EARLY AND MIDDLE JURASSIC RADIOLARIAN BIOSTRATIGRAPHY, QUEEN CHARLOTTE ISLANDS, B.C.

By

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22

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ABSTRACT

Radiolarian biostratigraphy is used to construct an informal zonation for sediments of upper Pliensbachian to lower Bajocian age from the Maude and Yakoun Formations, Queen Charlotte Islands, B.C. Paleoenvironmental studies assess depositional environment and the effects of changing facies relationships on the fauna.

Seven distinctive assemblages are recognized comprising 167 species of spumellarian and nassellarian Radiolaria. The first well established middle Toarcian radiolarian assemblages are documented and both these and upper Toarcian assemblages are highly diverse and contain many new and unusual forms. Five genera and 89 new species are described many of which have restricted biostratigraphic ranges. A chlorophyte algal cyst appearing in all lowest Bajocian samples may, with further study, prove to be a significant marker for the lower Bajocian in the Queen Charlotte Islands.

Although Toarcian Radiolaria have been little studied, the assemblages compare with others from North America, the Mediterranean and Japan, and are distinctly Tethyan in aspect. This is consistent with the position of Wrangellia, which paleomagnetic and ammonite biogeographic evidence indicates was in the northern hemisphere within 30° of the equator during the Early to Middle Jurassic.

Studies of the abundance of spumellarians vs. nassellarians indicate that

nassellarians predominate, are abundant and diverse in deeper-water deposits (middle Toarcian and lower Bajocian shales) whereas spumellarians, particularly those with multi-layered or spongy tests, dominate in shallow-water deposits (upper middle Toarcian to Aalenian sandstones). Shallow-water nassellarians are much less diverse but a few species (all multicyrtids with thickened tests) are very abundant. Depth appears to be the major factor controlling radiolarian distribution patterns in this relatively shallow-water setting.

Studies of eustatic sea-level changes throughout the Jurassic have indicated that major phases of sea-level rise occurred in the early to mid Toarcian and in the early Bajocian with a major phase of sea-level lowering in the late Toarcian to Aalenian; detailed study of the radiolarian faunal succession in the Queen Charlotte Islands appears to confirm this major worldwide trend.

TABLE OF CONTENTS Page

TITLE PAGE-- i

ABSTRACT-- ii

TABLE OF CONTENTS-- iv

LIST OF TABLES-- x

LIST OF FIGURES-- xi

LIST OF PLATES-- xii

ACKNOWLEDGEMENTS-- xiv

I INTRODUCTION-- 1

General Statement-- 1

Brief History of Radiolarian Study------------------------------ 1

Summary of Previous Jurassic Work in the Queen Charlotte Islands- 3

Location and Objectives-- 5

II METHODS AND ANALYSIS-- 7

General Statement-- 7

Area and Sample Locations-- 7

Sample collecting-- 9

Laboratory Procedures-- 9

Species identification-- 12

Scanning electron microscopy------------------------------ 15

Analytical Methods-- 16

III LITHOSTRATIGRAPHY-- 18

General Statement-- 18

Maude Formation-- 18

General description-- 18

Maude Island-- 22

Graham Island--Yakoun River area-- 25

Yakoun Formation-- 25

General Description-- 25

Maude Island-- 28

Graham Island--Yakoun River area-- 28

IV BIOSTRATIGRAPHY-- 30

Radiolarian Occurrences and Faunal Correlation-- 30

Upper Pliensbachian samples-- 33

Middle Toarcian sample-- 34

Upper middle to upper Toarcian samples-- 35

Aalenian sample-- 36

Lower Bajocian samples-- 37

Lithostratigraphic Correlation-- 39

Biostratigraphic Correlation-- 40

Radiolarian Zonation-- 44

Introduction-- 44
Zone 1-- 48
Zone 2-- 49
Zone 3-- 50
Zone 4-- 50
Zone 5-- 51
Zone 6-- 52
Zone 7-- 53
Subzone 7A-- 54
Subzone 7B-- 54
Subzone 7C-- 54
Early Bajocian stratigraphic marker ?------------------------ 54
Discussion-- 55
Conclusion-- 56
V PALEOENVIRONMENTAL INTERPRETATION------------------------ 58
Introduction-- 58
Method of Analysis-- 59
Summary of Previous Work-- 59
Latitudinal distribution-------------------------------------- 60
Depth distribution-- 61
Characteristics of Lower/Middle Jurassic radiolarian assemblages- 63

Latitudinal distribution-- 64
Radiolarian evidence-- 64
Discussion-- 65
Paleomagnetic evidence-- 68
Ammonite biogeography-- 69
Jurassic Radiolaria--shallow shelf microfauna------------------ 70
Depth distribution-- 73
Conclusion-- 83
VI SYSTEMATIC PALEONTOLOGY-- 85
Classification-- 85
Basis for description of new taxa---------------------------- 86
Storage-- 87
Notes on use of the stage name "Aalenian"---------------------- 87
Suborder Spumellariina-- 89
Family Actinommidae-- 89
Family Hagiastridae-- 92
Family Praeconocaryommidae-- 104
Family Staurolonchidae-- 111
Family Pantanelliidae-- 124
Family Heliodiscidae-- 128
Family Patulibracchiidae-- 129

Family Pseudoaulophacidae---------------------------------- 145

Family Orbiculiformidae-------------------------------------- 146

Family Spongodiscidae--- 157

Family Parasaturnaliidae------------------------------------ 158

Family Euchitoniidae-- 159

Incertae sedis--- 160

Suborder Nassellariina--- 163

Family Archeodictyomitridae-------------------------------- 163

Family Bagotidae-- 164

Family Canoptidae--- 165

Family Canutidae-- 170

Family Hsuidae-- 173

Quantitative analysis for *Hsuum* sp. cf. *H. rosebudense*--- 177

Family Theoperidae-- 185

Family Parvicingulidae-- 187

Family Xitidae--- 194

Family Ultranaporidae--- 197

Family Paleoscenidiidae--------------------------------------- 200

Family Eptingiidae--- 202

Family Eucyrtidiidae-- 204

Family Pylontenemidae--- 207

Spongocapsulidae incertae sedis---------------------------- 207

Family Amphipyndacidae------------------------------------- 209

Family Theocorythidae-------------------------------------- 210

Nasellariina incertae sedis-------------------------------- 212

Early Bajocian Stratigraphic Marker ?------------------------ 216

VII SUMMARY AND CONCLUSIONS-------------------------------- 217

VIII BIBLIOGRAPHY-- 221

IX PLATES AND PLATE DESCRIPTIONS--------------------------- 241

X APPENDICES-- 278

Appendix 1-- 278

Appendix 2-- 290

Appendix 3-- 291

LIST OF TABLES Page

Table I: Table of formations for Queen Charlotte Islands------------- 19

Table II: Jurassic genera with environmental connotations------------ 66

Table III: Abundance of Spumellaria and Nassellaria in samples containing >100 specimens---------------------------------- 76

Table IV: Position of the Lower/Middle Jurassic boundary (after Westermann, 1979)-- 88

Table V: Statistics for three variants of *Hsuum* sp. cf. *H. rosebudense*------------------------ 181

Table VI: Values derived for T- and F-tests on samples compared-------181

LIST OF FIGURES

	Page
Figure 1: A, Map of Queen Charlotte Islands; B, Detail A shows distribution of the Maude and Yakoun Formations	8
Figure 2: A, Distribution of the Maude and Yakoun Formations; B, Detail C shows GSC localities on Maude Island	10
Figure 3: A, Distribution of the Maude and Yakoun Formations; B, Detail B shows GSC localities in the Yakoun River area	11
Figure 4: Stratigraphic sections and lithologic correlation	24 (OVERSIZE IN SPECIAL COLLECTIONS)
Figure 5: Distribution and relative abundance of Spumellaria	31
Figure 6: Distribution and relative abundance of Nassellaria	32
Figure 7: Stratigraphic sections and biostratigraphic correlation	42
Figure 8: Proposed Radiolarian Zonation	45
Figure 9: Biostratigraphic distribution of all taxa (OVERSIZE IN SPECIAL COLLECTIONS)	47
Figure 10: Model for basin deposition in the Jurassic, Queen Charlotte Islands	74
Figure 11: Percentages of Spumellaria to Nassellaria; radiolarian abundance curve shows general trend	77
Figure 12: Correlation of radiolarian abundance curve with a composite lithologic column	78
Figure 13: Eustatic sea-level curve (after Hallam, 1978)	81
Figure 14: Correlation of radiolarian abundance curve, composite lithologic column and Hallam's eustatic sea-level curve for the Jurassic	83
Figure 15: Diagram of measurements for genus *Amphibrachium* ?	130
Figure 16: Frequency distribution of W/L ratio for *Hsuum* sp. cf. *H. rosebudense*	179

LIST OF PLATES Page

1. Scanning electron micrographs of Lower Jurassic (late Pliensbachian) Spumellariina from the Maude Formation, Maude Island, Queen Charlotte Islands, B.C.-- 243

2. Scanning electron micrographs of Lower Jurassic (late Pliensbachian) Radiolaria from the Maude Formation, Maude Island, Queen Charlotte Islands, B.C.-- 245

3. Scanning electron micrographs of Lower Jurassic (late Pliensbachian) Nassellariina from the Maude Formation, Maude Island, Queen Charlotte Islands, B.C.-- 247

4. Scanning electron micrographs of Lower and Middle Jurassic (late Pliensbachian - early Bajocian) Radiolaria from the Maude and Yakoun Formations, Queen Charlotte Islands, B.C.------------------------- 249

5. Scanning electron micrographs of Lower Jurassic (mid to late Toarcian) Radiolaria from the Maude Formation, Queen Charlotte Islands, B.C.-- 251

6. Scanning electron micrographs of Lower and Middle Jurassic (mid Toarcian to early Bajocian) Radiolaria from the Maude and Yakoun Formations, Queen Charlotte Islands, B.C.------------------------- 253

7. Scanning electron micrographs of Lower Jurassic (late mid/early late to late Toarcian) Spumellariina from the Maude Formation, Graham Island, Queen Charlotte Islands, B.C.---------------------- 255

8. Scanning electron micrographs of Lower and Middle Jurassic (late mid/early late Toarcian to Aalenian) Radiolaria from the Maude Formation, Queen Charlotte Islands, B.C.-------------------------- 257

9. Scanning electron micrographs of Lower and Middle Jurassic (late mid/early late Toarcian to Aalenian) Spumellariina from the Maude Formation, Queen Charlotte Islands, B.C.-------------------------- 259

10. Scanning electron micrographs of Lower and Middle Jurassic (late mid/early late Toarcian to early Bajocian) Radiolaria from the Maude and Yakoun Formations, Queen Charlotte Islands, B.C.---------------- 261

11. Scanning electron micrographs of Lower Jurassic (late mid/early late Toarcian) Patulibrachiidae from the Maude Formation, Queen Charlotte Islands, B.C.--- 263

12. Scanning electron micrographs of Lower Jurassic (late mid/early late to late Toarcian) Spumellariina from the Maude Formation, Graham Island, Queen Charlotte Islands, B.C.---------------------- 265

13. Scanning electron micrographs of Lower Jurassic (late mid to late Toarcian) Nassellariina from the Maude Formation, Graham Island, Queen Charlotte Islands, B.C.------------------------------------- 267

14. Scanning electron micrographs of Lower Jurassic (late mid/early late to late Toarcian) Nassellariina from the Maude Formation, Graham Island, Queen Charlotte Islands, B.C.---------------------- 269

15. Scanning electron micrographs of Middle Jurassic (Aalenian to early Bajocian) Radiolaria (and algal cyst) from the Maude and Yakoun Formations, Queen Charlotte Islands, B.C.------------------------ 271

16. Scanning electron micrographs of Middle Jurassic (early Bajocian) Radiolaria from the Yakoun Formation, Graham Island, Queen Charlotte Islands, B.C.--- 273

17. Scanning electron micrographs of Middle Jurassic (early Bajocian) Radiolaria from the Yakoun Formation, Graham Island, Queen Charlotte Islands, B.C.--- 275

18. Scanning electron micrographs of Middle Jurassic (early Bajocian) Nassellariina from the Yakoun Formation, Graham Island, Queen Charlotte Islands, B.C.--- 277

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I INTRODUCTION

GENERAL STATEMENT

Radiolaria are marine planktonic protozoans. Polycystine Radiolaria possess tests of almost pure opaline silica and comprise the suborders Spumellariina and Nassellariina (Ehrenberg, 1838). Ranging throughout Phanerozoic time, these protists apparently were as widespread and diverse in the Paleozoic as they are now. Spumellarian (spherical) radiolarians are known from the Cambrian on, and with few major morphological adaptations, have undergone great proliferation since then, particularly in the Cenozoic. Nassellarian (cone-shaped) radiolarians evolved in the Triassic and have steadily diversified since.

Early workers judged Radiolaria to be extremely long ranging and too microscopic to study well. However, recent intensive study stimulated by the Deep Sea Drilling Program and the development of the scanning electron microscope have shown Radiolaria to be particularly well suited to biostratigraphy because of their planktonic habitat, diversity of form, rapid evolution and frequent occurrence in otherwise unfossiliferous rocks.

BRIEF HISTORY OF RADIOLARIAN STUDY

Study of Radiolaria began in Europe in the mid 1800's with Ehrenberg (1838, 1847, 1854) and Müller (1858). The first major work was by Ernst Haeckel

(1887a, b) on material obtained from the Challenger Expedition 1873-1876. In these comprehensive monographs, Haeckel produced the first classification scheme which included fossil forms, but was based primarily on modern Radiolaria from plankton and bottom sediments. Haeckel was also the first to study distribution patterns and stated that Radiolaria occur in all oceans, in all climatic zones and at all depths in the water column. Undoubtedly, this work provided the stimulus for other workers such as Rüst (1885, 1898), Parona (1890), Vinassa de Regny (1899) and Squinabol (1903, 1904) to further examine Mesozoic Radiolaria in southwestern Europe. Following a lull in activity, work was resumed in the 1940's when new workers, many of them Russian, began further studies sparked by recognition of the importance of planktonic foraminifers in interpreting the stratigraphy of Cretaceous, Tertiary and Recent sediments of the continental and oceanic crust..

In North America in the mid 1960's, Emile Pessagno began a series of studies on the Great Valley Sequence of the California Coast Range which produced (1971, 1973, 1976, 1977a, b) a radiolarian zonation scheme encompassing strata of Upper Jurassic (late Kimmeridgian / early Tithonian) to Upper Cretaceous (Maastrichtian) age. This zonation was integrated with biostratigraphic data supplied by ammonites, buchiid bivalves and planktonic foraminifers. Since the inception of the Deep Sea Drilling Program in 1968, abundant data have accumulated on siliceous pelagic sediments and our knowledge of both ancient and modern Radiolaria has greatly increased. Results published in the Initial Reports of the Deep Sea Drilling Program by Moore (1973), Foreman (1973, 1975, 1978), Riedel and Sanfilippo (1974) and others, can now be more accurately cross-correlated with land based sections in light of Pessagno's California data.

Increased knowledge of the complicated structure of the radiolarian test has led to a continuing trend among modern workers to amend Haeckel's classification, based on test shape and form, by placing more emphasis on structure as a basis for comparison.

SUMMARY OF PREVIOUS JURASSIC WORK IN THE QUEEN CHARLOTTE ISLANDS

Geological investigations in the Queen Charlotte Islands prior to 1916 concerned exploration for coal and mineral deposits. Initial study by Richardson (1873) was followed soon after by the classical work of G.M. Dawson (1880) who studied the geography and geology of the central and eastern shores of the islands as well as the fauna, flora and anthropology. Dawson separated the sedimentary rocks of central Graham Island into five subdivisions and believed them all to be of Cretaceous age. Whiteaves (1876, 1883, 1884, 1900) studied the paleontological collections and saw only one ammonite fauna; a transitional one encompassing the Upper Jurassic and lowermost Cretaceous. Mackenzie (1916) systematically studied Graham Island, revising Dawson's stratigraphy and incorporated Jurassic beds into two formations: the Maude and the Yakoun, which he considered Lower and Middle Jurassic respectively. In 1921, F.H. McLearn collected in Skidegate Inlet and published extensively on Jurassic ammonites (1927, 1929, 1930, 1932) as well as a summary of Jurassic stratigraphy (1949). He believed ammonites of the Maude Formation (at Maude Island and Whiteaves Bay) were Toarcian only, and those of the Yakoun middle Bajocian. Frebold (1967) adjusted the age of the Maude to upper Sinemurian and lower Pliensbachian as well as Toarcian, based on study of the genus *Fanninoceras*. The next major work was by Sutherland Brown (1968) who mapped in detail both Graham and Moresby Islands.

In 1974 the Geological Survey of Canada began a series of biostratigraphic studies of Jurassic Formations in the Queen Charlotte Islands (Tipper, 1976, 1977; Tipper and Cameron, 1979, 1980; Cameron and Tipper, 1981). Sections were examined at Maude Island (type locality of the Maude Formation), Whiteaves Bay and in the Yakoun River area on central Graham Island. Studies of ammonites collected up to the present indicate that a nearly complete section of Jurassic strata of Sinemurian to middle Callovian age is present. Current research by Cameron is expected to bring about a foraminiferal zonation of these Jurassic sediments while Tipper and Smith are working towards a western North American zonation for the ammonites.

Work was begun on Radiolaria in the late 1970's when Pessagno and several of his students initiated studies on the morphology, phylogeny and stratigraphic distribution of Upper Triassic and Lower Jurassic Radiolaria in California, east-central Oregon and the Queen Charlotte Islands. Jurassic samples, ranging in age from Hettangian ?-Sinemurian to late Pliensbachian, were collected at Kunga Island, Maude Island and Whiteaves Bay. Results, confined primarily to the description of new taxa with some preliminary range zone data, are found in Pessagno and Blome (1980) and Pessagno and Whalen (1982); major zonal schemes are proposed in Blome (1983) and Pessagno et al (in preparation).

LOCATION AND OBJECTIVES

The Queen Charlotte Islands are located approximately 140 km off the west coast of British Columbia between 52° 00' N and 54° 15' N. They consist of two large islands; Graham Island in the north and Moresby Island in the south, plus a number of smaller islands located within Skidegate Inlet (separating the larger islands) and along the eastern coast of Moresby.

Jurassic rocks in the Queen Charlottes are named the Kunga, Maude and Yakoun Formations; the latter two outcrop mostly in the central portion of the islands, and are the subject of this study. Measured sections and microfossil samples examined are from localities on Maude Island (in Skidegate Inlet) and the Yakoun River area of central Graham Island.

This study represents the first research on Radiolaria of Toarcian to early Bajocian age in the Queen Charlotte Islands. Its pertinence to oil exploration is opportune as possible source beds exist within the Maude and Yakoun Formations and oil stain and/or bitumen have been recorded (Cameron and Tipper, 1981). Objectives are:

(1) To develop an informal radiolarian zonation for sediments of late Pliensbachian to early Bajocian age based on the age of associated ammonites.

(2) To assess the influence of changing facies on the fauna.

(3) To determine how distribution patterns for Jurassic Radiolaria relate to those of populations in other ancient and in modern oceans.

(4) To describe new taxa. Since Toarcian Radiolaria are poorly known worldwide, this is by far the largest (and perhaps the most important) part of the work.

(5) To increase our pioneer understanding of radiolarian paleoecology in the Jurassic.

II METHODS AND ANALYSIS

GENERAL STATEMENT

Fieldwork was conducted in May/June 1982 when the author joined a Geological Survey of Canada field party engaged in continuing biostratigraphic studies of the Queen Charlotte Islands. Numerous localities, both those visited previously by survey members and new ones, were examined in order to gain overall knowledge of the stratigraphy and an appreciation for the problems involved in interpreting the complex history of the area.

Twenty-one samples containing Radiolaria were examined during this study. The majority of these were collected by B.E.B. Cameron in 1980-82 and are referred to on sections measured and described by Cameron (see Cameron and Tipper, in preparation) illustrated in Figs. 4 and 5 (p. 24 and 31, respectively). All samples were processed for micropaleontological analysis and made available for study by the Geological Survey of Canada, Pacific Geoscience Centre, Sidney, B.C.

AREA AND SAMPLE LOCATIONS

Exposures of the Maude and Yakoun Formations in the central Queen Charlotte Islands are shown in Fig. 1A and 1B (p. 8). These are on central Graham Island, northern Moresby Island and in the Skidegate Inlet area. Localities were examined on Maude Island in Skidegate Inlet and in areas bordering the Yakoun River on

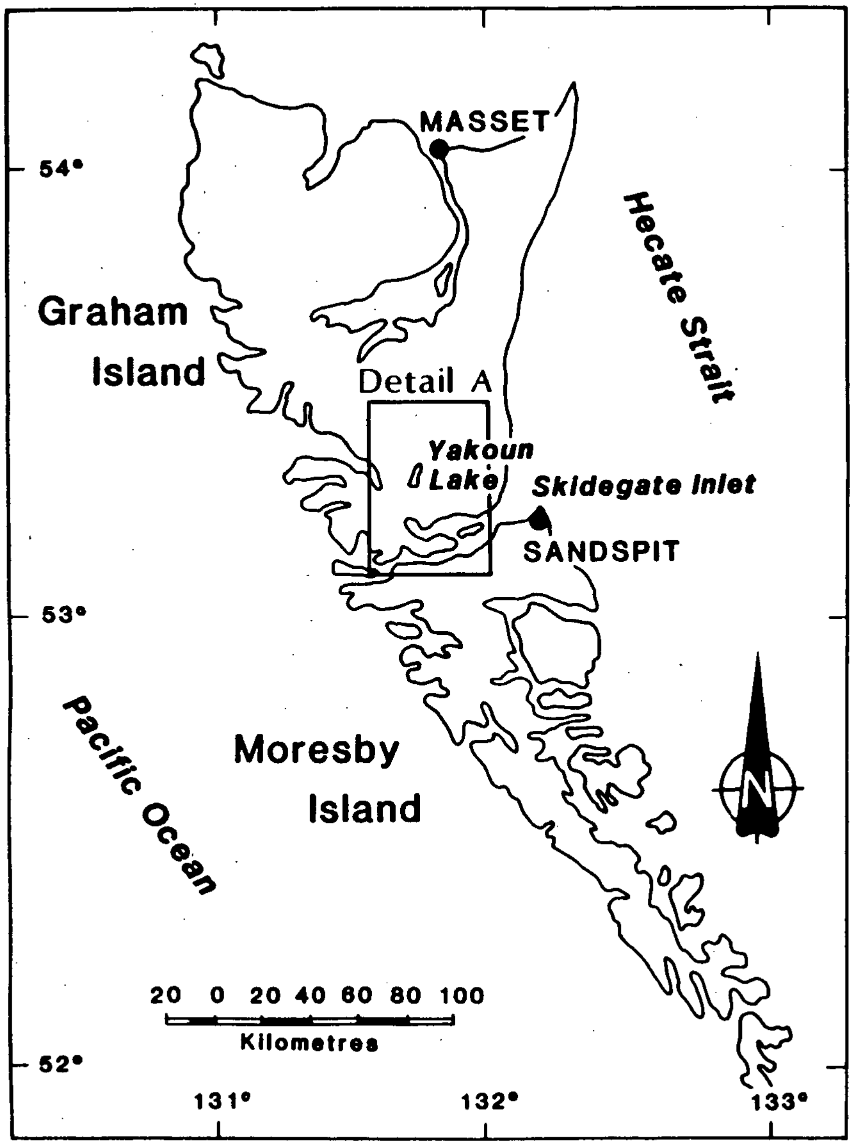

Figure 1A: Map of Queen Charlotte Islands.

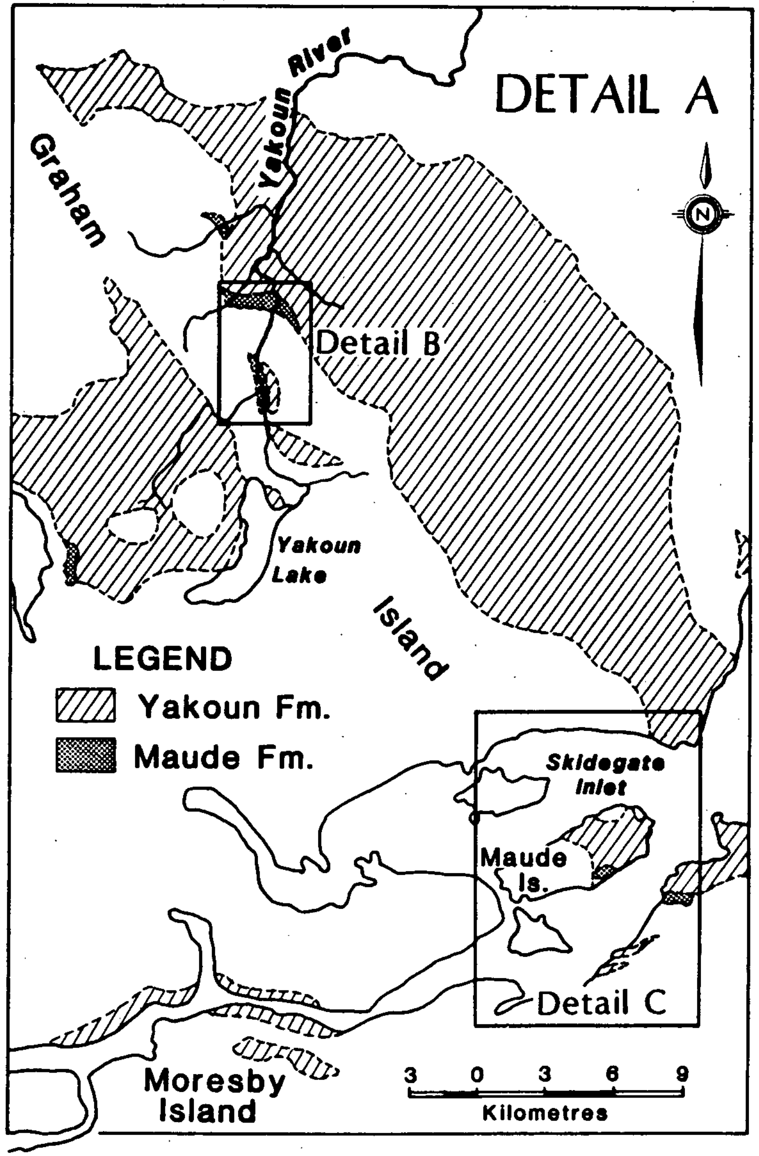

Figure 1B: Detail A shows distribution of the Maude and Yakoun Formations.

central Graham Island.

On Maude island limestones C-080577, C-080578 and C-080579 were collected from exposures on two creeks (marked "A" and "B" on Fig. 2B, p. 10) which empty onto the beach near Fannin Bay on the southeast coast of the island. All other samples were collected from exposures along the Yakoun River approximately 2.5 km south of Ghost Creek and from three creeks (marked "C","D" and "E" on Fig. 3B, p. 11) to the south which drain a prominent bluff approximately 0.5 km east of the river. For location of samples see Figs. 2B and 3B (p. 10 and 11, respectively). Detailed geographic and stratigraphic information of localities and lithologic description of samples is found in Appendix 1.

Sample Collecting

As this is a preliminary study, radiolarian-bearing limestones were collected as composite samples over approximately 3 m intervals, a sampling interval consistent with the length of geologic time encompassed by this study. With the exception of C-080579 from a limestone nodule, all samples are from bedded concretionary limestone.

LABORATORY PROCEDURES

Choice of laboratory procedures used to extract Radiolaria is determined by matrix lithology and the mineralogy of the radiolarian tests. Polycystine

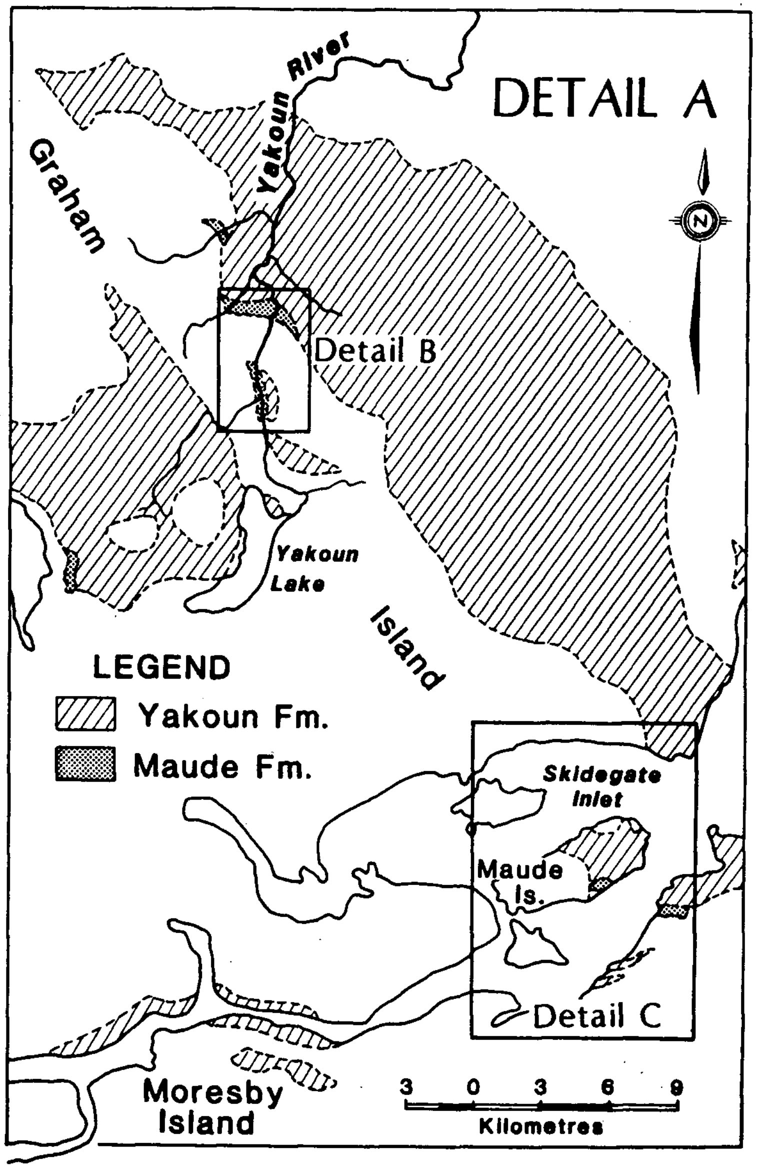

Figure 2A: Distribution of the Maude and Yakoun Formations.

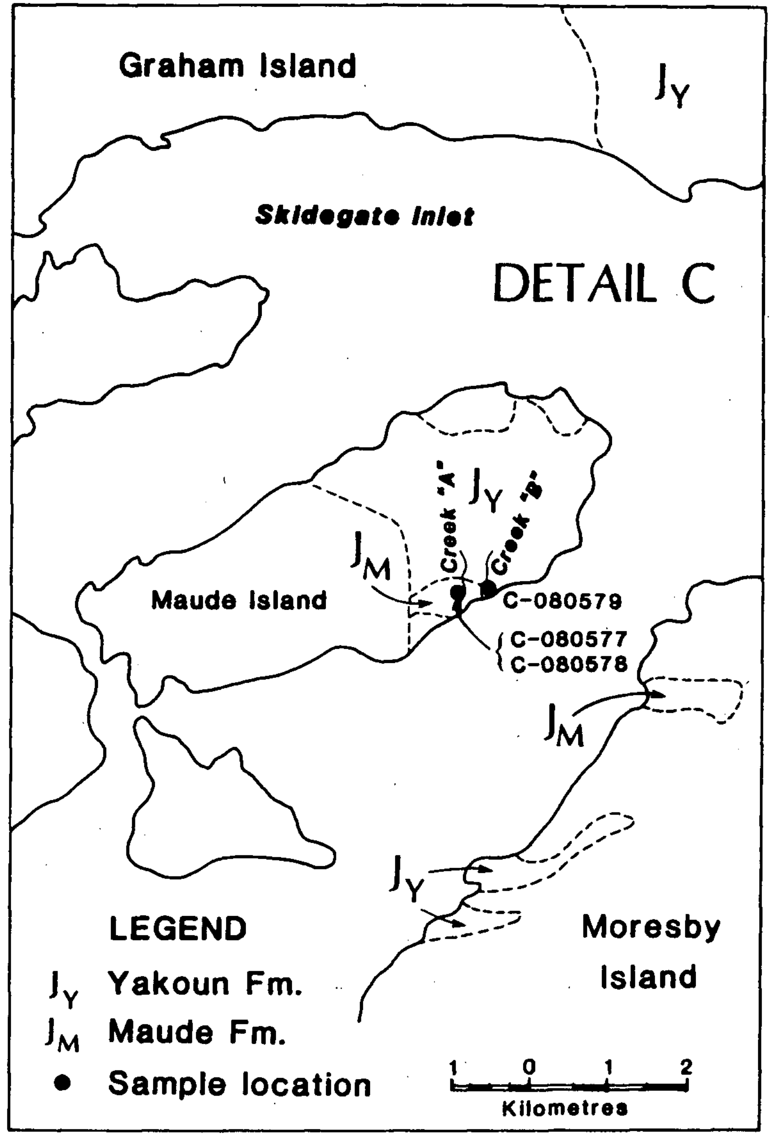

Figure 2B: Detail C shows GSC localities on Maude Island.

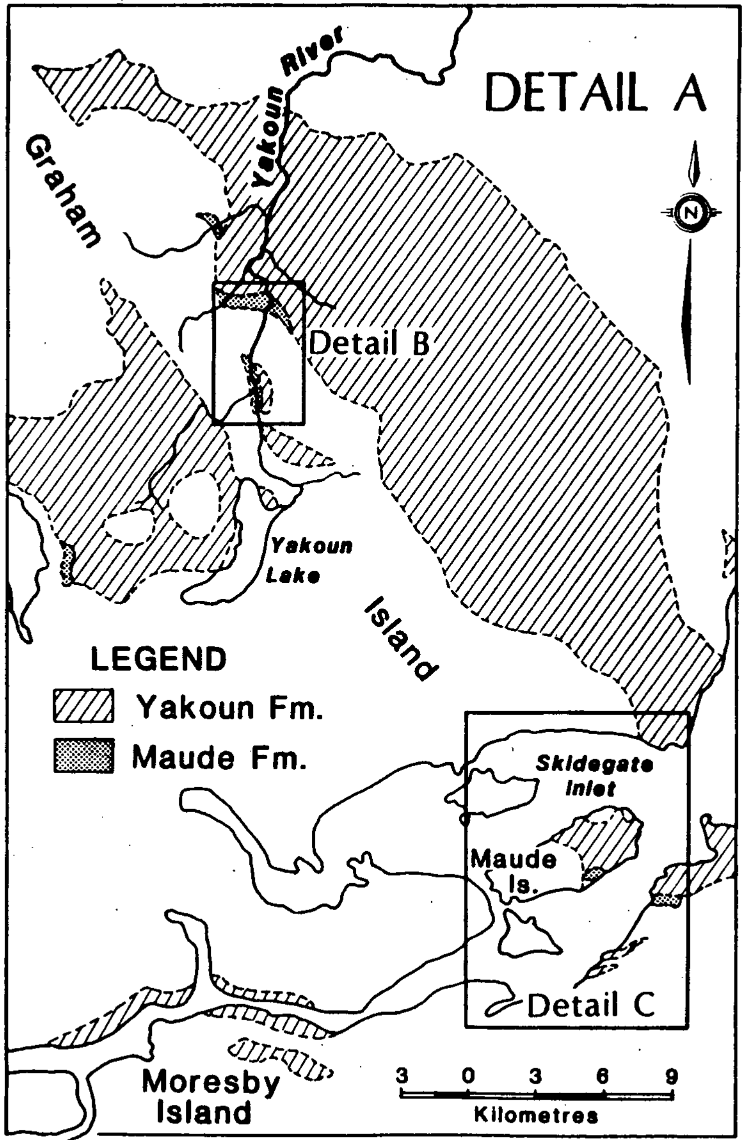

Figure 3A: Distribution of the Maude and Yakoun Formations.

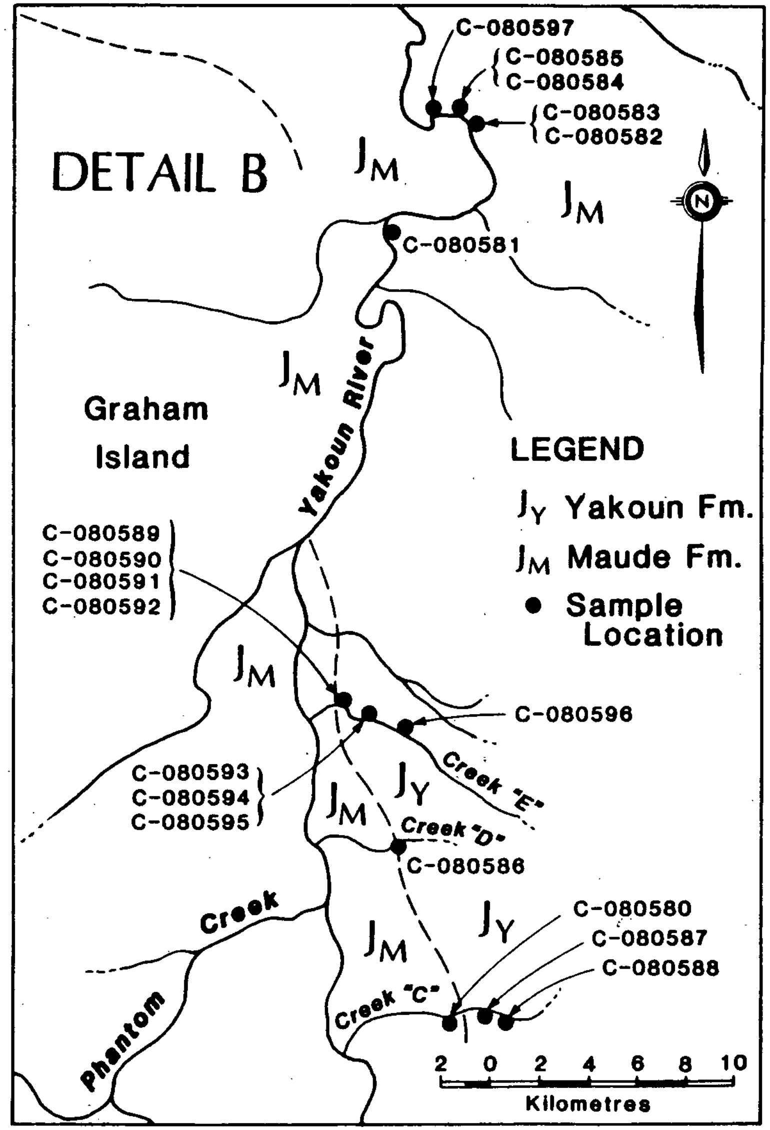

Figure 3B: Detail B shows GSC localities in the Yakoun River area.

Radiolaria build their tests of opaline silica extracted from seawater. In Mesozoic Radiolaria, however, the opal has been converted to crystobalite or quartz often with accompanying filling of the lattice pores and loss of detail (Goll and Merinfeld, 1979). In addition to silica transformations radiolarian tests can be replaced by calcite, pyrite, limonite, smectite and other silicate minerals (Pessagno, 1977c). For limestones bearing silicified Radiolaria, the standard processing technique is acid digestion using either glacial acetic or hydrochloric acid, wet sieving, treatment with hydrogen peroxide to clean the tests, further wet sieving and drying. See Appendix 2 for details of procedure.

Samples were picked in fractions obtained by using a set of micropaleontological sieves (40, 60, 80, 100, 120, 200 and a pan for material finer than 200 mesh). Radiolaria were picked from sediment fractions with the aid of a binocular microscope and a 002 camel hair brush. In good samples, i.e. those containing abundant radiolarians, only a small portion of the sample was picked; whereas where fauna were sparse, a large proportion, if not the whole sample, had to be picked. In addition to Radiolaria other microorganisms included small pyritized foraminifers, algal cysts, sponge spicules, wood and plant material.

Species Identification

Specimens were examined by means of binocular microscope and SEM photomicrographs. Measurements of various parameters were used to enhance descriptions and some have been subjected to statistical procedures. Identification of taxa to genus and species level is based on comparison with figures and descriptions from the literature. The main difficulty has been the lack of published information on Jurassic Radiolaria: particularly those of Toarcian age. Most useful of early publications are those of Haeckel (1862, 1881, 1887) and Rüst (1885, 1898). Haeckel's is based on material from the Challenger expedition 1873-1876, whereas Rüst's is based on Jurassic sequences in western Europe. Unfortunately much type material has been destroyed (Baumgartner, 1980), many of these descriptions are unclear and line drawings somewhat suspect.

The Treatise on Invertebrate Paleontology: Part D, Protista 3, by Campbell (1954) initiated the more modern era. This work revised much of Haeckel's original classification scheme but is now outdated. Since the commencement of the Deep Sea Drilling Program (JOIDES) in 1968, knowledge of deep sea sediments has greatly increased, and with it has come an awareness of Radiolaria as potent biostratigraphic tools, particularly in otherwise nonfossiliferous strata. Consequently, many new workers have entered the field in the past 12-15 years.

Some, but by no means all, of the more useful publications on Mesozoic Radiolaria include those previously mentioned of Pessagno and his students (1971c - 1982) concerning western North America and Baja California; Baumgartner (1980), De Wever et al (1979) De Wever (1981, 1982), Dumitrica (1970, 1978a,b,) Pessagno and Poisson (1981) in Mediterranean areas (particularly Greece, Turkey, Italy, Sicily and Romania) and Yao and others (1972, 1976, 1979, 1980, 1982) in central Japan. Through the DSDP, Foreman (1973) has studied the northwest Pacific Ocean, Pessagno (1971a) and Foreman (1978) the Atlantic Ocean, and Riedel and Sanfilippo (1974) the Indian Ocean.

Precise number counts have not been used in this study because of the range of variation in total numbers of Radiolaria in the samples which probably does not reflect true abundance [for example, C-080578 contains under 20 Radiolaria in the total sample (12.83 g) whereas C-080583 contains over 800 Radiolaria in approx. one-half (18.37 g) total sample. Reasons for this variability include:

1. Dilution of radiolarian fauna by variable amounts of terrigenous material in shelf or near shore environments and by pyroclastic material in areas exposed to volcanism. The latter could partially explain the paucity of microfauna in some lower Bajocian samples. Observations in modern oceans indicate the volume of tephra produced during subaerial eruptive phases of volcanism could effectively mask siliceous deposits that normally form by chemical precipitation or by plankton blooms (Garrison, 1974, p. 374).
2. Effects of dissolution. Exposed polycystine tests are subjected to extensive dissolution both within the water column and as sediments accumulating on the seafloor. Dissolution is greatest near the

surface and decreases with depth, a pattern reflecting bathymetric distribution of dissolved silicon and reduced temperature (Berger, 1968). Most tests reaching the bottom do so encapsulated in fecal pellets (Adelseck and Berger, 1975). In modern oceans dissolution affects delicate forms composed of thinner elements first (Berger, 1968), thus biasing the fauna in favour of deep-living forms with more robust skeletons.

3. Differential preservation: Preservation is usually best in silicified tests but detail remains reasonably clear in many that are pyritized. Recrystallization obliterates most structural detail making positive identification impossible.

4. Sedimentary compaction can destroy all but the sturdiest tests (Pessagno, 1976, p. 59). It is particularly prevalent in shales and mudstones but can affect other lithologies to a lesser degree.

Scanning Electron Microscopy

Type specimens and some paratypes, illustrating specific morphologic features, were mounted on standard aluminium SEM stubs, coated with gold palladium and photographed with the scanning electron microscope. A technique for mounting radiolarians on SEM stubs described by De Wever (1980) with minor modifications suggested by R.M. Goll (pers. comm., 1983) achieved the most satisfactory results. Details are found in Appendix 3. SEM photomicrographs are essential for identification and adequate description of Radiolaria, which are exceedingly small in size (50-250µm) and have minute diagnostic pore structure.

The majority of SEM micrographs in plates 1 to 18 were taken on the Cambridge-Stereoscan 100 instrument located at the Geological Survey of Canada, Pacific Geoscience Centre, Sidney, B.C. Additional micrographs were taken on the SEMCO Nanlab 7 instrument at the Department of Geological Sciences, University of British Columbia.

ANALYTICAL METHODS

Radiolaria were analysed for: species or morphotypes; relative abundance; stratigraphic range; age of associated biota; and in relation to surrounding lithofacies (exclusive of limestone matrix). Stratigraphic sections were analysed in terms of lithology and contained biota. Lithologic description of samples (see Appendix 1) was limited to sample residues.

The relative abundance of each taxon present from sample to sample is shown on Figs. 5 (p. 31) and 6 (p. 32). Taxa are designated **Rare** (1-2 specimens), **Common** (3-6 specimens) or **Abundant** (> 6 specimens). Where poor preservation prohibited positive identification, brief comments regarding the general character of the specimens are listed under the sample number in

Appendix 1.

Range charts showing local ranges (teilzones) of all taxa were used to develop a zonation for Radiolaria in the Queen Charlotte Islands using first and final appearances of abundant taxa to mark the boundaries. Well preserved ammonite suites, identified by H.W. Tipper and P.L. Smith, were found in close association with most radiolarian assemblages, providing excellent stratigraphic control. In intervals lacking ammonites the microassemblages were dated by comparison with other radiolarian faunas of known age. Where neither of the above means could be used, tentative ages were based on lithologic correlation.

Statistical methods were utilized in one instance to confirm the presence of a single species with wide limits of variation. Measured parameters on a number of specimens were compared using the T-test and standard F-test of the Michigan Interactive Data Analysis System (MIDAS). Results are shown on p. 181.

Separate counts of spumellarians and nassellarians were made for each sample in an effort to determine if the ratios could be correlated with facies changes and ultimately related to bathymetry.

III LITHOSTRATIGRAPHY

GENERAL STATEMENT

The Vancouver Group in the Queen Charlotte Islands includes the Karmutsen, Kunga, Maude and Yakoun Formations which were deposited on the tectonostratigraphic terrane known as Wrangellia (see Table 1, p. 19). Volcanic rocks predominate and sedimentary sequences are normally thin and in part volcaniclastic. Vancouver Group rocks are marine with the exception of a small portion of the Yakoun Formation, and are Triassic and Jurassic in age. The stratigraphy of the Maude and Yakoun Formations follows; general descriptions are based on published literature, chiefly Sutherland Brown's most recent interpretation (1968) while detailed information of localities relevant to this study draws upon field notes and information provided by B.E.B. Cameron and H.W. Tipper (see also Cameron and Tipper, in preparation).

MAUDE FORMATION

General Description

The Maude Formation, established by MacKenzie (1916) has been redescribed by McLearn (1949) and Sutherland Brown (1968); with each redefinition further restricting the original concept. The Maude is a thin sedimentary marine unit not exceeding 300 m in thickness. It is exposed in small, widely scattered

AGE		STRATIGRAPHIC UNITS		Sutherland Brown (1968)	This Paper	
				(Thicknesses in feet)	(Thicknesses in metres)	
LOWER CRET.	Barremian and Hauterivian, Late Valanginian	Longarm Formation		4000		
Conformable to unconformable on Yakoun Formation, highly unconformable to all older units						
MIDDLE JURASSIC	Callovian – Bajocian	VANCOUVER GROUP	Yakoun Formation	E member: 455	E member	
				D member: 800	D member	
				C member: 950	C member	
				B member: 100+	B member	
				A member: 650	A member: 244	
	Aalenian		Conformable to slightly conformable			
LOWER JURASSIC	Toarcian		Maude Formation	Up to 600	300 — Upper	Belemnite sandstone
	Pleinsbachian					Grey sandstone
	Sinemurian					Grey shale
						Paraconformity
					300 — Lower	Harpoceratid beds
						Tuffaceous siltstone, shale, sandstone, minor limestone
			Conformable contact			
UPPER TRIASSIC	Norian		Kunga Formation	Black argillite member up to 1900	Black argillite member	
				Black limestone member 700 – 900	Black limestone member	
	Karnian			Grey limestone member 100 – 600	Grey limestone member	
			Conformable contact			
			Karmutsen Formation	14,000 +		

TABLE I: Table of Formations for Queen Charlotte Islands.

discontinuous outcrops mostly in the central portion of the Queen Charlotte Islands (see Fig. 2A, p. 10). The type section is recognized by subsequent authors as located just west of Fannin Bay on the southeast shore of Maude Island. Where present, the Maude lies with gradational contact on the Kunga Formation. The upper member of the Kunga is a thinly bedded black argillite which is not readily distinguished from the Maude except where well exposed or where fossils are collected. The Maude is overlain conformably by the Yakoun Formation, at least in some localities. The transition is abrupt, normally signalled by an increase in volcaniclastic material. The upper Maude at all localities is invariably sandstone whereas the lower Yakoun consists typically of interbedded shale, siltstone and sandstone, all with high tuffaceous content.

The Maude is composed of siltstone, shale, calcareous shale and lithic sandstone with minor limestones and a few tuffaceous beds. Fine grained components are very dark to light grey; sandstones are grey to grey-green and limestones are light grey, weathering to buff. Bedding of siltstones and some sandstones is slabby to blocky but shales and other sandstones have little apparent bedding.

Considerable facies variation is apparent within the Maude. The lower Maude contains mostly dark, thinly-bedded, fine grained rocks. Carbonaceous content is variable but high at some localities on Graham Island where shales are black and fetid; bitumen and oil stain have been observed (McLearn, 1949; Cameron and

Tipper, 1981). Rich pelagic macro and microfaunas are found throughout these rocks in contrast to the "dwarfed", low diversity benthic microfauna. McLearn (1949) was the first to suggest that deposition took place in deep water, possibly stagnant at times. In the overlying strata coarse clastics predominate, glauconite grains are frequent and beds containing chamosite ooliths have been noted on Creek "A", Maude Island. A benthic macrofauna (trigoniid bivalves, brachiopods) is abundant as are silicified ostracods and shallow water agglutinated foraminifers (B.E.B. Cameron, pers. comm., 1983). Trace fossils, including *Thalassinoides* , which is common in sandy nearshore environments (Pemberton and Frey, 1983, fig. 8, p. 31) are exceedingly common. All the evidence, then, points to shallow water deposition of the uppermost lower Maude. In the upper Maude shales are light to medium grey in colour; pyrite is present in the sediments, but abundant and diverse benthic foraminifers (B.E.B. Cameron, pers. comm. 1983) indicate well oxygenated (but deeper) bottom conditions. The uppermost Maude is composed of massive clean sandstone with only occasional shale interbeds. These sands may signify either increased contribution of continental deposits or, more likely, another slight shallowing of seas. Both macro and microfauna are extremely abundant. Collectively, all evidence indicates that deposition of upper Maude sediments took place in fairly shallow shelf waters. Tuffaceous components in the lower Maude and rare volcaniclastic sands in the upper Maude indicate that intermittent volcanism was active on the fringes of the basin during late

Pliensbachian and Toarcian time.

The age of the Maude as presently understood is late Early Jurassic to earliest Middle Jurassic. The Maude is known to span the Pliensbachian, much of the Toarcian and at least a portion of the Aalenian stages. Most of Pliensbachian time is represented in the lower Maude both at the type section and at Creek "C" (a high waterfall locality) on Graham Island. The upper Maude contains some problematical ammonites, and is highly faulted as well. It is certain that a considerable portion of the middle and upper Toarcian is present, but details of precise extent must await final study of the ammonites by H.W. Tipper and P.L. Smith. The occurrence of the ammonite *Tmetoceras* indicates that at least some part of the Aalenian is represented.

Maude Island

Here the Maude underlies a wedge-shaped area on the southeast side of the island. It is exposed on inland stream beds and at intervals along the shore; just west of Fannin Bay the type section (lower Maude only) is partially exposed along the beach at low tide. It consists of interbedded dark grey flaggy tuffaceous siltstone, shale and calcareous shale; minor light grey concretionary limestone is found as thin beds, lenses and nodules; upper beds are more lithic and tuffaceous. These rocks are rich in benthic and pelagic fossils; well preserved ammonites and bivalves collected extensively by field parties over the years have been described by Whiteaves (1876, 1883, 1884, 1900), McLearn (1927, 1929, 1930, 1932, 1949) and Frebold (1967, 1979). More recently the microfaunal assemblages have proved prolific as well (Tipper and Cameron, 1979, 1980; Cameron and Tipper, 1981).

East of the type section is a covered interval (presumed to represent a paraconformity) overlain by a prominent exposure of limy sandstone with limy coquinoid nodular beds containing an abundant "harpoceratid" fauna, and the aforementioned trace fossils. The transition from Pliensbachian to Toarcian is difficult to document in all localities where rocks of this age are exposed and, to compound the problem, very few diagnostic fossils have been collected. It is likely that exposures of these transitional beds are present on Creek "A" (see Fig. 4, sec. I, p. 24), that empties onto the beach about midway through the type section. The lower exposures in this creek comprise dark grey slightly calcareous siltstones, grey sandstones and buff-weathering limestone pods which Cameron and Tipper (pers. comm., 1983) believe are lithologically equivalent to the harpoceratid beds on the beach. No ammonites have been collected in creek "A" and shales sampled for Foraminifera are barren (B.E.B. Cameron, pers. comm. 1983) however, limestones have yielded an excellent radiolarian fauna. In the upper reaches of Creek "A" and in the bed of a small creek to the east (Creek "B", see Fig. 2B, p. 10), which empties above the harpoceratid beds, is green weathering grey shale containing limestone nodules, one of which has yielded an extremely rich, pyritized radiolarian fauna. Ammonites collected in Creek "B" indicate middle Toarcian age (H.W. Tipper, pers. comm., 1983). Strata of similar age in all

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localities yet surveyed, are characterized by these same greenish-grey shales containing limestone nodules, plant debris and, in most cases, septarian nodules.

Graham Island -- Yakoun River area

The upper Maude thickens northward to Graham Island. The most complete section is found on the Yakoun River south of Ghost Creek (see Fig. 4, sec. III and IV, p. 24). Here a thick sequence of greenish-grey weathering shale is overlain conformably by greenish-grey sandstone, in part volcaniclastic, intercalated with rare sandy limestone lenses and thin sandy shale; this sand in turn is overlain by a distinctive pale brown belemnite-rich sandstone. Ammonites collected from these sandstones indicate mid Toarcian to Aalenian age (H.W. Tipper, pers. comm., 1983). This same sequence of rocks is seen in the lower portions of several creeks which drain the high bluffs east of the river (see Fig. 4, sec. V and VI, p. 24; also occurs in the lower (unfigured) portion of sec. VII). The sandstone is more variable in thickness than the shale; it is thickest on the river, but thins to no more than a few meters on Creeks "C" and "D"; its absence represents a hiatus in late Toarcian time.

YAKOUN FORMATION

General Description

The Yakoun Formation was named by MacKenzie (1916) following earlier work by Clapp (1914) and others. McLearn (1949) reviewed the area in detail recognizing a lower predominantly volcanic sequence and an upper non-volcanic marine sedimentary section characterized by ammonite faunas of Bajocian and Callovian age. The most recent study by Sutherland Brown (1969) covered a more extensive area and established the type locality on the south shore of Maude Island and made minor revisions to McLearn's study.

The Yakoun is a highly variable volcanic unit dominated by pyroclastic rocks. Those most characteristic are formed of porphyritic andesite agglomerate, bedded water-lain tuff, and lapilli tuff which is in part calcareous. Marine sedimentary rocks include volcanic sandstone, some conglomerate, siltstone and shale, with minor coal representing a subordinate non-marine phase of deposition. The Yakoun is most widely distributed in the central region of the Queen Charlotte Islands, particularly central and southern Graham Island (see Fig. 1B, p. 8). It overlies the Maude Formation conformably in some areas whereas in others it may be disconformable to conformable on the Kunga (Sutherland Brown, 1968). It is overlain by the Longarm Formation, but little is known of contact relationships. In other areas its upper contact with the Haida Formation is angularly unconformable. The Yakoun may be distinguished from the subjacent Maude by the increased volcanic content of all members. The overlying Longarm is a massive calcareous siltstone unit, however, minor volcanic sandstones are remarkably similar to Yakoun sandstones, and the two are distinguishable by fossil content only.

