27. UPPER CRETACEOUS RADIOLARIA FROM DSDP SITE 275[1]

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INTRODUCTION

Twelve samples from four cores at Site 275 contain a well-preserved Late Cretaceous (latest Campanian) radiolarian assemblage. The intervals sampled, the total abundance of the Radiolaria, and their general state of preservation are indicated in Figure 1.

Site 275 is situated at 50°26.34'S 176°18.99'E on the southeast part of the Campbell Plateau near New Zealand. The Cretaceous sequence at this site can be divided into the following lithologic units: Unit 1—a pale yellow and olive soft, moderately to intensely mottled sandy silt and glauconite-rich radiolarian-diatomaceous ooze (Cores 1 and 2), and Unit 2—a dark gray, stiff, massive glauconite- and nodule-bearing detrital clay silt (Cores 3-5).

The late Campanian assemblage present at Site 275 is significant for the following reasons: (1) It is the first

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Age	Zone	Sample (Interval in cm)	Total Abundance	Preservation	*Phaseliforma laxa*	*Phaseliforma subcarinata*, n.sp.	*Orbiculiforma australis*, n. sp.	*Orbiculiforma renillaeformis*	*Orbiculiforma campbellensis*, n.sp.	*Prunobrachium (?) aucklandensis*, n.sp.	*Prunobrachium longum*, n.sp.	*Prunobrachium kennetti*, n.sp.	*Prunobrachium sibericum*	*Patulibracchium* sp.	*Paronaella* sp. 1	*Paronaella* (?) sp. 2	*Paronaella* (?) sp. 3	*Peritivator labyrinthi*	*Staurodictya* (?) *fresnoensis*	*Spongosaturninus* sp. 1	*Spongosaturninus* sp. 2	*Neosciadiocapsa jenkinsi*, n.sp.	*Microsciadiocapsa* (?) sp.	*Amphipyndax stocki*	*Amphipyndax* sp.	*Theocampe* sp. aff. *T. altamontensis*	*Archaeodictyomitra* (?) *regina*	*Dictyomitra densicostata*	*Cornutella californica*	*Cinclopyramis* (?) sp.	*Lophophaena* (?) *polycyrtis*	*Lithomelissa* (?) sp.	*Diacanthocapsa amphora*
late Campanian	*Patulibracchium dickinsoni*	1-1, 140-142	2	–	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	1	0	0
		1-2, 140-142	3	–	0	1	1	1	1	0	2	2	0	1	0	0	0	0	0	0	0	0	1	0	2	0	0	0	1	1	0	1	0	0
		1-3, 140-142	3	–	2	1	2	1	2	1	2	3	0	2	2	0	0	0	0	0	0	0	3	1	3	1	0	0	0	0	0	1	0	0
		1-4, 140-142	4	–	0	2	2	1	2	2	1	3	0	3	0	0	0	0	0	0	0	0	2	0	3	0	0	1	1	0	0	2	0	1
		2-1, 140-142	5	–	1	3	3	3	3	2	2	4	0	2	1	1	1	2	1	1	0	4	1	4	1	1	1	2	0	1	3	0	0
		2-2, 140-142	5	–	1	3	3	3	3	2	3	4	1	2	1	0	1	1	2	0	0	4	1	4	0	0	0	2	1	1	2	0	0
		2-3, 140-142	4	–	1	2	3	3	3	2	3	4	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	1	0	0	2	0	0
		2-4, 140-142	3	–	1	1	2	2	2	2	3	3	0	0	0	0	0	0	1	0	0	2	1	2	0	0	1	2	0	1	2	0	1
		2-5, 140-142	3	–	1	2	2	2	2	2	2	2	1	0	1	0	0	0	0	0	0	2	3	0	3	0	1	1	1	1	1	2	1	1
		2-6, 140-142	1	–	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0
		4-2, 140-142	1	D	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	2	0	1	0	0	2
?	?	5-1, 80-82	1	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

Note: Total abundance – This is a visual estimate of the number of Radiolaria on a 60-hole, 28-ply slide. It is based on the amount of residue remaining after a 2-cc sample is sieved through a 230-mesh (0.0025μ) sieve. 0: Absent; 1: $<10^1$ specimen; 2: $10^1 - 10^2$ specimens; 3: $10^2 - 10^3$ specimens; 4: $10^3 - 10^4$ specimens; 5: $>10^4$ specimens. Relative abundance – The relative abundance of each taxon is based on a stew of the 230-mesh (0.0025μ) sieved residue on a 60-hole, 28-ply slide. Relative abundance is expressed by a number (see below). Preservation – The state of preservation is indicated by a letter. If the preservation is good, no lettered notation is made.

Relative Abundance	No. Specimens	Preservation
0 = Absent		
1 = Rare	1-10	D = Dissolution
2 = Moderately rare	11-25	M = Mechanical erosion
3 = Common	26-50	
4 = Abundant	51-100	R = Reworked
5 = Very abundant	100	
* = Hundreds to thousands of specimens		

Figure 1. *Abundance, preservation, age, and zone of radiolarians at Site 275.*

Upper Cretaceous radiolarian assemblage figured from the Antarctic region; (2) It is a high-latitude assemblage displaying markedly lower diversity than those from middle or low latitudes (e.g., that of the late Campanian of California). (3) Even with its lower diversity, it can be readily correlated with the upper Campanian of California using the detailed zonation proposed by Pessagno (1974). As indicated by Pessagno (1974), the diversity gradient displayed by Mesozoic Radiolaria does not seem to be nearly as great as that of other microfossil groups such as the Foraminiferida. Hence, the Radiolaria may well serve as a matrix for interrelating zonal schemes proposed for other groups of fossils in high, middle, and low latitudes.

BIOSTRATIGRAPHY

At Site 275 the interval from Core 1, Section 1, 140-142 cm to Core 4, Section 2, 140-142 cm is correlative with the latest Campanian *Patulibracchium dickinsoni* Zone of Pessagno (1974) (Figure 2). The interval below Core 4, Section 2, 140-142 cm to Core 5, Section 1, 80-82 cm is tentatively assigned to the *Patulibracchium dickinsoni* Zone.

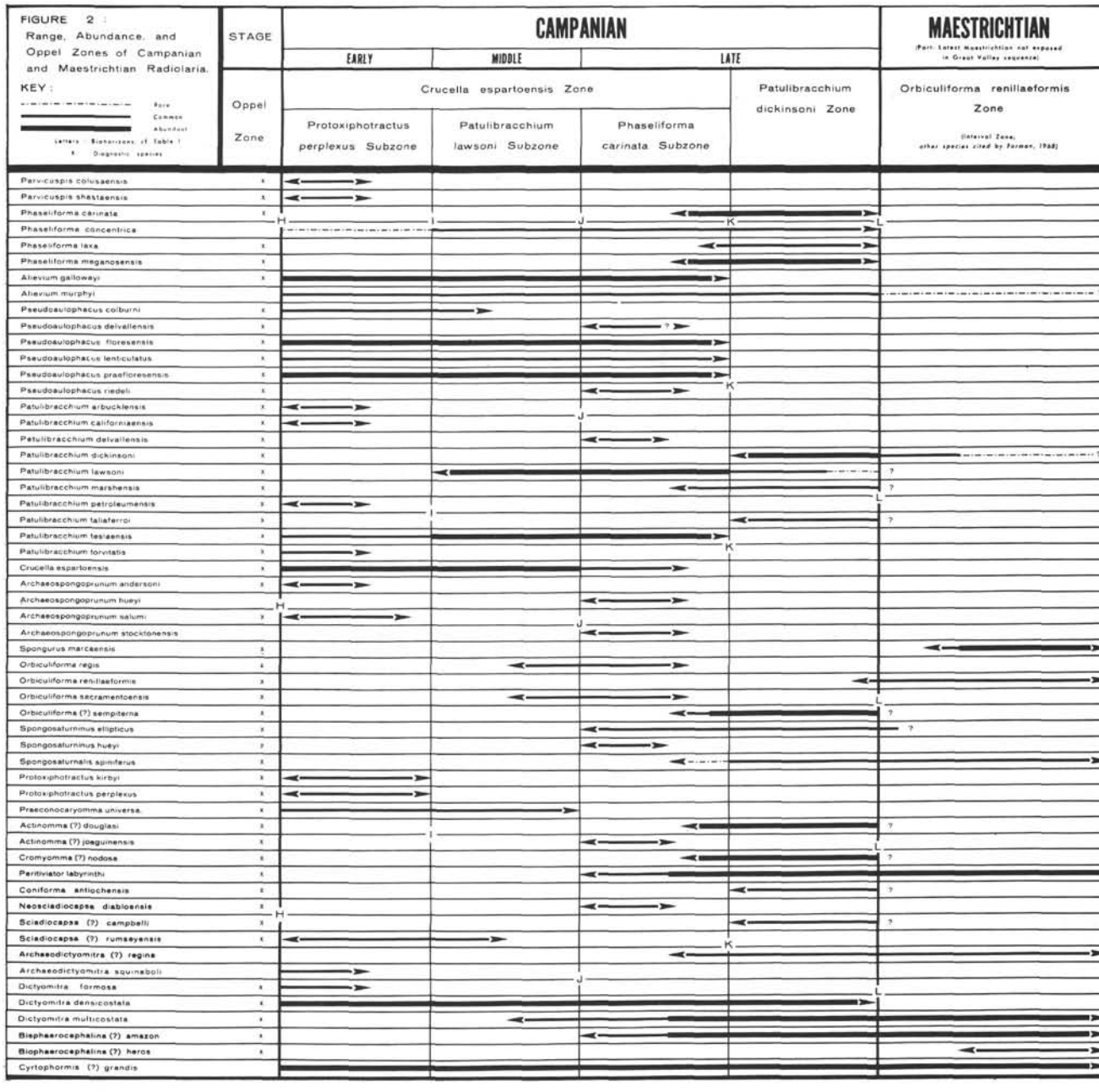

Figure 2. *Range, abundance, and oppel zones of Campanian and Maestrichtian Radiolaria.*

