
Species code KOZ03

Spongosaturnalis gracilis Kozur and Mostler 1972, p. 35, pl. 1, fig. 17.
Kozurastrum gracilis (Kozur and Mostler 1972), in De Wever 1984, p. 18.
Kozurastrum gracilis (Kozur and Mostler), in Bragin 1991, p. 93, pl. 10, fig. 11.

Remarks. Queen Charlotte specimens are very similar to Kozur and Mostler's species from Austria, but the ring is generally less circular in outline and widened in direction perpendicular to polar axis.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimens GSC 101905 from GSC locality C-158510 (88 SHB 3), Shields Bay (Peril Formation); specimen GSC 101906 from GSC locality C-140474 (87 KPA 3B), Kennecott Point (Sandilands Formation). Pötschenkalk, Austria (see Kozur and Mostler, 1972). Eastern region USSR (see Bragin, 1991).

Kozurastrum huxleyense n. sp.
Plate 4, figures 4, 5 and 6
Species code KOZ04

Diagnosis. Narrow circular to subcircular ring with 10 to 12 long tapering spines

Description. Test with moderately narrow flat ring, circular to subcircular in outline. Generally 10 to 12 long narrow tapering spines (rarely up to 14) surround periphery of ring (5-6 to either side of polar axis). Internal rays (commonly 6) differentiated into polar and auxiliary rays with polar rays being the longer.

Internal rays narrow in plan view but are flattened perpendicular to the plane of the ring. Internal sphere large but not preserved in type material.

Remarks. Differs from *Kozurastrum gracilis* (Kozur and Mostler) as illustrated herein (pl. 4, fig. 10 and 11), in having a smaller ring with shorter, narrower peripheral spines that taper more.

Etymology. This species named for Huxley Island, first named by G.M. Dawson in 1878 after the celebrated British biologist Thomas Henry Huxley.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Maximum diameter of ring and cavity (w/o spines)	268	266	275	251
Maximum length peripheral spines	112	103	120	75

Type locality. GSC locality C-173308 (98 SKU B19), Kunga Island: see Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. GSC 101898 (holotype) and GSC 101899 (paratype) from type locality. GSC 101900 (paratype) from GSC loc. C-173301 (89 SKU B12), Kunga Island.

Kozurastrum sandspitense (Blome)
Plate 4, figure 2
Species code KOZ05

Paleosaturnalis aff. *quinquespinosa* (Kozur and Mostler 1972), in Yao, 1982, p. 58, pl. 3 fig. 18.
Pseudoheliodiscus sandspitensis Blome 1984, p. 27, pl. 3, fig. 6, 7. Blome, Reed and Tailleur, 1989, pl. 33.2, fig. 21. Cheng, 1989, p. 146, pl. 9, fig. 10.

Remarks. This species has peripolar spines and, following the classification of De Wever (1984), is assigned to *Kozurastrum* De Wever.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimen GSC 101896 from GSC locality C-164693/14 (87 SKU B14), Sandilands Formation, Kunga Island. Blome's type material from Peril Formation, Kunga Island (see Blome, 1984). Also: Japan (see Yao, 1982); Uson Island, Philippines (see Cheng, 1989).

Kozurastrum sp. aff. *K. sandspitense* (Blome)
Plate 4, figure 3
Species code KOZ06

aff. *Paleosaturnalis* aff. *quinquespinosa* (Kozur and Mostler 1972) in Yao, 1982, p. 58, pl. 3 fig. 18.
aff. *Pseudoheliodiscus sandspitensis* Blome 1984, p. 27, pl. 3, fig. 6, 7.

Remarks. Differs from *K. sandspitense* in having 8 rather than 7 peripheral spines either side of polar axis.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101897 from GSC locality C-164693/14 (87 SKU B14), Kunga Island.

Kozurastrum sp. A
Plate 5, figure 10
Species code KOZ07

Remarks. Differs from *Kozurastrum gracilis* (Kozur and Mostler, 1972) in having 11-14 flat, peripheral spines that lack ridges and grooves.

Range. Upper Triassic; upper Norian.

Occurrence. Peril Formation, Queen Charlotte Islands. Illustrated specimen GSC 101916 from GSC locality C-158510 (88 SHB 3), Shields Bay.

Kozurastrum sp. B
Plate 4, figures 9 and 12
Species code KOZ08

Remarks. Test small, composed of a narrow, flat, undifferentiated circular ring having numerous short peripheral spines and four internal rays (2 polar, 2 auxillary) at right angles. Differs from *Pseudoheliodiscus quadriradiatus* (Kozur and Mostler 1972) in having smaller, more numerous peripheral spines.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101903 from GSC locality C-164696/8 (87 SKU D8), Kunga Island; GSC 101904 from GSC locality C-158569 (88 LI 1), Louise Island.

Genus *Mesosaturnalis* Kozur and Mostler 1981
emend. De Wever 1984

Type species. *Paleosaturnalis levis* Donfrio and Mostler 1978.

Remarks. As emended by De Wever (1984), the genus *Mesosaturnalis* includes forms both with and without a carina and the carina can be more or less developed within the same species. Species described and illustrated in this report probably represent some of the most primitive forms of *Mesosaturnalis* , and all lack a carina.

Range. Upper Triassic (Rhaetian) to Cretaceous.

Mesosaturnalis acuminatus n. sp.
Plate 5, figures 1, 2 and 3
Species code MES01

Diagnosis. Large circular to subcircular ring, moderately wide, with 14 to 18 sharply pointed peripheral spines.

Description. Test large with moderately wide ring, circular to subcircular in outline. Ring surrounded by 14 to 18 relatively short, sharp tapering spines. Polar rays of moderate length, one and one-quarter to one and one-half times length of peripheral spines. Internal sphere not preserved in type material.

Remarks. Differs from *Paleosaturnalis triassicus* (Kozur and Mostler, 1972) in having axial spines in the peripolar (versus polar) position. Similar to the Cretaceous *Mesosaturnalis horridus* (Squinabol, 1903) figured by Donfrio and Mostler, 1978, (pl. 1, fig. 7, 8a, 8b, 11) but *M. acuminatus* n. sp. is uppermost Triassic and almost certainly a different species.

Etymology. Latin, *acuminatus* (adj.), pointed, sharpened; describes shape of spines.

Measurements (microns).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of ring and cavity (measured along polar axis)	338	346	384	336
Length of longest spine	90	73	94	56

Type locality. GSC locality C-173287 (89 SKU D25), Kunga Island: see Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands; Illustrated specimens GSC 101907 (holotype) and GSC 101908 and GSC 101909 (paratypes) from type locality.

Mesosaturnalis sp. A
Plate 5, figure 6
Species code MES03

Remarks. Test with narrow, flat, undifferentiated ring; ring and ring cavity elliptical in outline. Peripheral spines variable in size; 6 or 7 to either side of polar axis. Polar rays long and pointed. Larger than *Mesosaturnalis* sp B herein.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101913 from GSC locality C-127798 (86 SP 1/1), Louise Island.

Mesosaturnalis sp. B
Plate 5, figure 5
Species code MES04

Remarks. Differs from *Mesosaturnalis latimarginatus* (Donfrio and Mostler, 1978) in having more peripheral spines (12 versus 10). *M.* sp. B is smaller than *M.* sp. A and has a more irregularly elliptical ring cavity.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101912 from GSC locality C-164696/7 (87 SKU D7), Kunga Island.

Family PSEUDOACANTHOCIRCIDAE Kozur and Mostler 1990

Type genus. None desiginated.

Genus *Pseudoacanthocircus* Kozur and Mostler 1990

Type species. Pseudoacanthocircus mediospinosus Kozur and Mostler 1990.

Pseudoacanthocircus troegeri Kozur and Mostler
Plate 5, figures 4 and 7
Species code MES02

Mesosaturnalis sp. 1, in Carter, 1990, pl. 2, fig. 3.
Pseudoacanthocircus troegeri Kozur and Mostler 1990, p. 210, pl. 11, fig. 7.

Remarks. The holotype of this species has a transversely elongated ring. Queen Charlotte specimens always have a circular to subcircular ring that is not transversely elongated but otherwise they are similar to *P. troegeri*.

Range. Upper Triassic (Rhaetian) to Lower Jurassic (Hettangian).

Occurrence. Sandilands Formation, Queen Charlotte Islands; Illustrated specimens GSC 85925 and GSC 101911 from GSC locality C-164674 (87 SKU SP 1), Kunga Island. Also, Bavaria (see Kozur and Mostler 1990) and Oman.

No suprageneric classification is applied to the following saturnalid form.

Genus *Saturnosphaera* Tichomirova 1975
emend. Kozur and Mostler 1983

Type species. Saturnosphaera gracilis Tichomirova 1975.

Remarks. Following Kozur and Mostler (1983), the genus *Saturnosphaera* Tichomirova is used here for saturnalid forms having inner rays of equal size without differentiation as to polar, auxiliary or subsidiary rays.

Saturnosphaera sp. aff. *S. convertus* (Kozur and Mostler)
Plate 5, figure 9

aff. *Spongosaturnalis convertus* Kozur and Mostler 1972, p. 34, pl. 2, fig. 16, 19.
aff. *Saturnosphaera convertus* (Kozur and Mostler 1972) in Kozur and Mostler 1983, p. 23.

Remarks. Differs from *Saturnosphaera convertus* in having shorter, broader based, more strongly tapering peripheral spines. Differs from *Kozurastrum pannosus* (Kozur and Mostler 1972) in having six inner rays of equal size with no apparent differentiation as to polar, auxiliary or subsidiary rays.

Range. Upper Triassic; upper Norian.

Occurrence. Peril Formation, Queen Charlotte Islands. Illustrated specimen GSC 101915 from GSC locality C-158510 (88 SHB 3), Shields Bay.

Family PANTANELLIIDAE Pessagno 1977b
emend. Pessagno and Blome, 1980

Subfamily PANTANELLIINAE Pessagno 1977b

Type genus. Pantanellium Pessagno 1977b.

Remarks. The system of measurements for Pantanelliinae used herein is taken from Pessagno and Blome, 1980, p. 241.

Genus *Betraccium* Pessagno 1979

Type species. Betraccium smithi Pessagno 1979.

Remarks. Confusion has sometimes arisen regarding the distinction between the pantinelliniid genera *Betraccium* Pessagno 1979 and *Gorgansium* Pessagno and Blome 1980. The genus *Betraccium* was described by Pessagno (1979) for Pantinelliinae having a "subspherical cortical shell with coarse polygonal meshwork and 3 radially arranged primary spines and radial beams situated in the same plane". *Gorgansium* Pessagno and Blome (1980) was subsequently described for Pantinelliinae having a cortical shell that is typically elliptical with 3 primary spines of unequal length usually in the same plane. Furthermore, the primary spines of *Gorgansium* are asymmetrically arranged with 2 spines closer together.

Strict comparison of the generic descriptions of these two genera suggest they are very similar, but in practice they are quite different. *Gorgansium* usually has 2 short spines positioned close together and a third spine (at the opposite pole) that is longer, whereas *Betraccium* has spines that are equal in length and are radially arranged at or close to 120°. Pessagno and Blome (1980) suggest *Gorgansium* gave rise to *Betraccium* through "a shift in the primary spines to equidistant positions and by developing primary spines which are equal rather than subequal in length".

Gorgansium ranges from Upper Triassic (Carnian? Norian) to Middle or Upper Jurassic (Pessagno and Blome, 1980). *Betraccium* , on the other hand, is restricted to the Upper Triassic particularly to the upper Norian and Rhaetian. It is the dominant pantanelliid genus in strata of this age in the Queen Charlotte Islands, and is diverse and abundant in most samples. Furthermore *Betraccium* is commonly found in upper Norian and Rhaetian strata around the world and is diagnostic for this time period. In contrast, *Gorgansium* is extremely rare in the upper Norian and Rhaetian of Queen Charlotte Islands and apparently is rare to absent in other areas as well.

In summary, the definitions of *Gorgansium* and *Betraccium* differ as do their overall ranges and periods of greatest abundance. *Betraccium* is retained here and is considered of primary importance in defining the upper Norian and Rhaetian.

Betraccium deweveri Pessagno and Blome
Plate 6, figure 1
Species code BET01

Betraccium deweveri Pessagno and Blome 1980, p. 230-231, pl. 1, fig. 1, 2, 5-8, 13, 14. Blome, 1984, p. 37-38, pl. 5, fig. 6, 7, 13, 20. Bragin, 1986, pl. 1, fig. 5. Sato et al., 1986, fig. 16, no. 16. Spörli and Aita, 1988, pl. 1, no. 4. Blome, Moore, Simes and Watters, 1989, pl. 1, fig. 11. Cheng, 1989, p. 145, pl. 11, fig. 8, 9, 16; NON pl. 8, fig. 8. Bragin, 1990, pl. 3, fig. 15. Bragin 1991, p. 84, pl. 7, fig. 13, 14. Yeh, 1992, p. 59, pl.1, fig. 9, 13-14.

Remarks. In the Queen Charlotte Islands, *Betraccium deweveri* is found in the uppermost part of the Peril Formation in beds containing the pelagic bivalve *Monotis*. These beds are equivalent to the Cordilleranus Ammonoid Zone and are "early Late Norian" in age according to Tozer (1979). In the overlying Sandilands Formation, *B. deweveri* has been found only in the basal beds which approximate either the uppermost part of the Cordilleranus Zone or the lower part of the Amoenum Zone. Thus the range of *B. deweveri* can be extended to include the lowest post-*Monotis* beds, but no higher. *B. deweveri* has been used by Blome (1984) and others as name bearer for a radiolarian zone proposed to encompass the entire upper Norian and Rhaetian. The present study suggests that this zone should be restricted only to the upper Norian substage i.e. strata equivalent to the Cordilleranus Ammonoid Zone.

Range. Upper Triassic; upper Norian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimen GSC 101919 from GSC locality C-156789 (88 KPA R3), Sandilands Formation, Kennecott Point. Other occurrences in Japan (see Sato et al.,1986); Kawakawa Bay, New Zealand (see Spörli and Aita,1988); Uson Island, Phillipines (see Cheng, 1989; Yeh, 1992); Eastern region USSR (see Bragin, 1986, 1990, 1991).

Betraccium inornatum Blome
Plate 6, figures 3 and 8
Species code BET02

Betraccium inornatum Blome 1984, p. 38, pl. 5, fig. 9, 12, 17, 19. Blome, Reed and Tailleur, 1989, pl. 33.2, fig. 14.

Remarks. The *Betraccium inornatum* group is common throughout upper Norian and Rhaetian strata. This group includes *B. inornatum* Blome s.s. and many variants some of which are informally discussed and figured here (see *B.* sp. cf. *B. inornatum* , *B.* sp. aff. *B. inornatum* , and *B.* sp. C). Variation among members of this group is commonly expressed by change in overall size, size of nodes, number of pores on surface of cortical shell, angular disposition of radial spines (some specimens more akin to genus *Gorgansium*), length of spines, and variation in width of spine ridges and grooves. Specimens illustrated here both conform closely to *B. inornatum* s.s..

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Oueen Charlotte Islands. Illustrated specimens GSC 101921 and GSC 101922 from GSC localitites C-164696/9 (87 SKU D9) and C-150179 (86 SKU B10) respectively, Kunga Island. Otuk Formation, Alaska (see Blome, Reed and Tailleur, 1989).

Betraccium sp. cf. *B. inornatum* Blome
Plate 6, figure 13
Species code BET03

cf. *Betraccium inornatum* Blome 1984, p. 38, pl. 5, fig. 9, 12, 17, 19.
Betraccium sp. cf. *B. inornatum* Blome, in Carter, 1990, pl. 2, fig. 2.

Remarks. Differs from *B. inornatum* s.s. in having a larger cortical shell (diameter 136 microns as opposed to a mean of 65 microns for type material) and primary spines that maintain equal width throughout most their length.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 85924 from GSC locality C-140489 (87 KPA 17), Kennecott Point.

Betraccium sp. aff. *B. inornatum* Blome
Plate 6, figures 4, 7, 9 and 12
Species code BET04

aff. *Betraccium inornatum* Blome 1984, p. 38, pl. 5, fig. 9, 12, 17, 19.
Betraccium chengi Yeh 1992, p. 58, pl 1, fig. 1-3, 5-6.

Remarks. This form differs from *B. inornatum* s.s. only in having a larger cortical shell (diameter 103-114 microns, as opposed to a mean of 65 microns for type material) and narrow, rather than wide, grooves on primary spines.

Range. Upper Triassic; upper Norian and Rhaetian. Yeh (1992) finds this form in the *B. deweveri* Assemblage of Uson Island, Phillippines. In the Queen Charlotte Islands, *B.* sp aff. *B. inornatum* occurs only in the Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101923, GSC 101924 and GSC 101925 from GSC localities C-164694/1 (87 SP 3/1), Louise Island; C-164693/14 (87 SKU B14), Kunga Island; and C-140484 (87 KPA 12), Kennecott Point, respectively. Uson Island, Philippines (see Yeh, 1992).

Betraccium kennecottense n. sp.
Plate 6, figures 10, 14 and 19
Species code BET05

Betraccium sp. 1, in Carter 1990, pl. 1, fig. 2.

Diagnosis. Cortical shell with relatively few, large, deep-walled, strongly nodose pore frames. Primary spines moderately long and slightly twisted.

Description. Cortical shell spherical with large pentagonal and hexagonal pore frames having large well developed nodes at vertices; nodes high in relief. Bars of pore frames moderately thick in Y direction; thick in Z direction. Four pore frames normally visible on upper and lower surfaces in line with axis of primary spines. Primary spines moderate in length (approximately equal to diameter of cortical shell), triradiate, composed of alternating ridges and grooves. Ridges wide and rounded; grooves narrow and deep proximally becoming shallow to absent at distal end of spine. Ridges and grooves display low to moderate torsion.

Remarks. This species is compared to *B. perilense* n. sp. under the latter species. *B. kennecottense* n. sp. most likely evolved from *B. perilense* n. sp. by increasing the overall size of the test and pore frame nodes, and by developing spinal torsion. Biostratigraphically, the ranges of the two species suggest very little overlap: *B. perilense* is the older, *B. kennecottense* the younger.

The holotype and paratype shown on pl. 6 , fig. 10 and 19 respectively, illustrate differing degrees of silicification: the entire radiolarian assemblage from the paratype locality (GSC loc. C- 140484 (87 KPA 12) is heavily silicified.

Etymology. This species is named for type locality at Kennecott Point, Queen Charlotte Islands.

Measurements (microns).

	Holotype	Average of 16 specimens	Max.	Min.
Diameter of cortical shell	112	110	120	94
Length of longest spine	110	116	131	97

Type locality. GSC locality C-140377 (85 SP 10/2), Skidegate Inlet. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101928 (holotype) from type locality; paratypes GSC 101929 and GSC 85911 from GSC localities C-164696/7 (87 SKU D7), Kunga Island and C-140484 (87 KPA 12), Kennecott Point respectively.

Betraccium maclearni Pessagno and Blome
Plate 6, figure 2
Species code BET06

Betraccium maclearni Pessagno and Blome 1980, p. 231, pl. 1, fig. 3, 9, 10, 15. Blome, 1984, p. 38-39, pl. 5, fig. 10. Blome, Moore, Simes and Watters, 1989, pl. 1, fig. 15. Yeh, 1992, p. 59-60, pl. 2, fig. 2, 6, 7, 15.

Remarks. *Betraccium maclearni* is common in the Peril Formation in strata containig the pelagic bivalve *Monotis* , but like *B. deweveri* , its occurrence in the overlying Sandilands Formation is limited to the lower beds only.

Range. Upper Triassic; upper Norian, ? basal Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimen GSC 101920 from GSC locality C-156789 (88 KPA R3), Sandilands Formation, Kennecott Point. Other occurrences in Torless Terrane, Kapiti Island, New Zealand (see Blome et al., 1989); Uson Island, Philippines (seeYeh, 1992).

Betraccium nodulum n. sp.
Plate 6, figures 15 and 17
Species code BET07

Diagnosis. Cortical shell small with large hexagonal pore frames and small highly raised nodes at vertices. Primary spines long with wide rounded ridges.

Description. Cortical shell small and subspherical with large hexagonal pore frames having small, highly raised nodes at vertices; pore frames thin in Y direction, moderately thick in Z direction. Three to four pore frames visible on upper and lower surfaces of cortical shell in line with axis of primary spines. Primary spines long (one and one-half to one and three-fourth times diameter of cortical shell), tapering, approximately equal in length, and triradiate in axial section. Spines longitudinally composed of three wide rounded ridges and three grooves of variable width; grooves deeply incised proximally, becoming shallow distally. Ridges and grooves straight, lacking torsion.

Remarks. Differs from *Betraccium* sp. C in having a smaller more spherical cortical shell with prominent, highly raised nodes at pore frame vertices, and spinal grooves that shallow distally.

Etymology. *nodulum* = diminutive of *nodus* (Latin) meaning a small knot or swelling.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Diameter of test	75	78	84	75
Length of longest spine	131	131	137	122

Type locality. GSC locality C-164696/9 (87 SKU D9), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101933 (holotype) and GSC 101934 (paratype) from type locality, and GSC locality C-164674 (87 SKU SP 1), both on Kunga Island.

Betraccium perilense n. sp.
Plate 6, figures 5 and 6
Species code BET08

Betraccium sp. C, in Cheng, 1989, p. 145, pl. 11, fig. 6.
Betraccium sp. B, in Yeh, 1992, p. 60, pl. 1, fig. 11.

Diagnosis. Cortical shell with large, thickened pore frames having low rounded nodes at vertices. Spines short and straight with wide rounded ridges and tapering grooves.

Description. Cortical shell of moderate size, spherical with large pentagonal and hexagonal pore frames having well developed nodes at pore frame vertices; nodes low to moderate in relief. Bars of pore frames thick in both Y and Z directions. Five pore frames visible on top and bottom surfaces of cortical shell in line with axis of primary spines. Primary spines triradiate; most commonly disposed radially at 120° but the angles may vary slightly. Spines composed of three wide rounded ridges that alternate with three tapering grooves; grooves wide and deep proximally becoming narrow and shallow distally. Ridges and grooves straight, lacking torsion.
Remarks. Differs from *Betraccium kennecottense* n. sp. in having a smaller cortical shell, less massive nodes, and primary spines that are shorter and lack torsion. Spinal angle variable up to 10° either side of 120°.

Etymology. This species is named for Peril Bay located immediately north of Kennecott Point, Queen Charlotte Islands.

Measurements (microns).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of cortical shell	106	103	112	94
Length of longest spine	84	85	112	75

Type locality. GSC locality C-156789 (88 KPA R3), Kennecott Point. See Appendix 1.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101926 (holotype) and GSC 101927 (paratype) from type locality. Other occurrences: Uson Island, Philippines (see Cheng, 1989; Yeh, 1992).

Betraccium sp. A
Plate 6, figure 16
Species code BET09

Betraccium sp. A, in Yeh, 1992, p. 60, pl. 1, fig. 7.

Remarks. Small form with subspherical cortical shell and short, but relatively strong, triradiate spines. Pore frames of cortical shell mostly hexagonal, thick in Z direction, with well developed, raised nodes at vertices of bars. Spine ridges and grooves approximately equal in width; spinal angle variable up to 10° either side of 120°.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101935 from GSC locality C-150179 (86 SKU B10), Kunga Island. Other occurrences: Uson Island, Philippines (see Yeh, 1992).

Betraccium sp. B
Plate 6, figures 18 and 22
Species code BET10

Remarks. Similar to *Betraccium* sp. A in size and outline but cortical shell is spherical, and pore frames are pentagonal rather than hexagonal. Differs from all other known species of *Betraccium* in having both a primary and secondary system of pore frame nodes; the secondary nodes are centrally positioned on the surface edge of each bar comprising the pore frame. These nodes appear to be the external expression of microgranular silica deposited as ridges (positioned perpendicular to the outer surfaces of the shell) on the inner surfaces of each bar. Internal outline of pores shaped as a five-petal form.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101936 from GSC locality C-150179 (87 SKU B10), Kunga Island.

Betraccium sp. C
Plate 6, figure 11
Species code BET11

Remarks. A member of the *Betraccium inornatum* group, this variable form has a cortical shell that is triangular to subtriangular in outline, and triradiate primary spines of variable length having wide rounded ridges and narrow deep grooves. It differs from *B. inornatum* s.s. in having nodes with higher relief and primary spines frequently disposed at other than 120° (this angle varies more than in *B. perilense*); spine grooves are wide and shallow proximally becoming narrow and deep distally.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101931 from GSC locality C-164696/3 (87 SKU D3), Kunga Island.

Betraccium sp. D
Plate 6, figure 21
Species code BET12

Remarks. This species has a small, spherical, nodose, cortical shell and long , slim, primary spines that maintain constant width throughout most of length; spines composed of narrow, rounded ridges and deep, narrow grooves. Spines only slightly twisted.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101938 from GSC locality C-164693/12 (87 SKU B12), Kunga Island.

Betraccium sp. E
Plate 6, figure 20
Species code BET13

Remarks. This species has a small, smooth, subspherical cortical shell with hexagonal pore frames and short primary spines possessing narrow ridges and grooves of about equal width.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101937 from GSC locality C-140489 (87 KPA 17), Kennecott Point.

Genus *Cantalum* Pessagno 1979

Type species. *Cantalum holdsworthi* Pessagno 1979.

Cantalum gratum n. sp.
Plate 7, figures 18 and 19
Species code CTL02

Diagnosis. Cortical shell with large, deep-walled, strongly nodose pore frames. Primary spines moderately long and slightly twisted.

Description. Cortical shell subcircular in outline with large, hexagonal pore frames having well developed nodes at pore frame vertices; nodes moderate to high in relief. Bars of pore frames thick in Y direction, very thick in Z direction. Primary spines long (approximately equal in length to diameter of cortical shell), triradiate in axial section, composed longitudinally of alternating ridges and grooves; ridges wide and rounded, grooves narrow and deep proximally becoming shallow and wide distally. Spinal torsion varies from slight to moderate; twisting commonly occurs over the entire spine length but sometimes is more prominent in the distal portion.

Remarks. *Cantalum gratum* n. sp. is compared to *C. tianense* n. sp under the latter species. Differs from *C. globosum* Blome in having a cortical shell with fewer (but larger) pore frames that are thicker in the Z direction and have larger nodes.
Etymology. *gratum* (Latin) = agreeable, pleasing.

Measurements (microns).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of test	122	112	122	107
Length of primary spines	116	109	116	103

Type locality. GSC locality C-140489 (87 KPA 17), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101953 from type locality.

Cantalum tianense n. sp.
Plate 7, figures 15, 16, 17 and 23
Species code CTL01

Diagnosis. Cortical shell with large, hexagonal pore frames; walls very thick in Z direction. Primary spines moderately long and straight.

Description. Cortical shell subspherical, composed of very large hexagonal pore frames having small, slightly raised nodes at pore frame vertices. Bars of pore frames thin in Y direction, very thick in Z direction, giving pores a fluted appearance. Primary spines triradiate, slightly longer than diameter of cortical shell. Spines longitudinally composed of alternating ridges and grooves; ridges wide and rounded, grooves narrow and deep. Spines striaght and untwisted.

Remarks. Differs from *C. gratum* n. sp. in having smaller pore frames that are thinner in the Z direction, and in having longer, untwisted spines. Differs from *C. globosum* Blome in having fewer but larger pore frames, and longer, untwisted primary spines.

Etmology. Named for Tian Head, a prominent point on the west coast of Queen Charlotte Islands.

Measurements (microns).

	Holotype	Average of 12 specimens	Max.	Min.
Diameter of test	109	102	112	94
Length of primary spines	131	122	141	112

Type locality. GSC locality C-173303 (89 SKU B14), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101951 (holotype), and GSC 101952 (paratype) from type locality.

Cantalum sp. A
Plate 7, figure 20
Species code CTL03

Remarks. This species has a large, smooth, spherical cortical shell and four long tapering spines that are approximately equal in length to diameter of cortical shell. Cortical shell composed of large hexagonal pore frames; nodes at pore frame vertices very low in relief. Primary spines have wide, rounded ridges and very narrow, deep grooves with only a hint of torsion. Differs from *C. alium* Blome in having less nodose pore frames and spines only slightly twisted with narrower grooves.
Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101954 from GSC locality C-158569 (88 LI 1), Louise Island.

Cantalum sp. B
Plate 7, figures 21 and 24
Species code CTL04

Remarks. This species has a small subtriangular cortical shell composed of large hexagonal pore frames with large, highly raised nodes at vertices of bars. Primary spines long, triradiate, composed of narrow ridges and wide grooves; spines display only very slight torsion.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101955 from GSC locality C-164693/12 (87 SKU B12), Kunga Island.

Genus *Pantanellium* Pessagno 1977a

Type species. *Pantanellium riedeli* Pessagno 1977a.

Pantanellium fosteri Pessagno and Blome
Plate 7, figure 1
Species code PAN01

Pantanellium fosteri Pessagno and Blome, 1980, p. 242, pl. 3, fig. 1, 8, 16.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands Formations, Queen Charlotte Islands. Illustrated specimen GSC101939 from GSC locality C-173303 (89 SKU B14), Kunga Island.

Pantanellium sp. aff. *P. fosteri* Pessagno and Blome
Plate 7, figures 2 and 3
Species code PAN02

aff. *Pantanellium fosteri* Pessagno and Blome, 1980, p. 242, pl. 3, fig. 1, 8, 16.
Pantanellium sp. A, in Cheng, p. 145, pl. 11, fig. 1, 2.
Pantanellium ultrasincerum Pessagno and Blome in Yeh, 1992, p. 60-61, pl. 2, fig. 1,3,9.

Remarks. This species has affinities to both *P. fosteri* Pessagno and Blome and *P. dawsoni* Pessagno and Blome, both of which occur in lower Upper Norian strata of the Queen Charlotte Islands. The cortical shell is similar to *P. fosteri*, the spines to *P. dawsoni* ; but the form figured here has a larger cortical shell (BB' = 94-112 microns measured on 15 specimens) than either of the compared species. It differs from *P. fosteri* in having pore frames that are less thick in the Z direction, and primary spines that are longer, subequal in length, and have narrower ridges. Differs from *P dawsoni* in having smaller pore frames that are thicker in the Z direction.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101940 from GSC locality C-164696/3 (87 SKU D3) Kunga Island; GSC 101941 from GSC locality C-127798 (86 SP 1/1), Louise Island. Other occurrence: Uson Island, Philippines (see Cheng, 1989; Yeh, 1992).

Pantanellium sp. aff. *P. kungaense* Pessagno and Blome
Plate 7, figures 4 and 22
Species code PAN03

aff. *Pantanellium kungaense* Pessagno and Blome, 1980, p.243-244, pl. 5, fig. 6, 7, 12, 15.

Remarks. Differs from *P. kungaense* in having more regularly-sized pore frames that lack flattened spines at nodal points, and in having less tapering spines. This species is also slightly larger than *P. kungaense* ; on three specimens measured, it is 81-94 microns along BB', 64-75 microns along AS, and 94-103 microns along A'S'.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101942 from GSC locality C-164696/7 (87 SKU D7), Kunga Island.

Pantanellium newkluense n. sp.
Plate 7, figures 5, 6, 7, 13 and 14
Species code PAN04

aff. *Pantanellium browni* Pessagno and Blome, 1980, in Carter, 1990, pl. 2, fig. 4.

Diagnosis. Cortical shell small with numerous small, fluted pore frames having strongly raised nodes. Polar spines subequal in length, tapering.

Description. Cortical shell subspherical with small, uniformly sized hexagonal and pentagonal pore frames that appear fluted. Bars of pore frames thin along Y, three times thicker along Z; prominent, well-developed nodes situated at vertices of bars; nodes high in relief. Six pore frames visible along AA' and BB'. Polar spines triradiate, subequal in length and tapering; one spine approximately four-fifths length of other one. Spines composed longitudinally of alternating ridges and grooves; ridges narrow and rounded, grooves wide and shallow.

Remarks. Differs from *P. browni* in having a cortical shell with less numerous pore frames, and primary spines that have narrower ridges and wider grooves. Differs from *P.* sp. aff. *P. kungaense* herein by having smaller pore frames composed of thicker bars, and smaller nodes with less relief.

Etymology. Named for the Haida village of New Klue on the north end of Louise Island near Kitson Point, Queen Charlotte Islands.

Measurements (microns).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of test (BB')	94	93	94	75
Length of shortest spine (AS)	86	68	86	56
Length of longest spine (A'S')	97	87	103	66

Type locality. GSC locality C-127798 (86 SP 1/1), Louise Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85926 (holotype) from type locality; GSC 101944 and GSC 101945 (paratype) from GSC localities C-164696/6 (87 SKU D6) and C-164696/7 (87 SKU D7), Kunga Island respectively.

Pantanellium sp. aff. *P. skidegatense* Pessagno and Blome Var A
Plate 7, figure 8
Species code PAN05

aff. *Pantanellium skidegatense* Pessagno and Blome, 1980, p. 246, pl. 3, fig. 4, 11, 17.

Remarks. This form varies from *P. skidegatense* in having slightly larger pore frames that are thinner in the Z direction, and much longer primary spines (avg. of 160 microns on five specimens measured). It occurs commonly in strata immediately overlying the *Monotis* beds. Its range appears to be short, and it is replaced higher in the stratigraphic column by *P.* sp. aff. *P. skidegatense* Var B.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101946 from GSC locality C-164696/3 (87 SKU D3), Kunga Island.

Pantanellium sp. aff. *P. skidegatense* Pessagno and Blome Var B
Plate 7, figures 9, 10, 11, and 25
Species code PAN06

aff. *Pantanellium skidegatense* Pessagno and Blome, 1980, p. 246, pl. 3, fig. 4, 11, 17.
Pantanellium skidegatense Pessagno and Blome, 1980, in Carter, 1990, pl. 1, fig. 13.

Remarks. This variant of *P. skidegatense* has a larger cortical shell (avg. 93 microns along BB' on 6 specimens as compared to avg. 66 microns on type material) and longer primary spines (avg. 157 microns on 6 specimens as compared to avg. AS = 70 microns; A'S' = 86 microns on type material). It further differs from *P. skidegatense* in having pore frame nodes that are higher in relief, and nearly always the distal part of the shorter primary spine is slightly twisted. See stratigraphic comments under *P.* sp. aff. *P. skidegatense* Var A.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101948 and GSC 85922 from GSC locality C-140373 (85 SP 9/1), Louise Island; specimen GSC 101947 from GSC locality C-140480 (87 KPA 8), Kennecott Point.

Pantanellium sp. A
Plate 7, figure 12
Species code PAN07

Remarks. This species has a cortical shell composed of large, fluted hexagonal and pentagonal pore frames (thick in Y direction, very thick in Z direction) having massive raised nodes at vertices of bars. Primary spines equal in length, slightly twisted. Whereas most Rhaetian species of *Pantanellium* have straight spines, this rare form has retained the twisted spines more characteristic of upper Norian forms.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101950 from GSC locality C-140484 (87 KPA 12), Kennecott Point.

Family XIPHOSTYLIDAE Haeckel 1881
emend. Pessagno and Yang 1989

Genus *Archaeocenosphaera* Pessagno and Yang 1989

Type species. Archaeocenosphaera ruesti Pessagno and Yang 1989.

Remarks. Archaeocenosphaera is described by Pessagno and Yang (1989, p. 203) as "cortical shell spherical, lacking spines, consisting of two fused latticed layers". The 'spines' referred to are the prominent secondary spines such as those possessed by *Xiphostylus* , with two secondary spines, and by *Triactoma* , *Tripocyclia* , *Zanola* , and *Neotripocyclia* , each with three secondary spines. In this report two upper Norian archaeocenosphaerid forms are illustrated each having 8 or more very short spines that originate in the outer shell. They are assigned to *Archaeocenosphaera* because in all other respects these forms adhere to the definition of this genus.

Archaeocenosphaera sp. aff. *A. laseekensis* Pessagno and Yang
Plate 1, figures 14, 19 and 20
Species code ARC01

aff. *Archaeocenosphaera laseekensis* Pessagno and Yang, 1989, p. 203, pl. 2, fig. 18, 21, 22, 15.

Remarks. Outwardly this species appears identical *A. laseekensis* , it differs only in possessing a much thinner exterior wall.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101871 and GSC 101872 from GSC locality C-164696/7 (87 SKU D7), Kunga Island. Sample QC 543 of Pessagno and Yang (1989) from the Sandilands Formation, north side of Kunga Island.

Archaeocenosphaera sp. A
Plate 1, figures 12 and 16
Species code ARC02

Spumellarian gen. and sp. indet. 1, in Carter, 1990, pl. 1, fig. 4.

Remarks. Cortical shell spherical with symmetrical meshwork and 8 or more very short, fine, triradiate spines projecting from the surface of shell. Diameter of test 169-188microns on over 30 specimens measured. *Archaeocenosphaera* sp. A is smaller than *A. laseekensis* and possesses multiple short radial spines.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101869 and GSC 85913 from GSC localities C-140484 (87 KPA 12), Kennecott Point and C-164696/6 (87 SKU D6), Kunga Island respectively.

Archaeocenosphaera sp. B
Plate 1, figure 18
Species code ARC03

Remarks. Cortical shell spherical with symmetrical meshwork and 10 to 12 short, triradiate spines projecting from the surface of shell. Diameter of test 161-188 microns on 13 specimens measured. Differs from *A.* sp. A in having longer, stronger spines. Short biostratigraphic range - found only in upper Rhaetian beds thus far.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101873 from GSC locality C-C-164696/9 (SKU D9) Kunga Island.

Family FERRESIIDAE n. fam.

Type genus. Ferresium Blome 1984.

Description. Test spherical, elliptical, triangular or three-armed in outline with three, coplanar primary spines. Upper and lower surfaces of test planiform to convex, sides vertical to convex. Test composed of multiple layers of more or less regular, concentrically arranged meshwork. The outer shell, considered cortical, has thickened latticed meshwork composed of polygonal pore frames (mostly triangular) usually with prominent nodes at pore frame vertices; nodes interconnected by thin bars. Inner structure of test comprised of spongy meshwork that generally thickens centrifugally. Primary spines solid, bladed, equal to subequal in length, symmetrically to asymmetrically arranged, and usually twisted.

The FERRESIIDAE share a common internal skeletal structure. All spines and spongy meshwork are initiated from a very small chamber with large polygonal pore frames in the central part of the test. This structure remains unchanged during external morphological change. The inner spongy meshwork consists of a multitude of small arches. The vertex of each arch gives birth to 2 bars in opposite directions and in a plane approximately perpendicular to the plane of the previous arch. These two bars are ends of the new arches which form an external layer. Primary spines develop from the innermost layer of the test and grow in width as each layer of spongy meshwork is added. The innermost part of the meshwork is very delicate and easily dissolved frequently creating a hollow cavity in the center of the test.

Note: The internal structure of the FERRESIIDAE has been studied by Paulian Dumitrica and all comments relating to these structures are attributed to him.

Remarks. The FERRESIIDAE n. fam. are very similiar to the Upper Jurassic and Cretaceous PSEUDOAULOPHACIDAE Riedel, emend. Pessagno, with the genus *Ferresium* having particular affinity to the three-spined pseudoaulophacid genus *Alevium* Pessagno. Both genera have a thickened outer shell composed of massive polygonal pore frames. They differ in that the meshwork of *Alievium* is composed exclusively of equilateral triangular pore frames, whereas in *Ferresium*, the predominantly triangular meshwork is less uniform in size and shape. The inner meshwork of the PSEUDOAULOPHACIDAE also consists of equilateral triangles arranged in concentric layers; in the FERRESIIDAE, the meshwork is spongy and less regular. The Triassic FERRESIIDAE can also be distinguished from the stratigraphically younger PSEUDOAULOPHACIDAE, by their normally twisted spines.

Included in the FERRESIIDAE at this time are *Ferresium* Blome and *Risella* n. gen. Both genera appear, diversify, and apparently die out at the end of the Triassic. However, a diverse group of undescribed radiolarians from Lower Jurassic (Hettangian and Sinemurian) strata of the Queen Charlotte Islands may also be part of this group (see Whalen, 1985).

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Western North America (Alaska, California, Oregon, Queen Charlotte Islands), Oman, Russia, Japan, Philippines, New Zealand.

Genus *Ferresium* Blome 1984, emend. herein

Type species. *Ferresium laseekense* Blome 1984.

Emended definition. Test ovate, spherical to triangular in outline, composed of of a thickened cortical shell and inner spongy meshwork.

Remarks. The inner spongy meshwork of *Ferresium* is developed from a very small chamber with large polygonal pore frames in the central part of the test. In *Ferresium* s.s. there appears to be no evidence of an internal spicule. However, in another outwardly similar form having a subspherical test and asymmetrical spines, the test is composed of a thick cortical shell and inner shell made up of a loose meshwork that may begin from an initial spicule (Dumitrica, written communication, 1992).

The shape of the test appears to be directly related to the evolutionary transition of this genus. In upper Norian strata containing radiolarians of the *Betraccium deweveri* Zone, the cortical shell of *Ferresium* is always circular, subcircular or elliptical in outline. In younger strata, species having a subtriangular to strongly triangular test predominate.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Western North America (Alaska, California, Oregon, Queen Charlotte Islands), New Zealand, Japan, the Philippines, and Oman.

Ferresium conclusum n. sp.
Plate 9, figures 1, 2, 3, 4, and 5
Species code FER01

Spumellaria gen. and sp. indet. D, in Yeh, 1989, p. 68, pl. 14, fig. 9.

Diagnosis. Test large, flattened, triangular in outline with relatively short, tapering, moderate to strongly twisted spines.

Description. Test large, flattened, triangular in outline. Upper and lower surfaces planiform, sides vertical. Meshwork of cortical shell composed mostly of triangular pore frames. Nodes at pore frame vertices well developed, high in relief. Primary spines triradiate, length variable, generally about one-half to two-thirds diameter of test. Spine ridges wide proximally becoming narrow and sharp distally; grooves about twice width of ridges proximally becoming much wider as ridges narrow. Spines display moderate to strong sinistral torsion.

Remarks. F. conclusum n. sp. possesses the most clearly triangular test of all ferresiid species observed thus far. In fact, the edges of some tests even bear a very slight concavity (see pl. 9, fig. 3 and 4). *F. conclusum* n. sp. differs from *F. teekwoonense* n. sp. in having a more triangular test and finer meshwork; from *F. triquetrum* n. sp. in having finer meshwork and less massive primary spines; from *F.* sp. C in having more twisted spines.

Etymology. conclusum (Latin) meaning end, close.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Diameter of test	158	155	169	150
Length of longest spine	100	92	122	75

Type locality. GSC locality C-164696/9 (87 SKU D9), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101968 (holotype) and GSC 101969, GSC 101970, and GSC 101971 (paratypes) from type locality; GSC 101972 (paratype) from GSC locality C-164696/7 (87 SKU D7), Kunga Island. Fields Creek Formation, east-central Oregon (see Yeh, 1989).

Ferresium sp. aff. *F. laseekense* Blome
Plate 8, figure 1
Species code FER02

aff. *Ferresium laseekense* Blome, 1984, p. 43, pl. 7, fig. 10, 11, 14, 15, 22; pl. 8, fig. 1, 5, 8, 12, 14; pl. 17, fig. 2.

Remarks. Test differs from that of *F. laseekense* in having a subtriangular rather than circular outline, and almost vertical sides.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101956 from GSC loc. C-140480 (87 KPA 8), Kennecott Point.

Ferresium teekwoonense n. sp.
Plate 8, figures 7, 8, 9, 12 and 13
Species code FER03

Diagnosis. Test large, subtriangular in outine with boundary (or edge) between horizontal and vertical surfaces sharply defined. Spines medium in length, slim, and moderately twisted.

Description. Test large, subtriangular in outline. Upper and lower surfaces slightly convex, sides vertical. In well preserved specimens boundary between horizontal and vertical surfaces is sharply defined. Meshwork of cortical shell composed of triangular and tetragonal pore frames with large, rounded nodes at vertices. Primary spines slim, triradiate, of medium length (approximately two-thirds to three-quarter diameter of test) and moderately twisted (sinistral). Spines composed of ridges and grooves; ridges narrow, grooves approximately three times width of ridges.

Remarks. Differs from *F. triquetrum* n. sp. in having a smaller, less inflated test, and slimmer primary spines.