Sutherland Brown established five members for the Yakoun and defined them at the type section on the southeast coast of Maude Island. Of these rocks he states "they may be considered typical but in no way a standard as the unit is highly variable" (1968, p. 68). Included here are both volcanic and sedimentary rocks and the basal lapilli tuff (Member A) is well exposed. This widely distributed unit is normally present wherever the base of the Yakoun is exposed (Table 1, p. 19). Member B, is a thin sedimentary unit consisting of interbedded shale, tuffaceous shale and sandstone and tuff. Outcrops of early Bajocian age on Graham Island are composed chiefly of shales and tuffs which are generally thick, and equivalent to Member A at the type section. Member C is entirely marine and consists of porphyritic andesite agglomerate. It is thick and normally massive in outcrop both at the type section and at Graham Island localities. Member D, mostly volcanic, is composed of tuff, lapilli tuff, volcanic and pebbly sandstones and some conglomerate. Member E, contains volcaniclastic sandstone and siltstone with minor shale, tuff and pebble conglomerate.

The Yakoun Formation records a time when quiet marine sedimentation was interrupted frequently by pulses of local volcanic activity. One important episode occurred during the early Bajocian when a great thickness of thinly bedded sands and fine material was laid down. The shales are typically hard, brown and tuffaceous; some are bituminous. Limestones are finer grained than seen in the Toarcian. Benthic fossils are uncommon; those present (i.e. bivalves, foraminifers) are diverse but small (B.E.B. Cameron, pers. comm., 1984). Thus,

Thus, deposition in deeper water, occasionally anoxic, is considered likely. Certainly there was abundant terrigenous source material as some deposits in the Yakoun River area are exceedingly thick. Later, thick massive agglomerates record a more intense phase of volcanism when, according to Sutherland Brown (1968, p. 75) " a series of vents opened up along a line subparallel and west of the later sandspit Fault". Towards the close of Middle Jurassic time erosion dominated and sandstone, siltstone and shale were again deposited in a marine environment.

Age of the Yakoun is Middle Jurassic (McLearn, 1927, 1949; Sutherland Brown, 1968, p. 76). Ongoing study of the ammonites, including all recent collections made by Tipper and Cameron, has established that much of early Bajocian time is represented (Hall and Westermann, 1980) together with portions of the latest Bathonian *Iniskinites* fauna (Frebold, 1978) and early Callovian *Seymourites* fauna (McLearn, 1949).

Maude Island

Exposures of Yakoun Formation in the uppermost portions of creeks A and B (see Fig. 4, sec. I and II, p. 24) are thin, and consist of massive hard grey siltstone. Contact with the underlying Maude is conformable in both instances, although it is possible that an erosional surface (with paleosol) may be present on Creek A . No fossils have been collected in either of these localities.

Graham Island -- Yakoun River area

Although lithologically similar to Member A at the type section, exposures are more variable in composition and thickness. At the waterfall on Creek "C" (see Figs. 3A and 3B, p. 11; Fig 4, sec. V, p. 24) are 85 m of thinly bedded tuffaceous grey sandstone, darker grey siltstone and shale with a few ash beds. The weathered rock has a distinctive banded appearance. On Creeks "D" and "E" (Fig. 4, sec. VI and VII, p. 24) thicknesses of 119 m and 244 m respectively, have been measured; siltstone is a more important component than on Creek "C" and buff weathering thin sandy limestones in the lowermost sections occasionally yield radiolarians. Contact with the Maude is conformable except on Creek "E" where drag folds, evidence of a fault, separate the two. Fossils are uncommon and consist only of a few belemnites, bivalves and poorly preserved early Bajocian ammonites (sonninids) (Sutherland Brown, Yorath and Tipper, 1983). Overlying massive green volcanic sandstone also contains sonninid ammonites and is probably of early Bajocian age.

IV BIOSTRATIGRAPHY

RADIOLARIAN OCCURRENCES AND FAUNAL CORRELATION

The chronostratigraphic interpretation of Queen Charlotte radiolarian material as stated above is based on age of associated ammonites and, to a lesser degree, on comparison with other radiolarian assemblages from western North America.

Ammonites are dated by comparison with Northwest European Standard Ammonite zones (Dean, Donovan and Howarth, 1961) and western North American Ammonite Zones for the Bajocian, proposed by Hall and Westermann (1980). A number of problems exist for workers trying to reconcile Liassic ammonite occurrences in western North America with the Standard Ammonite Zones of Northwest Europe. To mention but a few: the first and final appearances of some species differ significantly between the two regions, thus creating ambiguous associations of ammonites. Furthermore, many guide fossils found in Northwest Europe do not exist here, and vice versa. North American sequences appear to be more similar to those seen in the Tethyan provinces of southern Europe and North Africa. It has thus become increasingly apparent that a zonal scheme for western North America is needed. Work now in progress by J. Guex, P.L. Smith, D. Taylor and H.W. Tipper will resolve many of these problems upon its completion.

The distribution and relative abundance of Spumellaria and Nassellaria at each sample locality is shown on Figs. 5 and 6 (p. 31 and 32), respectively.

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Upper Pliensbachian

The two samples on Creek "A" were collected from silty-sandy limestones lithologically similar to the harpoceratid beds on the beach, but no associated macrofossils were found at this locality. C-080577 contained a rich, well preserved radiolarian fauna, whereas C-080578 was almost totally barren. The *Lingulina* beds (MF 11 to MF 14 in Cameron and Tipper, 1981, p. 209), early Pliensbachian in age, are much lower in the creek and correspond in age to the lower part of the type section. The harpoceratids are a problematical group of ammonites whose age relationships in North America are not yet clearly understood and, until their study is complete, age of the harpoceratid beds and that of the samples from Creek "A", are considered to be late Pliensbachian (*Pleuroceras spinatum* Zone) (H.W. Tipper, pers. comm., 1984). Sample C-080580 was collected in sand 3 m stratigraphically below middle Toarcian grey shales on Creek "C" (see Fig. 4, sec. V, p. 24) and just above rocks known to be upper Pliensbachian. A single harpoceratid ammonite collected could possibly be *Protogrammoceras* , an upper Pliensbachian genus (ibid).

Sample C-080577 from Creek "A" contains a rich and highly diversified radiolarian assemblage (well over 50 species). Many of these forms have not previously been described. Comparison with known taxa favours a late Pliensbachian age. Numerous species described by Pessagno and Whalen (1982) are present e.g. *Canutus blomei*, *C. giganteus*, *C. hainaensis*, *C. izeensis* and

Wrangelluim sp. A., and all, as presently known, do not range above the late Pliensbachian. *Praeconocaryomma immodica* Pessagno and Poisson, on the other hand, has not yet been found below the Toarcian. *Syringocapsa* sp. A and B (this paper) appear almost identical to *S.* sp B and C, of Yao (1982, pl. 4, fig. 14-16) assigned to the *Parahsuum simplum* Assemblage (early Early Jurassic) of central Japan.

Following more recent investigations by Tipper and Cameron, it is now clear that Pessagno's samples QC 622 and QC 624 from Whiteaves Bay, are no younger than latest Pliensbachian. QC 628 (27.4 m above QC 624) is from beds referred to above as the harpoceratid beds.

Middle Toarcian sample

Sample C-080579 was collected on Creek "B" (see Fig. 4, sec. II, p. 24) from the lower half of the greyshale unit. A single ammonite identified by Tipper as *Phymatoceras*, is from the *Hildoceras bifrons* Zone; lower middle Toarcian. *Hildoceras*, *Hildoceratoidea* and *Peronoceras*, also from the *H. bifrons* Zone are found in association with *Phymatoceras* in other lithologically similar localities.

This is the first well documented middle Toarcian radiolarian fauna. Most forms in this large pyritized assemblage are either entirely new or have affinities with taxa found higher in the column. Consequently, very few are useful age indicators. Of Toarcian marker taxa proposed by Pessagno et al (in preparation, see Text.-fig. 5), only *Canoptum anulatum* Pessagno and Poisson is present, and it is not found in younger samples. Although not included in Fig. 5 (this paper), the presence of *Praeconocaryomma parvimamma* Pessagno and Poisson cannot be completely ruled out, as pyrite overgrowths obscure the delicate meshwork of many praeconocaryommids, making them extremely difficult to identify. A form almost identical to *Lupherium* sp. A of Pessagno and Whalen (1982) from Pliensbachian radiolarian cherts of California, is common here, and ranges in reduced numbers into the lower Bajocian.

Upper middle to upper Toarcian samples

Yakoun River samples (see Fig. 4, sec. III and IV, p. 24) are middle to upper Toarcian in age. Stratigraphically the lowest of these (C-080581), occurs with ammonites "compared tentatively to *Haugia*, *Haugiella* and *Denckmannia* " (H.W. Tipper, pers. comm., 1984) all representative of the *Haugia variabilis* Zone; late middle Toarcian. Remaining samples (excluding C-080597) from higher in the section are associated with *Haugia* and *Haugiella* as well as abundant *Hammatoceras* (a late Toarcian genus). This ammonite association, endemic to the Charlottes, is either late middle or early late Toarcian: *Haugia variabilis* to *Grammoceras thouarsense* Zone (ibid). An ambiguous age for these samples results from the fact that in Europe, *Haugia* occurs beneath *Hammatoceras*

(Dean, Callomon and Howarth, 1981), whereas on the Yakoun River the two are found together. In Europe, condensing of sediments is very common at this interval -- a similar situation may be present in the Queen Charlotte Islands. The exact position of C-080597 is uncertain; it was collected by Tipper in 1975, before river floods carved out the excellent exposures now available. He believes it to be from the highest Toarcian beds on the river, above samples C-080581 - C-080585 but below *Esericeras* ; thus to the best of current knowledge, probably late Toarcian in age (*Grammoceras thouarsense* to *Dumortieria levesquei* Zones).

There are few established marker taxa known for the middle to late Toarcian, however the rich fauna (including 5 new genera) promises more precise subdivision of this interval of geologic time. Upper Toarcian age is established by the incoming of *Turanta* spp., specifically *T. morinae* Pessagno and Blome in C-080581 and *T. nodosa* Pessagno and Blome in C-080583. Less significant are a small, spiny praeconocaryommid with affinities to *P. parvimamma* (perhaps a juvenile form?), *Trillus elkhornensis* Pessagno and Blome and *Diceratigalea* sp. (which may be reassigned to *Rolumbus*, a genus newly established by Pessagno, Whalen and Yea, in press), whose presence more broadly dates the assemblage as late Pliensbachian to late Toarcian.

Aalenian sample

A single talus sample (C-080586) was collected on Creek "D" (see Fig. 4, sec VI) from thin sandstones (< 2 m thicKness) underlain by typical middle Toarcian greyshales and overlain by distinctly different, lower Bajocian tuffs, volcanic sandstones and shales. A sandstone ledge at this locality represents all that remains of upper middle/upper Toarcian to Aalenian deposition. Lower sandy beds contain *Esericeras*, *Haugia*, abundant *Hammatoceras* and a fragment of *Dumortieria*, found in float; *Tmetoceras* and *Pseudolioceras* have been collected from the upper beds (H.W. Tipper, pers. comm., 1984). Lithologically this talus sample is similar to the upper sands and, based on Westermann's work in Alaska (1969), has been dated as "Aalenian, possibly early" (ibid).

The radiolarian assemblage is less diverse than middle and upper Toarcian ones: the combination of few new occurrences and absence of some of the previously occurring forms however make ths Aalenian radiolarian sample reasonably distinctive. According to Pessagno et al (in preparation) the base of the Aalenian is marked by the incoming of *Parvicingula*, *Perispyridium* and *Higumastra*; in the Queen Charlotte Islands, these taxa first appear in the middle to upper Toarcian. *Turanta morinae* Pessagno and Blome, a primary marker for the upper Aalenian ? (see Pessagno et al, in preparation) is present, but its range in the Queen Charlotte Islands extends down to the late middle Toarcian.

Lower Bajocian samples

Samples collected on Creek "E" (with the exception of C-080596) and the upper portion of Creek "D" (see Fig. 4, sec. VII and V, respectively, p. 24) co-occur with poorly preserved, but nonetheless identifiable, ammonites. According to Tipper, "some of the ammonites can be compared to *Guhsania* and other sonninids; possibly *Dorsetensia* " futhermore, "if McLearn (1926) is correct in his assessment of the Hazleton area as *Sowerbyi* Zone, then ammonites on these creeks are also *Sowerbyi*" ; equivalent to the *Docidoceras widebayense* and *Parabigotites crassicostatus* Zones of western North America (see Hall and Westermann, 1980). C-080596 from higher in the section is *Sauzei* Zone or above, or is perhaps part of a lower interval repeated by faulting (H.W. Tipper, pers. comm., 1984).

Chlorophyte algal cysts identified by Dr. G.E. Rouse, as *Lophodictyotidium* sp. cf. *L. sargenti* Pocock, are abundant in all lowest Bajocian samples. *L. sargenti* from the Shaunavon Formation, southern Sasketchewan, and the Sawtooth Formation, southern Alberta, is from Pocock's Floral Zone $J2^2$ (late Bajocian).

Radiolarian marker taxa from Pessagno et al's zonation (in preparation) making their first appearance in these assemblages include *Gorgansium silviesensis* Pessagno and Blome, *Parvicingula matura* Pessagno and Whalen, *Zartus thayeri* Pessagno and Blome and forms comparable to *Trillus seidersi* Pessagno and Blome and *Hsuum mirabundum* Pessagno and Whalen. *Perispyridium* and

Parvicingula s.l., rare in mid/upper Toarcian samples, are abundant in lower Bajocian assemblages. Longer ranging taxa include *Trillus elkhornensis* Pessagno and Blome and *Zartus jurassicus* Pessagno and Blome.

LITHOSTRATIGRAPHIC CORRELATION

Several distinctive lithologic markers were found useful for correlating stratigraphic sections on Graham and Maude Islands. These include the harpoceratid beds, the greyshale unit and a belemnite sandstone. The following discussion refers to sections illustrated in Fig. 4 (p. 24). The first of these markers comprises the limy sand and buff concretionary limestone of the harpoceratid beds. Rocks of similar lithology are found in a 30 m interval, approximately 60 m above the base of Sec I (Creek "A"), at the base of Sec II (Creek "B"), Sec V (Creek "C") and Sec VI (Creek "D"). Total thickness of these beds has not been determined as in some instances covered intervals lie immediately below exposed beds, and elsewhere i.e. Sec VI, Creek "D", the section is repeated by faulting (not shown on figured portion of section). Chamosite ooliths present in the upper two-thirds of the section on Creek "A", are not found on Graham Island.

The greyshale unit is widely distributed, distinctive and the most easily identified of all Toarcian rocks. The lower portion is characterized by septarian nodules, rare concretions, large ammonites, wood and rare bivalves whereas upper portions contain more abundant limy concretions and lack septarian nodules.

Shales on Graham Island are separated by a sandy layer which marks an abrupt faunal change. In addition to the greyshales shown on sec. I-VI, a thick sequence present at the base of Creek "E" is not illustrated. Generally, the greyshale unit is thicker on Graham Island and contains the lower and the upper shales; the upper portion only is present on Maude Island. It is exposed on Creek "B", while on nearby Creek "A" an erosional surface and paleosol(?) caps the uppermost shales containing only rare limy concretions. On the Yakoun River and at Creek "C" both shales are present; Creek "C" shales although very thin, are equivalent to the upper shales (Sutherland Brown, Yorath and Tipper, 1983).

Overlying sandstones, more variable lithologically, are normally recognized by their abundant hammatoceratid ammonite fauna. These sands are present at all Graham Island localities but are missing on Maude Island. The overlying belemnite sandstone is distinctive and provides excellent correlation for all lower Aalenian rocks. Nearly 12 m has been measured on the Yakoun River; it is thinner elsewhere.

The high tuffaceous content of Yakoun rocks undoubtedly contributes to the thick sequences found on Graham Island. Lithologically, stratigraphic sections, even in close proximity, are exceedingly variable and few markers are available for correlation. The relative position of radiolarian samples on Creeks "C" and "E" has been determined by distance below the lowest recorded conglomerate bed.

BIOSTRATIGRAPHIC CORRELATION

Biostratigraphic and lithostratigraphic boundary lines correspond closely with only a few exceptions. This situation results from the fragmentary nature of sections exposed, the paucity of limestones available for sampling and/or the absence of radiolarians in some limestones. Hence the radiolarian zonation proposed, and the constituent rocks of these zones, have few distinct boundaries. This study spans a time interval (late Pliensbachian to early Bajocian) of about 15 Ma, within which time only seven distinct assemblages of Radiolaria can be recognized. It has been shown that most Radiolaria are short ranging; given that other short ranging species such as mammals and ammonites (Raup and Stanley, 1978; Simpson, 1970) have an average duration of roughly 1.5 Ma and planktonic Foraminifera only 1.0 Ma (Robaszynski, 1981), further sampling and study will probably reveal additional faunal assemblages within this time span. Six radiolarian zones have been differentiated within rocks of the upper lower and upper Maude Formation, with one additional zone (and 3 subzones) in the lower Yakoun.

Biostratigraphically, all rocks below the greyshale unit (see Fig. 7 , sec. I, I I,V and VI, p. 42) are confined to Zone 1. Only one sample from the greyshale unit has yielded radiolarians (Creek "B", Fig. 7, sec. II, p. 42), thus until further information is obtained, all greyshales are placed in Zone 2, a large zone with poorly defined boundaries. As mentioned previously, the shales on Maude Island are equivalent to

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the upper shales on the Yakoun River, unfortunately the lower shales on the river contain few limestones, and those sampled have failed to yield Radiolaria. Two foraminiferal assemblages have been obtained from the lower shales in addition to one from the upper shales (B.E.B. Cameron, pers. comm., 1984). Productive sampling of sandstones, up to but not including the belemnite sandstone, on the Yakoun River (Fig. 7. sec. III and IV, p. 42) has yielded extremely diverse assemblages of Radiolaria which have been divided into 3 zones (3 through 5) based on a significant number of first and final appearances. A very thin upper sandstone, present only on Creek "D" (Fig. 7, sec. VI, p. 42), carries a fairly rich microfauna characterized by very numerous final appearances in the lower part (and somewhat fewer first appearances): it has, therefore, been assigned to Zone 6. Lower Bajocian rocks of the Yakoun Formation contain Radiolaria that are, in general, distinctly different from those of older rocks and all, up to the highest interval sampled (C-080596) are included in Zone 7. This zone has been subdivided into 3 subzones based on first appearances of new taxa. These breaks may be significant however, the validity of these subzones is largely contingent on preservation (which is poor in the lower half). Further sampling will be necessary to determine whether Zone 7 should be subdivided or perhaps only treated as a single unit.

RADIOLARIAN ZONATION

Introduction

Jurassic rocks of the Maude and Yakoun Formations have yielded radiolarian assemblages that are rich and diverse. Over 167 species (98 spumellarians, 69 nassellarians) have been recovered from strata ranging in age from late Pliensbachian to early Bajocian: of these, 5 genera and more than 50% of species are new, with many forms demonstrating restricted biostratigraphic ranges. Fewer than 15% are similar to known species of Tethyan aspect found in North America, the Mediterranean area and Japan; remaining forms have affinities with both older and younger taxa. The species described represent approximately 80% of the total radiolarian assemblage present.

A zonal scheme is proposed for the Queen Charlotte Islands which distinguishes seven radiolarian zones and three subzones (see Fig. 8, p. 45); six are easily recognizable while a seventh (Zone 6) is, in essence, more transitional. Further study of additional samples (in hand) from this stratigraphic interval will hopefully clarify the position of Zone 6, allowing it to stand alone, or be assimilated with either of the adjacent ones. Zones 2 to 5 (middle to upper Toarcian) are characterized by highly diverse assemblages which are distinctive in that they contain many new and unusual forms. This is a local zonation, which has not yet been tested in other areas to determine gaps, overlaps, areas of collection failure, preservational failure and so forth. Ranges for species are local range

Chronostratigraphic Units			STANDARD AMMONITE ZONES Northwest Europe	AMMONITE ZONES Western North America	RADIOLARIAN ZONES
MIDDLE JURASSIC	Lower Bajocian		*SAUZEI*	*Parabigotites crassicostatus*	
					?
			LAEVISCULA		7 — 7C
					?
			OVALIS	*Docidoceras widebayense* (Alaska)	7B
					?
			DISCITES		7A
	Aalenian		*CONCAVUM*	*Presently under study*	
					?
			OPALINUM		6
LOWER JURASSIC	Toarcian	Upper	*LEVESQUEI*		
			THOUARSENSE		5
					?
					4
		Middle	*VARIABILIS*		3
			BIFRONS		2
		Lower	*FALCIFER*		
			TENUICOSTATUM		
	Late Pliens.		*MARGARITATUS*		1
					?

Figure 8: Proposed Radiolarian Zonation.

zones (= teilzones), see Fig. 9 (p. 47). Proposed zones are informal, with units numbered 1 through 7. These are Oppel zones (=concurrent range zone of ISSC, 1976, p. 55, 57) which according to the ISSC (1983, p. 863) are "characterized by having more than two taxa, and having boundaries based on two or more documented first and/or last occurrences of the included characterizing taxa". For the 7 zones established here there are a significant number of first and/or final appearances; for instance Zone 3 has 12 first appearances but no final appearances, whereas Zone 6 has 16 final appearances but only 3 first appearances.

Throughout this study and particularly in discussion of zones, I have relied upon two "rules" set forth by Baumgartner (1980, p. 279) for the stratigraphic comparison of different samples:

> " Rule 1: Two assemblages of different diversity and state of preservation are considered to be faunistically identical, if the poorer sample only differs in the absence of certain species.
>
> Rule 2: (The inverse of rule 1). Two assemblages of different diversity and state of preservation are considered to be faunistically different if the richer sample differs by the absence of certain species which are present in the poorer sample."

Discussion of individual zones focuses on abundant taxa, but includes rarer forms where there are grounds for believing them to be significant, such as those having utility in other regions.

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ZONE 1: The lower limit of Zone 1 is defined by the first appearance of *Emiluvia*, sp. I, *Tripocyclia* sp. A and *Acaeniotyle* (?) sp. A, all only sparsely represented. Abundant genera include *Canutus*, *Orbiculiforma* , *Pantanellium* , *Paronaella*, *Praecomocaryomma* and *Syringocapsa*. A number of Pessagno and Whalen's (1982) species of *Canutus* are found i.e. *C. blomei*, *C. giganteus*, C. *hainaensis*, *C. izeensis* and *C. tipperi*. All range into the late Pliensbachian with the exception of *C. tipperi*, which is confined to the early Pliensbachian. My specimens of *C. tipperi* now extend the range for this species to late Pliensbachian. In addition, two new species of *Canutus* (sp. A, sp. B) are recognized. Less abundant taxa characteristic of this zone include *Canoptum*, *Crucella*, *Wrangellium*, *Praeconocaryomma* sp. aff *P. media* Pessagno and Poisson and *P. immodica* Pessagno and Poisson, which does not occur below the Toarcian in California. Several new species of *Praeconocaryomma* and *Orbiculiforma*, along with *Hagiastrum* sp. A, *Lupherium* (?) sp. B and *Stephanastrum* (?) sp. A, appear to be confined to this zone. The top of the zone is delimited by the final appearance of the family Canutidae (genus *Canutus*) and *Syringocapsa* sp A and sp. B. The latter species are similar to *Syringocapsa* sp. B and sp. C, of Yao (1979) from the *Parahsuum simplum* Assemblage (Early Jurassic) of central Japan.

ZONE 2: This zone contains a rich and distinctive radiolarian fauna. Of the over 30 species making their first appearance many are entirely new. The zone is dominated by species of *Emiluvia*, *Hsuum*, *Xitus*, *Parvicingula* and *Perispyridium* (?), all highly abundant. The base of Zone 2 is defined by the first appearance of *Perispyridium* (?) sp. B, a number of forms assigned to *Parvicingula*, *Xitus* and a very diversified *Emiluvia* fauna. Other abundant taxa making their first appearance include *Protounuma* (?) sp. A, *Lithocampe* (?) sp. A, *Tricolocapsa* sp. cf. *T. rusti* Tan, *Stichocapsa* sp cf. *S. convexa* Yao and Genus A, undet; while *Homoparonaella* sp. A, *Pseudocrucella* sp. C, *Archeodictyomitra* sp. aff. *A. primagena* Pessagno and Whalen, *Alievium* (?) sp. A and *Ristola* sp. B (all confined to Zone 2, in Queen Charlotte Islands) are less common. The bulk of the zone is characterized by the coincidence of a number of species of *Praeconocaryomma*, *Paronaella*, *Crucella*, *Canoptum*, *Wrangellium*, *Napora* and *Lupherium* together with those mentioned previously. The top of Zone 2 is marked by the final appearance of *Napora* sp. A, *Hsuum* sp. cf. *H. rosebudense* Pessagno and Whalen, *Parvicingula* (?) sp. and *Canoptum anulatum* Pessagno and Poisson. Although according to Pessagno, et al (in preparation) *C. anulatum* ranges throughout the Toarcian, it has not been recorded in any of my samples from Zones 3, 4 and 5 (middle/upper Toarcian) which are extremely rich and diversified.

ZONE 3: This zone is defined on first appearances only; no extinctions are observed and no taxa are restricted exclusively to this rock interval. Although represented by a single sample, the radiolarian assemblage is fairly diverse and abundant. The lower boundary is defined by the first appearance of *Turanta morinae* Pessagno and Blome, *Hagiastrum* sp. cf. *H. egregium* Rüst, *Elodium* n. gen. (including *E. cameroni* n. sp., *E.* sp. A and *E.* (?) sp. B) and ?*Emiluvia amplissima*. Other new taxa occurring initially are *Homoparonaella* sp. aff. *H. argolidensis* Baumgartner, *Amphibrachium* (?) sp. A, *Emiluvia* sp. H and *Paronaella* sp. C, E and F. Longer ranging abundant taxa include *Paronaella* sp. D and *Xitus* (?) sp. B. The upper boundary of this zone (coincident with the lower boundary of Zone 4) is defined by the first appearance of *Tripocyclia* s.s. and new genera *Spongiostoma*, *Tympaneides* and *Maudia*.

ZONE 4: This zonal assemblage is the largest studied, and very distinctive. Over 70 species have been recorded, 40 of which, including members of 4 new genera, make their first appearance in this zone. The assemblage is dominated by spumellarians, particularly the Hagiastridae Riedel and the Patulibracchiidae Pessagno, some of which are similar to Baumgartner's (1980) Upper Jurassic taxa, i.e. *Homoparonaella* sp. aff. *H. elegans* (Pessagno), *Pseudocrucella sanfilippoae* (Pessagno) and *Tetratrabs* sp. aff. *T. gratiosa* Baumgartner. *Paronaella* is the single most abundant genus; 6 new species appear in this zone.

The lower limit of Zone 4 is characterized by the first appearance of *Spongiostoma saccideon* n. sp., *Tympaneides charlottensis* n. sp. and *Paronaella* sp. I. Other abundant forms include *Emiluvia*, *Crucella*, *Elodium* n. gen., *Hagiastrum* sp. cf. *H. egregium* Rüst, *Homoparonaella* sp. A., *Lupherium* sp. C, *Xitus* (?) sp. B and less distinctive spongy forms such as *Spongostaurus*, *Spongotrochus* and *Spongotripus*. The first evolutionary appearance of *Tripocyclia* s.s. is recorded here. *Paronaella bandyi* Pessagno and *Turanta nodosa* Pessagno and Blome first appear near the base of the zone, but are rare. *Acanthocircus* is used as a Tethyan marker by Pessagno (Radiolarian Workshop; Dallas, 1983); the two species found here are compared to *Spongosaturnalis* (?) *hexagonus* Yao and *Spongosaturnalis* (?) *septispinus* Yao, but their precise age was not specified by Yao. The upper limit of the zone is defined by the final appearance of *Homoparonaella* sp. A and *Crucella* sp. B plus *Maudia yakounensis* and *Diceratigalea* sp. A, new species confined to Zone 4.

ZONE 5: This large zone is characterized by many extinctions at the upper boundary but only a few first appearances at the base of the zone. As in Zone 4, spumellarians dominate the assemblage; *Paronaella*, *Spongotrochus*, *Spongotripus*, *Spongostaurus* and the new genus *Spongiostoma* are the most abundant spongy forms along with latticed genera such as *Emiluvia*, *Praeconocaryomma* and *Tympaneides* n. gen. Nassellarians are much less numerous but a few (*Elodium* n. gen., *Lupherium and Xitus*) are very abundant. The lower limit of the zone is defined by the incoming of *Tripocyclia* sp. C, and a small spiny praeconocaryommid with affinities to *Praeconocaryomma parvimamma* (both confined to this zone) and by the first evolutionary appearance of *Higumastra*. The upper limit is defined by the final appearance of *Canoptum*, *Xitus* sp. A, *Lupherium* (?) sp. C, *Crucella* sp. A, *Staurolonche* sp. A and *Spongiostoma saccideon* n. sp.

ZONE 6: This is the smallest assemblage and the most transitional. Many forms from Zones 3 to 5 disappear at the base or make their final appearance (usually less abundantly) in this zone, and a number of typically Middle Jurassic forms first appear (also in fewer numbers). None is confined exclusively to this zone. For these reasons, boundaries are difficult to establish and are more likely subject to future modification. The base of Zone 6 is defined by the first appearance of *Crucella* sp. C, *Ristola* sp. A and *Hsuum* sp. cf. *H. belliatulum* Pessagno and Whalen. The top of this zonal unit is marked by the extinction of (?)*Emiluvia amplissima* Rüst, *Hagiastrum* sp. cf. *H. egregium* Rüst, *Paronaella* spp. B, C, D, E and F, *Tripocyclia* sp. B, *Elodium cameroni* n. sp., *E.* sp. A and *Xitus* (?) sp. B.

ZONE 7: This diverse assemblage is characterized by the association of abundant *Parvicingula*, *Hsuum*, *Perispyridium*, *Eucyrtidium* and *Emiluvia* together with a number of smaller 3 and 4-chambered, thin-shelled forms (i.e. *Tricolocapsa* and *Stichocapsa*). The base of this zone is defined by the first appearance of *Perispyridium* sp. A, *Parvicingula* sp. B and *P.* sp. aff. *P. profunda* Pessagno and Whalen. Auxiliary taxa *Gorgansium silviesensis* Pessagno and Blome, *Trillus* sp. cf. *T. seidersi* Pessagno and Blome and *Zartus thayeri* Pessagno and Blome all appear first near the base of the zone with *Emiluvia* sp. A and B, *Hsuum* sp. aff. *H. mirabundum* Pessagno and Whalen and *Mita* sp. A appearing somewhat higher. The upper limit for Zone 7 is indefinite as no significant faunal extinctions are recognized. The uppermost sample (C-080596) contains a very sparse radiolarian fauna but all constituents are found lower in the zone as well. It should be noted that basal samples generally contain sparse, poorly preserved Radiolaria, whereas samples higher in the section yield a rich and well preserved radiolarian fauna. In this regard Baumpartner's "rules" (p. 46) have been most helpful in evaluating the total assemblage. Although a number of marker taxa used by Pessagno have not been found in Zone 7, it is believed this zone is approximately equivalent to the lower portion of Pessagno's Subzone 1B (Pessagno et al, in preparation) based on the appearance of abundant *Parvicingula* and *Perispyridium*. The following three subzones have been differentiated on the basis of first appearances only. Further collecting and study of this stratigraphic interval will be necessary to determine whether these subzones are valid or Zone 7 should be treated as a whole.

Subzone 7A: The base of this subzone is defined by the first appearance of *Perispyridium* sp. A, *Parvicingula* sp. aff. *P. profunda* Pessagno and Whalen, *Parvicingula* sp. B, *Gorgansium silviesensis* Pessagno and Blome and *Stichocapsa* sp. aff. *S. japonica* Yao.

Subzone 7B: The lower limit of this subzone is defined by the incoming of *Trillus* sp. cf. *T. seidersi* Pessagno and Blome, *Zartus thayeri* Pessagno and Blome, *Hsuum* sp. cf. *H. mirabundum* Pessagno and Whalen, *Parvicingula* sp. C. and *Tetraditryma* sp. A.

Subzone 7C: The lower boundary of this subzone is defined by the first appearance of *Emiluvia* sp. A and B, *Paronaella mulleri* Pessagno, *Hsuum* sp. aff. *H. mirabundum* Pessagno and Whalen and *Mita* sp. A.

Early Bajocian Stratigraphic Marker ?

A chlorophyte algal cyst, common in all lowest Bajocian samples, has been identified by Dr. G.E. Rouse, U.B.C., as *Lophodictyotidium* , and compared to *L. sarjeanti* Pocock. Pocock confines its occurrence to his $J2^2$ Floral Zone (late

Bajocian). It is not found in higher samples that are generally more productive of well preserved Radiolaria. Further study is needed to establish whether this cyst occurs randomly throughout the Bajocian, or is confined only to lowest Bajocian strata and can therefore be used with confidence as a palynological marker in the Queen Charlotte Islands.

DISCUSSION

The Lower/Middle Jurassic succession of the Queen Charlotte Islands contains a faunal assemblage allied to the Tethyan faunal Province. The ammonites for instance are more closely related to those of southern Europe, North Africa and South America than to those of northern Europe and cratonal North America. Likewise, the radiolarian fauna has more similarities to Tethyan assemblages from Greece, Turkey and other Mediterranean areas (see Baumgartner, 1980; De Wever, 1981a-c, 1982; Pessagno and Poisson, 1981) than to boreal faunas from California studied by Pessagno et al. Insufficient data are available (and are beyond the scope of this study) for comprehensive comparison and evaluation of Queen Charlotte Islands Radiolaria in terms of Tethyan and boreal radiolarian assemblages found elsewhere. Suffice it to say, that in the present samples the most abundant taxa are (1) entirely new (2) conspecific with species previously described from the Maude Formation and (3) have affinities to Late Jurassic Tethyan species from southern Europe and the Mediterranean; forms comparable to

Pessagno's species from Oregon and California, though present are not normally abundant.

The proposed zonal scheme, reflecting the radiolarian faunal succession in the Queen Charlottes, is in general agreement with a North American Radiolarian Zonal Scheme proposed by Pessagno et al (in preparation). Minor deviations suggested by the occurrence of species such as *Canutus tipperi*, whose range extends higher in the column than previously reported, are probably a result of sampling in new localities. Of greater consequence, is the first appearance, lower in the general stratigraphic column, of *Turanta*, *Perispyridium* , *Parvicingula* , *Higumastra* and *Tripocyclia* . Reasons for this are more difficult to explain. Considering the embryonic state of radiolarian study, sampling in new localities normally leads to further documentation of paleogeographical distribution and increased stratigraphic range for a species. More complex possibilities might include factors such as climatic change (which affects oceanic circulation patterns and ultimately, the distribution patterns of radiolaria), species migration and latitudinal distribution during the Jurassic.

CONCLUSION

Radiolaria from 21 sample localities are examined, described, their local range zones plotted and a preliminary Radiolarian Zonal Scheme is proposed. Chronostratigraphic age of all zonal taxa has been determined from associated well dated ammonites and by comparison with other radiolarian assemblages from western North America and Japan. Included within this zonation are 167 species of spumellarian and nassellarian Radiolaria, with many forms demonstrating restricted biostratigraphic ranges. Zones are local, informally numbered and, until further tested, apply only to the Queen Charlotte Islands. Their boundaries are in some instances difficult to establish in terms of known Radiolaria because so many abundant forms are new. Nevertheless seven faunal zones (Oppel Zones) are differentiated. Those of middle to upper Toarcian age are particularly distinctive in that they contain many new and unusual forms.

V PALEOENVIRONMENTAL INTERPRETATION

INTRODUCTION

Research throughout the past fifteen years has increased our understanding of Radiolaria to the extent that they are now regarded as useful indicators of ecologic conditions in both modern and ancient oceans. Some excellent ecological studies are available by Casey (1963, 1971a,b, 1972), Petrushevskaya (1971a), Goll and Bjørklund (1971, 1974), Nigrini (1967), Renz (1976) and Bjørklund (1977), but all are restricted to the Cenozoic. More recently an interesting paper by Empson-Morin (1984) discusses depth and latitude distribution of Campanian (late Cretaceous) Radiolaria; apart from the latter, very little is known of the environmental aspects of Mesozoic Radiolaria.

A basic concept inherent to this study is the extent to which living radiolarian populations are reflected in the bottom sediments of modern oceans. Based on evidence from Petrushevskaya (1971a) and Renz (1976), Empson-Morin (1984) concludes that "while the thanatocoenoses may not duplicate the living populations, they do reflect their domains; and diagenetic modifications of populations do not negate their usefulness for paleoecologic interpretations".

Since the beginning of this study it has been apparent that radiolarian faunal composition differed significantly between samples of differing age and rock type. Could this be a reflection of changing environmental conditions within the basin that ultimately affect radiolarian distribution patterns? This study represents a first attempt to analyse distribution patterns of Jurassic Radiolaria; given that assemblages are certainly all from a shallow water, nearshore basin, major emphasis will be placed on faunal changes in relation to depth. Secondarily, evidence from paleomagnetics and ammonite biogeography places the Queen Charlotte Islands (Wrangellia) within tropical to subtropical latitudes in the Early/Middle Jurassic; can this position be checked independently by the Radiolaria?

METHOD OF ANALYSIS

Latitudinal distribution was studied from two aspects: first, by comparing long-ranging genera with environmental connotations and second, by establishing modern morphologic analogues for extinct Jurassic genera (see Table 2, p. 66).

Environmental studies related to depth distribution were conducted by analysing radiolarian assemblages for morphotypes present and diversity (Fig. 5 and 6, p. 31 and 32, respectively) and relative abundance; specific counts of spumellarians and nassellarians (in samples containing over 100 total individuals) are found in Table 3, p. 76. Results were assessed by comparing 'apparent' depth related assemblages of radiolarians with corresponding lithofacies.

SUMMARY OF PREVIOUS WORK

Radiolaria are exclusively marine, found in all oceans, in all climatic zones and at all depths in the water column (Haeckel, 1887). Their distribution is governed by ecologic factors such as temperature, salinity, light, ocean currents, water chemistry and biological competition. The interaction of these parameters determines the horizontal and vertical distribution of Radiolaria in the oceans.

Latitudinal distribution

Temperature is perhaps the main factor governing the latitudinal distribution of Radiolaria (Haeckel, 1887; Casey, 1971a,b; Petrushevskaya, 1971b et al). Haeckel (1887), was the first to discuss geographical distribution of Radiolaria. He observed that greatest densities of individuals occur in equatorial waters and thereafter species abundance seems to diminish regularly towards the poles (and more rapidly in the northern than southern hemisphere); the southern hemisphere possesses more species than the northern; species diversity and abundance is greatest in the Pacific Ocean. Studies by other authors (Popovsky, 1908, 1912, 1913; Petrushevskaya, 1966, 1971b; Riedel, 1958; Renz, 1976; Kling, 1966 [MS] and Casey, 1971a,b, 1977) confirm these findings and a number of biogeographic schemes have been established based on temperature. In one of the most recent, Casey (1971a,b) distinguishes the following biogeographic units: Subarctic, Transition, North Central, Equatorial, South Central, Subantarctic and Antarctic, based on examination of plankton and bottom sediments in the Pacific.

Depth Distribution

First studies of depth distribution were also conducted by Haeckel (1887) as part of his monograph on Radiolaria from the Challenger Expedition. Haeckel recognized three bathymetric associations: pelagic, zonarial and abyssal. The pelagic zone extends from the surface to 46 m depth; fauna consist primarily of spumellarians with relatively few nassellarians. The zonarial zone (46-3656 m) is characterized by spumellarians in the upper layers with increasing numbers of nassellarians with depth, and the abyssal zone (>3656 m) is dominated by nassellarians; browsing forms with large, greatly thickened shells. Since then, depth zonations for phaeodaria and polycystine Radiolaria have been proposed by Lo Bianco (1903), Haecker (1907), Popofsky (1913), Reshetnjak (1955), Hulsemann (1963), Petrushevskaya (1966, 1971a, b), Renz (1976) and Casey (1977); the resulting consensus still is that spumellarians are the most abundant forms in shallow waters with nassellarians becoming increasingly dominant at depth.

From investigations off southern California Casey has proposed three major depth zones for polycystines from the surface to 1000 m (1966, 1971a,b): a surface zone from 0-200 m, an intermediate zone from 200 to 400-500 m, and a deeper zone from 400-500 to 1000 m. Radiolarian distribution patterns in these zones are related to specific physical and chemical oceanographic conditions (such as the movement of large water masses) and to such phenomena as upwelling, eutrophism and oligotrophism. Because all sediments involved in this study are from shallow shelf environments, the surface zone is of particular interest as it is here where radiolarian populations are subject to seasonal fluctuation; Casey believes this zone can be divided into 4 depth subzones. Faunal breaks have been correlated with thermoclines and weak pycnoclines both of which possibly act as shear zones for the movement of "micro-water masses" (ibid). An important break separating surface from subsurface forms may be due to "such biological factors as bottom of the photic zone, phytoplankton compensation depth or pigment layer" or perhaps more importantly to the nutricline which often coincides with the thermocline. The nutricline marks the boundary between nutrient depleted surface waters and deeper nutrient rich waters (Casey, Spaw and Kunze, 1982).

McMillen (1979) used the ratio of nassellarian (cone-shaped) radiolarians to spumellarian (spherical) radiolarians to define the Pleistocene - Holocene boundary in piston cores from carbonate-free sediments off the west coast of Guatemala. Upper slope cores show an increase in planktonic foraminifers down-core, but deeper cores lack calcareous microfossils due to dissolution. In these cores the decrease in the nassellarian to spumellarian ratio (showing increased abundance of spumellarians) going down-core marks this boundary. Studies of living radiolarians on the south Texas continental shelf by Casey and Bauer (1976) have shown that the n/s ratio generally decreases inshore. Thus in his studies, McMillen believes sea level to be the most likely control on radiolarian distribution, not in terms of actual water depth, but in terms of proximity to shore. A lowering of sea level in the late Pleistocene, then, would cause the Guatemalan shoreline to move seaward, placing core sites closer to shore. This would lower the n/s ratio until sea level rose again in the early Holocene.

CHARACTERISTICS OF LOWER/MIDDLE JURASSIC RADIOLARIAN ASSEMBLAGES

In all assemblages examined, Radiolaria having thick walled and/or spongy tests are more frequent than those with latticed tests constructed of thinner bars or having thin shells. Petrushevskaya (1971a) recorded similar results and suggested that latticed forms are less common in sediments than in the water column because of their greater susceptibility to destruction and dissolution.

Spumellaria are the most diverse and abundant forms, representing over 60% of species and 65% of total individuals. Those most widely represented are spongy forms (Spongodiscacea) belonging to the Patulibrachiidae (2,3 and 4-armed spongy forms), Orbiculiformidae and the Spongodiscidae. Latticed forms such as the Hagiastridae (2,3 and 4-armed latticed forms) and Praeconocaryommidae are common, as is *Emiluvia*, a genus with double layered latticed shell and 4 radial spines, which may be ancestral to the hagiastrids (Baumgartner, 1980). Members of the Pantanellidae are less frequent, possibly because their delicate tests were more easily destroyed.

Nassellarians belong chiefly to the Theoperidae, a large, probably polyphyletic group that includes the majority of cyrtoids (Riedel, 1967). In Jurassic assemblages multicyrtids (large, thick shelled, cone-shaped forms possessing numerous chambers) are the most important constituent of the fauna and many families have now been differentiated e.g. the Canoptidae, Canutidae, Hsuidae, Eucyrtidae, Parvicingulidae and Xitidae. The Ultranaporidae, Syringocapsidae and thin-shelled genera such as *Tricolocapsa*, *Stichocapsa*, *Perispyridium* and *Turanta* (all of uncertain higher taxonomic affiliation) are less abundant.

LATITUDINAL DISTRIBUTION

Radiolarian Evidence

In modern oceans and in Tertiary sediments, certain Radiolaria are recognized as indicators of warm-water masses and cold-water masses. Much less however, is known of Mesozoic forms. Empson-Morin (1984, p. 94) discusses Cretaceous Radiolaria characteristic of low, intermediate and high latitude assemblages, but as yet no such indicators have been established for the Jurassic. To compound this problem very few Jurassic genera persist in modern oceans and one cannot be certain that environmental controls governing the distribution of modern genera can be extrapolated so far back in time. Faced with few alternatives, it was decided to assume a 'similar preferred environment' for long-ranging genera, provided the species compared were alike morphologically. Firstly then, Jurassic genera are compared with their younger descendants in Cretaceous and Tertiary sediments and in the plankton of the modern ocean (see Table 2A, p. 66). Secondly modern genera with well understood environmental limits are suggested as morphologic analogues for extinct Mesozoic genera with the corollary that both members of the analogous pair have probably occupied a similar environmental niche through time (see Table 2B, p. 66).

Discussion: *Eucyrtidium* is a long-ranging multicyrtid genus having an ovate or spindle-shaped test and solid apical horn; *Eucyrtidium* sp. A is abundant in Queen Charlotte Island assemblages of Zones 2 and 7. In the Pacific Ocean today *E. hexagontum* and *E. hertwigii* are dominant in the warm water and transition -central water regions (Petrushevskaya, 1971b; Casey, 1971b, 1977) and are also populating the shelves (Casey et al, 1982). Furthermore, Maurasse (1978) suggests that in Paleocene assemblages most theoperids (including *Eucyrtidium*) are warm water species, particularly large smooth forms with apical horns of varying length (cf. *Eucyrtidium* sp. A, above). As is shown below, the Queen Charlotte Islands were well within tropical to subtropical latitudes during the Lower/Middle Jurassic, therefore it seem likely that *Eucyrtidium* has been a warm water genus for a long time.

Alievium, *Acaeniotyle* and *Xitus* are mentioned among the many genera

TABLE II: Jurassic genera with environmental connotations.

A. Long-ranging genera with environmental connotations.

Genus	Environmental implications	Geologic range
a. *Eucyrtidium*	abundant in warm water regions	Jurassic - Recent
b. *Alievium*	low and intermediate latitudes (Cret.)	Jurassic - Cretaceous
c. *Acaeniotyle*	low and intermediate latitudes (Cret.)	Jurassic - Cretaceous
d. *Xitus*	low and intermediate latitudes (Cret.)	Jurassic - Cretaceous
e. *Orbiculiforma*	periphery "notched" in high latitude forms	Triassic - Cretaceous

B. Forms with analogous morphology.

Jurassic genus	Modern analogue	Environmental Implication
a. *Paronaella*	*Euchitonia*	modern form abundant in shallow water tropical environment.
b. *Crucella*	*Spongaster*	modern form abundant in shallow water tropical environment.

diagnostic of low and intermediate latitudes that Empson-Morin (1984) finds in late Cretaceous (Campanian) assemblages (other forms discussed had not yet evolved in the Jurassic). All three of the above genera (or more primitive ancestral forms) are abundant in Queen Charlotte Island Jurassic assemblages suggesting the preferred environment for these forms was similar from the Early/Middle Jurassic to Late Cretaceous. *Orbiculiforma* has a wider environmental preference appearing worldwide in Campanian assemblages (ibid), however structural modifications between high and low latitude morphotypes are evident, with those from high latitudes (>45°) displaying a characteristic notch on the periphery. Empson-Morin finds that notched forms found in intermediate and low latitudes are generally rare. *Orbiculiforma* is abundant in my samples; 4 new species are described, and a number of indeterminate forms have been examined, of these only one "notched" specimen has been observed ,suggesting that this structural trend may have originated during the Jurassic.

Blueford and Christopher King (1983) describe three groups of spongodiscids in modern oceans and note that those with radial arms are most abundant in tropical waters. As mentioned earlier, spongy forms (Patulibrachiidae) with radial arms dominate many assemblages in this study; two genera that are particularly abundant are *Paronaella* (3-armed) and *Crucella* (4-armed), both extinct since the Cretaceous. In modern oceans *Euchitonia* and *Spongaster* are spongy forms with 3 and 4 radial arms, respectively. Because of their morphological similarities, one cannot help but speculate whether *Euchitonia* and *Spongaster* may be modern-day analogues of *Paronaella* and *Crucella*, inhabiting similar environments. *Euchitonia elegans* is a shallow water tropical species today (Petrushevskaya, 1971b; Casey, 1977); *Spongaster* is prevalent in the open Gulf of Mexico (Casey et al, 1979a).

Faunal comparison, of Queen Charlotte Island Radiolaria with Cretaceous and Cenozoic assemblages from tropical zones, suggests that similar taxonomic groups are dominant in all assemblages. Of comparable genera, morphology ,and in some cases structural modifications, appear to be the same at least from Jurassic to Cretaceous time, and a few trends apparently persist to the present. Modern-day generic analogues are postulated for two extremely abundant Mesozoic genera. In total, this evidence combined with previously noted similarities between Queen Charlotte Island species and Upper Jurassic Tethyan species from Mediterranean areas (see discussion, p. 55), strongly suggests these Radiolaria were warm water forms populating tropical to subtropical oceans.

Paleomagnetic Evidence

Mesozoic rocks in the Queen Charlotte Islands were deposited on the tectonostratigraphic terrane known as Wrangellia (Jones et al, 1977). This allochthonous stratal assemblage is thought to have originated far to the south of its present location, perhaps in equatorial regions (Coney et al, 1980; Irving et al, 1980; Yole and Irving, 1980). Latest evidence from the Bonanza volcanics (Irving and Yole, 1983) places northern Vancouver Island and the Queen Charlotte Islands at a paleolatitude of 21° (with an uncertainty of 5°) in the Early to Middle Jurassic, but ambiguity still exists as to whether this is north or south latitude. Assuming north latitude, position would approximate that of southern California to northern Mexico today, where waters are well within the subtropical realm. A south latitudinal option would necessitate northward transport of this island arc system through both tropical and subtropical waters.

Ammonite Biogeography

Taylor et al (in press) find Tethyan ammonites dominant in the Queen Charlotte Islands at least through the Toarcian, pandemic forms prevalent in the Aalenian and pandemic and boreal forms widely distributed in western North America (East Pacific Realm) by the Bajocian. Consequently they favour a northern hemisphere position for Wrangellia in order to move it out of the tropical zone (to a position greater than 30° North) by the early Bajocian.

Perhaps the most conclusive evidence of Tethyan origin for the package of rocks detailed in this study is that it rests directly on top of Pliensbachian rocks containing well established Tethyan ammonites (Smith, 1983).

In summary, evidence from such diverse disciplines as paleomagnetics, ammonite biogeography and radiolarian paleoecology, leaves little doubt that the

Queen Charlotte Islands were positioned in tropical to subtropical oceans during the Early to Middle Jurassic.

JURASSIC RADIOLARIA -- SHALLOW SHELF MICROFAUNA

In modern oceans Radiolaria are almost exclusively open ocean forms, and nearly absent from the shelf (Kling, 1978), to the extent that no endemic neritic polycystine species are known (Casey, 1977). However, they appear to have been an important constituent of ancient shelf assemblages (Casey et al, 1981). In the Queen Charlotte Islands diverse and abundant assemblages of Lower to Middle Jurassic Radiolaria are found in sediments deposited in a shallow shelf environment. Thus, the question: why?

On the Texas continental shelf Casey et al (1976, 1981) have found that density of the radiolarian fauna fluctuates seasonally. Highest densities and diversities were recorded for winter months, and appear to represent incursions of open ocean water (driven by currents and wind) that mix shelf waters to a depth of approximately 70 m. Lower densities in the spring are attributed to lower salinity resulting from runoff of the major river systems. A mechanism similar to this (whereby ancient current systems would have mixed seasonally with shelf waters, contributing to a higher nutrient supply and increased proliferation of the siliceous micro-zooplankton) may have been operative on the shelves of island arc systems in the Pacific Ocean during the Jurassic. Other factors to consider with regard to radiolarian abundance include lack of competition for available nutrients by other planktonic organisms and the influence of nearby volcanism on levels of silicon dioxide in adjacent waters.

A notable characteristic of the fossil record is the appearance, relatively late in geologic time, of many of the important sediment-forming groups of planktonic organisms (Bramlette, 1958; Lipps,1970). Radiolaria are known from the Cambrian on, but other microplankton such as the diatoms and silicoflagellates first appear in mid Cretaceous rocks. More importantly, the planktonic Foraminifera though appearing in the Middle Jurassic (Bathonian) do not become abundant until the mid Cretaceous (Albian). Thus, in Jurassic oceans there may have been less competition for available nutrients than later. Studies by Casey et al (1979a) indicate that modern Radiolaria are able to occupy a wide variety of niches: as herbivores, bacterivores, detritivores and/or associated with symbiotic algae. If Jurassic Radiolaria were as indiscriminate in their feeding habits, it is likely that they were able to exploit a much wider range of environmental settings than they do in modern oceans, contributing to their increased abundance in ancient shelf settings.

Silica may be an important factor in the growth and proliferation of Radiolaria (Funnell,1967) in that these parameters may be accelerated by additional silica introduced by upwelling (Heath,1971) or submarine volcanism. Indirectly, pyroclastic material appears to help preserve siliceous tests from dissolution after burial (Riedel, 1959). In the Queen Charlotte Islands volcanism was active at least on the fringes of the basin during the Lower/Middle Jurassic as volcaniclastic components are common in upper Pliensbachian rocks, less so in Toarcian rocks and again dominate in lower Bajocian sequences. In modern oceans the abundance of Radiolaria and other siliceous microplankton is determined by plankton productivity [Riedel, Kozlova and Lisitzen (in Heath, 1971)] which generally can be related to areas of upwelling of nutrient rich (silica rich) deeper water into the photic zone. It is beneath such areas of high primary productivity that maximum abundances of Radiolaria are found in the bottom sediments. In a more general way, controversy has long existed over the role of submarine volcanism in the genesis of thin bedded cherts and pelagic limestones in eugeosynclinal areas. Data from modern oceans argue against a direct relationship between volcanism and formation of pelagic sediments either by chemical precipitation or influences on the plankton bloom. Studies of the influence of submarine eruptions on the chemistry of sea water have been few, but all suggest that the silica content of sea water becomes enriched locally [Stefansson, Elderfield and Zelenov (in Garrison, 1974)]. The long term effects of these factors are unknown but Garrison (1974) concludes that if a relationship exists between sea-floor igneous activity and the formation of bedded siliceous deposits, it may likely be indirect and result from enhanced preservation of siliceous microfossil tests in waters containing an increased level of dissolved silica.

In the Queen Charlotte Islands increased levels of dissolved silica in near shore waters, resulting from nearby volcanism may have contributed directly to plankton blooms and/or the tendency for shallow water forms to develop heavier skeletal material or, indirectly, to greater preservation of siliceous tests.

DEPTH DISTRIBUTION

Radiolaria are pelagic organisms and are distributed throughout the entire water column. Depth at which most polycystine Radiolaria are abundant and diverse apparently varies with latitude which is controlled primarily by temperature. Petrushevskaya (1971a) found polycystine Radiolaria in tropical waters to be most abundant from 1-100 m depth, while in colder antarctic waters they are absent from the surface and reach maximum abundance between 50-400 m. Because they are planktonic, Radiolaria are independent of bottom facies but the character of each faunal assemblage or thanatocoenose is influenced by its relative position in the basin and/or distance from shore.

Evidence from lithology and faunal associations discussed previously, suggest that upper Pliensbachian to lower Bajocian sediments in the Queen Charlotte Islands were deposited in shallow shelf waters. A model for basin deposition is shown in Fig.10, p. 74. Bottom sediments on the slope grade from sandstone to siltstone to grey and finally, brown shale at depth. Shallow water radiolarians

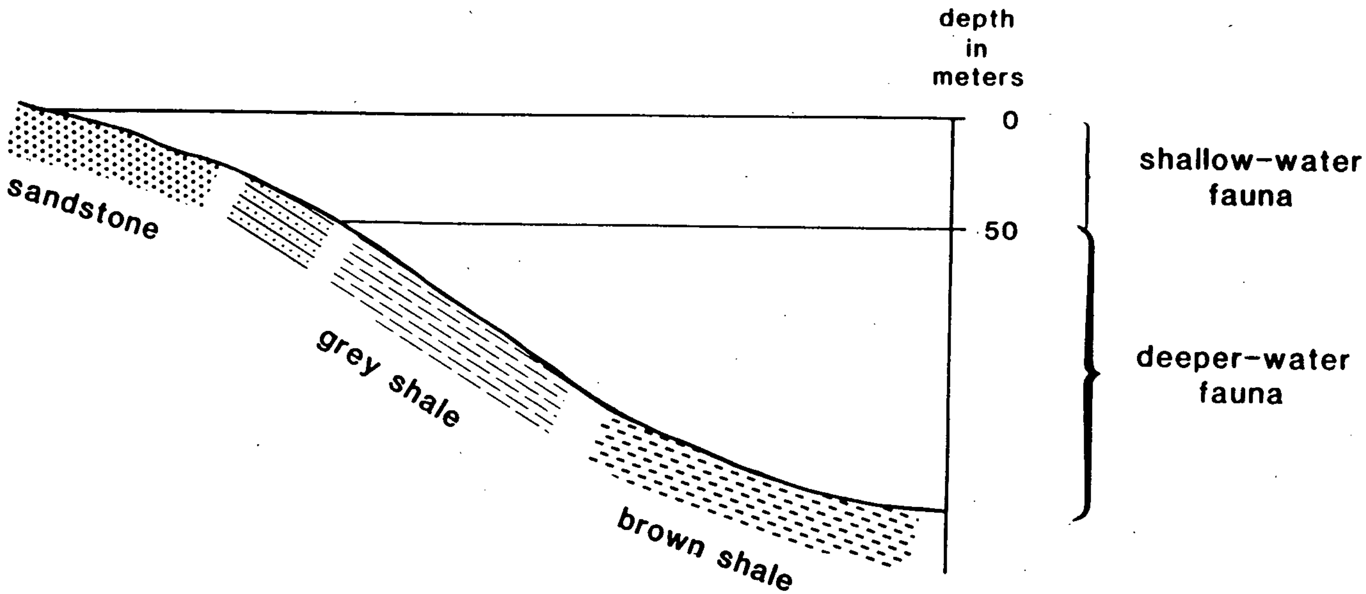


Figure 10: Model for basin deposition during the early to middle Jurassic, Queen Charlotte Islands.

occur in approximately the upper 50 m of the water column with deeper water fauna below. Consequently shallow water species may be expected to dominate in near shore facies (sandstones) whereas offshore facies are likely to contain shallow water forms with an increasing number of deep water forms.

