14. MIOCENE DINOCYSTS FROM DEEP SEA DRILLING PROJECT LEG 81, ROCKALL PLATEAU, EASTERN NORTH ATLANTIC OCEAN[1]

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ABSTRACT

The biostratigraphic occurrences of dinoflagellate cysts from the Miocene sediments of DSDP Leg 81 are documented using 38 fossiliferous samples from Holes 555, 553A, 552, 552A, 554, and 554A, Rockall Plateau, eastern North Atlantic Ocean. Lower Miocene dinocysts were recovered from Hole 555, middle Miocene dinocysts from Holes 555 and 553A, and upper Miocene dinocysts from Holes 555, 552, 552A, 554, and 554A.

In the middle Miocene, important species at Leg 81 sites include: "*Nematosphaeropsis*" *aquaeducta* (lowest and highest occurrences within the middle Miocene), *Tectatodinium simplex* n. comb. (lowest occurrence within the middle Miocene), *Danea*? sp. (lowest and highest occurrences), *Labyrinthodinium truncatum* (lowest and highest occurrences), *Hystrichostrogylon* sp. (lowest occurrence), *Batiacasphaera* sp. I (highest occurrence), *Invertocysta tabulata* n. gen., n. sp. (lowest occurrence), *Invertocysta lacrymosa* n. gen., n. sp. (lowest occurrence), *Operculodinium* sp. of Jan du Chêne (lowest occurrence), Incertae sedis sp. I (lowest occurrence), *Fibrocysta*? *fusiforma* n. sp. (lowest occurrence), and *Pentadinium laticinctum* (highest occurrence).

In the upper Miocene, important species from Leg 81 sites include: Incertae sedis sp. II (lowest occurrence), *Fibrocysta*? *fusiforma* n. sp., (highest occurence), and Incertae sedis sp. I (highest occurrence).

Invertocysta tabulata n. gen., n. sp. reveals a unique and well-developed paratabulation.

INTRODUCTION

Leg 81 of the Deep Sea Drilling Project drilled eight holes at four sites in the southwestern part of the Rockall Plateau in the eastern North Atlantic Ocean (Fig. 1). This chapter deals with the biostratigraphic occurrences of dinoflagellate cysts in the Miocene sediments of this leg. The Plio-Pleistocene dinocysts are discussed by Harland (this volume) and the Paleogene dinocysts are treated by Brown and Downie (this volume).

Relatively few detailed stratigraphic studies of Miocene dinoflagellate cysts have been made. Maier (1959) and Gerlach (1961) documented ranges of selected dinoflagellate cysts in Germany and included Miocene deposits. Habib (1971) reported the occurrences of dinoflagellates across the Miocene/Pliocene boundary in northern Italy. In 1972, Habib included Miocene dinocysts in his report on the Mesozoic and Cenozoic dinoflagellates from offshore North America. Williams (1975) and Williams and Brideaux (1975) included Miocene as well as older and younger dinoflagellate material in their studies of the Grand Banks and Scotian Shelf. In his 1977 work, Williams presented a zonation of the Triassic to Pliocene, which includes three zones in the Miocene.

Manum (1976) studied the Tertiary dinocysts from the Norwegian–Greenland Sea sediments and erected a provisional zonation. Costa and Downie (1979) reported on the Cenozoic dinocysts from the Rockall Plateau and established nine informal partial-range zones. For this same leg, Harland (1979) documented the ranges of dinocysts from the Neogene and Quaternary of the Bay of Biscay. He, too, erected a different, tentative fourfold informal zonation. Piasecki (1980) erected four formal biozones based on successive first occurrences and documented the dinoflagellate cyst biostratigraphy in the Miocene of Denmark. In this chapter, the observed dinocyst ranges for the Miocene are given, but no formal or informal zonation is introduced.