Etymology. This species named for Tee-kwoon, as Kennecott Point was originally known to the Haidas.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Diameter of cortical shell	145	154	172	143
Length of primary spines	95	104	118	94

Type locality. GSC locality C-140489 (87 KPA 17), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101962 (holotype) from type locality, GSC 101963 (paratype) from GSC loc. C-140377 (85 SP 10/2), Skidegate Inlet, and GSC 101964 from GSC locality C-140484 (87 KPA 12), Kennecott Point.

Ferresium triquetrum n. sp.
Plate 8, figures 10, 11 and 14
Species code FER04

Diagnosis. Test large, thick and inflated; strongly triangular in outline with long, massive, very highly twisted spines.

Description. Test large, inflated, triangular in outline. Upper and lower surfaces slightly convex to planiform, sides vertical. Meshwork of cortical shell composed of mostly triangular pore frames with large, raised nodes at vertices. Primary spines massive, symmetrically arranged, and normally equal in length. Spines triradiate; proximally ridges and grooves are of the same width but as spines begin to twist, ridges narrow and grooves become much wider (up to three times width of ridges). Spines exhibit very strong sinistral torsion.

Remarks. This large triangular form may be derived from *Ferresium* sp. A (this report) whose test is subtriangular in outline and less inflated, and whose primary spines are both less massive and less strongly twisted. Both forms first appear at approximately the same level in the stratigraphic succession. *T. triquetrum* is compared with *F. teekwoonense* n. sp. under the latter species.

Etymology. *Triquetrum* (Latin) meaning three-cornered, triangular.

Measurements (microns).

	Holotype	Average 8 specimens	Max.	Min.
Diameter of cortical shell	178	157	178	135
Length of primary spines	169	138	169	98

Type locality. GSC locality C-164696/7 (87 SKU D7), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101966 (holotype) and GSC 101967 (paratype) from type locality.

Ferresium sp. A
Plate 8, figures 2 and 3
Species code FER05

Remarks. Test subtriangular in outline; upper and lower surfaces slightly convex, sides vertical. Spines moderately long and strongly twisted. See *F. triquetrum* n. sp. for comparison. Nomenclature left open because of relative scarcity of specimens.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101957 and GSC 101958 from GSC loc. C-140377 (85 SP 10/2), Skidegate Inlet, and GSC loc. C- 150179 (86 SKU B10) Kunga Island respectively.

Ferresium sp. B
Plate 8, figures 4, 5 and 6
Species code FER06

Remarks. Differs from *Ferresium* sp. A in having a smaller test with planiform surfaces and much finer meshwork; primary spines are also slimmer and less twisted.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101959 and GSC 101960 from GSC loc. C- 127798 (86 SP 1/1), Louise Island; GSC 101961 from GSC locality c-140480 (87 KPA 8), Kennecott Point.

Ferresium sp. C
Plate 9, figure 6
Species code FER07

Remarks. Differs from *F. conclusum* n. sp. in having narrow shoulders at apices of test, and very slim, straight primary spines that are distally circular in axial section.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101973 from GSC loc. C-164696/9 (87 SKU D9), Kunga Island.

Genus *Risella* n. gen.

Type species. *Risella tledoensis* n. sp.

Diagnosis. Test three-armed in outline; tips of arms expanded laterally and bear primary spines.

Description. Test three-armed in outline; arms equal in length'and radiate from central area in the same plane at approximately 120°. Arms expand laterally in distal direction and are rectangular to elliptical in cross section. Upper and lower surfaces of test convex to planiform; sides vertical to convex. In species with well developed arms and deep concave interradia, the spongy meshwork is very thin in the interradia but thick along arms where each spine has inside shell up to 6-7 verticils which represent supports for the inner layers of spongy meshwork. Primary spines solid, bladed, composed of alternating ridges and grooves, triradiate in cross section. Spines of most species strongly twisted.

Remarks. *Risella* n. gen. differs from *Ferresium* Blome in having a three-armed rather than circular to triangular outline. *Risella* n. gen. is similar in external appearance to *Paronaella* Pessagno 1977a, emend. Baumgartner 1984, but differs in possessing an inner spongy meshwork composed of arches and bars that arises from a very small chamber with large polygonal pore frames in the central part of the test. *Risella* n. gen. is also morphologically similar to some Angulobracchinae having layered internal meshwork but it lacks prominent external beams on the arms.

Further discussion. During initial studies of the Upper Triassic part of the Sandilands Formation it was apparent that two abundant spumellarian forms would be important in working out the radiolarian succession. These were *Ferresium* Blome, and a new form designated 'Gen. nov. C' by Carter in 1990, and herein described as *Risella* n. gen.. More detailed studies based on close systematic sampling of sections at Kennecott Point and Kunga Island now suggest that an evolutionary continuum exists between the two genera. Furthermore, their stratigraphic distribution as shown in Fig. 7 indicates that *Risella* gradually replaces *Ferresium* as the dominant ferresiid form, and in topmost Rhaetian strata (GSC loc. C-173287 (89 SKU D25)) *Risella* alone is present.

It is suggested that the evolutionary transition from *Ferresium* to *Risella* as shown in fig. 15, takes place as follows: the earliest forms of *Ferresium* i.e. those characteristic of the *Betraccium deweveri* Zone, possess a circular, subcircular or elliptical test, whereas in younger species the test becomes increasingly more triangular in outline. Two morphological trends can be observed as the triangularly-shaped *Ferresium* is transformed to the three-armed genus *Risella*. With respect to test outline, these are: (1) the straight edges of the triangular test gradually become concave (or begin developing interradia) and (2) the triangular apices of the test (or tips of arms) begin to widen laterally or appear to be developing 'shoulders'. These trends combine to produce a new form with a distinctive three-armed outline such as *R. tledoensis* (designated the type species).

This study required that a morphological marker be chosen in the continuum from *Ferresium* to *Risella* to establish the point at which the former genus could be readily distinguished from later. This marker has been chosen where the sides of the ferresiid test change from **straight** to **concave**.

Etymology. *Risella* is a name formed by an arbitrary combination of letters (ICZN, 1985, p. 201, Appendix D, pt. VI, Recommendation 40).

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Also, Fields Creek Formation, east-central Oregon (see Yeh, 1989); Uson Island, Philippines (see Yeh, 1992); eastern Russia (see Bragin, 1992).

Risella ellisensis n. sp.
Plate 9, figure 7
Species code RIS01

Diagnosis. Test large, inflated and just barely three-armed in outline. Primary spines of medium length, massive and highly twisted.

Description. Test as with genus. Test large, inflated, subtriangular to three-armed in outline. Upper and lower surfaces of test planiform to slightly convex, sides vertical. Cortical shell composed of triangular and tetragonal pore frames with nodes at vertices of pore frames; nodes rounded and well developed with high relief. Primary spines at tips of arms moderate in length (approximately two-thirds diameter of cortical shell), triradiate, composed of narrow ridges and wide grooves. Spines strongly twisted sinistrally.

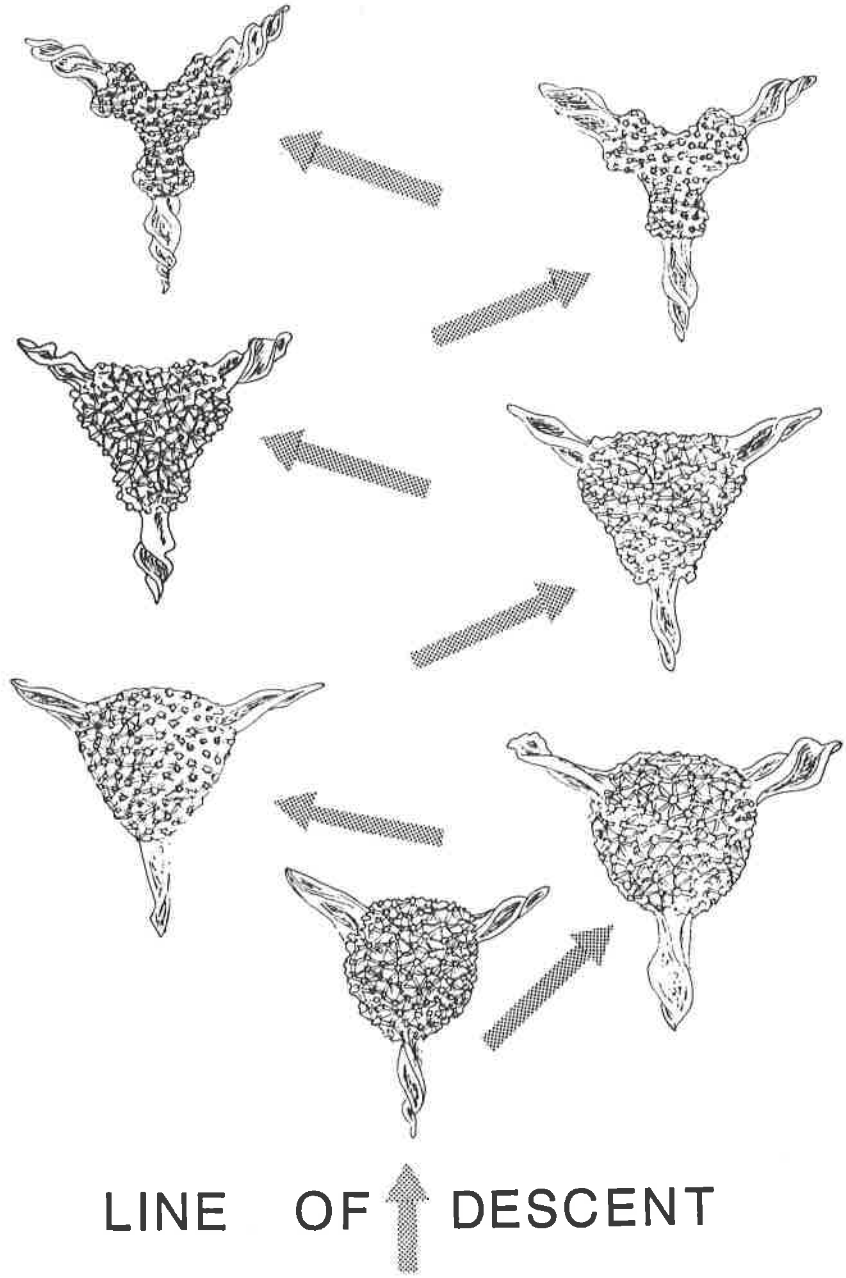


Figure 15. Diagram showing how the shape of the cortical shell changes in the evolutionary progression from Genus *Ferresium* to *Risella* n. gen. Shape changes from spherical (bottom center), to slightly subtriangular (lower right), to subtriangular (lower left), to strongly triangular (middle right). At this stage, the apices of the triangle begin to widen (developing 'shoulders') and in the next stage, the sides/edges of shell become slightly concave (middle left). From here the sides/edges of the cortical shell become more and more concave the the three-armed form emerges (upper right). Form in upper left shows a more extreme three-armed form having very highly twisted spines. Genus *Ferresium* is transformed to *Risella* n. gen at stage where sides of test start to become concave (i.e. form at middle left).

Remarks. This species with only slightly concave sides (producing a modified three-armed outline) is probably one of the earliest forms of *Risella*.

Etymology. This species named for Ellis Point on the southern tip of Frederick Island, which lies directly west of the type locality.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Diameter of test	137	159	178	141
Length of spines	97	107	131	94

Type locality. GSC loc. C-140489 (87 KPA 17), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101974 (holotype) from type locality.

Risella stalkungiensis n. sp.
Plate 9, figure 8
Species code RIS02

Paronaella sp. B in Yeh, 1992, p. 62, pl. 2, fig. 12.

Diagnosis. Ray tips rounded in outline, quite flattened, and commonly elliptical in cross section. Primary spines of medium length and strongly twisted.

Description. Test as with genus. Test large, three-armed in outline. Upper and lower surfaces slightly convex, sides vertical to slightly convex. Arms rounded at tips and generally quite flattened, elliptical in cross section. Outer layer of meshwork composed of large, coarse, triangular and tetragonal pore frames with nodes at vertices; nodes small and rounded, low to moderate in relief. Primary spines relatively short (approximately one-half diameter of cortical shell), composed of alternating ridges and grooves; ridges narrow and sharp, grooves wider and deeper. Spines strongly twisted.

Remarks. Differs from *R. tledoensis* n. sp. in having more rounded ray tips, coarser meshwork, and shorter primary spines.

Etymology. This species named for Stalkungi Point on the northwest tip of Tanu Island, west of type locality.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Diameter of test	160	144	160	131
Average length of spines	85	90	122	66

Type locality. GSC loc. C-164696/7 (87 SKU D7), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101975 (holotype) from type locality. Also: Uson Island Philippines (see Yeh, 1992).

Risella tangilensis n. sp.
Plate 9, figures 12 and 15
Species code RIS03

Diagnosis. Arms of test strongly rectangular in cross section, and laterally widened at tips. Primary spines short, slim, and straight.

Description. Test as with genus. Test large with very pronounced three-armed outline. Arms rectangular in axial section and strongly widened laterally at tips. Upper and lower surfaces moderately convex, sides vertical. Cortical shell composed of small, polygonal pore frames (many triangular) with small, rounded nodes at vertices; nodes low in relief. Primary spines at tips of arms short, slender and straight. Primary spines triradiate, composed of sharp, narrow ridges and somewhat wider, deep grooves.

Remarks. Differs from *R. tledoensis* n. sp. in having very wide ray tips, and primary spines that are much shorter, smaller, and lack torsion. This form looks very much like some species of *Angulobracchia* and *Paronaella* ; it differs from both by the character of the ferresiid internal structure.

Among species of *Risella* n. gen. discussed and figured here, *R. tangilensis* n. sp. may be the most advanced form. The three-armed outline is the most accentuated, and the spines are greatly reduced in size, and straight. Twisted spines appear to be a unique feature of Middle and Upper Triassic radiolarians. In all lowest Jurassic (Hettangian) faunas examined (Carter, unpublished data), this twisting is almost completely absent. In some species, as here in *R. tangilensis* n. sp., the tendancy to 'untwist' appears to begin in the very uppermost Triassic.

Etymology. This species named for Tangil Penninsula northwest of type locality. Tangil is a modification of the Haida word for *tongue*.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Diameter of test	215	199	215	191
Average length of spines	89	69	89	56

Type locality. GSC loc. C-164696/9 (87 SKU D9), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101979 (holotype) from type locality.

Risella tledoensis n. sp.
Plate 9, figures 10, 11 and 13
Species code RIS04

Gen. nov. C sp. 1, in Carter 1990, pl. 2, fig. 1.
Hagiastrum (?) sp., in Bragin 1991, pl. 7, fig. 2.

Diagnosis. Test three-armed, large and thick with massive, highly twisted spines.

Description. Test as with genus. Test large, thick, three-armed in outline; upper and lower surfaces planiform, sides vertical. On well preserved specimens the boundary between horizontal and vertical surfaces is very sharp. Arms slightly widened laterally at tips; rectangular in cross section. Cortical shell composed of triangular and tetragonal pore frames with small, rounded nodes at vertices of bars. Primary spines moderate in length, approximately three-quarters diameter of cortical shell. Spines triradiate and strongly twisted sinistrally, composed of alternating ridges and grooves; ridges narrow and sharp, grooves wide (4 to 5 times width of ridges) and deep.

Remarks. Differs from *R. ellisensis* n. sp. in having strongly concave sides/ interradia that produce a more accentuated, three-armed outline.

Etymology. Named for a frequently used seasonal village of the Haida sea otter hunters, north of type locality.

Measurements (microns).

	Holotype	Average of 12 specimens	Max.	Min.
Diameter of test	154	152	169	131
Average length of spines	142	120	131	103

Type locality. GSC loc. C-140489 (87 KPA 17), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85923 (holotype) from type locality, GSC 101978 (paratype) from GSC loc. C-164674 (87 SKU SP 1), Kunga Island. Other occurrence: eastern region USSR (see Bragin, 1991).

Risella sp. A
Plate 9, figure 14
Species code RIS04

Remarks. Differs from *R. tledoensis* n. sp in having more strongly concave sides/interradia and more highly twisted primary spines.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101980 from GSC loc. C-164696/9 (87 SKU D9), Kunga Island.

Risella sp. B
Plate 9, figure 9
Species code RIS05

Brief definition. Test large, central part triangular in shape and highly inflated with convex upper and lower surfaces. Arms short and stubby bearing moderately long and twisted spines.

Remarks. The highly inflated test of *Risella* sp. B suggests this form was more likely derived from *Ferresium triquetrum* n. sp. than via the more common evolutionary pathway represented sequentially by *F. teekwoonense* n. sp., *F. conclusum* n. sp., *Risella ellisensis* n. sp. and *R. tledoensis* n. sp. The rather sparse occurrence of *Risella* sp. B in uppermost Rhaetian beds precludes its formal description at this time.

Range. Upper Triassic; upper Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101976 from GSC loc. C-173284 (89 SKU D25), Kunga Island.

Family PARATRIASSOASTRIDAE Kozur and Mostler 1981

Type genus. *Paratriassoastrum* Kozur and Mostler 1981.

Remarks. The monogeneric Family Paratriassoastridae Kozur and Mostler 1981, has much in common with the Patulibracchiidae Pessagno 1977, emend. Baumgartner, 1980. The separation of the two families appears to be justifiable: in the former the internal meshwork of the arms seems completely irregular, whereas in the latter, the meshwork is arranged in layers parallel to the equatorial plane of the test.

Genus *Paratriassoastrum* Kozur and Mostler

Type species. *Paratriassoastrum austriacum* Kozur and Mostler 1981.

Remarks. This genus is common in Rhaetian samples but seldom well preserved. However its distinctive shape makes it recognizable (and useful) even in some of the more poorly preserved, depauperate faunas.

Paratriassoastrum crassum n. sp.
Plate 11, figures 1, 2, 5 and 6
Species code PTR01

Spumellaria gen. and sp. indet. C, in Yeh, 1989, p. 68, pl. 14, fig. 4.

Diagnosis. Test large, tetrahedral in shape with very short, stout rays terminated with short, porous central spines.

Description. Test as with genus. Large, tetrahedral, composed of irregular, spongy meshwork. Four rays of test very short (one-quarter to one-third diameter of cortical shell) and stout. Boundary between central shell and rays poorly defined. Pore frames of rays have thicker walls than those of central shell. Rays terminated by short, strongly tapering, porous, central spines that are subtriangular in cross section at their base. Rays and spines nearly equal in length.

Remarks. This form differs from all described species of *Paratriassoastrum* in having a much larger central shell, very short rays, and porous spines at ray tips.

Etymology. *crassum* (Latin) meaning thick, fat, stout.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Diameter of cortical shell	157	145	171	128
Length of rays	45	43	47	40
Length of spines	45	38	45	32

Type locality. GSC locality C-164674 (87 SKU SP 1), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101994 (holotype) from type locality; GSC 101995 (paratype) from GSC loc. C-164696/9 (87 SKU D9), Kunga Island. Fields Creek Formation, east-central Oregon (see Yeh, 1989).

Paratriassoastrum sp. aff. *P. crassum* n. sp.
Plate 11, figure 3
Species code PTR02

aff. *Paratriassoastrum crassum* n. sp.

Remarks. This form is very closely related to *P. crassum* n. sp. from which it differs only in having short, needle-like spines (rather than widely-based porous spines) at tips of rays.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101996 from GSC loc. C-127798 (86 SP 1/1), Louise Island.

Paratriassoastrum omegaense n. sp.
Plate 11, figures 4, 7, 8, 14 and 19
Species code PTR03

Diagnosis. Test of medium size with rays slightly expanded medially and terminating with a central spine or multiple short spines.

Description. Test as with genus. Central shell small, subspherical to subtetrahedral. Rays of medium length, slightly expanded medially, circular in cross section. Tips of rays bear short spines; most often there is a single, short, porous central spine but sometimes there are multiple short, fine, solid spines. Meshwork of central shell and rays entirely spongy, coarse and irregularly arranged. On well preserved specimens fine spinules extend randomly from surfaces of rays.

Remarks. Differs from *P. cordevolicum* Kozur and Mostler in having longer rays that are slightly expanded medially and bear short spinules. Furthermore, *P. omegaense* n. sp. most commonly has central spines, rather than multiple spines, on the ray tips. *P. omegaense* is quite similar to *Paronaella ? beatricia* (see remarks under that species) except that it has a fourth ray and the rays are positioned tetrahedrally. It is possible *P. omegaense* is an anomalous species of *P.? beatricia* that becomes more common in youngest Triassic beds. It is described here as a separate species because its distinctive shape (even when poorly preserved) and restricted range make it a useful marker for the latest Rhaetian.

Etymology. This species named for Omega Mountain directly east of the type locality at Kennecott Point.

Measurements (microns).

	Holotype	Average of 7 specimens	Max.	Min.
Diameter of cortical shell	94	94	109	75
Length of rays plus spines	142	149	171	131

Type locality. GSC locality C-164748 (89 KPA 18), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101997 (holotype) and GSC 101998 from type locality; GSC 101999 from GSC loc. C-158569 (88 LI 1), Louise Island.

Paratriassoastrum sp. A
Plate 11, figure 11
Species code PTR04

Remarks. This species has a small central shell at the confluence of four very long, slender rays. On entire specimens rays expand distally, ray tips rounded and terminated with short, fine spines. Pore structure of rays may be irregularly arranged throughout, or linearly arranged proximal to the cortical shell, becoming more irregular distally. Differs from *P. cordevolicum* Kozur and Mostler in having much longer rays, a portion of which may have linearly arranged pore frames. Rays seldom preserved entire. Length of rays: 304 microns on largest specimen measured, and these not entire.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102002 from GSC loc. C-158569 (88 LI 1), Louise Island.

Paratriassoastrum sp. B
Plate 11, figures 15 and 18
Species code PTR05

Remarks. Small form with moderately large central shell and short rays terminated with strong, triradiate spines. Rays approximally equal in length to diameter of central shell. This species common to abundant in Rhaetian samples and can be recognized even where poorly preserved.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102005 from GSC loc. C-164696/11 (87 SKU D11), Kunga Island.

Family PATULIBRACCHIIDAE Pessagno 1971
emend. Baumgartner 1980

Subfamily PATULIBRACCHIINAE Pessagno 1971
emend. Baumgartner 1980

Genus *Bistarkum* Yeh 1987

Type species. Bistarkum rigidum Yeh 1987.

Bistarkum ? cylindratum n. sp.
Plate 10, figures 1 and 18
Species code AMP01

Diagnosis. Large, cylindrical test with slightly bulbous ray tips that terminate with a porous fringe edged with small spines.

Description. Test large, cylindrical with slightly bulbous, rounded ray tips that terminate in a porous, fringe-like structure (hollow in center) edged with numerous short, slightly blunt spines. Test completely spongy, meshwork composed of small, very irregular pore frames of approximately the same size.

Remarks. Genus queried because of fringe-like structure extending from ends of both rays. *Bistarkum ?cylindratum* n. sp. is seldom well preserved and rarely is the distal fringe preserved. Most commonly this species is found as a recrystallized, dumbell-shaped form that easily may be overlooked but is a significant marker for the Rhaetian.

Etymology. *cylindratum* (Latin) meaning in the form of a cylinder.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Length of test (w/o fringe)	375	330	375	296
Diameter of test (at center)	94	133	212	94
Length of fringe	-	*68	71	66

* on 4 specimens measured.

Type locality. GSC locality C-173275 (89 SKU D13), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101981 (holotype) from type locality.

Genus *Paronaella* Pessagno 1971
emend. Baumgartner 1980

Type species. Paronaella solanoensis Pessagno 1971.

Remarks. Genus *Paronaella* is interpreted in the sense of Baumgartner, whose definition (in contrast to that of Pessagno) includes forms with bulbous or expanded ray tips. Thus the genus *Sontanella* erected by Yeh (1989) for forms with bulbous tips, is considered a junior synonymn of *Paronaella* Pessagno.

Paronaella ? beatricia n. sp.
Plate 10, figures 7, 8, 15 and 16
Species code PAR01

Diagnosis. Test has distinct central area and moderately long, medially expanded rays with randomly arranged fine spinules on ray surfaces. Rays terminated by central spines or multiple short spines.

Description. Test of medium size, completely spongy, having a distinct but gently raised central area and moderately long rays somewhat expanded in medial to distal part. Terminal spines variable within the same specimen and consist of either a tapering central spine or, more usually, multiple short spines in a crown-like structure (see pl. 10, fig. 15). Rays circular in cross section. Meshwork irregular and fine throughout, slightly coarser in central area. Nodes small, raised, and sometimes sharp. A few fine spinules randomly distributed on surfaces of rays. Central spines short and basally grooved; multiple spines, where present, are much shorter.

Remarks. *P. ? beatricia* n. sp. differs from all other species of *Paronaella* in the upper Norian and Rhaetian in having a larger, distinct central area, shorter rays with slight medial expansion, and (frequently) multiple terminal spines arranged in a crown-like structure. This form has 3 rays in the same plane and is completely spongy, but one cannot help but note the morphological similarities between it and *Paratriassoastrum omegaensis* n. sp.; the only apparent difference between the two is that *P. omegaensis* n. sp. has 4 rays lying in more than one plane. This suggests the two may be conspecific and simply variants of one species - but which one?. As has been mentioned previously in this report, the uppermost Triassic is teeming with short lived, irregular forms whose ambivalent morphology presents the worker with a confusing array of generic assignments from which to choose. While generic assignment in this case may be in doubt, more importantly, the new species described here as *Paronaella ? beatricia* n. sp. is much more abundant than *Paratriassoastrum omegaensis* n. sp. and is more easily identified when poorly preserved; consequently it is useful biostratigraphically.

Etymology. Named for the Charter vessel Beatrice that was used in 1987, as a logistics base for Geological Survey of Canada investigations of the Early Mesozoic Kunga Group of eastern Moresby Island.

Measurements (microns).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of central area	92	85	94	73
Length of rays (incl. spine)	206	223	263	188
Maximum width of rays	90	83	90	71

Type locality. GSC locality C-164696/7 (87 SKU D7), Kunga Island. See Appendix 1.

Range. Upper Triassic; upper Norian? Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101987 (holotype) and GSC 101988 (close-up of ray tip) from type locality; GSC 101989 (paratype) from GSC locality C-127798 (86 SP 1/1) Louise Island.

Paronaella bifida n. sp.
Plate 10, figures 2 and 3
Species code PAR02

Diagnosis. Stout form with short rays each terminally bifurcating into two large lobes.

Description. Stout form composed of multiple layers of pore frames having a small central area and short rays that distally bifurcate into two large lobes. Ray tips (measured perpendicular to axis of spine) approximately equal in width to axial length of rays. Meshwork, of central area and rays, spongy throughout. Pore frames generally uniform in size but sometimes smaller at lobe tips. Pore frames predominantly tetragonal and triangular with low rounded nodes at vertices. Ray tips usually eroded but on rare specimens short spines, one per lobe, have been observed.

Remarks. See *P. ultrabifida* n. sp for comparative discussion. *P. bifida* n. sp. first appears near the base of the Sandilands Formation. In slightly younger beds, *P. ultrabifida* n. sp. (a larger form whose birfurcating features are even more strongly developed) appears and rapidly becomes the dominant form of *Paronaella* with bifurcating rays.

Etymology. Latin, *bifida* meaning split into two parts.

Measurements (microns).

	Holotype	Average of 9 specimens	Max.	Min.
Axial length of rays	188	156	188	131
Width of rays at base	50	53	66	42
Width of ray tips	150	162	188	141

Type locality. GSC locality C-156743 (88 KPA E), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101982 (holotype)and GSC 101983 (paratype) from type locality.

Paronaella pacofiensis n. sp.
Plate 10, figure 5
Species code PAR03

Sontanella sp. A, in Yeh, 1992, p. 62, pl. pl. 2, fig. 8.

Diagnosis. Large test with very long slender rays with slightly expanded, rounded ray tips.

Description. Test large with small central area and very long slender rays expanding very gradually over entire length of ray and terminating in wider, blunt-ended to rounded ray tips. No terminal spines have been observed. Rays circular to subrectangular in cross section. Meshwork coarse, completely spongy, and irregular throughout; pore frames of rays sometimes display weak linear arrangement; those on ray tips much finer.

Remarks. Differs from *P. ultrabifida* n. sp. and *P. yaogusensis* n. sp in having longer spines that widen only slightly at their terminal end and have simple, rounded tips rather than bifurcating branches or extremely widened, irregularly blunt-ended tips, respectively. Many forms having the basic configuration of *P. pacofiensis* n. sp. are present in the uppermost Triassic but only those with extremely long, slender, and near complete rays are attributed to this species.

Etymology. Named for Pacofi Bay off the west end of Talunkwun Island, west of type locality.

Measurements (microns).

	Holotype	Average of 11 specimens	Max.	Min.
Length of rays*	394	322	394	263
Width of rays at base	47	50	56	47
Maximum width of ray tips*	144	110	154	84

* Rays long and fragile; specimens not always complete.

Type locality. GSC locality C-164693/14 (87 SKU B14), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101985 (holotype) from type locality. Also: Uson Island, Philippines (see Yeh, 1992).

Paronaella sp. cf. *P. pacofiensis* n. sp.
Plate 10, figure 9

cf. *Paronaella pacofiensis* n. sp.

Remarks. Differs from *P. pacofiensis* n. sp. in having shorter, broader arms with more rounded tips terminated by a short spine. Forms similar to the one illustrated range throughout the entire Rhaetian. They may truly belong to a separate species, or may be specimens of other paronaellid species whose long terminal rays or branches are broken or worn away.

Range. Upper Triassic; Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimen GSC 101990 from GSC locality C-164674 (87 SKU SP 1), Kunga Island.

Paronaella ultrabifida n. sp.
Plate 10, figure 6
Species code PAR04

Diagnosis. Test very large with long slender rays that bifurcate into two long, straight-sided, blunt-ended branches, each terminated with 2-3 short spines.

Description. Very large test composed of multiple layers of pore frames having a small central area and long, slender rays that bifurcate into two equally-sized, slender, blunt-ended branches. Branches terminated with 2-3 short spines. Branches about one-half to two-thirds axial length of ray; rays and branches approximately equal in width. Rays circular in cross section; branches subcircular to elliptical. Meshwork of central area and rays coarse, spongy, fairly uniform in size, and irregularly arranged throughout. A few nodes on central area moderately developed, those on rays weakly developed. Terminal spines short and grooved.

Remarks. P. ultrabifida n. sp. is derived from *P. bifida* n. sp. by developing longer axial rays and by extension of the large, bifid lobes into distinct, equally-sized branches. A continuum is present between the two species and clearly indicates how this transition took place. *P. ultrabifida* n. sp. is the more distinctive of the two and even when very poorly preserved, if reasonably complete its identification is never in doubt.

Etymology. Latin, combination of *ultra* (= beyond) and *bifida* (= split into two parts), meaning beyond *Paronaella bifida* n. sp.

Measurements (microns).

	Holotype	Average of 8 specimens*	Max.	Min.
Axial length of rays	227	224	244	199
Width of rays at base	56	52	56	45
Maximum width of ray tips	245	239	281	206

* This species is abundant and distinctive but because it has very long rays and branches, it is difficult to find complete specimens. For this reason only 8 were measured.

Type locality. GSC locality C-140373 (85 SP 9/1), Louise Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen (holotype) GSC 101986 from type locality.

Paronaella yaogusensis n. sp.
Plate 10, figures 4 and 17
Species code PAR05

Paronaella ? sp. 1, in Carter, 1990, pl. 1, fig. 11.

Diagnosis. Test very large with long slender rays having widely flaring ray tips with multiple, short, irregularly spaced spines.

Description. Very large test composed of multiple layers of pore frames having a small central area and long rays that flare distally to produce very wide, semi- triangular ray tips. Ray tips terminate irregularly with multiple short spines. Width of ray tips approximately equal to axial length of ray. Rays subcircular in cross section; ray tips flattened and elliptical. Meshwork of central area and rays coarse, spongy, fairly uniform in size, and irregularly arranged; meshwork of ray tips slightly smaller. Nodes moderately developed throughout. Terminal spines short, irregularly spaced and basally grooved.

Remarks. P. yaogusensis n. sp. resembles *P. ultrabifida* n. sp. but differs in having widely flaring ray tips which terminate in irregularly blunt ends rather than in two distinct ray branches. The terminal spines on *P. yaogusensis* n. sp. are irregularly spaced along the entire blunt end of a single ray whereas in *P. ultrabifida* n. sp. they are restricted to the tips of two separate branches.

Etymology. This species named for Yaogus Village, a Raven Crest Haida village on the west shore of Louise Island.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Axial length of rays	244	257	300	225
Width of rays at base	56	57	66	50
Maximum width of ray tips	206	227	281	197

Type locality. GSC locality C-164693/14 (87 SKU B14), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 85920 (holotype) from type locality.

Genus *Crucella* Pessagno 1971
emend. Baumgartner 1980

Type species. Crucella messinae Pessagno 1971.

Remarks. The forms discussed below lack bulbous tips with central and lateral spines and thus do not conform to the description of genus *Triassocrucella* Kozur, 1984. Instead, these forms generally possess tapering tips that have only one prominent spine at the tip of each ray a feature more characteristic of *Crucella* Pessagno, 1971. The only difference from Baumgartner's emended definition of the Family Patulibracchiidae Pessagno and genus *Crucella* Pessagno is that occasionally the internal spongy layers are composed of smaller pore frames than those of the external layers. These forms are assigned to *Crucella* Pessagno and may be the first true representatives of this genus.

Crucella flowerpotensis n. sp.
Plate 10, figures 13 and 14
Species code CRU01

Diagnosis. Test large and cruciform. Rays long, thick, laterally expanded distally. Central spines medium in length, triradiate.

Description. Test large, cruciform, and slightly inflated in central area. Rays equal in length, thick, gently expanded laterally. Rays strongly rectangular in cross section. Outer layers of meshwork of central area and rays composed of small, mostly tetragonal and triangular pore frames of near equal size with small rounded nodes at vertices of bars; inner layers of meshwork composed of much smaller pore frames. Pore frames on rays sometimes in weakly linear arrangement. Rays taper to strong triradiate central spines. Occasionally the central spine of one ray may be replaced by two or even three relatively short spines.

Remarks. This species resembles *C. mijo* De Wever in size and shape, but differs in having surface pore frames of near equal size throughout, and in lacking a patagium. The internal cavity illustrated in fig. 14 is considered to be an artifact of preservation.

Etymology. This species named for Flower Pot Island west of type locality.

Measurements (microns).

	Holotype	Average of 6 specimens	Max.	Min.
Length of rays	216	209	217	195
Maximum width of rays	93	98	109	93
Length of longest spine	123	85	123	69

Type locality. GSC locality C-164696/6 (87 SKU D6), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen (holotype) GSC 101993 from type locality.

Crucella ? sp. A
Plate 11, figure 13
Species code CRU02

Remarks. This 4-rayed form has a cortical shell composed of multiple layers of pore frames. The long spines frequently have two rows of linearly arranged pore frames at their base as in *Catoma* Blome. This form resembles *Crucella* Pessagno but differs in having shorter, less developed rays, and twisted spines with a few pores at the base.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102004 from GSC locality C-164696/9 (87 SKU D9), Kunga Island.

Crucella sp. B
Plate 10, figures 10 and 11
Species code CRU03

Remarks. This species is related to *C. flowerpotensis* n. sp. but differs in having rays of uniform width, larger nodes at vertices of pore frames, and longer spines. In some specimens the spines are considerably longer than those illustrated here and may twist sinistrally.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101991 from GSC locality C-164696/3 (87 SKU D3), Kunga Island.

Crucella sp. C
Plate 10, figure 12
Species code CRU04

Remarks. This medium-sized form has straight-sided rays that taper distally to short, circular, central spines. Occasionally one central spine is replaced by two, short lateral spines. Arms square to rectangular in cross section. Meshwork of test very fine. This form resembles *Hagiastrum longispinosum* Kozur and Mostler 1978, but differs in having longer, more slender rays, and shorter central spines.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 101992 from GSC locality C-173308 (89 SKU B19), Kunga Island.

Genus *Triassocrucella* Kozur 1984

Type species. Hagiastrum baloghi Kozur and Mostler 1978.

Triassocrucella sp. aff. *T. triassicum* (Kozur and Mostler)
Plate 11, figure 16
Species code TCR01

aff. *Hagiastrum triassicum* Kozur and Mostler 1978, p. 146, pl. 1, fig. 4; pl. 2, fig. 11.
aff. *Triassocrucella triassicum* (Kozur and Mostler 1978), in Kozur, 1984, p. 33.

Remarks. This species differs from *T. triassicum* in having more slender rays, shorter spines and coarser meshwork. Rays rectangular in cross section, slightly flattened near tips.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102006 from GSC loc. C-164694/1 (87 SP 3/1), Louise Island.

Triassocrucella sp. A
Plate 11, figure 12
Species code TCR02

Remarks. Test cruciform with moderately short rays of equal width throughout. Tips of rays blunt terminated with numerous fine, short spinules. Rays subrectangular in cross section. Pore frames of meshwork uniform in size, irregular in shape.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102003 from GSC loc. C-140373 (85 SP 9/1), Louise Island.

SPUMELLARIINA incertae sedis

Genus *Loupanus* n. gen.

Type species. Loupanus thompsoni n. sp.

Diagnosis. Test with small cortical shell and five prominent spines; three spines arranged symmetrically in the radial plane, and two bipolar spines in the axial plane.

Description. Cortical shell small, circular to five-sided with spines projecting from each side; three spines project at 120° in the radial plane, two bipolar spines extend in the axial plane. Shell composed of multiple layers of pore frames. Pore frames of outer layer/s have thick bars; inner layers composed of small, thin, fragile bars. Spines apparently arise from the outer surfaces of test and have no internal expression. All spines triradiate, tapering distally.

Remarks. Loupanus n. gen. differs from all other Triassic spinose Spumellaria in having five prominent spines; three symmetrically disposed in the radial plane, and two in the axial plane (bipolar spines). It most closely resembles an undescribed Hettangian (Lower Jurassic), six-spined form having four spines in the radial plane, two bipolar spines, and a cortical shell composed of more regularly arranged meshwork. *Loupanus* n. gen. is found in most well preserved, uppermost Triassic samples and may survive the terminal Triassic extinction to reappear, in slightly altered form, in the Hettangian.

Etymology. Loupanus is a name formed by an arbitrary combination of letters (ICZN, 1985, p. 201, Appendix D, pt. VI, Recommendation 40).

Range. Upper Triassic; Rhaetian, so far as known.

Occurrence. Queen Charlotte Islands, British Columbia.

Loupanus thompsoni n. gen., n. sp.
Plate 13, figures 4 and 5
Species code LOU01

Gen. nov. D sp. 1, in Carter, 1990, pl. 2, fig. 6.

Diagnosis. Cortical shell small and five-sided, having upper and lower surfaces, and three sides. A single long, robust, tapering spine extends from the center of each of the five sides.

Description. Test as with genus. Cortical shell shaped like a three-sided box. Upper and lower surfaces of cortical shell triangular in outline with polar spines projecting in the axial plane; the three sides of the shell square in outline, each with a single spine projecting in the radial plane from the intersection of adjacent sides. All five spines approximately equal in length. Outer layer of pore frames irregularly polygonal in shape, composed of thick, deep bars with small nodes at vertices. Spines long, massive, triradiate, tapering and slightly twisted.

Remarks. Depending on the angle of view, the cortical shell walls/surfaces of *L. thompsoni* n. sp. can appear either triangular (polar view) or square (lateral view). However, when specimens are obliquely oriented, the five-sided, regular shape of the shell becomes quite apparent. For comparison, see *Loupanus* sp. A.

Etymology. Named in honour of R.W. Thompson (Geological Survey of Canada), Head, Frontier Geoscience Program - Queen Charlotte Project (1987-1988), for his contribution towards understanding the complicated history of the Queen Charlotte Islands.

Measurements (microns).

	Holotype	Average of 13 specimens	Max.	Min.
Diameter of cortical shell*	116	118	143	109
Length of longest spine	181	174	206	150

*Measured in radial/lateral plane as width of shell side.

Type locality. GSC locality C-164694/1 (87 SP 3/1), Louise Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102023 (holotype) and GSC 102024 (paratype) from type locality and GSC locality C-127798 (86 SP 1/1) Louise Island, respectively.

Loupanus sp. A
Plate 13, figure 9
Species code LOU02

Remarks. Differs from *L. thompsoni* n. sp. in having a spherical, rather than five-sided, cortical shell that is composed of more regularly arranged (mostly triangular and tetragonal) pore frames having small, sharp nodes. The illustrated specimen, an aberant form with one radial spine replaced by twin spines, further illustrates the unusual morphological irregularity exhibited by many uppermost Triassic radiolarians.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102029 from GSC locality C-164674 (87 SKU SP 1) Kunga Island.

Genus *Pentaspongodiscus* Kozur and Mostler 1979
emend. Dumitrica, Kozur and Mostler 1980

Type species. *Pentaspongodiscus tortillus* Kozur and Mostler 1979.

Pentaspongodiscus ?dihexacanthus n. sp.
Plate 13, figures 1, 2 and 3
Species code PSD01

Diagnosis. Large test with six long, dextrally twisted, radial spines and two shorter polar spines.

Description. Cortical shell large, subspherical (slightly oblate in plane of radial spines), subhexagonal in outline with six equally- spaced, radial spines and two polar spines. Cortical shell comprised of two to three layers of very irregularly arranged pore frames. Outer layer of pore frames irregular in size and shape with low, rounded nodes at vertices of bars. No concentric arrangement of pore frames noted nor does test display pseudoaulophacid structure. Interior of test hollow; internal microsphere, if present, not preserved in type material. Radial spines long (approximately equal diameter of cortical shell), triradiate, and moderately twisted dextrally. Ridges and grooves approximately equal in width; ridges rounded, grooves narrow and deep. Distal portions of radial spines occasionally widen slightly before terminating in sharp, needle-like points. Polar spines much shorter than radial spines, with triradiate structure less developed.

Remarks. Generic assignment queried because meshwork of cortical shell is latticed rather than spongy and test possesses polar and radial spines. Differs from *P. mesotriassicus* Dumitrica, Kozur and Mostler, and all other described species of *Pentaspongodiscus* , in the above.

Etymology. *di-hex-acanthos* (Greek) meaning two *plus* six spines.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Diameter of cortical shell	188	163	188	150
Length radial spines	178	172	231	112
Length polar spines	103	91	150	66

Type locality. GSC locality C-127798 (86 SP 1/1) Louise Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102020 (holotype) from type locality; GSC 102021 and GSC 102022 from GSC loc. C-164674 (87 SKU SP 1) and C-164696/9 (87 SKU D9) Kunga Island respectively.

Genus *Pseudohagiastrum* Pessagno 1979

Type species. Pseudohagiastrum monstruosum Pessagno 1979.

Remarks. Pseudohagiastrum is typical of the many 4-armed irregular forms present in the uppermost Triassic. Others have been described under genus *Paratriassoastrum*. Most specimens of *Pseudohagiastrum* are too poorly preserved to permit careful study of the inner structure, but the rays appear to be hollow, at least in the more inflated distal part. For this reason, *Pseudohagiastrum* is not included here in Family Patulibracchiidae.

Pseudohagiastrum longabrachiatum n. sp.
Plate 12, figures 1 and 8; Plate 13, figures 17 and 18

Diagnosis. Test with four long , distally expanded rays almost in the same plane, and one or several terminal spines per ray.

Description. Test as with genus, very large. Rays long (3 to 4 times diameter of central area), approximately equal in length, more or less inflated distally, and hollow, at least in inflated portion. Rays not in same plane but do not deviate strongly from it. Pore frames of rays and central area irregular in size and shape. Terminal spines on rays variable in size and number and the number of spines per ray may vary considerably on the same specimen. Most frequently several short, fine spines extend from tips of rays but occasionally there is only a central spine.

Remarks. Differs from *P. monstruosum* in having longer rays and more variable terminal spines. See *P.* ? *tasuense* n. sp. for further comparison.

Etymology. From the Latin, a combination of*longus* meaning long, plus *brachiatus* , meaning with rays or branches.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Length of rays	271-306	293	351	244
Width of rays	87	85	97	75

Type locality. GSC locality C-158510 (88 SHB 3) Shields Bay. See Appendix 1.

Range. Upper Triassic; upper Norian.

Occurrence. Peril Formation, Queen Charlotte Islands. Illustrated specimens GSC 102035 (holotype) and GSC 102007 (paratype) from type locality.