Percentages of nassellarian and spumellarian radiolarians for all samples containing over 100 total individuals are seen in Table 3, p. 76. Poorer samples are generally indicative of unfavourable conditions during deposition and/or diagenesis where preservation potential is low and excessively biased. It must be emphasized that these are relative abundances, as samples were picked only with a view to obtaining a representative assemblage of individuals. I believe however, that as long as generalized rather than exact percentages are compared, results do reflect the living population, although the numbers may vary as a result of diagenetic modification.

Percentages are plotted on Fig. 11, (p. 77) along with a radiolarian abundance curve which traces variation in faunal assemblages from zone to zone. Results indicate that nassellarians are most abundant in Zones 2 and 7, spumellarians are totally dominant in Zones 3, 4 and 5, and Zones 1 and 6 have a balanced fauna. When the radiolarian curve is compared with a lithologic column for the same stratigraphic interval (Fig. 12, p. 78), it is apparent that samples containing a high percentage of nassellarians are found in shales, and those with a high percentage of spumellarians are from sandstones. This repeating pattern strongly suggests a

TABLE III: Abundance of Spumellaria and Nassellaria in samples containing > 100 specimens.

Sample #	# Spumellaria	# Nassellaria	% Spumellaria	% Nassellaria
C-080577	215	163	57	43
C-080579	247	465	35	65
C-080581	67	40	63	37
C-080582	239	31	92	8
C-080583	683	125	84	16
C-080584	501	54	90	10
C-080585	404	45	90	10
C-080597	466	190	71	29
C-080586	97	88	52	48
C-080589	95	59	62	38
C-080592	58	48	55	45
C-080588	137	41	77	23
C-080593	68	91	43	57
C-080594	83	196	30	70
C-080595	120	264	31	69

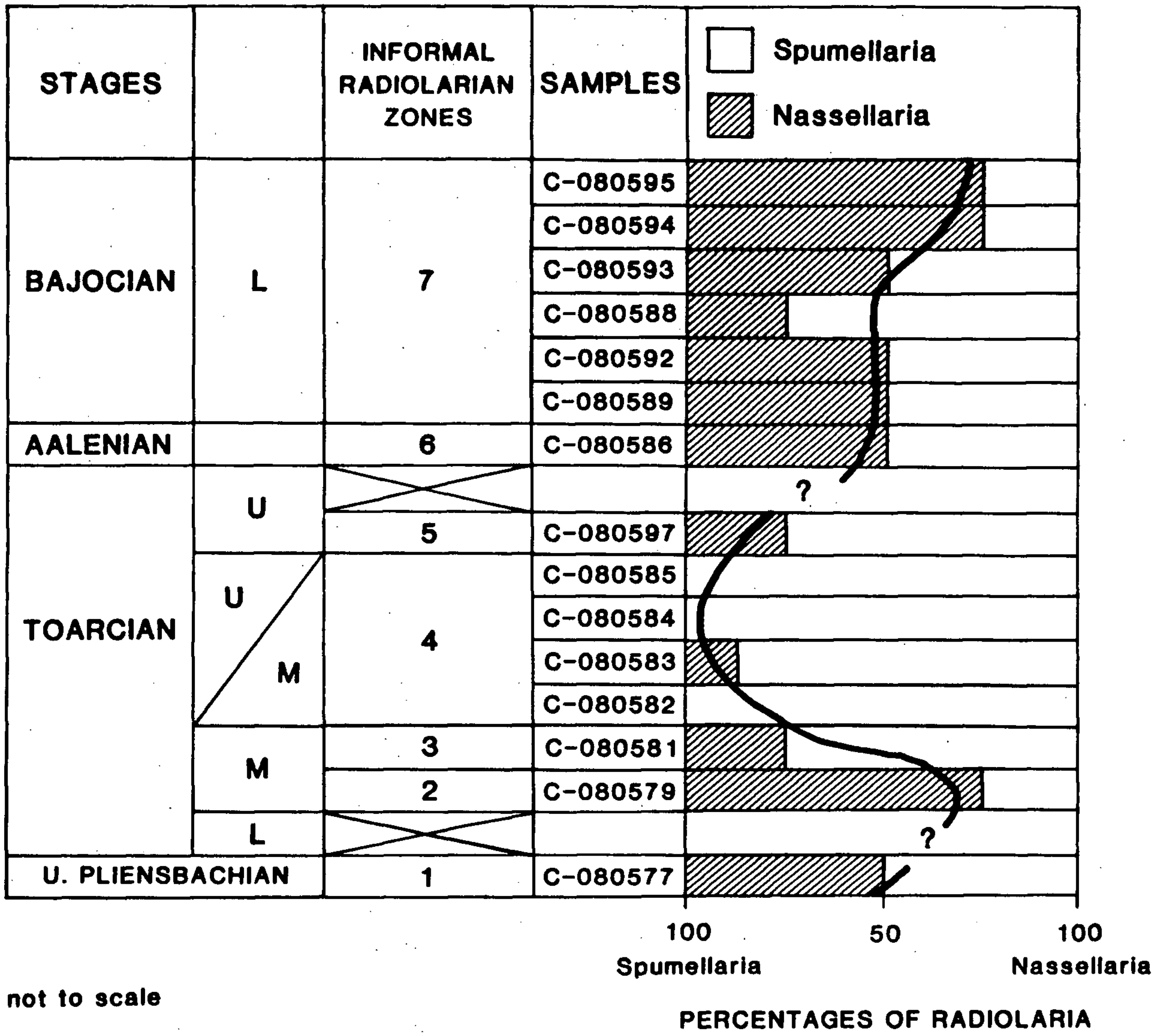


Figure 11: Percentages of spumellarians to nassellarians; radiolarian abundance curve shows general trend.

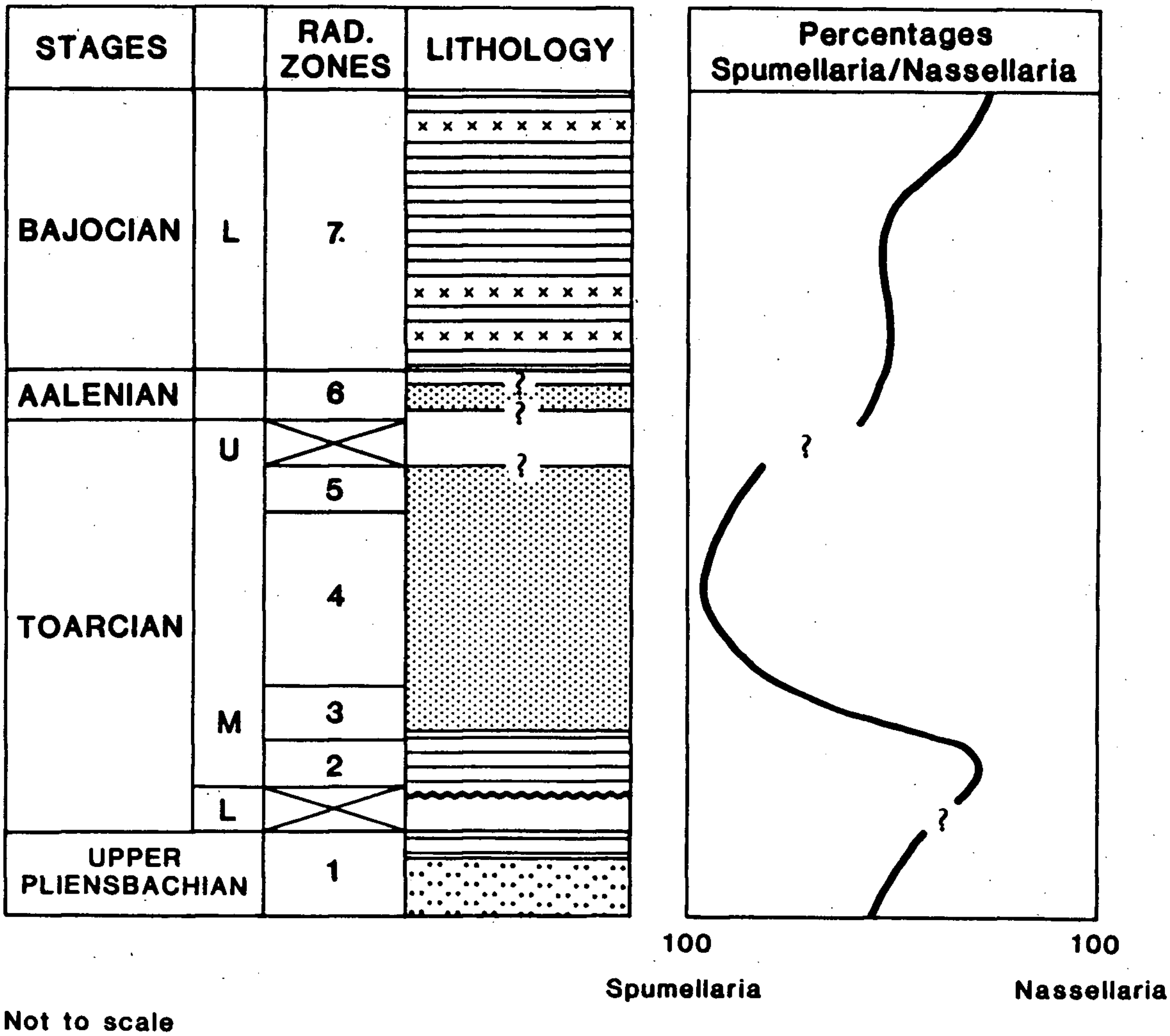


Figure 12: Correlation of radiolarian abundance curve with a composite lithologic column.

correlation between the dominant radiolarian group present, lithology and water depth: such that in deeper water deposits, namely middle Toarcian and lower Bajocian shales, assemblages are dominated by an abundant nassellarian fauna (mostly multicyrtids). Conversely, in shallow water deposits of late middle Toarcian to Aalenian age, spumellarians far outnumber nassellarians: the former are diverse and abundant, particularly spongy forms many of which normally prefer shallow depths. Shallow water nassellarians are comparatively less diverse; only a few species are abundant and these have robust rather than thin tests. These results agree with Haeckel's, except for the presence of large nassellarian tests in shallow water assemblages. Empson-Morin (1984) noted that an influx of large numbers of multicyrtids in Campanian assemblages was generally indicative of deeper waters. This trend has now been confirmed for Jurassic assemblages as well, however depth is measured on a much smaller scale: approximately 100 m as compared with several thousand m. for Empson-Morin's open ocean samples. She found nassellarians to have a bimodal distribution, being most common in shallowest and deepest waters. In shallow water assemblages nassellarians had robust tests, very low diversity (two or three species only) and comprised from 60 to 90% of the population. In my samples from Zones 3, 4 and 5, nassellarians are an important constituent, but much less abundant than spongy spumellarians. Lack of thin shelled nassellarians in shallow water assemblages may be due either to destruction in the higher energy nearshore environment or to their ecological preference for deeper waters.

Barring tectonic movement within the basin or source area, the fluctuating pattern observed seems to suggest local depositional response to environmental changes; it is postulated, therefore, that sea level may be the major control affecting distribution of pelagic microfauna in the basin.

Hallam (1978, 1981) has proposed a eustatic sea level curve for the Jurassic based on (1) shallowing and deepening events inferred from the facies sequence; (2) changes through time in areal spread of epicontinental seas; and (3) seismic stratigraphy (from Vail et al, 1977; Vail and Todd, 1981). This curve (Fig. 13, p. 81) shows an overall rise in sea level throughout the Jurassic with major phases of sea level rise in the early to mid Toarcian and early Bajocian and a major phase of sea level fall in the late Toarcian to Aalenian.

When Hallam's curve is plotted alongside the radiolarian curve and lithological succession (Fig. 14, p. 83), a threefold correlation is observed such that: during periods of rising sea level, deeper-water shales were deposited which contained a predominantly nassellarian fauna whereas, during periods of falling sea level, coarser sands containing extremely abundant spumellarians were deposited in a relatively shallow, high energy environment. The radiolarian curve departs from the sea level curve only in the latest Toarcian where Hallam notes a minor transgression [this latter is less well documented, based only on ammonites occurring in the Chilean-Argentinian Andes (Von Hillebrandt, 1971)]. Supporting

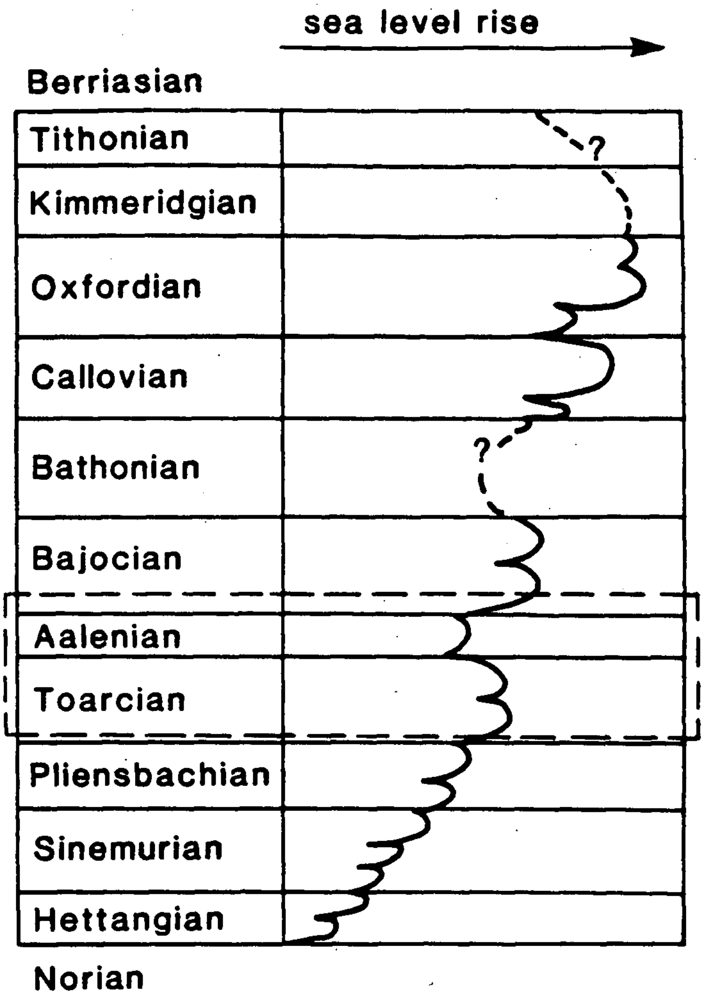


Figure 13: Eustatic sea-level curve (after Hallam, 1978).

evidence for this transgression in the Queen Charlotte Islands is weak as few rocks of this age are present; a single sample of late Toarcian age (C-080597) is extremely rich, contains fewer spumellarians than late mid/early late Toarcian samples but still spumellarians number over 70% of the total sample population. However, foraminifers retrieved from thin shale interbeds slightly higher in the section than the highest sampled limestones do display deeper water affinities (B.E.B. Cameron, pers. comm., 1984). In conclusion, the strong correlation observed in the Queen Charlotte Islands between the facies sequence, Hallam's sea level curve and the radiolarian abundance curve appears in general to confirm the major worldwide trend for sea level changes in the Jurassic.

CONCLUSION

Initial paleoenvironmental studies indicate that trends in abundance and diversity reflect those of modern day Radiolaria. Faunal comparison must be based on broad morphological groups, as few Jurassic genera are extant in modern oceans. To achieve the closest possible approximation to the living radiolarian population and reduce preservational bias only abundant, well preserved assemblages should be used in paleoenvironmental analysis.

Comparison with Cretaceous, Paleocene and Recent Radiolaria indicates that deposition took place in tropical to subtropical latitudes. This independently confirms that the Queen Charlotte Islands (Wrangellia) were positioned far to the

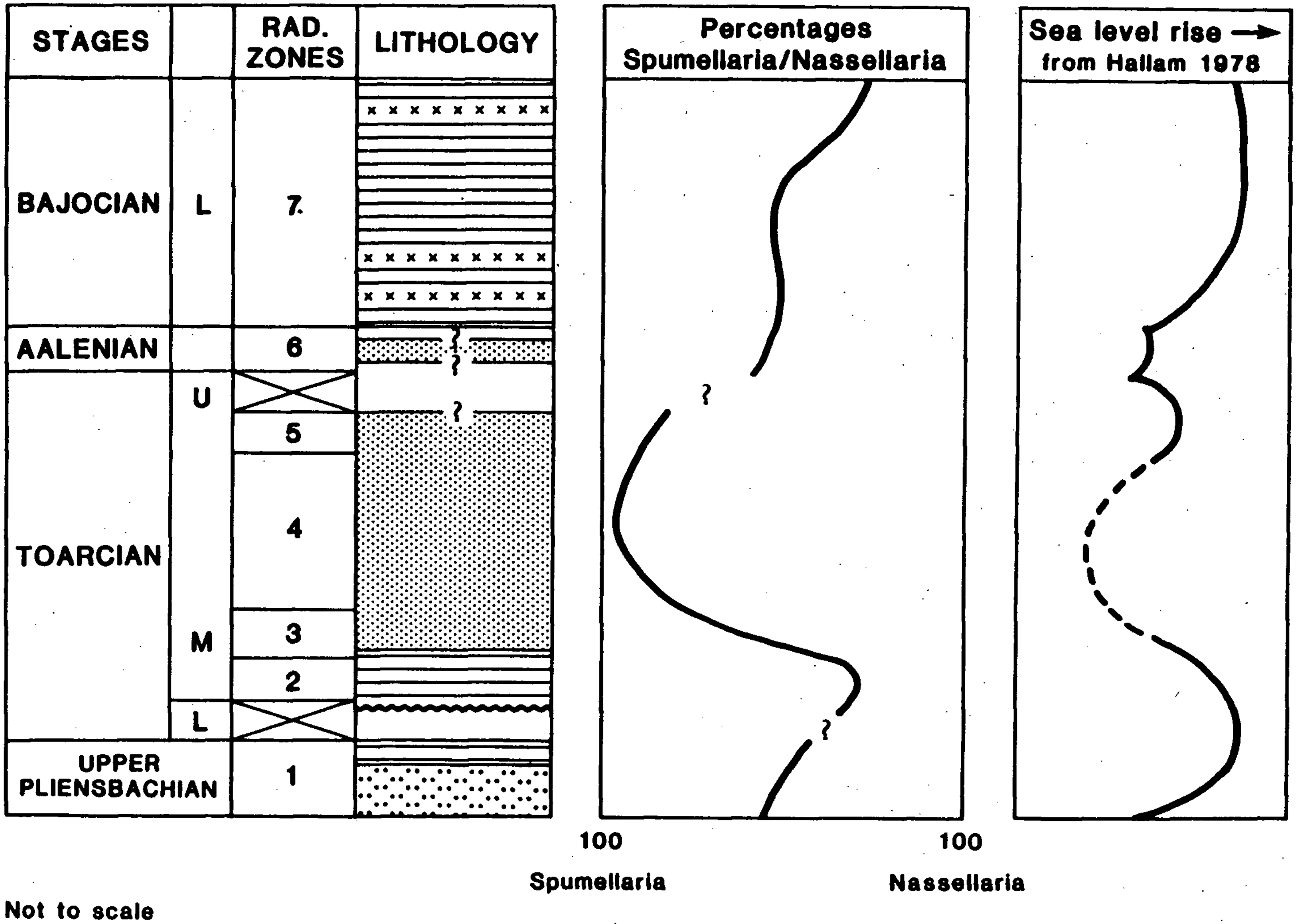


Figure 14: Correlation of radiolarian abundance curve, composite lithologic and Hallam's eustatic sea-level curve for the Jurassic.

south of their present position in the Lower/Middle Jurassic.

Increased silica levels in nearshore waters, resulting from volcanic activity around the basin, may have contributed directly or indirectly to greater faunal diversity and the dominance of thick shelled forms.

Depth distribution studies indicate that offshore facies are characterized by a dominantly nassellarian (multicyrtid) deeper-water fauna, whereas nearshore facies mostly contain spumellarians which are extremely abundant and diverse.

Finally, fluctuations in sea level in the Queen Charlotte Islands, as evidenced by the facies sequence and radiolarian faunal succession, appears to confirm worldwide trends of sea level change in the Jurassic.

VI SYSTEMATIC PALEONTOLOGY

CLASSIFICATION

The earliest classification system for Radiolaria, proposed by Haeckel (1887 a,b), was based on geometry or test shape. This was a comprehensive work and until recently has remained the major source of information on radiolarian taxonomy and diversity. Riedel (1971a) was the first to suggest Haeckel's classification was artificial (i.e. not based on clear phylogenetic lineages), and should be abandoned. In recent years Radiolaria have been studied from both a paleontological and ecological/physiological standpoint, for only by incorporating both disciplines, can a more natural system of classification be achieved (Petrushevskaya, 1971,1983). Paleontologists have intensified their study of fossil forms and subsequently, several excellent treatises on specialized topics have appeared that adopt a more natural approach to classification (e.g. Riedel, 1967a,b; Petrushevskaya, 1971a; Foreman and Riedel,1972; Pessagno 1977; Dumitrica, 1970; Goll, 1972 a,b and Riedel and Sanfilippo, 1977). Studies on the living organism by Hollande and Enjumet (1960), Cachon and Cachon (1971, 1972, 1974, 1976) and more recently by Anderson (1976a,b, 1977, 1980,1981,1983) and Swanberg (1980, 1981), have contributed valuable information to the ontogeny of Radiolaria, and functions of nutrition, locomotion and skeletal morphogenesis.

In summary, knowledge of Radiolaria has increased tremendously in specialized areas, but as yet no one researcher has become sufficiently familiar with all the numerous species to be able to recast them into a more natural and fundamentally different classification. As an addendum to this, at EURORAD III in Bergen, Norway (1983), M.A. Petrushevskaya presented a preliminary draft of polycystine classification (in Radiolaria 7, 1983, ed. P. De Wever) that is more comprehensive and detailed than any heretofore.

The taxonomy applied here results from a combination of the "Polycystine Systematics" proposed by W.R. Riedel, (1967a,b); the polycystine classification discussed by Petrushevskaya (1971a); Haeckel's original classification (1887); Kozur and Mostler's studies of Mesozoic Radiolaria (1972,1979) and suprageneric groupings proposed by Baumgartner (1980); Pessagno (1976, 1977a,b, 1979), Pessagno and Blome (1980,1983), Pessagno and Whalen (1982) and De Wever (1981a).

BASIS FOR DESCRIPTION OF NEW TAXA

Definitions of new taxa are based on external diagnostic features of the cortical shell plus elements of internal structure visible with the binocular or scanning electron microscope. Specimens were not viewed in transmitted light. New species are named informally e.g. *Emiluvia* sp. A, n. sp., except in the case of new genera, and their type species, which are fully described according to the International Code of Zoological Nomenclature, 1964. Hypotypes have brief synonymies; comments regarding individual differences from type material etc.

are given under Remarks. The distribution of each taxon is documented both in figures 5 and 6 (along with relative abundance) and under described Occurrence.

Measurements of the Hagiastridae and Patulibracchiidae follow a system of measurements proposed by Pessagno (1971, p. 18, text-fig. 4). The length of rays always includes the ray tip minus spines. For other supraspecific taxa, measurements are normally self explanatory; where they are not, a diagram is included showing the system of measurements utilized. Ranges are based on the faunal correlations discussed in chapter IV.

STORAGE

Holotypes and all illustrated material, as well as some unfigured specimens, are catalogued and deposited with the Geologiucal Survey of Canada, Ottawa, under numbers GSC 80499 to GSC 80798. Most specimens remain attached to SEM stubs, others are mounted on cardboard micropaleontological slides.

NOTES ON USE OF THE STAGE NAME "AALENIAN"

The Aalenian stage has been recognized since 1962 [1st and 2nd Luxembourg Colloquia (1962,1967), and the Cassis Colloquia (1964)], but only recently has achieved total acceptance. This has led to much potential confusion when referring to the lowest Middle Jurassic. The Aalenian is used here, in preference to the synonymous lower Bajocian substage, and ranges for previously described species included have been changed to correspond to this usage. The following table illustrates the stages as used prior to 1962, and as used here.

TABLE IV: Position of the Lower/Middle Jurassic boundary (after Westermann, 1979).

Customary English and N. American usage	Classic German usage		1st Luxembourg Coll. 1962 (1964); van Hinte (1976, 1978); Cook and Bally (1975)		Cassis Coll. 1964	2nd. Luxembourg Coll. 1967 (1971)	This paper
Bajocian	Dogger	(Bajocian)	Dogger	Bajocian	Bajocian	Bajocian	Bajocian
		(Aalenian)		Aalenian	Aalenian	Aalenian	Aalenian
Toarcian	Lias	Toarcian	Lias	Toarcian	Toarcian	Toarcian	Toarcian

Phylum: Protozoa
Subphylum: Sarcodina Schmarde, 1871
Class: Actinopoda Calkins, 1909
Subclass: Radiolaria Müller, 1858
Order: Polycystina Ehrenberg, 1838, emend. Riedel, 1967b
Suborder: Spumellariina Ehrenberg, 1875
Superfamily: Actinomacea Haeckel, 1862, emend. Kozur and Mostler, 1979
Family: Actinommidae Haeckel, 1862, emend. Riedel, 1967b

Definition: Solitary spumellarians with shells spherical or ellipsoidal (or modifications of those shapes), not discoidal, generally without internal spicule, generally much smaller than orosphaerids.

Remarks: The Actinommidae Haeckel, include a vast number of genera: the only one discussed herein in *Tripocyclia*.

Genus: *Tripocyclia* Haeckel, 1882, emend. Pessagno, 1977a
Triactoma Rüst, 18855, p. 289 = *Triactus* Haeckel, 1881, p. 457 (Type species = *Triactoma tithonianum* Rüst, 1885).
Type species: *Tripocyclia trigonium* Rüst, 1885 (subsequent designation by Campbell, 1954, p. D 82).

Definition: Cortical shell smooth, perforate, globular to subtriangular in outline and somewhat flattened with three symmetrically placed massive tribladed spines.

Remarks: The interpretation used herein follows Pessagno's emended definition. He regards *Triactoma* Rüst, 1885 as a junior synonym of *Tripocyclia* Haeckel, 1882.

Tripocyclia sp. cf. *T. echiodes* (Foreman)
plate 10, figure 4

cf. *Triactoma echiodes* Foreman, 1973, p. 260, pl. 3, fig. 1; pl. 16, fig. 21

Remarks: *Triactoma echoides* Foreman has spines placed at approximately 80°, 90° and 170°. Spines on species illustrated are arranged in a manner similar to those of a related undescribed form which was illustrated by Foreman (1973, pl. 3, fig. 2,3). Spines are less sturdy than on *T.echiodes*. All spines on my specimens are incomplete, therefore lengths cannot be compared.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen GSC 80499 from GSC loc. C-080583. This species collected also at GSC loc. C-080584 and C-080585.

Subsequent to the completion of fig. 6, 7, 8 and plate 10, this form has been reassigned to 'unnamed spongodiscid'.

Tripocyclia (?) sp. A, n. sp.
plate 1, figure 4

Diagnosis: Test large, with large irregularly-sized, deep pore frames and three slender tribladed spines.

Description: Large, spherical test with three equatorial spines. Meshwork coarse, irregularly-sized. Deep walled pore frames are triangular, tetragonal and pentagonal with small nodes at vertices giving test a roughened, spiny appearance. Tribladed spines are quite slender with alternating longitudinal ridges and grooves. Spine length is undetermined as none is entire; almost every spine is broken off very close to the base.

Remarks: This species is has larger pore frames and a more spiny appearance than any species of *Tripocyclia* previously described. Genus is queried because of the irregularly-shaped pore frames.

Measurements (µm):	Holotype	avg. 5 spec.	min.	max.
Diameter of test	268	241	240	268

Type locality: GSC loc. C-080577. See Appendix I

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80500 from type locality. Species recorded at this locality only.

Tripocyclia sp. B, n.sp.
plate 10 , figures 2, 3

Diagnosis: Test rounded triangular with small uniformly-sized pore frames and three short, massive tribladed spines with enlarged blunt tips.

Description: Test rounded triangular in outline. Small and uniformly-sized pore frames pentagonal and hexagonal, lacking nodes at bar vertices. Three triradiate equatorial spines are short and massive with alternating longitudinal ridges and grooves of approximately equal width; ridges are rounded and enlarged somewhat at the distal ends producing a widened blunt tip. Spine length little more than half test diameter.

Remarks: This species shows some affinity with *T. blakei* Pessagno (1977a). It differs by having pentagonal as well as hexagonal pore frames, and spines that have enlarged blunt tips and a primary system of grooves only. *T. blakei* has a primary and secondary system of grooves. Terminal portion of spine diagnostic and identifiable even on broken specimens.

Measurements (µm):	Holotype	avg. 3 spec.	max.	min.
Diameter of test	171	193	230	180
Length of longest spine	90	87	100	70

Type locality:GSC loc. C-080597. See Appendix I.

Range: Zones 4 and 6; late mid/early late Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80501 from type locality. Species found also at GSC loc. C-080583, C-080584, and C-080586. Rare at all localities.

Tripocyclia sp. C, n. sp.
plate 10, figure 1

Diagnosis: Test small with uniform, mostly hexagonal, pore frames and three slender tribladed spines.

Description: Test small, spherical and slightly flattened in plane of spines. Three triradiate spines are slender with alternating ridges and grooves. Ridges narrow and rounded; grooves about twice width of ridges. Terminal portion of spines normally pointed but occasionally ridges widen at tip to produce a crown-like extension. Pore frames small, most are hexagonal, a few pentagonal.

Remarks: This species is similar in pore frame size and shape, and spine structure to *Tripocyclia trigonium* (Rüst), (1885, p. 23, pl. 30(5), fig. 3; Parona, 1890, p. 155, pl. 2, fig. 15 and Pessagno, 1977a, p. 80, pl. 7, fig. 6,7) but differs in having a distinctly spherical rather than subtriangular test shape.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Diameter of test	141	143	150	140
length of longest spine (on 4 complete specimens)	136	126	148	110

Type locality: GSC loc. C-080597. See Appendix I.

Range: Zone 5; late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80502 from type locality to which it appears to be confined.

Family: Hagiastridae Riedel, 1971, emend. Baumgartner, 1980

Remarks: Kozur and Mostler in their emended definition of the Superfamily Actinommacea (1979) denied inclusion of the Hagiastridae (originally introduced as Subfamily Hagiastrinae by Riedel (1971) and later elevated to family level by Pessagno (1971)) because of the spongy wall structure of most forms. Both Riedel and Pessagno placed the Hagiastridae in a higher group, the Spongodiscidae Haeckel, emend. Riedel and the Spongodiscacea Haeckel, respectively, limited to forms having a spongy wall structure. The family as emended by Baumgartner confines the Hagiastridae to forms having 2 to 4 (or 5) rays with cortical and medullary shells and canals, and homologizes these with the Actinommidae Haeckel, emend. Riedel. A further group having a similar external shape but with irregular spongy wall structure is now confined to the Family Patulibracchiidae Pessagno, emend. Baumgartner and is discussed on p.

Subfamily: Hagiastrinae Riedel, 1971, emend. Baumgartner, 1980

Genus: *Homoparonaella* Baumgartner, 1980
Type species: *Paronaella elegans* Pessagno, 1977a

Homoparonaella sp. aff. *H. argolidensis* Baumgartner
plate 7, figures 5, 6

aff. *Homoparonaella argolidensis* Baumgartner, 1980, p. 288, pl. 2, fig. 1, 8-12: pl. 11, fig. 4

Remarks: This species appears to be closely related to *H. argolidensis* and differs only by lacking a porous hump (with raised central tip) in the central area. If further study eventually proves this species to be *H. argolidensis* then Baumgartner's quoted range of "late Bathonian - early Callovian to Tithonian" must be lowered considerably.

Range: Zones 3 to 6; late mid Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island. Figured specimen GSC 80503 from GSC loc. 080584; species found also at GSC locs. C-080581, C-080582, C-080583, C-080585 and C-080586. Eastern Oregon: Snowshoe Formation; Pessagno collection OR 501. Romania: Jasper beds and Argolis Penninsula; see Baumgartner (1980).

Homoparonaella sp. aff. *H. elegans* (Pessagno)
plate 16, figure 7

? aff. *Rhopalastrum slavatum* Squinabol, 1903, p. 122, pl. 9, fig. 3
aff. *Paronaella elegans* Pessagno, 1977a, p. 70, pl. 1, fig. 10,11; De Wever et al, 1979, p. 88, pl. 5, fig. 9
aff. *Homoparonaella elegans* (Pessagno) Baumgartner, 1980, p. 289, pl1, fig. 15; pl. 2, fig. 2-6; pl. 11, fig. 6

Remarks: This form differs from *H. elegans* by having less expanded ray tips, subaligned and tetragonal pore frames on almost all test surfaces and by having less prominent nodes at pore frame vertices.

Range: Zones 4 to 7: late mid/early late Toarcian to early Bajocian. Range of *H. elegans* given by Baumgartner (1980) is " middle Callovian - Oxfordian or older to Tithonian".

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80504 from GSC loc. C-080588. Species collected also at C-080585 and C-080587. *H. elegans* found in Central Japan: Yao collection In 7 (1972); Romania and Argolis Penninsula: see Baumgartner (1980); California: see Pessagno

(1977a).

Homoparonaella sp. A, n. sp.
plate 7, figures 2, 3

Diagnosis: Test has three rays of moderate (near equal) length with strongly expanded ray tips terminated by numerous short, fine spines. Pore frames and beams are aligned longitudinally producing a pattern of single rows of square pore frames that alternate with double rows of triangular pore frames.

Description: Three-rayed test. Rays of moderate length, interradial angles subequal. Rays composed of 8-10 longitudinal beams with transverse bars oriented perpendicular to, and oblique to the beams, forming single rows of square pore frames that altermate with double rows of triangular pore frames. Rays circular in axial section. Pore frames on ray tips are irregularly distributed, polygonal in shape.

Remarks: Rays are short and stout compared with those of *H. argolidensis*. The alternating pore frame pattern between beams is diagnostic but observable on well preserved specimens only. Abundant.

Measurements (µm):		Holotype	avg. 11 spec.	max.	min.
Length of rays	AX:	185	191	210	150
	BX:	202			
	CX:	202			
Width of rays		46-49	56	62	46
Width of ray tips		122-133	128	140	95
Length of longest spine		23	29	43	22

Type locality: GSC loc. C-080584. See Appendix I.

Range: Zones 2 to 4; mid to late mid/early late Toarcian.

Occurrence: Maude Formation, Maude Island, Graham Island. Illustrated specimen (Holotype) GSC 80505, from type locality. Species recorded also at GSC loc. C-080579, C-080582, C-080583 and C-080585.

Genus: *Hagiastrum* Haeckel, 1881, emend. Baumgartner, 1980
Type species: *Hagiastrum plenum* Rüst, 1885

Hagiastrum sp. cf. *H. egregium* Rüst
plate 7, figures11,12

cf. *Hagiastrum egregium* Rüst, 1885, p. 299, pl. 34, fig. 5

Remarks: This species compares closely with *H. egregium* except for the apparently twisted rays, the near equal length of all rays and the reduced size; overall length horizontally from ray tip to ray tip of this species is 600-800 µm whereas in Rüst's type specimen this dimension is over 1100 µm. This species differs from *H.* sp. A by having fewer longitudinal beams and thus more slender arms.

Range: Zones 3 to 6; late mid Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island. Illustrated specimens GSC 80506 and GSC 80507 from GSC loc. C-080583 and C-080597. Species also at GSC. locs. C-080581, C-080582, C-080584, C-080585 and C-080586. Western Switzerland: see Rüst (1885).

Hagiastrum sp. A, n. sp.
plate 2, figure 2

Diagnosis: Test large, possessing 4 slender and elongate rays with elliptical tips. Each ray with 8-10 longitudinal beams alternating with linear rows of pore frames. Rays may be slightly twisted.

Description: Large test with 4 slender perpendicular rays of nearly equal length. Ray tips expanded, elliptical in outline. Each cortical ray composed of 8-10 longitudinal beams. Transverse bars between beams form rows of square to parallelogram-shaped pore frames. Central area large; pore frames irregularly placed, small and mostly triangular. Rays circular in axial section.

Remarks: This species differs from *Hagiastrum* cf. *H. egregium* (described above) by virtue of having slightly wider rays with more longitudinal beams per ray and by having a larger more complex central area with smaller, more irregularly arranged pore frames. The lack of observed spines on ray tips may be because of poor preservation. This form bears no resemblance to other described species of *Hagiastrum*.

Measurements (µm): This is a large form with slender easily-breakable rays; no complete specimens have been found, but partial specimens are common; even the holotype lacks a complete ray. Two specimens have rays 320 and 360 µm long. Width, measured on 10 specimens, ranges from 43-62 µm (average 57 µm).

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1: late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80508 from type locality to which it is apparently confined.

Hagiastrum sp. B, n. sp.

Description: Four-rayed test of medium size. Rays relatively short (subequal in length) and perpendicular to each other, tips expanded and wedge-shaped. Each ray has 8 longitudinal beams alternating with 8 rows of rectangular pore frames. Rays circular in axial section. Central area complex; pore frames smaller than in other described species, tetragonal and triangular in shape. Square to tetragonal pore frames on ray tips are also smaller. Nodes well-developed on central area and on rays: less so on ray tips. This form is believed to have either one or several terminal spines per ray, however, specimens are incompletely preserved and no spines have been observed.

Remarks: This form differs from both *Hagiastrum* cf. *H. egregium* Rüst and *H.* sp. A, by having shorter arms, less expanded ray tips, straight rather than slightly twisted longitudinal beams and heavier nodes at all pore vertices. In addition it differs from *H.* sp. A by having 8 rather than 10-12 longitudinal beams per ray.

Measurements (µm): Only 3 incomplete specimens are available for study therefore measurements are incomplete. This species should be treated more thoroughly when further collecting yields additional specimens.

	Holotype	Paratype 1	Paratype 2
Length of rays	252	240	240
Average width of rays / spec.	55	62	62
Width of ray tips	115	95	-

Type locality: G.S.C. loc. C-080586. See Appendix 1.

Range: Zones 4 to 6; late mid/early late Toarcian to Aalenian.

Occurrence : Maude Formation, Graham Island; Type specimen GSC 80509 (unfigured) from type locality. Single specimens occur at G.S.C. loc. C-080582, C-080585 and C-080586.

Subfamily: Higumastrinae Baumgartner, 1980

Genus: *Higumastra* Baumgartner, 1980
Type species: *Higumastra inflata* Baumgartner, 1980

Higumastra sp. A, n. sp.
plate 10, figure 6

Diagnosis: Test has 4 equal, short, tapering rays, each terminated by a short, massive central spine. Ray surfaces have three linear rows of large circular pores. Central area large and slightly depressed.

Description: Test with 4 rays at right angles. Rays are short, equal in length slightly inflated, and taper to a short massive central spine. Rays subrounded in axial section. Thin longitudinal beams and regular bars together produce three rows of circular pores on the upper and lower surfaces of rays. Pores in median pore row slightly smaller than those of flanking rows. Pores in central area irregular in size and shape; they are smallest in the center with a few extra large ones towards the periphery of the central area, especially between rays. Weakly developed nodes at all pore vertices. Central spines circular in axial section.

Remarks: This species has much coarser meshwork with correspondingly fewer and larger pores than any previously described species of *Higumastra*. In addition it has a larger more inflated central area and more massive central spines. It has some affinity with *Astractura tetraxiphus* Rüst (1898, p. 22, pl.7, fig. 3) but has coarser meshwork with fewer pores and shorter spines.

Measurements (µm): 6 specimens are available for study however, none are complete. Therefore measurements given are preliminary, and limited to features observable on fragments.

	Holotype	avg. 6 spec.	max.	min.
Length of rays	150-155	143	155	120
Width of rays (at base)	75-80	96	80	65

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Zones 5 to 7; late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimen (Holotype) GSC 80510 from type locality. Species occurs only sparsely at GSC loc. C-080597.

Genus: *Pseudocrucella* Baumgartner, 1980
Type species: *Crucella sanfilippoae* Pessagno 1977a

Pseudocrucella sanfilippoae (Pessagno)
plate 7, figures 1, 4

Crucilla sanfilippoae Pessagno 1977a, p. 72, pl. 2, fig. 15-16.
Pseudocrucella sanfilippoae (Pessagno) Baumgartner, 1980, p. 291, pl. 8, fig. 1,23,24.

Remarks: This species appears to be the same as that described by Pessagno (1977a) and illustrated also by Baumgartner (1980).

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian. Pessagno and Baumgartner however, indicate its range as Kimmeridgian to Tithonian

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimens GSC 80511 and 80512 from GSC locs. C-080583 and C-080597. Species occurs also at GSC locs. C-080582, C-080584, C-080585, C -080586, C-080587, C-080594 and C-080595; California: see Pessagno (1977a); Greece: see Baumgartner (1980).

Pseudocrucella sp. A, n. sp.
plate 7, figures 8, 9

Diagnoses: Four rays are slender, uniform in width with long triradiate spines. Ray surfaces have 2-3 rows of sublinear pore fromes between 3 external beams.

Description: Test with 4 slender rays nearly at right angles. Rays uniform in width and terminate with long triradiate spines. Upper and lower surfaces of rays display 3-4 external beams (one median and two lateral) connected by regular bars to form tetragonal pore frames. Corners of all pore frames marked by strong nodes. Rays rectangular in cross section. Meshwork in central area irregularly arranged.

Remarks: The rays on this form appear to expand slightly at tips (this is likely a preservational feature resulting from cortical shell being worn away to expose the more delicate inner structure). This species has affinity with *Pseudocrucella* sp. C, illustrated by Baumgartner (1980, p. 292, pl. 8, fig. 10, 11, 14). It differs in having larger, less numerous pore frames marked by stronger nodes, and in having shorter spines.

Measurements (µm):	Holotype	avg. 11 spec.	max.	min.
Length of rays	118	132	160	110
Width of rays	57	63	80	50
Length of longest spine	52	58	75	40

Type locality: GSC loc. C-080584. See Appendix 1.

Range: Zone 4; late mid/ early late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80513 from type locality. Species occurs also at GSC locs. C-080583 and C-080585.

Pseudocrucella sp. B

Description: Test composed of 4 flattened, slender rays terminated by strong triradiate spines. Rays at right angles to one another and tapering slightly towards their tips. Beams and transverse bars both fine. Pore frames sublinear, square to tetragonal. Rays subrounded to elliptical in cross section. Central area large with irregular meshwork. Spines triradiate proximally; circular distally.

Remarks: This form appears almost identical to *Pseudocrucella* sp. A of Baumgartner (1980, p. 292, pl. 1, fig. 13; pl. 8, fig. 3,5,7,9,13; pl. 11, fig. 11,12,14) which he describes as being intermediate between *P.*

sanfilippoae (Pessagno) 1977a and *P. adriani* Baumgartner, 1980. Their identity might be established if the actual specimens could be compared.

Range: Subzones 7B to 7C; early Bajocian. Baumgartner's sp. A occurs in strata of Oxfordian to Kimmeridgian age.

Occurrence: Yakoun Formation, Graham Island. Holotype GSC 80514 (not illustrated) occurs at GSC loc. C-080588. Other specimens are found at GSC locs. C-080587 and C-080593. Greece; Argolis Penninsula: see Baumgartner 1980, test-fig. 5.

Pseudocrucella sp. C
plate 7, figure 7

Description: Rays not at 90°, slender with 2 to 3 rows of sublinear pore frames. Spines long and tapering, triradiate in cross section.

Remarks: This species appears almost identical to *Pseudocrucella* sp. C of Baumgartner (1980, p. 292, pl. 8, fig. 10,11). Although in Greece and Romania it is restricted to Tithonian and younger samples, it appears to be longer ranging.

Range: Zones 2 to 5; mid to late Toarcian.

Occurrence: Maude Formation, Maude Island and Graham Island. Illustrated specimen GSC 80516 from GSC loc. C-080583. Species occurs also at GSC locs. C-080579, C-080582 and C-080597. Greece; Argolis Penninsula and Romania: Margucera Formation: see Baumgartner (1980).

Pseudocrucella sp. D

Description: Test has four rays that cross at near 90°. Rays short, tapering, conical, with long triradiate spines and a large, somewhat depressed central area.

Remarks: This appears almost identical to *Pseudocrucella* sp. B illustrated by Baumgartner (1980, p. 292, pl. 8, fig. 2,6), which occurs in Greece in samples of Oxfordian and Kimmeridgian age. It differs from my sp. C, by having a larger central area and shorter, wider rays.

Range: Zones 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Single specimens occur at GSC locs. C-080584 and C-080597.

Subfamily: Tritrabinae Baumgartner, 1980

Genus: *Tetratrabs* Baumgartner, 1980
Type species: *Tetratrabs gratiosa* Baumgartner, 1980

Tetratrabs sp. aff. *T. gratiosa* Baumgartner
plate 7, figure 10

aff. *Tetratrabs gratiosa* Baumgartner, 1980, p. 294, pl. 1, fig. 11; pl. 5, fig. 2-7; pl. 6, fig. 4-7, 9-14; pl. 11, fig. 7-9.

Remarks: This form is remarkably similar to *T. gratiosa* but differs by occasionally having single rather than double pore rows between adjacent beams. Moreover, measurements on a number of specimens indicate that average size is about half that of *T. gratiosa*. This size difference may represent either an ecological variation or may indeed be a new species. It is also worth noting that Baumgartner considers the lower range for *Tetratrabs* to be Callovian (based on information available to him in 1980). With further work on Toarcian and Aalenian forms it is possible either that the genus range will be lowered or that this form may be considered ancestral to *Tetratrabs* (s.s.).

Range: Zones 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen GSC 80518- from GSC loc. C-080584. Occurs also at GSC locs. C-080582, C-080583, C-080585 and C-080597.

Subfamily: Tetraditryminae Baumgartner, 1980

Genus: *Tetraditryma* Baumgartner, 1980
Type species: *Tetraditryma pseudoplena* Baumgartner, 1980

Tetraditryma sp. A, n. sp.
plate 16, figures 9, 12

Diagnosis: Test small. Rays slender with expanded tips terminated by short triradiate spines. Two rows of paired linear pore frames on upper and lower surfaces of each ray. Rays strongly rectangular in cross section.

Description: Small 4-rayed test. Rays slender, subequal in length, not at 90°. Upper and lower surfaces of rays composed of 2 strong lateral beams and 1 weak median beam. Beams connected by transverse bars to form 2 rows of paired circular pores. Sides vertical to slightly concave with 3 horizontal rows of circular pore frames. Tips of rays expanded somewhat, round in outline; terminal spines short and triradiate with 3 primary and 3 secondary grooves at base. Central area small and planiform with slightly larger pores. Nodes at all pore vertices weak to absent. Rays rectangular in cross section.

Remarks: This bears no resemblance to any described species of *Tetraditryma* or to any known 4-rayed form. This description is based on a single specimen, therefore measurements are not treated and will await collection of more specimens.

Type locality: GSC loc. C-080587. See Appendix 1.

Range: Subzone 7B; early Bajocian

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80519 from type locality.

Tetraditryma sp. B, n. sp.
plate 16, figure 8

Diagnosis: Test small, with 4 slender lenticular rays terminated by tapering triradiate spines. Rays have 2 rows of paired to offset circular pores. All beams have small but well defined nodes.

Description: Small delicate test with four rays of equal length, at 90°. Rays slender, lenticular in outline, composed of 2 strong lateral beams and one median beam of weak to medium strength. Sides vertical to slightly concave. 2 rows of paired to offset circular pores on upper and lower surfaces of rays. Rays subrectangular in cross section. Ray tips have tribladed spines with 3 wide primary grooves and 3 narrower secondary grooves that arise from base of spine ridges. Central area planiform, with larger pores around periphery, particularly between each pair of adjacent rays. Nodes very distinct, larger on central area than on rays.

Remarks: I have seen no forms of similar aspect in literature published to date. Nevertheless, measurements are not given because only two specimens of this small, delicate form are available for study at this time.

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Subzone 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype), GSC 80520 from type locality, to which this species appears to be confined.

Tetraditryma sp. aff. *T. pseudoplena* Baumgartner

non *Hagiastrum plenun* Rüst, in Pessagno, 1977a, p. 72, pl. 2, fig. 14
Tetraditryma pseudoplena Baumgartner, 1980, p. 297, pl. 1 fig. 9; pl. 7, fig. 1-11.

Remarks: This form is nearly identical to *T. pseudoplena* but is smaller (rays 160-200 µm in length), and lacks stout lateral spines on ray tips. However, preservation of ray tips on my specimens appears incomplete. Baumgartner notes that in Pessagno's material from Oregon, a form similar to *T. pseudoplena* exists but with "less strong lateral and equal central spines". He believes this variation is insufficient to warrant distinction of two different species. In addition he mentions forms from the Middle Jurassic of Oregon and Central Japan that contain an ancestor species of *T. pseudoplena* that too is smaller and has a "reduced, porous cortical wall Direct comparison of my specimens with those in Oregon and Japan might prove this same ancestor species to exist in the early Bajocian of the Queen Charlotte Islands.

Range: Subzone 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Unfigured specimen GSC 80521. All specimens confined to GSC loc. C-080595.

Family: Praconocaryommidae Pessagno, 1976

Genus: *Praeconocaryomma* Pessagno, 1976
Type species: *Praeconocaryomma universa* Pessagno, 1976

Praeconocaryomma immodica Pessagno and Poisson
plate 1, figure 1

Acanthosphaera magnimamma Rüst, 1898, p. 12, pl. 4, fig. 1
non *Praeconocaryomma magnimamma* (Rüst) Pessagno, 1977a, p. 27, pl. 5, fig. 14-16, pl. 6, fig. 1
Praeconocaryomma immodica Pessagno and Poison, 1981, p. 57, pl. 7, fig. 2-9

Remarks: Specimens appear identical in size and description with *P. immodica*

Range: Zones 1 to 5; late Pliensbachian to late Toarcian. Previous to this report *P. immodica* was known to range from the Toarcian to late Kimmeridgian/early Tithonian in California only (Pessagno and Poisson, 1981).

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen GSC 80522 from GSC loc. C-080577. Species occurs also at GSC loc. C-080579 and C-080597, and in greater abundance. California: see Pessagno and Poisson (1981).

Praeconocaryomma sp. aff. *P. media*
plate 1, figure 2

aff. *Praeconocaryomma media* Pessagno and Poisson, 1981, p. 57, pl. 8, fig. 1-4

Remarks: This form differs from *P. media* by having pentagonal rather than hexagonal shaped mammae and 5 rather than 6 basal mammary pores. It also has slightly more complex intermammary areas. It differs from *P. immodica* by having more widely spaced nodes with lower relief.

Range: Zones 1 and 2; late Pliensbachian to mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80523 from GSC loc. C-080577. Species also occurs at GSC loc. C-080579.

Praeconocaryomma sp. aff. *P. parvimamma* Pessagno and Poisson
plate 9, figure 1

aff. *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981, p. 58, pl. 7, fig. 5-8; pl. 9, fig. 2

Remarks: *P. parvimamma* is thought to be the simplest (earliest) form in the *Praeconocaryomma* lineage (Pessagno and Poisson, 1981). It has six small mammary pores that slope gently outward from raised mammae. The legs of these pore frames interconnect with those of adjoining mammae forming large subelliptical pores in intermammary areas. This form has an even more simple configuration and differs from *P. parvimamma* (s.s.) by completely lacking the small basal mammary pores and in addition, is much smaller (90 and 97 µm in diameter on 2 specimens, as opposed to maximum and minimum diameters of 260 and 200 µm respectively, on *P. parvimamma*).

Range: Zone 5; late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen GSC 80524 from GSC loc. C-080597.

Praeconocaryomma sp. aff. *P. mamillaria* (Rüst)
plate 9, figure 2

aff. *Heliosphaera mamillaria* Rüst, 1898, p. 12, pl. 4, fig. 2
Praeconocaryomma mamillaria (Rüst) Pessagno, 1977a, p. 77, pl. 6, fig.2

Remarks: This form differs from *P. mamillaria* (s.s.) by having subcircular to subtriangular, rather than distinctly triangular, pore frames surrounding mammae and in intermammary areas and in addition, it is much smaller.

Range: Zones 2 to 5; mid to late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen GSC 80525 from GSC loc. C-080597. Species also occurs commonly at GSC locs. C-080579, C-080583 and C-080584.

Praeconocaryomma sp. aff. *P. californiensis* Pessagno
plate 17, figure 10

aff. *Praeconocaryomma californiensis* Pessagno, 1976, p. 41, pl. 7, fig. 1-8

Remarks: This form appears very similar in size and described characteristics to *P. californiensis* (s.s.). It differs in having either 5 or 6 basal mammary pores and by lacking triradiate spines (over and above the normal fine circular spines). . Furthermore, *P. californienses* is much younger: it is late Cretaceous.

Range: Subzones 7B and 7C; early Bajocian

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80526 from GSC loc. C-080588. Species occurs also at GSC locs. C-080587, C-0080593, C-080595 and C-080596.

Praeconocaryomma sp. aff. *P. universa* Pessagno
plate 17, figure 6

aff. *Praeconocaryomma universa* Pessagno, 1976, p. 42, pl. 6, fig. 14-16

Remarks: Form almost identical to *P. universa*, but has circular rather than triradiate spines. It differs from *P.* sp. aff. *P. californiensis* by having more widely spaced (and larger) mammae with large sloping mammary pores.

Range: Subzone 7C; early Bajocian

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80527 and other specimens confined to GSC loc. C-080588.

Praeconocaryomma sp. A, n. sp.
plate 1, figures 3, 6

Diagnosis: Spherical test with small, closely spaced porous mammae. Pores in intermammary areas normally much larger: elliptical and subtriangular in shape.

Description: Test spherical with small closely-spaced porous mammae. Surfaces of mammae penetrated by a number of small circular pores centered around a small spine which is circular in section. Pores in intermammary area irregularly-sized; larger pores are subtriangular in shape, smaller pores mostly elliptical. Occasional nodes arise near centers of intermammary areas where a number of pores converge. First medullary shell has pentagonal pore frames of varying size with weakly-developed nodes at bar vertices. Sturdy triradiate beams connect medullary shell with mammae on cortical shell.

Remarks: This form is somewhat similar to *P.* sp. aff. *P. magnimamma* (Rüst) illustrated by Pessagno and Poisson (1981, p. 59, pl. 9, fig. 3-5). It differs by having smaller mammae and correspondingly larger intermammary areas with larger pores. Compared with *P. magnimamma* (Rüst) 1898 and *P.* sp. aff. *P. magnimamma* figured by Feary and Pessagno (19801, fig. 3,4) these differences become even more apparent and are considered significant enough to warrant designating this form a new species.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Diameter of cortical shell	196	189	200	180
Height of mammae	15	14	20	11

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimens GSC 80528 (Holotype) and GSC 80529 (Paratype) from type locality. All specimens confined to this locality.