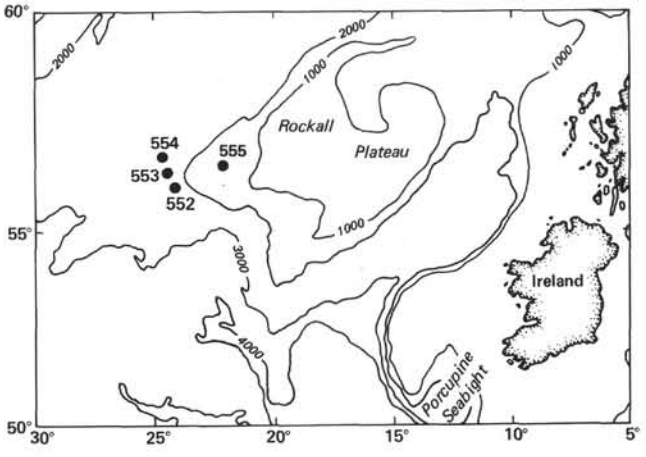

Figure 1. Map of North Atlantic showing position of sites for Leg 81.

METHODS

Six of the eight holes drilled on Leg 81 recovered Miocene sediments. From these, 54 samples were taken for dinoflagellates, 38 of which contained identifiable dinocysts. Samples (10–40 cm^3 of sediment) were treated with hydrochloric and hydrofluoric acids, oxidized with nitric acid, separated by floating in heavy liquid ($ZnCl_2$, sp. gr. 1.8) if there was sufficient residue or by swirling if there was little residue, and stained with Bismark brown. All samples were observed by light microscope using Nomarski interference contrast. In addition, two samples (555-22-1, 107–109 cm and 555-21-2, 60–62 cm) were ex-

[1] Roberts, D. G., Schnitker, D., et al., *Init. Repts. DSDP*, 81: Washington (U.S. Govt. Printing Office).

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amined using the scanning electron microscope (SEM). All processed and bulk material is housed at the U.S. Geological Survey palynology collection in Reston, Virginia. All microscope slide coordinates used in the text, systematic descriptions, and plate captions are given for Olympus microscope 201526[3] held by a specially milled metal insert.

RESULTS

The dinocysts from Leg 81 are discussed by site, in order of decreasing age of recovered dinocysts. Site 555 (Fig. 2) is by far the most complete and contains assemblages of early, middle, and late Miocene age. Site 553 (Fig. 3) yielded middle Miocene dinoflagellates and one sample of late Miocene/early Pliocene age. Site 552 (Fig. 4) and Site 554 (Fig. 5) yielded late Miocene dinocysts. In the discussions and the accompanying charts, the ages given are those determined by Leg 81 micropaleontologists (see Backman et al., this volume). Dinocyst preservation ranges from good to poor. In many samples, dinocyst recovery was sparse; usually less than 100 specimens were observed per slide.

Site 555

The most complete Miocene section in this study comes from Hole 555, drilled at 56°33.70′N, 20°46.93′W, at a water depth of 1659 m in the southwestern part of the Rockall Plateau. This site was the most landward and the shallowest of the four Leg 81 sites. Twenty-one samples were taken and all included dinocysts. The highest sample (555-3-7, 40–42 cm) contained only rare reworked Paleogene specimens. The dinocyst occurences from Hole 555 are shown in Figure 2.

Only two samples (555-26-3, 50–52 cm and 555-25-4, 70–72 cm) are from the early Miocene, and these contain species such as *Lingulodinium machaerophorum* (Deflandre and Cookson) Wall, *Nematosphaeropsis labyrinthea* (Ostenfeld) Reid, *Batiacasphaera* sp. I (Plate 1, Fig. 2), *B. sphaerica* Stover, *Hystrichosphaeropsis obscura* Habib, *Operculodinium* sp. of Piasecki, 1980 (Plate 5, Fig. 3) and ?*Cannosphaeropsis* sp. b of Shimakura et al., 1971 (Plate 1, Fig. 4). The highest occurrence of *Systematophora placacantha* (Deflandre and Cookson) Davey et al. is found in the lowest middle Miocene (555-24-3, 70–72 cm).