Pseudohagiastrum sp. cf. *P. monstruosum* Pessagno
Plate 12, figure 4
Species code PSH01

cf. *Pseudohagiastrum monstruosum* Pessagno, in Pessagno et al., 1979, p. 165, pl. 6, fig. 1-2.

Remarks. This species very similar to *P. monstruosum* but rays are longer and slightly expanded medially.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102011 from GSC loc. C-164696/7 (87 SKU D7) Kunga Island.

Pseudohagiastrum ? tasuense n. sp.
Plate 12, figures 2, 3, 6 and 14
Species code PSH02

Diagnosis. Large test with very long, slender rays. Pore frames on proximal portions of rays nodose with strong, linear alignment.

Description. Test very large with small central area and four long rays (at least 4 times diameter of central area) in the same plane. Pore frames of central area irregular in size and shape, strongly nodose. Rays very slender ·proximally, slightly wider distally; rays apparently hollow. Arrangement of pore frames on rays variable: usually they are linearly aligned on proximal one-fourth to one-half of ray, and irregularly arranged beyond this; on other specimens all pore frames are irregularly arranged. Pore frames of rays strongly nodose throughout. Rays terminated by very short, longitudinally grooved, central spines.

Remarks. This species differs from *P. longabrachiatum* n. sp by having (1) all rays lying in the same plane, (2) proximal portions of rays possess pore frames displaying varying degrees of linear arrangement, and (3) rays terminate in short central spines. Genus queried because all four rays lie in the same plane and the rays possess central spines rather than multiple peripheral spines. This new species includes specimens whose rays display strong linear arrangement of pore frames in the proximal portion, as well as other specimens totally lacking this feature. Both forms occupy the same interval of time and occur together, often abundantly, in most samples. They are described here as one species because their differences are not considered great enough for separation into two. *P. longabrachiatus* n. sp. figured on pl. 12, fig. 1 and 8 has much stronger central spines than the holotype of *P. ? tasuense* n. sp.: the former is abundant in the upper Norian part of the Peril Formation, and is probably the immediate ancestor of *P. ? tasuense* n. sp..

Etymology. This species named for Tasu Sound on the west coast of Moresby Island.

Measurements (microns).

	Holotype	Average of 11 specimens	Max.	Min.
Length of rays	366	*429	529	356
Maximum width of rays	71	75	94	64

*Rays very long and frequently not entire.

Type locality. GSC locality C-164696/3 (87 SKU D3) Kunga Island. See Appendix 1.

Range. Upper Triassic; upper Norian? Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102009 (holotype) and GSC 102008 (paratype) from type locality; GSC 102010 from GSC loc. C-150179 (86 SKU B10) Kunga Island.

Pseudohagiastrum ? sp. A
Plate 12, figure 5
Species code PSH03

Remarks. Large test with 4 long rays in the same plane. This form may be a direct descendant of *P. tasuense* n. sp.; it differs in having rays with entirely irregular meshwork, rounded ray tips that lack terminal spines.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102012 from GSC loc. C-164696/7 (87 SKU D7) Kunga Island.

Genus *Tetraporobrachia* Kozur and Mostler

Type species. Tetraporobrachia haeckeli Kozur and Mostler 1979.

Remarks. The external arm structure of this genus appears to be very similar to that of *Hagiastrum* Rüst. Internally, however, slender triradiate beams extend the length of the arms, then enlarge to become strong triradiate spines as they project beyond the arm tips. In some species of *Tetraporobrachia* the dividing line between*cortical shell* and *arms* is rather difficult to determine. In the system of measurements used here for this genus, the boundary is placed at the junction where the irregularly arranged pore frames of the shell begin to be linearly arranged.

Range. Upper Triassic

Occurrence. Queen Charlotte Islands, British Columbia and Austria.

Tetraporobrachia composita n. sp.
Plate 12, figures 7 and 11
Species code TET01

Diagnosis. Tetrahedrally shaped cortical shell with four symmetrically to asymmetrically arranged, long arms composed of linearly arranged pore frames. Arms terminate in long triradiate spines.

Description. Test as with genus. Cortical shell large, tetrahedrally shaped, composed of regular, deep-walled, polygonal pore frames having small nodes at vertices of bars. Test has four, slender, symmetrically to asymmetrically arranged arms, one arm extending from each corner of the cortical shell. Length of arms usually one-half to three-quarters diameter of shell; arms circular in cross section. Pore frames of arms linearly arranged, composed of longitudinal beams and horizontal cross bars that together form square pore frames; large rounded nodes situated at vertices of pore frames. Inner sphere connected to cortical shell by slender internal beams that extend the length of the arms and become fairly massive triradiate spines as they emerge beyond the arm tips. Length of spines approximately equal to length of arms; spines composed of wide rounded ridges and narrow, deep grooves.

Remarks. Differs from *T. haeckeli* Kozur and Mostler in having a larger, more tetrahedral-shaped cortical shell that is composed of well defined pore frames, and by having shorter terminal spines. *T. composita* n. sp. is quite variable in both test diameter and arm length. Some forms have a smaller test with long arms, whereas others have a larger, more globose test, and correspondingly shorter arms

Etymology. *composita* (Latin) meaning orderly, well arranged..

Measurements (microns).

	Holotype	Average of 17 specimens	Max.	Min.
Diameter of cortical shell	207	217	272	169
Max. length of arms	133	125	159	94
Max. length of spines	126	132	188	66

Type locality. GSC locality C-158510 (88 SHB 3), Shields Bay. See Appendix 1.

Range. Upper Triassic; upper Norian.

Occurrence. Peril Formation, Queen Charlotte Islands. Illustrated specimens GSC 102013 (holotype) and GSC 102014 (paratype) from type locality.

Tetraporobrachia sp. A
Plate 12, figure 9
Species code TET03

Remarks. Cortical shell large, tetrahedral in shape with four, short, stout arms composed of distinct but more randomly arranged pore frames. Long spines extend from arm tips. Proximal half of spines massive, triradiate, and highly twisted sinistrally; distal portion long, slim, and needle-like.

Range. Upper Triassic; upper Norian.

Occurrence. Peril Formation, Queen Charlotte Islands. Illustrated specimen GSC 102015 GSC loc. C-158510 (88 SHB 3) Shields Bay.

Tetraporobrachia ? sp. B
Plate 12, figure 13
Species code TET04

Remarks. Cortical shell large, tetrahedral in shape with four, short, stout arms composed of irregularly arranged, almost spongy meshwork. Long spines extend from arm tips. Proximal half of spines massive, triradiate, and very slightly twisted; spine ridges very wide and rounded, grooves narrow. Distal portion of spines long and needle-like.

Range. Upper Triassic; upper Norian.

Occurrence. Peril Formation, Queen Charlotte Islands. Illustrated specimen GSC 102018 from GSC loc. C-158510 (88 SHB 3) Shields Bay.

Tetraporobrachia sp. C
Plate 12, figures 12, 15 and 16
Species code TET05

Undescribed four-spined form, in Blome, Moore, Simes and Watters, 1989, pl.1, fig. 20.

Remarks. Cortical shell very large, tetrahedral, with four, long slender arms composed of two layers of regular to irregular, linearly arranged pore frames. Boundary between cortical shell and arms not well defined. Arms circular in cross section and very slightly twisted sinistrally. Arms terminate in short triradiate spines.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Peril and Sandilands formations, Queen Charlotte Islands. Illustrated specimen GSC 102017 from GSC loc. C-164693/14 (87 SKU B14) Kunga Island.

Tetraporobrachia sp. D
Plate 12, figure 17
Species code TET06

Remarks. Cortical shell spherical composed of several layers of irregularly arranged latticed meshwork. Arms arranged symmetrically in tetrahedral position. Arms composed of six prominent longitudinal beams and cross bars; together these form pore frames that enclose circular to elliptical pores. Arms terminated by a central spine and frequently by several peripheral spines formed as sharp projections of the longitudinal beams.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102019 from GSC loc. C-164696/9 (87 SKU D9) Kunga Island.

Spumellaria gen. and sp. indet A
Plate 13, figure 7
Species code SIN01

Remarks. Small disc-shaped cortical shell with 4 spines in the same plane. Cortical shell composed of several layers of fragile polygonal pore frames with small nodes at vertices. Spines equal in length and width for approximately three-quarters of length, then tapering. Spines triradiate in transverse section, composed of narrow rounded ridges and very wide, moderately shallow grooves. Spines twisted only at tips.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102028 from GSC locality GSC C-140480 (87 KPA 8) Kennecott Point.

Spumellaria gen. and sp. indet. B
Plate 13, figures 6, 8 and 11
Species code SIN02

Remarks. Variably sized, disc-shaped cortical shell with 4 sharply tapering spines in the same plane. Cortical shell composed of several layers of polygonal pore frames with small rounded nodes at vertices. Spines equal in length, triradiate in axial section, composed of narrow rounded ridges and very wide grooves. Common to abundant.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102026 AND GSC 102027 from GSC locality C-140373 (85 SP 9/1), Louise Island; GSC 102025 from GSC locality GSC C-164696/7 (87 SKU D7) Kunga Island.

Spumellaria gen. and sp. indet. C
Plate 13, figure 10
Species code SIN03

Remarks. Cortical shell large, square in outline, composed of numerous layers of irregular polygonal pore frames. Primary spines long, straight, triradiate in axial section; one spine frequently longer than the other three. Very abundant in upper part of section D, Kunga Island. This form may be ancestral to the *Emiluvia* -like forms found in Hettangian and Sinemurian strata of the Queen Charlotte Islands: see Whalen (1985).

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102030 from GSC locality GSC C-164696/7 (87 SKU D7) Kunga Island.

Spumellaria gen. and sp. indet. D
Plate 13, figures 12 and 13

Remarks. The two forms included here are representative of a large group of tetrahedrally-shaped, completely spongy forms with four spines; one spine extending from each apex of test. Test variable in size and surface ornamentation. Spines always solid and triradiate, but size, shape and degree/direction of twisting variable.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102031 and GSC 102032 from GSC localities GSC C-140484 (87 KPA 12) and C-140489 (87 KPA 17) Kennecott Point respectively.

Spumellaria gen. and sp. indet. E
Plate 13, figures 14 and 15
Species code SIN04

Remarks. This species has a large subtetrahedral cortical shell, at least one inner shell, and four, long spines of equal length. Meshwork of cortical shell symmetrical, composed of small hexagonal pore frames with deep walls; small, sharp nodes at vertices of bars. Spines slim, composed longitudinally of alternating ridges and grooves; ridges wide and rounded, grooves narrower than ridges, and deep. Spines triradiate in cross section.

Externally this form resembles *Triactoma* Haeckel (emend. Pessagno and Yang, 1979) but has four spines arranged tetrahedrally rather than three spines in a radial plane. It also possess more than one shell.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102033 from GSC locality C-164674 (87 SKU SP 1) Kunga Island.

Suborder NASSELLARIINA Ehrenberg 1875

Family EPTINGIIDAE Dumitrica 1977

Genus *Eptingium* Dumitrica 1977

Type species. Eptingium manfredi Dumitrica 1977.

Eptingium ? *amoenum* n. sp.
Plate 14, figures 1, 8, 12 and 16
Species code EPT01

Sarla sp. 1, in Carter, 1990, pl. 1, fig. 8.

Diagnosis. Large globular cephalis with double wall of small, irregular pore frames. Triradiate horns subequal in length with strongly tapering, sharp-edged blades and wide grooves.

Description. Cephalis globular, subtriangular in outline, with three, asymmetrically arranged, stout horns lying in one plane. Horns subequal in length, apical horn (A) longer than the two primary lateral horns (L). Horns triradiate in axial section, and twisted. Blades simple, wide, sharp-edged, gently expanding initially, then rapidly tapering to a long, sharp point. Grooves very wide proximally but rapidly taper and become restricted distally. Wall of cephalis composed of two layers of large irregularly polygonal pore frames. Outer layer of pore frames with small nodes located at vertices; nodes raised and frequently sharp in relief. Internal skeleton connected to inner layer of cephalis by bars of radial horns (that are greatly reduced in size) as well as by several branched apophyses.

Remarks. Cursory examination of the internal spicule of this form suggests assignment to the genus *Eptingium*. *E.* ? *amoenum* n. sp. differs from *E.* ? *onesimos* n. sp. by having (1) a larger cephalis not compressed in the lateral plane, (2) horns that at mid point taper rapidly to a long, sharp point rather than gradually to a blunter point, and (3) more strongly bladed horns that possess narrower ridges and wider grooves

Etymology. *amoenus-a-um* (Latin) = pleasant, delightful.

Measurements (microns).

	Holotype	Average of 12 specimens	Max.	Min.
Maximum diameter of cephalis	187	180	188	160
Length of apical horn	142	141	183	122
Length of lateral horns (L)	105	112	128	94

Type locality. GSC loc. C-127798 (86 SP 1/1), Louise Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85917 (holotype) from type locality; GSC 102038 (paratype) from GSC loc. C-140373 (85 SP 9/1) Louise Island; GSC 102037 (paratype) from GSC loc. C-164693/14 (87 SKU B14), Kunga Island.

Eptingium? onesimos n. sp.
Plate 14, figures 2, 3, 4 and 17
Species code EPT02

Diagnosis. Small, slightly compressed cephalis with gradually tapering horns of near equal length composed of wide ridges and narrow grooves.

Description. Cephalis subspherical, subcircular to subtriangular in outline, slightly compressed in direction perpendicular to plane of radial horns. Test with three relatively short, stout horns of approximately equal length, arranged equally to subequally in one plane (horns represent distal expression of apical (A) spine and primary lateral (L) spines). Horns gradually tapering, triradiate throughout length, and weakly twisted; composed of wide rounded ridges and narrow grooves. Wall of cephalis composed of two layers; both layers consisting of small, polygonal pore frames with subcircular to elliptical pores. Outer layer of pore frames deep-walled in direction perpendicular to surface of test. Small, raised nodes positioned at vertices of pore frames. Internal spicule not easily observed but connected to inner layer of cephalis by inner parts of radial horns.

Remarks. For comparison see 'Remarks' under *E. ? amoenum* n. sp. It is suspected that *E. ? onesimos* n. sp. may have evolved from *E. ? amoenum* n. sp. in the uppermost Triassic, through reduction in size both of the cephalis and horns. Forms intermediate between the two have been observed, although rare. Biostratigraphic distribution of these taxa (Fig. 8) shows that *E. ? onesimos* n. sp. is the only species of *Eptingium* found in uppermost Triassic beds. Furthermore, it is abundant in almost all samples of this age, and is considered an important marker for this interval of time.

Etymology. onesimos (Greek) = beneficial, useful.

Measurements (microns).

	Holotype	Average of 12 specimens	Max.	Min.
Maximum diameter of cephalis	131	132	154	112
Average length of horns	79	76	94	66

Type locality. GSC locality C-140489 (87 KPA 17), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102039 (holotype) and GSC 102040 (paratype) from type locality; GSC 102041 from GSC loc. C-156803 (88 KPA R15), Kennecott Point.

Family DEFLANDRECYRTIIDAE Kozur and Mostler 1979

Genus *Deflandrecyrtium* Kozur and Mostler 1979

Type species. Deflandrecyrtium popofskyi Kozur and Mostler 1979.

Dreyericyrtium Kozur and Mostler 1979 (see Kozur and Mostler, 1981, p. 89).

Deflandrecyrtium nobense n. sp.
Plate 14, figures 13, 14 and 15
Species code DEF01

Diagnosis. Large, conical cephalis, short funnel-shaped thorax, and long, cylindrical abdomen flaring distally to perforate skirt with smooth edge.

Description. Cephalis conical with short apical horn. Thorax short and funnel-shaped. Length of abdomen somewhat variable; abdomen cylindrical proximally, flaring distally to a perforate skirt. Meshwork of cephalis, thorax and proximal portion of abdomen composed of multiple layers; inner layer of pores generally circular becoming larger distally; outer layer/layers quite irregular and obscure inner layer except on abdominal skirt. Outer layer of pores on cephalis generally larger than those of succeeding chambers. Abdominal skirt composed of several rows of large, circular pores; rim of skirt smooth.

Remarks. Differs from all species of *Deflandrecyrtium* described by Kozur and Mostler, in that the separation of chambers is less distinct. *D. nobense* n. sp. is larger overall than *D.* sp. A (this report) and further differs in having a larger cephalis and thorax, but smaller apical horn.

Etymology. This species named for Nob Rock located about one mile off the northeast corner of Kunga Island.

Measurements (microns).

	Holotype	Average of 6 specimens	Max.	Min.
Length of test (incl. horn)	300	290	349	234
Length of cephalis	66	61	67	56
Diameter of cephalis, distally	89	73	89	56
Length of thorax	47	36	47	28
Length of abdomen	169	160	206	122
Diameter of abdomen, proximally	159	164	188	141
Diameter of abdominal skirt	235	232	248	206

Type locality. GSC locality C-164696/7 (87 SKU D7), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC GSC 102046 (holotype), and paratypes GSC 102047 and GSC 102048 from type locality.

Deflandrecyrtium sp. A
Plate 14, figure 18
Species code DEF02

Dreyericyrtium sp. A , Yao, 1982, pl. 3, fig. 7; Yao, Mausuoka and Nakatani, 1982, pl. 2, fig. 2.
Nassellaria indet. gen. C sp. A, in Yeh, 1992, p. 70, fig. 4, 8, 13.

Remarks. This species appears to be the same as that of Yao (1982) belonging to the*Canoptum triassicum* Assemblage (Yao, 1982, p. 58) of "late Norian and Rhaetian (or Sevat - Rhaetian) age."

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102049 from GSC loc. C-150179 (86 SKU B10), Kunga Island. Inuyama area, central Japan (see Yao, 1982); Uson Island, Philippines (see Yeh, 1992).

Deflandrecyrtium sp. B
Plate 14, figures 7 and 11
Species code DEF03

Nassellaria gen. and sp. indet. B, in Cheng, 1989, p. 145-146, pl. 10, fig. 3, 7, 11.

Remarks. This form is usually found as illustrated on pl. 14, fig. 8, i. e. with incomplete distalmost chamber. Other specimens with similar proximal chambers, have a narrow, flaring rim (approximately 18 microns diameter) at their base (pl. 14 fig. 11).

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102044 and GSC 102045 from GSC localities C-164696/3 (87 SKU D3), Kunga Island and C-140478 (87 KPA 8), Kennecott Point respectively. Also: Uson Island, Philippines (see Cheng, 1989).

Genus *Haeckelicyrtium* Kozur and Mostler 1979 emend.

Type species. Haeckelicyrtium austriacum Kozur and Mostler 1979.

Emended definition. Includes forms with or without an apical horn. Distal rim of abdomen may be spinose as well as smooth.

Remarks. All species of *Haeckelicyrtium* described in this report (and others not treated here) possess an apical horn and the distal abdominal rim is spinose, rather than smooth. Of the three species described by Kozur and Mostler from the Cordevol of Austria (1979, 1981), only the type species has a smooth distal rim; *H. alpinum* and *H. ? spinosum* both have a spinose distal perimeter.

Haeckelicyrtium karcharos n. sp.
Plate 14, figures 5 and 9
Species code HCK01

Diagnosis. Large, hat-shaped form with two small circular horns. Abdomen widely flaring and net-like with sharp, jagged spines on periphery.

Description. Cephalis small and globular, imperforate with two small circular horns, the continuation of the apical and vertical spines. Thorax short, funnel-shaped, imperforate with partial outer layer of microgranular silica. Abdomen abruptly flaring to a wide, downwardly directed net-like skirt composed of large, subcircular pores; pores become larger towards periphery. Outer edge with long, flattened, jagged spines.

Remarks. All Rhaetian species have a smaller thorax and much wider abdomen than Cordevol (lower Carnian) forms described by Kozur and Mostler (1979, 1981).

Etymology. *karcharos* (Greek) meaning sharp-pointed, jagged; refers to the distal abdominal rim of this species.

Measurements (microns).

	Holotype	Average of 12 specimens	Max.	Min.
Diameter of cephalis	48	*47	48	46
Max. diameter of thorax (excluding spines)	345	325	356	296

* Cephalis rarely preserved, only 3 specimens measured.

Type locality. GSC locality C-164693/14 (87 SKU B14), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102042 (holotype) from type locality.

Haeckelicyrtium sp. aff. *H. karcharos* n. sp.
Plate 14, figures 6 and 10
Species code HCK02

aff. *Haeckelicyrtium karcharos* n. sp.

Remarks. Differs from *H. karcharos* s.s. in having flattered, lobate spines rather than sharp-tipped, jagged spines surrounding the perimeter of the abdomen.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102043 from GSC locality C-164693/14 (87 SKU B14) Kunga Island.

Family NEOSCIADIOCAPSIDAE Pessagno 1969

Genus *Citriduma* De Wever 1982

Type species. Citriduma radiotuba De Wever 1982.

Citriduma asteroides n. sp.
Plate 15, figures 3, 5, 8 and 9
Species code CIT01

Gen. nov. E sp. 1, in Carter, 1990, pl. 2, fig. 8.

Diagnosis. Large test, usually with 6 or 7 radial tubes. Test composed of a single layer of mostly large, polygonal pore frames.

Description. Large test with 5-8 (usually 6 or 7) gradually tapering, radial tubes. Tubes rounded distally, lacking spines. Tubes sometimes bifurcated rather than discretely individual. Test composed of a single layer of polygonal meshwork. Cephalis conical, finely perforate, partially covered with layer of microgranular silica; no horn visible on type material. Thorax broadly conical, slightly depressed distally, then rising near test perimeter and extending outward to form radial tubes. Radial beams sometimes poorly developed, more commonly absent. Thoracic pore frames small proximally, becoming much larger distally with small, rounded nodes at vertices of bars. Pores circular to subcircular; some quite large pores on outer thorax. Distal surface of test planiform; velum circular and closed. Outer row of velum pores moderate in size; inner ones very small.

Remarks. Differs from *Citriduma radiotuba* De Wever, in having fewer radial tubes, in lacking radial beams, and in having less complex meshwork. It has more in common with the several Rhaetian forms that follow in open nomenclature: see C. sp. A, sp. B and sp. C for comparisons. *C. asteroides* n. sp. has a very fragile test and, although abundant in uppermost Norian strata, it is usually found with cephalis, velum and tips of tubes missing (see pl. 15 fig. 8).

Etymology. aster- (Latin) meaning star; *asteroides* shaped as a member of the order of that name.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Max. diameter incl. tubes	403	491	581	403
Diameter without tubes	243	209	281	243

Type locality. GSC locality C-164674 (87 SKU SP 1), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85930 (holotype) and paratypes GSC 102054 and GSC 102055 from type locality.

Citriduma sp. A
Plate 15, figures 1 and 4
Species code CIT02

Remarks. Very large test with 6-10 (commonly 9) radial tubes, each tube rounded at tip with small spine. Radial beams present but not well defined. Under side of test planiform; velum circular and closed, composed of very small pore frames. *Citriduma* sp. A is larger than *C. asteroides* n. sp., usually has a greater number of radial tubes, and thoracic pores are smaller with some concentrically arranged.

Range. Upper Triassic; upper Norian.

Occurrence. Peril Formation, Queen Charlotte Islands. Illustrated specimens GSC 102050 and GSC 102051 from GSC locality C-158510 (88 SHB 3), Shields Bay.

Citriduma sp. B
Plate 15, figure 2
Species code CIT03

Remarks. Large discoidal test, usually with 10 very short rudimentary tubes terminated with short, robust spines. Cephalis imperforate, thorax composed of a single layer of thin, polygonal pore frames; pore frames small on conical portion of thorax, becoming much larger distally. Radial beams present (three visible on illustrated specimen) but not necessarily in line with radial tubes/spines. Under side of test planiform; velum circular, closed, composed of smaller pore frames. Differs from *C. asteroides* n. sp. in lacking well developed radial tubes.

Range. Upper Triassic; upper Norian? Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102052 from GSC locality C-150179 (86 SKU B10) Kunga Island.

Citriduma sp. C
Plate 15, figures 12, 13, 14 and 17
Species code CIT04

Remarks. Large test with 6-8 (usually 7) slender, tapering radial tubes. Ends of tubes pointed and closed. Cephalis small and conical, finely perforate. Thorax broadly conical, lacking radial beams. Thorax and radial tubes composed of a single layer of small, uniformly-sized, polygonal pore frames. Distal surface of test planiform; velum circular and closed, composed of smaller pore frames than those of surrounding surfaces. Very similar to *C. asterioides* n. sp. but has slender, pointed arms, and is composed of smaller, more uniformly-sized pore frames.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102060 and GSC 102059 from GSC locality C-164696/7 (87 SKU D7) Kunga Island.

Genus *Praecitriduma* Kozur 1984

Type species. Praecitriduma mostleri Kozur 1984.

Praecitriduma apexensis n. sp.
Plate 15, figures 6, 7, 10, 11, 15 and 16
Species code PCD01

Diagnosis. Strongly biconvex test with 15-17 radial beams; beams terminate at rim of test in very short, flattened, obtuse spines.

Description. Test dicyrtid, as with genus. Test broadly conical apically (cephalo-thorax), convex distally (velum). Cephalis small and conical, difficult to distinguish from broadly conical thorax. Cephalis with very short, rounded, apical horn. Thorax has 15-17 raised radial beams that extend to periphery of test and terminate in short, flattened, obtusely-angular spines. Thorax and velum joined at test margin. Cephalis and thorax composed of a double layer of pore frames; pore frames irregular proximally, becoming more regular and concentrically arranged distally. Inner layer of pore frames small, tetragonal to polygonal in outline. Outer layer built upon inner layer, pore frames more irregular, thicker walled, and larger (especially on central portion of test). Velum also composed of two lattice layers: inner layer of pore frames irregular and polygonal; outer layer as with those on apical portion of test.

Remarks. This species differs from *P. canthofistula* n. sp and *P. mostleri* Kozur in having less well defined radial beams, more irregularly arranged pores on thorax, and a saw-toothed, rather than smooth, outer rim. It further differs from *P. canthofistula* n. sp. in lacking a wide outer rim composed of a single row of large subcircular pores.

Etymology. This species named for Apex Mountain located between Botany Inlet and Anna Inlet west of type locality

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Maximum diameter of test	290	267	315	244

Type locality. GSC locality C-164696/7 (87 SKU D7), Kunga Island. See Appendix 1.

Range. Upper Triassic; upper Norian? Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102056 (holotype) and paratypes GSC 102057 and GSC 102058 from type locality.

Praecitriduma canthofistula n. sp.
Plate 16, figures 1, 2 and 15
Species code PCD02

Praecitriduma sp. 1, in Carter, 1990, p. 67, pl. 1, fig. 7.

Diagnosis. Large, radially-ridged test bounded by wide outer rim including a single row of very large subcircular pores; periphery of test smooth.

Description. Test dicyrtid, as with genus. Cephalis small, hemispherical, with small apical horn. Broad thorax has 16-20 raised radial beams that extend to periphery of test. Velum strongly convex. Thorax and velum join short of test margin, then both together are surrounded by a wide rim composed of a single row of very large, circular to subcircular pores separated by the radial bars; rim of test smooth. Porate rim of test occupies about one-third radius of test. Cephalis with heavy coating of microgranular silica. Thorax composed of a single layer of mostly square pore frames arranged concentrically. Velum has two lattice layers: inner layer of pore frames irregular and polygonal; outer layer (built upon inner layer) has larger, more irregular, thicker walled, and dendritically arranged pore frames.

Remarks. This species differs from *P. mostleri* Kozur in having a wide outer rim composed of a single row of large subcircular pores. It is also larger in diameter, and velum does not extend to outer margin of test.

Etymology. *canthus* (Latin), tire of a wheel, rim; *fistulus* (Latin), full of holes. Thus *canthofistula* meaning rim of wheel full of holes.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Maximum diameter of test	300	324	349	300

Type locality. GSC locality C-164693/14 (87 SKU B14), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85916 (holotype) and GSC 102062 (paratype) from type locality and GSC locality C-127798 (86 SP 1/1) Louise Island, respectively.

Praecitriduma mostleri Kozur 1984
Species code PCD03

Praecitriduma mostleri Kozur 1984, p. 67, pl. 4, fig. 6; pl. 6, fig. 3.
?Nassellaria indet. gen. D, sp. A, in Yeh, 1992, p. 70, pl. 6, fig. 14, not fig. 12 and 15.

Remarks. Specimens from the Queen Charlotte Islands are larger (diameter 244 - 304 microns on 5 specimens measured) than type material from Austria, but otherwise are identical.

Range and occurrence. Upper Triassic; Rhaetian. Queen Charlotte Islands. Thus far, this species has not been found in those upper Rhaetian beds of the Sandilands Formation that are equivalent to the *Choristoceras crickmayi* Ammonoid Zone. Also: Zlambachgraben, Austria (see Kozur, 1984).

Genus *Squinabolella* Pessagno 1969

NOT *Squinabolella* Kozur 1979.

Type species. Squinabolella putahensis Pessagno 1969.

Diagnosis. Hat-shaped dicyrtid test. Hemispherical cephalis has an apical horn with four apical pores at the base and a cephalopyle. Cephalis contains nine cephalic skeletal elements. Thorax large, conical proximally, flaring distally to a broad thoracic skirt. Thoracic velum well developed.

Remarks. Pessagno (1969) described Family Neoscadiocapsidae and genus *Squinabolella* from Cretaceous material of the Great Valley Sequence of the California Coast Range. In discussion of the Neosciadiocapsidae, he mentions the presence of a neoscadiocapsid-like species (*"Clathrocyclas " reginae* Rüst) in the Jurassic of Germany, and suggests the family may have a lengthy geologic history. In support of this view, discussion of several Rhaetian squinabolellid species follows. All species conform to the original descriptors of *Squinabolella* except that none possess a cephalopyle, and preservation of inner cephalis elements has been insufficient for the 'ninth' skeletal element, or axial spine, to be recognized.

Genus *Squinabolella* was proposed by Pessagno in 1969. Ten years later, Kozur (1979) proposed *Squinabolella* n. gen., for a "similar but different" hat-shaped form of Upper Triassic (Carnian) age. This form has a more lengthy thorax with brim and short side spines. As the name *Squinabolella* was at this time already preoccupied, *Squinabolella* Kozur 1979 is an invalid taxon (ICZN, 1985, Art 52 (a), p. 99; Art. 53 (b), p. 101).

Squinabolella causia n. sp.
Plate 16, figures 5, 8, 12 and 14
Species code SQN01

Squinabolella ? sp. 1, in Carter, 1990, pl. 2, fig. 7.

Diagnosis. Irregularly porous, hat-shaped form with conical cephalis and moderately wide abdominal skirt edged with a double row of small nodes.

Description. Cephalis small and conical with slim apical horn. Thorax large, hemispherically-elongate proximally; abruptly expanding distally to form a narrow thoracic skirt. Meshwork of cephalis and thorax (excepting thoracic skirt) multilayered; inner layer consisting of large circular pore frames, outer layer with smaller pore frames arranged dendritically. Thoracic skirt composed of a single layer of large circular pores. Rim of thoracic skirt edged with two rows of small rounded nodes. Thoracic velum gently angled downward, composed of irregular meshwork similar to that of cephalis and thorax.

Remarks. Differs from *S. desrochersi* n. sp. in having a conical cephalis, a narrower thoracic skirt is narrower, composed of fewer, smaller pores and the edge is nodose rather than smooth.

Etymology. causia (Latin) meaning a light, broad-brimmed hat.
Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Diameter thorax at base	178	188	197	178
Diameter thoracic skirt	291	291	300	268

Type locality. GSC locality C-164674 (87 SKU SP 1), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 85929 (holotype) from type locality.

Squinabolella sp. aff. *S. causia* n. sp.
Plate 17, figures 10 and 14
Species code SQN02

aff. *Squinabolella* ? sp. 1, in Carter, 1990, pl. 2, fig. 7.
aff. *Squinabolella causia* n. sp.

Remarks. Differs from *S. causia* n. sp. in having a narrower thoracic skirt and a more accentuated, double row of nodes on the brim. Illustrated specimen is one of the few having a complete thoracic velum.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102075 from GSC locality C-140489 (87 KPA 17), Kennecott Point.

Squinabolella desrochersi n. sp.
Plate 16, figures 3, 4, 6, 7, 9, 10, 12 and 13
Species code SQN03

Haeckelicyrtium ? sp. 2, in Carter, 1990, pl. 1, fig. 9.

Diagnosis. Rounded conical form composed of multilayered irregular meshwork, with a wide, single layered, perforate, abdominal skirt having a doubly-ridged, smooth rim.

Description. Cephalis hemispherical with short, cylindrical apical horn. Thorax large, conical proximally; flaring distally to form a broad thoracic skirt. Two layers of meshwork present on cephalis and thorax, but thoracic skirt has only a single layer of large circular pores. Inner layer of meshwork perforate with pores enlarging distally; outer layer dendritically arranged. Rim of thoracic skirt smooth, bounded by a double ridge. Thoracic velum directed downward, composed of irregular meshwork similar to that of cephalis and thorax.

Remarks. See Remarks under *Squinabolella causia* n. sp. for comparison.

Etymology. Named in honour of Dr. André Desrochers, University of Ottawa, for his contribution to the stratigraphy and sedimentology of the Kunga Group, Queen Charlotte Islands.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Height of test (incl. horn)	*244	-	-	-
Diameter thorax at base	188	182	200	169
Diameter thoracic skirt	310	309	324	283

* Only holotype measured.

Type locality. GSC locality C-164696/6 (87 SKU D6), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102063 (holotype) and GSC 102064 (paratype) from type locality; paratypes GSC 102065 and GSC 85918 from GSC locality no. C-140484 (87 KPA 17), Kennecott Point; GSC 102067 (paratype) from GSC locality no. C-127798 (86 SP 1/1), Louise Island.

Squinabolella sp. aff. *S. desrochersi* n. sp.
Plate 17, figures 1 and 5
Species code SQN04

aff. *Haeckelicyrtium* ? sp. 2, in Carter, 1990, pl. 1, fig. 9.
aff. *Squinabolella desrochersi* n. sp.

Remarks. Differs from *S. desrochersi* n. sp. in having a more rounded thorax and narrower thoracic skirt. The large pores are not totally confined to the brim but extend up onto base of thorax.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102069 from GSC locality no. C-164674 (87 SKU SP 1), Kunga Island.

Squinabolella ? *trispinosa* n. sp.
Plate 17, figures 3 and 4
Species code SQN05

Diagnosis. Conical form with three triradiate spines positioned equally around perimeter of test at juncture of cephalis and thorax. Test has narrow thoracic skirt and prominent velum.

Description. Test probably dicyrtid. Cephalis large, conical with strong triradiate horn. Thorax long and conical, gradually widening distally and flaring abruptly at base to form narrow thoracic skirt with finely nodose rim. Three short triradiate spines, representing elements of the internal spicule, extend outward radially from juncture of cephalis and thorax. Meshwork of cephalis and thorax composed of two or more layers of fine irregular pore frames. A ridge of relatively large, deep pore frames surrounds base of apical horn. Test has prominent downwardly-directed thoracic velum composed of irregular meshwork similar to that of thorax. Oral opening circular.

Remarks. Genus queried because of presence of three spines at juncture of cephalis and thorax. Differs from all other species of *Squinabolella* in the above characteristic, from *S. causia* n. sp. in having a longer, more conically-shaped thorax, and narrower thoracic skirt.

Etymology. *trispinosa* (Latin) combination of *tri* meaning three, and *spinosa* meaning thorny; thus, three-spined.

Measurements (microns).

	Holotype	Average of 8 specimens	Max.	Min.
Length (incl. horn)	310	300	319	277
Diameter cephalis at base	94	100	112	90
Diameter thorax at base	178	156	188	131
Diameter thoracic skirt	244	238	268	214

Type locality. GSC locality C-164696/3 (87 SKU D3), Kunga Island. See Appendix 1.
Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102071 (holotype) from type locality.

Squinabolella sp. A
Plate 17, figures 2 and 6
Species code SQN06

Remarks. This large, helmet-shaped form with small circular apical horn, has a narrow thoracic skirt composed of large circular pores, and a gently sloping, downwardly-directed thoracic velum. Meshwork of cephalis and proximal part of thorax composed of several layers; inner layer with large circular pores, outer layer/layers coarsely porate with small rounded nodes at pore frame vertices. Differs from *S. desrochersi* n. sp. in having a narrower thoracic skirt with fewer large pores and a nodose, rather than smooth, periphery.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102070 from GSC locality C-156743 (88 KPA E), Kennecott Point.

Squinabolella ? sp. B
Plate 17, figures 12, 13 and 15
Species code SQN07

Haeckelicyrtium sp. 1, in Carter, 1990, pl. 1, fig. 5.

Remarks. This tricyrtid form has a small, imperforate cephalis with long circular apical horn; a short, funnel-shaped, coarsely porate thorax with dendritically arranged outer layer; and a flaring abdomen composed of large, circular pores. Abdomen has spinose outer rim. On underside of abdomen is a very rudimentary "velum-like" structure composed of a few transverse rods some of which appear to be connected to spines of the skeletal elements. These are perhaps similar to the "arches" Kozur and Mostler refer to in their description of Squinabolella (1979).

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 85914 from GSC locality C-127798 (87 SP 1/1), Louise Island.

Squinabolella sp. C
Plate 17, figures 7, 9, 11 and 16
Species code SQN08

Remarks. True cone-shaped test with strong, triradiate apical horn and narrow thoracic skirt with 12-13 short, flattened, round-tipped spines. Test composed of two or more layers of very irregular meshwork. Thoracic velum almost planiform, oral opening circular. Differs from all other species of *Squinabolella* in having a true cone-shaped test with no visible separation between cephalis and thorax.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102073 from GSC locality C-140373 (85 SP 9/1), Louise Island, and GSC 102072 from GSC locality C-164696/6 (87 SKU D6), Kunga Island. The latter is an aberrant form with an outer growth of pore frames surrounding the angled apical horn.

Squinabolella sp. D
Plate 17, figure 8
Species code SQN09

Squinabolella (?) sp. C, in Yao, 1982, p. 58, pl. 3, fig. 8. Yao, Matsuoka and Nakatani, 1982, pl. 2, fig. 3.

Remarks. The form illustrated from the Queen Charlotte Islands has a slightly shorter thorax, but otherwise is almost identical to the form figured by Yao (1982) belonging to the *Canoptum triassicum* Assemblage of upper Norian to Rhaetian age.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102074 from GSC locality C-164674 (87 SKU SP 1), Kunga Island. Inuyama area, central Japan (see Yao, 1982).

Family BAGOTIDAE Pessagno and Whalen 1982

Genus *Droltus* Pessagno and Whalen 1982

Type species. *Droltus lyellensis* Pessagno and Whalen 1982.

Droltus orchardi n. sp.
Plate 18, figures 1, 2 and 3
Species code DRO01

Diagnosis. Large subconical to cylindrical test with strong apical horn and coarse, very irregularly arranged exterior meshwork.

Description. Test very large, subconical to cylindrical, usually with six to eight post-abdominal chambers. Test lacking strictures. Cephalis hemispherical and imperforate with strong apical horn. Thorax and abdomen trapezoidal in outline; post-abdominal chambers generally cylindrical, gradually narrowing in width distally. Test walls thick, composed of two or more lattice layers of pore frames. Inner layer of meshwork consisting of thin, square to rectangular pore frames, 2 rows per chamber. Outer layer built upon and fused to inner layer; pore frames polygonal and very irregularly arranged with thickened walls especially on more distal chambers. In some specimens there appear to be one or two slight constrictions between distal post-abdominal chambers, in others this feature is not apparent.

Remarks. Differs from *D. hecatensis* Pessagno and Whalen and *D. lyellensis* Pessagno and Whalen in having a much larger, more cylindrical test with stronger apical horn. Furthermore, the meshwork is coarser and irregularly arranged throughout, rather than having some distal linearity.

Etymology. Named for Dr. M.J. Orchard, Geological Survey of Canada, for his contribution to the Triassic biostratigraphy and paleontology of British Columbia.

Measurements (microns).

	Holotype	Average of 10 specimens	Max.	Min.
Length of test	474	440	497	394
Maximum width of test	152	151	158	141

Type locality. GSC locality C-164737 (89 KPX 3), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102077 (holotype) and paratypes GSC 102078 and GSC 102079 from type locality.

Family CANOPTIDAE Pessagno 1979
Subfamily CANOPTINAE Yeh 1987

Genus *Canoptum* Pessagno 1979

Type species. *Canoptum poissoni* Pessagno 1979.

Canoptum sp. aff. *C. dixoni* Pessagno and Whalen
Plate 18, figures 4, 5, 6 and 7
Species code CAN01

aff. *Canoptum dixoni* Pessagno and Whalen 1982, p. 124, pl. 2, fig. 1, 2, 8, 9, 14; pl. 12, fig. 2.
Canoptum aff. *C. dixoni* Pessagno and Whalen, in Carter, 1990, pl. 2, fig. 10.

Remarks. This is most common species of *Canoptum* to appear in the Triassic Sandilands Formation, and it ranges through the entire sample set of this study. It resembles *C. dixoni* but has smaller pores, and wider, more rounded circumferential ridges that lack beadlike structures.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102081 and GSC 102082 from GSC locality C-127798 (86 SP 1/1), Louise Island; GSC 102083 from GSC locality C-164693/13 (87 SKU B13), Kunga Island; and GSC 85932 from GSC locality C-140480 (87 KPA 8), Kennecott Point.

Canoptum sp. cf. *C. triassicum* Yao
Plate 18, figures 11, 12 and 13
Species code CAN02

cf. *Canoptum triassicum* Yao, 1982, p. 60, pl. 3, fig. 1-4.

Remarks. Almost identical to *C. triassicum* but has a slightly asymmetrical cephalis with indications of a small apical horn. *Canoptum triassicum* Yao is the name bearer of the *Canoptum triassicum* Assemblage (Yao, 1982) which is reported to be upper Norian to Rhaetian in age.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102087, GSC 102089, and GSC 102088 from GSC localities C-140373 (85 SP 9/1) Louise Island, C-164693/13 (87 SKU B13) Kunga Island, and C-140484 (87 KPA 12) Kennecott Point, respectively.

Canoptum sp. aff. *C. unicum* Pessagno and Whalen
Plate 18, figure 10
Species code CAN03

aff. *Canoptum unicum* Pessagno and Whalen 1982, p. 125, pl. 1, fig. 5, 14, 19, 23; pl. 12, fig. 4.
Canoptum cf. *C. unicum* Pessagno and Whalen, in Carter 1990, pl. 2, fig. 11.

Remarks. This long, slender, multi-chambered form resembles *C. unicum* of Hettangian age, but when perfectly preserved the apical portion of the test is seen to be quite different. This species has a wide, conical cephalo-thorax with a crown-like horn having five or more irregular branches in the manner of *Katroma neagui* Pessagno and Poisson. *C. unicum* has a simple, knob-shaped cephalis and thorax.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 85933 from GSC locality C-140489 (87 KPA 17), Kennecott Point.

Canoptum sp. A
Plate 18, figures 8 and 9
Species code CAN04

Canoptum sp. 1, in Carter, 1990, pl. 2, fig. 12.

Remarks. Large, slender, spindle-shaped form having about 12 post-abdominal chambers, an irregular, multiforked apical horn (when complete) and narrow, flaring terminal tube. Test generally has a heavy coating of microgranular silica that obscures many of the pores. In poorly preserved material it is almost impossible to distinguish *Canoptum* sp. A from *Laxtorum perfectum* n. sp. Thus, in this report, only well preserved specimens have been included for study. *Canoptum* sp. A differs from *L. perfectum* n. sp. in having a slimmer, less inflated test with constrictions almost always covered by a heavy layer of microgranular silica; it has an irregularly-shaped apical horn, and lacks medial spines.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85934 and GSC 102085 from GSC locality C-140484 (87 KPA 12), Kennecott Point.

Canoptum sp. B
Plate 18, figure 14
Species code CAN05

Remarks. Spindle-shaped form with 9-12 post-abdominal chambers. Initial chambers conical in outline, increasing in width, last two or more chambers decreasing in width; all chambers slightly increase in height as added. Pores confined almost exclusively to circumferential ridges; pores generally very small but larger on distal chambers. Pores on distal chambers less obscured (than proximal ones) by microgrqanular silica. Test has long apical horn, and a few small, randomly arranged lateral spines on largest distal chambers. The linear arrangement of the pores of this test becomes evident only when the specimen is wet, consequently, it does not show in photographs.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102090 from GSC locality C-140489 (87 KPA 17), Kennecott Point.

Family PARVICINGULIDAE Pessagno, 1977a

Genus *Proparvicingula* n. gen.