Praeconocaryomma ? sp. B, n. sp.
plate 1, figure 5

Diagnosis: Test large with many small, very closely-spaced mammae. Mammae are directly connected to one another by heavy bars. Surfaces of mammae are flattened and finely perforate.

Description: Test large, subspherical with small, very closely-spaced mammae. Mammae are small, knob-shaped and possess minute rounded pores on their flattened distal surfaces. Mammae connected directly with massive bars. In some places these bars are so heavy and shortened that mammae almost merge. 5-6 triangular to tetragonal intermammary pores surround each mamma. At least one medullary shell is present but further details of inner structure cannot be determined at this time.

Remarks: Genus is queried because the tubercles (termed mammae) are more knob-shaped than cone-shaped. Although they possess surface perforations they normally lack radial spines which are invariably present in *Praeconocaryomma* . In only one specimen have primary spines (2) been noted; they are circular in section.

Measurements (µm):	Holotype	avg.16 spec.	max.	min.
Diameter of cortical shell	225	207	252	150
Height of mammae	12	10	13	8

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zones 1 to 6; late Pliensbachian to Aalenian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80530 from GSC loc. C-080577, where species occurs in great abundance. Found also at GSC loc. C-080586.

Genus: *Acaeniotyle* Foreman, 1973
Type species: *Xiphosphaera umbilicata* Rüst, 1898

Definition: "spherical or ellipsoidal shell with a surface of large porous nodes from which two or three spines extend" (Foreman, 1973, p. 258).

Remarks: To the writers knowledge only four species of *Acaeniotyle* have been described: *A. diaphorogona* Foreman, 1973; *A. tribulosa* Foreman, 1973; *A. umbilicata* (Rüst) Foreman, 1973 and *A.* sp. A, Pessagno, 1977a. All are late Jurassic and early Cretaceous in age. The three forms described below are doubtfully assigned because nodes are smaller, knob-like rather than rounded, and have fewer perforations, and all are much earlier.

Acaeniotyle (?) sp. A, n. sp.
plate 2, figure 3

Diagnosis: Subspherical test bearing 3 sturdy, approximately equidistant tribladed spines. Surface of cortical shell covered with closely-spaced, rounded, porous nodes.

Description: Test subspherical and slightly flattened in equatorial plane, from which 3 sturdy primary spines radiate. Nodes finely perforate; some bear circular remnants of small spines. Nodes connected by massive bars;

resulting pore frames subtriangular and elliptical. Equatorial spines tribladed, possessing alternating ridges and grooves; ridges narrow and rounded, some bearing several small thorns near tips. At least one medullary shell is present, pores are larger than those of cortical shell.

Remarks: Genus queried: see "Remarks" under genus *Acaeniotyle*. Form, though smaller, is very similar to *Praeconocaryomma* ? sp. B, except for the 3 strong equatorial spines; both are abundant in the same sample. This species differs from *Acaeniotyle* sp. B, by having a less spherical cortical shell with more closely-spaced mammae.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Diameter of cortical shell				
(from base of spine,diagonally)	157	143.5	160	115
Length of longest spine	78	82	92	70

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1: late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80531 from type locality.

Acaeniotyle (?) sp. B, n. sp.
plate 9, figure 6

Diagnosis: Test subspherical and slightly flattened with 3 long sturdy tribladed spines. Surface of cortical shill covered with strong, slightly perforate nodes.

Description: Test subspherical, flattened in plane of equatorial spines. Nodes on cortical shell strong, moderately-spaced with somewhat flattened distal surfaces (tops); surfaces with fine perforations, some bearing remnants of fine central spines. Nodes connected by strong bars that form circular, elliptical and subtriangular pores. Spines tribladed and long (entire ones greater than 3/4 diameter of test) carrying narrow rounded ridges and wider grooves; complete spines are pointed. First medullary shell has small irregular pore frames connected to cortical shell by radial beams. Radial beams (3) are strong, triradiate and continuous with each primary spine; beams of lesser strength are attached to cortical shell at base of nodes.

Remarks: Genus queried; see "Remarks" under genus *Acaeniotyle*.

Measurements (μm):	Holotype	avg. 13 spec.	max.	min.
Diameter of test	146	145	175	130
Length of longest spine	121	108	145	82

Type locality: GSC loc. C-080597. See Appendix 1.

Range: Zone 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80532 from type locality. Species occurs also at GSC locs.C-080583, C-080584 and C-080585.

Acaeniotyle (?) sp. C, n. sp.
plate 9, figure 3

Diagnosis: Test small, subspherical with 3 long circular spines, basally grooved. Surface of cortical shell covered with closely-spaced, fine, very elongate nodes.

Description: Test small and subspherical. Three long spines extend from somewhat flattened equatorial plane of test. Nodes on cortical shell are extremely long and have fine perforations and remnants of secondary spines on their distal surfaces. Pore frames connecting nodes, where visible, are triangular and tetragonal. Unbroken spines approximately equal in length to diameter of test. Spines basally grooved, becoming circular in section in distal portions.

Remarks: Genus queried; see "Remarks" under genus *Acaeniotyle*. A very small, delicate nodose form. Rare and confined to Type Locality.

Measurements (μm): Measurements tentatively based on only 2 specimens and will be more detailed when additional material is available for study.

	Holotype	Paratype
Diameter of test	158	180
Height of nodes	26	32
Length of longest spine	147	-

Type locality: GSC loc. C-080597. See Appendix.

Range: Zone 5; late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80533 from type locality. All specimens confined to this locality.

Family: Staurolonchidae Haeckel, 1881, emend. Pessagno 1977a

Genus: *Staurolonche* Haeckel, 1881, emend. Pessagno 1977a
?*Staurosphaera* Haeckel, 1881, p. 450 (= nomen dubium) Pessagno, 1977a
Type species: *Staurolonche robusta* Rüst, 1885. Subsequent designation by Cambell (1954, p. D 56).

Staurolonche sp. aff. *S. robusta* Rüst

aff. *Staurolonche robusta* Rüst, 1885, p. 291, pl. 24(4), fig. 2; Pessagno, 1977a, p. 75, pl. 4, fig. 8

Remarks: This form is generally similar to Rüst's line drawing and to a form illustrated by Pessagno from the Upper Jurassic of California (1977a). Preservation such that size and shape of cortical shell and spines agree but meshwork is unclear in detail.

Range: Zones 1 and 2; late Pliensbachian to mid Toarcian.

Occurrence: Maude Formation, Maude Island. Single specimens occur at GSC loc. C-080577 and C-080579. GSC 80534 (not illustrated) from GSC loc. C-080579.

Staurolonche sp. A, n. sp.
plate 8, figures 2,3

Diagnosis: Test small, flattened, square in outline with extremely long tribladed spines. Pores are large with heavy nodes.

Description: Upper and lower surfaces of cortical shell are planiform; sides vertical. Test has two large pores at the base of each spine with a few smaller pores in the central area. Pores triangular, tetragonal and pentagonal, their vertices marked by heavy nodes. Spines extremely long (3-4 times diameter of test) bearing alternating ridges and grooves. Ridges wide and grooves narrow in proximal half; but grooves widen at the expense of ridges as spine comes to a sharp point distally. Atleast one small medullary shell present.

Remarks: Illustrated specimen has planiform surfaces bearing a few large pores. Other specimens have slightly convex surfaces with smaller and somewhat smaller pores. For the present, and until further specimens are collected, all forms are included together in this one species. This form is grossly similar to *Staurodoras mojsisovicsii* Dunikowski, 1882 (in Rüst, 1885, p. 292, pl. 29(4), fig. 11) however, *Staurodoras* has a solid spongy sphere and lacks a differentiated medullary shell.

Measurements: The following measurements are tentative, based on only three specimens: Diameter of test (measured at midpoint of sides, between adjacent spines) 67 µm on Holotype, 62-67 µm on paratypes; Length of longest spine, 267 µm on Holotype, 252-267 µm on paratypes.

Type locality: GSC loc. C-080584. See Appendix 1.

Range: Zones 4 and 5: late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80535 from type locality. Species occurs also at GSC locs. C-080583 and C-080597.

Staurolonche sp. aff. *S. extensa* Rüst?

aff. *Staurolonche extensa* Rüst, 1885, p. 291, pl. 29(9) fig. 3

Remarks: This species compares with *Staurolonche extensa* Rüst? illustrated by De Wever (1981c, p. 148, pl. 5, fig. 26) from upper Sinemurian? - lower Pliensbachian limestones of Turkey. It differs in having narrower based, more slender spines. Lattice structure appears similar but poor preservation of Q.C.I. specimens prohibits positive comparison. It differs from Rüst's original figure by having much shorter spines.

Range: Zone 4 to Subzone 7B; late mid/early late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Single specimens occur as GSC locs. C-080583 and C-080587. GSC 80536 (not illustrated) from GSC loc. C-080583.

Genus: *Emiluvia* Foreman, 1973, emend. Pessagno, 1977a
Type species: *Emiluvia chica* Foreman, 1973

Definition: Rectangular test with four spines, one at each corner arranged to form a cross. Surfaces of cortical shell planiform; sides concave to convex. Top and bottom surfaces of cortical shell with two layers: an inner layer of massive polygonal pore frames and a secondary outer layer consisting of nodes, connected by bars, forming triangular, tetragonal or irregularly polygonal pore frames. Sides of test are single layered. Primary spines have alternating longitudinal ridges and grooves.

Remarks: *Emiluvia* is interpreted in the emended sense of Pessagno as defined above. Pessagno's placement of *Emiluvia* in the Staurolonchidae Haeckel is based on the varying shape of pore frames in the secondary layer of the cortical shell. Foreman originally included *Emiluvia* with the Pseudoaulophacidae Riedel because of the pseudoaulophacid-like meshwork.

Range: Pessagno (1977a) states the range of *Emiluvia* as "Middle to Upper Jurassic". However, Baumgartner (1980) in discussing the origin of the Hagiastridae, notes that *Emiluvia* -like forms occur in a sample from the Rhaetian-Hettangian boundary in the Queen Charlotte Islands (Pessagno sample QC 545). Therefore the range of *Emiluvia* must be extended to include the Lower Jurassic. It is certain that many species of *Emiluvia* are not only present but abundant in the Toarcian of the Queen Charlotte Islands.

? *Emiluvia amplissima* (Foreman)
plate 8 , fig 10, 11, 12

? *Staurosphaera amplissima* Forman, 1973, p. 259, pl. 3, fig. 6

Remarks: This form bears some resemblance to *Staurosphaera amplissima* Foreman. Foreman (1973) assigned numerous Mesozoic species, all bearing four main spines arranged as a cross, to *Staurosphaera* Haeckel regardless of the nature or shape of shell and length of spines. This form is not *Staurosphaera* because it possesses a medullary shell. It has been reassigned herein to genus *Emiluvia* tentatively because of its subrectangular to subrounded shape and by the presence of occasional radiating spinules. This species is abundant in all upper Toarcian samples.

Range: Zones 3 to 6; late mid to Aalenian.

Occurrence: Maude Formation, graham Island. Illustrated specimens GSC 80537 and GSC 80538 from GSC locs. C-080586 and C-080584 respectively. Other specimens (unfigured) found at GSC locs. C-080581, C-080582, C-080583, C-080585 and C-080597.

? *Emiluvia antigua* (Rüst)

Staurosphaera antigua Rüst, 1885, p. 289, pl. 28(3), fig.2
? *Emiluvia antigua* (Rüst) Pessagno, 1977a, p. 76, pl. 4, fig. 9,10

Remarks: Genus and species doubtful because poor preservation obscures pore structure of cortical shell. In all other aspects this form is identical to that figured by Pessagno (1977a).

Range: Zone 7; early Bajocian. According to Rüst (1885, p.289) this species ranges from the Middle Triassic to Tithonian. In California it occurs at localities of late Kimmeridgian/early Tithonian age.

Occurrence: Yakoun Formation, Graham Island. Rare at GSC locs. C-080587 (unfigured specimen GSC 80539), C-080589 and C-080594. California and Puerto Rico: see Pessagno (1977a). Rüst's illustrated type from the Aptychus beds of Urschlau.

Emiluvia sp. A, n. sp.
plate 16, figures 5, 11

Diagnosis: Test square and inflated. Surface covered with large rounded nodes. Four massive tribladed spines of medium length. Terminal portion of each spine with crown-like structure, produced by small extensions or ridge tips.

Description: Test square and inflated with 4 massive corner spines. Upper and lower surfaces of test slightly convex and covered with well developed nodes connected by thin bars. Nodes much smaller on vertical sides of test. Pore frames square to triangular: inner pore frames small, subtriangular to irregularly polygonal. Spines sturdy with alternating longitudinal ridges and grooves. Ridges flattened, grooves wide, approximately 1.5 times width of ridges; ridges enlarge slightly at tips, extensions blunt-ended; central axis of spine extends to a fine point.

Remarks: This species has affinity with *E. hopsoni* but differs in having more convex surfaces, less massive nodes and much smaller crown-like structures on spine tips.

Measurements (µm):	Holotype	avg.11 spec.	max.	min.
Diameter of test	124	118	125	110
Length of longest spine	133	114	133	100

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Subzone 7C; early Bajocian

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80540 and (Paratype) GSC 80541; all are confined to type locality.

Emiluvia sp. B, n. sp.
plate 16, figures 3,4

Diagnosis: Test square with concave sides. Surface of test covered with massive nodes particularly near base of spines. Spines tribladed with small extensions on the ridge tips producing a modified crown-like structure.

Description: Test square in outline with 4 spines extending from corners. Top and bottom surfaces of cortical shell planiform, sides concave. Cortical shell composed of triangular and tetragonal pore fromes with heavy to massive nodes at vertices of connecting bars. Nodes tend to be concentrated along ray axes and extend somewhat onto base of spines. Spines large, composed of 3 alternating longitudinal ridges and grooves; ridges have a thorn-like extension near their tip. Ridges wide and rounded, grooves narrow and deep.

Remarks: Differs from *E. salensis* by having shorter spines with thorn-like extensions at the tips of spine ridges.

Measurements (µm):	Holotype	avg.11 spec.	max.	min.
Diameter of test	78	106	130	78
Length of longest spine	122	101	122	80

Type localtiy: GSC loc. C-080596. See Appendix 1.

Range: Zone 7C; early Bajocian

Occurrence: Yakoun Formation, Graham Island. Illustrated specimens (Holotype) GSC 80542 and (Paratype) GSC 80543 from type locality and GSC loc C-080588, respectively. unfigured specimens occur at GSC locs. C-080593.

C-080594 and C-080595.

Emiluvia ? sp. C, n. sp.
plate 4, figure 1

Diagnosis: Test small and inflated. Surface covered with large, closely-spaced nodes. Spines massive and strongly tapering.

Description: Test small, rectangular in transverse section, elliptical in vertical section with 4 spines radiating from corners of test. Upper and lower surfaces of test convex; covered with large nodes connected by thin bars to form triangular and rectangular pore frames. Spines massive and tapering, composed of longitudinal ridges and grooves: ridges narrow and rounded, grooves wide (approximately twice width of ridge) and fairly shallow.

Remarks: Genus queried because of the convex rather than planiform shape of test surfaces. Species occurs abundantly in pyritized fauna from Creek B (see fig. 3). It bears no resemblance to any previously described species of *Emiluvia*.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Diameter of test	84	97	130	84
Length of longest spine	74	76	100	50

Type locality: GSC loc. c-080579. See Appendix 1.

Range: Zones 2 to 4; mid to late mid/early late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated Holotype GSC 80544 from type locality. Single specimen occurs at G.S.C. loc. C-080584.

Emiluvia sp. D, n. sp.
plate 4, figure 2

Diagnosis: Spines arranged parallel to the diagonals of the rectangular test. Surface covered with well-developed, closely-spaced nodes. Pore frames mostly triangular.

Description: Test rectangular with 4 robust and strongly tapering spines. Top and bottom surfaces of test slightly convex, sides vertical. Surfaces covered with moderately to closely-spaced nodes of uniform size. Nodes connected by thin bars to form triangular and tetragonal pore frames. Spines composed of alternating ridges and grooves; ridges wide and rounded, grooves narrow and of variable length. Distal portion of spines circular in section.

Remarks: Specimens pyritized, but retain excellent detail. *Emiluvia* sp. D, differs from *E.* sp. C, in having smaller, more closely-spaced nodes and less robust spines, not at 90°.

Measurements (µm):	Holotype	avg. 5 spec.	max.	min.
Length of test	120	129	148	120
Width of test	111	117	123	111
Length of longest spine	89	91	102	80

Type locality: GSC loc. C-080579. See Appendix 1.

Range: Zone 2; mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80545 and all other specimens from type locality.

Emiluvia sp. E, n. sp.
plate 4, figure 3

Diagnosis: Test square and inflated. Surface covered with moderately-spaced nodes. Spines slender and tapering.

Description: Test square and somewhat inflated with 4 radial spines at 90°. Nodes on cortical shell connected by regular bars to form variably-sized triangular pore frames. Spines composed of alternating ridges and grooves of approximately equal widths; spines become circular in section in distal third, tips blunt.

Remarks: *Emiluvia* sp. E, differs from *E.* sp. D, in having (1) a square, rather than rectangular shape, (2) less closely-spaced nodes and stronger bars and (3) more slender spines.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Diameter of test	119	125	142	110
Length of longest spine	98	109	120	98

Type locality; GSC loc. C-080579. See Appendix 1.

Range: Zone 2; mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80546, and all other specimens from type locality.

Emiluvia (?) sp. F, n. sp.
plate 4, figures 4, 5

Diagnosis: Test outline a modified square with clearly concave sides. Surface nodes arranged along spine axes. Triradiate spines long and slender.

Description: Sides of test clearly concave, which gives test an almost "4-armed" rather than square appearance. Surface nodes arranged along spine axes: nodes uniform in size, pore frames irregularly-sized, mostly triangular. Spines slender, length variable but normally long. Spine ridges and grooves continuous almost to tip.

Remarks: This form appears to be *Emiluvia*, however its almost 4-armed appearance suggests it may be a form transitional to the Hagiastridae Riedel, such as *Crucella* (s.l.). Detailed study of the internal structure would be necessary for correct generic assignment.

Measurements (µm):	Holotype	avg. 8 spec.	max.	min.
Diameter of test	82	94	106	82
Length of longest spine	104	124	174	103

Type locality: GSC loc. C-080579. See Appendix 1.

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Maude and Graham Island. Illustrated specimens (Holotype) GSC 80547 and (Paratype) GSC 80548 from type locality and GSC loc. C-080595 respectively. Species also occurs abundantly at GSC locs. C-080583, C-080584, C-080585, C-080597 and C-080588.

Emiluvia sp. G, n. sp.
plate 8, figures 5, 6

Diagnosis: Surface of test covered with closely spaced heavy nodes arranged randomly. Spines long, tribladed near base becoming circular in distal portions.

Description: Test square to rectangular, inner layer of cortical shell has irregularly-sized subcircular to polygonal pore frames; outer layer composed of heavy closely-spaced nodes connected by regular bars to form triangular and tetragonal pore frames. Spines normally long and slender, tribladed at base, becoming circular distally.

Remarks: Considerable variation exists in this species. Sides of rectangle or square vary from straight to slightly concave. Spines tend to be longer and retain their triradiate character throughout complete length in mid Toarcian specimens, whereas in late mid/early late Toarcian specimens, spines are normally shorter and predominantly circular in section. This species is extremely abundant at all reported localities.

Measurements (µm):	Holotype	avg. 11 spec.	max.	min.
Length of test	124	130	150	110
Width of test	108	122	150	108
Length of longest spine	92	69	106	53

Type locality: GSC loc. C-080597. See Appendix 1.

Range: Zones 2 to 6; mid Toarcian to Aalenian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80549 from type locality. Unfigured specimens occur at GSC locs. C-080579, C-080581, C-080583, C-080584, C-080585 and C-080586.

Emiluvia sp. H, n. sp.
plate 8, figure 1, 4

Diagnosis: Test rounded-square to rectangular in outline. Meshwork fine, with weakly developed nodes. Spines slender, of moderate length, circular in section.

Description: Test rounded-square to rectangular in outline, test flattened with 4 slender spines at corners. Spines parallel to diagonals, so perpendicular on square tests but arranged as an "X" on rectangular ones. Meshwork fine; pores irregularly polygonal. Small nodes at vertices of exterior pore frames. Spines basally grooved, becoming circular in section in distal half to two-thirds of length.

Remarks: This form, unlike any described species of *Emiluvia* , is most abundant in the lower part of Zone 4; it is much rarer in Zone 6.

Measurements (µm):	Holotype	avg. spec.	max.	min.
Length of test	138	142	162	125
Width of test	127	134	160	118
Length of longest spine	91	81	117	55

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 3 to 6; late mid Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80550 and (Paratype) GSC 80551 from type locality. Unfigured specimens occur at GSC locs. C-080581, C-080582, C-080584, C-080585, C-080597 and C-080586.

Emiluvia sp. I, n. sp.
plate 8 , figure 8, 9

Diagnosis: Test square and flattened. Meshwork very fine with small nodes. Spines short and slender, triradiate basally becoming circular distally.

Description: Test square and flattened with 4 radial spines at 90°. Inner layer of cortical shell has circular to irregularly polygonal pore frames. Outer layer composed of small triangular pore frames with low rounded nodes at vertices. Spines may be variable in length on a single specimen. The form of spines is variable throughout the species: in some they are triradiate throughout most of their length, but others retain this character only in basal portions.

Remarks: In overall shape and spine structure this form is similar to *Emiluvia* sp. E. It differs by having finer more delicate meshwork and shorter spines.

Measurements (µm):	Holotype	avg.10 spec.	max.	min.
Diameter of test	129	127	140	105
Length of longest spine	82	67	85	40

Type locality: GSC loc. C-080597. See Appendix 1.

Range: Zones 1 to 5; late Pliensbachian to late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80552 from type locality. Other specimens of this species occur at GSC locs. C-080577 and C-080582.

Emiluvia sp. J, n. sp.
plate 16 , figure 6

Diagnosis: Test large, square with well defined massive triangular and tetragonal pore frames and massive nodes. Spines sturdy and tapering with strong basal grooves.

Description: Test large, square and inflated with 4 spines at corners of test. Test surfaces planiform. Large pore frames on outer layer of cortical shell composed of strong bars with large to massive nodes at their vertices; 3-5 nodes per row. Inner layer of pore frames triangular. Spines are subequal in length, taper strongly and have prominent ridges and grooves proximally. System of secondary grooves (moderate to weak) imposed on ridges. Spines become circular in distal section.

Remarks: This form appears initially to be a more robust variant of *Emiluvia* sp. G. However the coarser meshwork, with massive nodes, and system of secondary grooves on spine ridges are diagnostic and indicate this form should probably be designated a new species.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Diameter of test	128	130	142	121
Length of longest spine	155	131	155	110

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Subzone 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80553 from type locality. Other specimens of this species occur at GSC loc. C-080594.

Emiluvia sp. K, n. sp.
plate 15, figure 8

Diagnosis: Test square to cruciform in outline. Surface covered with massive nodes that extend onto base of spines. Spines of medium length, circular in section.

Description: Test has square to cruciform outline with a single radial spine at each of four corners. Surface pore frames triangular to tetragonal. Nodes heavy to massive (occasionally merging), some extend onto base of spines. Spines moderate in length, slender and tapering; circular in section with 3 strong basal grooves.

Remarks: This species very similar to *Emiluvia* sp. D. It differs by having much larger nodes and shorter spines that are circular rather than triradiate.

Measurements (µm):	Holotype	avg. 4 spec.	max.	min.
Diameter of test	93	100	110	93
Length of longest spine	96	94	100	85

Type locality: GSC loc. C-080589. See Appendix 1.

Range: Zone 7; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80554 from type locality. Other specimens occur at GSC locs. C-080587 and C-080588.

Genus: *Tympaneides* n. gen.
Type species: *Tympaneides charlottensis* n. sp.

Description: Test is a flattened sphere (= drum-shaped) with four spines extending from sides, in one plane, arranged to form a cross. Top and bottom surfaces planiform, sides vertical to slightly concave. Latticed cortical shell composed of two layers of pore frames on planar surfaces and a single layer on the sides. Nodes on outer layer interconnected by fragile bars to form triangular or tetragonal pore frames.

Remarks: *Tympaneides* is assigned to the Staurolonchidae Haeckal because of its shape, mode of shell construction and spine structure. It differs from *Emiluvia* in having a test that is circular and drum-shaped rather than rectangular, and from *Staurolonche* in having a double rather than single layered cortical shell.

Etymology: *Tympanon* (Greek, n.) = drum

Range: late mid/early late Toarcian

Occurrence: Queen Charlotte Islands.

Tympaneides charlottensis n. sp.
plate 9, figures 4, 5

Diagnosis: Test circular, drum-shaped. Meshwork on planar surfaces very fine, pore frames triangular, nodes minute. Equatorial spines long, slender and triradiate.

Description: Test circular (drum-shaped) with 4 long spines extending from sides of test at 90° to one another. Outer layer of cortical shell covered with very small triangular pore frames composed of thin bars with fine nodes at their vertices. Spines long (1-3 times test diameter), slender and of uniform width. Spines with alternating ridges and grooves. Ridges rounded and approximately twice as wide as grooves, which are narrow and deep.

Remarks: This species is very abundant in middle/upper Toarcian samples.

Etymology: This species is named for Queen "Charlotte" of Spain after whom the Queen Charlotte Islands were named.

Measurements (µm):	Holotype	avg. 14 spec.	max.	min.
Diameter of test	129	118	150	80
Length of longest spine	162	170	238	123

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimens (Holotype) GSC 80555 and (Paratype) GSC 80556 from type locality. Other specimens (unfigured) found at GSC locs. C-080584, C-080585 and C-080597.

Superfamily: Sphaerallacea Haeckel, 1881, emend. Pessagno, 1977a
Subsuperfamily: Liosphaerilae Haeckel, 1881
Family: Pantanelliidae Pessagno, 1977b, emend. Pessagno, 1980
Subfamily: Pantanelliinae Pessagno, 1977b, emend. Pessagno, 1980

Genus: *Betraccium* Pessagno, 1979
Type species: *Betraccium smithi* Pessagno, 1979

Betraccium sp. A, n. sp.

Description: Test subspherical with 3 solid, radially arranged primary spines. Pore frames of cortical shell large, mostly pentagonal; strong nodes at pore frame vertices. Spines triradiate, subequal in length, with alternating ridges and grooves: ridges are narrow, grooves wide.

Remarks: Specimen has affinity with *B. yakounense* Pessagno and Blome, 1980. The cortical shells are almost identical, however, the spines in this species are much longer, and display no torsion.

Measurements: A single specimen is known. Largest diameter of cortical shell is 100 µm; spines are 51, 62 and 70 µm long respectively. Detailed treatment of measurements must await collection of more specimens.

Type locality: GSC loc. C-080577. See Appendix 1.

Range: zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Holotype GSC 80557 from type locality.

Genus: *Gorgansium* Pessagno and Blome, 1980
Type species: *Gorgansium silviesense* Pessagno and Blome, 1980

Gorgansium silviesense Pessagno and Blome

Gorgansium silviesense Pessagno and Blome, 1980, p. 235, pl. 11, fig. 2, 3, 11, 24.

Remarks: Test is slightly wider than normal for this species (CD measurement = 80 µm, described range = 65-75 µm; see Pessagno and Blome, 1980 pl. 8, fig. 16 for system of measurements). Otherwise all measurements fall with the range given for the species.

Range: Subzone 7A, early Bajocian. This occurrence extends the lower range for this species which previously was known only from the late early Bajocian to early Callovian in eastern Oregon (Pessagno and Blome, 1980).

Occurrence: Yakoun Formation, Graham Island. GSC 80558 is one of three specimens occurring at GSC loc. C-080590. Eastern Oregon, Snowshoe Formation: see Pessagno and Blome (1980).

Genus: *Pantanellium* Pessagno
? *Sphaerostylus* Haeckel, 1881 (= nomen dubium)

Type species: *Pantanellium riedeli* Pessagno 1977a

Pantanellium sp. cf. *P. haidaensis* Pessagno and Blome
plate 2, figure 1

cf. *Pantanellium haidaensis* Pessagno and Blome, 1980, p. 242, pl. 5, fig. 5,18,19,21

Remarks: Compared with *P. haidaensis* the cortical shell is wider (BB' ranges from 102-130 µm) and the spines are slightly longer. Nevertheless, other measurements fall within the given range for this species.

Range: Zone 1; late Pliensbachian. This occurrence extends the upper range for the species previously known to occur only from the late Sinemurian to the early Pliensbachian (Pessagno and Blome, 1980).

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80559 from GSC loc. C-080577. In addition *P. haidaensis* occurs in the upper black argillite member of the Kunga Formation, Kunga Island and in the middle and upper parts of the type Maude Formation, Maude Island (ibid).

Pantanellium sp. cf. *P. inornatum* Pessagno and Poisson

cf. *Pantanellium inornatum* Pessagno and Poisson, 1981, p. 56, pl. 6, fig. 1-9; DeWever, 1980c, p. 144, pl. 5, fig. 2

Remarks: This species differs only from *P. inornatum*, in having a slightly larger cortical shell than the holotype and sharp and narrow rather than rounded spine ridges.

Range: Zone 1; late Pliensbachian. Pessagno and Poisson (1981, p. 49) limit the range of *P. inornatum* to early Pliensbachian. In addition they state (and illustrate *Pantanellium* sp., p. 7, fig. 1 from QC 550, Kunga Formation, Q.C.I.) that unnamed forms from western North America in upper Sinemurian to lower Pliensbachian strata are closely related to *P. inornatum.* De Wever (1981c, p. 138) compares specimens from type material with radiolarian faunas from North America and concludes they are late Sinemurian to early Early Pliensbachian.

Occurrence: Maude Formation, Maude Island. Unfigured specimen GSC 80560 from GSC loc. C-080577. Turkey: Gümüslü Allochthon: see Pessagno and Poisson (1981).

Pantanellium sp. cf. *P. cumshewaense* Pessagno and Blome

cf. *Pantanellium cumshewaense* Pessagno and Blome, 1980, p. 240, pl. 6, fig. 12, 15, 17, 21, 22

Remarks: This form differs from *P. cumshewaense* in having stronger nodes at vertices of pore frames,and spine ridges that are continuous throughout total length of spines rather than terminating in the distal third.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Unfigured specimen GSC 80561 from GSC loc. C-080577. Found also at type section of the Maude Formation, Maude Island (Pessagno, QC 534), and from Snowshoe Formation, eastern Oregon (Pessagno and Blome, 1980).

Genus: *Trillus* Pessagno and Blome, 1980
Type species: *Trillus seidersi* Pessagno and Blome, 1980

Trillus elkhornensis Pessagno and Blome

Trillus elkhornensis Pessagno and Blome, 1980, p. 249, pl. 6, fig. 11,12,16, 20, 25; pl. 9, fig. 11

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian. This is consistent with the extended range for this species of late Pliensbachian to late Early Bajocian (Pessagno and Blome, 1980).

Occurrence: Maude and Yakoun Formations, Graham Island. Unfigured specimens occur as GSC locs. C-080585, C-080592 and C-080594. Eastern Oregon, Nicely and Snowshoe Formations: see Pessagno and Blome (1980).

Trillus sp. cf. *T. seidersi* Pessagno and Blome
plate 16, figure 1

cf. *Trillus seidersi* Pessagno and Blome, 1980, p. 249, pl. 9, fig. 2-4,9,19

Remarks: This form is almost identical to *T. seidersi* but both cortical shell and spines are slightly more elongate.

Range: Subzones 7B and 7C; early Bajocian. *T. seidersi* has been reported in the mid Early to late Early Bajocian. If indeed this is the species, the range will now include the whole of the early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80563 from GSC loc. C-080592. Unfigured specimens occur also at C-080594. Eastern Oregon, Snowshoe Formation: see Pessagno and Blome (1980).

Genus: *Zartus* Pessagno and Blome, 1980
Type species: *Zartus jonesi* Pessagno and Blome, 1980

Zartus jurassicus Pessagno and Blome

Zartus jurassicus Pessagno and Blome, 1980, p. 251, pl. 7, fig. 5-7,9,11-13,17,19, 20,24

Remarks: only a single specimen has been observed, but it appears identical in size and description to a paratype (fig. 7) illustrated by Pessagno and Blome (1980).

Range: Subzone 7B; early Bajocian

Occurrence: Yakoun Formation, Graham Island. Unfigured specimen GSC 80564 from GSC loc. C-080592. Eastern Oregon, Snowshoe Formation: see Pessagno and Blome (1980).

Zartus thayeri Pessagno and Blome
plate 16, figures 2, 10

Zartus thayeri Pessagno and Blome, 1980, p. 254, pl. 8, fig. 3-61, 13,13-21

Remarks: Secondary spines on raised median band are worn down, but otherwise my illustrated specimen appears identical to *Zartus thayeri.*

Range: Subzone 7B; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80565 from GSC loc. C-080592. Eastern Oregon, Snowshoe Formation: see Pessagno and Blome (1980).

Superfamily: Coccodiscacea Haeckal 1862, emend. Kozur and Mostler, 1972
Family: Heliodiscidae Haeckel, 1881, emend. Kozur and Mostler, 1972
Subfamily: Heliodiscinae Haeckel, 1882, emend. Kozur and Mostler, 1972

Genus: *Heliodiscus* Haeckel, 1882, emend. Kozur and Mostler, 1972
Type species: *Heliodiscus inchoatus* Rüst, 1885

Heliodiscus inchoatus Rüst
plate 12, figures 2, 5

Heliodiscus inchoatus Rüst, 1885, p. 293(23), pl. 29(4), fig. 13; (Subsequent designation by Cambell, 1944, p. D84).

Remarks: This form corresponds closely with Rüst's original drawing but differs in having fine spongy meshwork rather than medium-sized circular pores. Therefore some doubt exists as to whether my specimens should be retained as *Heliodiscus* or be reassigned elsewhere.

Range: Zones 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen GSC 80566 from GSC loc. C-080597. Other specimens collected at GSC loc. C-080583. Rüst's illustrated type was from the Aptychus beds of Urschlau.

Superfamily: Spongodiscacea Haeckal, 1882, emend. Kozur and Mostler, 1978
Family: Patulibracchiidae Pessagno, 1971, emend. Baumgartner, 1980

Remarks: The Patulibracchiidae includes Spongodiscacea with 2 to 5 rays composed of uniform spongy meshwork (see Baumgartner, 1980, p. 297, for detailed description). Riedel (1967) and Pessagno (1971) originally included these forms within the Hagiastriidae furthermore Kozur and Mostler (1978, p. 2) state that differences between spongy and latticed tests do not warrant suprageneric rank. Contrary to this opinion the Hagiastriidae as emended by Baumgartner (1980) now includes only those forms having concentric shells and longitudinal canals and their skeletal structure is homologized with structures of the Actinommacea Haeckel, emend. Riedel. Baumgartner states (1980, p. 297) "the Patulibracchiidae differ from the Hagiastriidae by the lack of differentiated concentric shells and longitudinal canals".

Subfamily: Patulibracchiinae Pessagno, 1971, emend. Baumgartner, 1980

Genus: *Amphibrachium* Hertwig, 1879, emend. Baumgartner, 1980
Type species: *Amphibrachium diminutum* Rüst, 1885

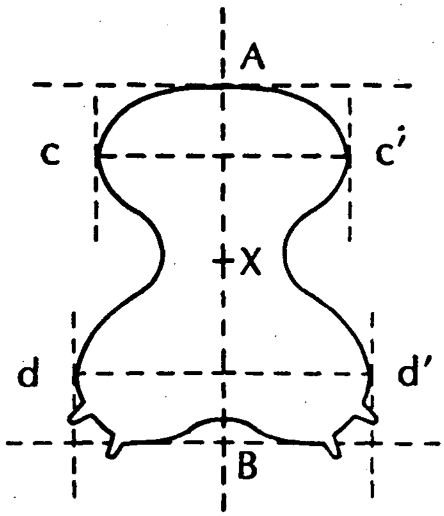
Amphibrachium (?) sp. A, n. sp
plate 12, figure 1

Diagnosis: Two-rayed form with very fine spongy meshwork. One or both rays variably bilobed.

Description: Two-rayed patulibracchiid with very fine layered spongy meshwork. Tips of rays widely expanded and rounded; may form either one large lobe or bifurcate to form two smaller lobes. On some bilobed specimens lobes become elongate, giving the test an almost 3-rayed appearance. Rays equal in length, very short and wide, no defined central area. Spines on ray tips vary from a single central spine to numerous fine ones.

Remarks: Genus is tentatively placed with *Amphibrachium* and queried because of the bilobed nature of ray tips. It is conceivable however, that it is and extreme variant of *Paronaella* sp. H (p. --). It is postulated that in the early late Toarcian a variant form of *Paronaella* had appeared (see pl.11, fig. 7); by the Late Toarcian the figured two-rayed bilobed form (*A.* sp. A.) had evolved through enlargement of the primary ray and reduction of the secondary and tertiary rays to form a single bilobed ray.

Figure 15: Diagram of measurements for *Amphibrachium* (?).



X = point at center of central area.
A = point at end of shortest ray.
B = point at end of longest ray.
AX = length of shortest ray.
BX = length of longest ray.
cc' = width of shortest ray.
dd' = width of longest ray (excluding spines).

Measurements (µm):		Holotype	avg.10 spec.	max.	min.
Length of rays	AX	130	137	170	125
	BX	135	140	170	125
Width of rays	cc'	166	185	280	140
	dd'	209	232	280	180

Type locality: G.S.C. loc. C-080597. See Appendix 1.

Range: Zones 3 to 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) gsc 80567 from type locality. Unfigured specimens occur at GSC loc. C-080581, C-080582, C-080583, C-080584 and C-080585.

Genus: *Paronaella* Pessagno, 1971, emend. Baumgartner, 1980
Type species: *Paronaella solanoensis* Pessagno, 1971

Paronaella bandyi (?) Pessagno
plate 11, figure 8

? *Paronaella bandyi* Pessagno, 1977a, p. 69, pl. 1, fig. 1-3; Baumgartner, 1980, p. 300, pl. 9, fig. 4.

Remarks: Identification is based on the morphology of the spines, which are identical to those of *P. bandyi.* However, assignment is queried because adhering clays totally obscure the meshwork. Specimens very rare.

Range: Zone 4; late mid/early late Toarcian. *P. bandyi* has previously been recognized as ranging from " (?) Callovian to Tithonian" (Baumgartner, 1980). If this form is the same species, then the range must be lowered to include the mid/late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen GSC 80568 from GSC loc. C-080585. Unfigured specimen from GSC loc. C-080582. California: see Pessagno (1977a), Greece: see Baumgartner (1980) and central Japan: In 7, Yao collection (1972).

? *Paronaella denudata* (Rüst)
plate 17, figure 1

Hymeniastrum denudatum Rüst, 1898, p. 27, pl. 9, fig. 2
Paronaella denudata (Rüst) Pessagno, 1977a, p. 70, pl. 1, fig. 9

Remarks: My specimens (14 in number) although poorly preserved, appear to be almost identical to those figured by Rüst and Pessagno. It is possible that the outer coarse meshwork is worn away in the central area of my specimens exposing an inner layer of smaller pore frames.

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian. Further collecting and study will no doubt show whether this occurrence does indeed extend the lower range for the species. It was previously restricted to the upper Kimmeridgian/lower Tithonian to upper Tithonian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80569, from GSC loc. C-080588. Unfigured specimens occur at GSC locs. C-080584, C-080587, C-080593, C-080594 and C-080595. California: see Pessagno (1977a).

Paronaella mulleri Pessagno

Paronaella mulleri Pessagno, 1977a, p. 71, pl. 2, fig, 2,3; Baumgartner, 1980, p. 304, pl. 9, fig. 8

Remarks: My specimens differ from *P. mulleri* in having slightly longer rays and a less elevated central area.

Range: Subzone 7C; early Bajocian. This occurrence extends the lower range for *P. mulleri* which was previously known to range only from the Oxfordian/ Kimmeridgian to Tithonian.

Occurrence: Yakoun Formation, Graham Island. Unfigured specimens including GSC 80570 occur at GSC loc. C-080595.

Paronaella sp. cf. *P. mulleri* Pessagno
plate 4, figure 8

cf. *Paronaella mulleri* Pessagno, 1977a, p. 71, pl. 2, fig. 2,3,9
Paronaella sp. cf. *P. mulleri* Pessagno in Baumgartner, 1980, p. 304, pl. 9, fig. 5, pl. 12, fig. 4-7

Remarks: This form appears almost identical to *Paronaella* sp. cf. *P. mulleri* Pessagno, described by Baumgartner (1980) from the late Jurassic of Greece.

Range: Zone 2; mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80571, from GSC loc. C-080579. All specimens confined to this locality.

Paronaella (?) sp. cf. *P. spinosa* (Parona)

Rhopalastrum (?) *spinosum* Parona, 1890, p. 159, pl. 3
Paronaella (?) *spinosa* (Parona) De Wever, 1981b, p. 34, pl. 2, fig. 10-12; pl. 3, fig. 1-4

Remarks: This species is very closely related to *Paronaella ? spinosa* (Parona) figured by De Wever (1981b), who queried the genus because "internal pores are aligned". My specimens are not well enough preserved to permit this observation. Secondary spines, diagnostic of *Paronaella ?spinosa* are lacking on my specimens, therefore only a "comparison" can be made. It is possible the delicate secondary spines have been lost during preservation.

Range: Zone 4 to Subzone 7B; late mid/early late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Unfigured specimens including GSC 80572 occur at GSC loc. C-080585 and C-080587.

Paronaella sp. A, n. sp.
plate 17, figure 2

Diagnosis: Test small with an unusually distinct central area and three lobe-shaped rays; one ray may be larger than the other two. Spines triradiate; normally spines are centrally placed but sometimes 2 or 3 smaller spines occur on the larger ray. Surface covered with small circular pores.

Description: Test small, composed of three lobate rays surrounding a definite, slightly raised central area; rays subequal in length becoming slightly flattened distally. Larger ray normally shorter and blunt-ended rather than round. Pore frames irregularly shaped, composed of thin bars with fine nodes at vertices. Pore frames in central area have additional silica deposited as burrs or thorns on their interior perimeter. Spines triradiate; normally there is one central spine per ray, however occasionally 2-3 smaller spines occur on the larger ray.

Remarks: This form is similar in size and shape to *Paronaella* sp. cf. *P. mulleri*, described on p. 132, (pl. 4, fig. 8), but differs in having more expanded ray tips, much finer meshwork and by sometines having 2 or more spines on the enlarged ray. It differs from *P. mulleri* by having wider rays with more expanded tips and smaller more irregular pore frames. *P. mulleri* always has rays of near equal size with central spines only.

Measurements (µm):	Holotype	avg. 8 spec.	max.	min.
Length of longest ray	140	121	140	100
Width of widest ray	92	83	110	68
Length of central spines	37	41	55	28

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimen (Holotype) GSC 80573 from type locality. Unfigured specimens occur at GSC locs.C-080582, C-080583, C-080584, C-080585, C-080590 C-080588 and C-080594.

Paronaella sp. B, n. sp
plate 4, figure 10; plate 11, figures 4, 5

Diagnosis: Three-rayed patulibracchiid having long, slender rays with clavate to wedge-shaped tips. Meshwork fine and irregular. Ray tips have numerous short fine spines.

Description: Test large with three long slender rays expanding at tips. Rays subequal in length at approximately 120°. Tips rounded to wedge-shaped. External pore frames small, sublinearly arranged; tetragonal to pentagonal with weak nodes at vertices. Numerous short fine spines extend from ray tips of well preserved specimens. Internal meshwork layered and spongy.

Remarks: This form strongly resembles *Rhopalastrum trixiphus* Rüst, 1898, but differs in having several short spines rather than a single central one on each ray tip. It has been assigned to *Paronaella* because of its layered spongy meshwork.

Measurements (µm):		Holotype	avg.11 spec.	max.	min.
Length of rays	AX	217	202	269	170
	BX	269			
	CX	251			
Avg. width of rays		112	107	130	78

Type locality: GSC loc. C-080584. See Appendix 1.

Range: Zones 1 to 6; late Pliensbachian to Aalenian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80575, from type locality. Paratypes GSC 80574 and GSC 80576, from G.S.C. loc. C-080597. Unfigured specimens found at GSC locs. C-080577, C-080579, C-080581, C-080582, C-080583 and C-080586.

Paronaella sp. C, n. sp.
plate 11, figure 6

Diagnosis: Robust form. Rays short and thick with large rounded tips having numerous short, fine terminal spines. Pore frames medium-sized with heavy nodes.

Description: Robust three-rayed test. Rays short (subequal in length) and massive, at approximately 120°. Rays widely expanded to form round tips. Pore frames on central area and arms of medium size, becoming much smaller on ray tips; mostly triangular is shape. Nodes prominent. Very short, slender spines are noted occasionally on ray tips of well preserved specimens.

Remarks: This form has some affinity with *P. gemmata* DeWever (1981b, p. 33, pl. 4, fig. 3-7), but ray tips are more enlarged and terminated by numerous fine spines rather than a single central spine. The presence of a bracchiopyle on one arm cannot be confirmed nor can the small secondary spines which characterize *P. gemmata*. It is possible their lack only represents imperfect preservation.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Length of longest ray	262	219	262	190
Width of ray tips	190	188	223	162

Type locality: GSC loc. C-080584. See Appendix 1.

Range Zones 3 to 6; late mid Toarcian to Aalenian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80577 from type locality. Unfigured specimens occur at GSC locs. C-080581, C-080582, C-080583, C-080585, C-080597 and C-080586.

Paronaella sp. D, n. sp.
plate 11, figures 1, 2, 3

Diagnosis: Three rayed patulibracchiid of variable morphology. Rays generally slender with greatly expanded elliptical, wedge or club-shaped tips. Mesh size irregular, coarse to medium, finer on ray tips. Rays terminate with numerous small spines.

Description: Three-rayed form variable in many respects. Rays moderately slender, expanding to large elliptical, club or wedge-shaped tips. The largest interradial angle varies from 120° to almost 150°, with a full continuum of angle sizes inbetween*. Pore frames irregularly arranged on most specimens, sublinear on others; always smaller on ray tips. Pore frames triangular and tetragonal, nodes highly developed. Rays cylindrical to subrectangular in cross-section.

* n=81	Mean	Standard Deviation
Maximum angle	128.41	5.88
Minium angle	111.99	5.93

Remarks: A variable form extremely abundant in all upper Toarcian samples. Resembles *P.* sp. cf. *P. kotura* figured by Baumgartner (1980, p. 304, pl. 9, fig. 14) but lacks fine meshwork in central area and has numerous fine spines on ray tips. It differs from *P. kotura* by having highly variable interradial angles, shorter wider rays with more expanded tips, and by lacking small pores in the central area.

Measurements (µm):		Holotype	avg. 10 spec.	max.	min.
Length of rays	AX	196	197	230	150
	BX	188			
	CX	182			
Width of rays		50	81	70	50
Width of ray tips		149	146	205	80

Type locality: GSC loc. C-080584. See Appendix 1.

Range: Zones 1 to 6; late Pliensbachian to Aalenian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimens (Holotype) GSC 80578 and (Paratypes) GSC 80579 and GSC 80580 from type locality and G.S.C. loc. C-080583, respectively. Unfigured specimens found at

GSC locs. C-080577, C-080581, C-080582, C-080585, C-080597 and C-080586.

Paronaella sp. E, n. sp.
plate 11, figures 10, 11, 12

Diagnosis: Moderate in size with short rays, expanded tips and slender, almost cylindrical central spines. Rays subrectangular in cross-section

Description: Three-rayed patulibracchiid of moderate size with slender central spines. Rays short, approximately equal in length. Tips enlarged and rounded; expansion may occur gradually throughout ray length or more abruptly in distal portion only. Pore frames irregular to sublinearly aligned, uniform in size, mostly tetragonal. Central spines on ray tips are slender, variable in length, circular in section. Rays subrectangular in cross-section.

Remarks: This form bears no resemblance to any known species of *Paronaella* and is considered to be new.

Measurements (µm):	Holotype	avg.7 spec.	max.	min.
Length of longest ray	171	167	200	125
Width of rays	47	60	70	47
Width of ray tips	118	122	140	102
Length of longest spine	65	58	130	35

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 3 to 6; late mid Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80582 and (Paratype) GSC 80581 from type locality. Unfigured specimens collected at GSC loc. C-080581, C-080582, C-080584, C-080585, C-080597 and C-080586.

Paronaella sp. F, n. sp.
plate 12, figure 3

Diagnosis: Robust form with three short, wide rays having expanded tips and sturdy triradiate cerntral spines. Meshwork coarse with heavy nodes.

Description: Robust three-rayed patulibracchiid with short wide rays of equal length with expanded tips, round in outline. Triradiate central spines rather flattened in horizontal plane. Spines with 3 to 6 grooves proximally, become circular in section distally. Meshwork coarse and irregular; composed of heavy bars and well-developed nodes. Pore frames triangular to tetragonal. Some forms show evidence of a poorly preserved patagium.

Remarks: Ray width quite variable. Specimens with the shortest and widest rays have affinities with *P. corpulenta* De Wever (1981b, p. 33, pl. 2, fig. 7-9) and an even more inflated form illustrated by De Wever as *Paronaella* sp. cf. *P. corpulenta* (pl. 3, fig. 7). This species differs by having larger, less numerous pore frames, no observable secondary spines, and by lack of a well-defined patagium. This species differs from *Paronaella* sp. D (this report) by having shorter wider arms, coarser meshwork and triradiate spines.

Measurements (μm):	Holotype	avg. 7 spec.	max.	min.
Length of rays	133	147	170	130
Width of ray tips	116	126	150	103
Length of longest spine	56	67	90	42

Type locality: GSCloc. C-080597. See Appendix 1.

Range: Zones 3 to 6; late mid/early late Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80583 from type locality. Unfigured specimens occur abundantly at GSC locs. C-080581, C-080582, C-080583, C-080584, C-080585 and C-080586.

Paronaella sp. G, n. sp.
plate 4, figures 6, 9

Diagnosis: Test has short expanded rays, triradiate central spines and very fine spongy meshwork.

Description: Test composed of three (or, very rarely even four or five) rays. Rays short, of equal to subequal length, subrectangular in cross-section, gradually expanding and flattening slightly near the tips. Triradiate central spines moderate in length, sturdy. Pore frames on rays small, irregularly arranged; in the central area they are even smaller.

Remarks: This form has extremely fine meshwork and differs from all previously described species of *Paronaella*. An atypical 4-rayed specimen GSC 80585 is figured from GSC loc. C-080597 (pl.4 ,fig. 9 that better illustrates the size difference of pore frames on the central area.

Measurements (µm):	Holotype	avg. 9 spec.	max.	min.
Length of rays	123	130	145	100
Width of ray tips	83	102	120	83
Length of longest spine	51	43	52	33

Type locality: GSC loc. C-080584. See Appendix 1.

Range: Zones 2 to 4; mid to late mid/early late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80584 from type locality. Unfigured specimens found at GSC locs. C-080579, C-080582, C-080583 and C-080585.

Paronaella sp. H, n. sp.
plate 11, figure 7

Diagnosis: Test small with three short rays of uniform width. Central spines small and basally grooved. Surface covered with small circular pores.

Description: Test small. Three rays are short, equal in length, uniform in width, with rounded tips and slender central spines. Spines have 3-6 basal grooves. Meshwork spongy, pores circular and uniform in size. Central area slightly raised. Rays elliptical in cross-section.

Remarks: This form is similar in size and shape to *Paronaella pygmaea* Baumgartner (1980, p. 306, pl. 9, fig. 2,9), but rays are wider in proportion to length and meshwork is finer and less regularly arranged.

Measurements (µm):	Holotype	avg. 6 spec.	max.	min.
Length of rays	109	112	120	109
Width of rays	90	84	70	95
Length of central spines	48	33	48	20

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 1 to 5; late Pliensbachian to late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80586 from type locality. Unfigured specimens from GSC locs. C-080577 and C-080597.

Paronaella sp. I, n. sp.
plate 11, figure 9

Diagnosis: Small test having a large slightly depressed central area and three short rounded rays with triradiate central spines.

Description: Small three-rayed patulibracchid. Rays short (equal in length), wide and flattened with rounded tips and triradiate central spines. Central area large and slightly depressed. Meshwork composed of small, uniformly-sized, polygonal pore frames. Spines long and moderately slender.

Remarks: This species is generally similar to *Paronaella denudata* (Rüst), but has shorter, more rounded arms, a slightly depressed rather than raised central area, less massive spines and less regularly arranged pore fromes.

Measurements (µm):	Holotype	avg. 9 spec.	max.	min.
Length of rays	134	122	138	101
Width of rays	92	85	95	70
Length of longest spine	37	51	67	37

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80587, from type locality. Unfigured specimens abundant also at GSC locs. C-080584, C-080585 and C-080597.

Paronaella sp. J, n. sp.
plate 12, figure 6

Diagnosis: Test has three slender rays with slightly expanded tips and long, slender central spines. Surface covered with fine polygonal pore frames.

Description: Three rays near equal in length; slender, expanding and become wedge-shaped distally. Rays terminate in uniformly slender central spines that are circular in cross-section. Meshwork fine; pore frames composed of thin bars with weak rounded nodes at vertices. Pore frames irregularly polygonal on central area and proximal portions of rays; sublinearly arranged and mostly tetragonal on ray tips. Rays rounded in cross-section.

Remarks: This form appears similar to *Paronaella* sp. B illustrated in Pessagno, Finch and Abbott, 1979, p. 165, pl. 3, fig. 13, from the Upper Triassic (Karnian ?, Norian) of Baja California.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Length of rays	173	154	200	110
Width of rays	60	58	70	45
Width of ray tips	116	95	116	70
Length of longest spine	76	68	110	50

Type Locality: GSC loc. C-080585. See Appendix 1.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated Specimen (Holotype) GSC 80588 from type locality. Unfigured specimens occur at GSC locs. C-080582, C-080583 and C-080584.

Paronaella sp. K, n. sp.
plate 17, figure 3

Diagnosis: Spongy three-rayed test with extremely massive tribladed spines.

Description: Three rays equal in length, short and thickened with massive tribladed central spines. Test surface covered with circular pores, irregularly arranged. Primary (largest) spine wider than other two. All spines have three longitudinal ridges of varying width alternating with three wide grooves. Secondary grooves developed on ridges; grooves wide and deep on primary spine but shallow to near absent on other spines.

Remarks: Massive spines on this species are diagnostic and differentiate it from all other described species of *Paronaella*.

Measurements : A single specimen has been found: rays are 105 µm long and single complete primary spine is 135 µm long.

Type locality: GSC loc. C-080594. See Appendix 1.

Range: Subzone 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80589 from type locality.

Genus: *Crucella* Pessagno, 1971, emend. Baumgartner, 1980
Type species: *Crucella messinae* Pessagno, 1971

Crucella sp. A, n. sp
plate 12, figures 11, 12

Diagnosis: Four-rayed patulibracchiid with a large, inflated central area, short tapering rays and strong central spines.

Description: Test has four short, tapering rays of nearly equal length, each terminated by a strong central spine. Central area large and inflated. Meshwork coarse. Pore frames irregularly polygonal with weak nodes at vertices of bars. Pore frames arranged randomly on central area becoming sublinear on rays. Cross-section of rays elliptical to subrectangular. Spines circular in section with basal grooves.

Remarks: This species has some affinity with *Crucella squama* (Kozlova) figured by De Wever (1981b, p. 38, pl. 5, fig. 7) from Pliensbachian limestones in Turkey, but differs in having much weaker spines.

Measurements (µm):	Holotype	avg. 11 spec.	max.	min.
Length of rays	109	103	140	88
Width of rays at base	74	70	90	58
Length of longest spine	49	56	70	45

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 1 to 5; late Pliensbachian to late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80590 from type locality. Unfigured specimens from GSC locs. C-080577, C-080582, C-080584, C-080585 and C-080597.

Crucella sp. B, n. sp.
plate 4, figures 11, 12

Diagnosis: Test cruciform. Rays medium to long and of uniform width, with long sturdy central spines.

Description: Test cruciform with medium to long rays terminated by long central spines. Rays uniform in width, of more or less equal length. Pore frames irregular in size, shape and arrangement; composed of thin bars with small rounded nodes at vertices. Rays rectangular in cross-section. Central spines have (three?) wide, rounded longitudinal ridges alternating with equally wide, strong grooves.

Remarks: This form although extremely variable in ray length, bears no resemblance to any described species of *Crucella*. Indeed, the longer-rayed forms (eg. Pl. 4, fig. 12), having finer bars and smaller nodes, may be found to represent another species when additional, better preserved specimens are found.