TABLE 1
Important Biohorizons in the Upper Cretaceous[a]

A	=	First occurrence of *Planomalina buxtorfi* (Gandolfi).
B	=	First occurrence of *Inoceramus labiatus* (Schlotheim), *Marginotruncana helvetica* (Bolli), *Alievium superbum* (Squinabol)
C	=	First occurrence of *Dictyomitra s.s.* Zittel
D	=	First evolutionary appearance of *Alievium praegallowayi* Pessagno
E	=	Final evolutionary appearance of *Alievium superbum* (Squinabol)
F	=	First evolutionary appearance of *Alievium gallowayi* (White)
G	=	Final evolutionary appearance of *Alievium praegallowayi* Pessagno
H	=	First occurrence of *Globotruncana arca* (Cushman); first occurrence of *Protoxiphotractus perplexus* Pessagno, and *Protoxiphotractus kirbyi* Pessagno
I	=	First occurrence of *Patulibracchium lawsoni* Pessagno
J	=	First occurrence of *Globotruncana hilli* Pessagno (= base of *Globotruncana calcarata* Zonule (Pessagno, 1967; 1969a) Family *Praeconocaryommidae* Pessagno becomes extinct immediately below this biohorizon
K	=	Extinction of Genus *Pseudoaulophacus* Pessagno and *Alievium gallowayi* (White); marked decline of *Pseudoaulophacidae* Riedel
L	=	Final occurrence of *Globotruncana ventricosa* White and *Globotruncana churchi* Martin (equivalent to the top of the *Globotruncana calcarata* Zonule of Pessagno, 1967; 1969a). Extinction of Genus *Phaseliforma* Pessagno and Family *Phaseliformidae* Pessagno

[a]From Pessagno, 1974. See also Figure 2.

Discussion

In the California coast ranges the base of the *Patulibracchium dickinsoni* Zone is defined by the first evolutionary occurrence of *P. dickinsoni* Pessagno (derived from *P. lawsoni* Pessagno). *Patulibracchium taliaferroi* Pessagno, *Coniforma antiochensis* Pessagno, and *Sciadiocapsa* (?) *campbelli* Pessagno make their first appearance at the base of this zone. The top of the *P. dickinsoni* Zone is marked by the extinction of *Phaseliforma* Pessagno, and in particular by the extinction of *Phaseliforma carinata* Pessagno, *P. laxa* Pessagno, and *P. meganosensis* Pessagno. *Orbiculiforma renillaeformis* (Campbell and Clark) makes its first appearance in the upper part of this zone. It should be noted that only one species (*Alievium murphyi* Pessagno) of the Pseudoaulophacidae Riedel is present at this horizon.

Basically, this zone can be defined by virtue of the fact that (1) its base occurs above the biohorizon offered by the extinction of *Pseudoaulophacus* Pessagno and the marked decline of the Pseudoaulophacidae and (2) its top occurs at the biohorizon offered by the extinction of *Phaseliforma* Pessagno and the Phaseliformidae Pessagno.

The presence of *Orbiculiforma renillaeformis* (Campbell and Clark) in the interval from Core 1, Section 1, 140-142 cm to Core 2, Section 5, 140-142 cm suggests that samples from this interval are assignable to the upper part of the *P. dickinsoni* Zone.

Associated planktonic foraminifera in the California section indicate that the *Crucella espartoensis* Zone, *Phaseliforma carinata* Subzone, and the *Patulibracchium dickinsoni* Zone are closely correlative with the *G. calcarata* Zonule of Pessagno (1967, 1969b) (see also Pessagno, 1974).

The total abundance of Radiolaria as well as the relative abundance and occurrence of various species are shown in Figure 1. One can easily discern from this figure that even in the samples where radiolarian total abundance is high (e.g., T.A. = 5 at 2/1 and 2/2), species diversity tends to be low. For example, Sample 275-2-1, 140-142 cm contains only 25 species of Radiolaria. Sample NSF 568-B from the *P. dickinsoni* Zone of California (latitude 35°N) contains 70 described and undescribed taxa; this latter sample is also comparable in terms of the total abundance of Radiolaria.

The late Campanian assemblage from the Campbell Plateau shows a great deal of similarity to that described by Lipman (1960) and Kozlova and Gorbovetz (1966) from the western Siberian lowland (latitude 65°N). Both assemblages seem to share species assignable to the Prunobrachidae, n. fam. Members of this family seem to be most abundant at high latitudes and are poorly represented at lower latitudes.

SYSTEMATIC PALEONTOLOGY

Subclass RADIOLARIA

Order POLYCYSTIDA

Suborder SPUMELLARIINA

Superfamily SPONGODISCACEA Haeckel, 1882

Subsuperfamily PSEUDOAULOPHACILAE Riedel, 1967

Family PHASELIFORMIDAE Pessagno, 1972

Type genus: *Phaseliforma* Pessagno, 1972.
Range: *Alievium praegallowayi* Zone to *Patulibracchium dickinsoni* Zone; Coniacian to Campanian.
Occurrence: Upper Cretaceous of California, Russia, and Antarctic region insofar as known.

Genus PHASELIFORMA Pessagno, 1972

Type species: *Phaseliforma carinata* Pessagno, 1972.
Range: *Alievium praegallowayi* Zone to *Patulibracchium dickinsoni* Zone; Coniacian to Campanian.
Occurrence: Upper Cretaceous of California, Russia, and Antarctic region.

Phaseliforma laxa Pessagno
(Plate 1, Figure 2)

Phaseliforma laxa Pessagno, 1972a, p. 276-277, pl. 23, fig. 7-9.
Range: *Crucella espartoensis* Zone, *P. carinata* Subzone; latest Campanian.
Occurrence: Latest Campanian portions of Forbes and "Marsh Creek" formations, Great Valley sequence, California. Site 275 (Figure 1).

Phaseliforma subcarinata Pessagno, n. sp.
(Plate 1, Figure 1)

Description: Test bean-shaped; about three quarters as wide as long with a V-shaped indentation along middle of one side. Test compressed posteriorly with angled periphery. Meshwork with irregular polygonal pore frames with nodes at vertices; pore frames triangular to hexagonal with circular to elliptical pores.
Remarks: *Phaseliforma subcarinata*, n. sp., is closely related to *P. carinata* Pessagno. It differs from *P. carinata* (1) by being nearly three

quarters as wide as long; (2) by having a more perforate periphery; and (3) by having a less angled periphery.

Measurements: Maximum length—holotype (1) 360μ; paratypes (7) 280-420μ. Maximum width—holotype (1) 280μ; paratypes (7) 220-330μ.

Type locality: DSDP Leg 29, Site 275, Core 2, Section 1, 140-142 cm.

Deposition of types: Holotype=USNM 207350; paratypes = USNM 207351.

Range: *Patulibracchium dickinsoni* Zone insofar as known; latest Campanian.

Occurrence: Site 275 (Figure 1).

Family ORBICULIFORMIDAE Pessagno, 1973

Type genus: *Orbiculiforma* Pessagno, 1973.

Range: Jurassic to Cretaceous; Cenozoic.

Occurrence: Worldwide.

Genus ORBICULIFORMA Pessagno, 1973

Type species: *O. quadrata* Pessagno, 1973.

Range: Jurassic to Cretaceous.

Occurrence: Worldwide.

Orbiculiforma australis Pessagno, n. sp.
(Plate 1, Figures 3, 4)

Description: Test quite thin, planiform with a wide, shallow central cavity occupying most of the surface of the test. Small V-shaped notch located on periphery. Meshwork dense; comprised of small triangular to hexagonal pore frames with nodes at vertices; pore frames predominantly tetragonal and pentagonal, with circular to elliptical pores.

Remarks: This species differs from *O. renillaeformis* (Campbell and Clark) (lectotype selected by Pessagno, 1974) by having fine, dense meshwork and a larger, flatter test. It seems to have been illustrated by Campbell and Clark (1944, pl. 6, fig. 8) as one of their syntypes for *Spongodiscus (S.) renillaeformis.*

Type locality: Holotype from DSDP Leg 29, Site 275, Core 2, Section 1, 140-142 cm; paratypes from this sample and Core 2, Section 2, 140-142 cm.

Deposition of types: Holotype=USNM 207352; paratypes = USNM 207353.

Range: Upper part of *Patulibracchium dickinsoni* Zone to *Orbiculiforma renillaeformis* Zone (California data); latest Campanian to Maestrichtian.

Occurrence: Site 275 (Figure 1). "Moreno Grande" Formation, Marca Shale, and upper part of the Marsh Creek Formation, California coast ranges.

Orbiculiforma campbellensis Pessagno, n. sp.
(Plate 1, Figures 5, 6)

Spongodiscus (S.) renillaeformis Campbell and Clark, 1944, p. 18, pl. 6, fig. 10; not pl. 6, fig. 5, 6, and 8 (fig. 6 = lectotype).