Type species. Proparvicingula moniliformis n. sp.

Diagnosis. Large, conical to cylindrically-shaped test with numerous, closely-spaced, porate, post-abdominal chambers separated by sharp, nodose circumferential ridges.

Description. Large, conical to cylindrically-shaped, multicyrtid test, with numerous closely spaced post-abdominal chambers separated by nodose circumferential ridges. Test walls consist of a double lattice layer of pores. Pores of inner layer primary, irregular in size, subcircular to elliptical in shape, not set in well-defined pore frames. Secondary or outer layer confined primarily to pores connected and adjacent to circumferential ridges; secondary layer built upon inner layer of pores. Three rows of irregularly offset pores per chamber; outer rows slope steeply to either side of circumferential ridges. Cephalis and thorax generally imperforate. Test has platform-like septal partitions continuous with circumferential ridges.

Remarks. *Proparvicingula* n. gen. seems very closely related to the genus *Parvicingula* Pessagno both in the development of post-abdominal chambers and circumferential ridges, and in the offset arrangement of pore frames. It differs from *Parvicingula* only in that the inner layer of pores are not set in well defined pore frames, and the outer layer of pore frames are somewhat less regularly arranged. For these reasons, *Proparvicingula* n. gen. appears to be a direct ancestor of *Parvicingula* even though there is a considerable gap in time between the respective ranges of each genus. Thus far *Proparvicingula* n. gen. has not been found in strata either older or younger than Rhaetian; whereas in western North America, the first appearance of *Parvicingula* takes place in the middle Toarcian.

Proparvicingula n. gen. is apparently monospecific in the Rhaetian and only the type species is described.

Etymology. *pro* (latin) meaning going before, plus *parvicingula* ; *Proparvicingula* meaning genus that preceeds *Parvicingula*.

Range. Upper Triassic; Rhaetian so far as known.

Occurrence. Sandilands Formation, Queen Charlotte Islands. ? Eastern Russia.

Proparvicingula moniliformis n. gen. n. sp.
Plate 18, figures 15 -22
Species code PRP01

Gen. nov. B sp. 1, in Carter, 1990, pl. 1, fig. 10 (printed in error as Gen. nov. E sp. 1).
?*Triassocampe* sp., in Bragin 1991, pl. 8, fig. 9.

Diagnosis. Large, conical to cylindrical test with long apical horn and nine to thirteen post-abdominal chambers having sharp circumferential ridges with beadlike nodes.

Description. Large, conical to cylindrical test usually with nine to thirteen closely spaced post-abdominal chambers separated by sharp, nodose circumferential ridges. Cephalis and thorax conical, imperforate (thorax sometimes sparsely porate); cephalis has long, slightly asymmetrical apical horn. Abdomen and first few post-abdominal chambers subtrapezoidal in outline, width and height increasing very slightly and in about equal degree. Succeeding post-abdominal chambers cylindrical, distalmost chamber slightly decreasing in width and usually longer. Three rows of subcircular pore frames per chamber. Outer rows of pore frames slope steeply away from ridges. Central row of pores usually smaller; relict on proximal chambers, becoming larger and more open on distal chambers, very large on final chamber. Pore frame nodes small, rounded and confined to circumferential ridges where they form distinct beadlike structures.

Remarks. Length of test varies directly with the number of post-abdominal chambers. Length of apical horn varies considerably also: some forms have a long, well developed horn (pl. 18, fig. 15, 17, and 18), others have a tiny horn (pl. 18, fig. 20 and 21). Regarding overall size of test, the trend is toward size increasing with time i.e. larger forms are more prevalent in younger strata. The environmental significance of this trend has not been thoroughly evaluated.

Etymology. *monil-i-formis* (Latin) meaning formed as a string of beads; refers to pattern of nodes on circumferential ridges.

Measurements (microns).

	Holotype	Average of 13 specimens	Max.	Min.
Length of test	424	387	484	281
Maximum width of test	137	132	150	114

Type locality. GSC locality C-140373 (85 SP 9/1), Louise Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85919 (holotype) from type locality; paratypes GSC 102093 and GSC 102094 from GSC localities C-164696/3 (87 SKU D3) and C-164693/14 (87 SKU B14), Kunga Island respectively; paratypes GSC 102092, and GSC 102095 from GSC localities C-140484 (87 KPA 12) and 140478 (87 KPA 6) Kennecott Point respectively. Also: ?Eastern region USSR (see Bragin, 1991).

Family CANUTIDAE Pessagno and Whalen 1982

Genus *Canutus* Pessagno and Whalen 1982

Type species. *Canutus tipperi* Pessagno and Whalen 1982.

Remarks. Assignment of Rhaetian forms to genus *Canutus* is based primarily on test wall structure i.e. two to three lattice layers connected by pillar-like nodes. Inner layer of pore frames large and open; outer layer/layers composed of fragile, irregular, polygonal pore frames. Outer layer frequently worn away to expose the inner structure. All forms described below differ from *Canutus* s.s. in having an apical horn and a cylindrical tube.

***Canutus* ? *beehivensis* n. sp.**
Plate 20, figures 1-5 and 18
Species code CTS01

Canutus ? sp. 1, in Carter, 1990, pl. 2, fig. 9.

Diagnosis. Large, highly inflated, spindle-shaped form with apical horn, stongly constricted distal chambers, and flaring terminal tube.

Description. Test large, spindle-shaped, highly inflated medially, usually with five to six post-abdominal chambers and terminal tube. Cephalis hemispherical and imperforate with short, robust apical horn. Thorax, abdomen and first two to three post-abdominal chambers trapezoidal, gradually increasing in height, strongly increasing in width; successive post-abdominal chambers reduced in height and width. Externally no constrictions or ridges are present between chambers. Inner layer of meshwork has two rows of open, polygonal pore frames per chamber; pore frames of outer layer irregularly polygonal in shape, their walls quite thin and deep. Outer layer of pore frames on distal chambers occasionally displays linear arrangement, particularly evident in widest portion of test (see pl. 20, fig. 3). Terminal tube flaring at base, composed of a single layer of meshwork with small, subcircular pores.

Remarks. Differs from *C.* ? *ingrahamensis* n. sp. in having (1) a shorter, more inflated test, (2) pore frames of the outer layer are usually irregular, rather than linearly arranged, and (3) terminal tube is flaring rather than cylindrical. The specimen figured previously by Carter (1990) appears to be identical to the holotype illustrated here except that it lacks a terminal tube. It is difficult to determine if this tube was originally absent, or if it has been merely broken away and the edges smoothly eroded. If the former, it may be a different species, but for the present it is retained here as a paratype of *C. ?beehivensis* n. sp.

Etymology. This species is named for Beehive Hill at the northern entrance to Peril Bay.

Measurements (microns).

	Holotype	Average of 9 specimens	Max.	Min.
Length of test	412	349	412	319
Maximum width of test	191	181	191	165
Width of terminal tube	60	65	75	56

Type locality. GSC locality C-164696/9 87 SKU D9), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102115 (holotype) and GSC 102116 (paratype) from type locality. Paratypes GSC 102117 and GSC 102118 from GSC localities GSC C-164696/7 (87 SKU D7) and GSC C-150179 (86 SKU B10), Kunga Island respectively; GSC 85931 (paratype) from GSC locality C-140484 (87 KPA 12), Kennecott Point.

Canutus ? ingrahamensis n. sp.
Plate 20, figures 6 and 17
Species code CTS02

Diagnosis. Large, inflated, spindle-shaped form with long apical horn, linearly aligned pore frames on distal chambers, and constricted, cylindrical terminal tube.

Description. Test large, spindle-shaped, inflated, usually with eight post-abdominal chambers, and cylindrical terminal tube. Cephalis hemispherical and imperforate with long massive apical horn. Thorax, abdomen and remaining chambers trapezoidal in outline. Initial post-abdominal chambers increasing more in width than height; distal chambers becoming constricted in width. Externally, no constrictions or ridges indicate separation of chambers. Test wall thick. Inner layer of meshwork has two rows of square pore frames per chamber; pore frames with prominent pillars at corners. Outer layer of pore frames small and very irregular on proximal chambers, becoming larger, square to rectangular in shape, and sublinearly aligned on distal chambers and terminal tube. Terminal tube cylindrical, composed of a single layer of meshwork.

Remarks. See remarks under *C.? beehivensis* n. sp. for comparison with that species.

Etymology. This species named for Ingraham Bay, which lies about five miles south of Kennecott Point on the west coast of Graham Island.

Measurements (microns).

	Holotype	Average of 9 specimens	Max.	Min.
Length of test	427	375	427	338
Maximum width of test	169	174	191	150

Type locality. GSC locality C-140484 (87 KPA 12), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102120 (holotype) from type locality.

Canutus ? sp. A
Plate 18, figure 23
Species code CTS03

Remarks. Test spindle-shaped with wide tubular extension and strong apical horn. Proximal portion of test conical, chambers moderately expanded in width; distal chambers slightly constricted. Outer layer of meshwork very irregular; pore frames small on initial chambers becoming larger distally, especially in area between distalmost post-abdominal chamber and tubular extension. Differs from *C.* ? *beehivensis* n. sp in having a slimmer test and a very wide tubular extension.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102096 from GSC locality C-127798 (86 SP 1/1), Louise Island.

NASSELLARIINA incertae sedis

Genus *Bipedis* De Wever 1982

Type species. *Bipedis calvabovis* De Wever 1982.

Remarks. It has been difficult to decide whether to assign the following two forms to the Middle Triassic genus *Triassobipedis* Kozur, 1984, or to the Early Jurassic genus *Bipedis* De Wever, 1982. Rhaetian forms display characteristics of both genera, which is not surprising, given their stratigraphic position. Both bipedid forms illustrated here are clearly dicyrtid, they have a large, flattened, broad based, spatulate apical horn, two feet of near similar shape at 180°, a perforate test, and small aperture. The body of the test is similar to *Bipedis* , but the horn and feet have greater affinity to *Triassobipedis*. This author would question assignment of these forms to *Bipedis* De Wever because they lack a prolongation of the V-spine and study of the internal structure has not confirmed the absence of the D-spine.

Bipedis acrostylus Bragin 1991
Plate 20, figures 10, 11 and 12
Species code BPD02

?Nassellarian gen. and sp. indet. sp. A, in Yao, 1982, pl. 3, fig. 14. Yao, Matsuoka, and Nakatani, 1982, pl. 2, fig. 6. Matsuoka, 1982, fig. 4, no. 3.
Undescribed nassellarian, in Blome, Reed, and Tailleur, 1989, pl. 33.2, fig. 2.
Triassobipedis ? sp. 1, in Carter, 1990, pl. 1, fig. 12.
Nassellaria indet. gen. A, sp. A. in Yeh, 1992, p. 69, pl. 5 fig. 7.
Nassellaria indet gen. B, sp. A. in Yeh, 1992, p. 70, pl. 6, fig. 1-3.
Bipedis acrostylus Bragin 1991, p. 107, pl. 7, fig. 8.

In the time between the present author's study of this form and the publication of this report, Bragin (1991) described a similar form from the USSR as *Bipedis acrostylus* n. sp. The following brief description and measurements are given only to supplement the original description.

Brief description. Dicyrtid test composed of subhemispherical cephalis with apical horn, and inflated subtrapezoidal thorax having two feet at 180°. Apical horn large, very flattened, acutely triangular in outline, with two prominent pores at base. Feet angled outward and slightly down from widest part of thorax at about 45°. Feet extremely wide, flattened, acutely triangular in outline.

Remarks. Differs from *Bipedis* ? sp. A herein, and all other species of *Bipedis* in that the apical horn and feet are flattened, and acutely triangular in outline.

Measurements (microns).

	Average of 6 specimens	Max.	Min.
Length of apical horn	73	79	66
Length cephalis plus thorax	119	131	113
Length of feet	84	94	75

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 85921 (lectotype) from GSC locality C-127798 (86 SP 1/1), Louise Island. Other occurrences: Otuk Formation, Alaska (see Blome, Reed, and Tailleur, 1989); Central Japan (see Yao, 1982); eastern region USSR (see Bragin, 1991); Uson Island, Philippines (see Yeh, 1992).

Bipedis ? sp. A
Plate 20, figure 13
Species code BPD01

Remarks. Dicyrtid test. Cephalis globular with large flattened apical horn having a subround outline. Thorax almost spherical, latticed. Feet extremely wide and flattened (thin), almost hemispherical in shape proximally, strongly tapering distally and joined at base. Aperture depressed, circular and very small.

Range. Upper Triassic; upper Norian? Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102126 from GSC locality C-150179 (86 SKU B10), Kunga Island.

Genus *Globolaxtorum* n. gen.

Type species. *Globolaxtorum tozeri* n. sp.

Diagnosis. Multicyrtid test, conical proximally, inflated medially and terminated with elongate tube. Test has long apical horn and medial spines.

Description. Multicyrtid test, spindle-shaped, consisting of more than five post-abdominal chambers; chambers gradually expand, become quite inflated, then constrict to form a terminal tube. Cephalis with apical horn. Thorax, abdomen, and first few post-abdominal chambers closely spaced, subtrapezoidal in outline, gradually increasing in width as added. Succeeding chambers inflated both in width and height; final chambers becoming constricted, reduced in height and leading to elongate terminal tube. Test consisting of two layers of irregular pore frames; inner layer lacking nodes, outer layer with quite massive nodes. Outer layer confined primarily to circumferential ridges. Terminal tube open, composed of a single layer of pore frames. Short medial spines extend radially from inflated area of test.

Remarks. *Globolaxtorum* n. gen. is derived from *Laxtorum* Blome, emend., in the Rhaetian by the inflation of medial post-abdominal chambers and the addition of a long terminal tube. *Globolaxtorum* differs from *Katroma* Pessagno and Poisson, *Pleesus* Yeh, and *Syringocapsa* Neviani in having a two-layered test. It further differs from *Katroma* and *Syringocapsa* in having a greater number of post-abdominal chambers, and from *Pleesus* and *Syringocapsa* in having radially arranged medial spines and an apical horn.

Etymology. *globosus* (Latin) meaning spherical, plus *Laxtorum*.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Also: Uson Island, Philippines, Oman.

Globolaxtorum cristatum n. sp.
Plate 19, figures 11, 12, 13 and 17
Species code GLO01

Diagnosis. Test multicyrtid, usually with eight to nine post-abdominal chambers all possessing circumferential ridges. Medial chambers quite inflated laterally but height of chambers throughout test fairly constant.

Description. Test as with genus, usually with eight to nine post-abdominal chambers. Cephalis and thorax conical, imperforate; cephalis with tapering apical horn. Succeeding chambers trapezoidal in outline, increasing more in width than height. Test becomes quite inflated medially (with chambers of greater width and height) then gradually constricts, terminating in a long, tapering tube. Test composed of two lattice layers of small, irregular pore frames: pore frames of inner layer slightly larger, lacking nodes;

outer layer with massive nodes. Outer layer confined primarily to low, rounded, circumferential ridges that are evident on all chambers. Terminal tube long and tapering, composed of a single layer of relatively large, square to rectangular pore frames. Well preserved specimens have several, short, downwardly sloping thorns at tip of tube. Short, slender, radially arranged medial spines extend from most inflated area of test.

Remarks. See Remarks under *G. tozeri* n. sp. for comparison with that species.

Etymology. *cristatum* (Latin; adj.) meaning having a crest; refers to the presence of circumferential ridges on all post-abdominal chambers.

Measurements (microns). Length excludes apical horn.

	Holotype	Average of 11 specimens	Max.	Min.
Length of test	319	328	356	310
Maximum diameter of test	150	151	176	129

Type locality. GSC locality C-164696/9 (87 SKU D9), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102107 (holotype) and paratypes GSC 102108 and GSC 102109 from type locality.

Globolaxtorum tozeri n. sp.
Plate 19, figures 14, 15, 16, 18 and 19
Species code GLO02

Podocapsa ? sp. 1, in Carter, 1990, pl. 2, fig. 5.
Katroma sp. A. in Yeh, 1992, p. 68, pl. 5, fig. 12.

Diagnosis. Spindle-shaped multicyrtid test with one highly inflated and heightened medial chamber, and long, tapering tube. Test has medial spines on inflated chamber and a robust apical horn.

Description. Test as with genus, usually with five post-abdominal chambers and long terminal tube. Cephalis conical, imperforate with long robust apical horn. Thorax, abdomen and first two post-abdominal chambers closely spaced, conical in overall outline; width of chambers gradually increasing, height almost constant. Circumferential ridges low in relief, rounded; one to two rows of pores per ridge. Third chamber becoming more expanded; fourth chamber highly inflated, forming maximum expansion of test, width about twice that of height; final chamber again constricted and reduced in height. Outer layer of pore frames small on initial chambers, confined mostly to circumferential ridges. Pore frames larger and very irregular on inflated chambers; walls deep with small, pointed nodes at vertices of bars. Terminal tube long and tapering, composed of a single layer of relatively large, square to rectangular pore frames. Well preserved specimens have several, short, downwardly sloping thorns at tip of tube. Test usually with six or seven very short, slender, radially arranged medial spines on inflated chamber.

Remarks. *Globolaxtorum tozeri* n. sp. is usually larger than *G. cristatum* n. sp. and further differs in having a single, highly inflated medial chamber that has greater width and height than all others.

Etymology. This species named in honour of E.T. Tozer, Geological Survey of Canada, for his contribution to the Triassic of Canada.

Measurements (microns). Length excludes apical horn.

	Holotype	Average of 11 specimens	Max.	Min.
Length of test	375	362	420	300
Maximum diameter of test	174	167	182	150

Type locality. GSC locality C-140489 (87 KPA 17), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85927 (holotype) and paratypes GSC 102011 and GSC 102112 from type locality; GSC 102113 from GSC locality C-156827 (88 KPD 1AA), Kennecott Point. Also: Uson Island, Philippines (see Yeh, 1992) and Oman.

Globolaxtorum ? sp. A
Plate 19, figures 20 and 21
Species code GLO03

Remarks. Genus queried because this species possesses three radially arranged spongy arms (tipped with slender spines) that extend from the most inflated chamber of test.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102114 from GSC locality C-164674 (87 SKU SP 1), Kunga Island.

Genus *Laxtorum* Blome 1984, emend.

Type species. *Laxtorum hindei* Blome 1984.

Diagnosis. Multicyrtid test possessing four or more chambers and having a large, well-developed apical horn. Test composed of two layers of large, polygonal pore frames: inner layer lacking nodes, outer layer with massive, polygonal nodes. Pore frames of outer layer generally restricted to circumferential ridges.

Emended definition. Genus emended to include the following: (1) test may possess up to twelve post-abdominal chambers, (2) test may have slender, lateral spines that extend radially from medial and/or distal post-abdominal chambers, and are distributed equally to subequally around perimeter of test, and (3) test may terminate in an open, flaring terminal tube that lacks septal partitions.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Western North America (Alaska, California, Oregon, Queen Charlotte Islands), New Zealand and Japan.

Laxtorum capitaneum n. sp.
Plate 19, figures 6, 7 and 8
Species code LAX02

?*Pleesus* sp. A. in Yeh, p. 68, pl. 5, fig. 14.

Diagnosis. Test very large with eight to twelve post-abdominal chambers and flaring terminal tube. Three or more fine spines extend laterally from distal chambers of test.

Description. Test as with genus. Test very large, spindle shaped, with eight to twelve closely-spaced, post-abdominal chambers and terminal tube. Cephalis and thorax conical; cephalis imperforate, thorax imperforate to sparsely perforate. Cephalis with short slightly asymmetrical apical horn. Abdomen and post-abdominal chambers subtrapezoidal in outline; initial chambers increasing gradually in width, final two chambers narrower. Test composed of two lattice layers of pore frames; inner layer of pores large, open, subcircular to elliptical in shape (two rows per chamber). Outer layer composed of numerous, small pores and massive nodes; outer layer much thicker and better developed on circumferential ridges. Ridges quite sharp, outer layer of pore frames with at least two rows. Terminal tube open and flaring with sparse small, subcircular pores. Test with at least three medial spines that extend radially from one or more distal circumferential ridges. Spines solid, short and slender, circular in cross section.

Remarks. Differs from all other species of *Laxtorum* in having a larger test with more post-abdominal chambers. Differs from *L. porterheadense* n. sp. in having a spindle-shaped test with lateral spines confined to one or two distal post-abdominal chambers rather than randomly arranged, and in having a terminal tube. Differs from *L. perfectum* n. sp. in having a larger test with less massive medial spines.

Etymology. capitaneus (Latin) meaning chief in size, large.
Measurements (microns). Length does not include apical horn or terminal tube.

	Holotype	Average of 14 specimens	Max.	Min.
Length of test	319	293	338	263
Maximum width of test	131	124	139	111

Type locality. GSC locality C-164696/9 (87 SKU D9), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102102 (holotype) and GSC 102103 (paratype) from type locality; GSC 102104 (paratype) from GSC locality C-140489 (87 KPA 17), Kennecott Point. Also: ?Uson Island, Philippines (see Yeh, 1992).

Laxtorum sp. aff. *L. kulense* Blome
Plate 19, figure 1
Species code LAX03

aff. *Laxtorum kulense* Blome, 1984, p. 57, pl. 15, fig. 5, 11, 12, 19.

Remarks. Differs from *L. kulense* in having fewer post-abdominal chambers (usually six not seven) and narrower, sharper, circumferential ridges possessing a single, rather than double, row of pores. Differs from *L.* sp. A of Blome (1984) in having a wider, more expanded test.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimen GSC 102097 from GSC locality C-164696/9 (87 SKU D9), Kunga Island.

Laxtorum perfectum n. sp.
Plate 19, figures 9 and 10
Species code LAX04

Laxtorum ? sp. 1, in Carter, 1990, pl. 2, fig. 13.

Diagnosis. Test long, slender, spindle-shaped with short flaring terminal tube, and three massive, medial spines.

Description. Test as with genus. Test spindle-shaped, with eight to ten post-abdominal chambers and short flaring terminal tube. Cephalis and thorax conical; cephalis imperforate, thorax very sparsely perforate. Cephalis with short, tapering apical horn (broken on holotype). Abdomen and post-abdominal chambers subtrapezoidal in outline; initial chambers increasing gradually in width, final two chambers narrower. Test composed of two lattice layers: inner layer of pore frames large, open, square to rectangular; outer layer composed of numerous, irregular, small pores with massive nodes. Outer layer much thicker and best developed on circumferential ridges. Terminal tube flaring with sparse, small, subcircular pores, some obscured by thin layer of microgranular silica. Test has three, strong medial spines; spines long, solid, circular in cross section.

Remarks. For comparisons, see Remarks under *L. capitaneum* n. sp. and *L. porterheadense* n. sp.
L. perfectum n. sp. appears to be a transitional species between the genus *Laxtorum* and the new genus *Globolaxtorum*. It has fewer post-abdominal chambers than other species of *Laxtorum* and medial ones are slightly more inflated (thus resembling *Globolaxtorum*), but the terminal tube is very short, mostly imperforate, and poorly developed. At the present time it is included in genus *Laxtorum*.

Etymology. perfectus (Latin) meaning complete, finished.

Measurements (microns). Length not including apical horn or terminal tube.

	Holotype	Average of 6 specimens	Max.	Min.
Length of test	225	250	266	225
Maximum width of test	120	120	131	109

Type locality. GSC locality C-140489 (87 KPA 17), Kennecott Point. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85935 (holotype) and GSC 102106 (paratype) from type locality and GSC locality C-164674 (87 SKU SP 1) Kunga Island, respectively.

Laxtorum porterheadense n. sp.
Plate 19, figures 2, 3, 4 and 5
Species code LAX05

Diagnosis. Test almost barrel-shaped with eight to nine post-abdominal chambers; with or without medial spines.

Description. Test as with genus, usually having eight to nine post- abdominal chambers. Cephalis conical to globular, imperforate, with short apical horn. Thorax and abdomen conical, sparsely perforate. Post-abdominal chambers subtrapezoidal; initial chambers increasing gradually in width, distal chambers narrowing to produce a barrel-shaped outline. Test composed of two lattice layers of pore frames; inner layer of pores large, open, subcircular to elliptical (two rows per chamber). Outer layer composed of small pores and massive nodes; outer layer much thicker. Circumferential ridges sharp, most commonly with only one row of pore frames Distalmost chamber quite constricted, of greater height and sparsely perforate, suggesting the presence of a terminal extension, however no specimens with terminal tube have been found thus far. Test with or without medial spines. When present, spines solid, short, very slender and extending randomly from various post-abdominal chambers of test.

Remarks. See Remarks under *L. capitaneum* n. sp. for comparison with the latter species. Differs from *L. perfectum* n. sp. in having a more barrel-shaped outline, finer medial spines, and in lacking a terminal tube.

Etymology. Named for Porter Head, the eastern extremity of Tangil Peninsula, west of type locality.

Measurements (microns). Length does not include apical horn or terminal tube.

	Holotype	Average of 14 specimens	Max.	Min.
Length of test	286	245	295	199
Maximum width of test	136	119	136	94

Type locality. GSC locality C-164696/9 (87 SKU D9), Kunga Island. See Appendix 1.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 102099 (holotype), and GSC 102100 and GSC 102098 (paratypes) from type locality; GSC 102101 (paratype) from GSC locality C-164674 (87 SKU SP 1), Kunga Island.

Eucyrtid gen. and sp. indet.
Plate 20, figures 15, 16 and 19
Species code EUC01

Remarks. Long, slim, spindle-shaped, multicyrtid nassellarian with strong apical horn. Chambers include cephalis, thorax, abdomen and usually 12 or more post-abdominal chambers; width of test gradually reduced distally. No visible constrictions or abdominal ridges separate chambers. Meshwork comprised of two layers: inner layer smooth with small to moderately-sized subcircular pores, outer layer spongy.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101870 and GSC 101877 from GSC localities C-164696/7 (87 SKU D7) and C-164696/9 (87 SKU D9), Kunga Island respectively. Also Oman.

Nassellaria gen. and sp. indet. A
Plate 20, figures 9 and 14
Species code NIN01

Remarks. Test tricyrtid, pear-shaped, with strong apical horn. Cephalis small and hemispherical, thorax trapezoidal, abdomen inflated with rounded outline, partially constricted at base. Oral opening large. Test walls thick, meshwork spongy. Apical horn generally large, flattened and almost arrow-shaped, on some specimens it is very long and tapering.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illlustrated specimens GSC 102123 and GSC 102124 from GSC localities C-140373 (85 SP 9/1), Louise Island and C-140480 (87 KAP 8), Kennecott Point respectively.

Nassellaria gen.and sp. indet. B
Plate 20, figures 7 and 8
Species code NIN02

Remarks. Reminescent of Nassellaria gen. and sp. indet. A but has two spongy wing-like arms at base of abdomen.

Range. Upper Triassic; upper Norian? Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illlustrated specimens GSC 102121 and GSC 102122 from GSC localities C-140373 (85 SP 9/1), Louise Island and C-164693/14 (87 SKU B14), Kunga Island respectively.

RADIOLARIA incertae sedis

Family LIVARELLIDAE Kozur and Mostler 1981

Type genus. *Livarella* Kozur and Mostler 1981

Remarks. In this study, Family Livarellidae is interpreted in the sense of Kozur and Mostler (1981) and not as subsequently emended by Yeh (1992). Kozur and Mostler believed the livarellid test to be hollow, of uncertain origin and consequently indicated no ordinal affiliation. Yeh believes the Livarellidae are dicyrtid nassellarians composed of a small cephalis and large thorax having three to six lateral rays aligned with the dorsal, vertical, primary lateral, or secondary lateral bars of the cephalic spicule.

The three-rayed genus *Livarella* is abundant in all uppermost Triassic strata of the Sandilands Formation, Queen Charlotte Islands. On nearly all specimens observed, a strong node is present on one side of the test (see pl. 21, fig. 3, 5, 6, 10, 11, 13, 14 and 16, herein). According to Yeh, this structure (node) would correspond to the cephalis. On the opposing surface of the test, the central area between the rays is slightly rounded to almost globular (see pl. 21, fig. 3, 5, 6, 8, 14, and 16 herein). Following Yeh again, this structure plus the three rays would correspond to the thorax. Yeh's hypothesis may be correct but evidence to suggest an internal cephalic structure, an essential characteristic of the Suborder Nassellariina, is thus far poor. Yeh's specimens intended to illustrate remnants of the internal structure (Yeh, 1992, pl. 3, fig. 8 and 11; fig. 9 and 12) are not entirely convincing and internal material instead may be artifacts of preservation. Furthermore, of the many livarellids examined during the course of this study, only one specimen contains any indication of bars that might possibly constitute part of an internal spicule. In the authors view, more study with the optical microscope (and the possible sectioning of specimens) is necessary before it can be positively ascertained whether the Livarellidae are Nassellariina or Spumellariina.

The Triassic six-rayed form illustrated by Yeh (1992, pl. 3 fig. 6) is also placed in the Family Livarellidae. In this report, similar to identical forms are assigned to the genus *Citriduma* and placed in Family Neosciadiocapsidae Pessagno.

Genus *Livarella* Kozur and Mostler 1981

Type species. *Livarella densiporata* Kozur and Mostler 1981.

Remarks. From observations of Queen Charlotte Island livarellids it is apparent that almost all specimens, including the type species *Livarella densiporata* Kozur and Mostler, possess a weakly to strongly developed node on one surface of the central area of the test, with some taxa having a single open pore on the side of this node (see pl. 21, fig. 3, 4, 6, 7 and 14). The function of this pore is unknown. If indeed the node represents the cephalis (see remarks under Family Livarellidae above), the pore may be an apical pore related to one of the skeletal elements, or a sutural pore positioned at the junction between the cephalis and thorax. The pore is imperforate and does not appear to be a cephalocone (see Pessagno, 1977b, p. 43). If the livarellids are spumellarians, the function of this pore may be even more uncertain.

Range. upper Norian and Rhaetian.

Occurrence. Western North America (California, Alaska and Queen Charlotte Islands), Europe, Middle East, Japan, China, eastern USSR, the Philippines, and Oman.

Livarella densiporata Kozur and Mostler
Plate 21 figures 1, 5, 10, 13 and 16
Species code LIV01

Livarella densiporata Kozur and Mostler, 1981, p. 115, pl. 9, fig. 1. Yoshida, 1986, pl. 2, fig. 1- 2. Carter, 1990. pl. 1, fig. 3. Yeh, 1992, pl. 4, fig. 8, 11, 12 15.

Remarks. In the original description of genus *Livarella* and of the type species *L. densiporata*, Kozur and Mostler make no mention of a large node on one surface of the central area of shell. But Yoshida (1986, p. 14) when describing *L. validus* and comparing it with *L. densiporata* indicates the latter lacks a node. All specimens of *L. densiporata* illustrated here clearly possess a large node on one side of the test.

Range. Upper Triassic; upper Norian and Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 85912, GSC 101901 and GSC 101910 from GSC localities C-164674 (87 SKU SP 1), C-164696/3 (87 SKU D3) and C-150179 (86 SKU B10), Kunga Island respectively. Other occurrences: Zlambachgraben, Austria (see Kozur and Mostler, 1981); Kagamigahara area, Central Japan (see Yoshida, 1986). Uson Island, Philippines (see Yeh, 1992); Oman.

Livarella sp. aff. *L. gifuensis* Yoshida
Plate 21, figures 8 and 9
Species code LIV02

aff. *Livarella gifuensis* Yoshida, 1986, p. 15, pl. 2, fig. 6-10.

Remarks. Shape similar to *L. gifuensis* but has a small node on one surface of central part of test. Meshwork has very small pores that lack discrete pore frames; pores tend to gather together in little groups creating small, irregular, raised areas on surface of test.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101977 from GSC locality C-164696/3 (87 SKU D3), Kunga Island.

Livarella validus Yoshida emend.
Plate 21, figures 2, 3, 4, 6, 7 and 14
Species code LIV03

Livarella validus Yoshida, 1986, p. 14, pl. 3, fig. 1-3. Kojima and Mizutani, 1987, fig. 3, no.18a,b.

Emended description. In addition to having a well-developed node on one side of central part of shell, there is also a single, large pore near the base of the node. As the test of *Livarella* appears to be hollow and lack internal structure, it is difficult to tell whether this is an apical pore related to the cephalic skeletal elements, or a distal sutural or apertural pore.

Range. Upper Triassic; Rhaetian.

Occurrence. Sandilands Formation, Queen Charlotte Islands. Illustrated specimens GSC 101930 and GSC 101932 from GSC localitY C-164696/3 (87 SKU D3), Kunga Island; GSC 101943 and GSC 101949 from GSC locality C-156827 (88 KPD 1AA), Kennecott Point. Other occurrences: Kagamigahara area, Central Japan (see Yoshida, 1986); Nadanhada Range, Northeast China (see Kojima and Mizutani, 1987); Oman.

Livarella sp.
Plate 21, figures 11 and 12

Remarks. The two early forms of *Livarella* illustrated have a relatively small central area compared to the overall diameter of the test. Rays are long, uniform in width and have blunt rather than tapered ends.

Range. Upper Triassic; upper Norian.

Occurrence. Peril Formation, Queen Charlotte Islands. Illustrated specimens GSC 101984 and GSC 102024 from GSC locality C-158510 (88 SHB 3), Shields Bay, Graham Island.

CHAPTER III

SUMMARY AND CONCLUSIONS

The use of fossil groups such as ammonoids, bivalves, brachiopods, conodonts, and foraminifers for biozonation of Rhaetian strata has generated the significant problem of time-equivalent facies. Radiolarians are planktonic open marine organisms found only in deeper water environments. They are as widely distributed in the oceans today as they were in the past. Their skeletons are preserved in a variety of deep water lithologies, but the degree of facies fluctuation is limited. Radiolarians have undergone intense study in recent years and are now recognized as excellent indicators of microfaunal change through time.

Radiolarians of Rhaetian age have been recovered from deep water lithologies at localities in western North America, Austria, Japan, China, eastern Russia, New Zealand, Oman, Peru, and the Philippines; but in none of these has a demonstrably complete faunal succession been described to a significant extent. In all localities ammonoids and conodonts are rather scarce.

The diverse and well preserved radiolarians of late Norian and Rhaetian age described herein have been recovered from limestone concretions in the lower part of the Sandilands Formation, Queen Charlotte Islands. Thick, continuous stratigraphic sections of the Sandilands are exposed on northwest Graham Island (Kennecott Point) and Kunga Island. These sections overlie upper Norian *Monotis* beds of the Peril Formation and underlie younger Sandilands strata containing earliest Hettangian faunas of radiolarians and ammonites. This suggests that Triassic-Jurassic Boundary sequences may be present in both areas. Localities on Louise Island and on the south shore of Skidegate Inlet (Moresby Island) are more limited in exposure but have yielded excellent faunas. These collections supplement radiolarian data for rock intervals of similar age that are less well documented in other areas. The wealthy radiolarian-bearing sections of Queen Charlotte Islands are believed to illustrate the optimal development of the Rhaetian stage in open marine facies. Independent dating for radiolarians is provided by a low diversity conodont fauna that co-occurs in some samples, and by rare ammonoids that are associated at several levels. These fossils indicate that the Sandilands Formation overlies upper Norian beds age-equivalent to the Cordilleranus Zone, and that the top of the sequence correlates with uppermost Triassic Crickmayi Zone. Between these two points of reference other fossils are absent, but radiolarians are abundant throughout the entire Rhaetian sequence.

The Rhaetian radiolarian fauna of the Queen Charlotte Islands provides a unique glimpse of a dynamic, rapidly-evolving, morphologically-complex fauna just prior to its sudden extinction at the very end of the Triassic. The fauna is comprised of many short-ranging forms whose evolutionary history can be traced from upper Norian to Rhaetian and, in some cases, into the basal Jurassic. Genera are similar to those found in the upper Norian, but species are mostly different. The spumellarian fauna (Suborder Spumellariina) includes a variety of the families Pantanelliinae Pessagno and Ferresiidae n. fam., and the genera *Fontinella* n. gen., *Icrioma* De Wever, *Paratriassoastrum* Kozur and Mostler, *Plafkerium* Pessagno, and *Tetraporobrachia* Kozur and Mostler with mostly highly twisted spines, and the families Entactiniidae Riedel and Paleoscenidiidae Riedel, emend. Holdsworth, with a complex internal spicule. The nassellarian fauna (Suborder Nassellariina) is about equally divided between complex genera such as *Citriduma* De Wever, *Deflandrecyrtium* Kozur and Mostler, *Eptingium* Dumitrica, *Haeckelicyrtium* Kozur and Mostler, *Praecitriduma* Kozur and *Squinabolella* Pessagno, and multicyrtid forms such as *Canoptum* Pessagno, *Laxtorum* Blome, and *Proparvicingula* n. gen. Several species of the Rhaetian Livarellidae are also present. The uncertain status of this family is discussed in Chapter 2 but has not yet been satisfactorily resolved. The remaining fauna is composed of forms very similar and probably ancestral to the Jurassic Hagiastridae Riedel, emend. Baumgartner and Patulibracchiidae Pessagno, emend. Baumgartner, and the nassellarian genera *Bipedis* De Wever, *Canutus* Pessagno and Whalen, and *Droltus* Pessagno and Whalen.

New radiolarian zonation for the Rhaetian defined by Unitary Associations (U.A.; Guex, 1977) is presented here. A database recording the appearance of 136 species in 69 superposed horizons or samples of 6 sections was used to establish 27 successive U.A. with each U.A. defined by the totality of its characteristic species. U.A. were grouped into assemblages (biochronozones) following terminology of Carter 1990. Three successive radiolarian assemblages are proposed whose age is calibrated with Late Triassic ammonoid biochronology of Tozer 1979 : Assemblage 1, the lower one, approximates the lower part of the Amoenum Zone; Assemblage 2 (divided into four subassemblages) approximates the middle and upper Amoenum Zone; and Assemblage 3 is correlated with the uppermost Triassic Crickmayi Zone.

The newly proposed Rhaetian assemblages directly overlie the *Betraccium deweveri* Zone as restricted herein. The *Betraccium deweveri* Subzone was established by Blome (1984) for upper Norian radiolarians occurring with the bivalve *Monotis*. In this study, following Yoshida (1986), this subzone is raised to zone rank, and its range is restricted to the range of the nominal species *B. deweveri*. This species ranges through the upper Norian part of the Peril Formation into the basal 10 m of the Sandilands Formation, but no higher. The *B. deweveri* Zone has been confirmed worldwide and the top of this zone sets the stage for the post-Norian zonation developed here. Previously described Upper Norian (Sevat) and Rhaetian species present in the Queen Charlotte Islands fauna are listed below together with their maximum ranges as determined by this study: *Betraccium deweveri* Pessagno and Blome and *B. maclearni* Pessagno and Blome (restricted to *Betraccium deweveri* Zone); *Spongosaturnalis gracilis* Kozur and Mostler (*Betraccium deweveri* Zone to lower part of Assemblage 1); *Pantanellium fosteri* Pessagno and Blome and *Kozurastrum sandspitense* (Blome) (*Betraccium deweveri* Zone to lower part Assemblage 2); *Praecitriduma mostleri* Kozur (Assemblage 2 only); *Livarella validus* Yoshida (Assemblages 1-3); *Betraccium inornatum* Blome, *Bipedis acrostylus* Bragin, a form similar to *Canoptum triassicum* Yao, and *Livarella densiporata* Kozur and Mostler (uppermost *Betraccium deweveri* Zone through Assemblage 3). Other authors have illustrated a few additional species but the majority of the Rhaetian fauna are new. One family, five genera and sixty-three species are described.

New radiolarian assemblages established here are for local correlation of Rhaetian faunas in Queen Charlotte Islands and wherever material of similar richness may be found. However, recognizing that most other faunas are impoverished by comparison, a system of formal radiolarian zones is proposed that have worldwide distribution (Pacific-Tethys) during the Rhaetian. The age of these zones is similarly correlated with the Late Triassic ammonoid biochronology of Tozer (1979).

The *Proparvicingula moniliformis* Zone contains radiolarians of Assemblage 1 and Assemblage 2 (this study); it is approximately equivalent to the Amoenum Zone and represents the lower Rhaetian. The *Globolaxtorum tozeri* Zone contains radiolarians of Assemblage 3 (this study); it is equivalent to the Crickmayi Zone and represents the upper Rhaetian.

Radiolarians are the only fossil group capable of correlating Rhaetian strata in Queen Charlotte Islands. The precise correlation achieved between Rhaetian sequences at Kennecott Point, Louise Island, and Kunga Island substantiates the belief that radiolarians are excellent biostratigraphic indicators for zoning rock. These results indicate radiolarians can independently date strata of Rhaetian age. New assemblages and zones presented here demonstrate there is good zonation at the end of the Triassic; zonation that can be universally identified; zonation that is clearly separate from any late Norian definition; and zonation that clearly preceeds that of earliest Jurassic faunas. This study has shown that radiolarians can provide a new and promising biostratigraphic tool that will contribute significantly to a meaningful definition of the Rhaetian.

REFERENCES

Anderson, R.G. and Grieg, C.J. (1989): Jurassic and Tertiary plutonism in the Queen Charlotte Islands, British Columbia; in Current Research, Part H, Geological Survey of Canada, Paper 89-1H: 95-104.

Baumgartner, P.O. (1980): Late Jurassic Hagiastridae and Patulibracchiidae (Radiolaria) from the Argolis Peninsula (Peloponnesus, Greece); Micropaleontology, v. 26 (3): 274-322.

Baumgartner, P.O. (1984a): Comparison of Unitary Associations and Probabilistic Ranking and Scaling as applied to Mesozoic radiolarians; Computers and Geosciences, v. 10 (1): 167-183.

Baumgartner, P.O. (1984b): A Middle Jurassic-Early Cretaceous low-latitude radiolarian zonation based on Unitary Associations and age of Tethyan radiolarites; Eclogae Geologicae Helvetiae, v. 77 (3): 729-837.

Baumgartner, P.O. (1987): Age and genesis of Tethyan Jurassic radiolarites; Eclogae Geologicae Helvetiae, v. 80 (3), p. 831-879.

Baumgartner, P.O., DeWever: and Kocher, R. (1980): Correlation of Tethyan Late Jurassic-Early Cretaceous radiolarian events; Cahiers de Micropaleontologie, 2-1980: 23-85.

Baumgartner, P.O., Jud, R., O'Dogherty, and Gorican, S. (1991). Mesozoic radiolarian occurrences in the Umbria-Marche Appennines; Pre-meeting excursion, 26 to 29 September 1991, VI INTERRAD 1991, Florence, Italy, 23 p.

Blome, C.D. (1983): Upper Triassic Capnuchosphaeridae and Capnodocinae (Radiolaria) from east-central Oregon; Micropaleontology, v. 29 (1): 11-49.

Blome, C.D. (1984): Upper Triassic Radiolaria and radiolarian zonation from western North America; Bulletins of American Paleontology, v. 85 (318): 1-88.

Blome, C.D., Moore:R., Simes, J.E., and Watters, W.A. (1987): Late Triassic Radiolaria from phosphatic concretions in the Torlesse Terrane, Kapiti Island, Wellington; New Zealand Geological Survey record 18: 103-109.

Blome, C.D., Reed, K.M., and Tailleur, I.L. (1989): Radiolarian biostratigraphy of the Otuk Formation in and near the National Petroleum Reserve in Alaska; U.S. Geological Survey Professional Paper 1399: 725-776.

Bragin, N. Ju. (1986): Triassic biostratigraphy of deposits in south Sakhalin; New proceedings, Academy of Science of the USSR, Moscow, Geological Series no. 4: 61-75 (in Russian).

Bragin, N. Ju. (1990): Triassic biostratigraphy of radiolarian deposits in Eastern USSR; in Radiolarian Biostratigraphy; Academy of Science of the USSR (Urals Department), Sverdlovsk, p): 26-31 (in Russian).

Bragin, N. Ju. (1991): Radiolaria and Lower Mesozoic units of the USSR east regions; Academy of Sciences of the USSR, M.: Nauka, Transactions. v. 469, 1-125 (in Russian, with English summary).

Cameron, B.E.B. and Tipper, H.W. (1985): Jurassic stratigraphy of the Queen Charlotte Islands, British Columbia; Geological Survey of Canada, Bulletin 365, 49 pp.

Campbell, A.S. (1954): In Treatise on Invertebrate Paleontology, pt. D, Protista 3, Protzoa (chiefly Radiolaria and Tintinnina), R.C. Moore (ed.); Geological Society of America, New York, 195 p.