In the middle Miocene, several forms are potentially diagnostic. Nine have their lowest occurrences within the lower part of the middle Miocene: *Impagidinium patulum* (Wall) Stover and Evitt, *Spiniferites mirabilis* (Rossignol) Sarjeant, "*Nematosphaeropsis*" *aquaeducta* Piasecki, "gen. et sp. indet." of Piasecki, 1980 (Plate 5, Fig. 7), *Tectatodinium simplex* (Harland) n. comb., *Danea*? sp. (Plate 4, Fig. 1, Plate 5, Figs. 4–6), *Labyrinthodinium truncatum* Piasecki, *Hystrichostrogylon* sp. (Plate 1, Fig. 7), and *Batiacasphaera* sp. II (Plate 1, Fig. 8). The two unnamed species of *Batiacasphaera* have their highest occurrences within the middle Miocene. First occurring within the middle Miocene are *Invertocysta tabulata* n. gen., n. sp. (Plate 3, Fig. 3), *Invertocysta lacrymosa* n. gen., n. sp. (Plate 3, Figs. 4, 5), *Operculodinium* sp. of Jan du Chêne, 1977 (Plate 2, Fig. 3), Incertae sedis sp. I (Plate 3, Figs. 7, 8), *Fibrocysta*? *fusiforma* n. sp. (Plate 4, Figs. 2, 3) and *Polykrikos*? (Plate 4, Fig. 4). Apparently, *Pentadinium laticinctum* Gerlach, *Dapsilidinium pseudocolligerum* (Stover) Bujak et al., and *Labyrinthodinium truncatum* do not range into the late Miocene in this core, and *Hystrichosphaeropsis obscura, Palaeocystodinium golzowense* Alberti, and *Operculodinium* sp. of Piasecki, 1980 just barely range into the late Miocene. The middle Miocene in Hole 555 is within the *Nematosphaeropsis aquaeducta* Zone of Piasecki (1980).

In the upper Miocene of this hole, three new forms were recognized which may prove biostratigraphically valuable. These are *Fibrocysta*? *fusiforma* n. sp. and Incertae sedis sp. I, which first appear high in the middle Miocene and last appear in the lower part of the upper Miocene, and Incertae sedis sp. II (Plate 3, Fig. 6) which first appears within the upper Miocene.

Reworked Paleogene specimens were observed in three samples in Hole 555: Samples 555-16-5, 50–52 cm; 555-7-6, 44–48 cm; and 555-3-7, 40–42 cm.

Site 553

Site 553 lies on the western margin of the Rockall Plateau (Fig. 1), 56°05.32′N, 23°20.61′W, at a water depth of 2329 m. Three holes were drilled at this site, but Miocene sediments were recovered from only one, Hole 553A. Seven samples within the Miocene interval were processed for dinoflagellates. Three samples contain dinocysts, but two of these have very sparse floras. The forms found and their stratigraphic occurrences are shown in Figure 3.

In Hole 553A, Sample 553A-8-3, 32–36 cm contains the middle Miocene species "*Nematosphaeropsis*" *aquaeducta*. Sample 553A-7-3, 130–134 cm contains a representative middle Miocene flora including *Batiacasphaera* sp. I, *Pentadinium laticinctum, Palaeocystodinium golzowense*, and *Hystrichostrogylon* sp. The flora is thus approximately correlative with the middle part of the middle Miocene in Hole 555. Sample 553A-3-2, 80–82 cm contains *Operculodinium* sp. of Piasecki, 1980, which in Hole 555 does not range above the lower part of the upper Miocene.

Site 552

Site 552 lies on the western margin of the Rockall Plateau, 56°02.56′N, 23°13.88′W, at a water depth of 2301 m, in proximity of Site 404 from Leg 48. Two holes were cored at Site 552: Hole 552, which was rotary cored, and Hole 552A, which was hydraulically piston cored. Seven samples in the Miocene interval were taken from Hole 552, three of which contained dinocysts; twelve samples were taken from Hole 552A, seven of which contained dinocysts. Dinocysts are not abundant at Site 552, and the lower part of the Miocene section in both Holes 552 and 552A (middle Miocene) did not yield dinoflagellate cysts. Figure 4 is the combined occurrence chart for this site.