Description: Test relatively thin, planiform with wide, shallow central cavity occupying somewhat over one-half of surface area of test. Test surface sloping from edge of central area to periphery. Periphery with prominent V-shaped notch and nearly 40 short spines. Meshwork consisting of tetragonal to hexagonal pore frames with circular to elliptical pores; pore frames predominantly tetragonal.

Remarks: This species differs from *O. australis,* n. sp., by having (1) a smaller central area; (2) finer meshwork; (3) a more prominent V-shaped peripheral notch; and (4) a highly spinose periphery. Diameter = 330-410μ for five type specimens.

This species takes its name from the Campbell Plateau near New Zealand.

Type locality: DSDP Leg 29, Site 275, Core 1, Section 3, 140-142 cm.

Deposition of types: Holotype = USNM 207354; paratypes = USNM 207355.

Range: Upper part of *Patulibracchium dickinsoni* Zone insofar as known, latest Campanian.

Occurrence: Occurrence at Site 275 shown in Figure 1. Moreno Grande Formation, Great Valley sequence, California coast ranges.

Orbiculiforma renillaeformis (Campbell and Clark)
(Plate 1, Figure 7)

Spongodiscus (Spongodisculus) renillaeformis Campbell and Clark, 1944, p. 180, pl. 6, fig. 5, 6, 8, 10, (Fig. 6 = lectotype; fig. 5 = paralectotype selected by Pessagno 1974; fig. 8 = *O. australis,* n. sp.; fig. 10 = *O. campbellensis,* n. sp.).

Range: Upper part of *Patulibracchium dickinsoni* Zone to *O. renillaeformis* Zone; latest Campanian to Maestrichtian.

Occurrence: Site 275 (Figure 1). Moreno Grande Formation, Marca Shale, and upper part of Marsh Creek Formation; Great Valley sequence, California coast ranges.

Family PRUNOBRACHIDAE Pessagno n. fam.

Type genus: *Prunobrachium* Kozlova and Gorbovetz, 1966.

Description: Test elongate, ellipsoidal to cylindrical, frequently lobate with tubular structures termed bracchiopyles at each pole. Spongy meshwork markedly concentric in center of test; less concentric elsewhere. Test with or without a pseudopatagium.

Remarks: On first glance, the Prunobrachidae, n. fam., seem related to either the Sponguridae Haeckel or the Hagiastriadae Riedel. However, it was found that the Prunobrachidae differ from the Sponguridae (1) by having well-developed concentric meshwork in a spherical mass only in the center of their tests; (2) by possessing bracchiopyles at their poles (3) by often developing a pseudopatagium (see *Prunobrachium*); and (4) by lacking solid polar spines.

The term bracchiopyle was first used by Pessagno (1971, p. 75) for the cylindrical, porous, spongy tube associated with the Hagiastridae Riedel (i.e., the Patulibracchinae Pessagno). Although the presence of bracchiopyles with the Prunobrachidae could suggest a relationship with the Hagiastridae, the general structure of the remainder of the test negates this conclusion. The Hagiastridae (see Pessagno, 1971, p. 19) possess tests with spongy meshwork arranged in parallel to subparallel layers axially, and with individual layers comprised of pore frames arranged linearly or sublinearly.

Range: Upper Cretaceous.

Occurrence: Antarctic Region, Russia; rare in California.

Genus PRUNOBRACHIUM Kozlova, 1966

Type species: *Prunobrachium crassum* (Lipman, 1960).

Emended definition: Test elongate, basically ellipsoidal to cylindrical, usually lobate with brachiopyles at each pole. Meshwork spongy, arranged in two distinct major layers (Plate 2, Figures 1, 2); parallel to the long axis of test; outer layer termed *pseudopatagium.*

Remarks: *Prunobrachium* is perhaps most similar to *Spongurus* Haeckel (Sponguridae): It differs from *Spongurus,* however, by possessing (1) bracchiopyles at its poles; (2) a test consisting of two distinct major layers; and (3) meshwork which is markedly less concentric in character.

The outer layer of the test of *Prunobrachium* is termed the pseudopatagium. It differs from a true patagium by having its meshwork arranged in a crudely concentric fashion.

Range: Upper Cretaceous; latest Campanian. Upper part of *Crucella espartoensis* Zone, *Phaseliforma carinata* Subzone to top of *Patulibracchium dickinsoni* Zone.

Occurrence: Antarctic Region, western Siberian lowland, eastern slope of the Urals, and Great Valley sequence of California.

Prunobrachium(?) auklandensis Pessagno, n. sp.
(Plate 1, Figure 8)

Description: Test elongate bilobate with long central constriction separating two terminal lobes. Bracchiopyles fragile, not preserved in their entirety. Pore frames ranging in shape from triangular to pentagonal.

Remarks: *P. auklandensis,* n. sp., differs from *P. incisum* Koslova by being bilobate and more elongate in character. This species is questionably assigned to *Prunobrachium* because it lacks a pseudopatagium.

Measurements: Length exclusive of bracchiopyles—holotype (1) 275μ; paratypes (2) 470, 480μ. Maximum width in center—holotype (1) 70μ; paratypes (2) 70, 80μ.

Type locality: DSDP Leg 29, Site 275, Core 2, Section 1, 140-142 cm.

Desposition of types: Holotype = USNM 207356; paratypes = USNM 207357.
Range: *Patulibracchium dickinsoni* Zone: latest Campanian.
Occurrence: Occurrence at Site 275 shown in Figure 1.

Prunobrachium longum Pessagno, n. sp.
(Plate 2, Figures 3-5)

Description: Test elongate, trilobate; divided by two constrictions into a long central lobe and two shorter terminal lobes; central lobe twice as long as either terminal lobe. Central lobe, elongate, ellipsoidal to cylindrical in shape; terminal lobes subcylindrical in aspect. Well-preserved specimens with tubular structure on each terminal lobe; one tubular structure greater in diameter than the other. Meshwork dominantly pentagonal.
Remarks: *Prunobrachium longum*, n. sp., differs from *P. incisum* (1) by having a more elongate test which tends to be more cylindrical in aspect; (2) by having a proportionately longer central lobe; and (3) by having dominantly pentagonal meshwork.
Measurements: Length exclusive of bracchiopyles—holotype (1) 350μ; paratypes (4) 370-430μ. Maximum width in center—holotype (1) 150μ; paratypes (4) 140-170μ.
Type locality: DSDP Leg 29, Site 275, Core 2, Section 2, 140-142 cm.
Deposition of types: Holotype = USNM 207358; paratypes = USNM 207359.
Range: *Crucella espartoensis* Zone; *Phaseliforma carinata* Subzone to *Patulibracchium dickinsoni* Zone; latest Campanian.
Occurrence: Upper part of Forbes formation; Great Valley sequence, California coast ranges. Site 275 (Figure 1).

Prunobrachium kennetti Pessagno, n. sp.
(Plate 1, Figures 9-12; Plate 2, Figures 1, 2)

Description: Test trilobate with elongate, ellipsoidal central lobe, flanked by cylindrical distal lobes; each distal lobe with polar bracchiopyles; one bracchiopyle having a greater diameter than the other. Meshwork fine with polygonal (triangular to pentagonal) pore frames which tend to be somewhat coarser on distal lobes; pore frames with circular to elliptical pores.
Remarks: This species seems closely related to *P. incisum* Kozlova. It differs from *P. incisum* by having a more elongate ellipsoidal central lobe. The central lobe of *P. incisum* tends to be subspherical in shape.
P. kennetti, n. sp., is named after James P. Kennett, Co-Chief Scientist, DSDP Leg 29.
Measurements: Length exclusive of bracchiopyles—holotype (1) 450μ; paratypes (10) 350-430μ. Maximum width in center—holotype (1) 200μ; paratypes (10) 170-250μ.
Type locality: DSDP Leg 29, Site 257, Core 2, Section 1, 140-142 cm.
Deposition of types: Holotype = USNM 207360; paratypes = USNM 207361.
Range: *Patulibracchium dickinsoni* Zone; latest Campanian insofar as known.
Occurrence: Site 275 (Figure 1).

Prunobrachium sibericum (Lipman)
(Plate 1, Figures 13, 14)

Amphymenium sibiricum Lipman, 1960, *In* Lipman, Glazunova, et al., 1960, p. 128, pl. 28, fig. 14; Koslova and Gorbovetz, 1966, p. 83-84, pl. 3, fig. 8.
Remarks: Lipman's illustrations show the distinctive two-layered test characteristic of *Prunobrachium* (cf. pl. 2, fig. 1, 2 herein). The tapered shape of one end of the holotype may suggest the presence of a bracchiopyle.
Range: *Patulibracchium dickinsoni* Zone; latest Campanian insofar as known.
Occurrence: Occurrence at Site 275 shown in Figure 1. According to Koslova and Gorbovetz (1966) this species occurs in the Campanian of the western Siberian lowland in the Tyumensko-Petropavlovsk, Berezovo Chueljsk and Toboljsko-Uvatsk areas.

Family HAGIASTRIDAE Riedel, 1970, emended Pessagno, 1971

Type genus: *Hagiastrum* Haeckel, 1882.
Range: Mesozoic.
Occurrence: Worldwide.