Carter, E.S. (1988): Radiolarian studies in the Queen Charlotte Islands, British Columbia; in Current Research, Part E, Geological Survey of Canada, Paper 88-1E: 235-238.

Carter, E.S. (1990): New biostratigraphic elements for dating Upper Norian strata from the Sandilands Formation, Queen Charlotte Islands, British Columbia, Canada; Marine Micropaleontology, v. 15: 313-328.

Carter, E.S. (1992). A new phyloglenetic lineage (Radiolaria) from the uppermost Triassic of the Queen Charlotte Islands, British Columbia; Fifth North American Paleontological Convention, Abstracts and Program, June 28 - July 1, 1992, Chicago, Illinois. The Paleontological Society, Special Publication No. 6, 1992: 53.

Carter, E.S. (1993): Evolutionary trends in latest Triassic (upper Norian) and earliest Jurassic (Hettangian) Radiolaria; Geobios, in press.

Carter, E.S. and Galbrun, B. (1990): A preliminary note on the application of magnetostratigraphy to the Triassic-Jurassic boundary strata, Kunga Island, Queen Charlotte Islands, British Columbia; in Current Research, Part F, Geological Survey of Canada, Paper 90-1F: 43-46.

Carter, E.S., Orchard, M.J., and Tozer, E.T. (1989): Integrated ammonoid - conodont - radiolarian biostratigraphy, Late Triassic Kunga Group, Queen Charlotte Islands, British Columbia; in Current Research, Part H, Geological Survey of Canada, Paper 89-1H: 23-30.

Cheng, Yen-nien (1989): Upper Paleozoic and Lower Mesozoic radiolarian assemblages from the Busuanga Islands, North Palawan Block, Philippines; Bulletin of the National Museum of Natural Science, Taiwan, No.1: 129-176.

Cordey, F., Gordey, S.P., and Orchard, M.J. (1991): New biostratigraphic data from the northern Cache Creek Terrane, Teslin map area, southern Yukon; in Current Research, Part E; Geological Survey of Canada, Paper 91- 1E: 67-76.

Dagys, A.S. (1988): An alternative interpretation of the Rhaetian; in Albertiana 7: 4-6): _Dagys, A.S. (1993): Global correlation of the terminal Triassic; Symposium on Triassic Stratigraphy, Lausanne, Switzerland, October 20-23, 1991. Symposium volume, in press.

Deflandre, G. (1953): Radiolaires fossiles; in Traité de Zoologie:P. Grassé (ed.); Masson, Paris; v. 1 (pt. 2) p. 389-436.

De Wever, P. (1982): Nassellaria (Radiolaires Polycystines) du Lias de Turquie; Revue de Micropaléontologie, v. 24 (4): 189-232.

De Wever, P. (1984): Révision des Radiolaires Mésozoïques de type Saturnalide, proposition d'une nouvelle classification; Revue de Micropaléontologie, v. 27 (1): 10-19.

De Wever, P. Sanfilippo, A., Riedel, W.R., and Gruber, B. (1979): Triassic radiolarians from Greece, Sicily and Turkey; Micropaleontology, v. 25 (1), p): 75-110.

Donfrio, D.A. and Mostler, H. (1978): Zur Verbreitung der Saturnalidae (Radiolaria) im Mesozoikum der Nördlichen Kalkalpen und Südalpen; Geologisch - Paläontologische Mitteilungen, Innsbruck Bd. 7 (5): 1-55 (in German, with English summary).

Dumitrica, P.(1978a): Family Eptingiidae, n. fam., extinct Nassellaria (Radiolaria) with sagital ring; Dari de seama ale sedintelor; Institutul de geologie si geofizica, v. 64, (1976-1977), pt. 3, Paleontology: 27-38.

Dumitrica, P.(1978b): Triassic Palaeoscenidiidae and Entactiniidae from the Vicentinian Alps (Italy) and Eastern Carpathians (Romania); Dari de seama ale sedintelor; Institutul de geologie si geofizica, v. 64, (1976-1977), pt. 3, Paleontology: 39-54.

Dumitrica, P.(1985): Internal morphology of the Saturnalidae (Radiolaria): systematic and phylogenetic consequences; Revue de Micropaléontologie, v. 28 (3): 181-196.

Dumitrica, P., Kozur, H., and Mostler, H. (1980): Contribution to the radiolarian fauna of the Middle Triassic of the Southern Alps; Geologisch - Paläontologische Mitteilungen, Innsbruck Bd. 10 (1): 1-46.

Ehrenberg, C.G. (1838): Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbar Organismen; Königliche Preussischen Akademie der Wissenschaften zu Berlin, Abhandlungen, Jahre 1838: 59-147, pls. 1-4.

Ehrenberg, C.G. (1875): Fortsetzung der mikrogeologischen Studien als Gesammtübersicht der mikroskopischen Paläontologie gleichartig analysierter Gebirgsarten der Erde, mit spezieller Rücksicht auf den Polycystinen -Mergel von Barbados; Königliche Preussischen Akademie der Wissenschaften zu Berlin, Abhandlungen, Jahre 1875: 1-225, pls. 1-30.

Epstein, A.G., Epstein, J.B. and Harris, L.D. (1977): Conodont Colour Alteration - an index to organic metamorphism; United States Geological Survey, Professional Paper 995, 27 p.

Foreman, H. (1969): Upper Devonian Radiolaria from the Huron member of the Ohio shale; Micropaleontology, v. 9 (3): 267-304, pls. 1-9.

Guex, J. (1977): Une nouvelle méthode de corrélations biochronologiques; Bull. Géol. Uni. Lausanne, no. 224: 309-322.

Guex, J. (1991): Biochronological Correlations; Springer Verlag, 252 p.

Guex, J. and Davaud, E. (1984): Unitary Associations method: Use of Graph Theory and Computer Algorithm; Computer Geosciences, v. 10 (1): 69-96.

Haeckel, E. (1862): Die Radiolarien (Rhizopoda, Radiolaria); Eine Monographie Reimer, Berlin, xiv + 572 p., atlas, 35 pls.

Haeckel, E. (1881): Entwurf eines Radiolarien-Systems auf Grund von Studien der Challenger-Radiolarien; Jenaische Zeitschrift für Naturwissenschafter, 15 (n. ser., 8; 1882) (3): 418-472.

Haeckel, E. (1882): Über die Radiolarien der Challenger-Expedition; Gesellschaft Deutscher Naturforscher und Aerzte, Tageblatt der Versammlung: 196-197.

Hillebrandt, A. v. (1993): The Triassic/Jurassic boundary and Hettangian biostratigraphy in the area of the Utcubamba Vallley (Northern Peru); Geobios, in press.

Holdsworth, B.K. (1977): Paleozoic Radiolaria: Stratigraphic distribution in Atlantic borderlands; in Stratigraphic micropaleontology of the Atlantic Basin and borderlands. Amsterdam; Elsevier Publication Co.: 167-184.

ICZN (International Code of Zoological Nomenclature). (1985): International Trust for Zoological Nomenclature, London, i-xx + 338 p. (third edition).

Jud, R. (1991): Biochronology and systematics of Early Cretaceous Radiolaria of the western Tethys; PhD thesis, Université de Lausanne.

Kishida, Y. and Sugano, K. (1982): Radiolarian Zonation of Triassic and Jurassic in Outer Side of Southwest Japan; News of Osaka Micropaleontologists v. 5: 271-300 (in Japanese, with English abstract).

Kishida, Y. and Hisada, K. (1985): Late Triassic to Early Jurassic Radiolarian Assemblages from the Ueno-mura area, Kanto Mountains, Central Japan; Memoirs of Osaka Kyoiku University, Ser. 3 (34), p): 103-120.

Kishida, Y. and Hisada, K. (1986): Radiolarian Assemblages of the Sambosan Belt in the western part of the Kanto Mountains, Central Japan; News of Osaka Micropaleontologists v. 7: 25-34 (in Japanese, with English abstract).

Kojima, S. (1989): Mesozoic terrane accretion in Northeast China, Sikhkote-Alin and Japan regions; Palaeogeography, Palaeoclimatology, Palaeoecology, v. 69: 213-232.

Kojima, S. and Mizutani, S. (1987): Triassic and Jurassic Radiolaria from the Nadanhada Range, Northeast China; Transactions and Proceedings Palaeontological Society of Japan, 148: 256-275.

Kozur, H. (1984a): New radiolarian taxa from the Triassic and Jurassic; Geologisch - Paläontologische Mitteilungen, Innsbruck, v. 13 (2): 49-88.

Kozur, H. (1984b): The Triassic radiolarian genus, *Triassocrucella* gen. nov. and the Jurassic *Hagiastrum* Haeckel, 1882; Journal of Micropalaeontology, v. 3 (1): 33-35.

Kozur, H. and Mostler, H. (1972): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil I: Revision der Oberfamilie Coccodiscacea HAECKEL 1862 emend. und Beschreibung iher triassischen Vertreter; Geologisch - Paläontologische Mitteilungen, Innsbruck, Bd. 2 (8/9): 1-60 (in German, with English abstract).

Kozur, H. and Mostler, H. (1978): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil II: Oberfamilie Trematodiscacea HAECKEL 1862 emend. und Beschreibung iher triassischen Vertreter; Geologisch - Paläontologische Mitteilungen, Innsbruck, Bd. 8: 123-182 (in German, with English abstract).

Kozur, H. and Mostler, H. (1979): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil III: Die Oberfamilien Actinommacea HAECKEL 1862 emend., Artiscacea HAECKEL 1882, Multiarcusellacea nov. der Spumellaria und triassische Nassellaria; Geologisch - Paläontologische Mitteilungen, Innsbruck, Bd. 9 (1/2):1-132 (in German, with English abstract).

Kozur, H. and Mostler, H. (1981): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil IV : Thalassosphaeracea HAECKEL, 1862, Hexastylacea HAECKEL, 1882, emend. Petrushevskaja, 1979, Sponguracea HAECKEL, 1862 emend. und weitere triassische Lithocycliacea, Trematodiscacea, Actinommacea und Nassellaria; Geologisch - Paläontologische Mitteilungen, Innsbruck, Sonderband 1, 208 pp. (in German, with English abstract).

Kozur, H. and Mostler, H. (1983): The polyphyletic origin and the classification of the Mesozoic saturnalids (Radiolaria); Geologisch - Paläontologische Mitteilungen, Innsbruck, Bd. 13, p. 1-47.

Kozur, H. and Mostler, H. (1990): Saturnaliacea Deflandre and some other stratigraphically important Radiolaria from the Hettangian of Lenggries/Isar (Bavaria, Northern Calcareous Alps); Geologisch - Paläontologische Mitteilungen, Innsbruck, Bd. 17, p. 179-248.

Krystyn, L. (1980): Triassic conodont localities of the Salzkammergut Region (Northern Calcareous Alps); Abh. Geol. Bundesanst. Wien, 35: 62-98.

Krystyn, L.(1988): Zur Rhaet-Stratigraphie in den Zlambach-Schichten (vorlaeufiger Bericht); Sitzungsber): der Oesterr. Akad. Wissensch, (Wien), 1, 196 (1-4): 21-36.

Lahm, Bernhard (1984): Spumellarienfaunen (Radiolaria) aus den mittletriassischen Buchensteiner-Schichten von Recoaro (Norditalien) und den obertriassischen Reiflinge-kalken von Grossreifling (Österreich) - Systematik - Stratigraphie; Münchner Geowissenschaftliche Abhandlungen (A) v. 1, 161 pp. (in German, with English and French abstract).

Matsuoka, A. (1982): Jurassic two-segmented nassellarians (Radiolaria) from Shikoku, Japan; Journal of Geoscience, Osaka City University, v. 25 (5): 71-86.

Matsuoka, A. (1983): The conformable relationship between chert beds and clastic beds in the Triassic-Jurassic sequence of the southern subbelt of the Chichibu Belt, Kochi Prefecture; Journal of the Geological Society of Japan, v. 89 (7): 407-410.

Matsuoka, A. (1984): Togano Group of the Southern Chichibu Terrane in the western part of Kochi Prefecture, southwest Japan; Journal of the Geological Society of Japan, v. 90 (7): 455-477.

Mizutani, S., Shao, J., and Zhang, Q. (1990): The Nadanhada Terrane in Relation to Mesozoic Tectonics on Continental Margins of East Asia; Acta Geologica Sinica, v. 3, no.1: 15-29.

Müller, J. (1858): Über die Thalassicollen, Polycystinen und Acanthometren der Mittelmeeres; Abhandlungen der Preussischen Akademie der Wissenschaftler zu Berlin, Jahrgang, 1858: 1-62, pls. 1-11.

Orchard, M.J. (1983): *Epigondolella* populations and their phylogeny and zonation in the Upper Triassic; Fossils and Strata, v. 15: 177-192.

Orchard, M.J. (1991): Late Triassic conodont biostratigraphy of the Kunga Group, Queen Charlotte Islands, British Columbia; in Evolution and hydrocarbon potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.), Geological Survey of Canada Paper 90-10:173-194.

Orchard, M.J., Carter, E.S. and Tozer, E.T. (Paleontological data); Weston, M.L., Woodsworth, G.J., Orchard, M.J., and Johns, M.J. (database design); Forester:J.L., Lesack, K., and McKay, K. (compilers). (1991): Electronic Database of Kunga Group Biostratigraphic data; Geological Survey of Canada, Open File 2284.

Orchard, M.J. and Forster P.J.L. (1991): Conodont colour and thermal maturity of the Late Triassic Kunga Group, Queen Charlotte Islands, British Columbia; in Evolution and Hydrocarbon potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.), Geological Survey of Canada Paper 90- 10: 453-464.

Orchard, M.J. and Desrochers, A. (1990): Stratigraphic revisions and carbonate sedimentology of the Kunga Group (Upper Triassic-Lower Jurassic), Queen Charlotte Islands, British Columbia; in Evolution and Hydrocarbon potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.), Geological Survey of Canada Paper 90-10: 163-172.

Palfy, J. (1991): Uppermost Hettangian to lowermost Pliensbachian (Lower Jurassic) biostratigraphy and ammonoid fauna of the Queen Charlotte Islands, British Columbia; Unpublished M. Sc. Thesis, University of British Columbia, April, 1991.

Pessagno, E.A. Jr. (1969): The Neosciadiocapsidae, a new family of Upper Cretaceous Radiolaria; Bulletins of American Paleontology, v. 56 (253): 377-439. (1971): Jurassic and Cretaceous Hagiastridae from the Blake-Bahama Basin (Site 5A, JOIDES leg 1) and the Great Valley Sequence, California Coast Ranges; Bulletins of American Paleontology, v. 60 (264): 1-83, Pls. 1-19, text-figs. 1-5.

Pessagno, E.A. Jr. (1977a): Upper Jurassic Radiolaria and radiolarian biostratigraphy of the California Coast Ranges; Micropaleontology, v. 23 (1): 56-113, pls. 1-12.

Pessagno, E.A. Jr. (1977b): Lower Cretaceous radiolarian biostratigraphy of the Great Valley Sequence and Franciscan Complex, California Coast Ranges; Cushman Foundation for Foraminiferal Research, Special Publication 15, 87 p.

Pessagno, E.A. Jr. and Blome, C.D. (1980): Upper Triassic Pantanelliinae from California, Oregon and British Columbia; Micropaleontology, v. 26 (3): 225-273.

Pessagno, E.A. Jr., Finch, W., and Abbott, P.L. (1979): Upper Triassic Radiolaria from the San Hipólito Formation, Baja California; Micropaleontology, v. 25: 160-197.

Pessagno, E.A. Jr., Six, W.M., and Yang, Q (1989): The Xiphostylidae Haeckel and Parvivaccidae, n. fam., (Radiolaria) from the North American Jurassic; Micropaleontology, v. 35 (3): 193-255, pls. 1-10.

Pessagno, E.A. Jr. and Whalen, P.A. (1982): Lower and Middle Jurassic Radiolaria (multicyrtid Nassellariina) from California, east- central Oregon and the Queen Charlotte Islands, B.C.; Micropaleontology, v. 28 (2), p): 111-169.

Riedel, W.R. (1967a): Some new families of Radiolaria; Proceedings of the Geological Society of London, no): 1640: 148-149.

Riedel, W.R. (1967b): Subclass Radiolaria; in The Fossil Record, W.R. Harland (ed.); Geological Society of London: 291-298.

Riedel, W.R. (1971): Systematic classification of polycystine Radiolaria; in The Micropalaeontology of Oceans, B.M. Funnell and W.R. Riedel (eds.); Cambridge University Press: 649-661.

Rüst, H. (1885): Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen des Jura; Palaeontographica, v. 31: 269-322, pls. 26-45.

Sato, T., Murata, M., and Yoshida, H. (1986): Triassic to Jurassic radiolarian biostratigraphy in the southern part of the Chichibu terrane of Kyushu, Japan; News of Osaka Micropaleontologists, Special Volume No. 7, p): 9-23 (in Japanese, with English abstract).

Savary, J. and Guex, J. (1991): BioGraph: un nouveau programme de construction de corrélations biochronologiques basées sur les associations unitaires; Bull. Géol. Lausanne, 313: 317-340.

Spörli, K.B. and Aita, Y. (1988): Field trip guide to Waipapa basement rocks, Kawakawa Bay, Auckland, Workshop of Radiolaria 1988; Geological Society of New Zealand Miscellaneous Publication 39, 27 p.

Spörli, K.B., Aita, Y, and Gibson, G.W. (1989): Juxtaposition of Tethyan and non-Tethyan Mesozoic radiolarian faunas in melanges, Waipapa terrane, North Island, New Zealand; Geology, v. 17: 753-756. August,1989.

Squinabol, S. (1903): Le Radiolarie dei noduli Seliciose nella Scaglia degli Euganei. Contribuzione 1; Rivista italiana di paleontologia, Bologne, v. 9 (4): 105-156.

Squinabol, S. (1914): Contributo alla conoscenza dei Radiolarii fossili del Venetas Appendice - Di un genera di Radiolarii caratteristico del Secondario; Università di Padova, Memorie, v. 2: 249- 306, pls. 20-24.

Sutherland Brown, A. (1968): Geology of the Queen Charlotte Islands, British Columbia; British Columbia Department of Mines and Petroleum Resources, Bulletin 54, 226 p.

Tichomirova, L.B. (1975): Novyj rod Saturnosphaera (radioljarii) iz kremnistych tolsc Sichote- Alinja; in Zamojda, A.I.: Sistematiceskoe i stratigraficeskoe znacenie radioljarii, Leningrad, p): 52-58.

Tipper, H.W. and Carter, E.S. (1990): Evidence for defining the Triassic-Jurassic boundary at Kennecott Point, Queen Charlotte Islands, British Columbia; in Current Research, Part F, Geological Survey of Canada Paper 90-1F: 37-41.

Tipper, H.W., Carter, E.S., Orchard, M.J. and Tozer, E.T. (1993): The Triassic-Jurassic (T-J) Boundary in Queen Charlotte Islands as defined by ammonoids, conodonts and radiolarians; Geobios, in press.

Tipper, H.W., Smith, P.L., Cameron, B.E.B., Carter, E.S., Jakobs, G.K. and Johns, M.J. (1991): Biostratigraphy of the Lower Jurassic formations of the Queen Charlotte Islands, British Columbia; in Evolution and hydrocarbon potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.), Geological Survey of Canada Paper 90-10, p): 203-236.

Tozer, E.T. (1979): Latest Triassic ammonoid faunas and biochronology, Western Canada; in Current Research, Part B, Geological Survey of Canada, Paper 79-1B: 127-135.

Vinassa de Regne: E. (1899): I Radiolari delle ftaniti titoniane de Carpena (spezoa); Paleontographica Italica, vol. 4: 217-238, pls. 17-18.

Whalen, P.A. (1985): Lower Jurassic radiolarian biostratigraphy of the Kunga Formation, Queen Charlotte Islands, British Columbia, and the San Hipolito Formation, Baja California Sur; Unpublished Ph.D Dissertation, The University of Texas at Dallas, 441 p.

Yang, Q. and Mizutani, A. (1991): Radiolaria from the Nadanhada Terrane, Northeast China; The Journal of Earth Sciences, Nagoya University, vol. 38: 49-78.

Yao, A. (1972): Radiolarian fauna from the Mino Belt in the northern part of the Inuyama area, Central Japan, Part 1, Spongosaturnalids; Journal of Geosciences, Osaka City University, v. 15 (2): 21-64.

Yao, A. (1982): Middle Triassic to Early Jurassic radiolarians from the Inuyama area, Central Japan; Journal of Geosciences, Osaka City University, v. 25 (4): 53-70.

Yao, A. (1983): Late Paleozoic and Mesozoic radiolarians from southwest Japan. in Ijima, A., Hein, J.R): and Siever, R., eds., Siliceous deposits in the Pacific Region, Elsevier Scientific Publishing Company, Amsterdam: 361-376.

Yao, A. (1991): Triassic and Jurassic Radiolarians (p. 329-345, Journal reference not cited); in Radiolarian Biostratigraphy and its International Correlation, Report of Co-operative Research (A), March 1991; Part 3: 499-515.

Yao, A., Matsuda, T., and Isozaki, Y. (1980a): Triassic and Jurassic Radiolarians from the Inuyama Area, Central Japan; Journal of Geoscience, Osaka City University, v. 23: 135-154.

Yao, A., Matsuda, T., and Isozaki, Y. (1980b): Triassic and Jurassic Radiolarians in Inuyama of the Mino Belt; Abstract Program, 1980 Annual Meeting Geological Society of Japan: 221.

Yao, A., Matsuoka, A., and Nakatani, T. (1982): Triassic and Jurassic radiolarian assemblages in Southwest Japan; News of Osaka Micropaleontologists, v. 5: 27-43 (in Japanese, with English abstract).

Yeh, Kuei-Yu (1987): Taxonomic studies of Lower Jurassic Radiolaria from East-Central Oregon; National Museum of Natural Science, Taiwan, Special Publication No. 2, 169 p.

Yeh, Kuei-Yu (1987): A revised classification for Family Canoptidae (Radiolaria); Memoir of the Geological Society of China, v. 8: 63-72.

Yeh, Kuei-Yu (1989): Studies of Radiolaria from the Fields Creek Formation, east-central Oregon, U.S.A.; Bulletin of the National Museum Natural Science, Taiwan, No.1: 43-110.

Yeh, Kuei-Yu (1992): Triassic Radiolaria from Uson Island, Philippines; Bulletin of the National Museum of Natural Science, Taiwan, No. 3: 51-91.

Yoshida, H. (1986): Upper Triassic to Lower Jurassic radiolarian biostratigraphy in Kagamigahara City, Gifu Prefecture, central Japan; Journal of Earth Science, Nagoya University, v. 34, p): 1-21.

APPENDIX I - LOCALITY DESCRIPTIONS

Introduction

Queen Charlotte Island samples are prefixed by the year collected and collector. Samples prefaced CNA , 88 OF, and JF were collected by E.S. Carter, M.J. Orchard, and M.J. Johns respectively, 86 OF and 90 OF samples (and 88 OF LI 1) collected jointly by E.S. Carter and M.J. Orchard. Geological Survey of Canada locality numbers follow sample numbers in parenthesis. Ammonite and conodont identifications in the following discussion by Drs. E.T. Tozer and M.J. Orchard respectively, both of the Geological Survey of Canada, Cordilleran Division, Vancouver, B.C..

Kennecott Point, northwest Graham Island

Upper Norian to lower Sinemurian strata of the Sandilands Formation are exposed on a widespread bench at Kennecott Point just south of Peril Bay. The Sandilands Formation conformably overlies the upper part of the Peril Formation whose resistant, highly-outcropping beds contain a great abundance of monotiid bivalves.

Section KPA (U.A. section 1): NTS Frederick Island 103 F/14. UTM 621160m E; 5975325m N (53° 54' 50.7" N, 133° 09' 19.4" W). Includes the upper Norian and Rhaetian part of the Sandilands Formation; base of section begins immediately above topmost beds of the Peril Formation. Samples prefixed KPX are from a short section that parallels KPA but lies directly west of it across a small fault. Thick calcareous sandstone marker beds in KPX can be traced across this fault to their counter-parts in KPA. The two sections are treated here as a single composite section.

90 JF KPH 1 (C-173404). Isolated sample collected west of section KPA just above a 2 m gulley (presumably a small fault) between top of Peril and base of Sandilands formations. Sample is a 5 cm x 15 cm flattened micrite concretion. Lithology of surrounding beds indicates sample from very low in the Sandilands Formation, probably in the basal five meters.
87 CNA KPA 3B (C-140474). Collected 4.5 m above base of Sandilands Formation; 8-10 cm thick concretionary limestone lens.
88 CNA KPA R3 (C-156789). Collected 7.5 m above base of Sandilands Formation; 3-4 cm thick concretionary limestone bed.
87 CNA KPA 5 (C-140477). Collected 8.5 m above base of Sandilands Formation; 2 cm x 20 cm micrite nodule. Occurs with *Epigondolella* ex gr. *bidentata* Mosher, and ramiform elements (Orchard et al. 1990).
88 CNA KPA R5 (C-156792). Collected 12.0 m above base of Sandilands Formation; 2 cm x 20 cm micrite nodule. Occurs with *Epigondolella* ex gr. *bidentata* Mosher, and ramiform elements (Orchard et al. 1990).
89 CNA KPA 3 (C-159341). Collected 12.6 m above base of Sandilands Formation; parts of three micrite nodules, each 3 cm x 10 cm.
87 CNA KPA 6 (C-140478). Collected 15 m above base of Sandilands Formation; 20 cm x 25 cm micrite nodule. Occurs with *Epigondolella* ex gr. *bidentata* Mosher (slender morph), and ramiform elements (Orchard et al. 1990).
88 OF KPA E (C-156743). Collected 15 m above base of Sandilands Formation; 4 cm x 15 cm micrite nodule. Occurs with *Epigondolella* ex gr. *bidentata* Mosher (slender morph) and *Parvigondolella* sp. (Orchard et al. 1990).
90 OF KPX 6 (C-176900). Collected 18.0 above base of Sandilands Formation; small irregular nodules. Occurs with *Epigondolella* ex gr. *bidentata* Mosher (slender morph) (M.J.O., personal communication, 1991).
89 CNA KPX 3 (C-164737). Collected 24.8 m above base of Sandilands Formation; 3 cm x 15 cm irregular micrite nodule. Occurs with *Epigondolella* ex gr. *bidentata* Mosher (slender morph) and ramiform elements (M.J.O., personal communication, 1990).
87 CNA KPA 8 (C-140480). Collected 26.5 m above base of Sandilands Formation; small micrite nodule in 3 cm siltstone bed.
90 OF KPX 14 (C-176904). Colleced from nodular bed 32.0 m above base of Sandilands Formation. Occurs with *Epigondolella* ex gr. *bidentata* Mosher (slender morph) (M.J.O., personal communication, 1991).
88 CNA KPA R8 (C-156796). Collected 33.0 m above base of Sandilands Formation; 5 cm x 30 cm concretionary nodule.
87 CNA KPA 10 (C-140482). Collected 34.5 m above base of Sandilands Formation; 10 cm x 40 micrite concretion at base of two thick concretionary sandstone beds.
89 CNA KPA 10 (C-159349). Collected 45.2 m above base of Sandilands Formation; 3 cm x 10 cm limestone nodule. Occurs with *Epigondolella* ex gr. *bidentata* Mosher (slender morph) (M.J.O., personal communication, 1990).

87 CNA KPA 12 (C-140484); 89 CNA KPA 11 (C-159348). Samples collected in 1987 and 1989 from the same 30 cm x 100 cm micrite nodule, 46.5 m above base of Sandilands Formation. *Neogondolella* sp. and ramiform elements in 89 CNA KPA 11 (M.J.O., personal communication, 1990).
87 CNA KPA 14 (C-140486). Collected 49.5 m above base of Sandilands Formation; 10 cm x 5 cm micrite nodule.
89 CNA KPA 14 (C-164744). Collected 57.2 m above base of Sandilands Formation; 5-10 cm limestone bed. Occurs with *Neogondolella* sp. (M.J.O., personal communication, 1990).
88 CNA KPA R15 (C-156803). Collected 60.75 m above base of Sandilands Formation; 25 cm x 60 cm limestone concretion. Occurs with *Neogondolella* sp. and ramiform elements (Orchard et al. 1990).
89 CNA KPA 16 (C-164746). Collected 65.5 m above base of Sandilands Formation; 10 cm x 40 cm limestone concretion.
89 CNA KPA 17 (C-164747). Collected 66.0 m above base of Sandilands Formation; small flattened nodules (5 cm x 15 cm).
90 OF KPA 17 (C-176863). Collected 68.0 m above base of Sandilands Formation; top of 5 cm limestone bed. Conodont ramiform elements (M.J.O., personal communication, 1991).
87 CNA KPA 17 (C-140489)/ 89 CNA KPA 18 (C-164748). Collected 69 m above base of Sandilands Formation; 15 cm x 100 cm micrite concretion.
88 OF KPA R18A (C-156526). Collected 73.5 m above base of Sandilands Formation in limestone shell bed; contains *Misikella posthernsteini* Kozur and Mock and ramiform elements (Orchard et al. 1990). Carter (1990) mentioned sample as occurring with *Choristoceras* cf. *C. rhaeticum* Guembel (E.T.T., personal communication,1988); Tozer now believes ammonoid is *Choristoceras nobile* Mojsisovics; sample occurs 4.5 m below an upper ammonoid level containing *Choristoceras rhaeticum* Guembel (E.T.T., personal communication,1990).
90 OF KPA 23 (C-176871). Collected 81.6 m above base of Sandilands formation; large sandy doughnut-shaped concretion (25 cm x 120 cm). Conodont ramiform elements (M.J.O., personal communication, 1991).
90 OF KPA 24 (C-176872). Collected 83.8 m above base of Sandilands Formation; 20 cm x 70 cm limestone nodule. *Thalassinoides* on surrounding siltstone bedding plane.
90 OF KPA 25 (C-176873). Collected across small fault 85.1 m above base of Sandilands Formation; limestone lens.

Section KPD (U.A. section 2). NTS Frederick Island 103 F/14. UTM: 621250m E; 5975340m N. (53° 54' 51.2" N, 133° 09' 14.5" W). Sandilands Formation. A continuous sequence of Rhaetian to lower Hettangian beds is exposed on another area of the bench southeast of section KPA, along the beach (Tipper and Carter, 1990). Only one sample from this section is included here.

88 CNA KPD 1AA (C-156827). Collected 1.0 m above base of section KPD (Triassic-Jurassic boundary section) from 30 cm x 50 cm limestone lens. Sandilands Formation. Occurs with *Neogondolella* sp. and ramiform elements (Orchard et al. 1990). Sample is 14.0 m below specimens of *Choristoceras* found in large float blocks . A upper level containing *Choristoceras* lies approximately 5.0 m above the former. Ammonoid levels are believed to be approximately equivalent to the ones found at 73.5 and 78 m in section KPA (E.T.T. personal communication, 1991).

Section KP. NTS Frederick Island 103 F/14. UTM 621170m E; 5975500m N (53° 54' 56.4" N, 133° 09' 18.6" W). Peril Formation. About 50 m of resistant, continuous lime mudstone beds are exposed on the most northerly part of the bench northwest of section KPA. These beds represent the uppermost part of the Peril Formation and contain several species of the pelagic bivalve *Monotis* and rare ammonoids referable to the upper Norian Cordilleranus Ammonoid Zone (Orchard et al. 1990). One sample from this section is included here.

88 OF KP M3A (C-156504). Collected 11.0 m above datum (= base of section at low tide mark) from shell bed. Occurs with *Monotis salinaria* Bronn and *Epigondolella bidentata* Mosher (Orchard et al. 1990).

Kunga Island, south side
Upper Norian, Rhaetian and Hettangian strata of the Kunga Group are exposed, younging eastward along strike, on the southeast shore of Kunga Island. The sequence is faulted and intruded by dykes and sills especially in the lower part (Peril Formation), but some quite lengthy coherent intervals are present between areas of disruption. Dip varies from moderately steep to almost vertical, and the entire sequence is overturned. Upper Norian rocks are exposed only at low tide but the Rhaetian sequence is generally more resistant, outcrops higher on the shore, and in one area forms quite a high seaside knoll. Two sections on Kunga Island (SKU B and SKU D) are discussed below.

Section SKU B (U.A. section 3): NTS Louise Island 103 B/13 & 103 B/14. UTM 326900m E; 5848075m N (52° 45' 24.1" N, 131° 33' 54.3" W). Section B (the more westward of the two) begins in the upper part of the Peril Formation immediately above a 2.5 m greenstone sill. The lower part of the section (Peril Formation) is overlain by basal beds of the Sandilands Formation over a contact interval of less than 0.5 m. The lowest sample (86 OF SKU B4) was collected in the Peril Formation but all succeeding samples are from the Sandilands Formation. The lower part of section B was first visited in 1986, the upper part in 1987. In 1989 the entire section was revisited and it was discovered that a lengthy sequence of beds existed between the lower and upper parts measured in 1986 and 1987 respectively. At this time the entire section was remeasured and collected and discrepancies have since been corrected. For these reasons, and because the section illustrated here (Fig. 4) is drawn only from above the greenstone sill, measurements formerly used by Carter (1990) have been revised.

86 OF SKU B4 (C-150173). Collected 7.0 m above base of section; 5 cm limestone bed.
89 CNA SKU B5 (C-173294). Collected 31.7 m above base of section; 4 cm x 18 cm micrite nodule.
89 CNA SKU B9 (C-173298). Collected 41.0 m above base of section; nodular layer, sample is 10 cm x 30 cm. Occurs with *Epigondolella* ex. gr. *bidentata* Mosher, *Parvigondolella* and ramiform elements (M.J.O., personal communication, 1991).
86 OF SKU B10 (C-150179). Collected 44.5 m above base of section from nodular layer; sample is 10 cm x 3 cm. Previously stated as 81.5 m above base of Sandilands Formation (Carter 1990).
89 CNA SKU B10 (C-173299). Collected 45.0 m above base of section; nodular layer, sample is 10 cm x 40 cm. Occurs with *Epigondolella* ex. gr. *bidentata* Mosher (slender morph) and ramiform elements (M.J.O., personal communication, 1991).
89 CNA SKU B11 (C-173300). Collected 48.0 m above base of section; 10 cm x 30 cm micrite nodule. Occurs with *Epigondolella* ex. gr. *bidentata* Mosher (slender morph), *Parvigondolella* and ramiform elements (M.J.O., personal communication, 1991).
89 CNA SKU B12 (C-173301). Collected 50.5 m above base of section; 8 cm x 40 cm micrite nodule.
89 CNA SKU B13 (C-173302). Collected 53.0 m above base of section; 15 cm x 45 cm micrite nodule. Occurs with *Epigondolella* ex. gr. *bidentata* Mosher (slender morph) and ramiform elements (M.J.O., personal communication, 1991).
89 CNA SKU B14 (C-173303). Collected 57.5 m above base of section; 10 cm x 30 cm micrite nodule. Occurs with *Epigondolella* ex. gr. *bidentata* Mosher (slender morph) (M.J.O., personal communication, 1991).
89 CNA SKU B15 (C-173304). Collected 62.5 m above base of section; 3 cm x 10 cm micrite nodule.
89 CNA SKU B16 (C-173305). Collected 62.9 m above base of section; limestone concretion.
87 CNA SKU B12 (C-164693/12). Collected 64.0 m above base of section; composite sample of two micrite nodules (75 cm x 5 cm; 30 cm x 5 cm). Previously stated as 87.0 m above base of Sandilands Formation (Carter, 1990).
89 CNA SKU B17 (C-173306). Collected 65.1 m above base of section; composite sample of three small concretions. Occurs with *Epigondolella* ex. gr. *bidentata* Mosher (slender morph) (M.J.O., personal communication, 1991).
87 CNA SKU B13 (C-164693/13). Collected 70.0 m above base of section; 3 cm x 10 cm micrite nodule. Previously stated as 90.0 m above base of Sandilands Formation (Carter 1990).
89 CNA SKU B19 (C-173308). Collected 71.2 m above base of section; 8 cm x 12 cm micrite nodule. Occurs with *Neogondolella* and ramiform elements (M.J.O., personal communication, 1991).
87 CNA SKU B14 (C-164693/14). Collected 72.0 m above base of section; 4 cm x 20 cm micrite nodule. Previously stated as 92.0 m above base of Sandilands Formation (Carter, 1990).
89 CNA SKU B22 (C-173311). Collected 78.2 m above base of section; 12 cm x 30 cm micrite nodule.
87 CNA SKU B16 (C-164693/16). Collected 81.0 m above base of section; 3 cm x 20 cm micrite nodule. Previously stated as 101.0 m above base of Sandilands Formation (Carter, 1990).

Section SKU D (U.A. section 5): NTS Louise Island 103 B/13 & 103 B/14. UTM 327240m E ; 5848290m N (52° 45' 31.4" N, 131° 33' 36.6" W). Sandilands Formation: an apparently conformable sequence of Rhaetian to lower Hettangian strata overlain, with little evidence of unconformity, by slightly younger Hettangian rocks (H.W. Tipper, Personal communication, (1991). Section SKU D begins about 75 m east of SKU B on the next small point, beyond a disrupted interval that may contain a small fault slice of Peril Formation. Lowest beds of SKU D are relatively low in the Sandilands Formation, but not basal. Section first visited in 1987, revisited in 1989 to collect additional samples and confirm measurements.

89 CNA SKU D1 (C-173263). Collected 1.0 m above base of section; 7 cm x 35 cm flattened micrite nodule. Occurs with *Epigondolella* ex gr. *bidentata* Mosher (slender morph) (M.J.O., personal communication, 1990).
87 CNA SKU D1 (C-164696/1). Collected 3.0 m above base of section; 3 cm x 7 cm micrite concretion. Occurs with *Epigondolella* ex gr. *bidentata* Mosher (slender morph) (Orchard et al. 1990).

89 CNA SKU D4A (C-173289). Collected 7.5 m above base of section; 10 cm x 35 cm flattened micrite nodule. Occurs with *Epigondolella* undifferentiated (M.J.O., personal communication, 1990).
87 CNA SKU D3 (C-164696/3). Collected 11.0 m above base of section; 4 cm x 8 cm micrite concretion.
89 CNA SKU D7 (C-173269). Collected 17.5 m above base of section; 10 cm x 35 cm flattened micrite nodule.
87 CNA SKU D4 (C-164696/4). Collected 21.5 m above base of section; three small micrite concretions (3 cm x 7 cm) from the same bed.
87 CNA SKU D5 (C-164696/5). Collected 26.5 m above base of section; small micrite nodule.
87 CNA SKU D6 (C-164696/6). Collected 28.5 m above base of section; 2 cm x 10 cm micrite concretion.
89 CNA SKU D12 (C-173274). Collected 31.7 m above base of section; lenticular nodule 10 cm x 35 cm.
87 CNA SKU D7 (C-164696/7). Collected 33.0 m above base of section; small micrite nodule. This sample listed in error as 38.0 m above base of section in Carter (1990).
87 CNA SKU D8 (C-164696/8). Collected 47.0 m above base of section; 15 cm x 40 cm flattened micrite nodule.
89 CNA SKU D13 (C-173275). Collected 47.1 m above base of section; two small nodules 4 cm x 12 cm.
89 CNA SKU D14 (C-173276). Collected 47.4 m above base of section; two small nodules 6 cm x 12 cm.
89 CNA SKU D15 (C-173277). Collected 49.9 m above base of section; parts of three medium-sized nodules, two are 10 cm x 25 cm, the other 10 cm x 45 cm.
89 CNA SKU D16 (C-173278). Collected 53.6 m above base of section in nodular layer; sample is 15 cm x 50 cm.
87 CNA SKU D9 (C-164696/9). Collected 56.0 m above base of section; 15 cm x 25 cm micrite nodule.
89 CNA SKU D18 (C-173280). Collected 61.3 m above base of section; from nodular layer; sample is 15 cm x 25 cm. Occurs with *Epigondolella* undifferentiated (M.J.O., personal communication, 1991).
89 CNA SKU D19 (C-173281). Collected 66.6 m above base of section; 12 cm x 30 cm nodule. Conodonts only: *Epigondolella* sp. and ramiform elements (M.J.O., personal communication, 1991).
89 CNA SKU D20 (C-173282). Collected 68.1 m above base of section; limy pocket in siltstone bed. Conodonts only: *Epigondolella* ex. gr. *bidentata* Mosher (slender morph) and *Parvigondolella* (M.J.O., personal communication, 1991).
89 CNA SKU D22 (C-173284). Collected 77.3 m above base of section; small pod of limestone. Occurs with conodont ramiform elements (M.J.O., personal communication, 1991).
87 CNA SKU D11 (C-164696/11). Collected 80.5 m above base of section; 15 cm x 40 cm flattened micrite nodule.
89 CNA SKU D25 (C-173287). Collected 82.4 m above base of section; large irregular limestone lens 20 cm x 30 cm. Occurs with *Neogondolella* sp. and ramiform elements (M.J.O., personal communication, 1991).
89 CNA SKU D339 (C-173357). Collected 84.8 m above base of section; large irregular limestone lens containing early Hettangian radiolarians.

U. A. section 6.
87 CNA SKU SP 1 (C-164674). 52°45'37" N, 131°33'37" W. Sandilands Formation. Isolated locality at head of small beach just around point from Section D; micrite nodule (5 cm x 20 cm).

Louise Island
U. A. section 4. NTS Louise Island 103 B/13 & 103 B/14. UTM 306300m E; 5879358m N. (53° 01' 55" N, 131° 53' 05" W). Quarry located on south side of LOUISE MAIN logging road approximately 0.25 km east of boat landing at Beattie Anchorage. Samples collected above a scree slope near base of outcrop, from nodular horizons in hard siliceous siltstone beds of Sandilands Formation.

85 CNA SP 9/1 (C-140373). Small micrite nodule.
86 CNA SP 1/1 (C-127798). Small micrite nodule, 4 cm x 20 cm.
87 CNA SP 3/1 (C-164694/1). Micrite nodule, 3 cm x 30 cm.
88 OF LI 1 (C-158569). Small micrite nodule.

Shields Bay, Graham Island
NTS Graham Island 103 F/8. UTM 669150m E; 5914810m N. (53° 21' 26.1"N, 132° 7' 30.1"W). Shoreline exposure north side of Shields Bay, Rennell Sound. Section begins seaward in lowest black limestone beds exposed at low tide. Peril Formation.

88 OF SHB 3 (C-158510). Collected from limestone bed 7.5 m above base of section, 4.5 m below lowest *Monotis* coquina. Occurs with *Epigondolella* ex gr. *bidentata* Mosher, *Parvigondolella* sp., and ramiform elements (Orchard et al. 1990). Sample contains *Betraccium deweveri* Pessagno and Blome, *Betraccium maclearni* Pessagno and Blome, and *Gorgansium richardsoni* Pessagno and Blome; it belongs to the *Betraccium deweveri* Zone as restricted here.

Skidegate Inlet (south side), north Moresby Island
NTS Graham Island103 F/1. UTM 69725m E; 5895225m N (53° 10' 17.5 N, 132° 02' 30.2" W). Sandilands Formation. Locality near high tide mark on south shore of Skidegate Inlet (Moresby Island) about midway between Macmillan Creek (to the east) and South Bay (to the west). About 10 m of strata are exposed at this locality. Other microfossil samples collected here (section SKID) have yielded radiolarians assignable to Assemblage 3 of Carter 1990, and *Epigondolella* ex. gr. *bidentata* Mosher (slender morph) (Orchard et al. 1990).

85 CNA SP 10/2 (C-140377). Spot sample collected from large, medium grey concretionary limestone nodule interbedded with thin, black siliceous siltstone.

APPENDIX II - RADIOLARIAN DATABASE

Includes first and final appearance of 136 species in 6 sections (69 sample horizons).
Format: section number; species code; lowest sample - highest sample. Species code consists of three letters (an abbreviation of genus name) plus two numbers.