Measurements (μm):	Holotype	avg. 10 spec.	max.	min.
Length of rays	111	124	191	111
Width of rays	39	51	66	39
Length of longest spine	95	71	119	45

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zones 1 to 4; late Pliensbachian to late mid/early late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimens (Holotype) GSC 80591 and (Paratype) GSC 80592 from type locality. Unfigured species from GSC locs. C-080579, C-080582, C-080583, C-080584 and C-080585.

Crucella sp. C, n. sp.
plate 15, figures 9, 12

Diagnosis: Four-rayed test with medium to large octagonal central area. Square to rectangular-shaped rays and long circular spines. Surface covered with well-developed, rounded nodes.

Description: Test has four rays terminating in long sturdy central spines. Central area octagonal. Pore frames irregularly arranged on central area becoming sublinear on rays. Pore frames mostly tetragonal but some are triangular on central area. Strong rounded nodes at vertices of pore frames. Spines long, circular in section with elongate basal grooves.

Remarks: This form has minor affinity with *Crucella plana* Pessagno (1971) but differs in having an octagonally-shaped central area, larger pore frames and heavier nodes.

Measurements : Measurements are considered preliminary as only two specimens have been recovered from separate localities.

	Holotype	Paratype
Length of rays	150	145
Width of rays	65	62
Diameter of central area	150	105
Length of longest spine	130	52

Type locality: GSC loc. C-080593. See Appendix 1.

Range: Subzone 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80593 from type locality. Paratypes from GSC locs. C-080594.

Family: Pseudoaulophacidae Riedel, 1967, emend. Pessagno, 1972

Remarks: In all reports up to the present, the Pseudoaulophacidae Riedel have been restricted in range to the Cretaceous. The only member of the family to be discussed herein is *Alievium* ?. Reasons for inclusion are given in "Remarks" under genus *Alievium*.

Genus: *Alievium* Pessagno 1973a, emend. Foreman, 1973
Type species: *Theodiscus superbus* Squinabol, 1914

Definition: The genus *Alievium* as emended by Foreman includes triangular and circular forms, lacking tholi, with three primary spines occurring at corners of test or radially arranged. Meshwork is coarse, massive and uniform in size; pore frames triangular.

Remarks: In the three following described species, the genus is queried because the pore frames vary in some manner from the coarse triangular meshwork characteristic of *Alievium* and all other genera belonging to the Pseudoaulophacidae. In other respects they conform to the criteria for genera of this family listed in Table 1, Pessagno 1973a, p. 297. If further collecting and study eventually proves these forms to be *Alievium*, then the range for the genus, as well as the famly, must be lowered considerably. It is far more likely that my specimens are a form ancestral to the Psuedoaulophacids, and if so should be assigned to a new genus.

Alievium (?) sp. A, n. sp.
plate 4, figure 7

Diagnosis: Test small and triangular with three massive tribladed spines. Pore frames large and uniform in size.

Description: Cortical shell very small and triangular with three massive equatorial spines. Top and bottom surfaces of test slightly convex. Pore frames triangular, tetragonal and pentagonal with moderately well-developed nodes at vertices. Spines long; length approximately 1.5 x diameter of test, when entire. Spines composed of alternating longtudinal ridges and grooves; ridges wider than grooves and somewhat flattened, grooves narrow and deep.

Remarks: Species queried because of variably shaped pore frames: see "Remarks" under genus *Alievium* (p. 144).

Measurements (µm): Detailed measurements are not given here since only these two specimens are known.

	Holotype	Paratype
Diameter of cortical shell	65	61
Length of longest spine	117	74 (not entire)

Type locality: GSC loc. C-080584. See Appendix 1.

Range: Zones 2 to 4; mid to late mid/early late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80594, from type locality. Paratype from GSC loc. C-080579.

Alievium (?) sp. B. n. sp.
plate 8, figure

Diagnosis: Test subcircular with fine surface meshwork and three slender tribalded spines.

Description: Cortical shell subcircular with three triradiate spines at 120° to each other. Surfaces of cortical shell convex. Meshwork delicate, composed of thin bars and small but distinct nodes. Pore frames uniform in size, triangular to tetragonal. Spines slender with ridges and grooves approximately equal in width. Some spines become circular in distal portions.

Remarks: Genus queried because pore frames are variably shaped and fine, rather than coarse. See "Remarks" under genus *Alievium* (p. 144).

Measurements (µm):	Holotype	avg. 11 spec.	max.	min.
Diameter of test	180	155	190	135
Length of longest spine	134	128	160	110

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80595 from type locality. Unfigured specimens from GSC locs. C-080582, C-080585 and C-080597.

Subsuperfamily: Pseudoaulophacilae Riedel, 1967, emend. Pessagno, 1971a
Family: Orbiculiformidae Pessagno, 1973

Genus: *Orbiculiforma* Pessagno, 1973
Type species: *Orbiculiforma quadrata* Pessagno, 1973

Orbiculiforma sp. A, n. sp.
plate 1, figures 7, 10

Diagnosis: Test discoidal with large central depression and three short radial spines. Meshwork spongy and coarse, pore frames larger in central area..

Description: Test a circular disc with large central cavity and 3 radial spines. Surface of test planiform, sides vertical. Central cavity large, approximately half test diameter, and deeply depressed. Pore frames polygonal and concentrically arranged; they are very small and delicate in the middle of the central area but the immediately surrounding ones are somewhat larger; composed of thin fragile bars. Pore frames on rim-like upper surfaces are small, bars are coarser and small nodes occur at vertices of bars. Spines short and circular in section.

Remarks: This form, with three prominent radial spines, bears no resemblance to any previously described species of *Orbiculiforma*.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Maximum diameter of test	206	218	230	200
Maximum diameter of central cavity	134	130	155	110
Length of spines	46	43	46	40

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimens (Holotype) GSC 80596 and (Paratype) GSC 80597 from type locality.

Orbiculiforma sp. B, n. sp.
plate 1, figures 8, 11

Diagnosis: Test disc-shaped, with rounded periphery and an undetermined number of short fine equatorial spines. Central cavity wide and deep, containing large irregular pore frames.

Description: Test disc-shaped, thick, round in outline with numerous short equatorial spines. Central cavity wide and deep. Spongy meshwork is fine and dense in the central cavity where pores are much larger and composed of fragile bars. Pore frames predominantly tetragonal and pentagonal, a few are triangular. Equatorial spines solid, slender, uniform in width.

Remarks: This species has some affinity with *Orbiculiforma monticelloensis* Pessagno (1973a) but test is thicker and central cavity is deeper with larger (rather than smaller) pores than on the surrounding rim. A related, undescribed form from the same stratigraphic interval (pl.1, fig. -) has features similar to sp. B, but has a larger central cavity with smaller pore frames.

Measurements (μm):	Holotype	avg. 7 spec.	max.	min.
Maximum diameter of test	260	235	270	190
Maximum diameter of central area	132	108	132	80
Maximum length of spines	-	11	12	10

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80599 and all other specimens confined to type locality.

Orbiculiforma sp. C, n. sp.
plate 1, figure 9

Diagnosis: Test thick, rounded-square in outline with 4 short primary spines, one at each corner. Central cavity wide, sides slope steeply.

Description: Disc-shaped test is thick, rounded-square in outline with 4 equatorial spines, one at each corner. Upper and lower surfaces planiform, sides vertical to concave. Central cavity wide, depth varying from fairly shallow to moderately deep; sides steeply sloping. Pore frames large, polygonal, uniform in size. The short, tapering spines have deep basal grooves proximally and develop circular cross section in distal portions.

Remarks: This form has minor affinity with *Orbiculiforma quadrata* Pessagno, (because of its rectangular outline and four triradiate spines) but differs significantly in having a much thicker test, massive pore frames and longer, stronger spines. A related undescribed form from the same stratigraphic interval is similar in shape, but more flattened, with rounded sides, a shallower central cavity and weaker spines.

Measurements (µm):	Holotype	avg. 9 spec.	max.	min.
Maximum diameter of test	182	170	210	80
Maximum diameter of central cavity	100	81	110	50
Length of longest spine	74	73	107	50

Type Locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80600 from type locality. A few specimens collected at GSC loc. C-080580.

Orbiculiforma sp. D, n. sp

Description: Test disc-shaped subtriangular in outline and quite flattened, with 3 short triradiate equatorial spines. Periphery rounded. Central area large, shallow and subtriangular in outline also. Concentrically arranged pore frames are large and fragile in central cavity, becoming smaller and quite dense around the rim; pentagonal and hexagonal in central cavity, tetragonal and pentagonal elsewhere.

Remarks: This triangular-shaped form bears to resemblance to any previously described species of *Orbiculiforma*.

Measurements (μm): Measurements will be treated in detail when additional specimens have been collected.

	Holotype	Paratype
Maximum diameter of test	205	188
Maximum diameter of central cavity	90	80
Length of longest spine	-	41

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Unfigured Holotype GSC 80601 and paratype from type locality.

Orbiculiforma sp. aff. *O. persenex* Pessagno

aff. *Orbiculiforma persenex* Pessagno, 1976, p. 35, pl. 6, fig. 12,13

Remarks: This form differs from *O. persenex* by having a smaller test (210 μm, as compared to an average diameter of 251 μm (on 8 specimens), measured by Pessagno) and by having a much smaller central cavity. It is likely this form will ultimately prove to be a new species.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Graham Island. A single specimen GSC 80602 occurs at GSC loc. C-080583.

Genus: *Spongostaurus* Haeckel, 1882
Type species: *Spongostaurus cruciatus* Haeckel, 1887

Remarks: This genus, formerly placed in the Spongodiscidae Haeckel, is herein assigned to the Orbiculiformidae Pessagno, because of its concentrically arranged spongy meshwork. All the following species of *Spongostaurus* are considered new, as they resemble no other described species.

Spongostauras sp. A, n. sp.
plate 10, figure 11

Diagnosis: Test rectangular, slightly indented along edges with short triradiate equatorial spines, shallow lacuna. Meshwork spongy, concentrically arranged.

Description: Test rectangular overall, edges slightly indented or concave, with 4 short equatorial spines, one at each corner. Meshwork spongy, pore frames irregularly polygonal. Poorly defined shallow lacuna with central raised area appears on upper and lower surfaces of test. All 4 spines equal in length, strongly triradiate; ridges and grooves irregular in width.

Remarks: For meaningful comparison see 'Remarks' under *Spongostaurus* sp. B.

Measurements (μm):	Holotype	avg.13 spec.	max.	min.
Maximum diameter of test	187	164	200	140
Length of longest spine	71	83	100	70

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimen (Holotype) GSC 80603 from type locality. Unfigured specimens from GSC locs. C-080584, C-080585, C-080597, C-080593 and C-080595.

Spongostaurus sp. B, n. sp.
plate 17, figures 4, 5

Diagnosis: Test square and flattened with 4 massive, bladelike, obliquely tapering primary spines. Meshwork spongy; pores small and circular.

Description: Test square and flattened with 4 equatorial spines, one at each corner. Meshwork very fine and spongy. Pore frames irregularly polygonal, pores circular and concentrically arranged. Spines massive, subequal in length, triradiate and distinctive; composed of irregular ridges and grooves. Ridges wide and rounded; grooves very shallow. Bladelike spines taper obliquely to sharp points.

Remarks: *Spongostaurus* sp. B is distinguished from *S.* sp. A, n. sp., by having a more flattened test, finer meshwork and more massive spines that taper obliquely to sharp points.

Measurements (µm):	Holotype	avg. 11 spec.	max.	min.
Maximum diameter of test	161	141	170	120
Length of longest spine	112	102	115	80

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Zones 5 to 7; late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimens (Holotype) GSC 80604 and (Paratype) GSC 80605 from type locality. Unfigured specimens from GSC locs. C-080597, C-080588, C-080593 and C-080596.

Spongostaurus sp. C, n. sp.
plate 10, figure 12

Diagnosis: test small, rounded to subrectangular with 4 strong triradiate spines. Meshwork fine and spongy.

Description: Test small, rounded to subrectangular in outline with 4 primary spines in equatorial plane. Test surfaces slightly convex. Meshwork fine, concentrically arranged; pore frames irregularly polygonal. Spines equal in length and strongly triradiate; composed of longitudinal ridges and grooves, both of approximately equal width.

Remarks: Differs from *S.* sp. A, n. sp and *S.* sp. B, n. sp. in having a smaller test with convex surfaces. Spines are also more distinctly triradiate than in either A or B.

Measurements (µm):	Holotype	avg. 5 spec.	max.	min.
Maximum diameter of test	97	98	115	83
Length of longest spine	76	59	76	40

Type locality: GSC loc. C-080597. See Appendix 1.

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimen (Holotype) GSC 80606 from type locality. Additional unfigured specimens at GSC locs. C-080585, C-080589 and C-080588.

Genus: *Spongotrochus* Haeckel, 1860
Stylospongidium Haeckel, 1882
Type species: *Spongotrochus brevispinus* Haeckel, 1862

Remarks: Genus in herein placed in the Orbiculiformidae Pessagno: see Remarks under genus *Spongostaurus*.

Spongotrochus (*Stylospongidium*) sp. aff. *S.* (*S.*) *echinodiscus*
Clark and Campbell
plate 10, figures 7, 10

aff. *Spongotrochus* (*Stylospongidium*) *echinodiscus* Clark and Campbell, 1942, p. 48, pl. 2, fig. 3

Remarks: This form appears closely related to *S.* (*S.*) *echinodiscus*. It differs by having a shallow depression in the upper and lower surfaces of the test and a fairly distinct small spongy medullary shell in the center of the test between the outer surfaces. *S.* (*S.*) *echinodiscus* is restricted to the Upper Eocene of California so far as is known. It is generally rare for radiolarian species to survive the Mesozoic/Cenozoic boundry, therefore it is unlikely that my specimens are conspecific with *S.* (*S.*) *echinodiscus*.

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimens GSC 80607 and GSC 80608 from GSC loc. C-080597. Unfigured specimens from GSC locs. C-080583, C-080584, C-080585, C-080593, C-080594 and C-080595. Abundant, particularly at mid/late Toarcian localities.

Spongotrochus sp. A, n. sp.
plate 10, figures 8, 9

Diagnosis: Disc-shaped test with 3 radial primary spines and 3 or more interradial secondary spines. Meshwork fine and spongy. All spines solid, of uniform width and circular in section.

Description: Test disc-shaped, round in outline with 3 equally-spaced radial primary spines and 3 or more secondary spines placed between primary spines. Upper and lower surfaces of test planar to slightly convex. Meshwork very fine, concentrically arranged; pore frames irregularly polygonal. Spines radiate from vertical sides of test. All spines very slender, solid, circular in section and blunt-ended. Primary spines are longer and larger in diameter than secondary spines.

Remarks: This species differs fromn *S.* (*S.*) sp. aff. *S.* (*S.*) *echinodiscus* by lacking a depression in upper and lower surfaces and by having a primary and secondary system of spines.

Measurements (µm):	Holotype	avg. 14 spec.	max.	min.
Diameter of test	167	184	220	133
Length of primary spines	81	127	150	81
Length of secondary spines	21			

Type locality: GSC loc. C-080597. See Appendix I.

Range: Zones 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimens (Holotype) GSC 80609 and (paratype) GSC 80610 from type locality and GSC loc. C-080583, respectively. Unfigured specimens from GSC locs. c-080582, C-080583, C-080584 and C-080585.

Genus: *Spongiostoma* n. gen.
Type species: *Spongiostoma saccideon* n. sp.

Diagnosis: Test disc-shaped, circular to subcircular with two large, closely -spaced primary spines (both arising within a seventh to a fifth of the circumference); with or without secondary spines. Meshwork concentrically arranged. Spongy layers gape open from hinge area (beginning at base of primary spines).

Description: Test two layered, circular to subcircular in outline, surfaces planiform. Upper and lower layers of test hinged at one side and gape open at approximately 30°. Hinge marked by 2 strong primary spines (one at either end) that extend in equatorial plane and appear as "horns". Meshwork fine and spongy; meshwork arranged concentrically on inner surfaces of layuers, irregular on outer surfaces. Primary spines circular to triradiate. Test may or may not have fine radial secondary spines.

Remarks: The morphology of this form is most confusing. Test layers appear to gape open as if hinged at one side. Remaining edges of test are ragged, but there is no solid evidence that major parts are missing (e.g. additional primary spines). The gape could be a preservational feature (two layers of test have partially separated) but on over 50 specimens examined there is little variation in test morphology or angle of gape.

Etymology: Name formed from a combination of *spongi* (Greek noun; a sponge) and *stoma* (fr. Greek *stoma, stomatos* ; mouth) *spongi-o-stoma* = spongy mouth.

Range: Early Jurassic; late mid to late Toarcian, so far as is known.

Occurrence: Maude Formation, Queen Charlotte Islands.

Spongiostoma saccideon, n. sp.
plate 12, figures 4, 7, 10

Diagnosis: Test subcircular in outline, composed of two spongy concentric layers which gape open. Short hinge on one edge marked by two strong triradiate spines; periphery with a few very fine secondary spines.

Description: Test as for genus; subcircular in outline. Hinge normally short and straight with a well-defined, triradiate primary spine on either end. A few short and very fine, secondary spines radiating from the circular periphery have been noted on some tests.

Remarks: Compared to *Spongiostoma* sp. A under that species. Common to very abundant in middle/upper Toarcian samples.

Etymology: From Latin noun *saccus* meaning bag, sack or pouch; *sacc-ideon* = of sack-like appearance.

Measurements(µm): Measurements are treated in a very preliminary manner as many of these specimens appear incomplete:-

	Holotype	avg.11 spec.	max.	min.
Maximum diameter of test	212	207	250	160
Length of hinge (between spine centers at margin)	109	100	120	76
Length of longest spine	109	124	165	80

Type locality: GSC loc. C-080583. See Appendix I.

Range: Zones 4 and 5; late mid/early late to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimens (holotype) GSC 80611 and (paratype) GSC 80612 from type localtiy. Additional specimens from GSC locs. C-080584, C-080585 and C-080597.

Spongiostoma sp. A, n. sp.
plate 12, figures 8, 9

Diagnosis: Test disc-shaped, circular in outline. Two layers gape open from rounded hinge-like area on one side of test. Two massive needle-shaped spines; one each extending from either end of hinge.

Description: Test as for genus; Hinge area rounded. Spines long, tapering, circular in section with shallow elongate grooves near base. Meshwork spongy, concentrically arranged on inner surfaces of layers, irregular on outer surfaces. Pore frames irregularly polygonal.

Remarks: Compares superfically with *Spongodiscus* sp. figured by Iwata,, Uozumi, Nakamura and Tajika, 1983, pl. 1, fig. 8. *Spongodiscus* sp. however, has a subcircular test and four spines arranged as an "X"; nothing can be seen of its inner meshwork. *Spongiostoma* sp. differs from *S. saccideon*, by having a more circular test and massive spines that are circular rather than triradiate in axial section.

Measurements : Only 2 specimens recovered and measured. Diameter of test 197 µm on holotype, 160 µm on paratype. Length of longest spine 240 µm on holotype, 220 µm on paratype.

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80613 from type localtiy.

Family: Spongodiscidae Haeckel, 1882

Genus: *Spongotripus* Haeckel, 1882
Type species: *Spongotripus regularis* Haeckel, 1887

Remarks: It is likely that this form possesses concentrically arranged meshwork, however, until this can be clearly ascertained, *Spongotripus* should remain within the Spongodiscacea Haeckel.

Spongotripus sp. A, n. sp
plate 10, figure 5

Diagnosis: Test triangular to rounded-triangular; upper and lower surfaces normally convex. The 3 spines, at corners, are slender and triradiate; becoming circular is distal portions. Meshwork fine and spongy.

Description: Test triangular to rounded triangular in outline with 3 slender spines, one at each corner. Surfaces of test strongly convex to flattened. Meshwork very fine and spongy. Spines vary: normally they are triradiate and become circular in distal half; others are mostly circular throughout.

Remarks: This form resembles *Spongotripus trigonus* Rüst (1898, p. 34, pl. 11, fig. 13). However, Rüst's drawing lacks detail of pore structure, and without this a true comparison cannot be made.

Measurements (µm):	Holotype	avg. 11 spec.	max.	min.
Maximum diameter of test	141	153	195	122
Length of longest spine (broken on Holotype)	58	95	130	70

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimen (Holotype) GSC 80614 from type localtiy. Unfigured species from GSC locs. C-080582, C-080584, C-080585, C-080597, C-080594 and C-080595. Abundant in mid/upper Toarcian, frequency reduces in lower Bajocian.

Superfamily: Coccodiscacea Haeckel, 1862, emend. Kozur and Mostler, 1972
Family: Parasaturnaliidae Kozur and Mostler, emend. Pessagno, 1979
Subfamily: Parasaturnaliinae Kozur and Mostler, 1972, emend. Pessagno, 1979

Genus: *Acanthocircus* Squinabol, 1903, emend. Pessagno, 1979

Acanthocircus Squinabol, 1903, p. 124

Spongosaturninus Campbell and Clark, 1944, p.7 (type species *S. elliptic*us Campbell and Clark)

Spongosaturnalis Cambell and Clark, 1944, p. 7 (type species *S. spinifer* Campbell and Clark)

Type species: *Acanthocircus irregularis* Squinabol, 1903 (subsequent designation by Campbell, 1954, p. D 106).

Acanthocircus hexagonus (Yao)
plate 9, figures 11, 12

Spongosaturnalis (?) *hexagonus* Yao, 1972, p. 31, pl. 6, fig. 1-3, pl. 11, fig. 3a-c)

Remarks: Appears identical to the species described by Yao. This species conforms to the emended definition of *Acanthocircus* (Pessagno, 1979), therefore the genus has been changed hereinfrom *Spongosaturnalis* , which Yao originally queried, to *Acanthocircus* .

Range: Zones 4 to 7; late mid/early late Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimens GSC 80615 and GSC 80616 from GSC loc. C-080583 and C-080586, respectively. Also from GSC locs. C-080584, C-080585, C-080597 and C-080588. Central Japan: see Yao (1972).

Acanthocircus sp. cf. *A. septispinus* (Yao)
plate 9, figure 10

cf. *Spongosaturnalis* (?) *septispinus* Yao, 1972, p. 32, pl. 6, fig. 4-6

Remarks: Compares closely with *S. septispinus*, but has much shorter peripheral spines. Name changed to *Acanthocircus*; see Remarks under *A. hexagonus*.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen GSC 80617 from GSC loc. C-080584. Rare. Central Japan: see Yao (1972).

Superfamily: Cenodiscacea Haeckel, 1887
Subsuperfamily: Euchitoniilae Haeckel, 1884
Family: Euchitoniidae Haeckel, 1887

Genus: *Stephanastrum* Ehrenberg, 1847
Type species: *Stephanastrum rhombus* Ehrenberg, 1854 (subsequent designation by Campbell, 1954, p. D 88).

Definition: Four undivided arms; patagium with 4 large interbrachial openings.

Stephanastrum (?) sp. A, n. sp.
plate 1, figure 12

Diagnosis: Test large, subround in outline with four equal-spaced primary spines and coarse latticed meshwork.

Description: Test large, disc-shaped, subround in outline, with 4, slender, equally-spaced primary spines extending from periphery in equatorial plane. Test surfaces convex, sides rounded. Spines on all specimens broken off near base but may (?) extend inward. Outer portion of test consists of 3 concentric layers of small polygonal pore frames; inner pore frames much larger. On outer surfaces, pore frames are large in central area becoming smaller towards the periphery of the test. Pore frames triangular and tetragonal. One or two small indentations (about five times the size of an average pore) slightly off-center, can be distinguished on upper and lower surfaces.

Remarks: Genus queried because it differs from *Stephanastrum*, as defined by Campbell, by possessing a more discoidal test with poorly differentiated arms. This form is somewhat similar to *S. orbiculare*, Rüst, 1898, p. 32, pl. 10, fig. 10) however, Rüst's illustration shows a form with very little detail of pore frame structure, particularly in the central portion of the test, and appears to have four internal rays but no exterior spines. Moreover, according to Campbell (1954, p. D 88) *Stephanastrum* ranges from Eocene to Recent. It is likely that further study of the internal structure will prove this form to be significantly different and worthy of assignment to a new genus.

Measurements (µm): Test diameter measured diagonally between spines.

	Holotype	avg. 6 spec.	max.	min.
Test diameter AA'	352	318	360	284
Test diameter BB'	310			

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80618 from type localtiy.

Incertae sedis

Genus: *Acanthotetrahedron* , n. gen.
Type species: *Acanthotetrahedron nodosum*, n. sp.

Diagnosis: Test tetrahedron-shaped with 4 tribladed spines, one at each corner. Meshwork latticed and massive.

Description: Test shaped as a tetrahedron with 4 triradiate primary spines, one extending from each corner or triple junction. Each of 4 test surfaces is planar and shaped as an equilateral triangle. Cortical shell latticed with massive pore frames composed of heavy bars with variable-sized nodes at vertices. Internal structure not determined.

Remarks: *Acanthotetrahedron* differs from *Emiluvia* by possessing tetrahedral rather than flattened rectrangular shape, and by having spines extend in four planes rather than in a single, equatorial one. From current studies the cortical shell appears to be single-layered; *Emiluvia* has a double-layered cortical shell.

Etymology: Name formed from a combination of *acantha* (fr. Gk. -*akantha* meaning spine) plus *tetrahedron* (fr. Gk. *tettares* meaning four; and *hedra*, a base), *Acanthotetrahedron* = spiny tetrahedron.

Range: Early Jurassic (late mid/early late Toarcian), so far as is known.

Occurrence: Maude Formation, Queen Charlotte Islands.

Acanthotetrahedron nodosum, n. sp.
plate 9, figures 7, 8, 9

Diagnosis: Test tetrahedron-shaped with 4 primary tribladed spines. Meshwork coarse and latticed with massive nodes at vertices of pore frames.

Description: Test as for genus. Pore frames on test surfaces triangular and tetragonal with massive nodes at vertices. Each side bordered by four nodes; sides joined together by heavy bars forming large tetragonal pore frames. Spines tribladed, moderate in length with longitudinal ridges and grooves; ridges narrrow and rounded, grooves wide and deep. Spine tips, when entire, are sharp.

Remarks: Rare in all middle/upper Toarcian samples. Absent so far in both older and younger well preserved material.

Etymology: *nodos-um*; from Latin *nodos*; meaning nodose.

Measurements (µm):	Holotype	avg. spec.	max.	min.
Length of triangular side	120	119	140	90
Length of longest spine	90	86	110	70

Type locality: GSC loc. C-080584. See Appendix I.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80619 from type localtiy. Unfigured specimens from GSC locs. C-080582, C-080583 and C-080585.

Genus: *Dicroa* Foreman, 1975
Type species: *Dicroa periosa* Foreman, 1975

Dicroa (?) sp(p).

Diagnosis: Complete spines are triradiate with area of attachment at one end and strongly bifurcating tips at the other. There are two distinct forms, one has spine base and straight spine tips arranged as a "Y" in one plane whereas the other form has tips that curve inward and point in opposing directions, not in the same plane.

Remarks: included are two forms of slightly varying morphology, questionably assigned to *Dicroa*. Foreman (1975) defines *Dicroa* as "a spherical or elliptical shell bearing two or three bifurcating spines". As whole spines only are preserved, identification is indeterminate. Specimens do compare closely with those figured by Foreman (1975, pl. 2E, fig. 8-11; pl. 3, fig. 8) and Pessagno (1977b, pl. 4, fig. 2,3,5). All previously described forms of *Dicroa* are Cretaceous.

Range: Both forms confined to Zone 7; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Unfigured specimens GSC 80620 and 80621 found at GSC locs. C-080589, C-080592 and C-080593.

For purposes of completeness, it should be noted that in all samples (even poorly preserved ones) there are large numbers of spherical Spumellariina. These have not been treated in this report because of their number, diversity and apparent tendency to be long ranging. The majority of these forms possess latticed meshwork and can be assigned to the superfamily Sphaerallacea, but others have thick-walled spongy meshwork with extremely small radial spines. Of the latticed forms, one is distinctly subspherical with large, coarse, hexagonal pore frames, circular pores and fine radial spines. It is similar to *Cenosphaera* Ehrenberg and is not too unlike "*Cenosphaera*" *boria* Pessagno (1977b, p. 36, pl. 3, fig. 13,19) from the early Cretaceous of California. Other latticed forms have pore frames of varying size and shape. Normally spines are either cylindrical, fine and numerous or strongly triradiate, length varying inversely with number.

Suborder: Nassellariina Ehrenberg, 1875
Superfamily: Cyrtoidea Haeckel, 1862
Family: Archeodictyomitridae Pessagno, 1976

Genus: *Archeodictyomitra* Pessagno, 1976
Type species: *Archeodictyomitra squinaboli* Pessagno, 1976

Archeodictyomitra sp. aff. *A. primigena* Pessagno and Whalen, 1982

aff. *Archeodictyomitra primigena* Pessagno and Whalen 1982 p. 116, pl. 10, fig. ;9, 17; pl. 13, fig. 4.

Remarks: In all samples studied, only two specimens of *Archeodictyomitra* have been recovered. As specimens are pyritized, detail of pores in intercostal areas is obscured by overgrowths of pyrite. Moreover, although they appear to be closely related to *A. primigena* (and also to *A.* sp., figured by Hattori and Yoshimura, 1983, pl. 9, fig. 3), my specimens are larger (length 155 µm, maximum width 90 µm), and less rounded apically.

Range: Zone 2; mid Toarcian (note that this is earlier than the Bajocian first occurrence given by Pessagno and Whalen (1982)).

Occurrence: Maude Formation, Maude Island. Unfigured specimen GSC 80622 and one paratype from GSC loc. C-080579.

Genus: *Mita* Pessagno, 1977b
Type species: *Mita magnifica* Pessagno, 1977b

Mita sp. A, n. sp
plate 17, figure 9

Diagnosis: Test short, broad and rounded apically. 14-16 costae visible laterally. Pores, primary throughout, large and mostly circular, becoming smaller apically. Final postabdominal chamber decreasing in width.

Description: Test conical, short and broad; cephalis rounded apically. Test costate throughout, costae converging apically. Post abdominal chambers have large, circular to subcircular primary pores arranged in single rows between costae. Pores much smaller apically. Test has 14-16 costae visible in lateral view.

Number of postabdominal chambers few, but not precisely determined. Early chambers expand rapidly in width; final chambers decreasing in width and costal projections are evident.

Remarks: This form is much shorter and broader than any known described species of *Mita*. It is rare but distinct in my youngest lower Bajocian samples.

Measurements (μm):	Holotype	avg. 4 spec.	max.	min.
Maximum length	215	175	215	155
Maximum width	139	121	139	120

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Zone 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80623 from type locality. Other specimens from GSC locs. C-080593 and C-080594.

Family: Bagotidae Pessagno and Whalen, 1982

Genus: *Droltus* Pessagno and Whalen, 1982
Type species: *Droltus lyellensis* Pessagno and Whalen, 1982

Droltus sp. cf. *D. lyellensis* Pessagno and Whalen
plate 3, figure 7

cf. *Droltus lyellensis* Pessagno and Whalen, 1982, p. 122, pl. 2, fig. 3, 10; pl. 12, fig. 7

Remarks: Form compares closely with *D. lyellensis* but tetragonal pore frames are less aligned and the single specimen found (and figured) is larger: length (excluding horn) 331 μm, maximum width 208 μm. *D. lyellensis* has previously been recorded from the upper Sinemurian portion of the Kunga Formation.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80624 from GSC loc. C-080577.

Droltus sp. A, n. sp
plate 17, figure 12

Diagnosis: Test short and broad with short massive horn. Pore frames also massive, subaligned distally, pores circular.

Description: Test conical with 4 or 5 post-abdominal chambers. Thorax and abdomen increase rapidly in width; post abdominal chambers increase very slightly. Cephalis small with short massive horn. Cephalis and thorax sparsely perforate. Outer latticed layer of abdomen and post abdominal chambers with irregularly-sized, massive, pentagonal and tetragonal pore frames; pores circular. Pore frames nonaligned proximally, but become subaligned distally.

Measurements: Holotype: length (excluding horn) 231 µm, maximum width 153 µm. Measurements will be further detailed when additional specimens are found.

Type locality: GSC loc. C-080593. See Appendix 1.

Range: Subzone 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Two specimens, of which one is illustrated (GSC 80625), are from the type locality.

Family: Canoptidae Pessagno, 1979

Genus: *Canoptum* Pessagno, 1979
Type species: *Canoptum poissoni* Pessagno, 1979

Canoptum sp. cf. *C. dixoni* Pessagno and Whalen
plate 14, figure 10

cf. *Canoptum dixoni* Pessagno and Whalen, 1982, p. 124, pl. 2, fig. 1,2,8,9,14; pl. 12, fig. 2

Remarks: This form, almost identical to *C. dixoni*, differs only in having somewhat larger pore frames.

Range: Zones 1 to 5; late Pliensbachian to late Toarcian.

Occurrence: Maude Formation, Maude Island (?), Graham Island. Illustrated specimen GSC 80626 from GSC loc. C-080597, other specimens found at GSC locs. C-080577, C-080579 and C-080583.

Canoptum anulatum Pessagno and Poisson
plate 5, fig. 9,10,14

Canoptum anulatum Pessagno and Poisson, 1979, p. 60, pl. 9, fig. 6-9; pl. 10, fig. 1-9, pl. 15, fig. 2,4; Pessagno and Whalen, 1982, p. 123, pl. 6, fig. 1,2

Remarks: The pyritized fauna from GSC loc. C-080579 contains abundant forms broader based but otherwise identical to *C. anulatum*. Present also are a number of extremely large forms (see pl. 5, fig. 9) with weaker ridge ornamentation, that appear closely related to *C. anulatum*.

Range: Zone 2; mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimens GSC 80628 and GSC 80627 from GSC loc. C-080579. Lower Jurassic of Turkey, California, Oregon, Baja California Sur (ibid).

Canoptum (?) sp.
plate 14, figure 6

Remarks: Genus is queried because form possesses two rows of primary pores, in H-linked configuration, flanking both sides of each circumferential ridge and two rows of offset relict pores between the ridges. This rare form appears almost identical to *Canoptum* (?) sp. A, figured by Pessagno and Whalen, 1982, p. 125, pl. 7, fig. 14, 16, from the lower lower Bajocian of the Snowshoe Formation, east-central Oregon.

Range: Zones 3 to 5; mid to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen GSC 80629 from GSC loc. C-080597. An additional specimen was collected at GSC loc. C-080579.

Genus: *Wrangellium* Pessagno and Whalen, 1982
Type species: *Wrangellium thurstonense* Pessagno and Whalen, 1982

Wrangellium sp.
plate 6, figure 8, 11

Remarks: This form closely resembles *Wrangellium* sp. A, figured by Pessagno and Whalen, 1982, p. 126, pl. 3, fig. 2,8,9, but is broader based and possesses fewer post abdominal chambers. Rare.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80630 and paratypes confined to GSC loc. C-080577.

Genus: *Elodium* n. gen.
Type species: *Elodium cameroni* n. sp.

Description: Test conical and large, with well developed horn and numerous closely-spaced post abdominal chambers separated by nodose circumferential ridges. Three rows of longitudinally aligned circular to subcircular pores in polygonal (mostly tetragonal) pore frames, between circumferential ridges. Lateral pore rows flanking ridges slope steeply away from ridges. Post abdominal chambers constricted between ridges. Pores in constricted area may be irregular to absent on distalmost chambers of test. Cephalis and thorax sparsely perforate to imperforate, covered with outer layer of microgranular silica; this covering may extend onto earliest post abdominal chambers.

Remarks: *Elodium* n. gen. differs from other genera of the Canoptidae Pessagno by possessing an apical horn and three rows of longitudinally aligned primary (open) pores between circumferential ridges.

Etymology: *Elodium* is formed by an arbitrary combination of letters (ICZN, 1964, Appendix D, Pt. VI, Recommendation 40, p. 113).

Range: Lower to Middle Jurassic: late mid Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island, Q.C.I.

Elodium cameroni n. sp.
plate 13, figures 1, 2, 6, 9

Diagnosis: Large conical-cylindrical test with 10 to 14 post abdominal chambers and a strong asymmetric apical horn. All pores large, primary and circular; 3 rows on proximal chambers, 2 rows on distal chambers.

Description: Test large with 10 to 14 strongly constricted post abdominal chambers separated by nodose circumferential ridges; nodes low and rounded. Cephalis and throax trapezoidal in outline externally, partially perforate, covered by veneer of microgranular silica. Cephalis has strong, asymmetric apical horn. All pores on post abdominal chambers circular and primary (open); those within constricted areas smaller, disappearing on distalmost chambers. Earliest post abdominal chambers trapezoidal, increasing gradually in width and height, distal chambers almost cylindrical with height decreasing somewhat.

Remarks: *Elodium cameroni* is compared to *E.* sp. A, under the latter species. Very abundant, in all middle/upper Toarcian samples.

Etymology: this species is named for B.E.B. Cameron in honour of his important contribution to the stratigraphy and foraminiferal biostratigraphy of the Jurassic formations in the Queen Charlotte Islands, B.C.

Measurements (µm):	Holotype	avg. 20 spec.	max.	min.
Length (excluding horn)	369	352	450	280
Maximum width	161	159	185	147

Type locality: GSC loc. C-080597. See Appendix 1.

Range: Zones 3 to 6; late mid Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80631 and (Paratype) GSC 80632 from type locality. Additional specimens collected at GSC locs. C-080581, C-080582, C-080583, C-080584 C-080585 and C-080586.

Elodium sp. A, n. sp.
plate 13, figures 3, 8, 11

Diagnosis: Test elongate, conical, produced apically into a short horn. Initial chambers imperforate, nodose, covered with dense layer of microgranular silica. Ridges wide and rounded, marked by elongate nodes.

Description: Test elongate, conical, apex pointed, with short well-developed horn.

Cephalis, thorax and abdomen (?) imperforate; covered with heavy coating of microgranular silica; boundaries indistinguishable. Pores on abdomen (?) and first post abdominal chamber/chambers relict, these too are covered with microgranular silica. As many as 12 moderately constricted post abdominal chambers, separated by wide, rounded circumferential ridges marked by elongate nodes. Three rows of longitudinally aligned to subaligned pores between ridges. Pores circular to subcircular in rows adjacent to ridges; pores in constricted area are smaller, mostly elliptical and become more irregularly arranged on distal chambers. When test complete, final chamber may be somewhat constricted.

Remarks: *Elodium* sp. A, differs from *E. cameroni*, n. sp. by having a more conical, apically pointed test with a heavier coating of microgranular silica. In addition, the horn is shorter and more symmetrical and circumferential ridges are wider and more rounded. It differs from *Lupherium* sp. C, n. sp. by having more prominent circumferential ridges. Abundant.

Measurements (µm):	Holotype	avg. 15 spec.	max.	min.
Length (excluding horn)	294	301	380	220
Maximum width	117	131	142	117

Type locality: GSC loc. C-080597. See Appendix 1.

Range: Zones 3 to 6; late mid Toarcian to Aalenian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80633 from type locality. Additional specimens found at GSC locs. C-080581, C-080582,C-080583, C-080584 and C-080586.

Elodium (?) sp. B, n. sp.
plate 13, figures 4, 7

Diagnosis: Slender, conical test with stubby apex carrying short horn. Pore frames on chambers uniform in size, circular. Ridges wide and weakly nodose.

Description: Test slender, conical, usually with 7 to 9 post abdominal chambers. Cephalis wide and hemispherical with short horn. Remaining chambers trapezoidal in outline increasing gradually in width and height. Cephalis and thorax with a few coarse perforations. Pores on remainder of test circular and uniform in size. Circumferential ridges wide with low rounded nodes between paired pores flanking ridges. Weakly developed "costae", continuous with nodes on ridges, appear to be developing between longitudinally aligned rows of pores.

Remarks: Genus queried because of the development of weak "costae" between longitudinal rows of pores. *Elodium* (?) sp. B differs from *E.* sp. A by virtue of being much less pointed apically, having more uniformly sized pores and by developing the weak costae mentioned above. It is possible this is a form intermediate between *Elodium* n. gen. and *Lupherium* Pessagno and Whalen, and that further study well warrant assignment of *E.* (?) sp. B to a new genus. Rare.

Measurements: Measurements will be treated when more than the present two incomplete specimens have been collected.

Type locality: GSC loc. C-080581. See Appendix 1.

Range: Zones 3 to 5; late mid to late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80634 from type locality. One additional specimen collected from GSC loc. C-080597.

Family: Canutidae Pessagno and Whalen, 1982

Genus: *Canutus* Pessagno and Whalen, 1982
Type species: *Canutus tipperi* Pessagno and Whalen, 1982

Canutus blomei Pessagno and Whalen
plate 3, figure 5

Canutus blomei Pessagno and Whalen, 1982, p.127, pl.3, fig.13-15; pl.12, fig. 20

Remarks: Extremely abundant at the Maude Island locality. All specimens appear to have a particularly well developed outer layer.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80635 and all others apparently confined to GSC loc. C-080577.

Canutus giganteus Pessagno and Whalen
plate 3, figure 1

Canutus giganteus Pessagno and Whalen, 1982, p. 127, pl. 4, fig. 5, 13

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80636 from GSC loc. C-080577.

Canutus hainaensis Pessagno and Whalen
plate 3, figures 10, 11

Canutus hainaensis Pessagno and Whalen, 1982, p. 128, pl. 4, fig. 3, 4; pl. 5, fig. 1, 13, 14, 16-18, 20; pl. 12, fig. 9

Remarks: Specimens generally larger (length 350-476 μm) than those from Pessagno and Whalen's type material, but otherwise they appear identical.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80637 and all others from GSC loc. C-080577.

Canutus izeensis Pessagno and Whalen
plate 3, figure 2

Canutus izeensis Pessagno and Whalen, 1982, p. 129, pl. 6, fig. 8, 10, 15

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimens GSC 80638 from GSC loc. C-080577.

Canutus tipperi Pessagno and Whalen
plate 3, figure 3

Canutus tipperi Pessagno and Whalen, 1982, p. 129, pl. 4, fig. 7-9, 11, 12, 14-17; pl. 12, fig. 21

Range: Zone 1; late Pliensbachian

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80639 and all others from GSC loc. C-080577.

Canutus sp. A, n. sp
plate 3, figured 4, 9

Diagnosis: Test large, spindle-shaped, elongate and inflated. Outer layer of pore frames small and very irregularly polygonal. Outer layer not developed on final chamber.

Description: Test spindle-shaped, large and inflated usually with atleast 7 post abdominal chambers. Cephalis and thorax conical, mostly imperforate, inner pore frames concealed by surficial layer of microgranular silica. First few post abdominal chambers widen rapidly, central 2 or 3chambers are equal in width; last 2 chambers constrict abruptly. All chambers increase gradually in height. Test has 3 layers of meshwork. Inner layers of pore frames large, square to rectangular. Outer layer small, irregularly polygonal, composed of microgranular silica. Outer layer(s) not developed on final chamber.

Remarks: *Canutus* sp. A, differs from *C. tipperi* by having a more elongate test with small irregularly polygonal pore frames in the outer layer.

Measurements (µm):	Holotype	avg. 4 spec.	max.	min.
Length	497	451	497	420
Maximum width	280	241	280	220

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80640 and all paratypes from type locality.

Canutus sp. B, n. sp.
plate 3, figures 6, 8, 12

Diagnosis: Test large, highly inflated with bluntly pointed apex. Outer layer of pore frames randomly triangular and tetragonal with large raised nodes at vertices.

Description: Test large and highly inflated, usually with 4 or 5 post abdominal chambers. Cephalis and thorax broadly conical. Pore frames on inner latticed layer of abdomen, small and irregular. Cephalis, thorax and abdomen coated with surficial layer of microgranular silica. Width of post abdominal chambers increases rapidly in first 2 chambers and decreases almost as abruptly in latter 2 or 3. Height of chambers increases in the first 3, but is much reduced distally. Test has 3 layers of meshwork. Pore frames on inner 2 layers (normally 2 lateral rows per chamber) large and irregularly polygonal; on outer layer pore frames are randomly arranged, triangular and tetragonal with rounded nodes of high relief at vertices.

Remarks: *Canutus* sp. B differs from *C. blomei* by having irregularly polygonal pore frames on inner latticed layer and heavy nodes, with high relief, at vertices of exterior pore frames. Furthermore, the outer layer is developed on even the most distal chamber.

Measurements (µm):	Holotype	avg. 5 spec.	max.	min.
Length	350	347	360	335
Maximum width	291	288	300	280

Type Locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80642, (Paratype) GSC 80641 and all others from type locality.

Family: Hsuidae Pessagno and Whalen, 1982

Genus: *Hsuum* Pessagno, 1977a
Type species: *Hsuum cuestaense* Pessagno, 1977a

Hsuum sp. aff. *H. belliatulum* Pessagno and Whalen
plate 15, figure 3

aff. *Hsuum belliatulum* Pessagno and Whalen, 1982, p. 131, pl. 7, fig. 7, 8, 12, 18, 22; pl. 13, fig. 3

Remarks: The present form differs from *Hsuum belliatulum* by having a test that is more subcylindrical than conical, with less continuous costae, larger pores, and a longer, stronger tapering horn.

Range: Zones 6 and 7; Aalenian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimen GSC 80643 from GSC loc. C-080595. Additional specimens collected at GSC locs. C-080586, C-080588 and C-080594.

Hsuum sp. cf. *H. mirabundum* Pessagno and Whalen
plate 15, figure 4

cf. *Hsuum mirabundum* Pessagno and Whalen 1982, p. 131, pl. 7, fig. 9, 17, 21

Remarks: My specimens compare well with *H. mirabundum,* but tend to be slimmer and more elgongate; indeed, some are one-third again as long as the illustrated specimen. In addition, very few lateral costae have been noted. Pessagno and Whalen described *H. mirabundum* from the middle lower Bajocian of the Snowshoe Formation in east-central Oregon.

Range: Subzones 7B and 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80644 from GSC loc. C-080595. Additional specimens collected at GSC loc. C-080587, C-080593 and C-080594.

Hsuum sp. aff. *H. mirabundum* Pessagno and Whalen
plate 17, figure 8

aff. *Hsuum mirabundum* Pessagno and Whalen, 1982, p. 131, pl. 7, fig. 9, 17, 21

Remarks: This form differs from *H. mirabundum* in having a test that is longer and less pointed apically. In addition pore frames are larger, and on distal portions there are 3 (not 2) longitudinally aligned rows of pore frames between costae. A related hsuid form, (#2) pl. 17, fig.7 (GSC 80645), appears to be indermediate between (#1) *H.* sp. cf. *H. mirabundum* (p. 91 pl. 15, fig. 4) and (#3), the form described herein. #2 is the same shape as #1, but has 3 rows of longitudinally aligned pore frames between costae, as does #3. As all three occur together at various localities, they probably represent a single variable species.
Range: Subzone 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80646 from GSC loc. C-080595. Other specimens found at C-080588.

Hsuum mulleri (?) Pessagno and Whalen

? *Hsuum mulleri* Pessagno and Whalen, 1982, p. 133, pl. 5, fig. 6, 8, 9; pl. 12, fig. 16, 17.

Remarks: Species name is queried because specimen is incomplete (cephalis and horn are missing). In all other respects form is identical to *H. mulleri*, which is described from the lower Pliensbachian of the Maude Formation, Maude Island. Rare.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island; GSC loc. C-080577, specimen GSC 80647 is not illustrated.

Hsuum sp. cf. *H. rosebudense* Pessagno and Whalen
plate 5, figures 3, 4, 5

cf. *Hsuum rosebudense* Pessagno and Whalen, 1982, p. 134, pl.6, fig. 3, 14, 19; pl. 12, fig. 14.

Remarks: Three variants of an extremely abundant form are illustrated, all of which have some affinity with *H. rosebudense*. Collectively they differ in having more slender, elongate tests. When viewed with the binocular microscope all variants display only minor differences with respect to length and width of test, but observation with the scanning electron microscope discloses distinct differences in shape and nature of costae as noted below:

Var. A (fig. 3), subcylindrical and slender, costae are long and continuous (this variant most similar to *H. rosebudense*).

Var. B (fig. 4), more elongate than Var. A, costae less continuous with lateral branching.

Var. C (fig. 5), test shorter and broader, distal chamber somewhat constricted. Costae discontinuous, some branching laterally.

See p. 177 for a quantitative discussion of this species.

Range: Zone 2; mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimens GSC 80648 (Var. A) and paratypes GSC 80649 (Var. B) and GSC 80650 (Var. C) from GSC loc. C-080579.

Quantitative analysis for *Hsuum* sp. cf. *H. rosebudense*.

Because of thie variability noted previously, it was decided to test the shape of the three variants statistically to determine the likelihood of their belonging to more than one or only to a single population.

Measurements of test length (excluding horn) and maximum test width were made on a total of 65 specimens (Var. A, n = 27; Var. B, n = 24; Var. C, n = 14) using a binocular microscope fitted with an eyepiece micrometer.

Using the ratio W/L, the data were analyzed by calculating the mean, variance (see Table V, p. 181), skewness and kurtosis and by plotting histograms for each variant plus the three combined (see Fig. 16, p. 179). In addition, the three variants were compared using the T- and F-tests to determine the statistical significance of any differences between populations.

The T-test is used for testing the hypothesis that two normal population means are equal, whereas the standard F-test tests the hypothesis of the equality of the two population variances. For both, the underlying assumptions are that the samples were randomly selected and are normally distributed. In addition the T-test demands that variances of the two populations compared are equal.

All pyritized specimens are from a single limestone nodule (C-080579). Selected specimens were those sufficiently preserved i.e. believed to be complete (judging from the condition of the distalmost post abdominal chamber and aperture) and without large overgrowths of pyrite -- to allow for accurate measurement.

Based on visual inspection of histograms for Var. A, Var. B and Var. C shown in Fig. 16 (p. 179), the distributions are unimodal and do not appear to deviate significantly from a normal distribution.

Using variants A and B as an example, we first test for equality of variance using the null hypothesis:

$$Ho: \sigma^2(A) = \sigma^2(B)$$

From Table VI (p.181), the calculated level of significance for the F-test is 0.3322 i.e. the null hypothesis cannot be rejected even at a 33% level of significance.

We now test for equality of means using the null hypothesis:

$$Ho: \mu(A) = \mu(B)$$

From table VI (p. 181) the calculated level of significance for the T-test is 0.2549 i.e. the null hypothesis cannot be rejected even at a 25% level of significance.

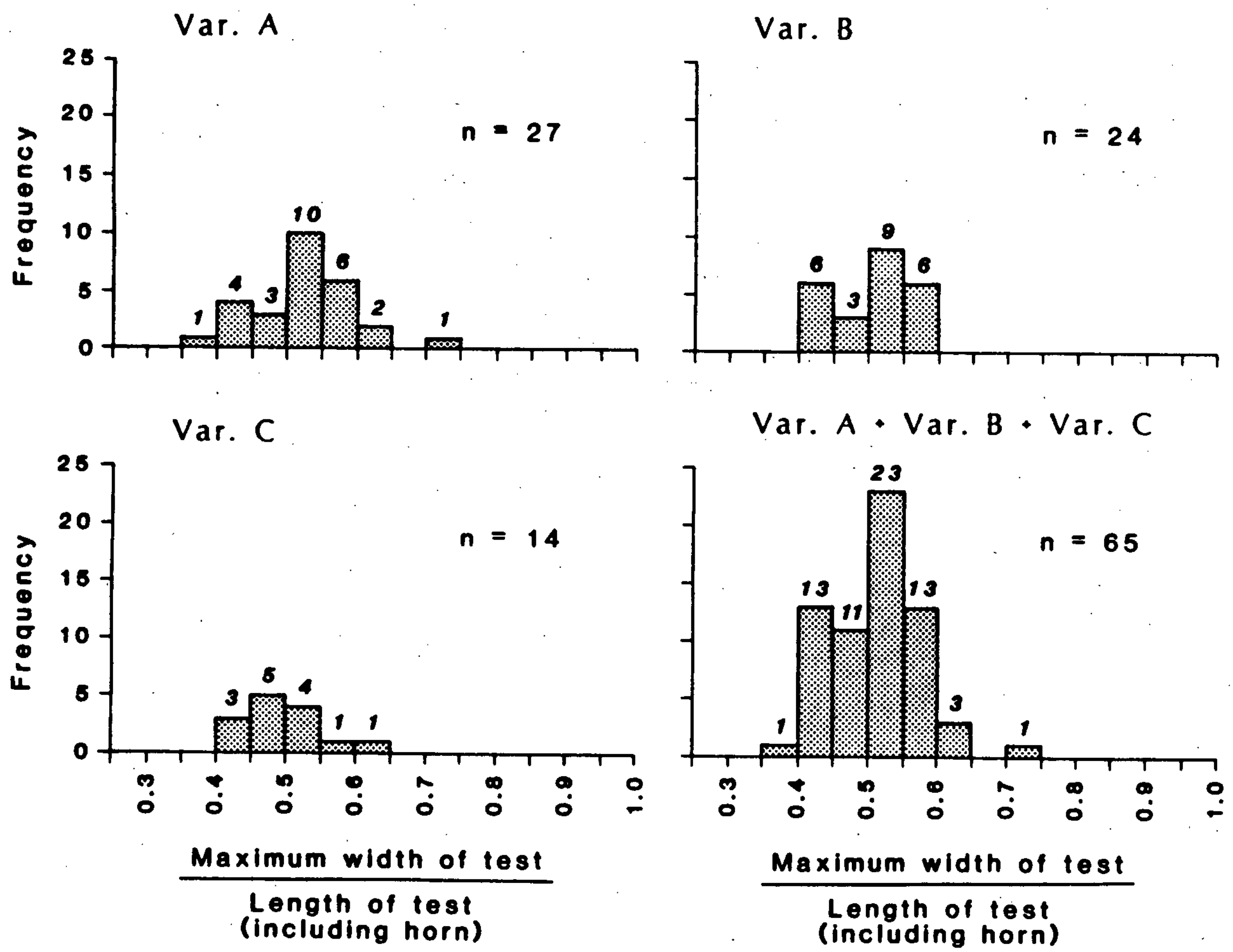


Figure 16: Frequency distribution of W/L ratio for *Hsuum* sp. cf. *H. rosebudense*.

Conclusion: there is no significant difference in the means of these two samples. Var. A and C, and Var. B and C were compared in the same way and no significant differences were found for them either.

It can be seen (Table VI, p. 181) that there is no significant difference between the means of all three samples and consequently that these Radiolaria cannot be separated on the basis of width - length ratios. This conclusion is strengthened when a histogram for all three samples is drawn (Fig. 15, p. 179 lower right; Var. A + Var. B = Var. C), the distribution is unimodal and does not appear to deviate significantly from a normal distribution.

Riedel (1978) has developed a system for Mesozoic radiolarians that uses a set of morphological descriptors to distinguish a taxon. His system essentially describes an image, the chief components of which are shape and structure. Throughout the modern era of radiolarian study primary emphasis has been placed on these two elements when defining species; consequently in the study of this species shape is considered to be of greater importance than ornamentation (e.g. pattern of costae). Therefore, all three variants are included here as a single species, but one which does exhibit considerable variability both in shape and ornamentation.

Table V: Statistics for three variants of *Hsuum* sp. cf. *H. rosebudense*.

	N	MEAN	VARIANCE
Var. A	27	0.52509	0.00504
Var. B	24	0.50400	0.00337
Var. C	14	0.49441	0.00237

Table VI: Values derived for T- and F-tests on samples compared.

COMPARISON	T statistic	F statistic	LEVEL OF SIGNIFICANCE	
	for MEAN	for VARIANCE	T stat.	F stat.
Var. A against Var. B	1.5121	1.4962	0.2549	0.3322
Var. A against Var. C	1.4461	2.1277	0.1561	0.1552
Var. B against Var. C	0.5203	1.4221	0.6060	0.5166

Hsuum sp. A, n. sp
plate 5, figure 2

Diagnosis: Test elongate, conical with short horn. Distalmost post abdominal chamber markedly constricted. Costae straight and continuous on distal two-thirds of test. 3 to 4 rows of pore frames between costae.

Description: Test elongate conical with short horn. Cephalis and thorax broadly conical to subrectangular. Abdomen and all post abdominal chambers trapezoidal. Chambers gradually increase in width except final chamber, which is markedly constricted. Costae short and discontinuous (almost node-like) on apical third of test, becoming continuous on distal two-thirds. 8 costae visible laterally. 3 to 4 longitudinally aligned rows of pore frames between costae.