Subfamily PATULIBRACCHINAE Pessagno, 1971

Type genus: *Patulibracchium* Pessagno, 1971.
Range: Mesozoic.
Occurrence: Worldwide

Patulibracchium sp. 1
(Plate 2, Figure 6)

Remarks: This form is characterized by the linearly arranged square to rectangular pore frames of its rays and by the rather massive patagium. Due to the massive nature of the patagium, it is usually preserved and tends to impart a triangular shape to the test.
Range and occurrence: *Patulibracchium dickinsoni* Zone; latest Campanian at Site 275 (Figure 1).

Genus PARONAELLA Pessagno, 1971

Type species: *Paronaella solaneonsis* Pessagno, 1971.
Range: Mesozoic.
Occurrence: Worldwide.

Paronaella sp. 1

Range and occurrence: *Patulibracchium dickinsoni* Zone; latest Campanian at Site 275 (Figure 1).

Paronaella (?) sp. 2
(Plate 2, Figure 7)

Remarks: This distinctive form should probably be placed in a new genus. It may have developed from *Paronaella* via formation of a thick patagium between the rays.
Range and occurrence: *Patulibracchium dickinsoni* Zone; latest Campanian at Site 275 (Figure 1).

Paronaella (?) sp. 3
(Plate 2, Figure 8)

Remarks: See comments under *Paronaella* (?) sp. 2.
Range and occurrence: *Patulibracchium dickinsoni* Zone; latest Campanian at Site 275 (Figure 1).

Spumellariina Incertae Sedis at Supergeneric Level

Genus PERITIVATOR Pessagno, 1974

Type species: *Peritivator labyrinthi* Pessagno, 1974.
Range: *Crucella espartoensis* Zone: *Phaseliforma carinata* Subzone to *Orbiculiforma renillaeformis* Zone; latest Campanian to Maestrichtian.
Occurrence: Campanian and Maestrichtian of California; Site 275.

Peritiviator labyrinthi Pessagno
(Plate 2, Figures 9, 10)

Peritiviator labyrinthi Pessagno, 1974, p. 137, pl. 13, fig. 2-4.
Range: *Crucella espartoensis* Zone: *Phaseliforma carinata* Subzone to *Orbiculiforma renillaeformis* Zone; latest Campanian to Maestrichtian.
Occurrence: Upper part of Marsh Creek Formation and Forbes Formation; Marca Shale; Moreno Grande Formation, Great Valley sequence, California coast ranges. Site 275 (Figure 1).

Genus STAURODICTYA Haeckel, 1882, emend. Kozlova and Gorbovetz, 1966

Type species: *Staurodictya beneckei* Rüst, 1885.

Staurodictya (?) fresnoensis Foreman
(Plate 2, Figure 11)

Range: *Crucella espartoensis* Zone: upper part of *Phaseliforma carinata* Subzone to *Orbiculiforma renillaeformis* Zone; latest Campanian to Maestrichtian.
Occurrence: Marca Shale; upper part of Forbes and Marsh Creek formations, Great Valley sequence, California coast ranges. Site 275 (Figure 1).

Genus SPONGOSATURNINUS Campbell and Clark, 1944

Type species: *Spongosaturninus ellipticus* Campbell and Clark.
Range and occurrence: Jurassic to Cretaceous; worldwide.

Spongosaturninus sp. 1
(Plate 2, Figure 12)

Range and occurrence: *Patulibracchium dickinsoni* Zone (latest Campanian) at Site 275 (Figure 1).

Spongosaturninus sp. 2
(Plate 2, Figure 13)

Range and occurrence: *Patulibracchium dickinsoni* Zone (latest Campanian) at Site 275 (Figure 1).

Suborder NASSELLARIINA Ehrenberg, 1875

Superfamily CYRTOIDEA Haeckel, 1862

Subsuperfamily EUCYRTIDILAE Ehrenberg, 1847

Family NEOSCIADIOCAPSIDAE Pessagno, 1969a

Type genus: *Neosciadiocapsa* Pessagno, 1969a.
Range: Jurassic to Tertiary.
Occurrence: Worldwide.

Genus NEOSCIADIOCAPSA Pessagno, 1969a

Type species: *Neosciadiocapsa diabloensis* Pessagno, 1969a.
Range: *Crucella espartoensis* Zone to *Patulibracchium dickinsoni* Zone insofar as known.
Occurrence: Leg 29, Site 275. Great Valley sequence, California coast ranges.

Neosciadiocapsa jenkinsi Pessagno, n. sp.
(Plate 3, Figures 1-12)

Description: Test lacking well-developed collar stricture. Cephalis with small irregularly shaped and disposed pores. Horn long, massive; triradiate in axial section proximally with one or two apical pores situated in each of three grooves at base of horn; remainder of horn circular in axial section and covered by fine, longitudinal striations. Thorax with well-developed uniformly shaped, hexagonal pore frames proximally; pore frames increasing in size distally and becoming more variable in shape; often varying from hexagonal to rectangular on thoracic skirt. Proximal (conical) portion of thorax having pore frames covered by secondary epithecal material and three radiating spinose ridges. Velum partially developed; coarsely perforate like that of *N. diabloensis*.

Remarks: *N. jenkinsi* Pessagno, n. sp., differs from *N. diabloensis* Pessagno (1) by displaying a horn which is triradiate only at its base; (2) by having a test of lower relief; (3) by displaying three radially arranged spinose ridges on the proximal part of the thorax; and (4) by having a broader thoracic skirt.

This species is named for Dr. D. Graham Jenkins, University of Canterbury, in honor of his many contributions to New Zealand stratigraphy.

Measurements: A-A^1—holotype (1) 470μ; paratypes (10) 460-560μ. B-B^1 (see Pessagno, 1969a, p. 381) holotype (1) 450μ; paratypes (10) 410-500μ.

Type locality: DSDP Leg 29, Site 275, Core 2, Section 1, 140-142 cm.

Deposition of types: Holotype = USNM 207362; paratypes = USNM 207363.

Range: *Patulibracchium dickinsoni* Zone insofar as known; latest Campanian.

Occurrence: Site 275 (Figure 1).

Genus MICROSCIADIOCAPSA Pessagno, 1969a

Type species: *Microsciadiocapsa monticelloensis* Pessagno, 1969.
Range and occurrence: Upper Cretaceous of California insofar as known.

Microsciadiocapsa (?) sp.
(Plate 4, Figures 1-3)

Range and occurrence: *Patulibracchium dickinsoni* Zone at Site 275 (Figure 1).

Family AMPHIPYNDACIDAE Riedel, 1967

Type genus: *Amphipyndax* Foreman, 1968.
Range and occurrence: Cretaceous. Worldwide.

Genus AMPHIPYNDAX Foreman, 1968

Type species: *Amphipyndax enesseffi* Foreman, 1968.
Range: Cretaceous. Albian to Maestrichtian insofar as known. Definitely not known from Jurassic.
Occurrence: Worldwide.

Amphipyndax stocki (Campbell and Clark), emend. Foreman, 1968
(Plate 4, Figures 3-8)

Stichocapsa (?) *stocki* Campbell and Clark, 1944, p. 44, pl. 8, fig. 31-33.
Stichocapsa megalocephalina Campbell and Clark, 1944, p. 44, pl. 8, fig. 26, 34.
Amphipyndax stocki (Campbell and Clark). Foreman, 1968, p. 78, pl. 8. fig. 12 a-c; Foreman, 1970, p. 430, pl. 13, fig. 5; Petrushevskaya and Kozlova, 1972, p. 545, pl. 8, fig. 16, 17.

Remarks: Foreman (1968, p. 79) noted the presence of hexagonally distributed nodes surrounding the pores of this species. Scanning electron micrographs of Leg 29 specimens demonstrate the presence of such nodes, but indicate that they are situated at the vertices of hexagonally arranged pore frames. Two forms seem to be present here: one with a spherical, papillose cephalothoracic region and the other with a smooth cephalothoracic region.

Range: *Patulibracchium dickinsoni* Zone to *Orbiculiforma renillaeformis* Zone; latest Campanian to Maestrichtian.

Occurrence: Moreno Grande Formation; upper part of Marsh Creek Formation; occurrence at Site 275 (Figure 1).

Amphipyndax sp.
(Plate 4, Figure 8)

Range and occurrence: Site 275 (Figure 1).

Family ARTOSTROBIIDAE Riedel, 1967

Type genus: *Artostrobium* Haeckel, 1887, designated herein.
Remarks: Riedel (1967) never designated a type genus for this family.
Range: Cretaceous to Tertiary.
Occurrence: Worldwide

Genus THEOCAMPE Haeckel, emend. Burma, 1959

Type species: *Dictyomitra ehrenbergi* Zittel, 1876
Range: Paleozoic to Recent.
Occurrence: Worldwide.

Theocampe sp. aff. T. altamontensis (Campbell and Clark)
(Plate 4, Figure 10)

Tricolocampe (Tricolocamptra) altamontensis Campbell and Clark, p. 33, pl. 7, fig. 24-26.

Remarks: The specimen figured herein differs from *T. altamontensis s.s.* by showing irregularly distributed pore frames on the distal part of the abdomen. The character of the remainder of the test is quite similar to that of *T. altamontensis*.

Range and occurrence: *Patulibracchium dickinsoni* Zone; latest Campanian at Site 275 (Figure 1).

Family ARCHAEODICTYOMITRIDAE Pessagno, 1974

Type genus: *Archaeodictyomitra* Pessagno, 1974.
Range: Jurassic to Cretaceous.
Occurrence: Worldwide.