SECTION 1 KENNECOTT POINT
AMP01 6-24 ARC01 7-17 ARC02 7-15 BET01 1-4 BET02 10-17 BET03 22-22 BET04 10-15 BET05 15-23 BET06 1-4 BET08 1-9 BET12 18-18 BET13 22-22 BPD01 1-1 BPD02 1-25 CAN01 1-22 CAN02 1-22 CAN03 20-22 CAN04 13-22 CAN05 12-22 CIT01 18-18 CIT03 1-9 CIT04 9-13 CRU01 7-10 CRU02 15-22 CRU04 9-22 CTL01 8-10 CTL02 15-23 CTL03 15-15 CTS01 1-22 CTS02 8-17 DEF01 9-18 DEF02 7-9 DEF03 7-7 DRO01 8-12 ENT01 1-19 ENT02 8-18 ENT03 13-18 EPT01 8-13 EPT02 15-22 EUC01 7-22 FER01 19-22 FER02 10-15 FER03 15-22 FER04 22-22 FER06 15-15 FER07 18-22 FON01 18-22 FON02 1-22 FON03 1-22 FON04 1-19 FON05 1-8 GLO01 12-20 GLO02 21-24 GLO03 21-21 HAL01 10-22 HCK01 13-15 ICR01 8-15 ICR02 9-22 KOZ02 1-10 KOZ03 1-2 KOZ04 8-15 KOZ08 18-18 LAX02 18-22 LAX03 7-8 LAX04 22-24 LAX05 18-22 LIV01 3-22 LIV03 8-22 LOU01 8-20 LOU02 15-15 MES02 22-22 MES04 19-19 NIN01 8-10 NIN02 3-15 ORB01 19-22 PAN02 7-8 PAN04 13-22 PAN05 10-10 PAN06 10-13 PAR01 3-21 PAR02 5-17 PAR03 8-13 PAR04 7-18 PAR05 7-22 PCD01 1-13 PLF01 15-15 PLF02 19-22 PLF03 8-22 PLF04 8-15 PLF05 15-15 PRP01 6-18 PSD01 12-22 PSH02 1-15 PSH03 8-8 PTC01 1-8 PTR02 6-6 PTR03 20-24 PTR04 13-23 RIS01 15-22 RIS02 15-19 RIS04 17-22 RIS05 19-22 SIN01 10-15 SIN02 10-22 SIN04 8-22 SIN05 10-18 SQN01 22-22 SQN02 22-22 SQN03 15-22 SQN04 15-22 SQN05 9-15 SQN06 7-7 SQN08 7-15 TBS01 1-9 TCR01 6-22 TCR02 6-22 TET05 6-13

SECTION 2 KENNECOTT POINT KPD
BET05 1-1 BPD02 1-1 CTL02 1-1 EPT02 1-1 FON01 1-1 FON02 1-1 FON03 1-1 GLO02 1-1 LIV03 1-1 PLF02 1-1 RIS04 1-1

SECTION 3 KUNGA ISLAND SKU B
AMP01 17-17 ARC01 5-16 ARC02 5-17 BET01 1-1 BET02 1-17 BET04 7-16 BET05 16-18 BET06 1-1 BET08 5-8 BET09 5-16 BET11 5-16 BET12 10-18 BET13 17-17 BPD01 5-6 BPD02 3-17 CAN01 4-17 CAN02 7-16 CIT03 5-6 CIT04 15-17 CRU01 5-15 CRU02 15-15 CRU04 7-15 CTL01 10-13 CTL02 15-18 CTL03 13-17 CTL04 11-15 CTS01 3-17 CTS02 6-16 DEF01 5-17 DEF02 5-15 DEF03 7-17 DRO01 3-7 ENT01 5-17 ENT02 5-5 ENT03 12-17 EPT01 7-17 EUC01 5-17 FER01 17-17 FER02 9-9 FER03 16-17 FER04 5-17 FER05 5-16 FER06 13-16 FON02 5-17 FON03 5-17 FON04 3-17 FON05 1-11 HAL01 5-17 HCK01 12-16 ICR01 3-8 ICR02 5-16 KAH01 7-16 KOZ01 13-16 KOZ02 3-3 KOZ03 1-3 KOZ04 3-16 KOZ05 1-16 KOZ06 12-16 KOZ08 9-17 LAX03 3-10 LIV01 4-17 LIV03 4-7 LOU01 5-17 LOU02 15-17 MES02 15-15 MES04 15-15 NIN01 15-17 NIN02 8-17 PAL01 8-17 PAN02 10-15 PAN03 15-15 PAN04 8-17 PAN05 8-15 PAN06 11-17 PAR01 5-18 PAR02 7-18 PAR03 5-16 PAR04 7-17 PAR05 10-17 PCD01 7-7 PCD02 7-16 PCD03 12-17 PLF01 17-18 PLF03 3-17 PLF04 5-16 PLF05 12-15 PRP01 5-17 PSD01 8-18 PSH02 1-11 PSH03 10-17 PTC01 5-16 PTR02 9-9 PTR04 10-17 RIS01 11-12 SIN01 12-17 SIN02 3-17 SIN03 15-17 SIN04 5-

10 SIN05 5-15 SQN01 15-15 SQN02 15-15 SQN03 15-16 SQN04 17-17 SQN05 3-15 SQN06 16-16 SQN08 12-15 TBS01 1-7 TCR01 5-17 TCR02 5-15 TET01 1-7 TET05 7-16

SECTION 4 LOUISE ISLAND ARC01 2-4
ARC02 2-3 BET02 2-3 BET04 2-3 BET05 2-4 BET09 2-3 BET11 4-4 BET12 2-2 BPD02 2-2 CAN01 1-4 CAN02 1-4 CAN05 4-4 CRU01 2-2 CTL01 2-2 CTL02 1-4 CTL03 2-3 CTL04 2-2 CTS01 1-4 DEF01 1-4 DEF03 1-2 DRO01 2-2 ENT01 2-3 ENT02 2-4 ENT03 1-4 EPT01 1-4 EPT02 3-4 EUC01 1-1 FER02 1-2 FER03 2-3 FER04 2-3 FER05 2-2 FER06 1-3 FON02 1-4 FON03 1-4 FON04 1-4 HAL01 2-4 HCK01 2-3 ICR02 1-2 KAH01 2-2 KOZ01 1-4 KOZ04 3-3 KOZ06 2-2 KOZ08 2-4 LOU01 1-4 LOU02 2-4 MES02 2-2 NIN01 1-4 NIN02 1-4 ORB01 4-4 PAL01 1-1 PAN04 1-3 PAN05 2-3 PAN06 1-4 PAR01 2-3 PAR02 2-3 PAR03 1-4 PAR04 1-4 PAR05 1-4 PCD01 3-3 PCD02 2-4 PCD03 3-3 PLF03 2-2 PLF04 1-4 PLF05 1-3 PRP01 1-4 PSD01 1-4 PTC01 1-3 PTR02 1-2 PTR03 4-4 PTR04 1-4 SIN01 1-4 SIN02 1-4 SIN03 1-2 SIN04 2-2 SIN05 1-4 SQN03 1-4 SQN08 1-4

SECTION 5 KUNGA ISLAND SKU D
AMP01 6-20 ARC01 1-15 ARC02 1-20 BET02 1-16 BET03 16-16 BET04 8-17 BET05 10-20 BET07 16-20 BET08 3-6 BET09 1-4 BET11 1-16 BET13 13-20 BPD02 4-20 CAN01 1-20 CAN02 4-19 CAN03 19-19 CAN04 10-16 CAN05 8-20 CIT01 14-17 CIT04 10-17 CRU01 8-12 CRU02 10-20 CRU04 4-4 CTL01 4-5 CTL02 10-20 CTL03 8-8 CTL04 12-12 CTS01 1-20 CTS02 1-12 DEF01 4-20 DEF02 1-3 DEF03 1-8 DRO01 1-10 ENT01 4-17 ENT02 10-20 ENT03 8-20 EPT01 5-12 EPT02 8-20 EUC01 6-19 FER01 10-19 FER02 3-3 FER03 8-19 FER06 4-8 FER07 15-17 FON01 4-17 FON02 2-20 FON03 2-20 FON04 2-17 GLO01 10-17 GLO02 16-20 GLO03 20-20 HAL01 1-20 HCK01 12-20 ICR01 1-1 ICR02 3-20 KAH01 4-8 KOZ01 6-6 KOZ02 3-3 KOZ03 3-3 KOZ04 4-12 KOZ05 1-4 KOZ06 10-20 KOZ08 10-12 LAX02 15-19 LAX03 1-1 LAX04 15-17 LAX05 12-20 LIV01 1-20 LIV03 10-20 LOU01 4-20 LOU02 10-15 MES01 20-20 MES02 11-17 MES04 10-10 NIN02 4-12 ORB01 15-20 PAL01 11-19 PAN02 1-8 PAN03 4-4 PAN04 4-19 PAN05 4-10 PAN06 8-15 PAR01 8-20 PAR02 5-14 PAR03 4-10 PAR04 5-15 PAR05 5-13 PCD01 10-16 PCD02 10-10 PCD03 10-12 PLF01 4-16 PLF02 10-17 PLF03 3-20 PLF04 4-16 PLF05 4-17 PRP01 3-12 PSD01 4-17 PSH02 1-12 PSH03 10-13 PTC01 4-19 PTR01 12-17 PTR02 3-3 PTR03 16-20 PTR04 8-20 PTR05 12-20 RIS01 9-17 RIS02 9-19 RIS03 16-17 RIS04 10-20 RIS05 16-20 SIN01 15-15 SIN02 8-20 SIN03 10-19 SIN04 1-19 SIN05 1-20 SQN01 11-17 SQN02 16-17 SQN03 8-17 SQN04 11-16 SQN05 1-8 SQN08 8-20 TBS01 2-2 TCR01 8-18

SECTION 6 KUNGA ISLAND 87 CNA SKU SP 1
AMP01 1-1 BET02 1-1 BET07 1-1 BET11 1-1 BET13 1-1 BPD02 1-1 CAN01 1-1 CAN02 1-1 CAN03 1-1 CAN04 1-1 CAN05 1-1 CIT01 1-1 CRU02 1-1 CRU04 1-1 CTS01 1-1 DEF01 1-1 ENT01 1-1 ENT02 1-1 EPT02 1-1 FER01 1-1 FER03 1-1 FER07 1-1 FON02 1-1 FON03 1-1 FON04 1-1 GLO01 1-1 GLO03 1-1 HAL01 1-1 ICR02 1-1 LAX02 1-1 LAX04 1-1 LAX05 1-1 LIV01 1-1 LIV03 1-1 LOU01 1-1 MES02 1-1 ORB01 1-1 PAL01 1-1 PAN06 1-1 PLF02 1-1 PLF03 1-1 PSD01 1-1 PTC01 1-1 PTR01 1-1 PTR03 1-1 PTR05 1-1 RIS01 1-1 RIS02 1-1 RIS03 1-1 RIS04 1-1 SIN02 1-1 SIN04 1-1 SIN05 1-1 SQN01 1-1 SQN02 1-1 SQN04 1-1 SQN08 1-1 TCR01 1-1

PLATES

PLATE 1

Scanning electron micrographs of Spumellariina from the Kunga Group, Queen Charlotte Islands, B.C. Specimens illustrated in Figures 2, 5, 17 from the Peril Formation (upper Norian), all other specimens from the Sandilands Formation (upper Norian? Rhaetian). Scale bar = number of microns for each specimen illustrated.

Figures 1, 2, 5, 17. *Entactinosphaera* ? sp. aff. *E.* ? *simoni* Kozur and Mostler. 1, GSC 101857 from GSC loc. C-164696/7 (87 SKU D7) Kunga Island. 2, 17, GSC 101858 and 5, GSC 101859 from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. Scale bar = 198, 196, 196, and 50 microns respectively.

Figures 3, 4, 8. *Entactinosphaera* ? *amphilapes* n. sp. 3, 4, GSC 101860 (holotype) and 8, GSC 101861 (paratype) from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 196, 198, and 132 microns respectively.

Figures 6, 7. *Entactinosphaera* ? *spinulata* n. sp. 6, GSC 101863 (paratype) and 7, GSC 101862 (holotype) from GSC loc. no. C-127798 (86 SP 1/1) and GSC loc. no. C- 140373 (85 SP 9/1) Louise Island, respectively. Scale bar = 209 microns for both specimens.

Figures 9, 10, 13. *Haliomma* ? *sewellense* n. sp. 9, GSC 101865 (paratype) 10 GSC 101864 (holotype) and 13, GSC 101866 (paratype) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. Scale bar = 100, 98, and 105 microns respectively.

Figures 11, 15. *Pentactinocarpus* sp. cf. *P. sevaticus* Kozur and Mostler. 11, GSC 101867 from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. 15, GSC 101868 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 139 microns.

Figures 12, 16. *Archaeocenosphaera* sp. A. 12, GSC 101869 from GSC loc. no. C-140484 (87 KPA 12) Kennecott Point, Graham Island. 16, GSC 85913 from GSC loc. no. C-164696/6 (87 SKU D6) Kunga Island. Scale bar = 105 microns.

Figures 14, 19, 20. *Archaeocenosphaera* sp. aff. *A. laseekensis* Pessagno and Yang. 14, 19, GSC 101871 and 20, GSC 101872 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 137, 34 and 100 microns respectively.

Figure 18. *Archaeocenosphaera* sp. B. GSC 101873 from GSC loc. no. C- 164696 /9 (87 SKU D9) Kunga Island. Scale bar = 100 microns.

PLATE 1

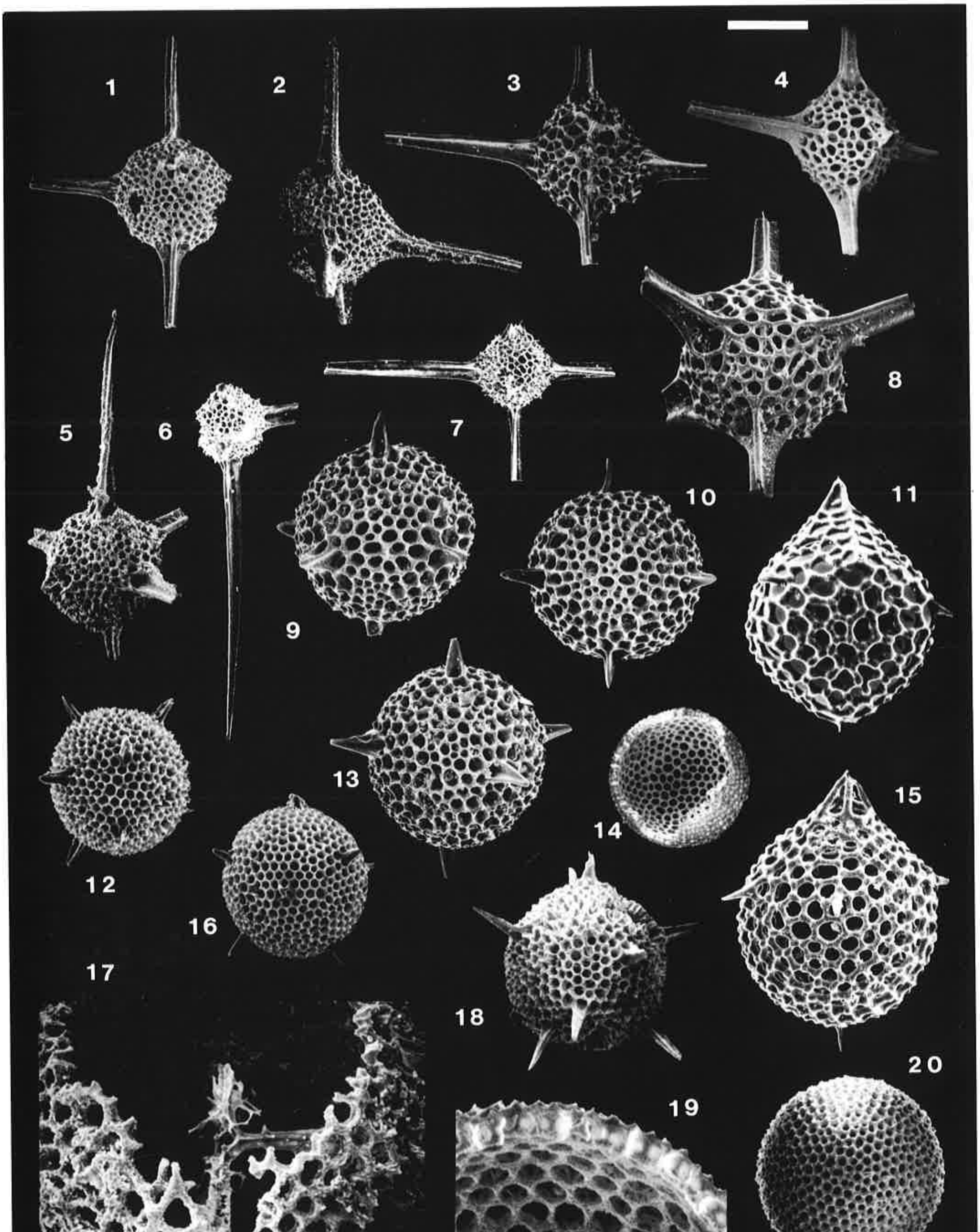


PLATE 2

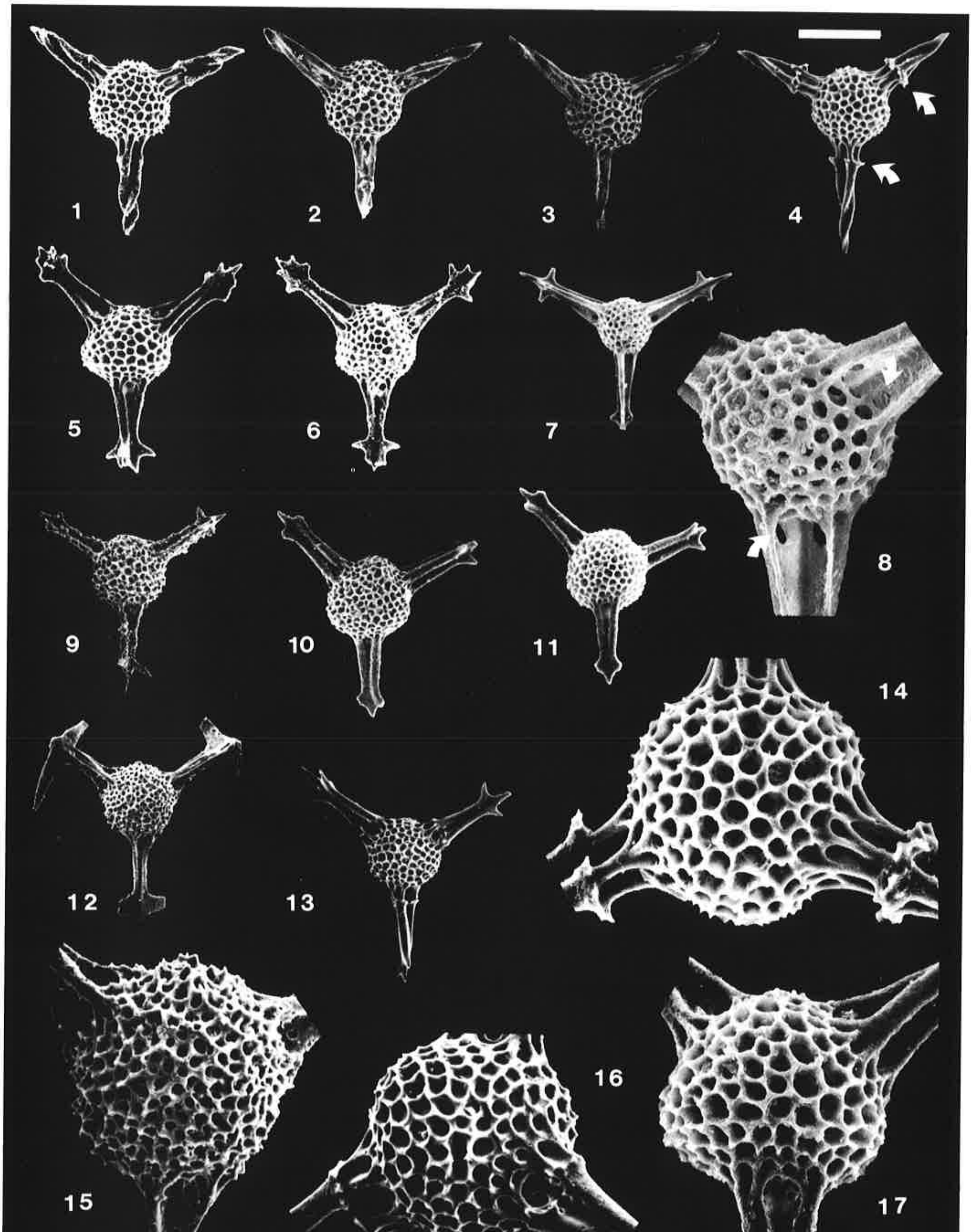


PLATE 2

Scanning electron micrographs of Spumellariina from the Kunga Group, Queen Charlotte Islands, B.C. Specimen illustrated in Figure 9 from the Peril Formation (upper Norian), all other specimens from the Sandilands Formation (upper Norian? Rhaetian). Scale bar = number of microns for each specimen illustrated.

Figures 1, 2, 3, 4, 14. *Fontinella louisensis* n. gen., n. sp. 1, GSC 101874 (holotype) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. 2, 3, 4, GSC 101875, GSC 101876, and GSC 85910 (paratypes) respectively: 2 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island; 3, 4 and 14 from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. 4, arrows point to thorny remnants near base of spines. Scale bar = 100 microns for fig. 1-4, 33 microns for fig. 14.

Figures 5, 6, 17. *Fontinella inflata* n. gen., n. sp. 5, 17, GSC 101878 (holotype) from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 100 microns and 39 microns respectively. 6, GSC 101879 (paratype) from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. No thorny remnants visible near spine bases of this species. Scale bar = 100 microns.

Figures 7, 8. *Fontinella clara* n. gen., n. sp. GSC 101880 (holotype) from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. 8, arrows point to prominent pores piercing base of each spine ridge. Scale bar = 100 microns and 30 microns respectively.

Figures 9, 10, 11. *Fontinella primitiva* n. gen., n. sp. 9, GSC 101882 (paratype) from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. 10, 11, GSC 101881 (holotype) from GSC loc. no. C-140478 (87 KPA 6) Kennecott Point, Graham Island. Scale bar = 94, 97 and 100 microns respectively.

Figures 12, 15. *Kahlerosphaera* sp. A. GSC 101884 from GSC loc. no. C-164696/387 SKU D3) Kunga Island. Scale bar = 98 microns and 31 microns respectively.

Figures 13, 16. *Fontinella habros* n. gen., n. sp. GSC 101883 (holotype) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. 16, arrow points to thorny remnants near base of spine. Scale bar = 94 microns and 31 microns respectively.

PLATE 3

Scanning electron micrographs of Spumellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1, 6. *Plafkerium fidicularium* n. sp. GSC 101885 (holotype) from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 100 microns.

Figures 2, 16. *Plafkerium gadoense* n. sp. GSC 101886 (holotype) from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100 microns and 53 microns respectively.

Figures 3, 5, 8, 12, 15. *Icrioma* ? sp. A. 3, GSC 101887 from GSC loc. no. C-140373 (85 SP 9/1) Louise Island. Scale bar = 100 microns. 5, GSC 101888 aberrant specimen with five arms from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 108 microns. 8, 12, 15, GSC 101889 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. 15, arrows point to spinal pores. Scale bar = 105, 34 and 50 microns respectively.

Figures 4, 11. *Plafkerium keloense* n. sp. 4, GSC 101890 (holotype); 11, GSC 101891 illustrating double wall structure of cortical shell. Both specimens from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 105 microns and 69 microns respectively.

Figures 7, 10. *Plafkerium* sp. A. GSC 101892 from GSC loc. no. C-158569 (88 LI 1) Louise Island. Scale bar = 100 microns and 81 microns respectively.

Figure 9. *Plafkerium* sp. B. GSC 101893 from GSC loc. no. C-164696/3 (87 SKU D3) Kunga Island. Scale bar = 101 microns.

Figures 13, 14. *Icrioma* ? *cistella* n. sp. GSC 101894 (holotype) from GSC loc. no. C- 150179 (86 SKU B10) Kunga Island. 14, arrows point to spinal pores. Scale bar = 102 microns and 61 microns respectively.

PLATE 3

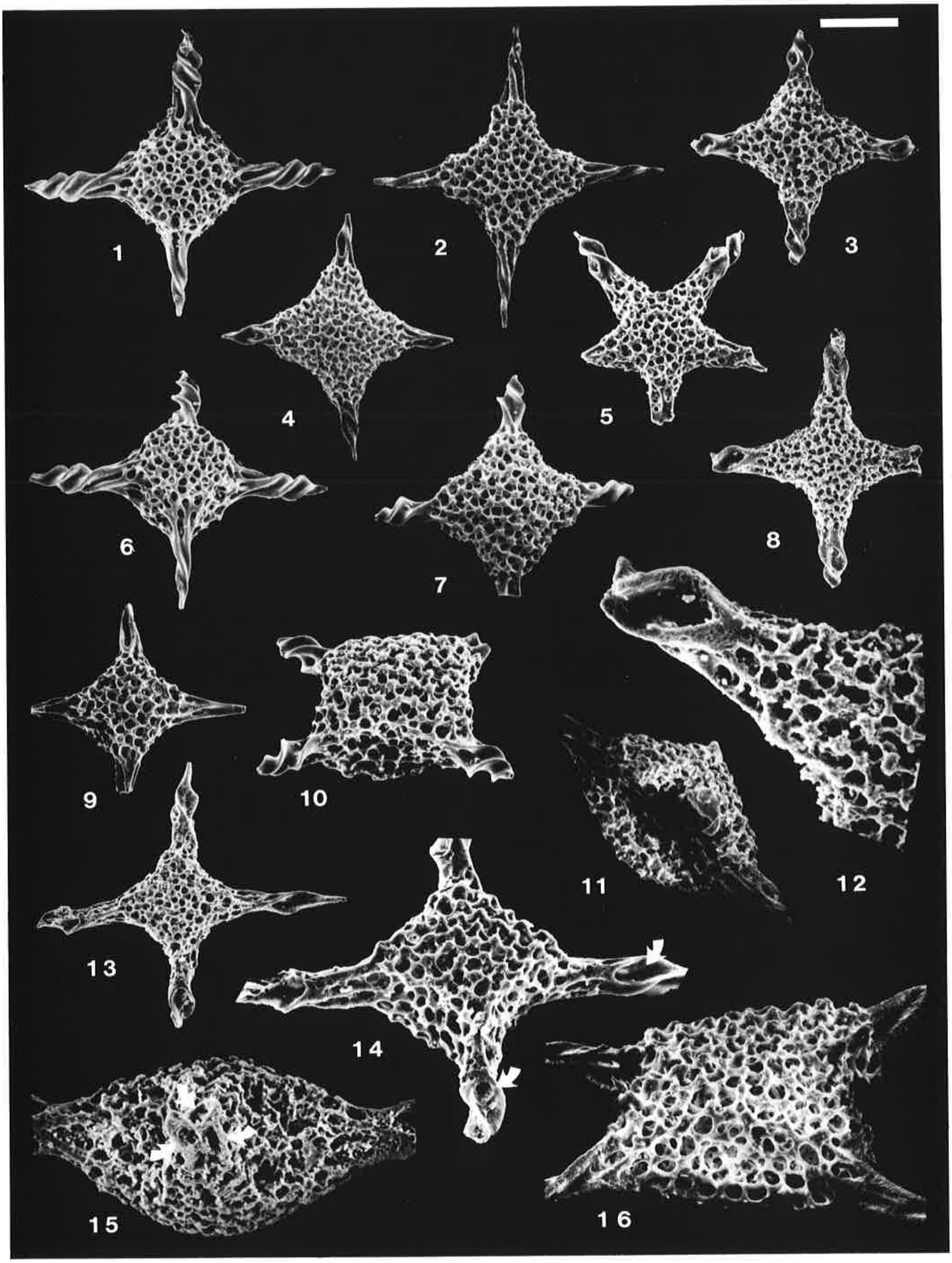


PLATE 4

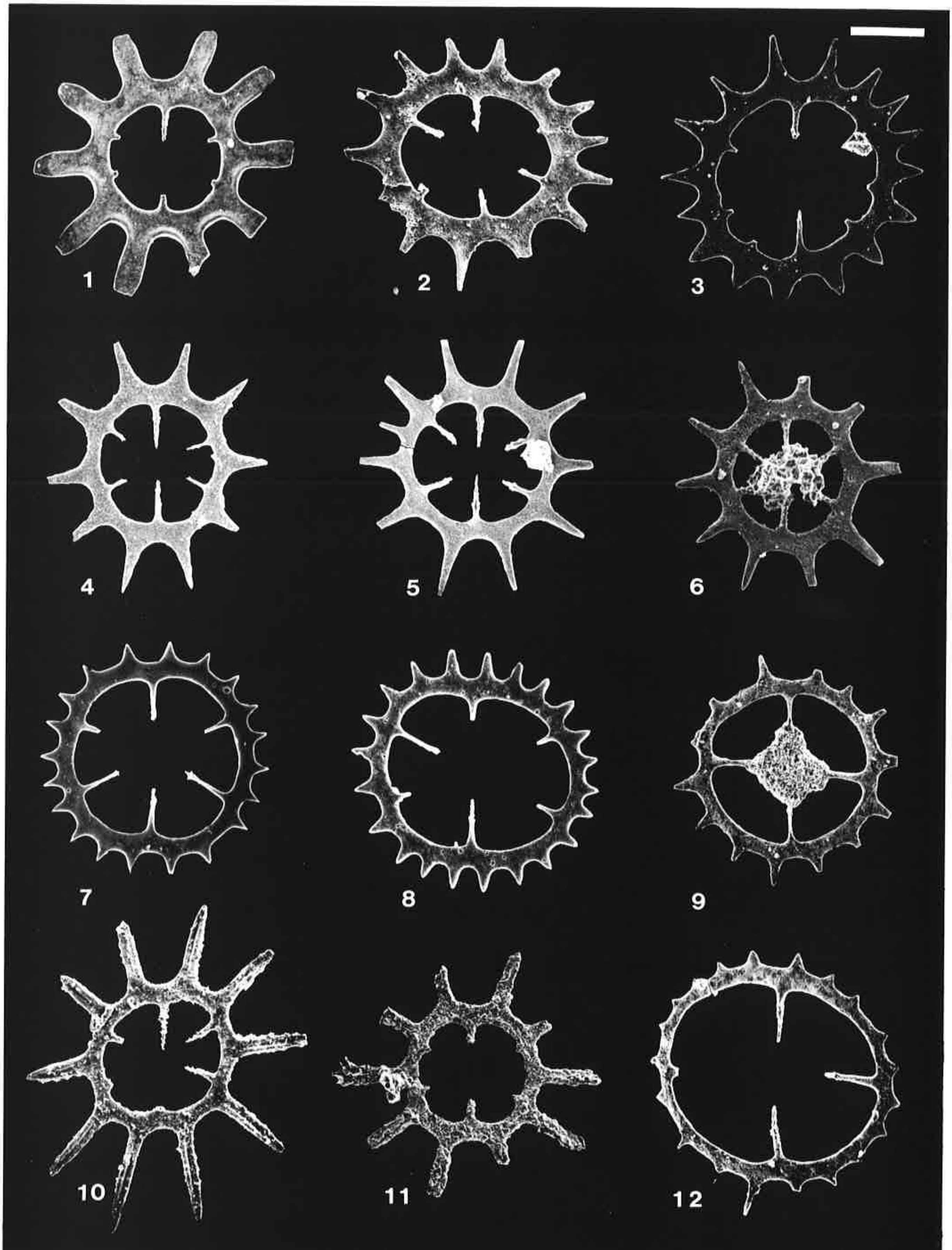


PLATE 4

Scanning electron micrographs of Spumellariina from the Kunga Group, Queen Charlotte Islands, B.C. Specimen illustrated in Figure 10 from the Peril Formation (upper Norian), all other specimens from the Sandilands Formation (upper Norian? Rhaetian). Scale bar = number of microns for each specimen illustrated.

Figure 1. *Kozurastrum decilobum* n. sp. GSC 101895 (holotype) from GSC loc. no. C-156789 (88 KPA R3) Kennecott Point, Graham Island. Scale bar = 129 microns.

Figure 2. *Kozurastrum sandspitense* (Blome). GSC 101896 from GSC loc. no. C- 164693/14 (87 SKU B14) Kunga Island. Scale bar = 126 microns.

Figure 3. *Kozurastrum* sp. aff. *K. sandspitense* (Blome). GSC 101897 from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. Scale bar = 133 microns.

Figures 4, 5, 6. *Kozurastrum huxleyense* n. sp. 4, GSC 101898 (holotype) and 5, GSC 101899 (paratype) from GSC loc. no. 173308 (89 SKU B19) Kunga Island. 6, GSC 101900 (paratype) from GSC loc. no. C-173301 (89 SKU B12) Kunga Island. Scale bar = 137, 147, and 133 microns respectively.

Figures 7, 8. *Kozurastrum beattiense* n. sp. 7, GSC 85915 (holotype) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. 8, GSC 101902 (paratype) from GSC loc. no. C-140373 (85 SP 9/1) Louise Island. Scale bar = 100 microns.

Figures 9, 12. *Kozurastrum* sp. B. 9, GSC 101903 from GSC loc. no. C-164696/8 (87 SKU D8) Kunga Island. 12, GSC 101904 from GSC loc. no. C-158569 (88 LI 1) Louise Island. Scale bar = 98 microns and 96 microns respectively.

Figures 10, 11. *Kozurastrum gracilis* (Kozur and Mostler). 10, GSC 101905 from GSC loc.no. C-158510 (88 SHB 3) Shields Bay, Graham Island. 11, GSC 101906 from GSC loc. no. C-140474 (87 KPA 3B) Kennecott Point, Graham Island. Scale bar = 154 microns and 133 microns respectively.

PLATE 5

Scanning electron micrographs of Spumellariina from the Kunga Group, Queen Charlotte Islands, B.C. Specimens illustrated in Figures 9 and 10 from the Peril Formation (upper Norian), all other specimens from the Sandilands Formation (upper Norian? Rhaetian). Scale bar = number of microns for each specimen illustrated.

Figures 1, 2, 3. *Mesosaturnalis acuminatus* n. sp. 1, GSC 101907 (holotype), GSC 101908 and 3, GSC 101909 (paratypes); all specimens from GSC loc. no. C-173287 (89 SKU D25) Kunga Island. Scale bar = 157, 158, and 157 microns respectively.

Figures 4, 7. *Pseudoacanthocircus troegeri* Kozur and Mostler. 4, GSC 85925 and 7, GSC 101911 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100 microns.

Figure 5. *Mesosaturnalis* sp. B. GSC 101912 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 98 microns.

Figure 6. *Mesosaturnalis* sp. A. GSC 101913 from GSC loc. no. 127798 (86 SP 1/1) Louise Island. Scale bar = 133 microns.

Figure 8. *Liassosaturnalis* sp. aff. *L. parvus* Kozur and Mostler. GSC 101914 from GSC loc. no. C-164696/8 (87 SKU D8) Kunga Island. Scale bar = 133 microns.

Figure 9. *Saturnosphaera* sp. aff. *S. convertus* (Kozur and Mostler). GSC 101915 from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. Scale bar = 163 microns.

Figure 10. *Kozurastrum* sp. A. GSC 101916 from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. Scale bar = 156 microns.

Figure 11,12. *Orbiculiforma multibrachiata* n. sp. 12, GSC 101918 (holotype) from GSC loc. no. C-173287 (89 SKU D25) Kunga Island. 11, GSC 101917 from GSC loc. no. C- 164696/6 (87 SKU D6) Kunga Island. Scale bar = 93 and136 microns.

PLATE 5

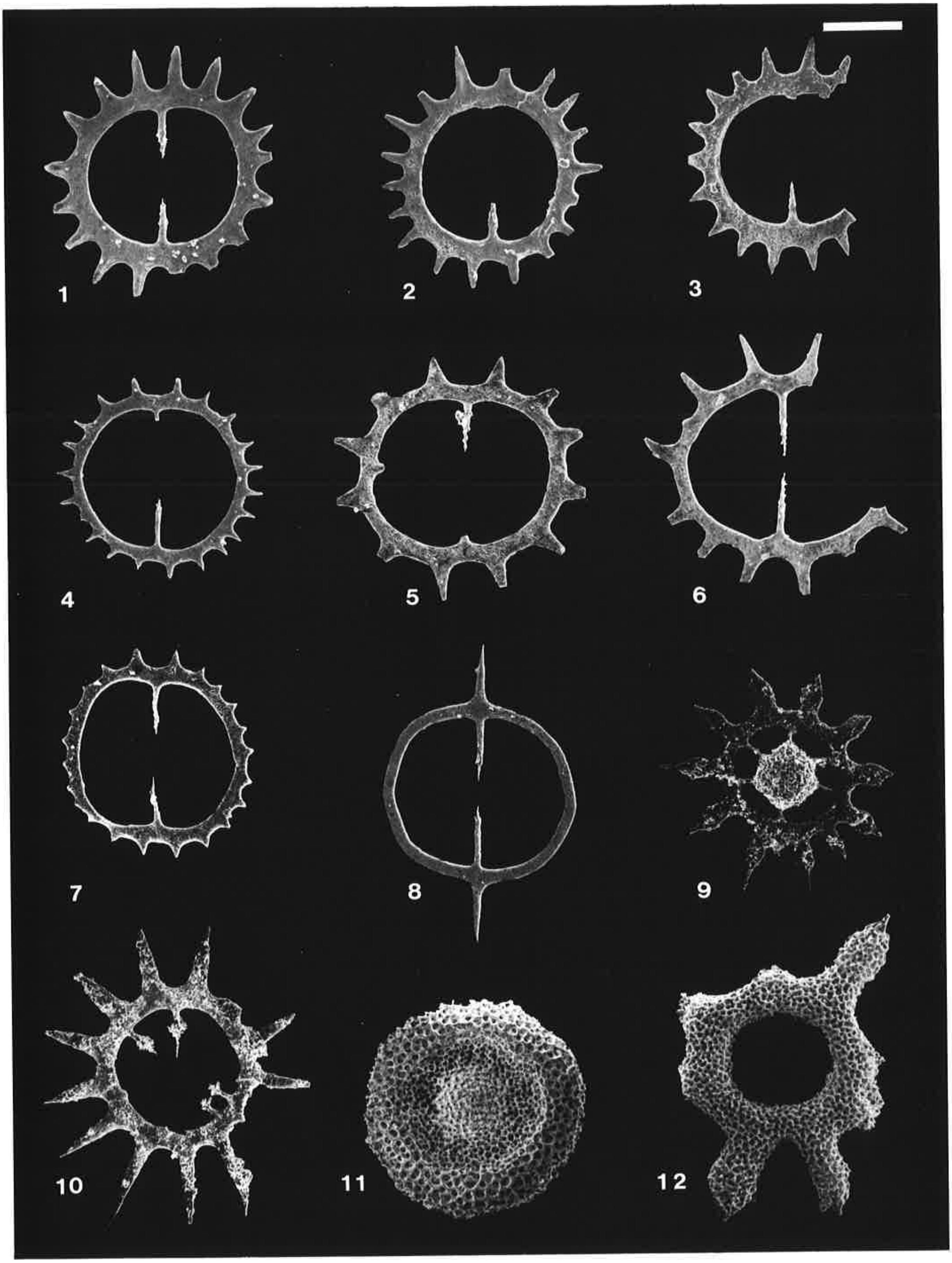


PLATE 6

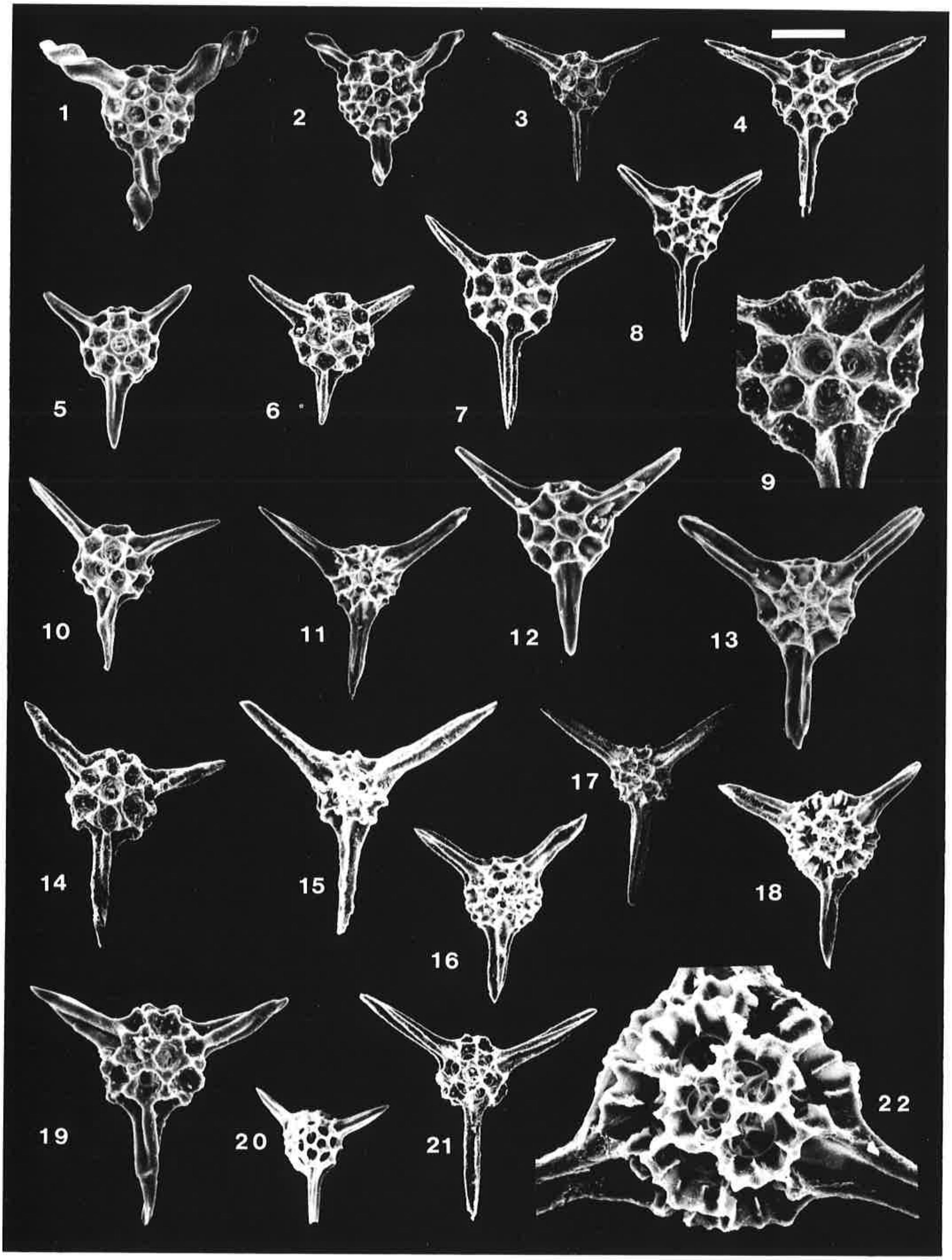


PLATE 6

Scanning electron micrographs of Spumellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figure 1. *Betraccium deweveri* Pessagno and Blome. GSC 101919 from GSC loc. no. C-156789 (88 KPA R3) Kennecott Point, Graham Island. Bar scale = 95 microns.

Figure 2. *Betraccium maclearni* Pessagno and Blome. GSC 101920 from GSC loc. no. C-156789 (88 KPA R3) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figures 3, 8. *Betraccium inornatum* Blome. GSC 101921 and GSC 101922 from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island and GSC loc. no. C-150179 (86 SKU B10) Kunga Island respectively. Scale bar = 95 microns and 80 microns.

Figures 4, 7, 9, 12. *Betraccium* sp. aff. *B. inornatum* Blome. 4, 9, GSC 101923 from GSC loc. no. 164694/1 (87 SP 3/1) Louise Island. 7, GSC 101924 from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. 12, GSC 101925 from GSC loc. no. C-140484 (87 KPA 12) Kennecott Point, Graham Island. Scale bar = 100, 100, 50, and 81 microns respectively.

Figures 5, 6. *Betraccium perilense* n. sp. 5, GSC 101927 (paratype) and 6, GSC 101926 (holotype) from GSC loc. no. C-156789 (88 KPA R3) Kennecott Point, Graham Island. Scale bar = 100 microns and 97 microns respectively.

Figures 10, 14, 19. *Betraccium kennecottense* n. sp. 10, GSC 101928 (holotype) from GSC loc. no. C-140377 (85 SP 10/2) Skidegate Inlet, Moresby Island. 14, GSC 101929 (paratype) from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. 19, GSC 85911 (paratype) from GSC loc. no. C-140484 (87 KPA 12) Kennecott Point, Graham Island. Scale bar = 93, 95, and 81 microns respectively.