Remarks: Specimens pyritized, consequently number of post abdominal chambers cannot be precisely determined. Aside from illustrated form, only two partial specimens have been collected, therefore measurements are not treated at this time. Rare.

Type locality: GSC loc. C-080579. See Appendix 1.

Range: Zone 2; mid Toarcian

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80651 and paratype from type locality.

Genus: *Lupherium* Pessagno and Whalen, 1982
Type species: *Lupherium snowshoense* Pessagno and Whalen, 1982

Lupherium sp. A

Remarks: This form appears almost identical to *Lupherium* sp. A, figured by Pessagno and Whalen (1982, p. 136, pl. 6, fig. 4), from the Pliensbachian of California (Franciscan Complex) and east-central Oregon (Nicely Formation).

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude Formation, Maude and Graham Islands. Specimens collected from GSC locs. C-080579, C-080597, C-080589 and C-080595. Specimen GSC 80652 from C-080579 (not illustrated).

Lupherium (?) sp. B, n. sp.
plate 2, figure 5, 6

Diagnosis: Test conical, rounded apically without horn. 9-12 strong, rounded longitudinal costae visible laterally between single rows of large circular pores. Test has a "welded" appearance.

Description: Test elongate, conical, rounded apically without horn and usually with 6 or 7 post abdominal chambers. Cephalis hemispherical, all other chambers trapezoidal in outline. All but final 1 or 2 chambers increasing gradually in height and width; distal chambers on complete specimens slightly reduced in width. Some tests very slightly constricted at joints. Cephalis and thorax perforate, covered with a smooth layer of microgranular silica. 2 rows of thin, square to rectangular pore frames per chamber; pores circular to subcircular. Continuous costae strong, and rounded; superimposed on test between single longitudinal rows of coarse pores; 9-12 costae visible laterally. Test has a "welded" appearance.

Remarks: Genus queried because the present form lacks an apical horn. Differs from all other species of *Lupherium* in possessing sparses and coarser costae. Differs from *Archeodictyomitra* sp. by having pores that are all primary and open. Abundant.

Measurements (µm):	Holotype	avg. spec.	max.	min.
Length	296	290	350	210
Maximum width	148	149	170	112

Type Locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimens (Holotype) GSC 80653 and (Paratype) GSC 80654 from type locality. Additional specimens found as GSC locs. C-080578 and C-080594.

Lupherium (?) Sp. C, n. sp.
plate 13, figures 5, 10, 12

Diagnosis: Test conical, slender, with short horn. Surface covered with numerous, fine costae of low relief. No ridges or strictures. Final 1 or 2 chambers slightly constricted.

Description: Test elongate, conical, pointed apically with short, cylindrical horn (broken on Holotype). Cephalis and thorax imperforate, covered with layer of microgranular silica. 10-12 post abdominal chambers, trapezoidal in outline. All chambers, other than final 1 or 2, increasing gradually in width and height. Distal chambers decrease in width. Costae fine, numerous, of low relief. Rows of longitudinally aligned pores (3 per row) alternate with costae; pores are small, circular to subcircular, increasing in size as chambers are added and are often obscured by coating of microgranular silica.

Remarks: This form in size and shape is superficially very like *Elodium* sp. A. It differs only in lacking rounded circumferential ridges between chambers and by having more prominent fine costae. Both *Lupherium* ? sp. C and *Elodium* sp. A occur abundantly together in most zone 3 samples.

Measurements (µm):	Holotype	avg. spec.	max.	min.
Length (including horn)	330	288	330	230
Maximum width	110	118	130	100

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zones 2 to 5; mid to late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80655 from type locality. Other specimens collected at GSC locs. C-080579, C-080582, C-080584 C-080585 and C-080597.

Lupherium (?) sp. D, n. sp
plate 5, figure 12

Diagnosis: Test large, broadly conical with short horn. 18 costae visible laterally; 3 longitudinally aligned pores per chamber between adjacent costae. Ridges slightly raised with small nodes superimposed on costae.

Description: Test broadly conical, rounded apically with short cylindrical horn. Cephalis hemispherical, all other chambers trapezoidal in outline. Cephalis imperforate, thorax and abdomen sparsely perforate; all three covered with a layer of microgranular silica. Usually 7-9 postabdominal chambers. All but final chamber increase gradually in width and height. Test appears to have slightly raised ridges/joints between chambers; chambers are somewhat constricted. 15 continuous narrow costae visible laterally, nodose along ridges. Single rows of longitudinally aligned pores (3 per chamber, set in square pore frames) alternate with costae.

Remarks: Genus *Lupherium* queried because joints/ridges between chambers are slightly raised and nodose. In addition chambers are constricted between rather than at joints. This appears to be an intermediate form between *Lupherium* and *Elodium*, but because of the strong longitudinal costae, it is assigned to *Lupherium*.

Measurements (µm):	Holotype	avg. 10 spec.	max.	min.
Length (excluding horn)	334	290	334	210
Maximum width	188	171	190	155

Type locality: GSC loc. C-080579. See Appendix 1.

Range: Zone 2, Subzone 7C ?; mid Toarcian, early Bajocian ?

Occurrence: Maude Formation, Yakoun Formation ?, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80656 from type locality. An additional specimen has been collected at GSC loc. C-080593.

Family: Theoperidae Haeckel, 1882, emend. Riedel, 1967

Genus: *Protounuma* Ichikawa and Yao, 1976
Type species: *Protounuma fusiformis* Ichikawa and Yao, 1976

Protounuma (?) sp. A, n. sp
plate 6, figures 9, 12

Diagnosis: Spindle-shaped, inflated, lacking horn. Base partially constricted;

aperture 1/2 maximum diameter of test. Test surface has 10-14 longitudinal plicae, with 2-3 longitudinal rows of circular pores between flanking plicae.

Description: Test spindle-shaped, multisegmented, final chamber partially constricted at base, aperture 1/2 maximum diameter of test. Apical horn lacking on all specimens examined. Cephalis small and imperforate. All chambers, except for the final 1 or 2, increase rapidly in width; final chamber(s) slightly constricted. 10 to 14 longitudinal plicae superimposed on surface of test, mostly continuous from thorax to aperture. 2-3 longitudinal rows of circular pores between adjacent plicae. Pores arranged diagonally as a rule but sometimes horizontally. Pore size increases very slightly from apex to base.

Remarks: *Protounuma* (?) sp. A is larger than *P. fusiformis*, has a larger aperture, fewer plicae and larger pores. Like *P. fusiformis* this species too is quite variable, having both short broad forms and more elongate 'slender' ones. The absence of horn is not thought to be caused by pyritization.

Measurements (µm):	Holotype	avg. 19 spec.	max.	min.
Maximum length	216	179	216	130
Maximum width	121	107	121	98

Tyoe locality: GSC loc. C-080579. See Appendix 1.

Range: Zones 2 to 5; mid to late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80657 from type locality. Single specimen collected at GSC loc. C-080597.

Family: Parvicingulidae Pessagno, 1977a, emend. Pessagno and Whalen, 1982

Remarks: A characteristic, not previously specified, is that pores are not arranged in linear series as in *Elodium*, but alternate in both *Parvicingula* and *Ristola*.

Genus: *Parvicingula* Pessagno, 1977a
Type species: *Parvicingula santabarbaraensis* Pessagno, 1977a

Parvicingula matura Pessagno and Whalen
plate 18, figures 6, 12, 16

Parvicingula matura Pessagno and Whalen, 1982, p. 139, pl. 7, fig. 1-3, 15, 19, 20; pl. 13, fig. 1.

Remarks: Form varies in development of circumferential ridges. Illustrated specimen has rows of small nodes at chamber boundaries while other specimens have weakly-developed ridges. As with other species, the earlier individuals seem to have coarser pores and fewer of them. Abundant in all early Bajocian samples.

Range: Zones 4 (?), 7; late mid/early late Toarcian (?), early Bajocian.

Occurrence: Maude (?) and Yakoun Formations, Graham Island. Illustrated specimen GSC 80658 from GSC loc. C-080595. Additional specimens collected at GSC locs. C-080583 (?), C-080589, C-080592, C-080588, C-080593 and C-080594. Snowshoe Formation of east-central Oregon; subsurface of Alaska: See Pessagno and Whalen (1982).

Parvicingula sp. aff. *P. burnensis* Pessagno and Whalen
plate 18, figures 8, 10, 15

aff. *Parvicingula burnensis* Pessagno and Whalen, 1982, p. 137, pl. 9, fig. 5-7, 14, 15, 19, 20; pl. 13, fig. 2.

Remarks: This species resembles *P. burnensis* but differs (1) in being larger (length 310-430 µm; width 130-160 µm on 7 specimens), (2) having less well developed circumferential ridges and (3) having coarse, somewhat less regular meshwork.

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimens GSC 80659 and 80660 from GSC locs. C-080594 and C-080588, respectively. Additional specimens collected at GSC locs. C-080579, C-080597 and C-080593.

Parvicingula (?) sp.
plate 5, figure 1

Remarks: This form appears related to *P. matura* but differs in having smaller nodes separating earliest post abdomional chambers, less regularly arranged pore frames and wider circumferential ridges between distal post abdominal chambers.

According to Pessagno and Whalen (1982) *P. matura* is one of the earliest species of *Parvicingula* s.s. to appear; indicated range is Aalenian to mid early Bajocian. No middle or upper Toarcian samples were included in their study; Toarcian material however, comprises a major portion of my study and thorough examination discloses abundant forms very similar to *P. matura* in a middle Toarcian sample. Again it should be noted that these have fewer, coarser pores than the later members of the species. This species is probably a form ancestral to true *Parvicingula*.

Range: Zone 2; mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen GSC 80661 from GSC loc. C-080579.

Parvicingula sp. aff. *P. media* Pessagno and Whalen
plate 18, figures 9, 11

aff. *Parvicingula media* Pessagno and Whalen, 1982, p. 139, pl. 9, fig. 3, 4, 17, 21; pl. 13, fig. 6.

Remarks: This species closely resembles *P. media* but test is more slender and tapering with a longer horn. Ridges between early chambers nodose, but nodes less well developed than on *P. media* .

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude Formation, Maude and Graham Island; Yakoun Formation, Graham Island. Illustrated specimen GSC 80662 from GSC loc. C-080595. Additional specimens found at GSC locs. C-080579, C-080586, C-080589 C-080587 and C-080594.

Parvicingula sp. aff. *P. profunda* Pessagno and Whalen
plate 18, figures 13, 14

aff. *Parvicingula profunda* Pessagno and Whalen 1982, p. 140, pl. 10, fig 3-6, 14, 15, 18, 19; pl. 13, fig. 7.

Remarks: This form differs from *P. profunda* by having a test that is less inflated distally (subcylindrical rather than conical in shape) and by having narrower circumferential ridges. *P. profunda* is known from the upper Bathonian part of the Snowshoe Formation of east-central Oregon. When originally described, upper and lower boundaries of range were left open.

Range: Zone 7; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80633 from GSC loc. C-080595. Additional specimens collected at GSC locs. C-080590, C-080588 and C-080593.

Parvicingula sp. A, n. sp.
plate 18, figures 1, 2, 7

Diagnosis: Test subcylindrical with 10 or more post abdominal chambers and very, short slender horn. Test has rows of pointed nodes in place of circumferential ridges between abdomen and first few post abdominal chambers.

Description: Test elongate, subcylindrical with 10 or more post abdominal chambers when well preserved. Cephalis small, conical with very short slender horn (not visible on all specimens). Thorax, abdomen and first few post abdominal chambers trapezoidal, remaining chambers subrectangular in outline. Cephalis and thorax sparsely perforate. Post abdominal chambers have 3 lateral rows of symmetrical (predominantly pentagonal) pore frames between ridges. Pore frames in rows flanking circumferential ridges slope steeply away from ridges. Those in central row depressed, smaller and staggered; pores elliptical. Test has rows of sharp pointed nodes, rather than discrete circumferential ridges, between abdomen and first 3 or 4 post abdominal chambers. More distal ridges are narrow with small rounded nodes.

Remarks: *Parvicingula* sp. A differs from all other species of *Parvicingula* by having a very short, almost non-existent, horn and sharp pointed nodes separating the abdomen and first few post abdominal chambers.

Measurements (µm):	Holotype	avg. 7 spec.	max.	min.
Length (excluding horn)	321	308	346	260
Maximum width	126	116	130	109

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude Formation, Maude and Graham Islands; Yakoun Formation, Graham Island. Illustrated specimens (Holotype) GSC 80664 and (Paratype) GSC 80665 from type locality. Other specimens collected at GSC locs. C-080579, C-080584, C-080591, C-080587, C-080588, C-080593 and C-080594.

Parvicingula sp. B, n. sp
plate 18, figures 3, 4

Diagnosis: Test conical to subcylindrical, rounded apically with strong, steeply tapering horn. Early chambers perforate; later ones with large hexagonal pore frames. Ridges poorly developed, consisting of rows of small rounded nodes; nodes more closely spaced on distal chambers.

Description: Test conical to subcylindrical, rounded apically, usually with 7 to 9 post abdominal chambers. Cephalis wide and hemispherical with strongly tapered horn of moderate length. Remaining chambers trapezoidal to subrectangular, increasing very slightly in width and height; final chamber may or may not decrease slightly in width. Cephalis, thorax and abdomen coarsely perforate. Post abdominal chambers with 3 rows of large (hexagonal) pore frames; pore frames in rows flanking ridges larger than those in central row. Final chamber may have only 2 rows of pore frames. Ridges poorly-developed throughout; those between abdomen and initial post abdominal chambers consisting only of rows of very small nodes. Nodes become more closely spaced and partially continuous with ridges in distal chambers.

Remarks: This species bears no resemblance to any previously described species of *Parvicingula*.

Measurements (µm):	Holotype	avg. 20 spec.	max.	min.
Length (excluding horn)	250	266	300	249
Maximum width	125	136	150	120

Type Locality: GSC loc. C-080595. See Appendix 1.

Range: Zone 7; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimens (Holotype) GSC 80666 and (Paratype) 80667 from type locality. Additional specimens collected at GSC locs. C-080589, C-080592, C-080587, C-080593 and C-080594.

Parvicingula sp. C
plate 18, figure 5

Range and Occurrence: Subzones 7B and 7C; early Bajocian of Yakoun Formation, Graham Island. Specimens collected at GSC locs. C-080592, C-080588, C-080594 and C-080595. Rare. Illustrated specimen GSC 80668 from GSC loc. C-080595.

Genus: *Ristola* Pessagno and Whalen, 1982
Type species: *Parvicingula* (?) *procera* Pessagno 1977a

Ristola sp. A, n. sp.
plate 15, figure 1, 2

Diagnosis: Test small, conical, rounded apically with 3 to 5 post abdominal chambers. Relict pores on cephalis and thorax. Ridges wide and flattened.

Description: Test small, conical, rounded apically, usually with 3 to 5 post abdominal chambers visible in type material. Cephalis hemispherical, other chambers trapezoidal in outline increasing gradually in length and width as added. Cephalis and thorax covered with small, elliptical relict pores. Circumferential ridges between post abdominal chambers are wide and flattened. 3 lateral rows of pore frames (mostly hexagonal) per chamber. Pores flanking ridges are large, circular and slope moderately away from ridges; pores in central row depressed, smaller, elliptical and staggered with respect to flanking rows.

Remarks: This rare form has not been described previously.

Measurements (µm):	Holotype	avg. 6 spec.	max.	min.
Length	192	177	220	145
Maximum width	99	97	110	81

Type locality: GSC loc. C-080586. See Appendix 1.

Range: Zones 6 and 7; Aalenian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Graham Island. Illustrated specimen (Holotype) GSC 80669 from type locality. Other specimens collected at

GSC locs. c-080594 and C-080595.

Ristola sp. B, n. sp.
plate 5, figure 13

Diagnosis: Test conical, rounded apically, usually with 6 post abdominal chambers. Cephalis and thorax separated by rows of large pores. All circumferential ridges nodose; those on earliest chambers very weak.

Description: Test conical, rounded apically, usually with about 6 post abdominal chambers. Apical portion of test conical. Cephalis hemispherical, all other chambers trapezoidal in outline. Cephalis, thorax and abdomen increase in width more rapidly than remaining chambers. Cephalis imperforate; separated from thorax by a row of large pores. Thorax and abdomen coarsely perforate, pore frames hexagonal. Abdomen and post abdominal chambers separated by nodose circumferential ridges; nodes very weak on earliest chambers, becoming larger and somewhat elongate on distal chambers. Ridges are H-linked only between last 4 or 5 post abdominal chambers. Pore frames of post abdominal chambers large, equal-sized, hexagonal, and arranged in 3 staggered rows between circumferential ridges.

Remarks: Bears some resemblance to *R. decora*, but is more gradually conical, less annulate, has more post abdominal chambers and has less massive nodes on ridges.

Measurements (μm):	Holotype	avg. 6 spec.	max.	min.
Length	273	248	290	210
Maximum width	120	121	125	120

Type locality: GSC loc. C-080579. See Appendix 1.

Range: Zone 2; mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80670 and all additional specimens from type locality.

Ristola sp. C
plate 17, figure 11

Range and Occurrence: Subzones 7B and 7C, early Bajocian of Yakoun Formation, Graham Island. Rare. Illustrated specimen GSC 80671 from GSC loc. C-080594. One additional specimen collected at GSC loc. C-080592.

Family: Xitidae Pessagno, 1977b

Genus: *Xitus* Pessagno, 1977b
Type species: *Xitus plenus* Pessagno, 1977b

Xitus sp. A, n. sp.
plate 5, figures 7 and 8

Diagnosis: Test broadly conical, pointed apically with short slender horn. Tubercles constituting outer layer marking chamber boundaries, are offset rather than aligned longitudinally, and are most strongly developed on earlier chambers.

Description: Test broad and conical, pointed apically with short slender horn. Usually with 7 to 10 post abdominal chambers. Cephalis imperforate, covered with layer of microgranular silica. Thorax and abdomen perforate; pore frames pentagonal. Post abdominal chambers have an inner layer of irregularly sized (mostly small and pentagonal) poreframes, outer layer consisting of tubercles and irregular interconnecting bars. Tubercles developed coincident with chamber boundaries, and are offset with respect to one another, rather than aligned longitudinally. Outer layer not developed on final chamber. All post abdominal chambers increasing slightly in width and height as added. Final chamber decreasing somewhat in width. No evidence of a tubular extension.

Remarks: This form bears no resemblance to, and is much older than, any described species of *Xitus*. Pyritized specimens from GSC loc. C-080579 are very large , but nonetheless appear identical to those from the type locality.

Measurements (µm):	Holotype	avg. 10 spec.	max.	min.
Length (excluding horn)	263	331	420	263
Maximum width	140	173	220	140

Type locality: GSC loc. c-080597. See Appendix 1.

Range: Zones 2 to 4; mid to late mid/early late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimens (Holotype) GSC 80672 and (Paratype) 80673 from type locality. Single specimens have been collected at GSC locs. C080583 and C-080584.

Xitus (?) sp. B, n. sp
plate 5, figure 6

Diagnosis: Test large, slender conical with short cylindrical horn. Chamber boundaries marked by rows of distinctive elongate nodes. Pores small and circular.

Description: Test large, elongate conical, pointed apically with short slender cylindrical horn and as many as 11 post abdominal chambers. Cephalis hemispherical and imperforate; all remaining chambers perforate, trapezoidal in outline. Chamber width increases gradually throughout entire test length; chamber height fairly constant. Test has inner layer of small polygonal (mostly pentagonal) pore frames, pores circular to subcircular. Outer layer consists of elongate nodes and a few interconnecting raised "costae-like" irregular bars which are confined principally to initial 3 or 4 chambers. Lateral rows of nodes coincide with chamber joints. Neither pores nor nodes are consistently aligned longitudinally.

Remarks: Genus queried because test is covered with elongate nodes rather than discrete tubercles; also interconnecting bars are very weak. This form differs from *Xitus* sp. A, in having a more conical shape with more numerous, closely-spaced tubercles. Extremely abundant.

Measurements (µm):	Holotype	avg. 14 spec.	max.	min.
Length (excluding horn)	346	293	346	210
Maximum width	190	165	190	125

Type Locality: GSC loc. C-080579. See Appendix 1.

Range: Zones 2 to 6; mid Toarcian to Aalenian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimens (Holotype) GSC 80674 from type locality. Additional specimens found at GSC locs. C-080581, C-080582, C-080583, C-080584, C-080585, C-080597 and C-080586.

Xitus (?) sp. C, n. sp.
plate 15, figure 5

Diagnosis: Test short and conical with sturdy massive horn. Pores moderate in size. Outer layer of tubercles and interconnecting bars appear more like discontinuous costae.

Description: Test short, conical, pointed apically with strong, massive symmetrical horn. 5 or 6 post abdominal chambers on specimens observed so far. Cephalis almost knob-like. Thorax, abdomen and all post abdominal chambers trapezoidal in outline. Thorax and abdomen expanding rapidly in width; remaining chambers expand gradually in width and height. Cephalis imperforate. Pores of thorax and abdomen small and relict, other pores of moderate size, set in polygonal (mostly pentagonal) pore frames. Raised elongate tubercles developed over surface of test, mostly in lateral rows coincident with chamber boundaries. Tubercles, connected by irregular bars, mostly positioned longitudinally, almost like costae.

Remarks: Differs from *Xitus* (?) sp B in being smaller,with larger pores and more massive horn.

Measurements: Will be treated at some future time when further collecting yields additional specimens.

Type locality: GSC loc. C-080594. See Appendix 1.

Range: Zones 6 ?, 7; Aalenian ?, early Bajocian.

Occurrence: Maude Formation ? and Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80675 from type locality. One additional specimen found at GSC loc. C-080593.

Family: Ultranaporidae Pessagno, 1977b

Genus: *Napora* Pessagno, 1977a
Type species: *Napora bukryi* Pessagno, 1977a

Napora sp. A, n. sp
plale 6, figure 10

Diagnosis: Robust form with massive sharply pointed horn and long, slightly curved triradiate feet. Mouth distinctly triangular. Thorax has 4 lateral rows of mostly tetragonal pore frames.

Description: Robust form with massive horn and long, slightly curved, triradiate feet. Cephalis knob-shaped, bearing a long pointed horn. Two thirds down length of horn below tip, are 9 small node-like protrusions arranged in three horizontal groups of 3. Each group is separated from the next by a deep narrow groove, but the 3 protrusions within each group alternate with a pair of shallow grooves. Thorax trapezoidal, strongly triangular in transverse section. 3 pronounced ridges are superimposed on thorax; these extend from base of cephalis to tips of feet. Cephalis and thorax covered with coarse, irregularly polygonal pore frames, those on thorax are larger, mostly tetragonal and arranged in 4-6 lateral rows concentric with base of thorax.

Remarks: This form differs from all other described species of *Napora* by having prominent rows of laterally aligned, mostly tetragonal, pore frames.

Measurements (μm):	Holotype	avg. 8 spec.	max.	min.
Height of cephalis and horn	138	120	138	100
Width of cephalis	79	69	79	60
Height of thorax	84	107	152	84
Width of thorax	157	152	162	130
Length of feet	88	113	130	88

Type locality: GSC loc. C-080579. See Appendix 1.

Range: Zones 1 and 2; late Pliensbachian to mid Toarcian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80676 and all measured paratypes from type locality. Single specimen from GSC loc. C-080577 destroyed during SEM photography.

Napora sp. aff. *N. bukryi* Pessagno
plate 14, figure 1

aff. *Napora bukryi* Pessagno, 1977a, p. 94, pl. 12, fig. 8

Remarks: This form is closely related (perhaps ancestral ?) to the Upper Jurassic *N. bukryi*, but differs in having a longer horn (70 - 90 µm , on 9 specimens) and longer feet (80 -120 µm, on 5 specimens).

Range: Zones 1 to 5; late Pliensbachian to late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen GSC 80677 from GSC loc. C-080583. Other specimens collected at GSC locs. C-080577, C-080579, C-080581, C-080584, C-080585 and C-080597.

Napora sp. B, n. sp.
plate 6, figure 7

Diagnosis: Robust form with long slightly twisted apical horn and long, massive, strongly-triradiate wide-spreading feet. Cephalis and thorax small. Basal aperture triangular.

Description: Cephalis small with extremely long and massive, slightly twisted, triradiate horn. Thorax small and dome-shaped, covered with small but coarsely polygonal, pore frames. Slight stricture separates cephalis and thorax. Basal aperture triangular and somewhat constricted. Feet curved and widely spreading, massive, long and strongly triradiate. Outermost ridge of each foot extends upwards over thorax to near base of cephalis. All feet broken.

Remarks: This form bears no resemblance to any previously described species of *Napora*. Abundant at GSC loc. C-080579, questionable at GSC loc. C-080589.

Measurements (µm):	Holotype	avg. 6 spec.	max.	min.
Height of cephalis and horn	180	188	205	150
Width of cephalis	60	55	60	45
Height of thorax	82	75	82	60
Width of thorax	120	115	130	100
Length of feet (broken)	140	-	140	-

Type locality: GSC loc. c-080579. See Appendix. 1.

Range: Zone 2 and Subzone 7A (?); mid Toarcian, earliest Bajocian (?), respectively.

Occurrence: Maude and Yakoun Formations, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80678 from type locality. Collected also at GSC loc. C-080589.

Napora sp. C,* n. sp
plate 14, figure 2

Diagnosis: Small delicate form. Cephalis has short, stout, triradiate horn with subsidiary spines. Thorax inflated with triangular basal mouth and 3 widely spread, curving triradiate feet.

Description: Cephalis small with short, stout, tribladed horn; horn with 3 subsidiary spines. Thorax inflated, dome-shaped with uniformly sized (mostly hexagonal) pore frames, a large rounded triangular basal aperture and 3 widely spread, curved, triradiate feet. On some specimens the outer ridge of each foot extends approximately halfway up meshwork of thorax.

Remarks: This form is similar to *Napora* sp. B, n. sp. but differs only in its smaller size, more delicate meshwork and in having a shorter horn with subsidiary spines. It has affinitites with some specimens figured by Yao, 1978, p. 39, pl. 10, fig. 2a,b and 3.

Measurements (µm):	Holotype	avg. 8 spec.	max.	min.
Height of cephalis and horn	97	103	121	90
Width of cephalis	50	42	51	35
Height of thorax	68	70	80	50
Width of thorax	109	108	112	103
Length of feet	141	111	141	100

Type locality: GSC loc. C-080584. See Appendix 1.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Maude and Graham Islands. Illustrated specimen (Holotype) GSC 80679 from type locality. Additional specimens collected at GSC locs. C-080583 and C-080584.

* Subsequent to the completion of Text figures 6 and 7, this species has been reassigned to *Napora* sp. aff. *N. cosmica*, Pessagno, Whalen and Yea (in press, p. 82, pl. 6, fig. 8). ? Aalenian; Warm Springs Member, Snowshoe Formation; east-central Oregon.

Family: Paleoscenidiidae Riedel, 1967, emend. Holdsworth, 1977

Remarks: The Paleoscenidiidae were tentatively assigned to suborder Spumellariina by Holdsworth (1977). Dumitrica (1978) and Furutani (1982) concur because of forms with spherical shells. However Takemura and Nakaseko (1982) in their studies of the Jurassic genera *Hilarisirex* and *Diceratigalea* note that these forms possess the cephalo-thorax and cephalic skeletal elements of Nassellariina as well as the spicular elements (4 basal spines; 2 to 4 apical spines) of the Paleosceniniidae. The taxonomic position of this family therefore is still uncertain.

Subfamily: Hilaricirecinae Takemura and Nakaseko, 1982

Genus: *Diceratigalea* Takemura and Nakaseko, 1982
Type species: *Diceratigalea hemisphaera* Takemura and Nakaseko, 1982

Diceratigalea hemisphaera ? Takemura and Nakaseko

? *Diceratigalea hemisphaera* Takemura and Nakaseko, 1982, p. 461, pl. 72, fig. 1-2.

Remarks: species queried because the lower-based, long and curving apical spine characteristic of *D. hemisphaera* is broken off near the base in my specimen. In all other respects this form appears identical to *D. hemisphaera*.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Graham Island. Unfigured specimen GSC 80680 from GSC loc. C-080583.

Diceratigalea sp. A, n. sp.
plate 14, figure 4

Diagnosis: Hemispherical dicyrtid with 2 stout, subequal, asymmetrical apical horns and 4 slender triradiate feet that extend obliquely outwards from base of thorax.

Description: Cephalis spherical and imperforate with 2 short, stout triradiate apical horns. Horns are subequal in length and asymmetrical (1 arises more apically than the other). Thorax hemispherical, surface covered with irregularly-sized, mostly circular pores. Basal aperture large and circular. Four long slender triradiate feet extend outwards obliquely from near base of thorax.

Remarks: Differs from *D. hemisphaera* in possessing 2 apical horns that are short and of equal length. In addition the outer ridge of each triradiate foot is not as prominently displayed on the lower thoracic wall as in *D. hemisphaera*.

Measurements (µm):	Holotype	avg. 8 spec.	max.	min.
Height of cephalis and thorax	152	131	152	110
Width of thorax	142	142	150	130
Length of longest horn	50	64	220	45

Type locality: GSC loc. C-080583. See Appendix 1.

Range: Zone 4; late mid/early late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80681 from type locality. Additional specimens from GSC locs. C-080582, C-080584 and C-080585.

Family: Eptingiidae Dumitrica, 1978

Genus: *Perispyridium* Dumitrica, 1978
Type species: *Trilonche* (?) *ordinaria* Pessagno, 1977b

Perispyridium sp. A, n. sp.
plate 15, figure 6

Diagnosis: Strongly triangular peripheral shell with medium-sized circular pores, well marked sleeve-like extensions and massive triradiate spines with crownlike tips.

Description: Cephalis relatively large and indistinct with large irregular pentagonal pore frames and irregular pores. Peripheral lattice shell triangular in outline and relatively thick at right angles to frontal plane. Apical and 2 primary lateral spines triradiate both within and outside of peripheral shell. External spines long and massive with alternating ridges and grooves. Grooves merge to form pointed tips. Ridges end abruptly before tips; distal ends of ridges have small subsidiary spines giving spine tips a crownlike appearance. Sides and edges of peripheral shell have medium-sized, irregular, tetragonal, pentagonal and hexagonal pore frames with moderately developed nodes at vertices. Nodes are larger and laterally aligned on sleevelike extensions at base of spines.

Remarks: Differs from *P. gemmatum* in having a strongly triangular shell with sleevelike extensions and longer more massive spines. Differs from *P. alinchakense* in having stronger nodes, wider sleevelike extensions and more massive spines with pointed rather than blunt tips.

Measurements (µm):	Holotype	avg.12 spec.	max.	min.
Width of test (along spine axis)	133	129	135	120
Length of longest spine	87	94	125	80

Type Locality: GSC loc. C-080595. See Appendix 1.

Range: Zone 7; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80682 from type locality. Additional specimens collected at GSC locs. C-080589, C-080593 and C-080594.

Perispyridium (?) sp. B, n. sp.
plate 6, figures 1, 2

Diagnosis: Strongly triangular thickened peripheral shell with concave sides, heavy nodes and prominent sleevelike extensions. 3 spines are massive and triradiate with crownlike extensions (produced by subsidiary spines on ridge tips).

Description: Cephalis indistinct, peripheral shell triangular in outline, sides concave; shell thickened at right angles to frontal plane. Apical and 2 primary lateral spines often not at 120°. Spines massive, triradiate with alternating ridges and grooves. Ridges wide and deep, grooves relatively shallow and merge to a point. Outer tip of each ridge is widened and blunt. The subsidiary spines together produce a crownlike structure.

Remarks: Differs from *P.* sp. A, n. sp. in having a thicker shell with concave sides, more massive pore frames and heavier nodes.

Measurements (µm):	Holotype	avg. 10 spec.	max.	min.
Width of test (along spine axis)	120	130	150	112
Length of longest spine	93	96	110	82

Type Locality: GSC loc. C-080588. See Appendix 1.

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude and Yakoun Formations, Maude and Graham Islands. Illustrated specimens (Holotype) GSC 80683 from type locality, (Paratype) GSC 80684 from GSC loc. C-080579. Additional specimens have been collected at GSC locs. C-080597, C-080589, C-080593 and C-080595. Species is abundant only at GSC loc. C-080579 (mid Toarcian).

Family: Eucyrtidiidae Ehrenberg, 1847

Genus: *Eucyrtidium* Ehrenberg, 1847
Type species: *Lithocampe acuminata* Ehrenberg, 1844

Eucyrtidium (?) *unumaensis* Yao

Eucyrtidium (?) *unumaensis* Yao, 1979, p. 39, pl. 9, fig. 1-11.

Range and Occurrence: Zones 2 to 7; mid Toarcian, early Bajocian. Rare specimens found at GSC locs. C-080579 and C-080591. Inuyama area, Gifu and Aichi Prefectures, Japan: see Yao (1979). Specimen GSC 80685 from GSC loc. C-080579.

Eucyrtidium sp. A, n. sp
plate 17, figure 13

Diagnosis: Ovate smooth multicyrtid with thick walled test (at least 2 layers), and medium-sized symmetrical horn.

Description: Test ovate, usually with 6-8 post abdominal chambers, and a medium -sized symmetrical horn. Boundaries between initial chambers indistinct; distal chambers separated by slightly thickened ridges and/or lateral rows of small, poorly-developed nodes. All chambers separated internally by planiform partitions with circular apertures. Apical chambers increase rapidly in width, intermediate chambers are cylindrical, final chamber always slightly constricted. Height of all chambers appears to be constant. Test walls thick, composed of at least 2 (and likely more) layers of pores set in hexagonal pore frames. Pores circular on outer layer; small on proximal chambers, becoming larger and more uniform in size on distal chambers.

Remarks: This form bears no resemblance to any known species of *Eucyrtidium*. Specimens (not illustrated) of mid Toarcian age are very similar (possibly ancestral ?) to *E.* sp. A, n. sp., but differ in having a greater number of post abdominal chambers and coarser meshwork with smaller, more irregularly arranged pore frames.

Measurements (µm):	Holotype	avg. 17 spec.	max.	min.
Maximum length (excluding horn)	244	287	350	230
Maximum width	144	153	170	135
Length of horn	38	28	40	20

Type locality: GSC loc. C-080595. See Appendix 1.

Range: Zone 7; early Bajocian.

Occurrence: Maude Formation, Maude Island; Yakoun Formation, Graham, Island. Illustrated specimen (Holotype) GSC 80686 from type locality. Additional specimens collected at GSC locs. C-080593 and C-080594. Middle Toarcian specimens (not illustrated) from C-080579. Abundant at all localities.

Genus: *Lithocampe* Ehrenberg, 1847
Type species *Lithocampe radicula* Ehrenberg, 1844 (subsequent designation by Frizzell, 1951)

Lithocampe (?) sp. A, n. sp
plate 6, figure 4

Diagnosis: Spindle-shaped multicyrtid with 3-4 post abdominal chambers separated by variably developed circumferential ridges. Pore frames hexagonal.

Description: Test spindle-shaped, inflated, normally with 3-4 post abdominal chambers. Cephalis hemispherical; thorax, abdomen and post abdominal chambers trapezoidal in outline. Thorax, abdomen and first post abdominal chamber increase rapidly in width. Width and height of remaining post abdominal chambers increases gradually except for final 1 or 2 chambers where width decreases gradually. Cephalis imperforate, all other chambers coarsely perforate. Pore frames which are hexagonal (2-3 rows per chamber) are small initially, becoming massive on post abdominal chambers. Post abdominal chambers separated externally by variably developed circumferential ridges which are continuous internally with weak to moderately developed circular planiform partitions having a circular aperture.

Remarks: This form has many features in common with the Parvicingulidae Pessagno, but is temporarily assigned to *Lithocampe* because it possesses few post abdominal chambers, the final ones always constricted. Abundant in middle Toarcian deep water assemblages. Rare in lower Bajocian samples.

Measurements (µm):	Holotype	avg. 18 spec.	max.	min.
Length of test	202	169	205	145
Maximum width	123	116	132	110

Type Locality: GSC loc. C-080579. See Appendix 1.

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude Formation, Maude Island; Yakoun Formation, Graham Island. Illustrated specimen (Holotype GSC 80687 from type locality. Additional specimens found at GSC locs. C-080589, C-080588 C-080594 and C-080595.

Lithocampe sp. B, n. sp.
plate 17, figure 14

Diagnosis: Spindle-shaped inflated test with 3-4 post abdominal chambers and irregular circular pores. Final chamber constricted.

Description: Test spindle-shaped and inflated with 3-4 post abdominal chambers. Cephalis hemispherical, all other chambers trapezoidal in outline. All but final chamber increasing gradually in width, final chamber constricted. Slight constrictions between chamnbers. Surface of test covered with irregularly sized circular pores. Large circular aperture.

Remarks: Rare in lower Bajocian samples.

Measurements: Holotype is 170 µm long and has a maximum width of 105 µm. Further measurements will not be treated until additional specimens are collected.

Type locality: GSC loc. C-080592. See Appendix 1.

Range: Subzones 7B and 7C; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen (Holotype) GSC 80688 from type locality. Single specimens collected at GSC locs. C-080588 and C-080595.

Family: Pylentonemidae Deflandre, 1963
Subfamily: Poulpinae De Wever, 1979

Genus: *Poulpus* De Wever, 1979
Type species: *Poulpus piabyx* De Wever, 1979

Poulpus (?) sp.
plate 2, figures 10, 11

Remarks: Single nodose specimen collected, tentatively assigned to *Poulpus*, has a triradiate horn and 3 (1 broken off) triradiate spinelike feet with weak subsidiary spines at distal ends of ridges. Further description will await collection of additional specimens.

Range and Occurrence: Zone 1; late Pliensbachian of Maude Formation, Maude Island. Illustrated specimen GSC 80689 from GSC loc. C-080577.

Spongocapsulidae incertae sedis

Remarks: Assignment of *Maudia* n. gen to the Spongocapsulidae Pessagno is questionable because *Maudia* apparently lacks septal platforms separating post abdominal chambers from each other. According to Pessagno (1977a) these partitions are characteristic of the Spongocapsulidae, which to date represent the only family of spongy nassellarians.

Genus: *Maudia* n. gen.
Type species: *Maudia yakounensis* n. sp.

Description: Conical test with thick spongy wall and long horn. Test probably has multiple chambers but these are not visibly divided and lack septal partitions. Details of internal structure unknown.

Remarks: *Maudia* n. gen. differs from *Spongocapsula* by possessing an apical horn and lacking septal partitions.

Etymology: Named for Maude Island in Skidegate Inlet; an important area for study of Lower Jurassic faunas.

Range: late Early Jurassic.

Maudia yakounensis n. sp.
plate 14, figure 9

Diagnosis: Elongate conical test with thick spongy walls and a long slender horn.

Description: Test elongate conical with a thick, porous spongy wall composed of minute irregularly polygonal pore frames. Cephalis dome-shaped, with a long slender needle-like horn. Remaining chambers trapezoidal in outline but thick wall obscures chamber boundaries. Apertural edges of all tests are ragged, and probably broken, thus knowledge of complete test is unknown at this time.

Etymology: Named for the Yakoun River; occurrence is restricted so far, to river localities.

Measurements (µm):	Holotype	avg. 11 spec.	max.	min.
Length (excluding horn)	300	222	300	170
Maximum width	220	164	220	130
Length of horn	85	95	120	80

Type locality: GSC loc. C-080585. See Appendix 1.

Range: Zone 4; late middle/early late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80690 from type locality. Additional specimens collected at GSC locs. C-080582, C-080583 and C-080584.

Family: Amphipyndacidae Riedel, 1967

Genus: *Stichocapsa* Haeckel, 1882
Type species: *Stichocapsa jaspidea* Rüst, 1885

Stichocapsa sp cf. *S. convexa* Yao
plate 6, figures 5, 6

cf. *Stichocapsa convexa* Yao, 1979, p. 35, pl. 5, fig. 14-16; pl. 6, fig. 1-7.

Remarks: Form is very similar to *S. convexa* but the dense row of pores at proximal part of thorax has not been noted. Abundant in all deeper water assemblages.

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude Formation, Maude Island; Yakoun Formation, Graham Island. Illustrated specimens GSC 80691 and 80692 from GSC locs. C-080579 and C-080594, respectively. Additional specimens found at GSC loc. C-080589, C-080590, C-080592, C-080588, C-080593 C-080595 and C-080596.

Stichocapsa sp. aff. *S. japonica* Yao
plate 15, figure 7

aff. *Stichocapsa japonica* Yao, 1979, p. 36, pl. 6, fig. 8-12; pl. 7, fig. 1-15.

Remarks: Species differs from *S. japonica* in having larger circular pores. Most specimens have 4 chambers only, when a 5th chamber is present it is either the same size as the 4th chamber or smaller (as in the illustrated specimen).

Range: Zone 7; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80693 from GSC loc. C-080594. Additional specimens collected at GSC locs. C-080589, C-080592, C-080588, C-080593 and C-080595.

Subfamily: Syringocapsinae Foreman, 1973

Genus: *Syringocapsa* Neviani, 1900
Type species: *Theosyringium robustum* Vinassa, 1900

Syringocapsa sp. A
plate 2, figures 4, 9

Remarks: A number of forms are tentatively grouped together as *Syringocapsa* sp. A and are thought to represent variants of one species. Collectively they differ in having a less or more expanded fourth globose chamber. Additionally, in many forms combined height of initial chambers appears to vary inversely with the height of the single expanded terminal chamber.

The more inflated forms are very similar to *Syringocapsa* sp. B of Yao, 1982, p. 58, pl. 4, fig. 14, 15, which is a species characteristic of the *Parahsuum simplum* Assemblage from the early Early Jurassic of Japan.

Range and Occurrence: Zone 1; late Pliensbachian. Maude Formation, Maude and Graham Islands. Illustrated specimens GSC 80694 and 80695 from GSC loc. C-080577 where the species is very abundant. Additional specimen collected at GSC loc. C-080580.

Syringocapsa sp. B

Remarks: This form appears identical to *Syringocapsa* sp. C of Yao, 1982, p. 58, pl. 4, fig. 16 and 1983, p. 369, pl. 2, fig 18, a characteristic species of the *Parahsuum simplum* Assemblage; early Early Jurassic of Japan.

Range and Occurrence: Zone 1; late Pliensbachian. Maude Formation, Maude Island. Rare at GSC loc. C-080577. GSC 80696 (not illustrated) from GSC loc. C-080577.

Family: Theocorythidae Haeckel, 1882

Genus: *Tricolocapsa* Haeckel, 1881
Type species: *Tricolocapsa theophrasti* Haeckel, 1881

Tricolocapsa (?) *fusiformis* Yao

Tricolocapsa (?) *fusiformis* Yao, 1979, p. 33, pl. 4, fig. 12-18; pl. 5, fig. 1-4.

Remarks: *Tricolocapsa* (?) *fusiformis* is common to the *Hsuum* B and *Unuma echinatus* Assemblages (late Early to middle Middle Jurassic) of Japan (Yao, 1983, p. 369).

Range and Occurrence: Zone 7; early Bajocian. Yakoun Formation, Graham Island. Specimen GSC 80697 (not illustrated). Occurs rarely at GSC loc. C-080594. Inuyama area, Japan: see Yao (1979).

Tricolocapsa sp. cf. *T. rusti* Tan (Yao)
plate 6, figure 3

Tricolocapsa sp. cf. *T. rusti* Tan, 1927 in Yao, 1979, p. 30, pl. 3, fig. 8-20.

Remarks: This form appears to be conspecific with *Tricolocapsa* sp. cf. *T. rusti* Tan, described by Yao (1979).

Range and Occurrence: Zones 2 to 7; mid Toarcian to early Bajocian. Maude Formation, Maude and Graham Islands; Yakoun Formation, Graham Island. Illustrated specimen GSC 80698 from GSC loc. c-080579. Additional specimens collected at GSC locs. C-080597, C-080586, C-080589, C-0805901, C-080591, C-080587, C-080593, C-080594 and C-080595. Abundant in all deep water assemblages. Inuyama area, Japan: see Yao (1979).

Nassellariina incertae sedis

Genus: *Turanta* Pessagno and Blome, 1983
Type species: *Turanta capsensis* Pessagno and Blome, 1983

Turanta morinae Pessagno and Blome
plate 14, figure 8

Remarks: The range for this species is now lowered to include the mid/late Toarcian as well as the Aalenian.

Range and Occurrence: Zones 3 to 6; late mid Toarcian to Aalenian. Maude Formation, Graham Island. Illustrated specimen GSC 80699 from GSC loc. C-080583. Other specimens found at GSC locs. C-080581, C-080582, C-080585, C-080597 and C-080586. Snowshoe Formation of east-central Oregon: see Pessagno and Blome (1983).

Turanta nodosa Pessagno and Blome
plate 14, figures 3, 11

Turanta nodosa Pessagno and Blome, 1983, p. 301, pl. 22, fig. 4; pl. 3, fig. 1-3, 8, 11, 12, 14.

Range and Occurrence: Zone 4; late mid/early late Toarcian. Maude Formation, Graham Island. Single specimen from GSC loc. C-080583 is illustrated GSC 80700. Snowshoe Formation of east-central Oregon: see Pessagno and Blome (1983).

Turanta sp. A
plate 14, figure 7

Remarks: Specimens are not well enough preserved to permit adequate description. This form with massive spines is comparable with *Turanta* sp. A, of Pessagno and Blome, 1983, p. 302, pl. 2, fig. 1.

Range and Occurrence: Zone 4; late mid/early late Toarcian. Maude Formation, Graham Island. Illustrated specimen GSC 80701 from GSC loc. C-080583. A few additional specimens collected at GSC locs. C-080582 and

C-080584.

Genus: *Lychnocanium* Ehrenberg, 1847
Type species: *Lychnocanium falciferum* Ehrenberg, 1854

Lychnocanium (?) * sp. A, n. sp.
plate 2, figures 7, 8

Diagnosis: Dicyrtid with small cephalis, globose abdomen with roughened surface, long triradiate horn and 2 downward curving terminal feet.

Description: Bilaterally symmetrical dicyrtid test. Cephalis medium-sized, spherical, sparsely perforate basally with long tapering apical horn. Horn triradiate with deep grooves on basal half. Thorax large and globose with constricted circular aperture and 2 strong, triradiate downward curving terminal feet. Thorax with roughened surface composed of low nodes or tubercles surrounded by small circular to elliptical pores.

Remarks: Genus queried because *Lychnocanium* has 3 terminal feet. This form is remarkable similar to *L.* (*Lychnocanella*) *pyriforme* Haeckel, 1887, figured by Campbell and Clark, 1954, p. D124, fig. 61, no. 10. No evidence of a third foot is visible on my specimens, therefore this taxon may ultimately turn out to be a new genus.

* Subsequent to the completion of text figures 6 and 7, this species has been reassigned to *Bipedis* sp. A, n. sp. *Bipedis* De Wever (1982, p. 92) was placed by De Wever in the Pylentonemidae Deflandre, 1963.

Measurements: Detailed measurements must await further collection as 2 specimens only, are available for study at this time. Length of cephalis and thorax (excluding horn) 132, 135 µm; maximum width of thorax 139, 140 µm; length of apical horn 60 µm on both; length of feet (paratype only) 92 µm.

Type locality: GSC loc. C-080577. See Appendix 1.

Range: Zone 1; late Pliensbachian.

Occurrence: Maude Formation, Maude Island. Illustrated specimen (Holotype) GSC 80702 and one additional specimen from Type Locality.

Genus: *Lithomelissa* Ehrenberg, 1847
Type species: *Lithomelissa micropteria* Ehrenberg, 1854

Lithomelissa sp. A, n. sp.
plate 14, figure 5

Diagnosis: Flattened conical form with short massive horn and 2 long triradiate lateral wings. Test surface has transverse rows of polygonal pore frames.

Description: Short conical form flattened in plane of lateral wings. Apical horn short and massive. Cephalis trapezoidal in outline; thorax trapezoidal proximally becoming flattened cylindrically in distal portions. Cephalis and thorax separated by a strong transverse raised ridge. Surface of both chambers covered with irregularly polygonal pore frames arranged in lateral rows. Pore frames small on cephalis (at least 5 lateral rows present) becoming larger on thorax. Thoracic ribs prolonged as 2 lateral triradiate wings that curve slightly downward. Complete length of thorax unknown as distal portion of single specimen is broken off.

Remarks: This form appoears to be new and totally unrecorded in the literature.

Measurements: measurements are given for a single specimen only. Height of cephalis 32 µm; maximum width of thorax 136 µm; width between wing tips 384 µm; length of apical horn 68 µm.

Type locality: GSC loc. C-080597. See Appendix 1.

Range: Zone 5; late Toarcian.

Occurrence: Maude Formation, Graham Island. Illustrated specimen (Holotype) GSC 80703 from type locality.

Genus A, undet.
plate 15, fig. 11, 13

Remarks: For completeness, this distinctive ovate form with a short stubby horn and a prominent depression in the cephalo-thoracic area, is included. It appears to have some affinity with *Sethocyrtis multicristata* Rüst (1898, p. 45, pl. 16, fig. 5) but Rüst's figure does not clearly illustrate the circular area below the horn. Further description must await study of the internal structure of this form by light micrographs. Abundant.

Range: Zones 2 to 7; mid Toarcian to early Bajocian.

Occurrence: Maude Formation, Maude and Graham Islands; Yakoun Formation, Graham Island. Illustrated specimen GSC 80704 from GSC loc. C-080586. Additional specimens collected at GSC locs. C-080579, C-080589. C-080588, C-080593, C-080594 and C-080595.

EARLY BAJOCIAN BIOSTRATIGRAPHIC MARKER ?

Group: Acritarcha Evitt
Subgroup: Herkomorphitae Downie, Evitt and Sarjeant

Genus: *Lophodictyotidium* Pocock, 1972
Organism B, Sarjeant, 1960, p. 404, pl. 14, fig. 21.

Lophodictyotidium sp. cf. *L. sarjeanti*
plate 15, figure 10

cf. *Lophodictyotidium sarjeanti* Pocock, 1972, p. 109 (14) pl. 25, fig. 5, 6

Remarks: *Lophodictyotidium* was identified by Dr. G.E. Rouse (pers. comm., 1984) as an acritarch similar to cysts of the Prasinophycea (chlorophyte algae). It compares closely to *L. sarjeanti* but may have an inner layer and is approximately 2X larger. Maximum diameter measured on 25 specimens: 82.0 (108.0) 130.0 µm. Diameter of *L. sarjeanti*: 52.0 (54.0) 58.0 µm. Colour, amber to reddish brown to black. Pocock restricts *L. sarjeanti* to his middle Jurassic Floral Zone $J2^2$ (late Bajocian).

Range: Zone 7; early Bajocian.

Occurrence: Yakoun Formation, Graham Island. Illustrated specimen GSC 80705 from GSC loc. C-080589. Additional specimens occur at GSC locs. C-080590, C-080591, C-080592, C-080587 and C-080588. *L. sarjeanti* occurs in the Shaunavon Formation, southern Sasketchewan and the Sawtooth Formation, southern Alberta.

VII SUMMARY AND CONCLUSIONS

The aim of this thesis was to examine Jurassic Radiolaria of late Pliensbachian to early Bajocian age, including the Toarcian, in the Queen Charlotte Islands. As Toarcian Radiolaria in particular have been little studied worldwide, this work is pioneering. 167 species of spumellarian and nassellarian polycystine Radiolaria have been examined. Of these, no fewer than five genera and 50% of the species are new, the remainder are similar to Tethyan forms from North America, the Mediterranean and Japan. Furthermore, studies of paleomagnetics, ammonite biogeography and radiolarian paleoecology suggest that enclosing sediments were deposited in the northern hemisphere within 30° of the equator.

Detailed and well-dated local zonations are of great value in petroleum exploration and are essential to the outgrowth of global biostratigraphy. Abundant Radiolaria in sediments of the Queen Charlotte Islands provide the basis for a stratigraphic zonation, correlated with the Jurassic Ammonite Zones of Northwest Europe and Western North America. Seven informal faunal zones and three subzones (Oppel zones) are distinguished which, until tested in other areas, apply only to the Queen Charlotte Islands. Marker taxa are erected for all zone boundaries except the upper limit of Zone 7 and Subzones 7A to 7C, which are undefined. The first well established middle Toarcian Radiolaria are documented in Zone 2, whereas late middle to late Toarcian assemblages have been separated into three zones (Zones 3, 4 and 5). All radiolarian assemblages representative of these zones are highly diverse, particularly distinctive and contain many new and unusual forms.

89 new species are described and figured herein: those comprising type species of new genera are fully described, the remainder are named informally. All taxa are included in a many-faceted classification scheme which is undergoing continual modification consistent with the current upsurge in radiolarian study.

A chlorophyte algal cyst comparable to *Lophodictyotidium sarjeanti* Pocock is found in all lowest Bajocian samples. For the present, then, *L.* cf. *sarjeanti* may be employed as a biostratigraphic marker for rocks of this age in the Queen Charlotte Islands.

Paleoenvironmental analysis has been based only on abundant, well preserved assemblages, because in these, preservational bias resulting from diagenesis is reduced and the extant radiolarian population is more closely approximated.

Whereas modern-day radiolarians are confined to the open ocean, Jurassic forms appear to have been abundant in shelf assemblages as well. It may be that: (1) other planktonic organisms (which would have provided biological competition) had not yet evolved and (2) increased silica levels in near shore waters, resulting from volcanic activity in the vicinity of the basin, increased plankton productivity and/or indirectly helped preserve siliceous tests from dissolution.

Depth distribution of radiolarians reflects facies variation in sediments of the upper Maude and lower Yakoun and seemingly parallels the trends in abundance and diversity of modern-day Radiolaria. Offshore facies (shales) are characterized by nassellarians, whereas nearshore facies (sandstones) contain highly diverse and abundant spumellarians most of which have thickened multi-layered or spongy tests. Shallow water nassellarians (multicyrtids) also have thickened tests and although they are less numerous and much less diverse, a few species are abundant. Evidence from the facies sequence and faunal succession of Radiolaria suggests that depth was the major factor controlling their distribution within the basin. Sea-level fluctuations in the Queen Charlotte Islands confirm worldwide trends for sea level change in the Jurassic proposed by other authors.

The apparent facies dependency recognized does not negate the usefulness of Radiolaria in biostratigraphy but does suggest that, when dealing with shallow water assemblages, reasonable caution should be exercised in interpreting biostratigraphic data. It was impossible to test this thesis as samples from differing facies equivalents were unavailable for study. Further collecting in a few key areas is essential in order to validate the overall usefulness of Radiolaria for biostratigrahic correlation, or to establish species correlatives for interpreting age relationships in differing environmental settings.

In summary, this thesis presents a substantial amount of new information and an increased understanding of radiolarian taxonomy, biostratigraphy, distribution patterns and paleoenvironmental relationships. It provides a new tool, of significant potential for petroleum exploration in the Queen Charlotte Islands and indeed for all those working in the early and middle Jurassic of the Pacific Rim.

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PLATE 1

Scanning electron micrographs of Lower Jurassic (late Pliensbachian) Spumellariina from the Maude Formation, Maude Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure Page

1. *Praeconocaryomma immodica* Pessagno and Poisson------------- 104
Hypotype, GSC 80522: scale = 107 µm. GSC loc. C-080577 : late Pliensbachian.

2. *Praeconocaryomma* sp. aff. *P. media* Pessagno and Poisson-------104
GSC 80523: scale = 105 µm. GSC loc. C-080577 : late Pliensbachian.

3,6. *Praeconocaryomma* sp. A, n. sp.-------------------------------- 106
3, Holotype, GSC 80528; 6, Paratype, GSC 80529: scales = 72 and 73 µm, respectively. GSC loc. C-080577 : late Pliensbachian.

4. *Tripocyclia* (?) sp. A, n. sp.------------------------------------ 90
Holotype, GSC 80500: scale = 102 µm. GSC loc. C-080577 : late Pliensbachian.

5. *Praeconocaryomma* (?) sp. B, n. sp.-----------------------------107
Holotype, GSC 80530: scale = 81 µm. GSC loc. C-080577 : late Pliensbachian.

7,10. *Orbiculiforma* sp. A, n. sp.-------------------------------------147
7, Holotype GSC 80596 and 10, Paratype GSC 80597: scale = 90 µm. GSC loc. C-080577 : late Pliensbachian.

8,11 *Orbiculiforma* sp. B, n. sp.-------------------------------------148
11, Holotype, GSC 80599 and 8, (undescribed form referred to in text) GSC 80598: scales = 90 and 100 µm, respectively. GSC loc. C-080577 : late Pliensbachian.