Archaeodictyomitra (?) regina (Campbell and Clark)
(Plate 4, Figures 11, 12)

Lithomitra (Lithomitrissa) regina Campbell and Clark, 1944, p. 41, pl. 8, fig. 30, 38, 40.
Dictyomitra regina (Campbell and Clark). Foreman, 1968, p. 68-69, pl. 8, fig. 5a-c.

Remarks: This species is questionably assigned to *Archaeodictyomitra*. Like *Archaeodictyomitra*, it lacks well-developed strictures. However, it seems to lack relict pores; all of its pores appear to be primary in nature. Furthermore. its test seems to be more cylindrical in shape and lacks well-developed partitions between the test joints.

Range: *Crucella espartoensis* Zone, *Phaseliforma carinata* Subzone to *Orbiculiforma renillaeformis* Zone; latest Campanian to Maestrichtian.

Occurrence: Upper part of the Forbes and Marsh Creek formations; Moreno Grande Formation; Marca Shale. Site 275 (Figure 1).

Archaeodictyomitra sp.
(Plate 5, Figure 4)

Range and occurrence: *Patulibracchium dickinsoni* Zone at Site 275 (Figure 1).

Genus DICTYOMITRA Zittel, 1876, emend. Pessagno, 1974

Type species: *Dictyomitra multicostata* Zittel, 1876. Lectotype designated by Pessagno, 1974.
Range: Turonian to Maestrichtian.
Occurrence: Worldwide.

Dictyomitra densicostata Pessagno
(Plate 5, Figures 1-3)

Dictyomitra densicostata Pessagno, 1974, pl. 14, fig. 10-14, 16.
Range: *Alievium praegallowayi* Zone, *Orbiculiforma vacaensis* Subzone to *Patulibracchium dickinsoni* Zone.
Occurrence: Sites, Funks, Forbes, and Marsh Creek formations; Great Valley sequence, California coast ranges. Site 275 (Figure 1).

Nassellariina Incertae Sedis at Suprageneric Level

Genus CORNUTELLA Ehrenberg, 1838, emend. Nigrini, 1967

Type species: *Cornutella clathrata* Ehrenberg, 1884.
Range and occurrence: Jurassic to Recent; worldwide.

Cornutella californica Campbell and Clark
(Plate 5, Figure 13)

Cornutella californica Campbell and Clark, 1944, p. 22-23, pl. 7, fig. 42; Foreman, 1968, p. 21-22, pl. 3, fig. 1a-c.
Range: *Crucella espartoensis* Zone, *Phaseliforma carinata* Subzone to *Orbiculiforma renillaeformis* Zone insofar as known; late Campanian to Maestrichtian.
Occurrence: Upper part of Forbes and Marsh Creek formations; Marca Shale, Moreno Grande Formation in Great Valley sequence, California coast ranges. Campanian and Maestrichtian of South Atlantic; Trinidad.

Genus CINCLOPYRAMIS Haeckel, 1881

Type species: *C. cribellum* Haeckel, 1887.
Range: Upper Cretaceous to Recent.
Occurrence: Worldwide.

Cinclopyramis sp.
(Plate 5, Figures 11, 12)

Range and occurrence: Site 275 (Figure 1).

Genus LOPHOPHAENA Ehrenberg, 1847

Type species: *Lophophaena galena* Ehrenberg, 1854.
Range and occurrence: Not fully established.

Lophophaena (?) polycyrtis (Campbell and Clark), emend. Foreman, 1968
(Plate 5, Figures 9, 10)

Sethoconus (Phlebarachnium) polycyrtis Campbell and Clark, 1944, p. 27, pl. 7, fig. 39, 40, 45, 48, 50, 51.
Lithomelissa (Sethomelissa) armata Campbell and Clark, 1944, p. 26, pl. 7, fig. 44, 47.
Lophophaena (?) *polycyrtis* (Campbell and Clark). Foreman, 1968, p. 23, pl. 3, fig. 3a-c.
Range: *Patulibracchium dickinsoni* Zone to *Orbiculiforma renillaeformis* Zone; latest Campanian to Maestrichtian.
Occurrence: Marca Shale, Moreno Grande Formation in Great Valley sequence, California coast ranges.

Genus LITHOMELISSA Ehrenberg, 1847

Type species: *Lithomelissa tartari* Ehrenberg, 1854.
Range and occurrence: Not established.

Lithomelissa (?) sp.
(Plate 5, Figure 8)

Range and occurrence: *Patulibracchium dickinsoni* Zone; latest Campanian. Site 275 (Figure 1).

Genus DIACANTHOCAPSA Squinabol, emend. Dumitrica, 1970

Type species: *Diacanthocapsa euganea* Squinabol, 1903.
Range: Cenomanian to Maestrichtian.
Occurrence: Worldwide.

Diacanthocapsa amphora (Campbell and Clark), emend. Foreman, 1968
(Plate 5, Figures 5-7)

Theocapsa (Theocapsomma) granti Campbell and Clark, 1944, p. 35, pl. 7, fig. 37, 38.
Theocapsomma amphora Campbell and Clark. Foreman, 1968, p. 31, pl. 4, fig. 9a-c.
Remarks: The specimen figured here is quite similar to that illustrated by Foreman (1968, pl. 4, fig. 9c). Foreman's photomicrographs indicate the presence of hexagonal pore frames and circular pores. The specimen from Site 275 shows a tubular aperture at the base of the abdomen; it is most likely better preserved than the California specimens figured in the literature.
Range: *Patulibracchium dickinsoni* Zone to *Orbiculiforma renillaeformis* Zone; latest Campanian to Maestrichtian.
Occurrence: Marca Shale, Moreno Grande Formation in the Great Valley sequence of the California coast ranges. Site 275 (Figure 1).

ACKNOWLEDGMENTS

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PLATE 1

All figures are scanning electron micrographs of late Campanian Radiolaria. Scale on all photos except Figures 10 and 12 = 100μ; scale on Figures 10 and 12 = 28μ and 24μ, respectively.

Figure 1 — *Phaseliforma subcarinata* Pessagno, n. sp.; Holotype (USNM 207359); Sample 29-275-2-1, 140-142 cm.

Figure 2 — *Phaseliforma laxa* Pessagno; Sample 29-275-2-1, 140-142 cm.

Figure 3 — *Orbiculiforma australis* Pessagno, n. sp.; Holotype (USNM 203352); Sample 29-275-2-1, 140-142 cm.

Figure 4 — *Orbiculiforma australis* Pessagno, n. sp.; Paratype (USNM 207353); Sample 29-275-2-1, 140-142 cm.

Figure 5 — *Orbiculiforma campbellensis* Pessagno, n. sp.; Holotype (USNM 207354); Sample 29-275-1-3, 140-142 cm.

Figure 6 — *Orbiculiforma campbellensis* Pessagno, n. sp.; Paratype (USNM 207355); Sample 29-275-1-3, 140-142 cm.

Figure 7 — *Orbiculiforma renillaeformis* (Campbell and Clark); Sample 29-275-2-1, 140-142 cm.

Figure 8 — *Prunobrachium* (?) *aucklandensis* Pessagno, n. sp.; Holotype (USNM 207356); Sample 29-275-2-1, 140-142 cm.

Figures 9-12 — *Prunobrachium kennetti* Pessagno, n. sp.; Sample 29-275-2-1, 140-142 cm.
9, 10. Holotype (USNM 207360).
11, 12. Paratype (USNM 207361). Note tubular structures (bracchiopyles) at either end of test. One bracchiopyle tends to be greater in diameter than the other; 140-142 cm.

Figures 13, 14 — *Prunobrachium sibericum* (Lipman); Sample 29-275-2-2, 140-142 cm.