Samples that contain dinocysts from Site 552 contain a late Miocene assemblage comparable to that found on Site 555. Important forms include: *Invertocysta tabula-*

[3] Any use of trade names in this chapter is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

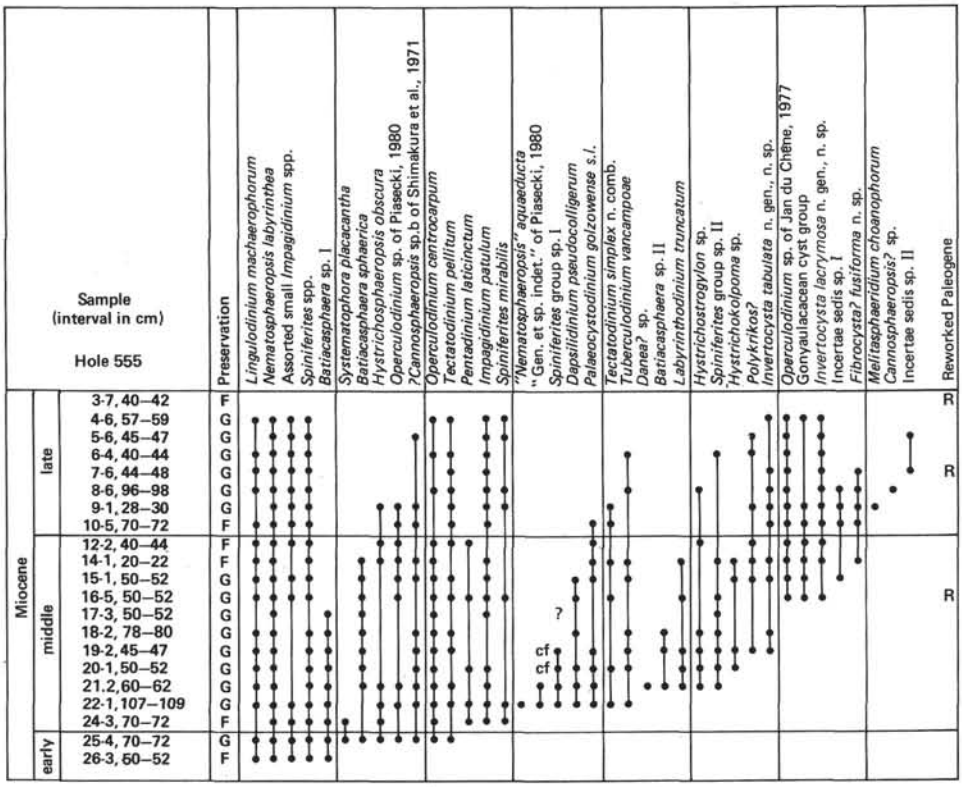

Figure 2. Range and distribution chart of dinoflagellate cysts recovered from Miocene sediments of Hole 555. Preservation: P = poor; F = fair; G = good. Age determinations from Leg 81 micropaleontologists.

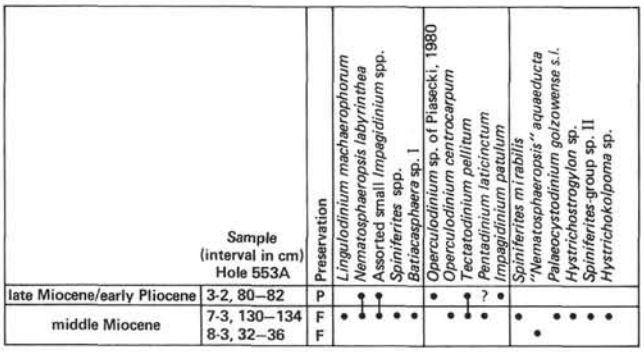

Figure 3. Range and distribution chart of dinoflagellate cysts recovered from Miocene sediments in Hole 553A. Preservation: P = poor; F = fair; G = good. Age determinations from Leg 81 micropaleontologists.

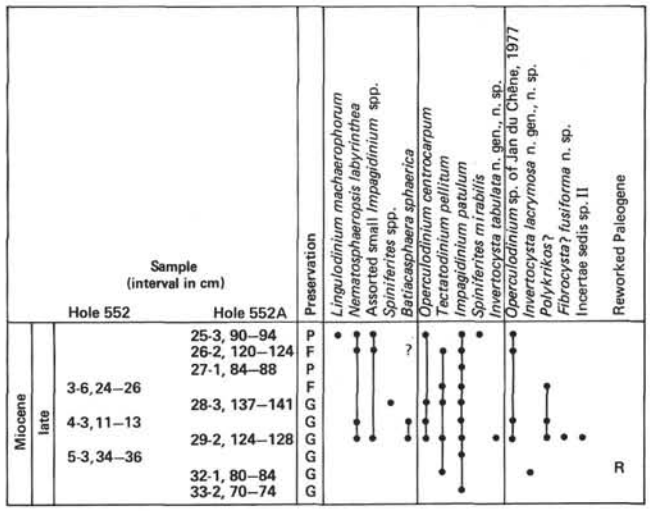

Figure 4. Range and distribution chart of dinoflagellate cysts recovered from Miocene sediments of Holes 552 and 552A. Preservation: P = poor; F = fair; G = good. Age determinations from Leg 81 micropaleontologists.