Figure 11. *Betraccium* sp. C. GSC 101931 from GSC loc. no. C-164696/3 (87 SKU D3)Kunga Island. Scale bar = 100 microns.

Figure 13. *Betraccium* sp. cf. *B. inornatum* Blome. GSC 101932 from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 81 microns.

Figures 15, 17. *Betraccium nodulum* n. sp. 15, GSC 101934 (paratype) from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. 17, GSC 101933 (holotype) from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 80 microns and 98 microns respectively.

Figure 16. *Betraccium* sp. A. GSC 101935 from GSC loc. no. C-150179 (86 SKU B10) Kunga Island. Scale bar = 80 microns.

Figures 18, 22. *Betraccium* sp. B. GSC 101936 from GSC loc. no. C-150179 (86 SKU B10) Kunga Island. Scale bar = 80 microns and 30 microns respectively.

Figure 20. *Betraccium* sp. E. GSC 101937 from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figure 21. *Betraccium* sp. D. GSC 101938 from GSC loc. no. C-164693/12 (87 SKU B12) Kunga Island. Scale bar = 100 microns.

PLATE 7

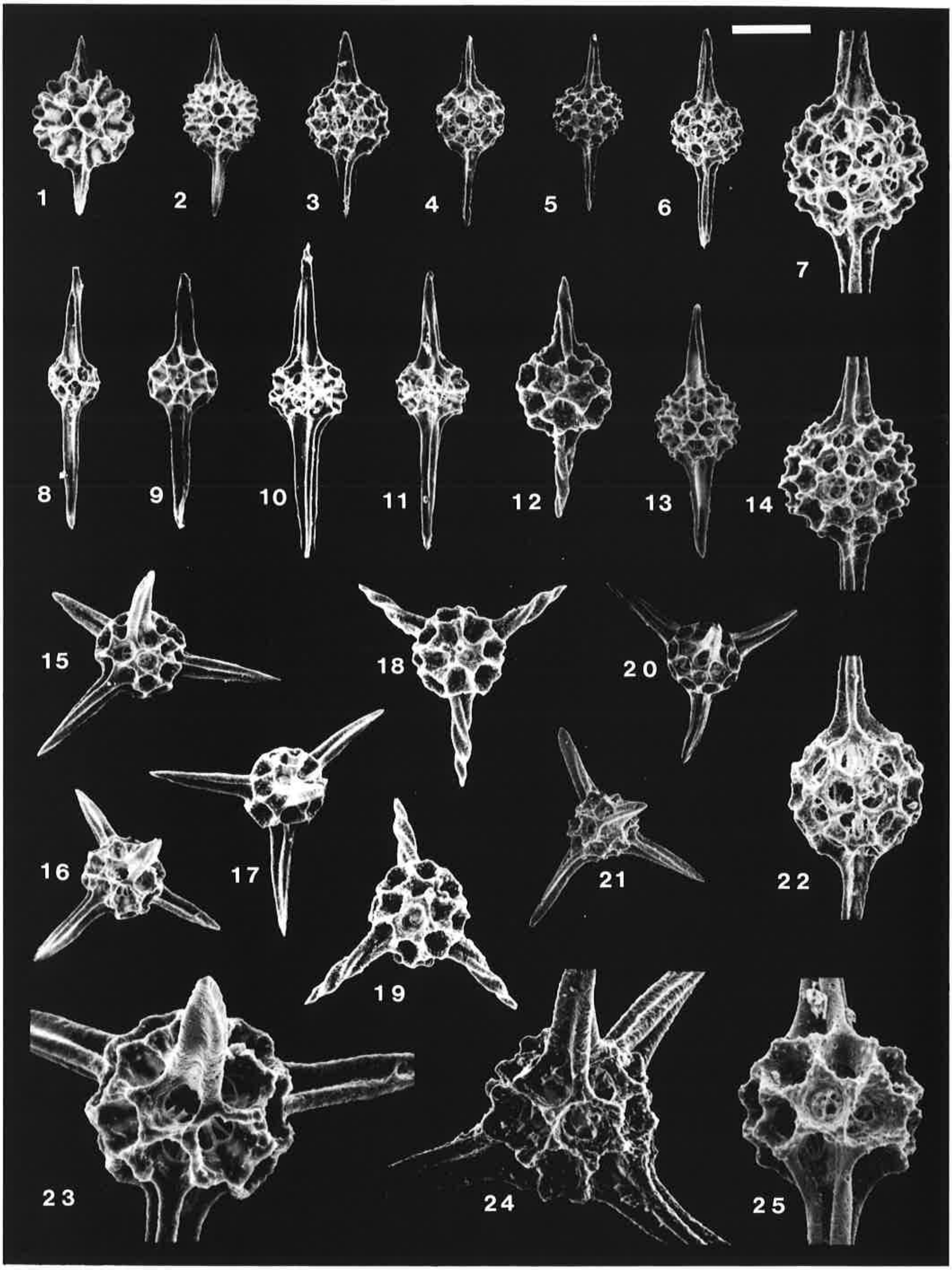


PLATE 7

Scanning electron micrographs of Spumellariina from the Sandilands Formation (upper Norian? Rhaetian) Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figure 1. *Pantanellium fosteri* Pessagno and Blome. GSC 101939 from GSC loc. no. C- 173303 (89 SKU B14) Kunga Island. Scale bar = 100 microns.

Figures 2, 3. *Pantanellium* sp. aff. *P. fosteri* Pessagno and Blome. 2, GSC 101940 from GSC loc. C-164696/3 (87 SKU D3) Kunga Island. 3, GSC 101941 from GSC loc. no. C- 127798 (86 SP 1/1) Louise Island. Scale bar = 100, and 80 microns respectively.

Figures 4, 22. *Pantanellium* sp. aff. *P. kungaense* Pessagno and Blome. GSC 101942 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 94 microns and 47 microns respectively.

Figures 5, 6, 7, 13, 14. *Pantanellium newkluense* n. sp. 5, 14, GSC 101944 (paratype) from GSC loc. no. C-164696/6 (87 SKU D6) Kunga Island; scale bar = 94 and 47 microns respectively. 6, 7, GSC 101945 (paratype) from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island; scale bar = 95 and 48 microns respectively. 13, GSC 85926 (holotype) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island; scale bar = 80 microns.

Figure 8. *Pantanellium* sp. aff. *P. skidegatense* Pessagno and Blome var. A. GSC 101946 from GSC loc. no. C-164696/3 (87 SKU D3) Kunga Island. Scale bar = 100 microns.

Figures 9, 10, 11, 25. *Pantanellium* sp. aff. *P. skidegatense* Pessagno and Blome var. B. 9, GSC 101947 from GSC loc. no. C-140480 (87 KPA 8) Kennecott Point, Graham Island. 10, GSC 101948 and 11, 25, GSC 85922 from GSC loc. no. C-140373 (85 SP 9/1) Louise Island. Scale bar = 100, 81, 100, and 38 microns respectively.

Figure 12. *Pantanellium* sp. A. GSC 101950 from GSC loc. no. C-140484 (87 KPA 12) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figures 15, 16, 17, 23. *Cantalum tianense* n. sp. 15, 17, GSC 101951 (holotype) and 16, 23, GSC 101952 (paratype) from GSC loc. no. C-173303 (89 SKU B14) Kunga Island. Scale bar = 100, 100, 100, and 43 microns respectively.

Figures 18, 19. *Cantalum gratum* n. sp. GSC 101953 (holotype) from GSC loc. no. C- 140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figure 20. *Cantalum* sp. A. GSC 101954 from GSC loc. no. C-158569 (88 LI 1) Louise Island. Scale bar = 95 microns.

Figures 21, 24. *Cantalum* sp. B. GSC 101955 from GSC loc. no. C-164693/12 (87 SKU B12) Kunga Island. Scale bar = 95 microns and 38 microns respectively.

PLATE 8

Scanning electron micrographs of Spumellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figure 1. *Ferresium* sp. aff. *F. laseekense* Blome. GSC 101956 from GSC loc. no. C- 140480 (87 KPA 8) Kennecott Point, Graham Island. Scale bar = 80 microns.

Figures 2, 3. *Ferresium* sp. A. 2, GSC 101957 from GSC loc. C-140377 (85 SP 10/2) Skidegate Inlet, Moresby Island. 3, GSC 101958 from GSC loc. no. C-150179 (86 SKU B10) Kunga Island. Scale bar = 100 microns.

Figures 4, 5, 6. *Ferresium* sp. B. 4, GSC 101959 and 5, GSC 101960 from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. 6, GSC 101961 from GSC loc. no. C-140480 (87 KPA 8) Kennecott Point, Graham Island. Scale bar = 102, 93, and 102 microns respectively.

Figures 7, 8, 9, 12, 13. *Ferresium teekwoonense* n. sp. 7, 13, GSC 101963 (paratype) from GSC loc. no. C-140377 (85 SP 10/2) Skidegate Inlet, Moresby Island. 8, GSC 101962 (holotype) from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. 9, GSC 101964 (paratype) from GSC loc. no. C-140484 (87 KPA 12) Kennecott Point, Graham Island. 12, GSC 101965 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100, 100, 95, 100, and 50 microns respectively.

Figures 10, 11, 14. *Ferresium triquetrum* n. sp. 10, 14, GSC 101967 (paratype) and 11, GSC 101966 (holotype) from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 95, 100, and 49 microns respectively.

PLATE 8

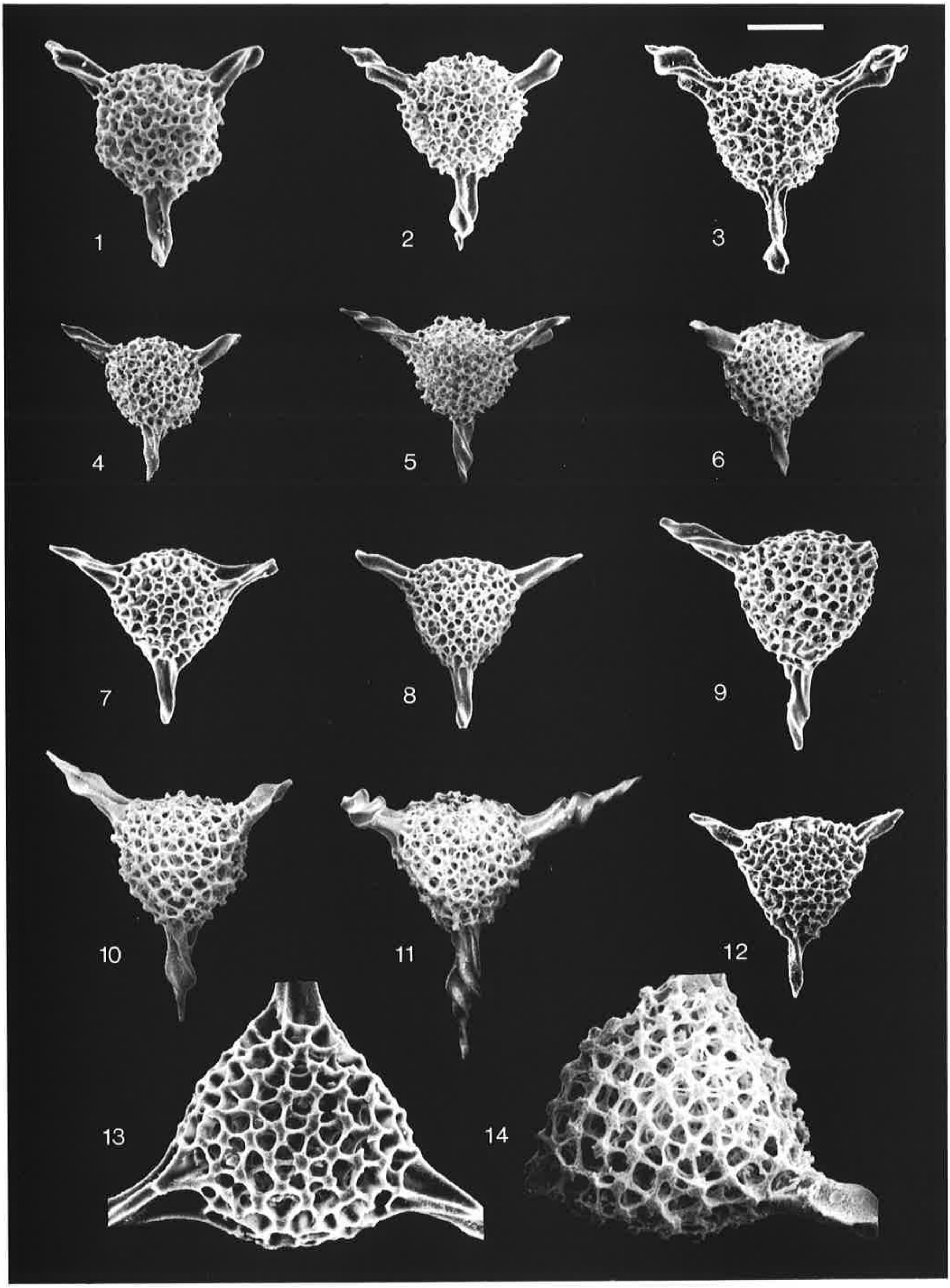


PLATE 9

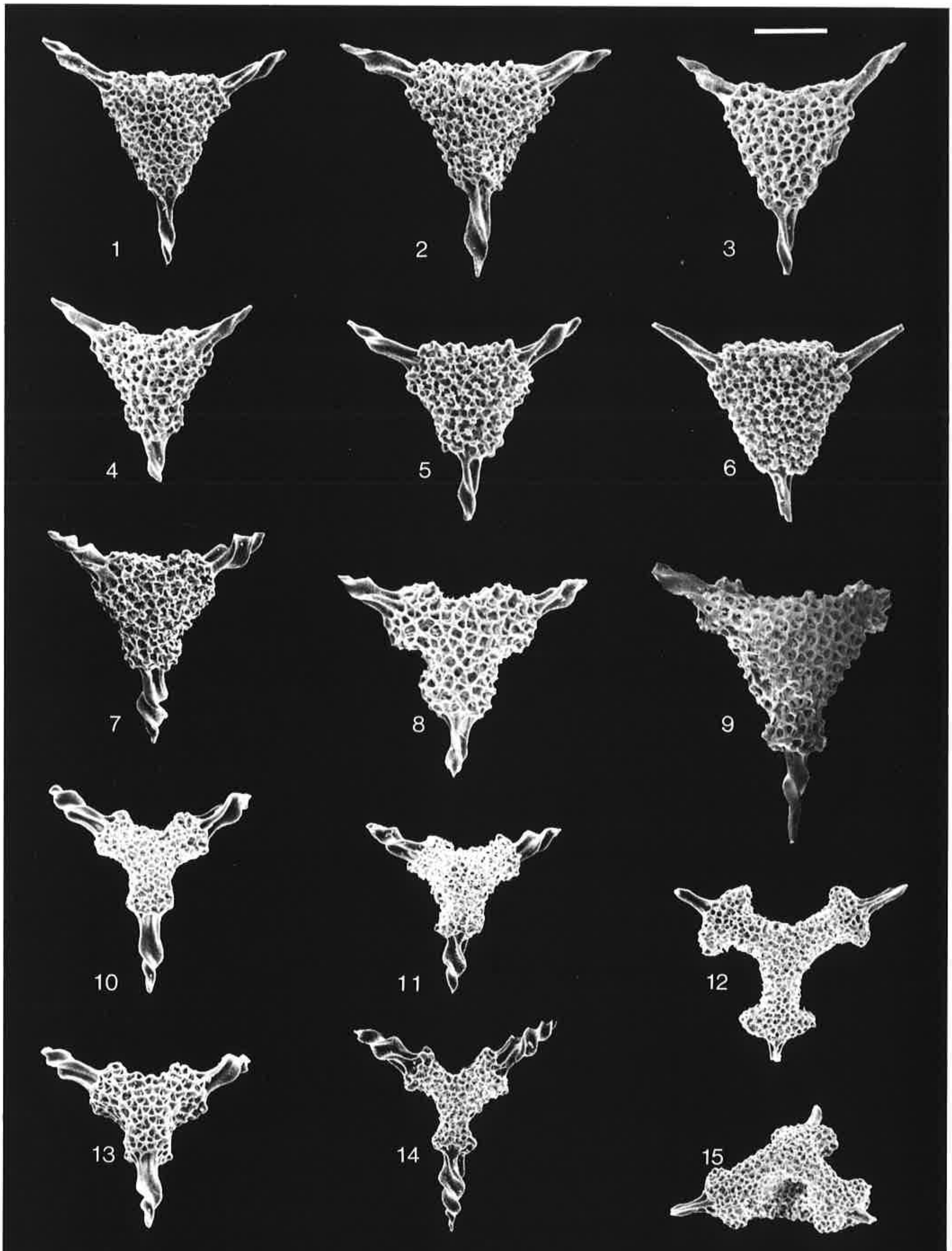


PLATE 9

Scanning electron micrographs of Spumellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1-5. *Ferresium conclusum* n. sp. 1, GSC 101969 (paratype); 2, GSC 101968 (holotype); 3, GSC 101970 (paratype); and 5, GSC 101971 (paratype) from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. 4, GSC 101972 (paratype) from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 98, 98, 94, 97, and 100 microns respectively.

Figure 6. *Ferresium* sp. C. GSC 101973 from GSC loc. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 100 microns.

Figure 7. *Risella ellisensis* n. gen., n. sp. GSC 101974 (holotype) from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 97 microns.

Figure 8. *Risella stalkungiensis* n. gen., n. sp. GSC 101975 (holotype) from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island; Scale bar = 100 microns.

Figure 9. *Risella* sp. B. GSC 101976 from GSC loc. no. C-173287 (89 SKU D25) Kunga Island. Scale bar = 98 microns.

Figures 10, 11, 13. *Risella tledoensis* n. gen., n. sp. 10, 13, GSC 85923 (holotype) from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. 11, GSC 101978 (paratype) from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 133 microns.

Figures 12, 15. *Risella tangilensis* n. gen., n. sp. GSC 101979 (holotype) from GSC loc.no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 133 microns.

Figure 14. *Risella* sp. A GSC 101980 from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 133 microns.

PLATE 10

Scanning electron micrographs of Spumellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1, 18. *Bistarkum* ? *cylindratum* n. sp. GSC 101981 (holotype) from GSC loc. no. C-173275 (89 SKU D13) Kunga Island. Scale bar = 100 microns and 37 microns respectively.

Figures 2, 3. *Paronaella bifida* n. sp. 2, GSC 101982 (holotype) and 3, GSC 101983 (paratype) from GSC loc. C-156743 (88 KPA E) Kennecott Point, Graham Island Scale bar = 135 microns.

Figures 4, 17. *Paronaella yaogusensis* n. sp. GSC 85920 (holotype) from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. Scale bar = 200 microns.

Figure 5. *Paronaella pacofiensis* n. sp. GSC 101985 (holotype) from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. Scale bar = 200 microns and 48 microns respectively.

Figure 6. *Paronaella ultrabifida* n. sp. GSC 101986 (holotype) from GSC loc. no. C-140373 (85 SP 9/1) Louise Island. Scale bar = 200 microns.

Figures 7, 8, 15, 16. *Paronaella* ? *beatricia* n. sp. 7, 16, GSC 101987 (holotype) and 15, GSC 101988 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. 8, GSC 101989 (paratype) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. Scale bar = 135, 135, 33, and 31 microns respectively.

Figure 9. *Paronaella* sp. cf. *P. pacofiensis* n. sp. GSC 101990 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 135 microns.

Figures 10, 11. *Crucella* sp. B. GSC 101991 from GSC loc. no. C-164696/3 (87 SKU D3) Kunga Island. Scale bar = 135, and 100 microns respectively.

Figure 12. *Crucella* sp. C. GSC 101992 from GSC loc. no. C-173308 (89 SKU B19) Kunga Island. Scale bar = 100 microns.

Figures 13, 14. *Crucella* ? *flowerpotensis* n. sp. GSC 101993 (holotype) from GSC loc. no. C-164696/6 (87 SKU D6) Kunga Island. Scale bar = 135 microns and 125 microns respectively.

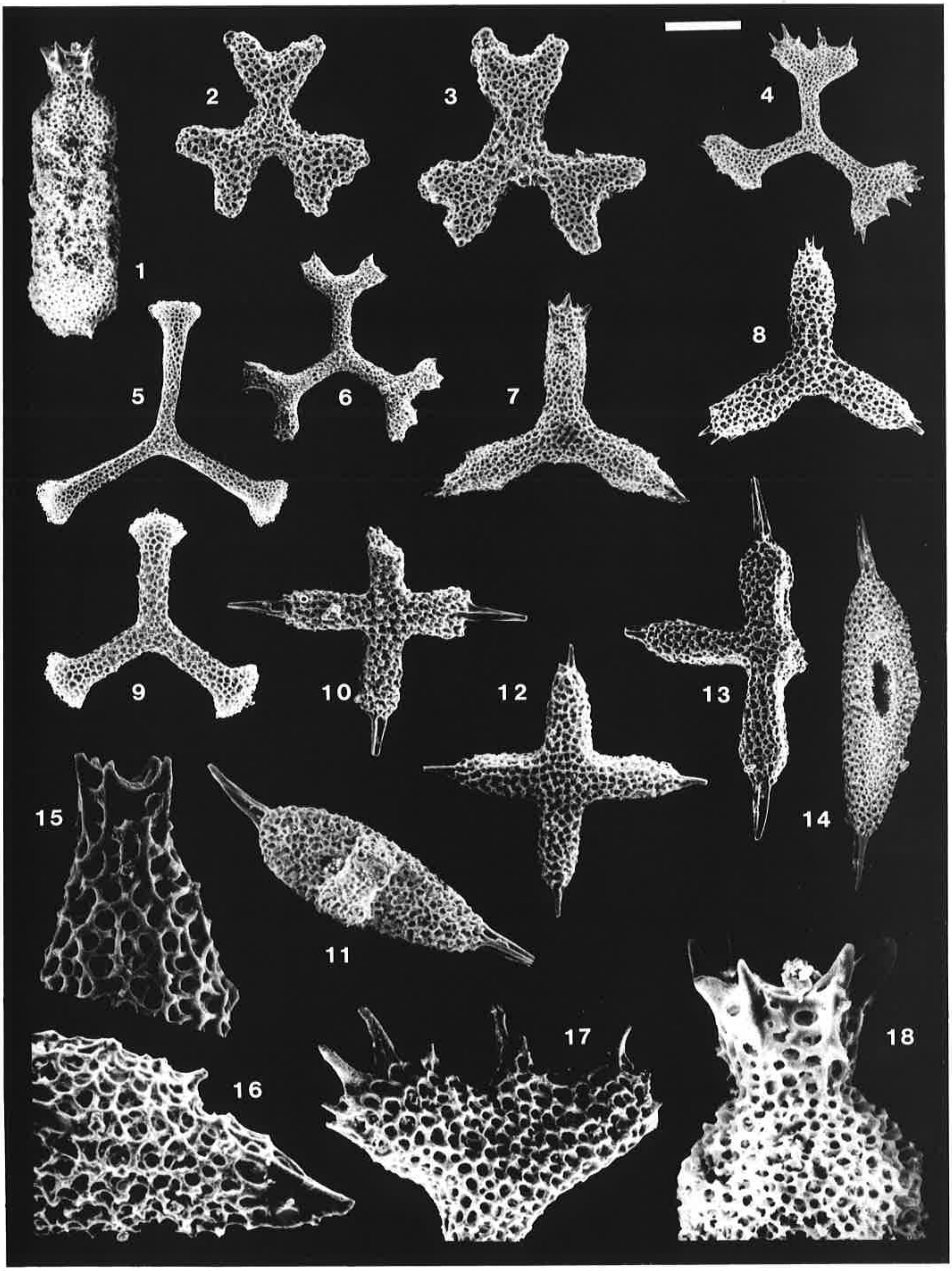

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

PLATE 11

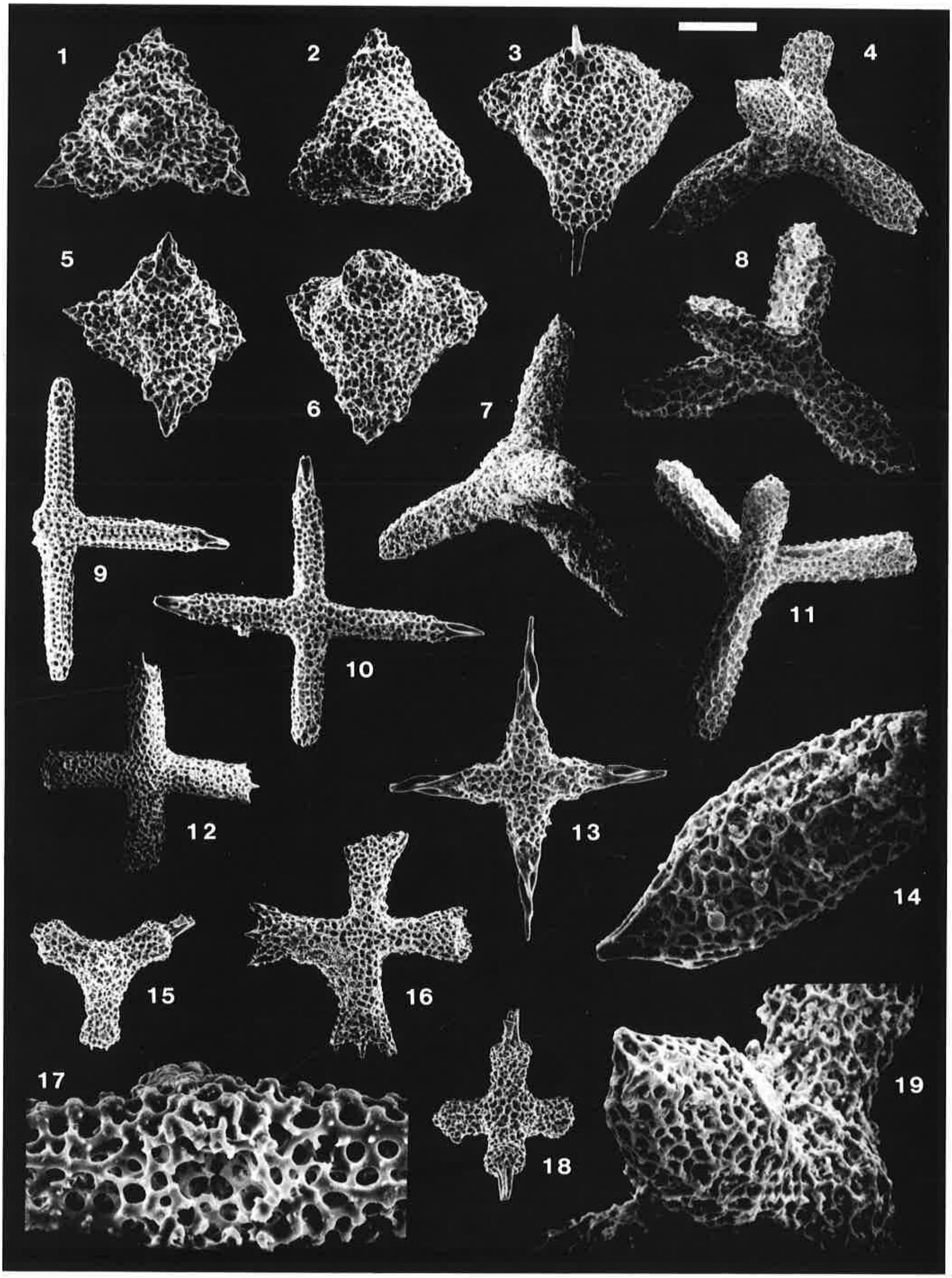


PLATE 11

Scanning electron micrographs of Spumellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1, 2, 5, 6. *Paratriassoastrum crassum* n. sp. 1, 5, GSC 101994 (holotype) from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. 2, 6, GSC 101995 (paratype) from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 100 microns.

Figure 3. *Paratriassoastrum* sp. aff. *P. crassum* n. sp. GSC 101996 from GSC loc. C- 127798 (86 SP 1/1) Louise Island. Scale bar = 80 microns.

Figures 4, 7, 8, 14, 19. *Paratriassoastrum omegaense* n. sp. 4, 14, 19, GSC 101997 (holotype) and 7, GSC 101998 (paratype) from GSC loc. no. C-164748 (89 KPA 18) Kennecott Point, Graham Island. 8, GSC 101999 (paratype) from GSC loc. no. C- 158569 (88 LI 1) Louise Island. Scale bar = 95, 98, 100, 32, and 31 microns respectively.

Figures 9, 10, 17. *Tetratrabs ? noricus* n. sp. 9, 17, GSC 102000 (holotype) from GSC loc. no. C-156789 (88 KPA R3) Kennecott Point, Graham Island. 10, GSC 102001 (paratype) from GSC loc. no. C-173404 (90 KPH 1) Kennecott Point, Graham Island. Scale bar = 133, 133, and 33 microns respectively.

Figure 11. *Paratriassoastrum* sp. A. GSC 102002 from GSC loc. no. C-158569 (88 LI 1) Louise Island. Scale bar = 95 microns.

Figure 12. *Triassocrucella* sp. A. GSC 102003 from GSC loc. no. C-140373 (85 SP 9/1) Louise Island, Scale bar = 126 microns.

Figure 13. *Crucella* ? sp. A. GSC 102004 from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 100 microns.

Figures 15, 18. *Paratriassoastrum* sp. B. GSC 102005 from GSC loc. no. C- 164696/11 (87 SKU D11) Kunga Island. Scale bar = 133 microns.

Figure 16. *Triassocrucella* sp. aff. *T. triassicum* (Kozur and Mostler). GSC 102006 from GSC loc. no. C-164694/1 (87 SP 3/1) Louise Island. Scale bar = 126 microns.

PLATE 12

Scanning electron micrographs of Spumellariina from the Kunga Group, Queen Charlotte Islands, B.C. Specimens illustrated in Figures 1, 7-11 and 13 from the Peril Formation (upper Norian), all other specimens from the Sandilands Formation (upper Norian? Rhaetian). Scale bar = number of microns for each specimen illustrated.

Figures 1, 8. *Pseudohagiastrum longabrachiatum* n. sp. GSC 102007 from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. Scale bar = 202 and 67 microns respectively.

Figures 2, 3, 6,14. *Pseudohagiastrum* ? *tasuense* n. sp. 2, 14, GSC 102008 (paratype) and 6, GSC 102009 (holotype) from GSC loc. no. C-164696/3 (87 SKU D3) Kunga Island. 3, GSC 102010 (paratype) from GSC loc. no. C-150179 (86 SKU B10) Kunga Island. Scale bar = 209,162, 202 and 35 microns respectively.

Figure 4. *Pseudohagiastrum* sp. cf. *P. monstruosum* Pessagno. GSC 102011 from GSC loc. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 132 microns.

Figure 5. *Pseudohagiastrum* ? sp. A. GSC 102012 from GSC loc. no. C-164696 /7 (87 SKU D7) Kunga Island. Scale bar = 209 microns.

Figures 7, 10, 11. *Tetraporobrachia composita* n. sp. 7, GSC 102013 (holotype), and 11, GSC 102014 (paratype) from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. 10, GSC 102016 (paratype) from GSC loc. no. C-156504 (88 KP M3A) Kennecott Point, Graham Island. Scale bar = 170, 132, and 132 microns respectively.

Figure 9. *Tetraporobrachia* sp. A. GSC 102015 from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. Scale bar = 132 microns.

Figures 12, 15, 16. *Tetraporobrachia* sp. C. GSC 102017 from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. Scale bar = 202, 33, and 196 microns respectively.

Figure 13. *Tetraporobrachia* ? sp. B. GSC 102018 from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. Scale bar = 196 microns.

Figure 17. *Tetraporobrachia* sp. D. GSC 102019 from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 100 microns.

PLATE 12

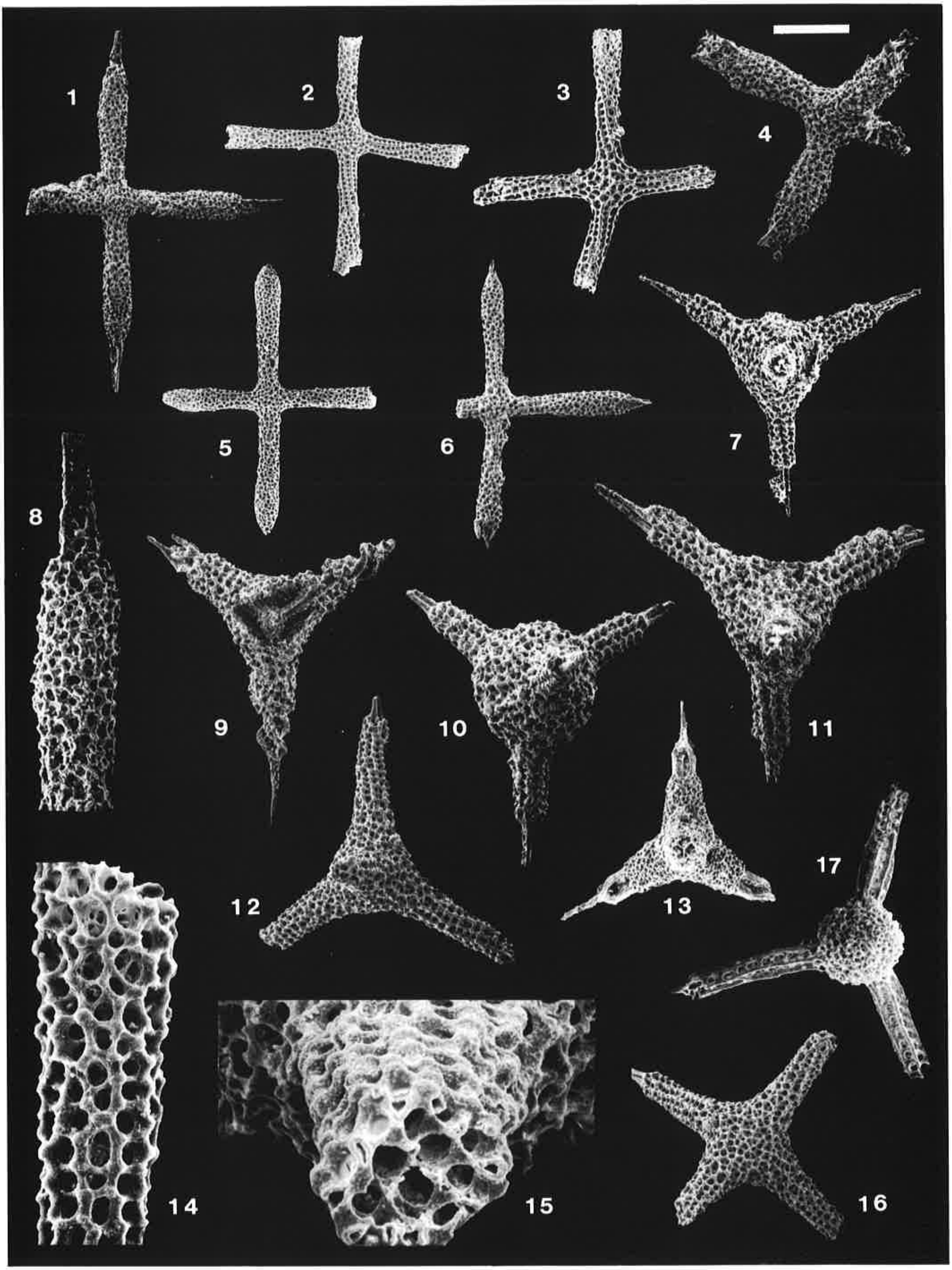


PLATE 13

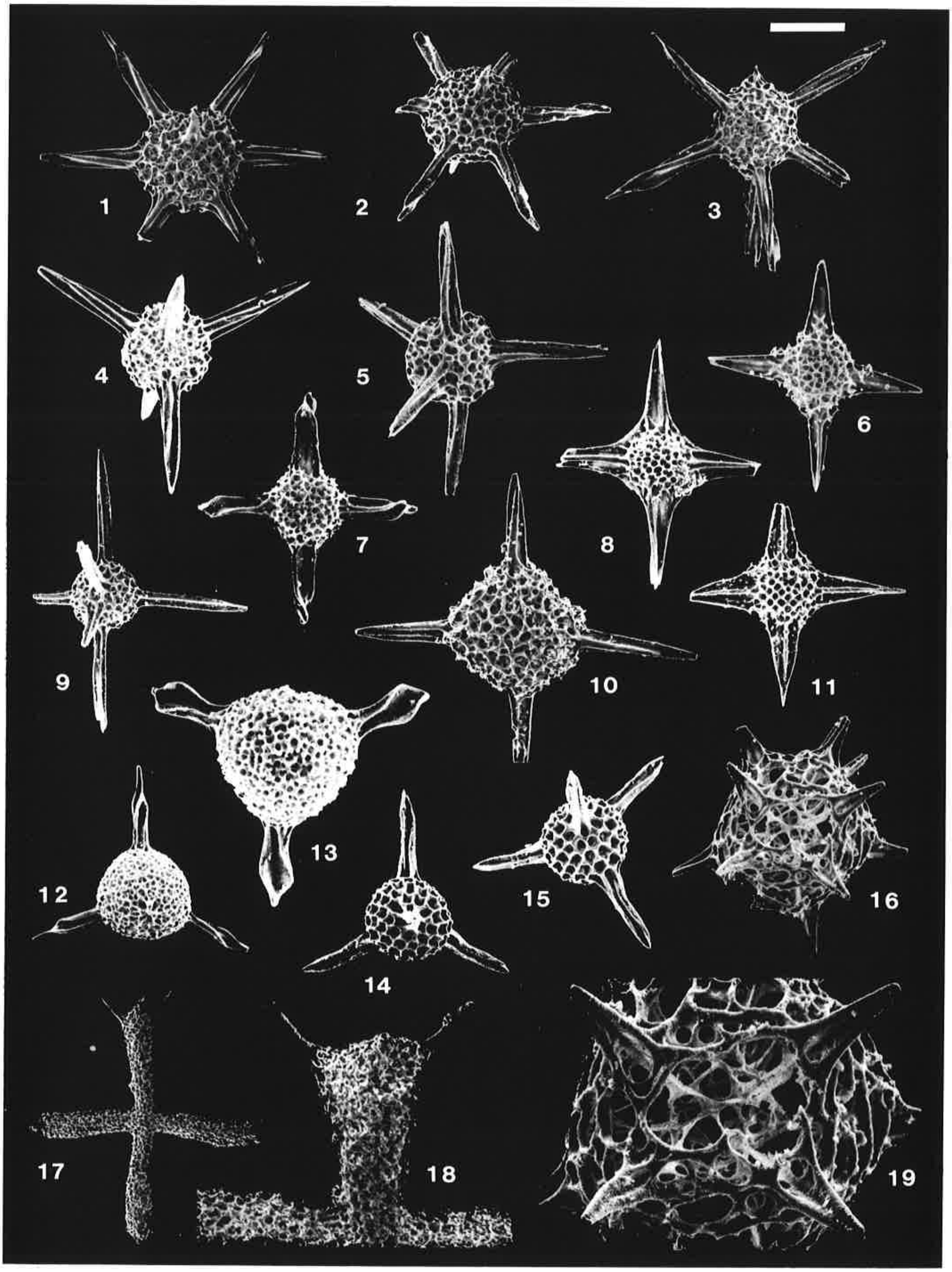


PLATE 13

Scanning electron micrographs of Spumellariina from the Kunga Group, Queen Charlotte Islands, B.C. Specimens illustrated in
Figures 17 and 18 from the Peril Formation (upper Norian), all other specimens from the Sandilands Formation (upper Norian? Rhaetian). Scale bar = number of microns for each specimen illustrated.

Figures 1, 2, 3. *Pentaspongodiscus* ? *dihexacanthus* n. sp. 1, GSC 102020 (holotype) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. 2, GSC 102021 (paratype) from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. 3, GSC 102022 (paratype) from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 131, 133, and 133 microns respectively.

Figures 4, 5. *Loupanus thompsoni* n. gen., n. sp. 4, GSC 102023 (holotype) from GSC loc. C-164694/1 (87 SP 3/1) Louise Island. 5, GSC 85928(paratype) from GSC loc. C- 127798 (86 SP 1/1) Louise Island. Scale bar = 100 and 102 microns respectively.

Figures 6, 8, 11. Spumellaria gen. and sp. indet. B. 6, GSC 102025 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. 8, 11, GSC 102026 and GSC 102027 from GSC loc. no. C-140373 (85 SP 9/1) Louise Island. Scale bar = 100 microns.

Figure 7. Spumellaria gen. and sp. indet A. GSC 102028 from GSC loc. no. C-140480 (87 KPA 8) Kennecott Point, Graham Island. Scale bar =100 microns.

Figure 9. *Loupanus* sp. A. GSC 102029 from GSC loc. no. C-164674 (87 SKUSP 1) Kunga Island. Scale bar = 133 microns.

Figure 10. Spumellaria gen. and sp. indet C. GSC 102030 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 133 microns.

Figures 12, 13. Spumellaria gen. and sp. indet D. 12, GSC 102031 and 13, GSC 102032 from GSC loc. no. C-140484 (87 KPA 12) and GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island respectively. Scale bar = 133 and 80 microns respectively.

Figures 14, 15. Spumellaria gen. and sp. indet E. GSC 102033 from GSC loc.no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 133 microns.

Figures 16, 19. Entactiniid gen. and sp. indet. GSC 102034 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 100 microns and 50 microns respectively.

Figures 17, 18. *Pseudohagiastrum longabrachiatus* n. sp. GSC 102035 (holotype) from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. Scale bar = 192 microns and 63 microns respectively.

PLATE 14

Scanning electron micrographs of Nassellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1, 8, 12, 16. *Eptingium ? amoenum* n. sp. 1, GSC 85917 (holotype) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. 5, 16, GSC 102037 (paratype) from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. 12, GSC 102038 (paratype) from GSC loc. no. C-140373 (85 SP 9/1) Louise Island. Scale bar = 100, 100, 100, and 51 microns respectively.

Figures 2, 3, 4, 17. *Eptingium ? onesimos* n. sp. 2, GSC 102039 (holotype) and 3, 17 GSC 102040 (paratype) from GSC loc. C-140489 (87 KPA 17) Kennecott Point, Graham Island. 4, GSC 102041 (paratype) pyritized specimen from GSC loc. C-156803 (88 KPA R15) Kennecott Point, Graham Island. Scale bar = 100, 98, 98, and 40 microns respectively.

Figures 5, 9. *Haeckelicyrtium karcharos* n. sp. GSC 102042 (holotype) from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. Scale bar = 133 microns.

Figures 6, 10. *Haeckelicyrtium* sp. aff. *H. karcharos* n. sp. GSC 102043 from GSC loc. no.C-164693/14 (87 SKU B14) Kunga Island. Scale bar = 133 microns.

Figures 7, 11. *Deflandrecyrtium* sp. B. 8, GSC 102044 from GSC loc. no. C-164696/3 (87 SKU D3) Kunga Island. 11, GSC 102045 from GSC loc. no. C-140478 (87 KPA 6) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figures 13, 14, 15. *Deflandrecyrtium nobense* n. sp. 13, GSC 102047 (paratype); 14, GSC 102046 (holotype); and 15, GSC 102048 (paratype) from GSC loc. no. C- 164696/7 (87 SKU D7) Kunga Island. Scale bar = 100 microns.

Figure 18. *Deflandrecyrtium* sp. A. GSC 102049 from GSC loc. no. C-150179 (86 SKU B10) Kunga Island. Scale bar = 100 microns.