9. *Orbiculiforma* sp. C, n. sp.-------------------------------------149
Holotype, GSC 80600: scale = 100 µm. GSC loc. C-080577 : late Pliensbachian.

12. *Stephanastrum* (?) sp. A, n. sp.---------------------------------159
Holotype, GSC 80618: scale = 129 µm. GSC loc. C-080577 : late Pliensbachian.

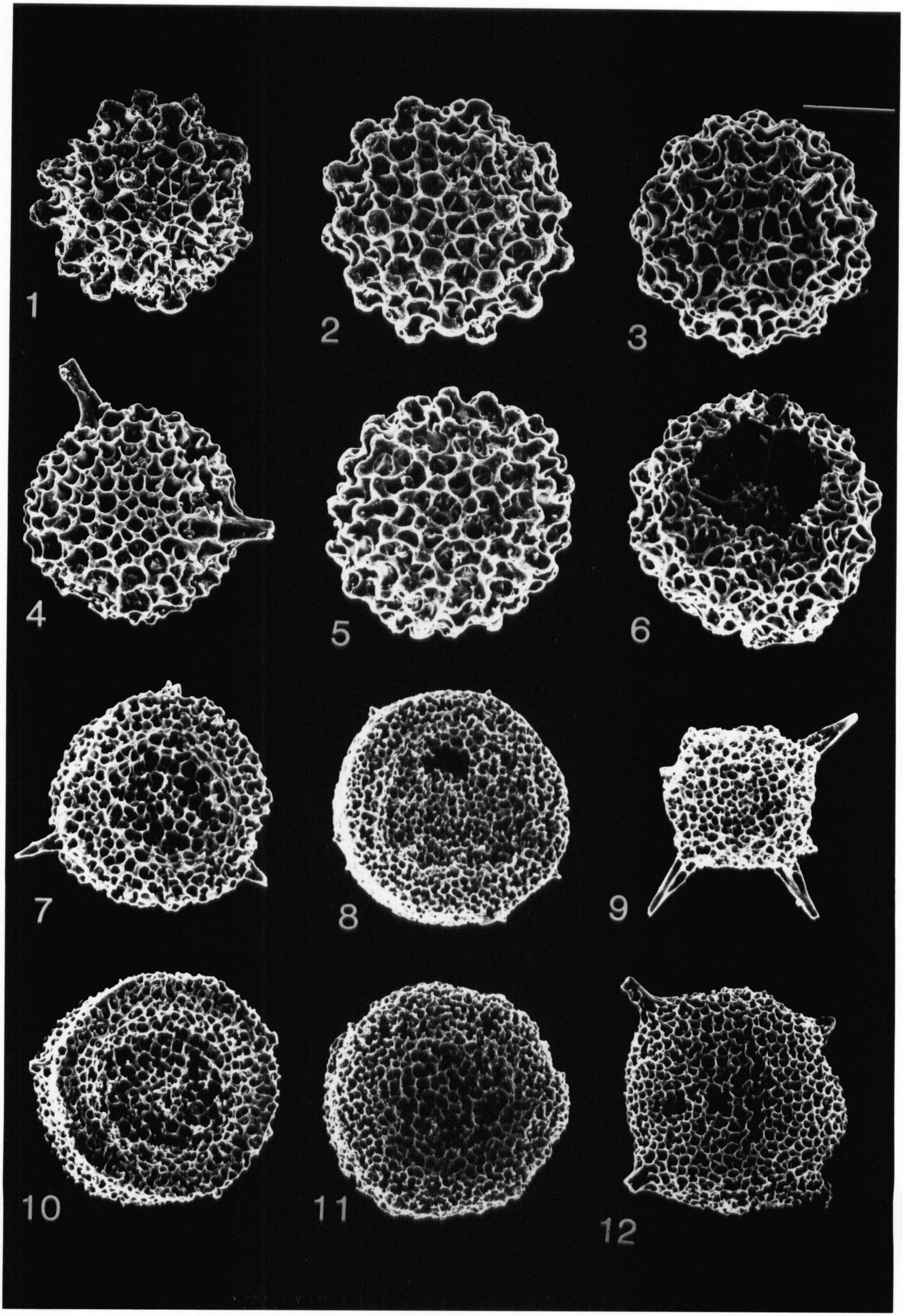
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PLATE 2

Scanning electron micrographs of Lower Jurassic (late Pliensbachian) Radiolaria from the Maude Formation, Maude Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure	Page

1. *Pantanellium* sp. cf. *P. haidaensis* Pessagno and Blome--------- 125
GSC 80559: scale = 83 µm. GSC loc. C-080577 : late Pliensbachian.

2. *Hagiastrum* sp. A, n. sp. -- 95
Holotype, GSC 80508: scale = 111 µm. GSC loc. C-080577 : late Pliensbachian.

3. *Acaeniotyle* (?) sp. A, n. sp.------------------------------------- 108
Holotype GSC 80531: scale = 100 µm. GSC loc. C-080577 : late Pliensbachian.

4,9. *Syringocapsa* sp. A--- 210
4, GSC 80694 and 9, GSC 80695: scales = 127 and 118 µm, respectively. GSC loc. C-080577 : late Pliensbachian.

5,6. *Lupherium* (?) sp. B, n. sp.------------------------------------ 183
5, Holotype GSC 80653 and 6, Paratype GSC 80654: scales = 124 and 102 µm, respectively. GSC loc. C-080577: late Pliensbachian.

7,8. *Lychnocanium* (?) sp. A, n. sp.--------------------------------- 213
Holotype, GSC 80564: scales = 91 and 78 µm, respectively. GSC loc. C-080577 : late Pliensbachian.

10,11. *Poulpus* (?) sp.--- 207
GSC 80689: scales = 91 and 53 µm, respectively. GSC loc. C-080577 : late Pliensbachian.

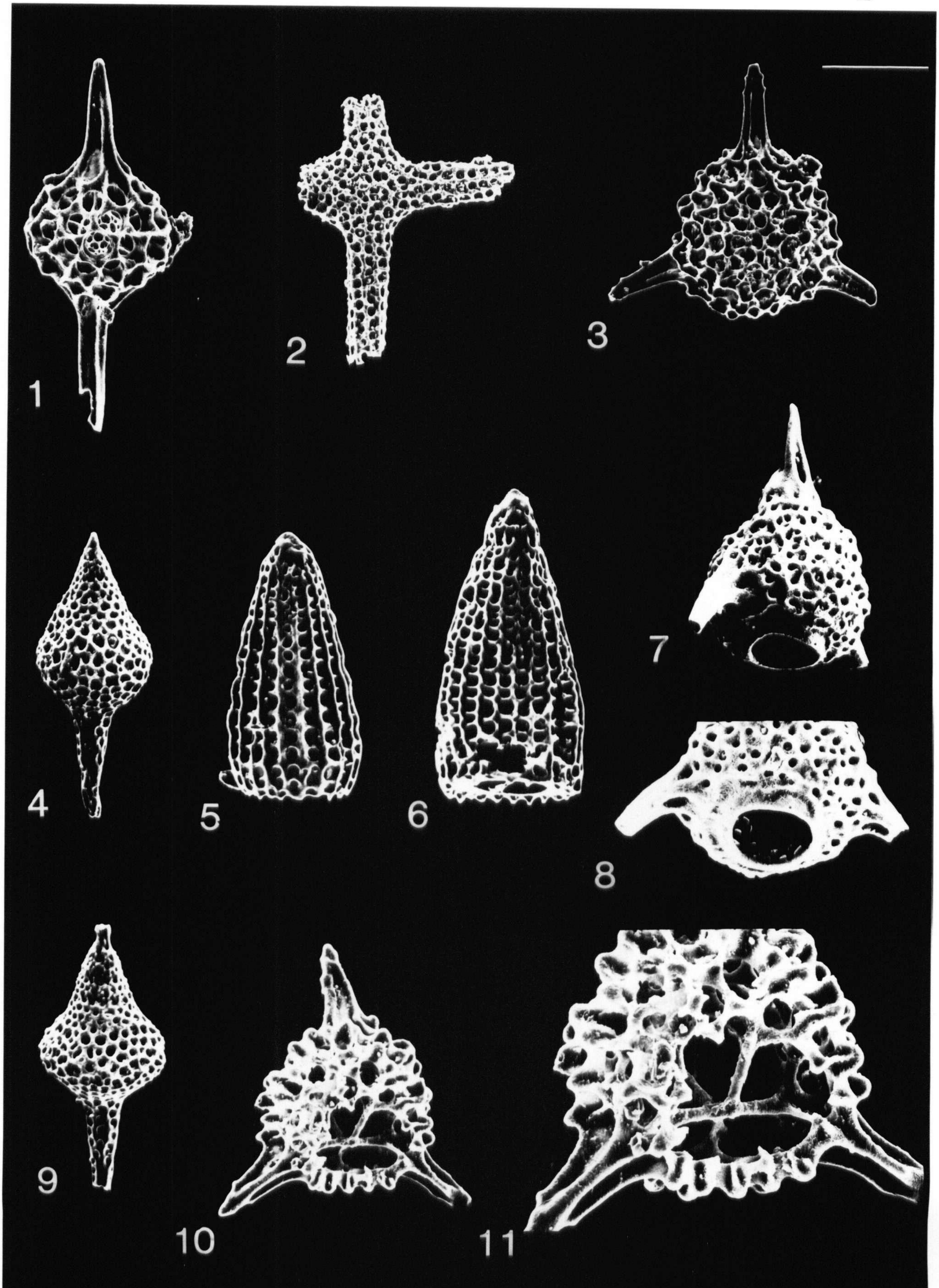
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PLATE 3

Scanning electron micrographs of Lower Jurassic (late Pliensbachian) Nassellariina from the Maude Formation, Maude Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure Page

1. *Canutus giganteus* Pessagno and Whalen------------------------ 171
GSC 80636: scale = 190 µm. GSC loc. C-080577 : late Pliensbachian.

2. *Canutus izeensis* Pessagno and Whalen------------------------- 171
GSC 80638: scale = 99 µm. GSC loc. C-080577 : late Pliensbachian.

3. *Canutus tipperi* Pessagno and Whalen-------------------------- 171
GSC 80639: scale = 170 µm. GSC loc. C-080577 : late Pliensbachian.

4,9. *Canutus* sp. A, n. sp.-- 172
Holotype GSC 80640: scales = 172 and 115 µm, respectively. GSC loc. C-080577 : late Pliensbachian.

5. *Canutus blomei* Pessagno and Whalen--------------------------- 170
GSC 80635: scale = 180 µm. GSC loc. C-080577 : late Pliensbachian.

6,8, 12. *Canutus* sp. B, n. sp.-- 173
8, 12, Holotype GSC 80642; 6, Paratype GSC 80641: scales = 203, 100 and 177 µm, respectively. GSC loc. C-080577 : late Pliensbachian.

7. *Droltus* sp. cf. *D. lyellensis* Pessagno and Whalen--------------- 164
GSC 80624: scale = 92 µm. GSC loc. C-080577 : late Pliensbachian.

10,11 *Canutus hainaensis* Pessagno and Whalen----------------------- 171
GSC 80637: scales = 96 and 227 µm, respectively. GSC loc. C-080577 : late Pliensbachian.

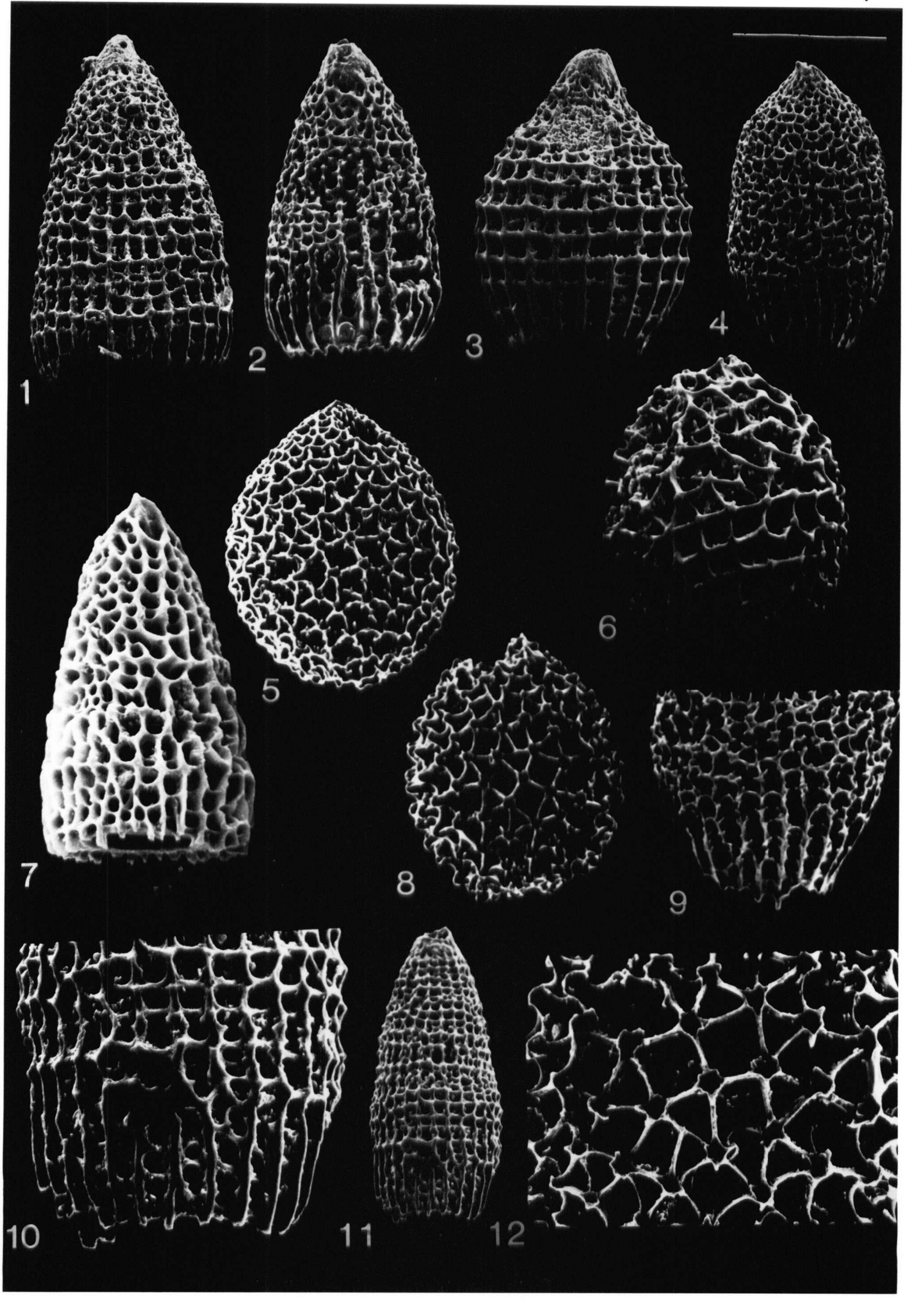

PLATE 4

Scanning electron micrographs of Lower and Middle Jurassic (late Pliensbachian - early Bajocian) Radiolaria from the Maude and Yakoun Formations, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure | Page

1. *Emiluvia* (?) sp. C, n. sp.-- 116
Holotype, GSC 80544 : scale = 61 µm. GSC loc. C-080579 : mid Toarcian.

2. *Emiluvia* sp. D, n. sp.-- 116
Holotype, GSC 80545 : scale = 100 µm. GSC loc. C-080579 : mid Toarcian.

3. *Emiluvia* sp. E, n. sp.-- 117
Holotype, GSC 80546 : scale = 100 µm. GSC loc. C-080579 : mid Toarcian.

4, 5. *Emiluvia* sp. F, n. sp.-- 118
4, Holotype, GSC 80547 : scale = 115 µm. GSC loc. C-080595 : early Bajocian. 5, Paratype, GSC 80548 : scale = 119 µm. GSC loc. C-080579. mid Toarcian.

6, 9. *Paronaella* sp. G, n. sp.-- 138
6, Holotype, GSC 80584 : scale = 98 µm. GSC loc. C-080584 and
9, Paratype, GSC 80585 : scale = 100 µm, abherent form with 4 arms.
GSC loc. C-080597: Late mid/early late Toarcian.

7. *Alievium* (?) sp. A, n. sp.-- 145
Holotype, GSC 80594 : scale = 57 µm. GSC loc. C-080579 : mid Toarcian.

8. *Paronaella* sp. cf. *P. mulleri* Pessagno-------------------------- 132
Holotype, GSC 80571 : scale = 81 µm. GSC loc. C-080579 : mid Toarcian.

10. *Paronaella* sp. B, n. sp. -- 134
Paratype, GSC 80574 : scale = 105 µm. GSC loc. C-080577 : late Pliensbachian.

11,12 *Crucella* sp. B, n. sp. ------------------------------------- 143
11, Holotype, GSC 80591: scale = 119 µm, and 12, Paratype, GSC 80592 : scale = 150 µm, from GSC loc. C-080577 : late Pliensbachian.

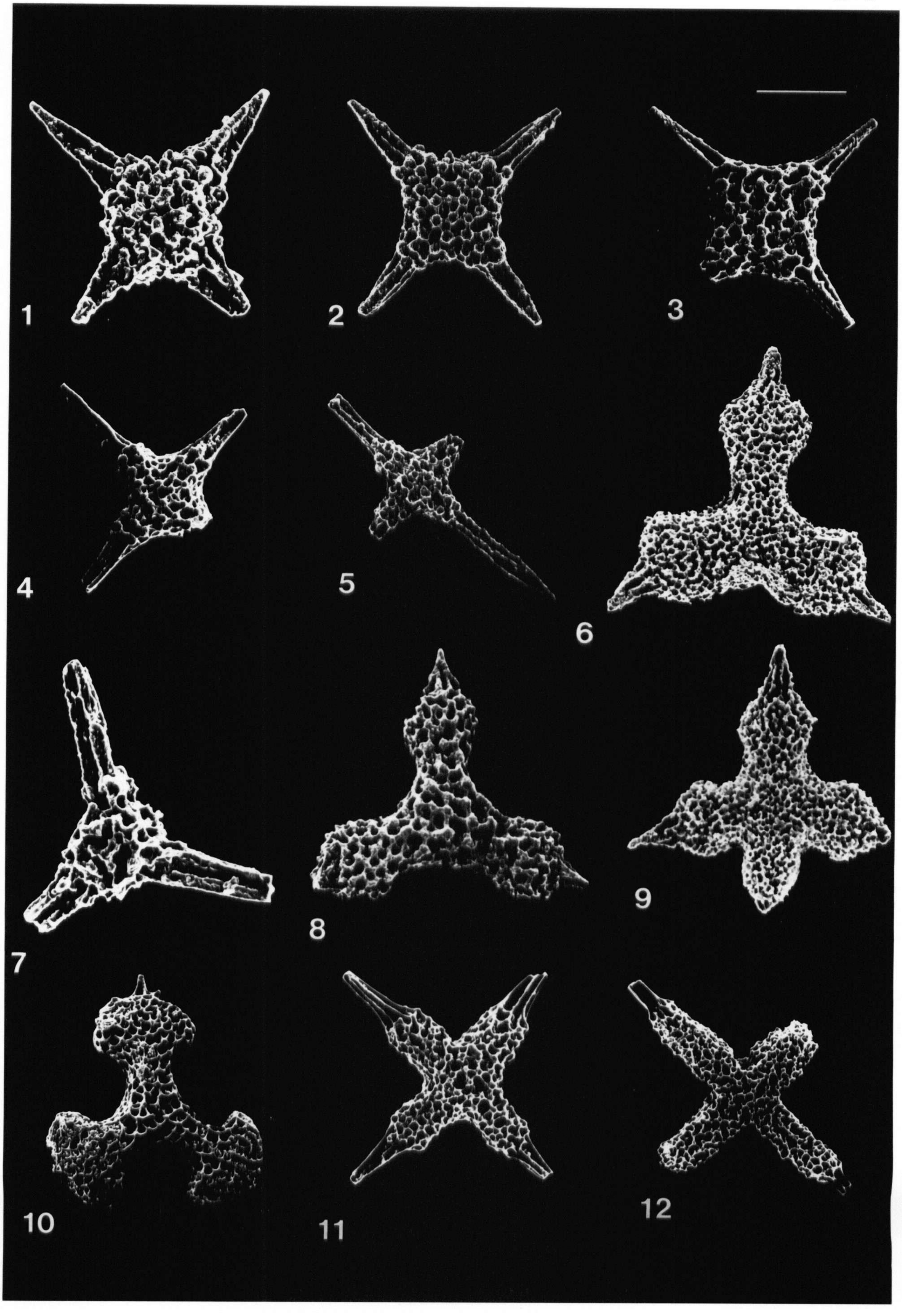
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PLATE 5

Scanning electron micrographs of Lower Jurassic (mid to late Toarcian) Radiolaria from the Maude Formation, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure | Page

1. *Parvicingula* (?) sp. -- 188
GSC 80661 : scale = 104 µm. GSC loc. C-080579 : mid Toarcian.

2. *Hsuum* sp. A, n. sp.-- 182
Holotype, GSC 80651: scale = 167 µm. GSC loc. C-080579 : mid Toarcian.

3,4,5. *Hsuum* sp. cf. *H. rosebudense* Pessagno and Whalen------------- 176
3 (Var. A), GSC 80648 ; 4 (Var. B), GSC 80649 ; 5 (Var. C), GSC 80650 : scales = 83,100 and 82 µm, respectively. GSC loc. C-080579 : mid Toarcian.

6. *Xitus* (?) sp. B, n. sp.-- 195
Holotype, GSC 80674 : scale = 128 µm. GSC loc. C-080579 : mid Toarcian.

7,8. *Xitus* sp. A, n. sp. -- 194
7, Holotype, GSC 80672 and 8, Paratype, GSC 80673 : scales = 128 and 156 µm, respectively. GSC loc. C-080597 : late Toarcian.

9,10, 14. *Canoptum anulatum* Pessagno and Poisson--------------------- 166
10,14, Hypotype, GSC 80628; 9, GSC 80627 (a large specimen questionably assigned to *C. anulatum*) : scales = 145 and 47 and 250 µm, respectively. GSC loc. C-080579 : mid Toarcian.

11. *Lupherium* (?) sp. C, n. sp.-- 184
Holotype, GSC 80655 : scale = 83 µm. GSC loc. C-080579 : mid Toarcian.

12. *Lupherium* (?) sp. D, n. sp.-- 184
Holotype, GSC 80656 : scale = 152 µm. GSC loc. C-080579 : mid Toarcian.

13. *Ristola* sp. B, n. sp.-- 193
Holotype, GSC 80670 : scale = 115 µm. GSC loc. C-080579 : mid Toarcian.

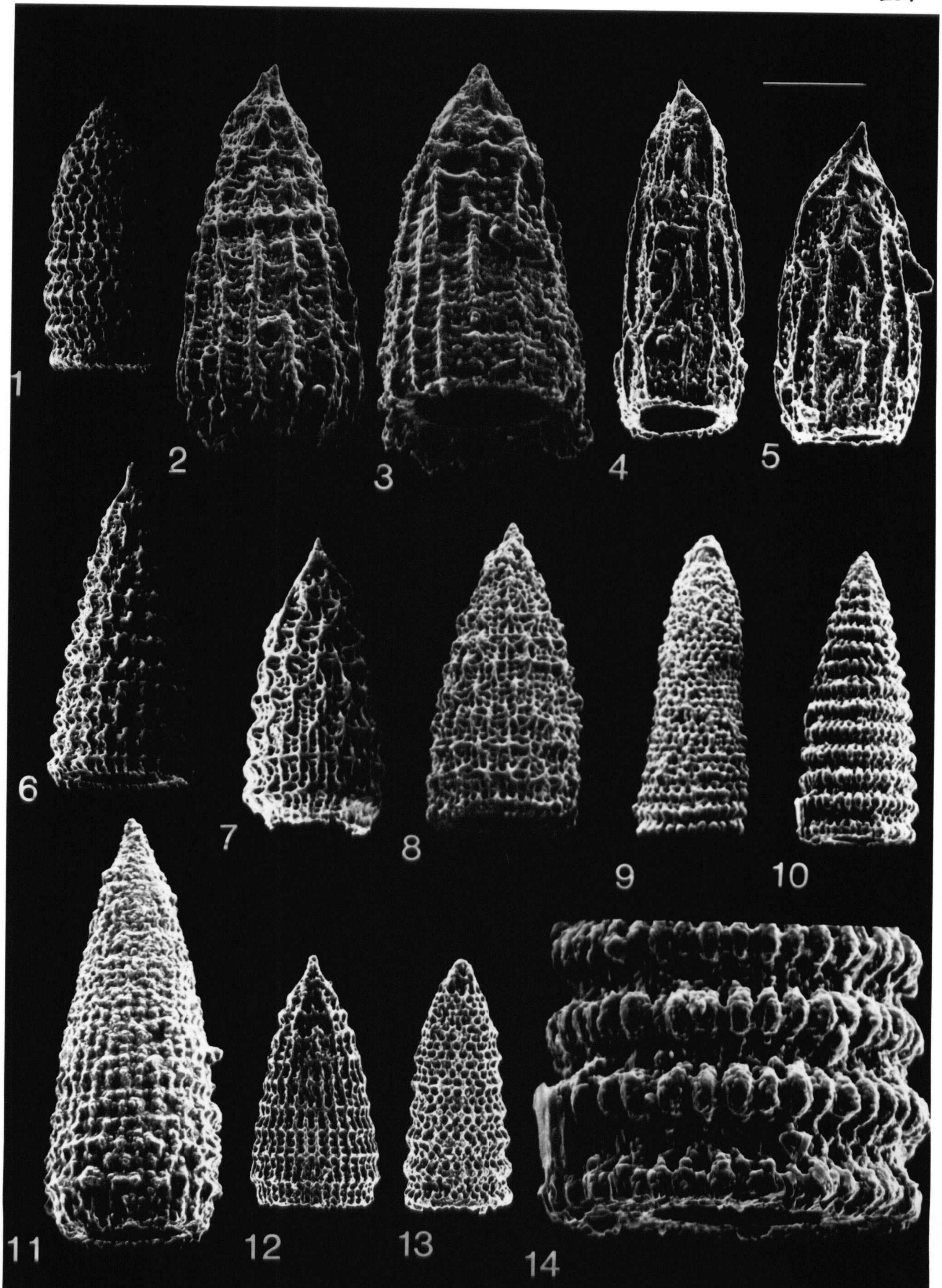
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PLATE 6

Scanning electron micrographs of Lower and Middle Jurassic (mid Toarcian to early Bajocian) Radiolaria from the Maude and Yakoun Formations, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure — Page

1,2. *Perispyridium* (?) sp. B, n. sp.---------------------------------- 203
1, Holotype, GSC 80683 : scale = 165 µm. GSC loc. C-080588 : early Bajocian. 2, Paratype, GSC 80684 : scale = 189 µm. GSC loc. C-080579 : mid Toarcian.

3. *Tricolocapsa* sp. cf. *T. rusti* Tan (Yao) ---------------------- 211
GSC 80698 : scale = 100 µm. GSC loc. C-080579 : mid Toarcian.

4. *Lithocampe* (?) sp. A, n. sp.-------------------------------------- 205
Holotype, GSC 80687 : scale = 138 µm. GSC loc. C-080579 : mid Toarcian.

5,6. *Stichocapsa* sp. cf. *S. convexa* Yao ------------------------- 209
5, GSC 80691 : scale = 116 µm. GSC loc. C-080579 : mid Toarcian.
6, GSC 80692 : scale = 105 µm. GSC loc. C-080593 : early Bajocian.

7. *Napora* sp. B, n. sp.--- 198
Holotype, GSC 80678 : scale = 230 µm. GSC loc. C-080579 : mid Toarcian.

8,11. *Wrangellium* sp.--- 167
GSC 80630 : scales = 208 and 83 µm, respectively. GSC loc, C-080579 : mid Toarcian.

9,12 *Protounuma* (?) sp. A, n. sp.------------------------------------ 185
Holotype, GSC 89657 : scales = 173 and 86 µm, respectively. GSC loc. C-080579 : mid Toarcian.

10. *Napora* sp. A, n. sp.--- 197
Holotype, GSC 80676 : scale = 243 µm. GSC loc. C-080579 : mid Toarcian.

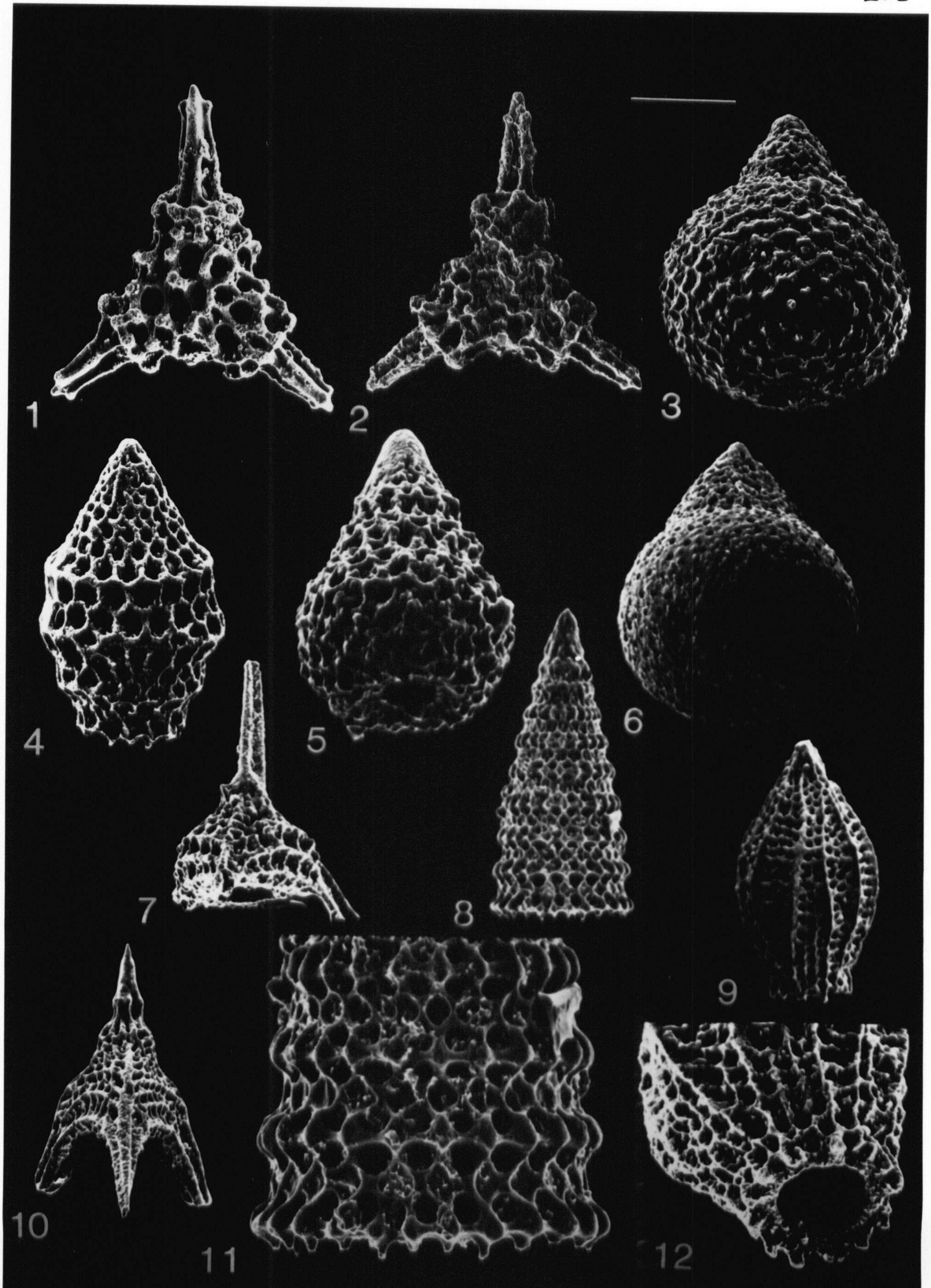
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PLATE 7

Scanning electron micrographs of Lower Jurassic (late mid/early late to late Toarcian) Spumellariina from the Maude formation, Graham Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure | Page

1,4. *Pseudocrucella sanfilippoae* (Pessagno)---------------------- 98
1, GSC 80511 and 4, GSC 80512: scales = 164 and 192 µm, respectively. GSC loc. C-080597 and C-080583 : late mid to late Toarcian, respectively.

2,3. *Homoparonaella* sp. A, n. sp.---------------------------------- 94
2,3 Holotype, GSC 80505: scales 190 and 53 µm, respectively. GSC loc. C-080584 : late mid/early late Toarcian.

5,6. *Homoparonaella* sp. aff. *H. argolidensis* Baumgartner---------- 93
5,6 Holotype GSC 80503: scales - 206 and 50 µm, respectively. GSC loc. C-080584 : late mid/early late Toarcian.

7. *Pseudocrucella* sp. C--------------------------------------- 100
GSC 80516: scale = 168 µm. GSC loc. C-080583 : late mid/early late Toarcian.

8,9. *Pseudocrucella* sp. A, n. sp.---------------------------------- 98
8,9, Holotype GSC 80513: scales = 143 and 54 µm, respectively. GSC loc. C-080584 : late mid/early late Toarcian.

10. *Tetratrabs* sp. aff. *T. gratiosa* Baumgartner------------------- 101
GSC 80518: scale = 210 µm. GSC loc. C-080584 : late mid/early late Toarcian.

11,12. *Hagiastrum* sp. cf. *H. egregium* Rüst------------------------- 95
11, GSC 80566 and 12, GSC 80567: scale = 311 and 57 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.

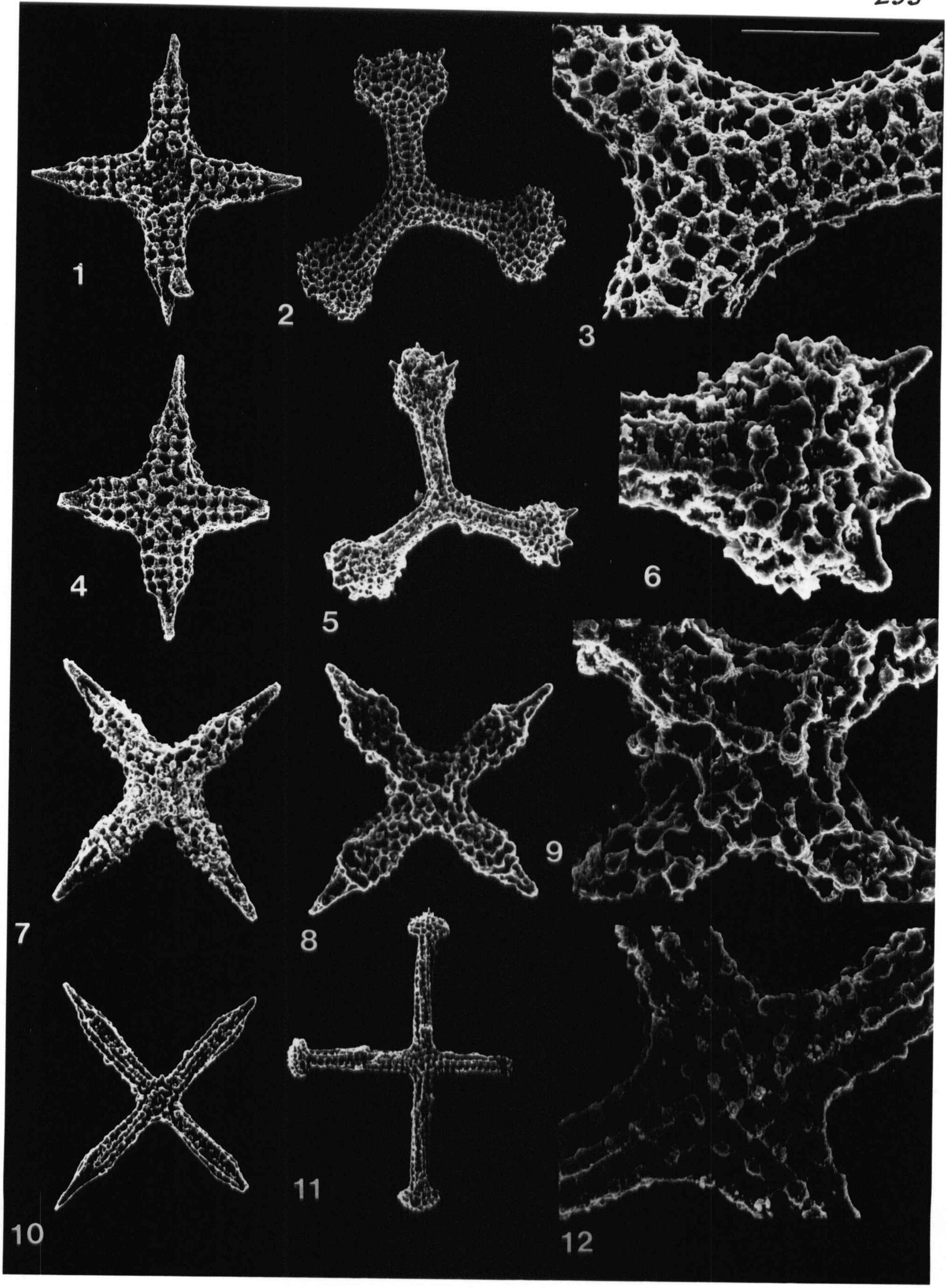
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PLATE 8

Scanning electron micrographs of Lower and Middle Jurassic (late mid/early late Toarcian to Aalenian) Radiolaria from the Maude Formation, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure		Page
1,4.	*Emiluvia* sp. H, n. sp. 1, Holotype, GSC 80550 and 4, Paratype, GSC 80551 : scales = 122 and 100 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.	119
2,3.	*Staurolonche* sp. A, n. sp. Holotype GSC 80535 : scales = 198 and 68 µm, respectively. GSC loc. C-080584 : late mid/early late Toarcian.	111
5,6.	*Emiluvia* sp. G, n. sp. Holotype GSC 80549 : scales = 131 and 73 µm, respectively. GSC loc. C-080597 : late Toarcian.	119
7.	*Alievium* (?) sp. B, n. sp. Holotype, GSC 80595 : scale = 185 µm. GSC loc. C-080583 : late mid/early late Toarcian.	146
8,9.	*Emiluvia* sp. I, n. sp. Holotype, GSC 80552 : scales = 140 and 57 µm, respectively. GSC loc. C-080597: late Toarcian.	120
10,11 12.	? *Emiluvia amplissima* (Foreman) 10, GSC 80537 : scale = 301 µm. GSC loc. C-080586 : Aalenian. 11.12, GSC 80538 : scales = 172 and 28 µm, respectively. GSC loc. C-080584 : late mid/early late Toarcian.	113

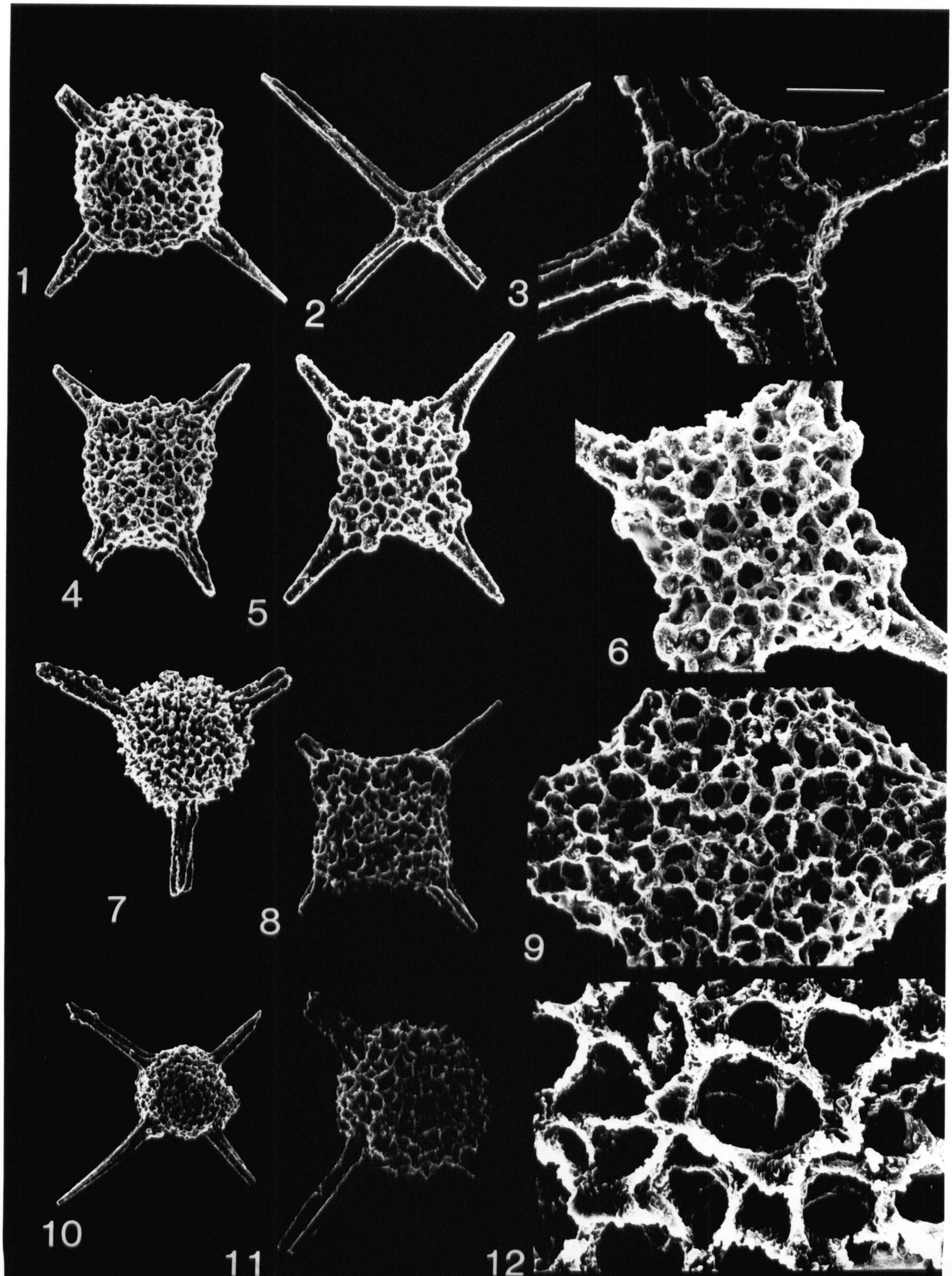
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PLATE 9

Scanning electron micrographs of Lower and Middle Jurassic (late mid/early late Toarcian to Aalenian) Spumellariina from the Maude Formation, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure — Page

1. *Praeconocaryomma* sp. aff. *P. parvimamma* Pessagno and Poisson 105
GSC 80524: scale = 49 µm. GSC loc. C-080597 : late Toarcian.

2. *Praeconocaryomma* sp. aff *P. mamillaria* Pessagno------------105
GSC 80525: scale = 48 µm. GSC loc. C-080597 : late Toarcian.

3. *Acaeniotyle* (?) sp. C, n. sp.------------------------------------110
Holotype GSC 80533: scale = 112 µm. GSC loc. C-080597 : late Toarcian.

4,5. *Tympaneides charlottensis* n. sp.------------------------------ 123
4, Holotype GSC 80555 and 5, Paratype GSC 80556: scales = 100 and 117 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.

6. *Acaeniotyle* (?) sp. B, n. sp.----------------------------------- 109
Holotype, GSC 80532 : scale = 89 µm. GSC loc. C-080597 : late Toarcian.

7,8,9. *Acanthotetrahedron nodosum* n. sp.---------------------------- 161
Holotype GSC 80619: scales = 89, 79 and 50 µm, respectively. 7,9 apical views; 8 lateral view. GSC loc. C-080584 : late mid/ early late Toarcian.

10. *Acanthocircus* sp. cf. *A. septispinus* (Yao)-------------------- 158
GSC 80617: scale = 130 µm. GSC loc. C-080584 : late mid/early late Toarcian.

11,12. *Acanthocircus hexagonus* (Yao)-------------------------------- 158
11, GSC 80615: scale = 129 µm. GSC loc. C-080583 : late mid/early late Toarcian. 12, GSC 80616 (enlargement of secondary spine, showing well developed spine ridges): scale = 19 µm.
GSC loc. C-080586 : Aalenian.

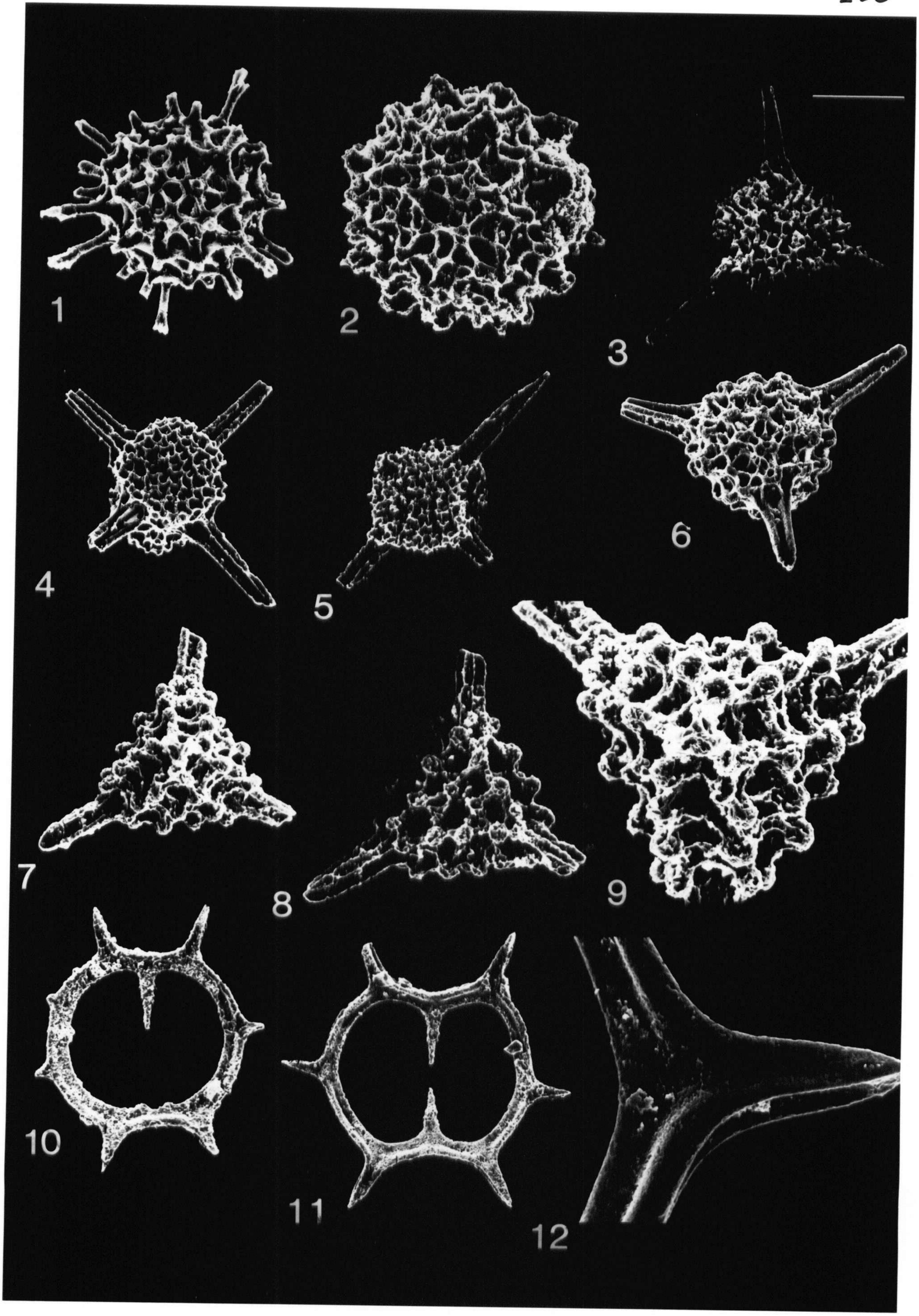
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PLATE 10

Scanning electron micrographs of Lower and Middle Jurassic (late mid/early late Toarcian to early Bajocian) Radiolaria from the Maude and Yakoun Formations, Queen Charlotte Islands. Length of scale in upper right = number of µm cited for each illustration.

Figure — Page

1. *Tripocyclia* sp. C, n. sp.-- 91
   Holotype, GSC 80502 : scale = 126 µm. GSC loc. C-080597 : late Toarcian.

2,3. *Tripocyclia* sp. B, n. sp.-- 90
   Holotype, GSC 80501 : scales = 134 and 33 µm, respectively. GSC loc. C-080597 : late Toarcian.

4. *Tripocyclia* sp. cf. *T. echoides* (Foreman) ------------------- 89
   GSC 80499 : scale = 124 µm. Subsequent to the completion of text-fig. 5 and 7, this form has beeen reassigned to 'Unnamed spongodiscid'. GSC loc. C-080583 : late mid/early late Toarcian.

5. *Spongotripus* sp. A, n. sp.------------------------------------ 157
   Holotype, GSC 80614 : scale = 100 µm. GSC loc. C-080583 : late mid/early late Toarcian.

6. *Higumastra* sp. A, n. sp.--------------------------------------- 97
   Holotype, GSC 80570 : scale = 141 µm. GSC loc. C-080595 : early Bajocian.

7,10. *Spongodiscus* (*Stylospongidium*) sp. aff. *S.* (*S.*) *echinodiscus* Campbell and Clark-- 153
   7, GSC 80607; 10, GSC 80608 : surface layer broken away to reveal inner concentric spongy structure. Scales = 151 and 150 µm, respectively. GSC loc. C-080597 : late Toarcian.

8,9. *Spongotrochus* sp. A, n. sp.---------------------------------- 154
   8, Holotype, GSC 80609 from GSC loc. C-080597; 9, Paratype, GSC 80610 from GSC C-080583 : scales = 105 and 138 µm, respectively: Late Toarcian, late mid/early late Toarcian, respectively.

11. *Spongostauras* sp. A, n. sp.---------------------------------- 151
   Holotype, GSC 80603 : scale = 107 µm. GSC loc. C-080583 : late mid/early late Toarcian.

12. *Spongostauras* sp. C, n. sp.---------------------------------- 152
   Holotype, GSC 80606 : scale = 92 µm. GSC loc. C-080597 : late Toarcian.

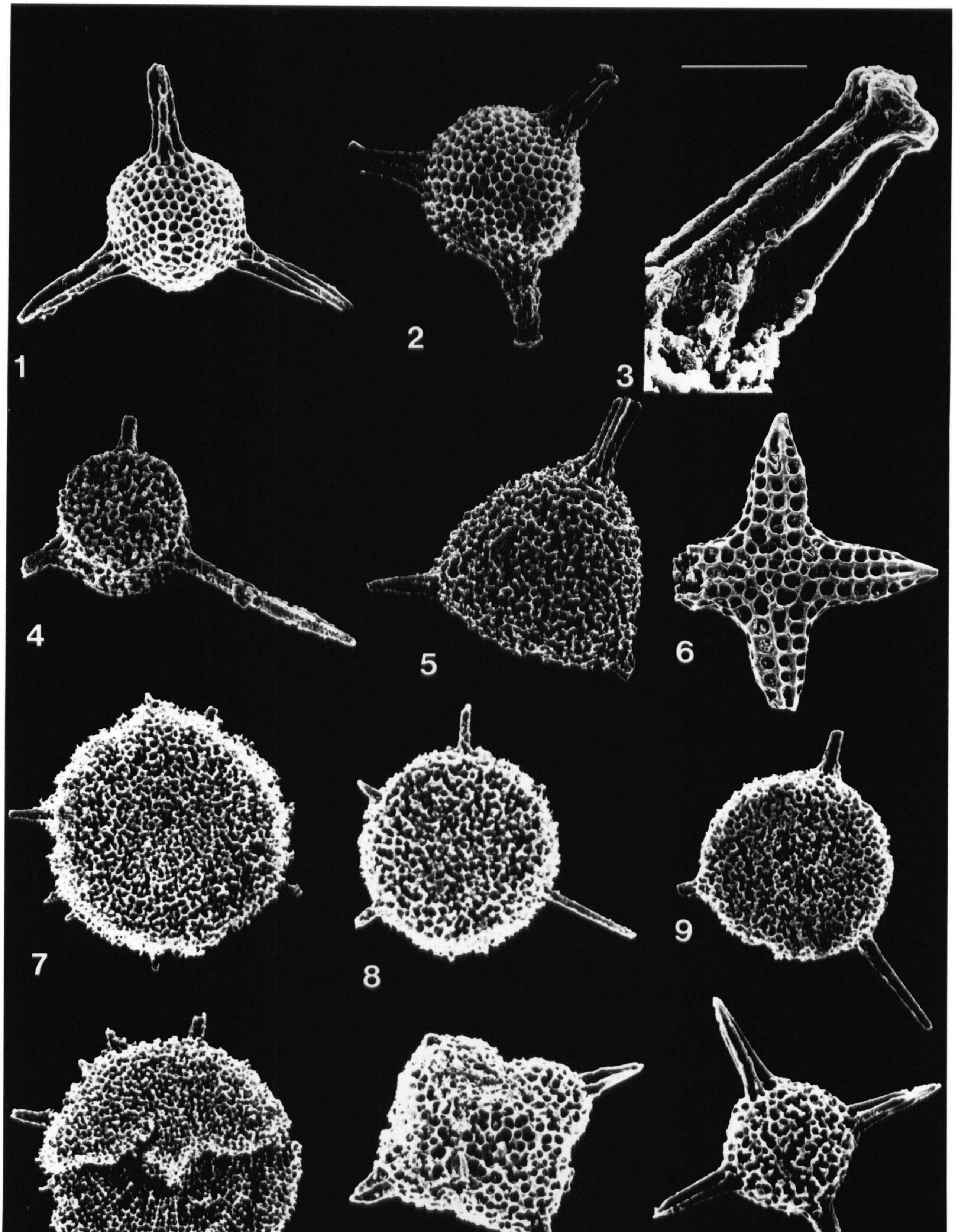
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PLATE 11

Scanning electron micrographs of Lower Jurassic (late mid/early late to late Toarcian) Patulibrachiidae from the Maude Formation, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure   Page

1,2,3. *Paronaella* sp. D, n. sp.--136
1, Holotype GSC 80578: scale = 127 µm. GSC loc. C-080584. 2,3, Paratypes GSC 80579 and 80580, respectively: scale = 152 µm. GSC loc. C-080583 : late mid/early late Toarcian.

4,5. *Paronaella* sp. B, n. sp.--134
4, Holotype, GSC 80575: scale = 173 µm. GSC loc. C-080584.
5, Paratype, GSC 80576: scale = 171 µm. GSC loc. C-080597 : late mid/ early late to late Toarcian, respectively.

6. *Paronaella* sp. C, n. sp.--135
Holotype, GSC 80577 scale = 150 µm, GSC loc. C-080584 : late mid/ early late Toarcian.

7. *Paronaella* sp. H, n. sp.--140
Holotype, GSC 80586: scale = 83 µm. GSC loc. C-080583: late mid/ early late Toarcian.

8. *Paronaella bandyi* Pessagno--------------------------------------131
GSC 80568: scale = 100 µm. GSC loc. C-080585 : late mid/early late Toarcian.

9. *Paronaella* sp. I, n. sp.--140
Holotype, GSC 80587: scale = 100 µm. GSC loc. C-080583 : late mid/ early late Toarcian.

10,11, *Paronaella* sp. E, n. sp.--137
12. 11,12, Holotype GSC 80582; 10, Paratype GSC 80581: scales = 135, 46 and 138 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.