PLATE 1

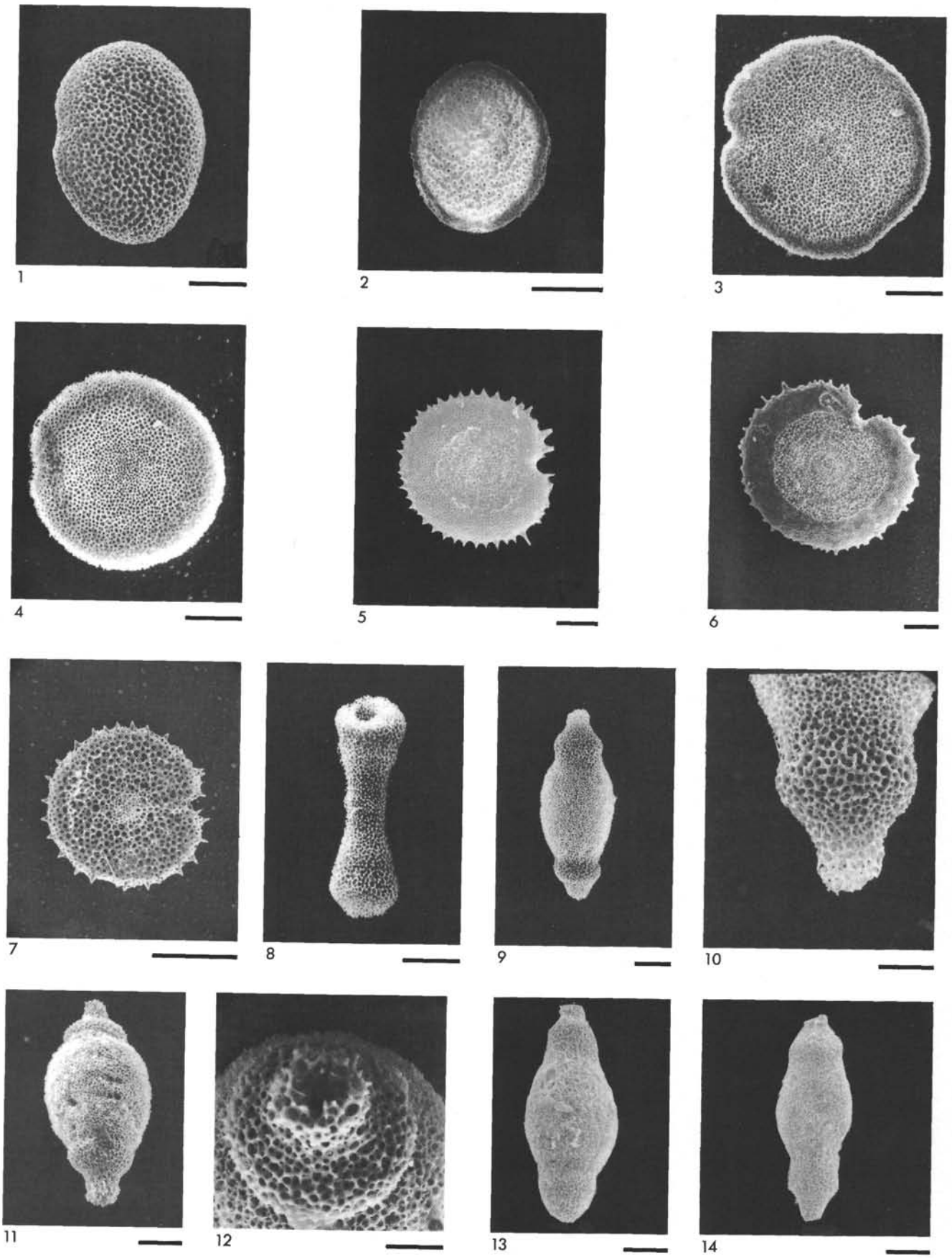


PLATE 2

All figures except 1 and 2 are scanning electron micrographs; Figures 1 and 2 are light photomicrographs; late Campanian Radiolaria. Scale on all figures except 9, 10, 12, and 13 = 100μ; scale on Figures 9, 10, 12, and 13 = 44, 32, 66, and 72μ, respectively.

Figures 1, 2 — *Prunobrachium kennetti* Pessagno, n. sp.; Sample 29-275-2-1, 140-142 cm.
1. Longitudinal section cut in plane through center of test. Note markedly concentric layering of central part of test and division of test into two major layers; outer layer termed the pseudopatagium.
2. Axial section through center of test; central portion with markedly concentric layering; pseudopatagium with crudely concentric layering.

Figures 3-5 — *Prunobrachium longum* Pessagno, n. sp.; Sample 29-275-2-2, 140-142 cm.
3, 4. Holotype (USNM 207358).
5. Paratype (USNM 207359).

Figure 6 — *Patulibracchium* sp.; Sample 29-275-2-1, 140-142 cm.

Figure 7 — *Paronaella* (?) sp. 2; Sample 29-275-2-1, 140-142 cm.

Figure 8 — *Paronaella* (?) sp. 3; Sample 29-275-2-1, 140-142 cm.

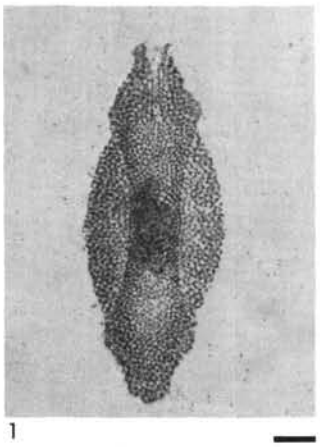
Figures 9, 10 — *Peritiviator labyrinthi* Pessagno; Sample 29-275-2-1, 140-142 cm.

Figure 11 — *Staurodictya* (?) *fresnoensis* Foreman; Sample 29-275-2-1, 140-142 cm.

Figure 12 — *Spongosaturninus* sp. 1; Sample 29-275-2-1, 140-142 cm.

Figure 13 — *Spongosaturninus* sp. 2; Sample 29-275-2-5, 140-142 cm.

PLATE 2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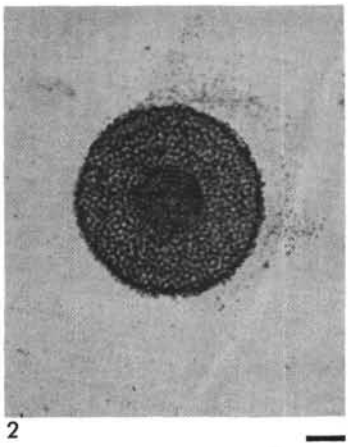
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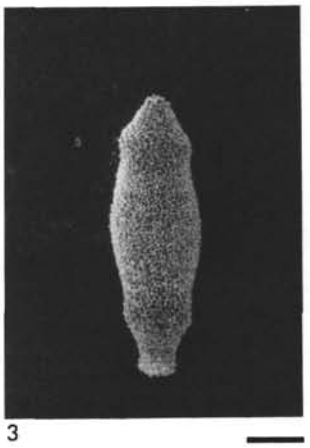
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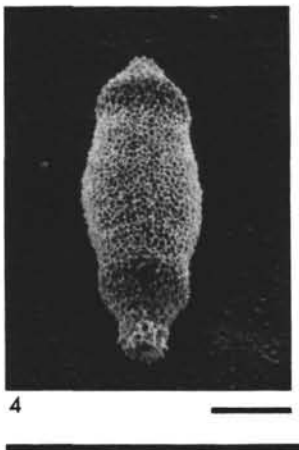
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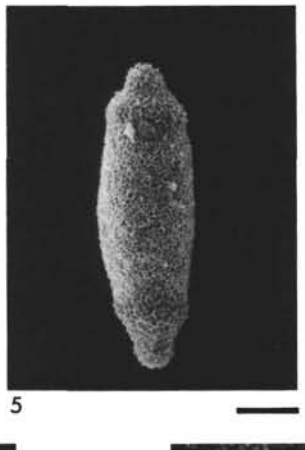
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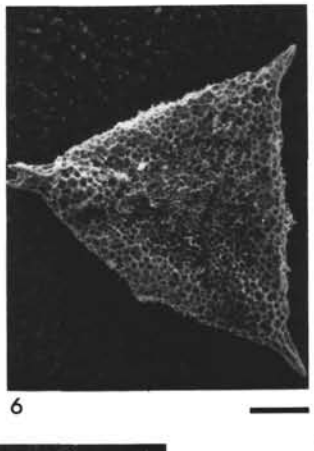
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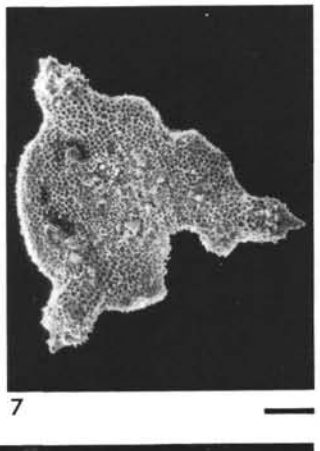
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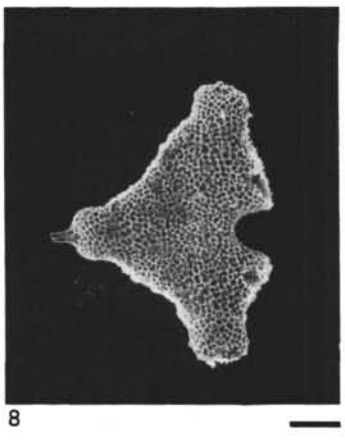
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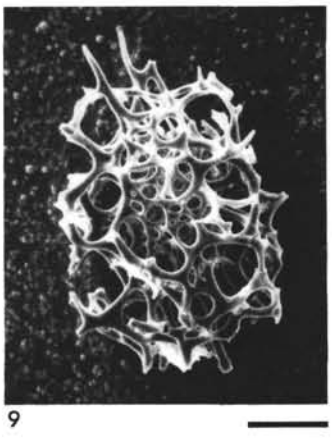
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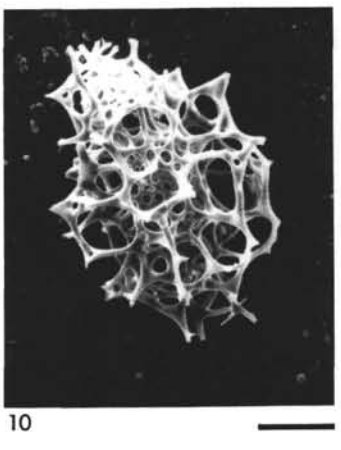
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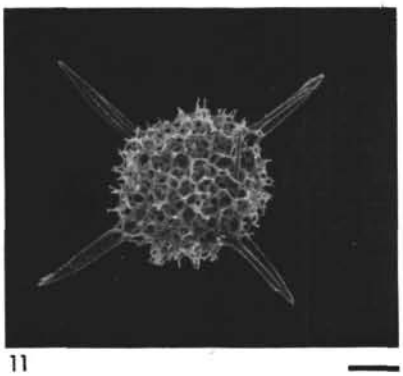
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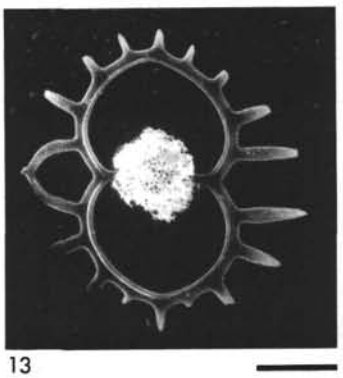
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PLATE 3

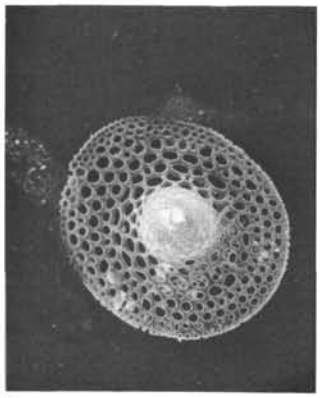
All figures are scanning electron micrographs of Campanian Radiolaria. Scale = 100μ unless otherwise noted.