PLATE 14

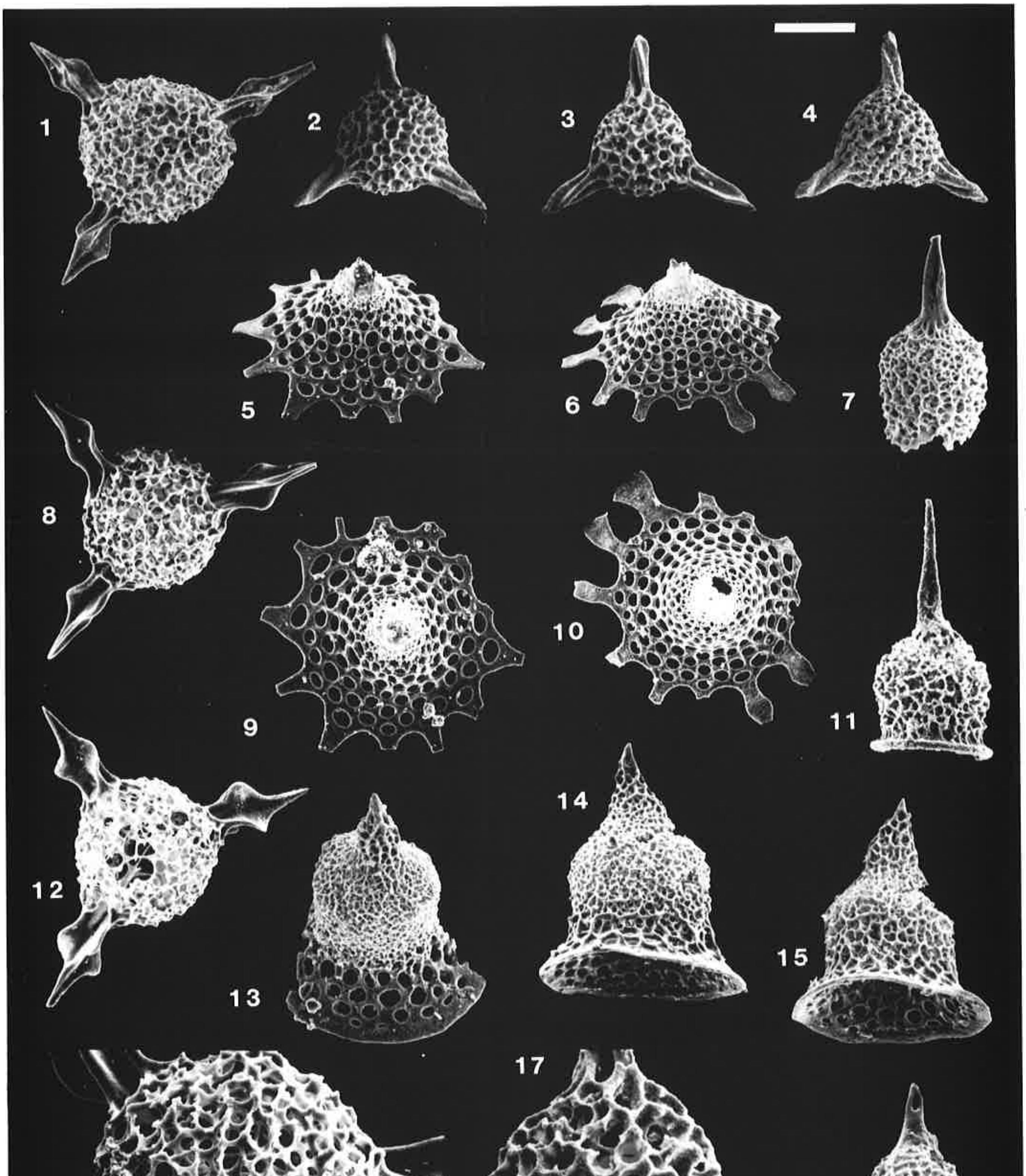


PLATE 15

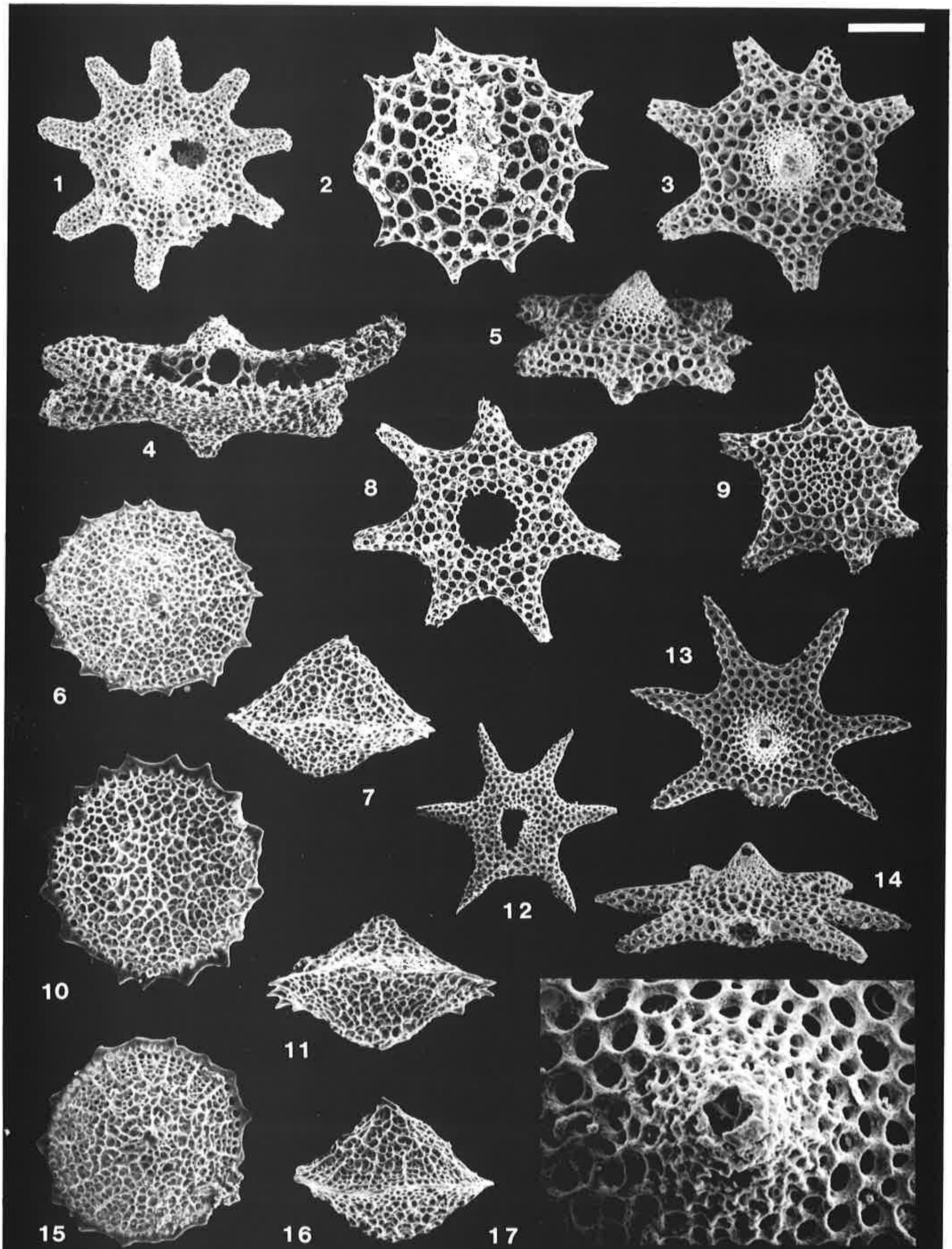


PLATE 15

Scanning electron micrographs of Nassellariina from the Kunga Group, Queen Charlotte Islands, B.C. Specimens illustrated in Figures 1 and 4 from the Peril Formation (upper Norian) all other specimens from the Sandilands Formation (upper Norian? Rhaetian). Scale bar = number of microns for each specimen illustrated.

Figures 1, 4. *Citriduma* sp. A. 1, GSC 102050 and 4, GSC 102051 from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. Scale bar = 162 and 101 microns respectively.

Figure 2. *Citriduma* sp. B. GSC 102052 from GSC loc. C-150179 (86 SKU B10) Kunga Island. Scale bar = 100 microns.

Figures 3, 5, 8, 9. *Citriduma asteroides* n. sp. 3, 5, GSC 85930 (holotype) and paratypes 8, GSC 102054 and 9, GSC 102055 (the latter shows circular shaped velum on underside of test). All specimens from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100, 100, 134, and 100 microns respectively.

Figures 6, 7, 10, 11, 15, 16. *Praecitruduma apexensis* n. sp. 6, 7, GSC 102056 (holotype); 10, 11, GSC 102057 (paratype showing underside of test) and 15, 16, GSC 102058 (paratype). All specimens from GSC loc. no. C-164696 /7 (87 SKU D7) Kunga Island. Scale bar = 100 microns.

Figures 12, 13, 14, 17. *Citriduma* sp. C. 12, GSC 102060; 13, 14, 17, GSC 102059; all specimens from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island. Scale bar = 200, 134, 123, and 34 microns respectively.

PLATE 16

Scanning electron micrographs of Nassellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1, 2, 15. *Praecitriduma canthofistula* n. sp. 1, 15, GSC 85916 (holotype) from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. 2, GSC 102062 (paratype illustrating under side of test) from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. Scale bar = 100, 100, and 31 microns respectively.

Figures 3, 4, 6, 7, 9, 10, 12, 13. *Squinabolella desrochersi* n. sp. 4, 7, GSC 102063 (holotype) from GSC loc. C-164696/6 (87 SKU D6) Kunga Island. 3, 10, GSC 102064 (paratype) from GSC loc. C-164696/7 (87 SKU D7) Kunga Island. 6, 9, GSC 102065 (paratype) and 12, GSC 85918 (paratype) from GSC loc. C-140484 (87 KPA 12) Kennecott Point, Graham Island. 13, GSC 102067 (paratype) from GSC loc. C-127798 (86 SP 1/1) Louise Island. Scale bar = 79 microns for Fig. 9; 100 microns for all other specimens.

Figures 5, 8, 11, 14. *Squinabolella causia* n. sp. GSC 85929 (holotype) from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100, 100, 80, and 37 microns respectively.

PLATE 16

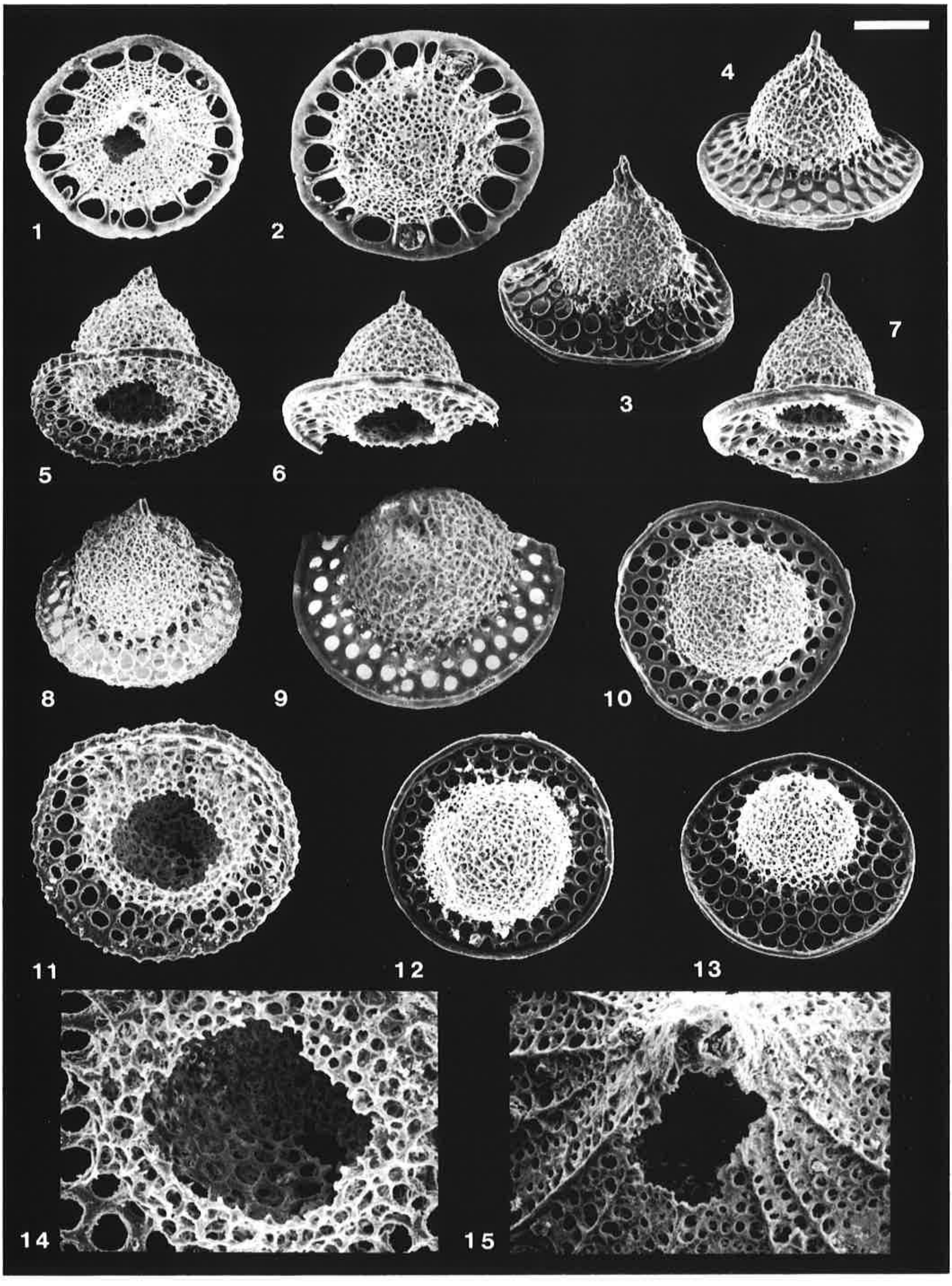


PLATE 17

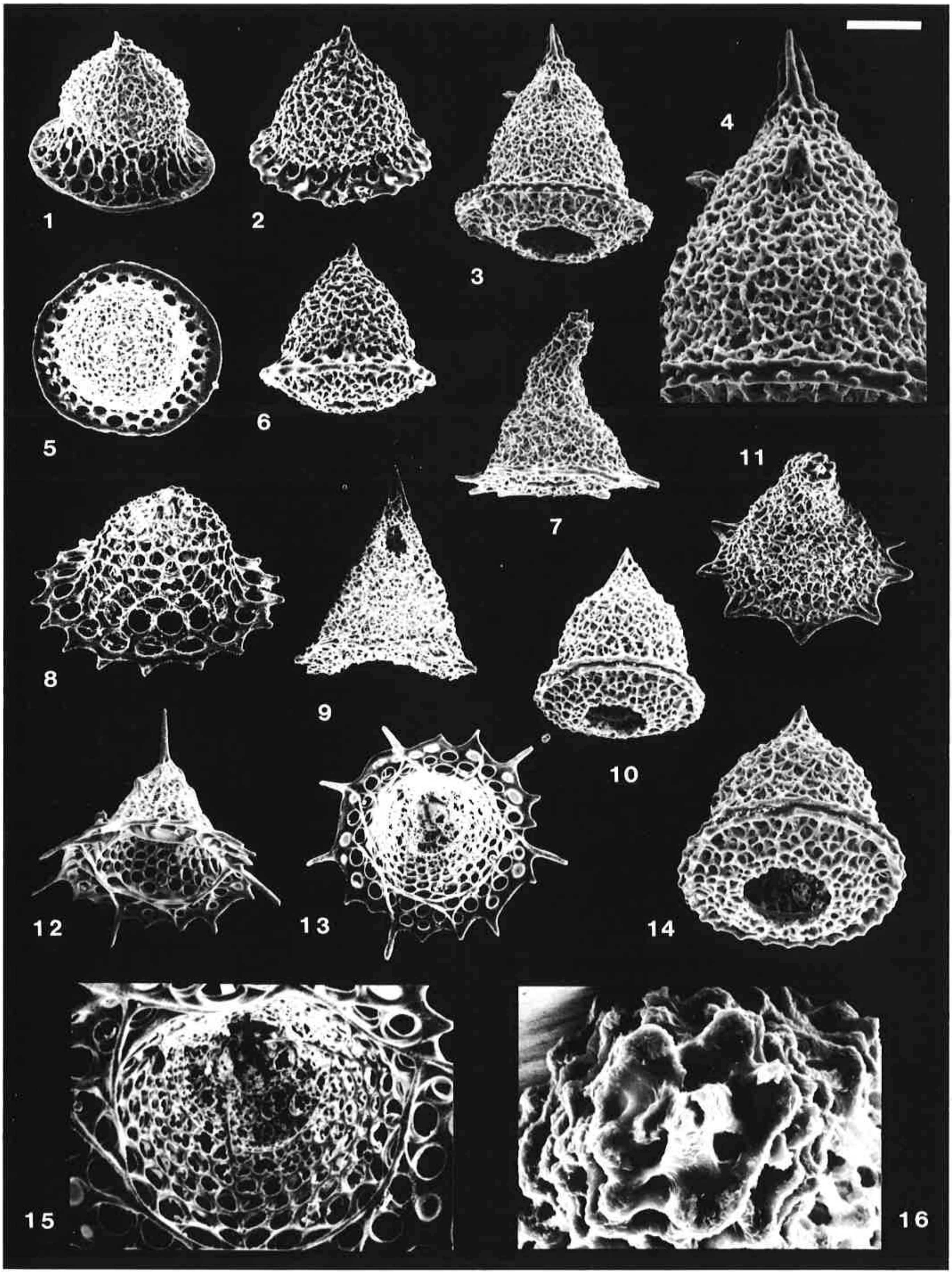


PLATE 17

Scanning electron micrographs of Nassellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1, 5. *Squinabolella* sp. aff. *S. desrochersi* n. sp. GSC 102069 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100 microns.

Figures 2, 6. *Squinabolella* sp. A. GSC 102070 from GSC loc. C-156743 (88 KPA E) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figures 3, 4. *Squinabolella* ? *trispinosa* n. sp. GSC 102071 (holotype) from GSC loc. no. C-164696/3 (87 SKU D3) Kunga Island. Scale bar = 100 microns and 51 microns respectively.

Figures 7, 9, 11, 16. *Squinabolella* sp. C. 7, 11, 16, GSC 102072 from GSC loc. no. C-164696/6 (87 SKU D6) Kunga Island. 9, GSC 102073 from GSC loc. no. C-140373 (85 SP 9/1) Louise Island. Scale bar = 100, 100, 100, and 14 microns respectively.

Figure 8. *Squinabolella* sp. D. GSC 102074 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100 microns.

Figures 10, 14. *Squinabolella* sp. aff. *S. causia* n. sp. GSC 102075 from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 100 microns and 81 microns respectively.

Figures 12, 13, 15. *Squinabolella* ? sp. B. GSC 85914 from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. Scale bar = 100, 100, and 46 microns respectively.

PLATE 18

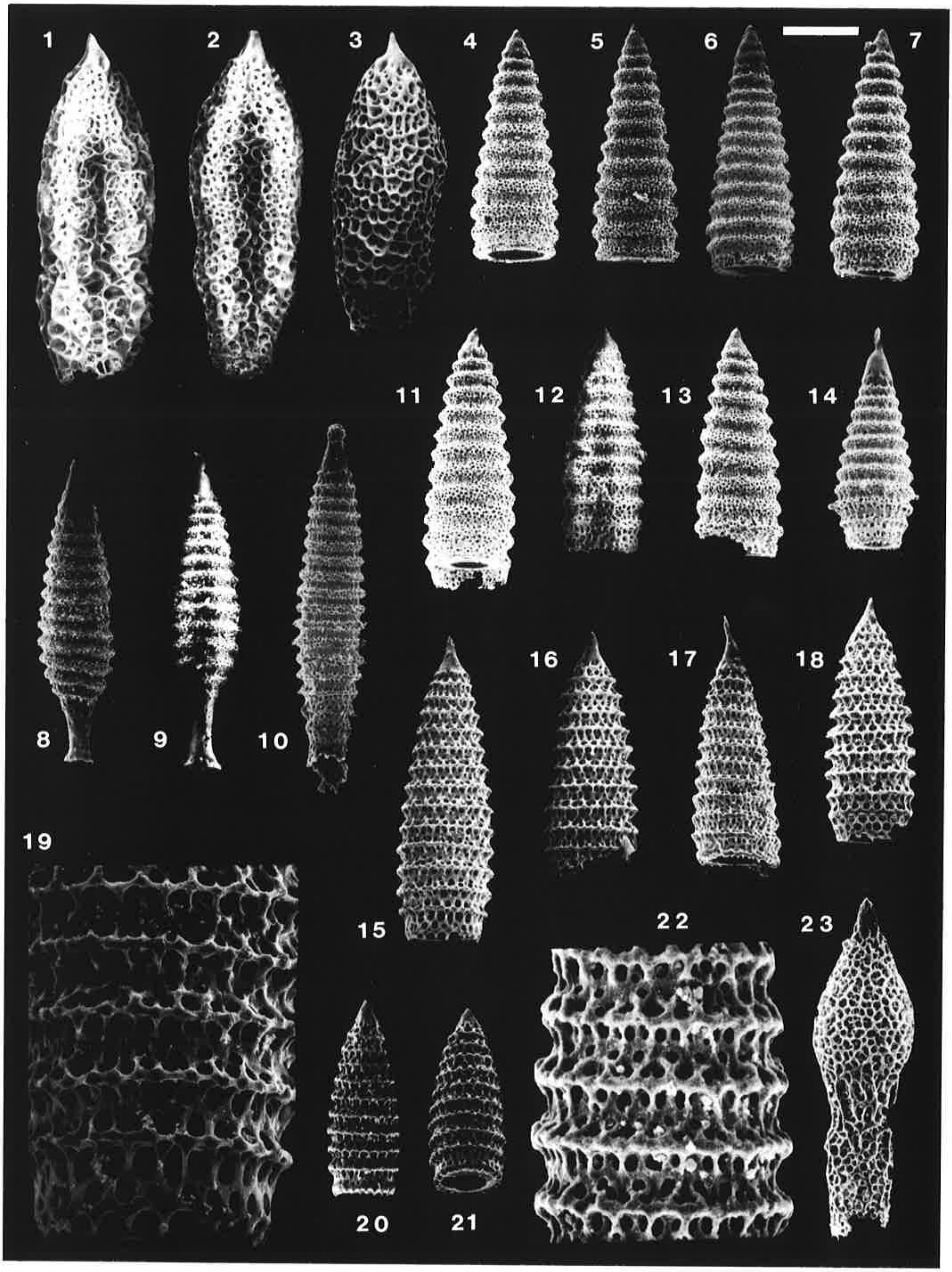


PLATE 18

Scanning electron micrographs of Nassellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1, 2, 3. *Droltus orchardi* n. sp. 1, GSC 102077 (holotype); 2 and 3, GSC 102078 and GSC 102079 (paratypes) from GSC loc. no. C-164737 (89 KPX 3) Kennecott Point, Graham Island. Scale bar = 94, 100, and 94 microns respectively.

Figures 4, 5, 6, 7. *Canoptum* sp. aff. *C. dixoni* Pessagno and Whalen. 4, GSC 85932 from GSC loc. C-140480 (87 KPA 8) Kennecott Point, Graham Island; 5, 6, GSC 102081 and GSC 102082 from GSC loc. C-127798 (86 SP 1/1) Louise Island; 7, GSC 102083 from GSC loc. C-164693/13 (87 SKU B13) Kunga Island. Scale bar = 100 microns.

Figures 8, 9. *Canoptum* sp. A 8, GSC 85934 and 9, GSC 102085 from GSC loc. no. C-140484 (87 KPA 12) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figure 10. *Canoptum* sp. aff. *C. unicum* Pessagno and Whalen. GSC 85933 from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figures 11, 12, 13. *Canoptum* sp. cf. *C. triassicum* Yao. 11, GSC 102087 from GSC loc. no. C-140373 (85 SP 9/1) Louise Island; 12, GSC 102088 from GSC loc. C-140484 (87 KPA 12) Kennecott Point, Graham Island; 13, GSC 102089 from GSC loc. C-164693/13 (87 SKU B13) Kunga Island. Scale bar = 100 microns.

Figure 14. *Canoptum* sp. B. GSC 102090 from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figures 15 - 22. *Proparvicingula moniliformis* n. gen., n. sp. 15, 19, GSC 85919 (holotype) from GSC loc. no. C-140373 (85 SP 9/1) Louise Island; 16, 17, 18, paratypes: 16, GSC 102092 from GSC loc. no. C-140484 (87 KPA 12) Kennecott Point, Graham Island; 17, GSC 102093 from GSC loc. C-164696/3 (87 SKU D3) Kunga Island; 18, GSC 102094 from GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island. 20, 21, 22, GSC 102095 (smaller specimen with tiny horn) from GSC loc. no. C-140478 (87 KPA 6) Kennecott Point, Graham Island. Scale bar = 100, 100, 100, 100, 33, 100, 97, and 27 microns respectively.

Figure 23. *Canutus* ? sp. A. GSC 102096 from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. Scale bar = 100 microns.

PLATE 19

Scanning electron micrographs of Nassellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figure 1. *Laxtorum* sp. aff. *L. kulense* Blome. GSC 102097 from GSC loc. no. C-150179 (86 SKU B10) Kunga Island. Scale bar = 81 microns.

Figures 2, 3, 4, 5. *Laxtorum porterheadense* n. sp. 2, GSC 102098 (paratype) 3, GSC 102099 (holotype) and 4, GSC 102100 (paratype) from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. 5, GSC 102101 (paratype) from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100 microns.

Figures 6, 7, 8. *Laxtorum capitaneum* n. sp. 7, GSC 102102 (holotype) and 6, GSC 102103 (paratype) from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. 8, GSC 102104 (paratype) from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. Scale bar = 100 microns.

Figures 9, 10. *Laxtorum perfectum* n. sp. 9, GSC 85935 (holotype) from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island; 10, GSC 102106 (paratype) from GSC loc. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100 microns.

Figures 11, 12, 13, 17. *Globolaxtorum cristatum* n. gen., n. sp. 11, GSC 102107 (holotype); 12, GSC 102108 (paratype); and 13, 17, GSC 102109 (paratype; with enlarged Figure (17) showing inner structure). All specimens from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 100, 100, 100, and 52 microns respectively.

Figures 14, 15, 16, 18, 19. *Globolaxtorum tozeri* n. gen., n. sp. 14, 18, GSC 85927 (holotype); 16, GSC 102111 (paratype) and 19, GSC 102112 (paratype) from GSC loc. no. C-140489 (87 KPA 17) Kennecott Point, Graham Island. 15, GSC 102113 (paratype) from GSC loc. no. C-156827 (88 KPD 1AA) Kennecott Point, Graham Island. Scale bar = 100, 76, 100, 27, and 100 microns respectively.

Figures 20, 21. *Globolaxtorum* ? sp. A. GSC 102114 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island. Scale bar = 100, and 47 microns respectively.

PLATE 19

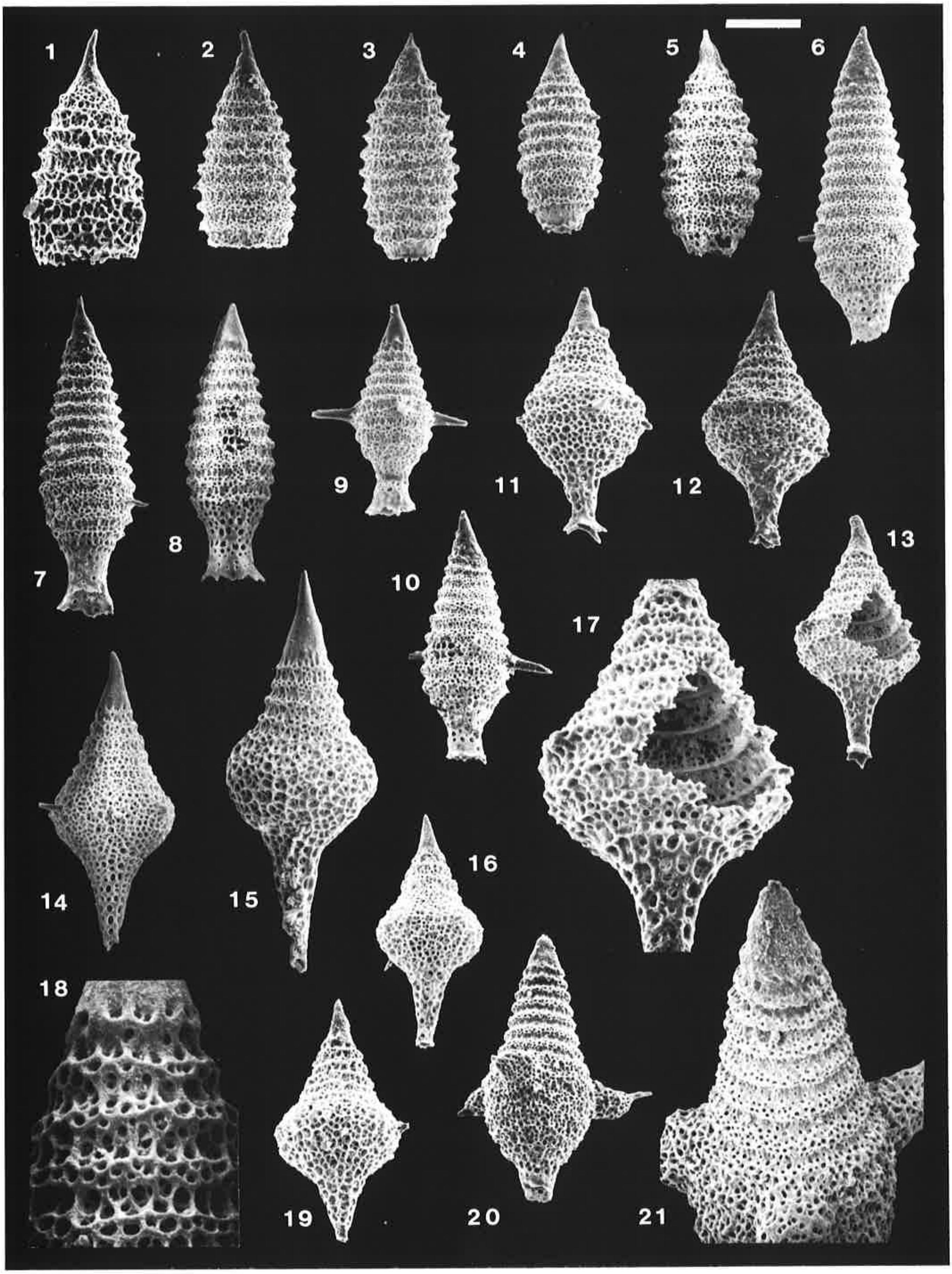


PLATE 20

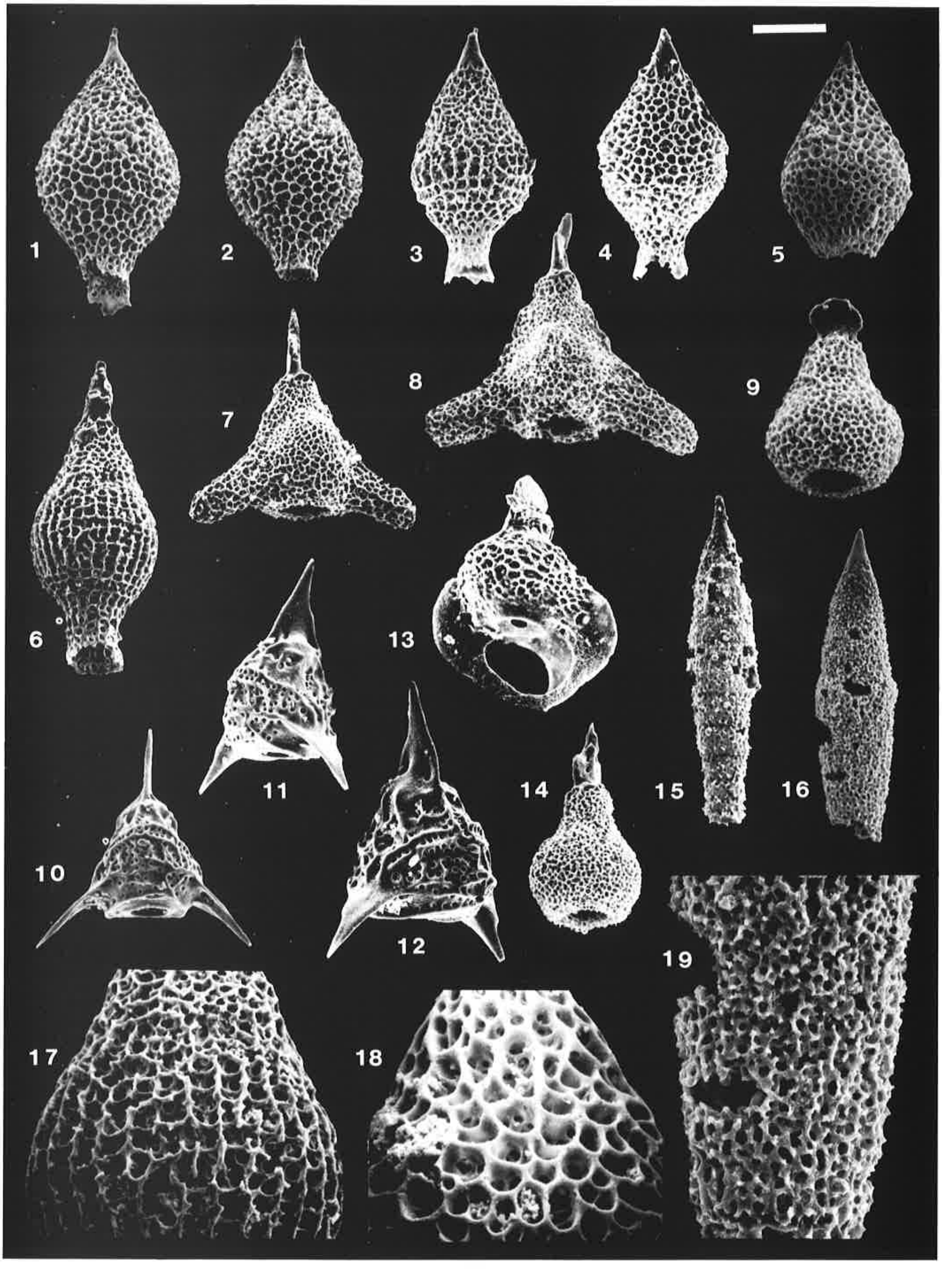


PLATE 20

Scanning electron micrographs of Nassellariina from the Sandilands Formation (upper Norian? Rhaetian), Kunga Group, Queen Charlotte Islands, B.C. Scale bar = number of microns for each specimen illustrated.

Figures 1, 2, 3, 4, 5, 18. *Canutus* ? *beehivensis* n. sp. 1, GSC 102115 (holotype) and 2, GSC 102116 (paratype) from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island; 3, GSC 102117 (paratype showing more linear arrangement of pores on post-abdominal chambers) from GSC loc. no. C-164696/7 (SKU D7) Kunga Island; 4, GSC 102118 (paratype) from GSC loc. no. C-150179 (86 SKU B10) Kunga Island; 5, 18, GSC 85931 (paratype) from GSC loc. C-140484 (87 KPA12) Kennecott Point, Graham Island. Scale bar = 31 for fig. 18, 100 microns for all other specimens.

Figures 6, 17. *Canutus* ? *ingrahamensis* n. sp. GSC 102120 (holotype) from GSC loc. C-140484 (87 KPA 12) Kennecott Point, Graham Island. Scale bar = 100 microns and 39 microns respectively.

Figures 7, 8. Nassellaria gen. and sp. indet. B. 7, GSC 102121 and 8, GSC 102122 from GSC loc. no. C-140373 (85 SP 9/1) Louise Island and GSC loc. no. C-164693/14 (87 SKU B14) Kunga Island respectively. Scale bar =100 microns.

Figures 9, 14. Nassellaria gen. and sp. indet. A. 9, GSC 102123 from GSC loc. no. C-140480 (87 KPA 8) Kennecott Point, Graham Island; 14, GSC 102124 from GSC loc. no. C-140373 (85 SP 9/1) Louise Island. Scale bar = 81, and 100 microns respectively.

Figure 10, 11, 12. *Bipedis acroslylus* Bragin. GSC 85921 from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. Scale bar = 81, 80, and 67 microns respectively.

Figure 13. *Bipedis* ? sp. A. GSC 102126 from GSC loc. no. C-150179 (86 SKU B10) Kunga Island. Scale bar = 100 microns.

Figures 15, 16, 19. Eucyrtid gen. and sp. indet. 15, GSC 101870 from GSC loc. no. C-164696/7 (87 SKU D7) Kunga Island; 16, 19, GSC 101877 from GSC loc. no. C-164696/9 (87 SKU D9) Kunga Island. Scale bar = 100, 100, and 34 microns respectively.

PLATE 21

Scanning electron micrographs of Nassellariina and Spumellariina from the Kunga Group, Queen Charlotte Islands, B.C. Specimens illustrated in Figures 11 and 12 from the Peril Formation (upper Norian); all others specimens from the Sandilands Formation (upper Norian? Rhaetian). Scale bar = number of microns for each specimen illustrated.

Figures 1, 5, 10, 13, 16. ***Livarella densiporata*** Kozur and Mostler. 1, 5, 16, GSC 85912 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island, 10, GSC 101901 from GSC loc. no. C-164696/3 (87 SKU D3) Kunga Island. 13, GSC 101910 from GSC loc. no. C-150179 (86 SKU B10) Kunga Island. In fig. 5, arrow points to raised node on underside of test. Scale bar = 100, 99, 69, 51, and 41 microns respectively.

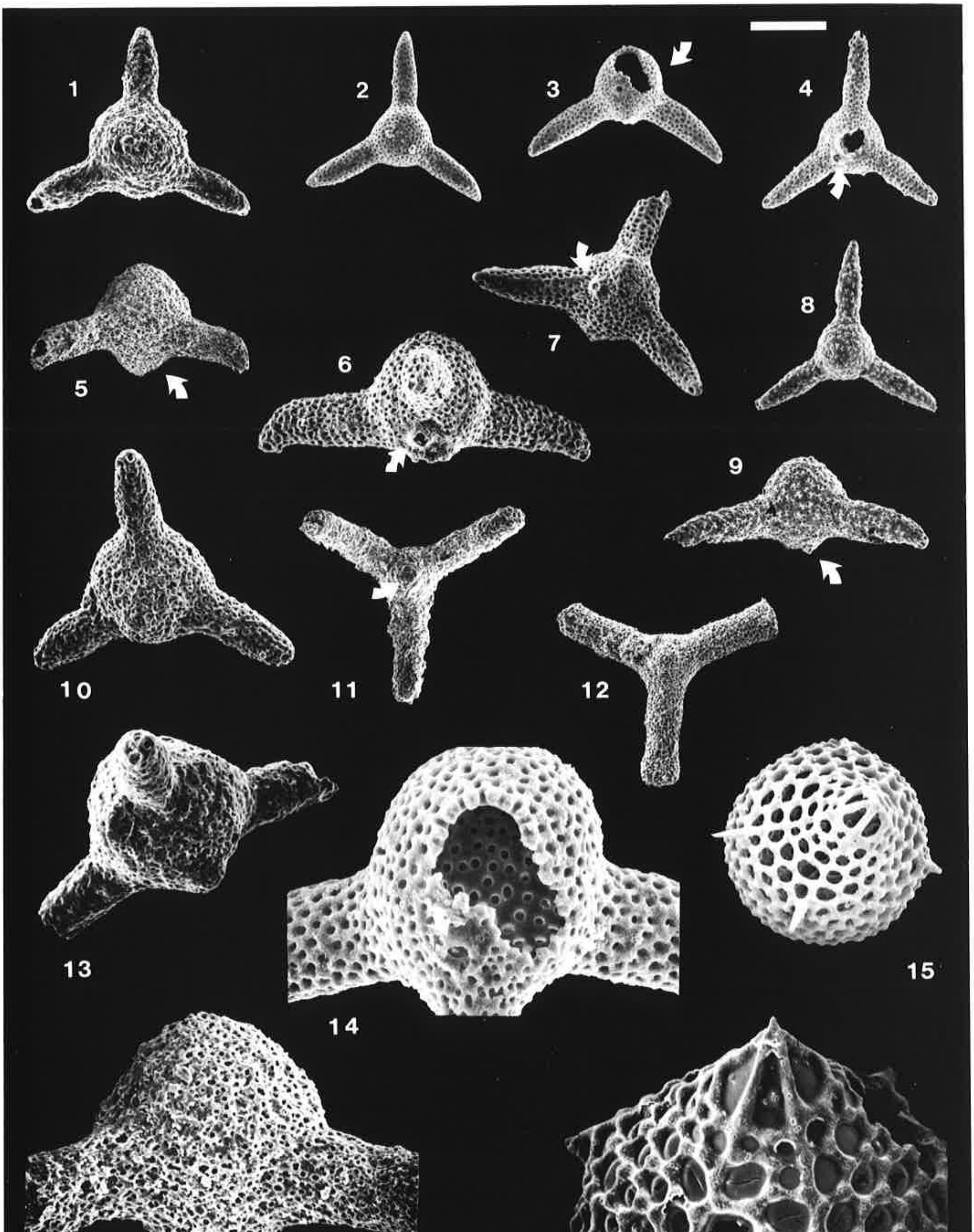
Figures 2, 3, 4, 6, 7, 14. ***Livarella validus*** Yoshida. 2, GSC 101930 and 4, 6, GSC 101932 from GSC loc. C-164696/3 (87 SKU D3) Kunga Island. 3, 14, GSC 101943 and 7, GSC 101949 from GSC loc. no. C-156827 (88 KPD 1AA) Kennecott Point, Graham Island. In fig. 3, arrow points to highly raised central area on upperside of test. In fig. 4, 6, 7, and 14, arrows point to open pore on underside of test. Scale bar = 141, 142, 141, 79, 101, and 42 microns respectively.

Figures 8, 9. ***Livarella*** sp. aff. ***L. gifuensis*** Yoshida. GSC 101977 from GSC loc. no. C-164696/3 (87 SKU D3) Kunga Island. In fig. 9 arrow points to slightly raised node on underside of test. Scale bar = 141, and 100 microns respectively.

Figures 11, 12. ***Livarella*** sp. 11, GSC 101984 and 12, GSC 102024 from GSC loc. no. C-158510 (88 SHB 3) Shields Bay, Graham Island. In fig. 11, arrow points to slightly raised node on underside of test. Scale bar = 196 microns.

Figures 15, 17. ***Pentactinocarpus*** sp. cf. ***P. sevaticus*** Kozur and Mostler. 15, GSC 101868 from GSC loc. no. C-164674 (87 SKU SP 1) Kunga Island; 17, GSC 101867 from GSC loc. no. C-127798 (86 SP 1/1) Louise Island. Scale bar = 137, and 67 microns respectively.

PLATE 21



IMPRIMERIE CHABLOZ SA.
CH - 1131 TOLOCHENAZ

IMPRIMÉ EN SUISSE

MEMOIRES DE GEOLOGIE, LAUSANNE

Mémoire 1
Baud A. 1987: *Stratigraphie et sédimentologie des calcaires de Saint-Triphon (Trias, Préalpes, Suisse et France).*

Mémoire 2
Escher A., Masson H., Steck A., 1988: *Coupes géologiques des Alpes occidentales suisses.*

Mémoire 3
Stutz E. 1988: *Géologie de la chaîne Nyimaling aux confins du Ladakh et du Rupshu (NW-Himalaya, Inde).*

Mémoire 4
Colombi A. 1989: *Métamorphisme et géochimie des roches mafiques des Alpes ouest-centrales (géoprofil Viège-Domodossola-Locarno).*

Mémoire 5
Steck A., Epard J.-L., Escher A., Marchand R., Masson H., Spring L. 1989: *Coupe tectonique horizontale des Alpes centrales.*

Mémoire 6
Sartori M. 1990: *L'unité du Barrhorn (Zone pennique, Valais, Suisse).*

Mémoire 7
Bussy F. 1990: *Pétrogenèse des enclaves microgrenues associées aux granitoïdes calco-alcalins: exemple des massifs varisque du Mont-Blanc (Alpes occidentales) et miocène du Monte Capanne (Ile d'Elbe,Italie).*

Mémoire 8
Epard J.-L. 1990: *La nappe de Morcles au sud- ouest du Mont-Blanc.*

Mémoire 9
Pilloud C. 1989: *Structures de déformation alpines dans le synclinal de Permo-Carbonifère de Salvan-Dorénaz (massif des Aiguilles Rouges).*

Mémoire 10
Baud A., Thelin P., Stampfli G. (éds) 1991: *Paleozoic geodynamic domains and their alpidic evolution in the Tethys.*

Prix de vente unitaire: SF 25.-
Commande: Secrétariat
Institut de Géologie et Paléontologie
BFSH-2, CH 1015 Lausanne. Fax. 021/6924899.