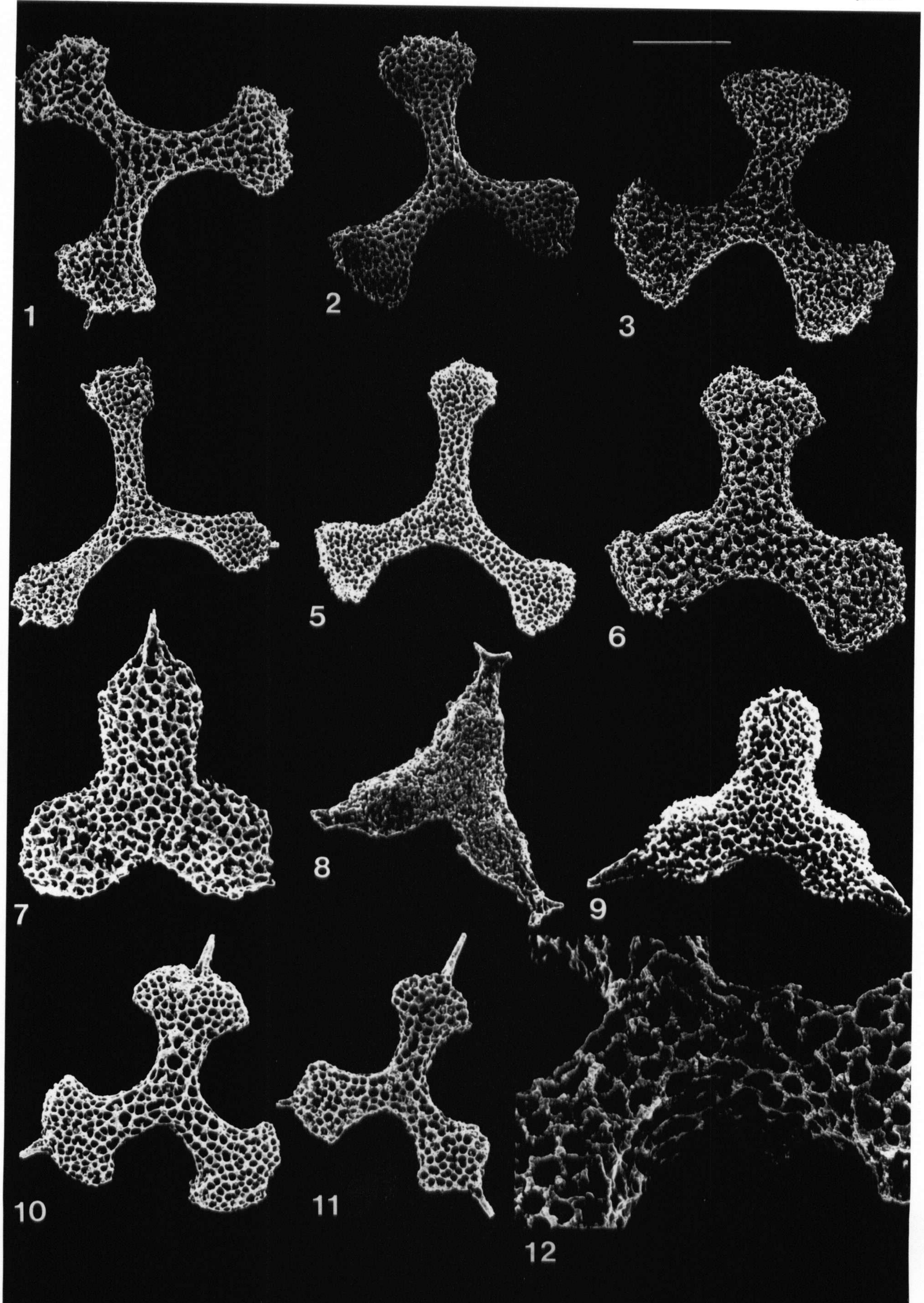
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PLATE 12

Scanning electron micrographs of Lower Jurassic (late mid/early late to late Toarcian) Spumellariina from the Maude Formation, Graham Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure — Page

1. *Amphibrachium* (?) sp. A, n. sp.---------------------------------- 129
   Holotype GSC 80567: scale = 100 µm. GSC loc. C-080597 : late Toarcian.

2,5. *Heliodiscus inchoatus* Rüst---------------------------------- 128
   GSC 80566: scales = 72 and 83 µm, respectively. GSC loc. C-080597 : late Toarcian.

3. *Paronaella* sp. F, n. sp.-- 137
   Holotype, GSC 80583: scale = 97 µm. GSC loc. C-080597 : late Toarcian.

4,7, 10. *Spongiostoma saccideon* n. sp.---------------------------------155
   4,10, Holotype GSC 80611; 7, Paratype GSC 80612: scales = 113, 94 and 115 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.

6. *Paronaella* sp. J, n. sp.-- 141
   Holotype GSC 80588: scale = 153 µm. GSC loc. C-080585 : late mid/ early late Toarcian.

8,9. *Spongiostoma* sp. A, n. sp.-------------------------------------156
   Holotype, GSC 80613: scales = 140 and 89 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.

11,12. *Crucella* sp. A, n. sp.-- 142
   Holotype, GSC 80590: scales = 80 and 24 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.

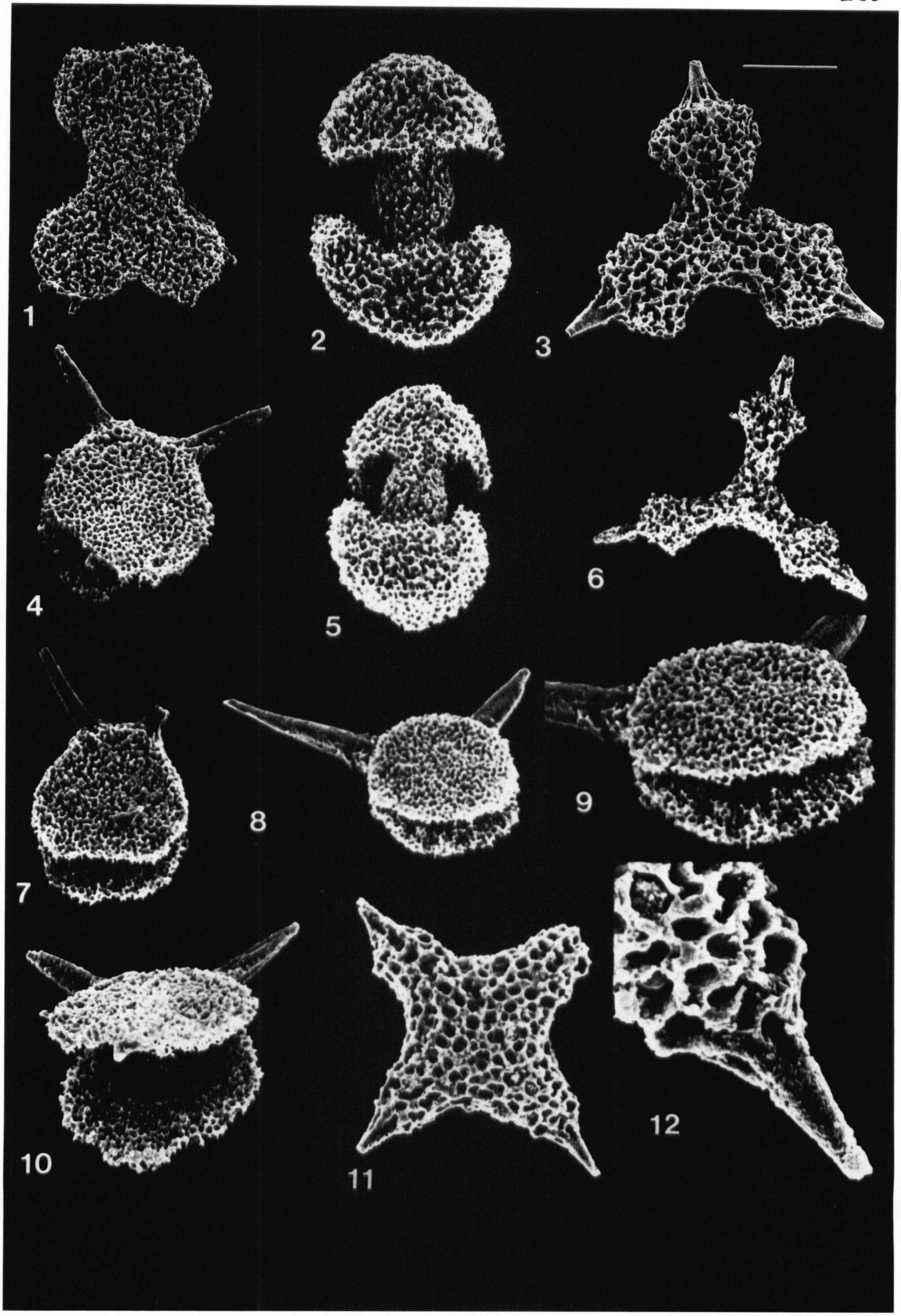
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PLATE 13

Scanning electron micrographs of Lower Jurassic (late mid to late Toarcian) Nassellariina from the Maude Formation, Graham Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

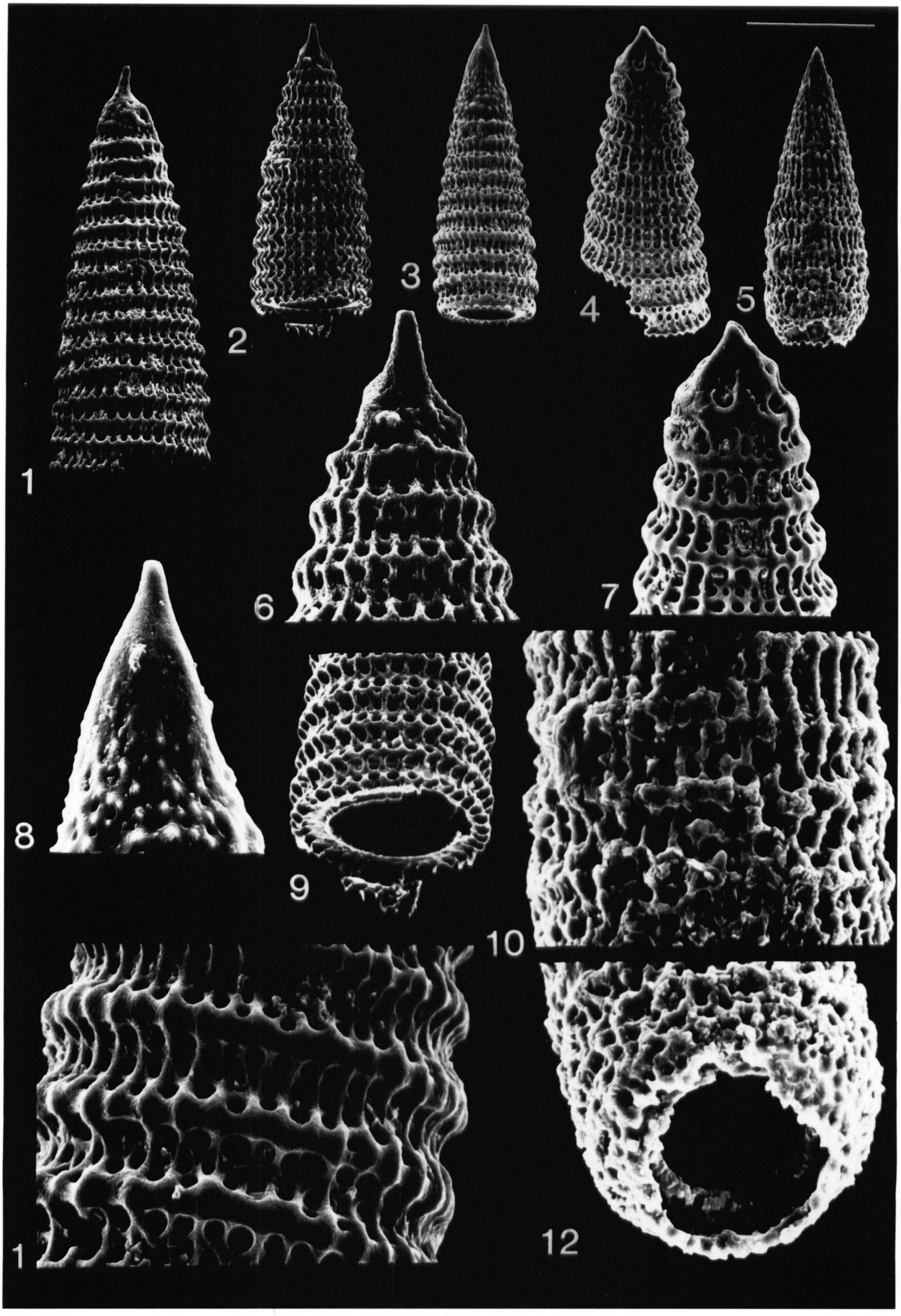
Figure Page

1,2,6 *Elodium cameroni* n. sp.------------------------------------ 167
9. 2,6,9, Holotype GSC 80631: scales = 173, 56 and 106 µm, respectively. 1, Paratype GSC 80632: scale = 153 µm. GSC loc. C-080597: late Toarcian.

3,8, *Elodium* sp. A, n. sp.--- 168
11. 3,8,11, Holotype GSC 80633: scales = 143, 37 and 34 µm, respectively. GSC loc. C-080581 : late mid Toarcian.

4,7. *Elodium* (?) sp. B, n. sp.--------------------------------------- 168
4,7, Holotype GSC 80634: scales = 140 and 71 µm, respectively. GSC loc. C-080581 : late mid Toarcian.

5,10, *Lupherium* (?) sp. C, n. sp.------------------------------------ 184
12. 5,10,12 Holotype GSC 80655: scales = 141, 42 and 50 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.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Scanning electron micrographs of Lower Jurassic (late mid/early late to late Toarcian) Nassellariina from the Maude Formation, Graham Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure Page

1. *Napora* sp. aff. *N. bukryi* Pessagno------------------------------ 198
GSC 80677: scale = 77 µm. GSC loc. C-080583 : late mid/early late Toarcian.

2. *Napora* sp. C, n. sp.--- 199
Holotype GSC 80679: scale = 100 µm. GSC loc. C-080583 : late mid/ early late Toarcian.

3,11. *Turanta nodosa* Pessagno and Blome------------------------------ 212
GSC 80700: scales = 74 and 47 µm, respectively. GSC loc. C-080583 : late mid/early late Toarcian.

4. *Diceratigalea* sp. A, n. sp.--------------------------------------- 201
Holotype, GSC 80681: scale = 111 µm. GSC loc. C-080583 : late mid/ early late Toarcian.

5. *Lithomelissa* sp. A, n. sp.--214
Holotype GSC 80703: scale = 89 µm. GSC loc. C-080597 : late Toarcian.

6. *Canoptum* (?) sp.--- 166
GSC 80629: scale = 71 µm. GSC loc. C-080597 : late Toarcian.

7. *Turanta* sp. A--- 212
GSC 80701: scale = 103 µm. GSC loc. C-080583 : late mid/early late Toarcian.

8. *Turanta morinae* Pessagno and Blome-----------------------------212
GSC 80699: scale = 96 µm. GSC loc. C-080583 : late mid/early late Toarcian.

9. *Maudia yakounensis* n. sp.-- 208
Holotype GSC 80690: scale = 183 µm. GSC loc. C-080585 : late mid/ early late Toarcian.

10. *Canoptum* sp. cf. *C. dixoni* Pessagno and Whalen------------------ 165
GSC 80626: scale = 133 µm. GSC loc. C-080597 : late Toarcian.

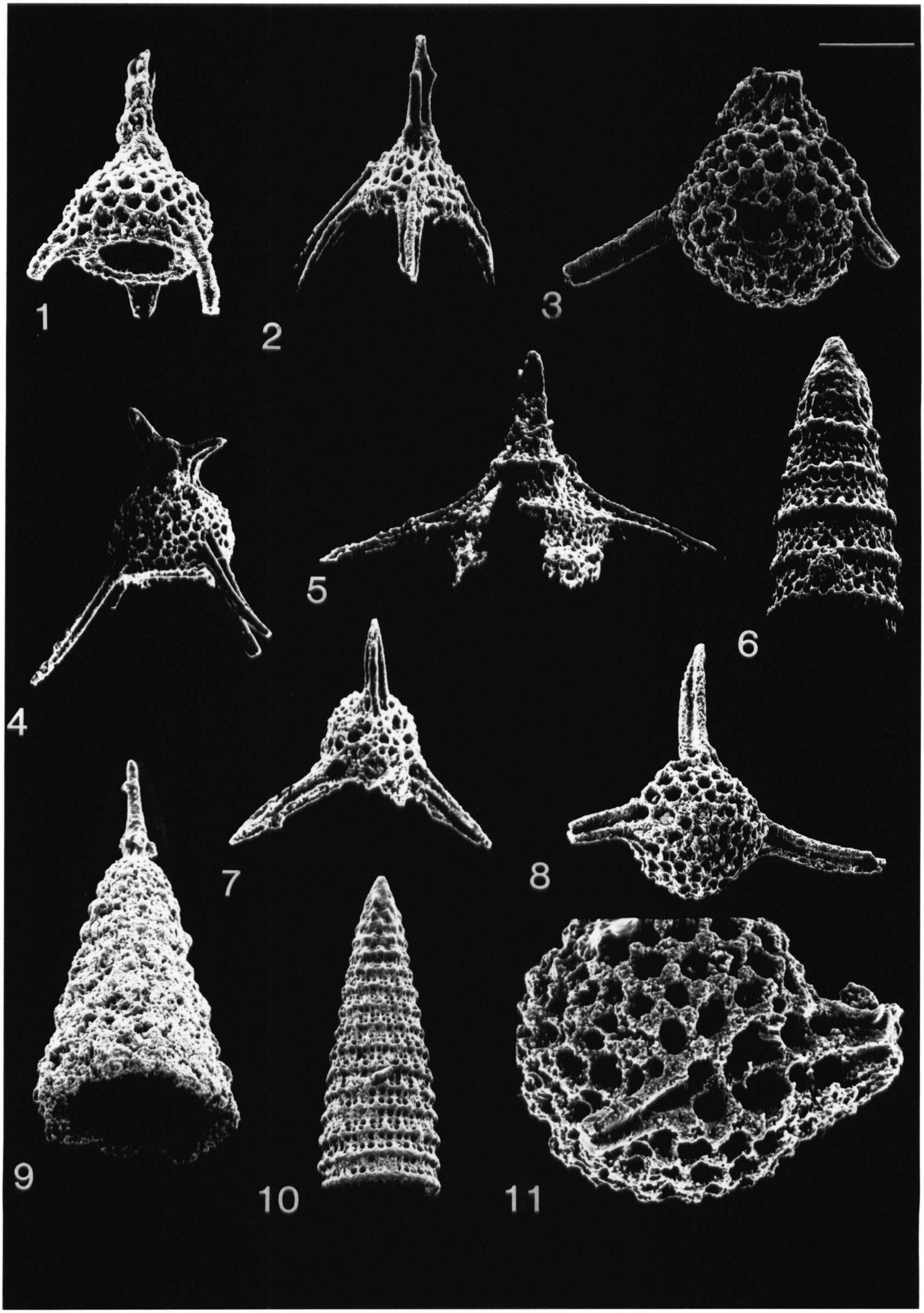
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PLATE 15

Scanning electron micrographs of Middle Jurassic (Aalenian - early Bajocian) Radiolaria from the Maude and Yakoun Formations, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure — Page

1,2. *Ristola* sp. A, n. sp.-- 192
Holotype, GSC 80669 : scales = 75 and 69 µm, respectively. GSC loc. C-080586 : Aalenian.

3. *Hsuum* sp. aff. *H. belliatulum* Pessagno and Whalen ------------ 174
GSC 80643 : scale = 129 µm. GSC loc. C-080586 : Aalenian.

4. *Hsuum* sp. cf. *H. mirabundum* Pessagno and Whalen ------------- 174
GSC 80644 : scale = 120 µm. GSC loc. C-080595 : early Bajocian.

5. *Xitus* (?) sp. C, n. sp.-- 196
Holotype, GSC 80675 : scale = 89 µm. GSC loc, C-080594 : early Bajocian.

6. *Perispyridium* sp. A, n. sp.------------------------------------- 202
Holotype, GSC 80682 : scale = 115 µm. GSC loc. C-080595 : early Bajocian.

7. *Stichocapsa* sp. aff. *S. japonica* Yao ----------------------- 209
GSC 80693 : scale = 89 µm. GSC loc. C-080594 : early Bajocian.

8. *Emiluvia* sp. K, n. sp.-- 122
Holotype, GSC 80554 : scale = 133 µm. GSC loc. C-080589 : early Bajocian.

9,12. *Crucella* sp. C, n. sp.--------------------------------------- 144
Holotype, GSC 80593 : scales = 184 and 65 µm, respectively. GSC loc. C-080593 : early Bajocian.

10. *Lophodictyotidium* sp. cf. *L. sarjeanti* Pocock --------------- 216
GSC 80705 : scale = 50 µm. GSC loc. C-080590 : early Bajocian.

11,13. Genus A, undet.-- 215
GSC 80704 : scales = 98 and 45 µm, respectively. GSC loc. C-080590 : early Bajocian.

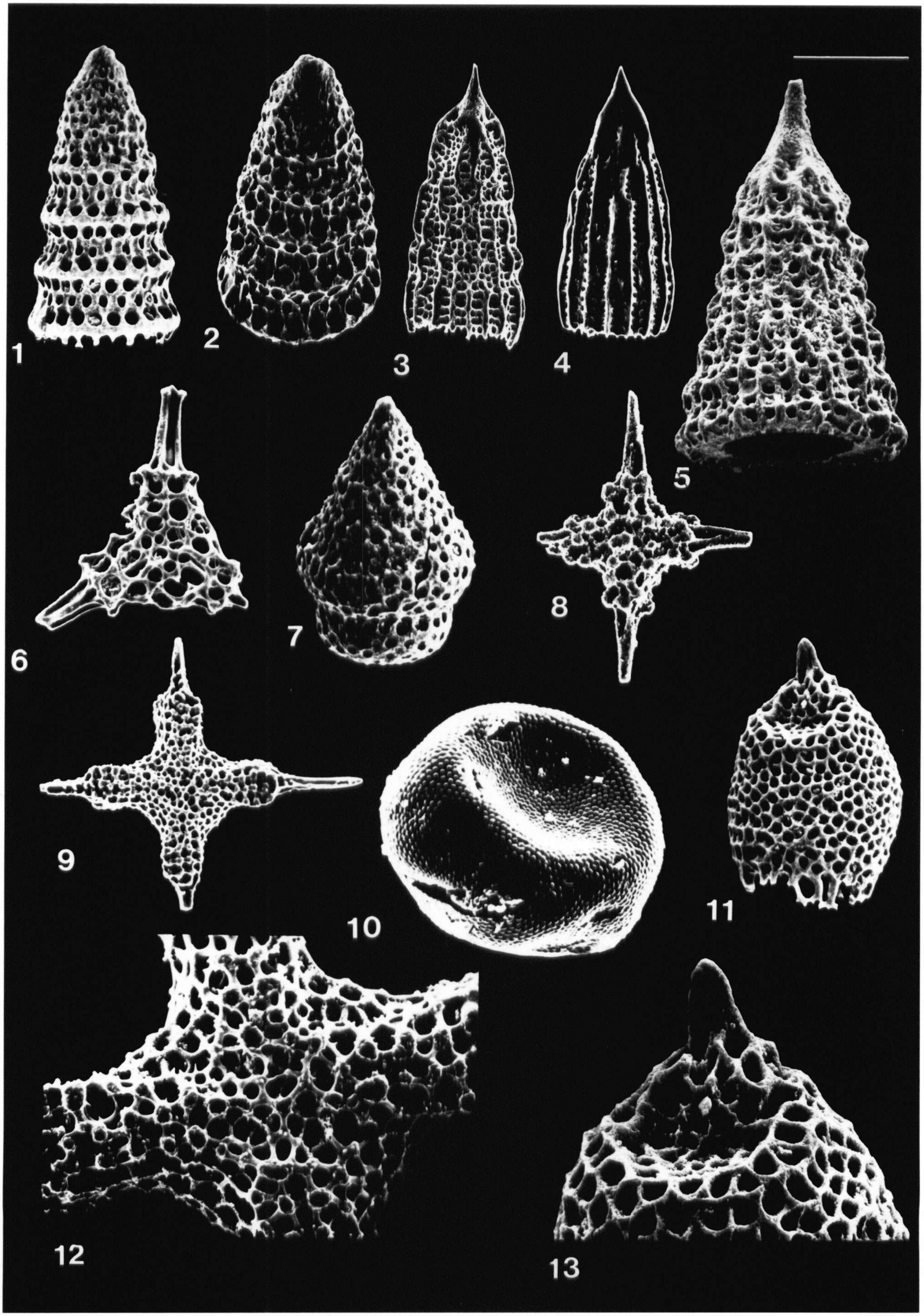
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PLATE 16

Scanning electron micrographs of Middle Jurassic (early Bajocian) Radiolaria from the Yakoun Formation, Graham Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure Page

1. *Trillus* sp. cf. *T. seidersi* Pessagno and Blome ---------------- 127
GSC 80563 : scale = 124 µm. GSC loc. C-080592 : early Bajocian.

2,10. *Zartus thayeri* Pessagno and Blome---------------------------- 128
GSC 80565 : scales = 127 and 48 µm, respectively.
GSC loc. C-080592 : early Bajocian.

3,4. *Emiluvia* sp. B, n. sp.-- 115
4, Holotype, GSC 80542 : scale = 76 µm. GSC loc. C-080596, and 5, Paratype, GSC 80543 : scale = 76 µm. GSC loc. C-080587 : early Bajocian.

5,11. *Emiluvia* sp. A, n. sp.-- 114
5, Holotype, GSC 80540 : scale = 103 µm, and 11, Paratype, GSC 80541 : scale = 47 µm. GSC loc. C-080595 : early Bajocian.

6. *Emiluvia* sp. J, n. sp.-- 121
Holotype, GSC 80553 : scale = 100 µm. GSC loc. C-080595 : early Bajocian.

7. *Homoparonaella* sp. aff. *H. elegans* (Pessagno) ---------------- 93
GSC 80504 : scale = 109 µm. GSC loc. C-080587 : early Bajocian.

8. *Tetraditryma* sp. B, n. sp.-------------------------------------102
Holotype, GSC 80520 : scale = 108 µm. GSC loc. C-080595 : early Bajocian.

9,12. *Tetraditryma* sp. A, n. sp.-------------------------------------102
Holotype, GSC 80579 : scales = 111 and 45 µm, respectively. GSC loc. C-080587 : early Bajocian.

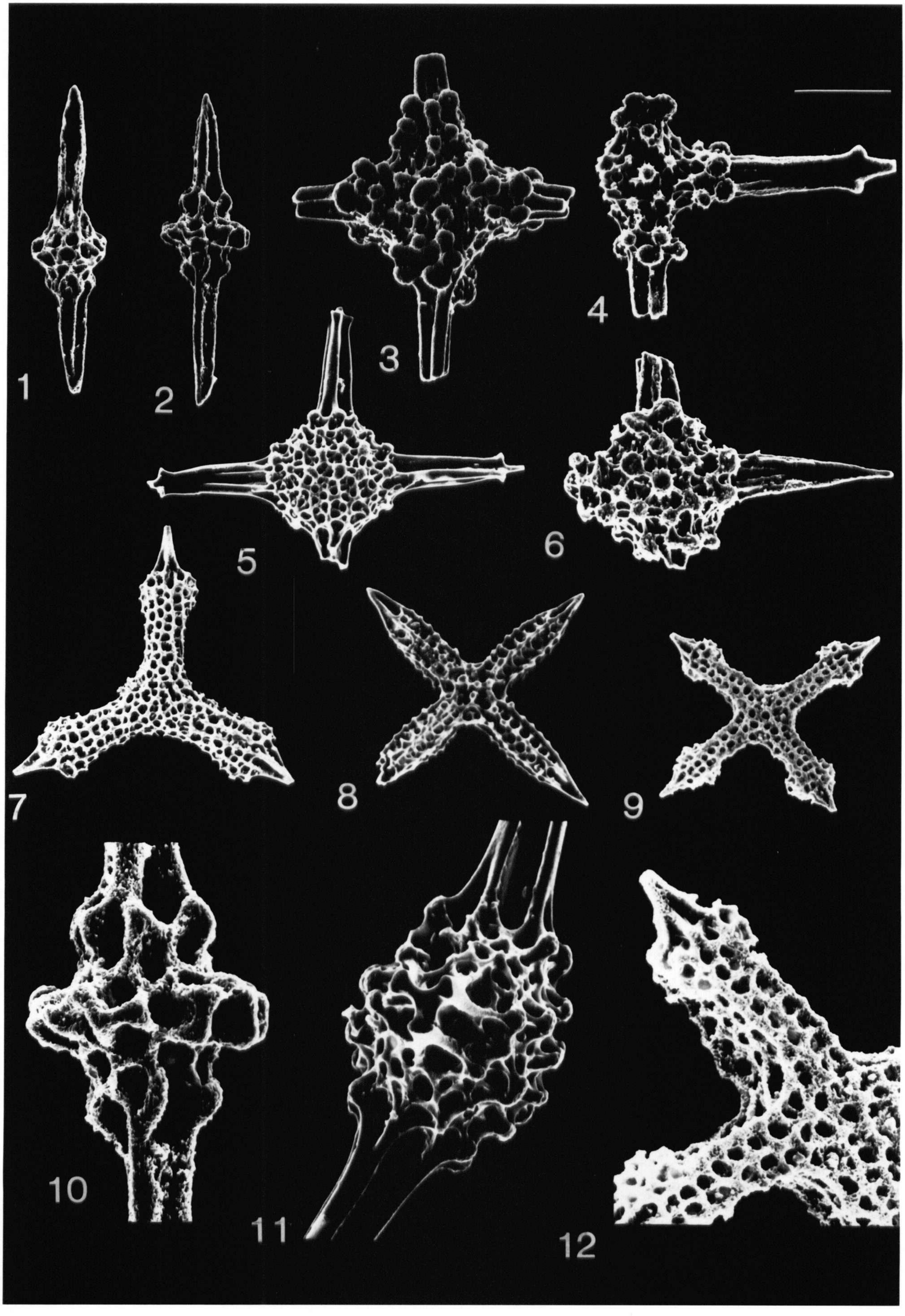
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PLATE 17

Scanning electron micrographs of Middle Jurassic (early Bajocian) Radiolaria from the Yakoun Formation, Graham Island, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure — Page

1. ? *Paronaella denudata* (Rüst)---------------------------------131
GSC 80569: scale = 81 µm. GSC loc. C-080588 : early Bajocian.

2. *Paronaella* sp. A, n. sp.--------------------------------------- 133
Holotype GSC 80573: scale = 100 µm. GSC loc. C-080595: early Bajocian.

3. *Paronaella* sp. K, n. sp.--------------------------------------- 142
Holotype GSC 80589: scale = 115 µm. GSC loc. C-080594: early Bajocian

4,5. *Spongostaurus* sp. B, n. sp.---------------------------------- 151
4, Holotype GSC 80604 and 5, Paratype 80605: scales = 119 and 90 µm, respectively. Both specimens from GSC loc. C-080595 : early Bajocian.

6. *Praeconocaryomma* sp. aff. *P. universa* Pessagno--------------- 106
GSC 80527: scale = 54 µm. GSC loc. C-080588 : early Bajocian.

7,8. *Hsuum* sp. aff. *H. mirabundum* Pessagno and Whalen-------------- 175
7, (#2, 'related form': see text) GSC 80645 and 8, (#3, see text) GSC 80646: scale = 100 µm. GSC loc. C-080595 : early Bajocian.

9. *Mita* sp. A, n. sp.--- 163
Holotype GSC 80623: scale = 77 µm. GSC loc. C-080595: early Bajocian.

10. *Praeconocaryomma* sp. aff. *P. californiensis* Pessagno--------- 105
GSC 80526: scale = 82 µm. GSC loc. C-080587 : early Bajocian.

11. *Ristola* sp. C, n. sp.-- 194
Holotype, GSC 80671: scale = 64 µm. GSC loc. C-080594: early Bajocian.

12. *Droltus* sp. A, n. sp.-- 165
Holotype, GSC 80625: scale = 72 µm. GSC loc. C-080595: early Bajocian.

13. *Eucyrtidium* sp. A, n. sp.-------------------------------------- 204
Holotype GSC 80686: scale = 103 µm. GSC loc. C-080595: early Bajocian.

14. *Lithocampe* sp. B, n. sp.--------------------------------------- 206
Holotype GSC 80688: scale = 64 µm. GSC loc. C-080592: early Bajocian.

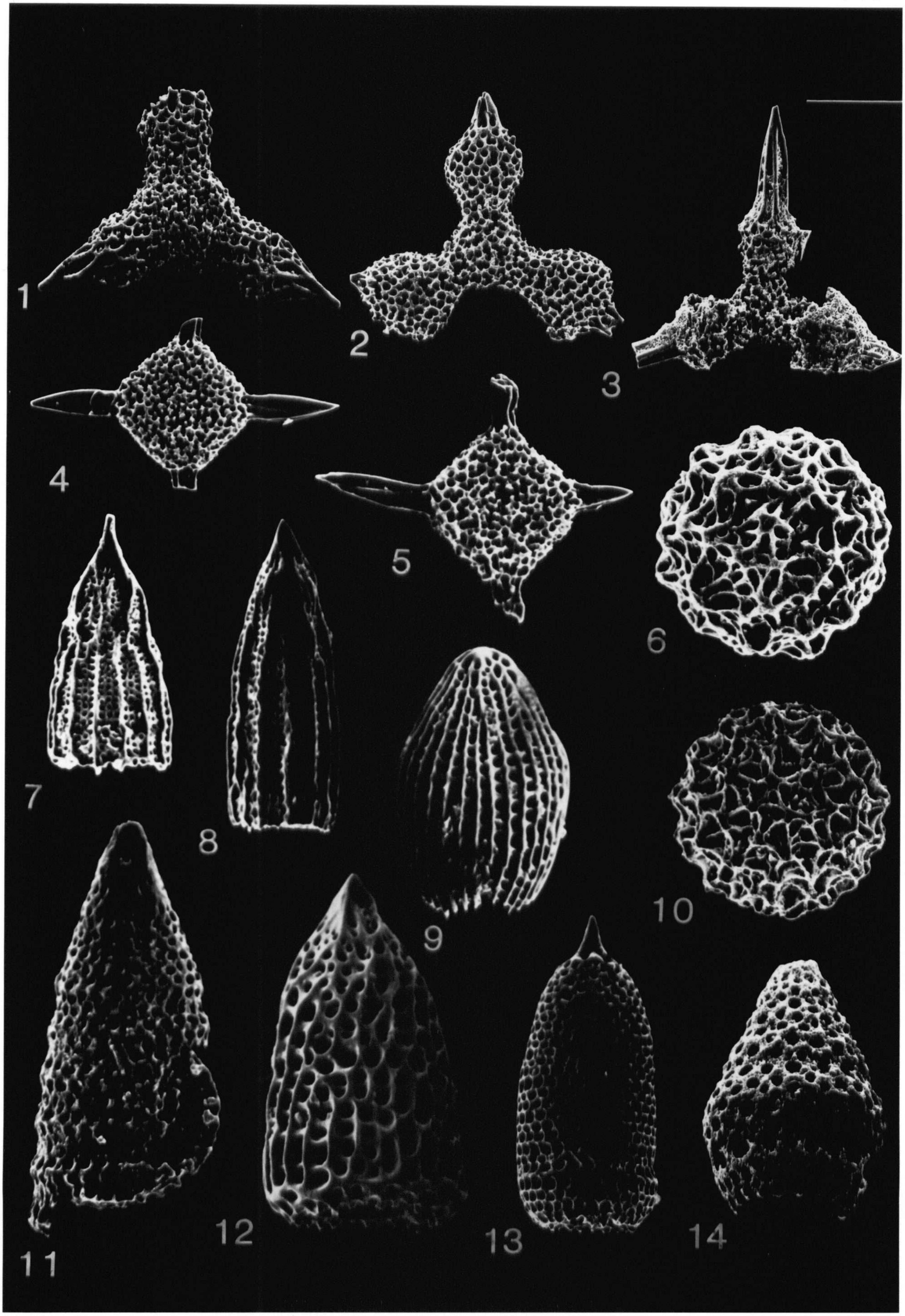
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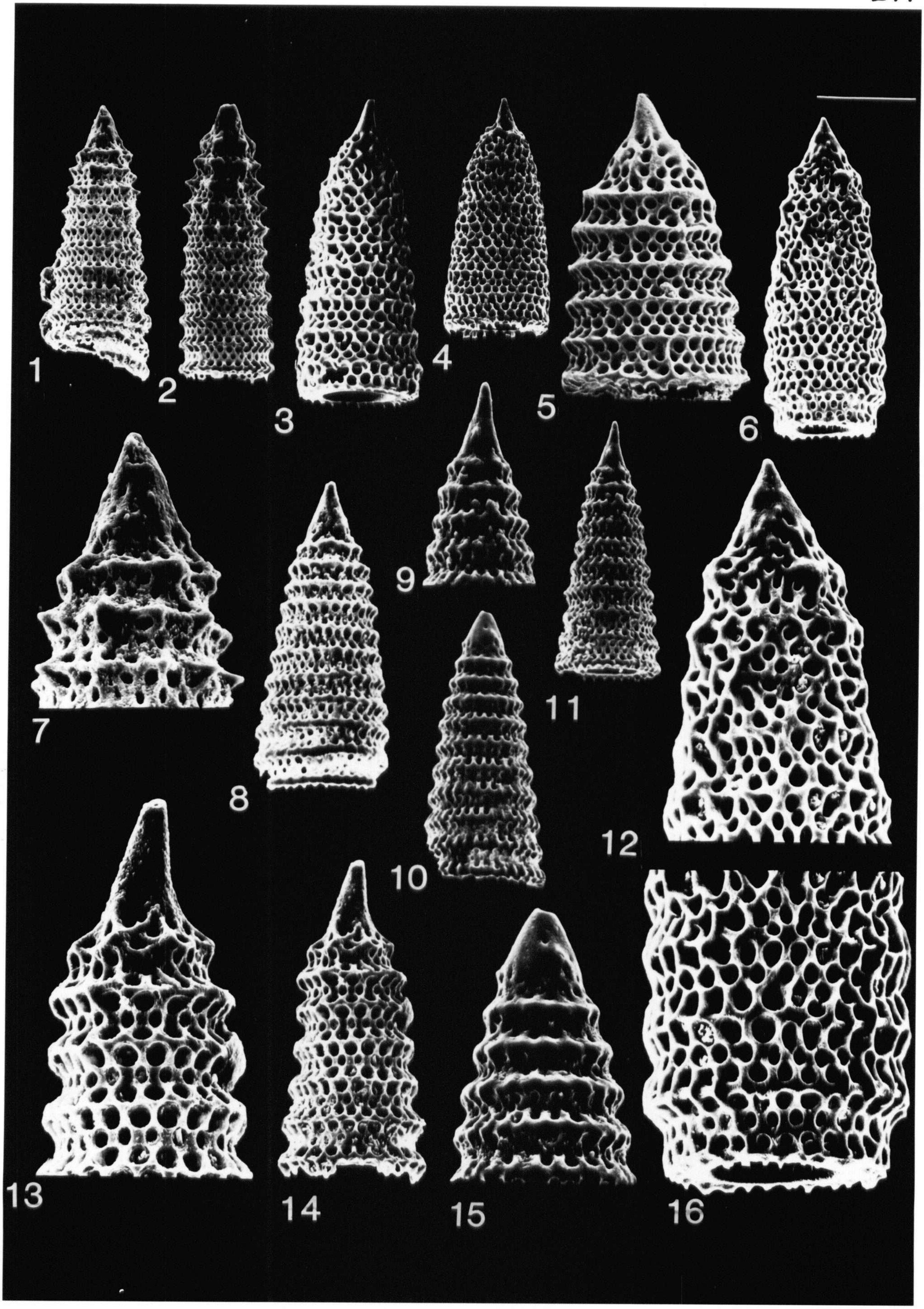
PLATE 18

Scanning electron micrographs of Middle Jurassic (early Bajocian) Radiolaria from the Yakoun Formation, Queen Charlotte Islands, B.C. Length of scale in upper right = number of µm cited for each illustration.

Figure		Page
1,2,7.	*Parvicingula* sp. A, n. sp.-------------------------------------- 187 1,7, Holotype, GSC 80664 : scales = 120 and 42 µm, respectively. 2, Paratype, GSC 80665 : scale = 114 µm. GSC loc. C-080595 : early Bajocian.	187
3,4.	*Parvicingula* sp. B, n. sp. 3, Holotype, GSC 80666 and 4, Paratype, GSC 80667 : scales = 100 and 125 µm, respectively. GSC loc. C-080595 : early Bajocian.	191
5.	*Parvicingula* sp. C GSC 80668 : scale = 114 µm. GSC loc. C-080595 : early Bajocian.	192
6,12, 16.	*Parvicingula matura* Pessagno and Whalen GSC 80658 : scales = 96 ,100 and 43 µm, respectively. GSC loc. C-080595: early Bajocian.	187
8,10, 15.	*Parvicingula* sp. aff. *P. burnensis* Pessagno and Whalen 8, GSC 80659 : scale = 89 µm. GSC loc. C-080588; 10,15, GSC 80660 : scales = 104 and 51 µm, respectively. GSC loc. C-080594 : early Bajocian.	187
9,11.	*Parvicingula* aff. *P. media* Pessagno and Whalen GSC 80662 : scales = 71 and 114 µm, respectively. GSC loc. C-080595 : early Bajocian.	188
13,14.	*Parvicingula* ap. aff. *P. profunda* Pessagno and Whalen GSC 80663 : scales = 45 and 75 µm, respectively. GSC loc. C-080595 : early Bajocian.	189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APPENDIX I

SAMPLE AND LOCALITY DESCRIPTIONS

GSC loc. C-080577

Latitude/longitude: 53° 11.82' N, 132° 3.63' W

Formation: Maude

Locality information: Creek"A", Maude Island see fig. 3. Creek empties onto beach approx. 100 m west of Fannin Bay (southwest coast of Maude Island).

Sample lithology: medium grey sandy limestone (fine calcarenite).

Lithologic sequence/sample position: interbedded medium grey sandstone, dark grey siltstone and rare shale. Collected 106 m stratigraphically below top of Maude Formation on Creek "A". See fig. 4, section I.

Related fossil occurrences: no ammonites; shale microfossil samples barren (B.E.B. Cameron, pers. comm., 1983).

Age: late Pliensbachian; based on lithology and position in section (H.W. Tipper, pers. comm., 1984).

Radiolarian fauna: rich, extremely diverse, well preserved

Sample collector: B.E.B. Cameron, 1980.

Comments: locality lithologically similar to sandy limestones exposed on beach just east of Fannin Bay (base of Creek "B"") that contain an abundant harpoceratid ammonite fauna.

GSC loc. C-080578

Latitude/longitude: 53° 11.82' N, 132°° 3.63' W

Formation: Maude

Locality information: Creek "A", Maude Island, see location map fig. 3.

Sample lithology: medium grey sandy limestone (fine calcarenite).

Lithologic sequence/sample position: see C-080577 for sequence information. Collected 111 m stratigraphically below top of Maude Formation.

Related fossil occurrences: see C-080577.

Age: see C-080577.

Radiolarian fauna: sparse, totally recrystallized; only gross morphology discernible. Many unrecognizeable spherical forms.

Sample collector: B.E.B. Cameron, 1980.

GSC loc. C-080579

Latitude/longitude: 53° 11.94' N, 132° 3.25' W

Formation: Maude

Locality Information: Creek "B", Maude Island, see fig. 3. Creek empties onto beach just east of Fannin Bay, above a prominent sandstone with nodular coquinoid beds containing ammonites, bivalves, brachiopods and nautiloids.

Sample lithology: very dark grey limestone (calcilutite) nodule.

Lithologic sequence/sample position: pale grey, green weathering shale with limestone nodules and septarian nodules. Collected 20.5 m stratigraphically below top of Maude Formation on Creek "B", see fig. 4, section II.

Related fossil occurrences: one poorly preserved specimen of *Phymatoceras* sp., *Trigonia* spp.

Age: middle Toarcian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: pyritized, preserved in excellent detail; distinctive and very abundant.

Sample collector: B.E.B. Cameron, 1979.

<u>GSC loc. C-080581</u>

Latitude/longitude: 53° 25.01' N, 132° 16.16' W

Formation: Maude

Locality information: Yakoun River, Graham Island. 3 km south of Ghost Creek, west side of river.

Sample lithology: light grey sandy limestone (fine calcarenite).

Lithologic sequence/sample position: exposed is contact between underlying grey-green weathering shales with nodular and concretionary limestones and septarian nodules and overlying grey-green sandstone. Collected in sandstone 2 m above contact, see fig. 4 section III.

Related fossil occurrences: ammonites (in limy concretions), nautiloids, belemnites and bivalves.

Age: middle Toarcian (H.W. Tipper, pers. comm., 1984).

Radiolarian fauna: not overly abundant but diverse, well preserved; green in colour.

Sample collector: B.E.B. Cameron, 1982.

GSC locs. C-080582, C-080583, C-080584

Latitude/longitude: 53° 25.19' N, 132° 15.64' W

Formation: Maude

Locality Information: Yakoun River, Graham Island, approximately 2 km south of Ghost Creek; east side of river.

Sample Lithology: light grey to brownish-grey sandy limestone (fine to very fine calcarenite).

Lithologic sequence/sample position: grey-green weathering shales overlain by pale brown sandstone with minor shale interbeds and common buff weathering sandy limestone lenses. Collected above high water mark 4.5 m, 10.5 m and 14.5 m stratigraphically, above shale. See fig. 4, section IV.

Related fossil occurrence: ammonites, belemnites.

Age: late middle/early late Toarcian (H.W. Tipper, pers. comm. 1984).

Radiolarian fauna: abundant (particularly hagiastrids), preservation fair to excellent

Sample collector: B.E.B. Cameron, 1980.

GSC loc. C-080585

Latitude/longitude: 53° 25.19' N, 132° 15.64' W

Formation: Maude

Locality information: Yakoun River, Graham Island, approximately 2 km south of Ghost Creek; east side of river.

Sample lithology: light grey limestone (fine calcarenite).

Lithologic sequence/sample position: sequence as in C-080582, C-080583 and

C-080584; position roughly equivalent also.

Related fossil occurrences: ammonites.

Age: late middle/early late Toarcian (H.W. Tipper, pers. comm., 1984).

Radiolarian fauna: abundant, preservation fair to good; most specimens recrystallized.

Sample collector: H.W. Tipper, 1975.

Comments: very little Jurassic outcrop exposed on river in 1975. Since then floods have made excellent exposures available.

GSC loc. C-080597

Latitude/longitude: 53° 25.22' N, 132° 15.73' W

Formation: Maude

Locality information: Yakoun River, Graham Island, 1.8 km south of Ghost Creek; east side of river.

Sample lithology: light grey limestone (fine calcarenite).

Lithologic sequence/sample position: sequence as in C-080582 to C-080585, Collected in sandstone.

Related fossil occurrences: ammonites.

Age: late Toarcian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: exceptionally rich, excellent preservation; white and green in colour.

Sample collector: H.W. Tipper, 1975.

GSC loc. C-080580

Latitude/longitude: 53° 21.89' N, 132° 16.04' W.

Formation: Maude

Locality information: Creek "C", Graham Island. Creek bed above a high waterfall east of McMillian Bloedell's logging road 'Queen Charlotte Main', 0.25 km north of junction of Q.C.Main with road to Rennell Sound.

Sample lithology: medium grey limestone (fine calcarenite)

Lithologic sequence/sample position: waterfall exposes mostly dark shales and siltstones (lower to upper Pliensbachian). In creek above, sandstone grades upward into grey-green weathering shale with septarian nodules. Collected from highest limestone bed in the sandstones. See fig. 4, section V.

Related fossil occurrences: none

Age: late Pliensbachian; based on lithology (H.W. Tipper, pers. comm., 1984).

Radiolarian fauna: very sparse; poor preservation

Sample collector: B.E.B. Cameron, 1980.

GSC loc. C-080587

Latitude/longitude: 53° 21.89' N, 132° 15.77' W

Formation: Yakoun

Locality information: Creek "C", Graham Island, see C-080580 for location.

Sample lithology: brownish-grey sandy limestone (fine calcarenite).

Lithologic sequence/sample position: condensed upper Toarcian sandstone overlain by interbedded buff coloured tuffaceous sandstone, siltstone and shale with minor sandy limestone. Collected in siltstone 182 , upstream of C-080580, 47 m stratigraphically above base of Yakoun. See fig. 4, section

V.

Related fossil occurrences: none

Age: early Bajocian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: few, well preserved; pale green in colour.

Sample collector: B.E.B. Cameron, 1982.

GSC loc. C-080588

Latitude/longitude: 53° 21.89' N, 132° 15.73' W.

Formation: Yakoun

Locality information: Creek "C", Graham Island. See C-080580 for location.

Sample lithology: buff coloured sandy limestone (fine calcarenite).

Lithologic sequence/sample position: sequence as in C-080587. Collected in light grey pelletal siltstone 52 m upstream of C-080587; 62.5 m stratigraphically above base of Yakoun. See fig. 4, section V.

Related fossil occurrences: none

Age: early Bajocian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: common, well preserved.

Sample collector: B.E.B. Cameron, 1982.

GSC loc. C-080586

Latitude/longitude: 53° 23.19' N, 132° 16.23' W

Formation: Maude

Locality information: small waterfall on east side of Branch Road #59, 0.5 kmfrom 'Queen Charlotte Main'; about 0.75 km north of junction with road to Rennell Sound.

Sample lithology: medium dark grey sandy pelletal limestone (fine calcarenite).

Lithologic sequence/sample position: Exposed is upper part of Maude Formation and base of Yakoun Formation. Lowest beds grey-green weathering shale and siltstones equivalent to shales on Maude Island, Yakoun River and above waterfall on Creek "C". Overlying shale is irregularly bedded poorly sorted sandstone. Above sand, thick sequence of interbedded shale and tuff (Yakoun Formation). Collected in sandstone talus block. See fig. 4, section VI.

Related fossil occurrences: 'hammatoceratid' ammonites below; *Tmetoceras* sp. above (H.W. Tipper, pers. comm., 1983).

Age: Aalenian (ibid).

Radiolarian fauna: common, excellent preservation; green in colour.

Sample collector: B.E.B. Cameron, 1982.

Comments: sample a talus block almost certainly from sandstone, as it bears no resemblance to overlying rocks.

GSC loc. C-080589

Latitude/longitude: 53° 23.65' N, 132° 16.41' W.

Formation: Yakoun

Locality information: Creek "E", Graham Island. Intersects 'Queen Charlotte Main' approximately 2 km north of its junction with the Rennell Sound Road.

Reached by following Branch Road # 57 to top of bluff, then descending ravine to creek at base of waterfall.

Sample description: medium grey limestone (calcisiltite).

Lithologic sequence/sample position: base of section in fault contact with upper Maude Formation. Exposed are dark grey shales and siltstones with rare sandy layers and thin beds of buff-weathering concretionary limestone. Collected in shale 2 m above base of formation. See fig. 4, section VII.

Related fossil occurrences: a few 'sonninid' ammonites in creek and on hillside to north.

Age: early Bajocian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: few, mostly recrystallized.

Sample collector: B.E.B. Cameron, 1982.

GSC locs. C-080590, C-080591

Latitude/longitude: 53° 23.65' N, 132° 16.29' W.

Formation: Yakoun.

Locality information: see C-080589.

Sample lithology: medium dark brownish-grey limestone (calcisiltite).

Lithologic sequence/sample position: see C-080589 for sequence. Collected in shale 21 m stratigraphically above base of Yakoun. See fig. 4, section VII.

Age: Early Bajocian (H.W. Tipper, pers. comm., 1984).

Radiolarian fauna: sparse; poorly preserved.

Sample collector: B.E.B. Cameron, 1982.

GSC loc. C-080592

Latitude/longitude: 53° 23.64' N, 132° 16.21' W.

Formation: Yakoun.

Locality information: see C-080589.

Sample lithology: brownish-grey limestone, buff weathering, containing some volcanic glass (fine calcarenite).

Lithologic sequence/sample position: see C-080589 for sequence. Collected in shale 34 m stratigraphically above base of Yakoun. See fig. 4, section VII.

Age: Early Bajocian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: few; well preserved.

Sample collector: B.E.B. Cameron, 1980.

GSC loc. C-080593

Latitude/longitude: 53° 23.63' N, 132° 16.1' W.

Formation: Yakoun.

Locality information: see C-080589.

Sample lithology: greenish-grey limestone (calcilutite).

Lithologic sequence/sample position: see C-080589 for sequence. Collected in shale 57 m stratigraphically above base of Yakoun. See fig. 4, section VII.

Age: Early Bajocian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: good; well preserved.

Sample collector: B.E.B. Cameron, 1980.

GSC loc. C-080594

Latitude/longitude: 53° 23.63' N, 132° 16.07' W.

Formation: Yakoun.

Locality information: see C-080589.

Sample lithology: brownish-grey limestone (very fine calcarenite).

Lithologic sequence/sample position: see C-080589 for sequence. Collected in shale 59.5 m stratigraphically above base of Yakoun. See fig. 4, section VII.

Age: Early Bajocian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: common, well preserved; yellowish-green in colour.

Sample collector: B.E.B. Cameron, 1982.

GSC loc. C-080595

Latitude/longitude: 53° 23.63' N, 132° 16.07' W.

Formation: Yakoun.

Locality information: see C-080589.

Sample lithology: greenish-brown limestone (very fine calcarenite).

Lithologic sequence/sample position: see C-080589 for sequence. Collected in shale 63 m stratigraphically above base of Yakoun. See fig. 4, section VII.

Age: Early Bajocian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: abundant, excellent preservation; green.

Sample collector: B.E.B. Cameron, 1982.

GSC loc. C-080596

Latitude/longitude: 53° 23.54' N, 132° 16.2' W.

Formation: Yakoun.

Locality information: see C-080589.

Sample lithology: greenish-grey sandy limestone (fine calcarenite).

Lithologic sequence/sample position: see C-080589 for general section. Collected above waterfall from a sandy, silty section near a pale grey ash bed, 192.5 m stratigraphically above base of Yakoun. See fig. 4, section VII.

Age: Early Bajocian (H.W. Tipper, pers. comm., 1983).

Radiolarian fauna: very few, preservation variable; pale green and white. Only 4 spp. identified.

Sample collector: B.E.B. Cameron, 1982.

APPENDIX 2

The following procedure was utilized to extract Radiolaria from limestone.

1. Crush sample using a rock-crusher or hammer, to fragments not exceeding 2-3 cm in size. Sample weight normally about 2 kg.

2. Place sample in a large plastic bucket (11 liter size). Fill bucket about three-quarters full with hot water.

3. Add 500 ml concentrated glacial acetic acid (60%). This should achieve a 5-10% concentration. A steady bubbling action is desired.

4. Place sample in fumehood and leave overnight or until reaction has ceased.

5. When most of sample is dissolved, pour sample and spent acid through a stack of two sieves; 20 mesh (841 µm) and 200 mesh (75 µm). Wash, dry and retain coarse fraction (from the 200 mesh sieve) for further use if needed. Wash the fines under a gentle stream of water. This removes the acid and much of the fine sediment.

6. Place fine residue in a beaker and cover with hydrogen peroxide (30%). A vigorous exothermic reaction normally will ensue. If reaction is slow, heat the sample to boiling for 1-2 minutes. Hydrogen peroxide oxidizes the organic matter on radiolarian tests and will free the clay that clings to the surface and obscures detail. Repeat this step if Radiolaria are still coated with clay..

7. Wet sieve the sample again on a 200 mesh sieve.

8. Dry the washed residue in an oven.

APPENDIX 3

Procedure for mounting radiolarians on SEM stubs: taken from De Wever (1981) with modifications by R.M. Goll (pers. comm., 1983).

This procedure uses nail polish as a mounting medium--dark red polish is best as it permits estimation of thickness of the coat. If too thick (polish distinctly red) specimens may sink too deeply into the polish, the lattice will fill with polish and obscure the pores. Nail polish is safe to use in an SEM but should be allowed to dry 24 hrs. before placing stub in the instrument.

1. On a watchglass, dissolve dark red nail polish in small amount of acetone.

2. Invert a clean standard aluminium SEM stub and dip surface in polish to achieve an even coating. Place stub in a holder and let dry overnight.

3. Transfer Radiolaria to the stub under a binocular microscope (selected specimens plus several extras), using a fine brush and distilled water. Orient in desired positions.

4. Carefully place stub (in holder) in petri dish. Moisten a small piece of folded tissue with acetone and place in dish alongside stub. Put lid on petri dish. Thirty seconds to one minute is usually sufficient time to embed some spines in the softened polish and obtain good electrical contact.

5. After taking stub from dish, wait one minute for polish to reharden then place stub under microscope and, using a fine wire or dry brush, prod one of the extra specimens. If it moves return stub to petri dish for additional time, if it breaks you can be reasonably confident other specimens are secure.

6. Clean off any debris with a damp brush. This last step is especially important as minute flecks of dust, clay or broken radiolarians will be most conspicuous on the even black backgrounds of SEM photomicrographs.