Figures 1-3 *Neosciadiocapsa jenkinsi* Pessagno, n. sp.; Holotype (USNM 207362); Sample 29-275-2-1, 140-142 cm. Scale on Figure 3 = 44μ.

Figures 4-10 *Neosciadiocapsa jenkinsi* Pessagno, n. sp.; Paratypes (USNM 207363); Sample 29-275-2-1, 140-142 cm. Note prominent grooves and apical pores at base of horn and 3 spinose ridges radiating downwards from horn (Figures 8-10). Scale on Figure 7 = 66μ; scale on Figure 10 = 22μ.

Figures 11, 12 *Neosciadiocapsa jenkinsi* Pessagno, n. sp. Note triradiate nature of proximal portion of horn and presence of apical pores. Sample 29-275-1-3, 140-142 cm. Scale = 20μ.

PLATE 3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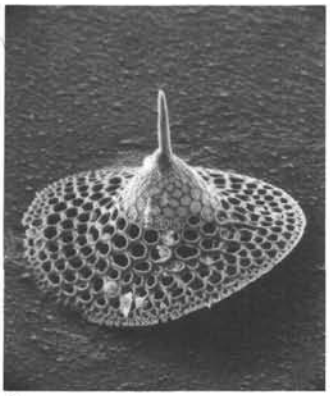
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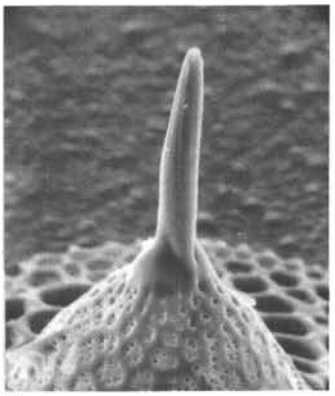
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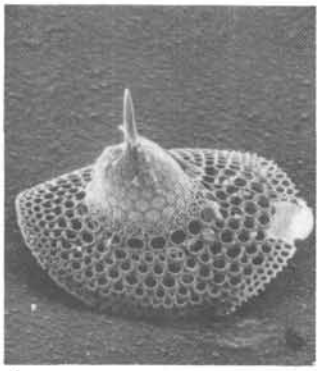
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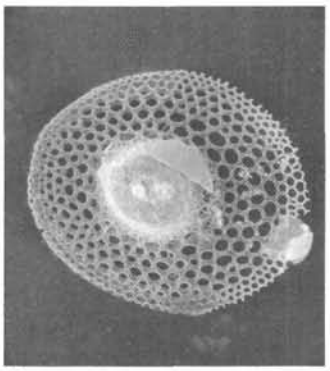
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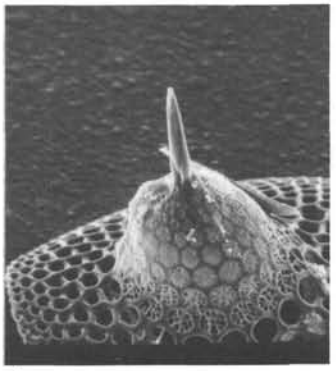
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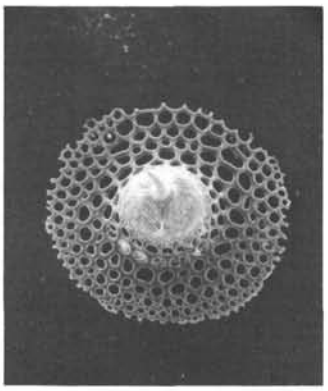
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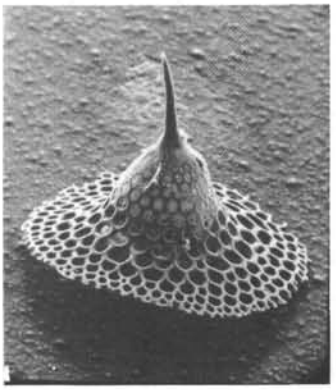
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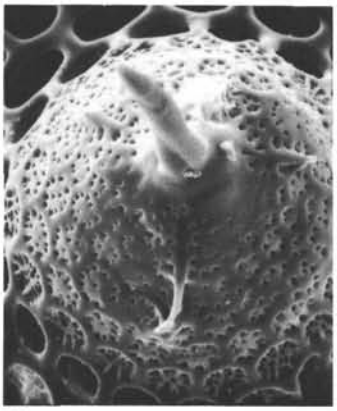
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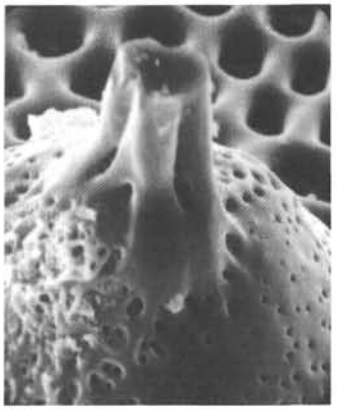
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PLATE 4

All figures are scanning electron micrographs of late Campanian Radiolaria.

Figures 1-3 — *Microsciadiocapsa* (?) sp.; Sample 29-275-1-3, 140-142 cm.
1, 2. Scale = 100μ.
3. Scale = 40μ.

Figures 4, 5 — *Amphiphydax stocki* (Campbell and Clark) s.s. Note bulbous cephalothorax covered with papillae (see descriptions of this species by Campbell and Clark, 1944; Foreman, 1968). Sample 29-275-2-5, 140-142 cm.
4. Scale = 100μ.
5. Scale = 20μ.

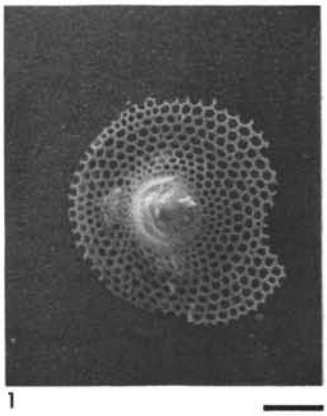
Figures 6-8 — *Amphipyndax stocki* (Campbell and Clark) s.l. Note less bulbous, smooth cephalothorax. This form should probably be treated as a new speices or a new subspecies of *A. stocki*. Sample 29-275-2-1, 140-142 cm. Scales = 50, 24, and 50μ, respectively.

Figure 9 — *Amphipyndax* sp.; Sample 29-275-2-1, 140-142 cm. Scale = 50μ.

Figure 10 — *Theocampe* sp. aff. *T. altamontensis* (Campbell and

Figures 11, 12 — *Archaeodictyomitra* (?) *regina* (Campbell and Clark); Sample 29-275-2-5, 140-142 cm. Scale = 100 and 66μ, respectively.

PLATE 4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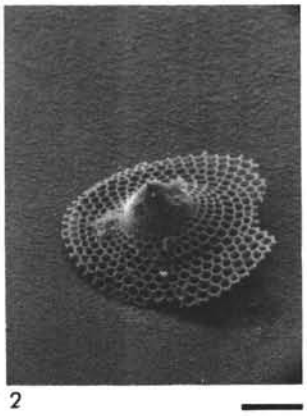
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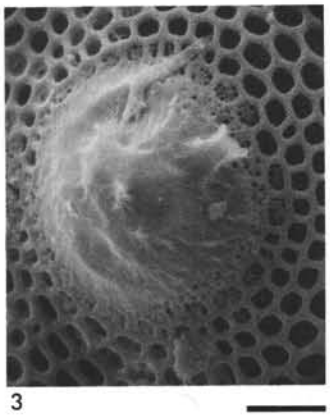
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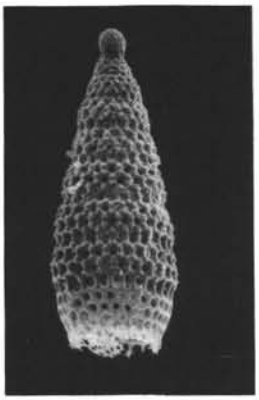
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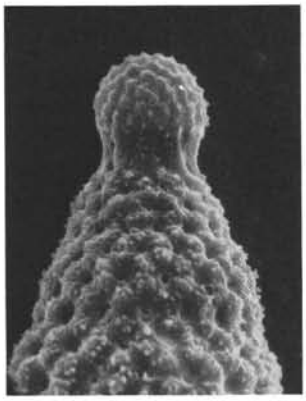
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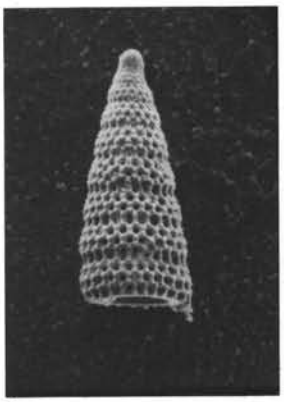
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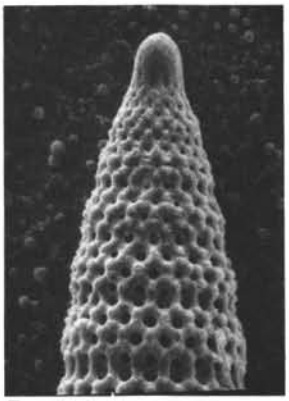
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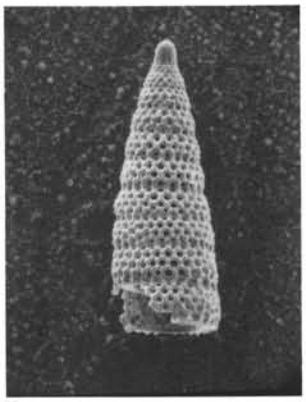
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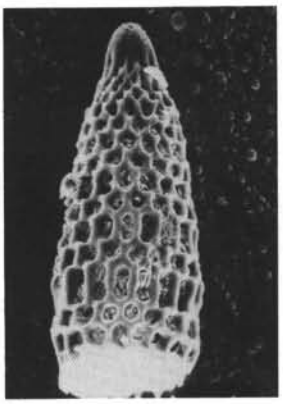
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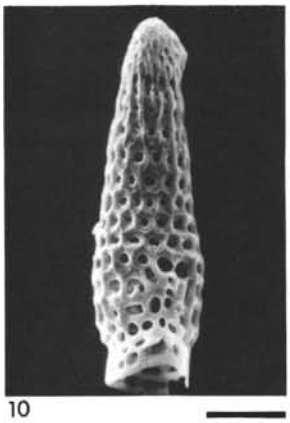
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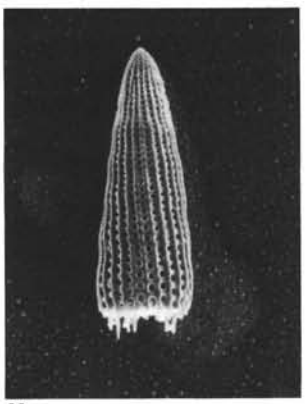
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12

PLATE 5

All figures are scanning electron micrographs of late Campanian Radiolaria.

Figures 1-3 — *Dictyomitra densicostata* Pessagno; Sample 29-275-2-5, 140-142 cm, scale = 80, 26, and 66μ, respectively.

Figure 4 — *Archaeodictyomitra* sp.; Sample 29-275-2-5, 140-142 cm; scale = 56μ.

Figures 5-7 — *Diacanthocapsa amphora* (Campbell and Clark); Sample 29-275-2-5, 140-142 cm; scale = 40, 50, and 24μ, respectively.

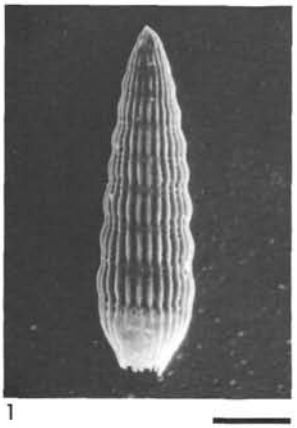
Figure 8 — *Lithomelissa* (?) sp.; Sample 29-275-2-5, 140-142 cm, scale = 50μ.

Figures 9, 10 — *Lophophaena* (?) *polycyrtis* (Campbell and Clark); Sample 29-275-2-5, 140-142 cm; scale = 100 and 50μ, respectively.

Figures 11, 12 — *Cinclopyramis* sp.; Sample 29-275-2-1, 140-142 cm; scale = 50μ each.

Figure 13 — *Cornutella californica* Campbell and Clark; Sample 29-275-2-1, 140-142 cm; scale = 40 μ.

PLATE 5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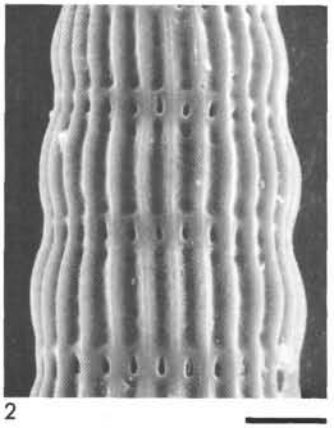
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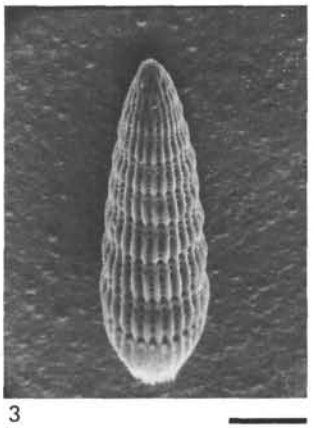
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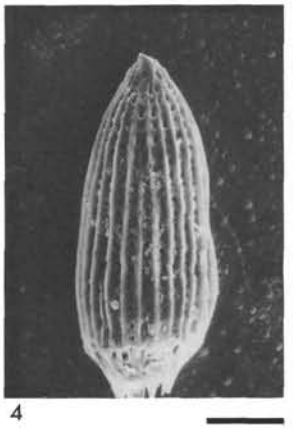
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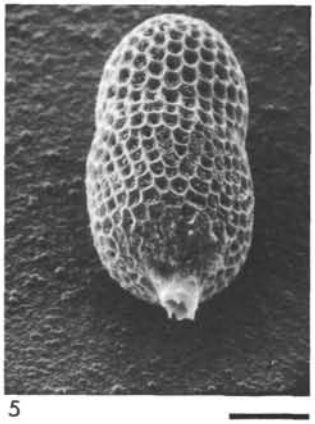
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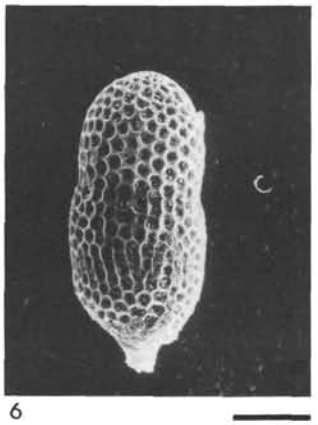
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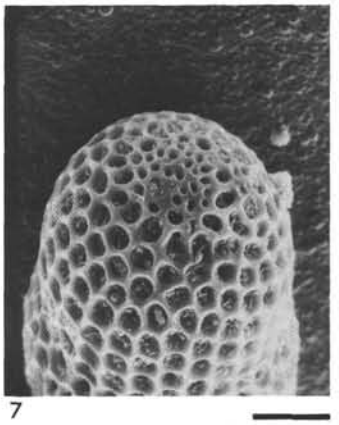
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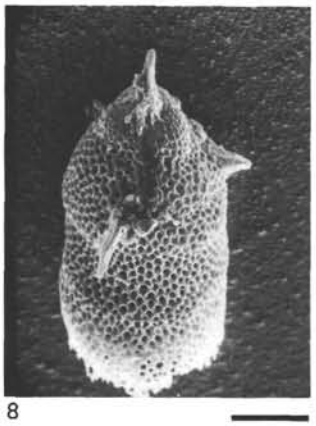
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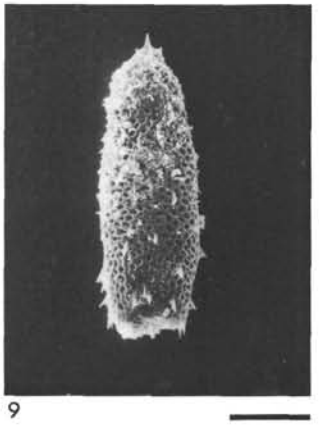
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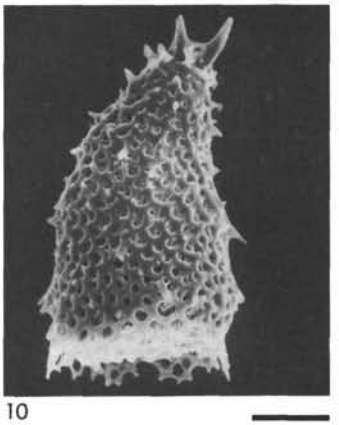
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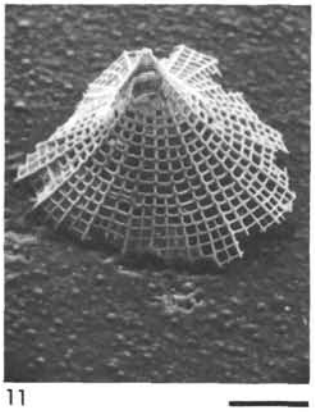
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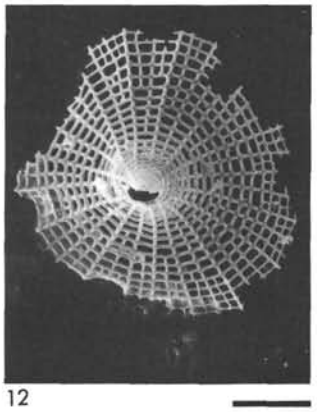
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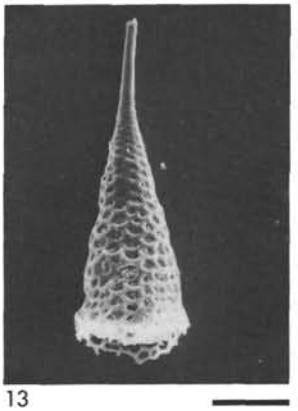
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