ta n. gen., n. sp., *Invertocysta lacrymosa* n. gen., n. sp., *Fibrocysta*? *fusiforma* n. sp., *Polykrikos*?, and Incertae sedis sp. II. Reworked Paleogene material was found in Sample 552A-32-1, 80–84 cm.

Site 554

Site 554 is on the outer high on the western edge of the Rockall Plateau, 56°17.41′N, 23°31.69′W, at a water depth of 2574 m. Two holes were cored at this site, Holes 554 and 554A. Three samples from the late Miocene were examined from Hole 554; all contained dinocysts. From Hole 554A, four samples were examined but only the upper sample, also late Miocene, contained dinocysts. Figure 5 is the combined occurrence chart for Holes 554 and 554A.

The samples from Site 554 contain a late Miocene assemblage comparable with that found in upper Miocene sediments at Sites 555 and 552. Important forms include:

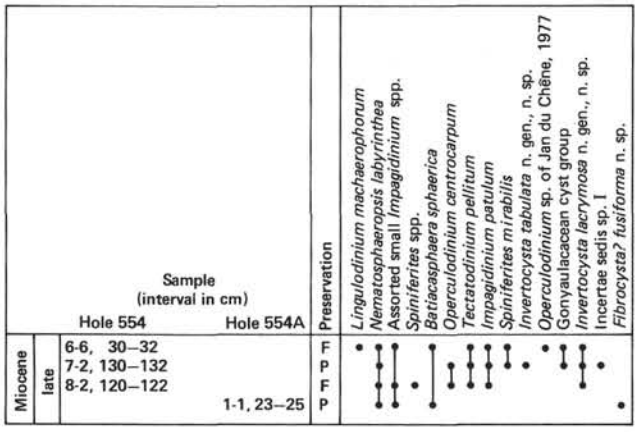

Figure 5. Range and distribution chart of dinoflagellate cysts recovered from Miocene sediments in Holes 554 and 554A. Preservation: P = poor; F = fair; G = good. Age determinations from Leg 81 micropaleontologists.

Invertocysta tabulata n. gen., n. sp., *Invertocysta lacrymosa* n. gen., n. sp., *Fibrocysta*? *fusiforma* n. sp., and Incertae sedis sp. I.

ZONAL COMPARISONS

Comparison of the Rockall Plateau material with other Miocene material is difficult because so little is known about the ranges of Miocene dinocysts. The middle Miocene at Sites 555 and 553 is within the *Nematosphaeropsis aquaeducta* Zone of Piasecki (1980) recognized from the Hodde Formation in Denmark. Piasecki's upper Miocene zones, his *Achomosphaera andalousiensis* and *Dinopterygium verriculum* Zones, were not recognized in the Rockall Plateau material. Costa and Downie (1979) used an informal partial-range zone, their Zone VIII, for the middle and late Miocene and the Pliocene. The base of this zone corresponds to the base of *Impagidinium patulum* (= *Leptodinium patulum*) and "*Nematosphaeropsis*" *aquaeducta* (= *Leptodinium* sp. V). Jan du Chêne (1977) used the highest occurrence of *Hystrichosphaeropsis obscura* to mark the top of the Miocene. For an unknown reason, this species has its last appearance somewhat lower in the Rockall material. Study of additional Miocene material may better establish dinocyst ranges.

CONCLUSIONS

For the documentation of the ranges of important dinocysts in the North Atlantic, Site 555 provides a nearly complete middle and upper Miocene section, as well as a short lower Miocene part. The occurrence data from Sites 552, 553, and 554 supplement Site 555 for the middle and upper Miocene.

In the middle Miocene, important species at Leg 81 sites include: "*Nematosphaeropsis*" *aquaeducta* (lowest and highest occurrences within the middle Miocene), *Tectatodinium simplex* n. comb. (lowest occurrence within the middle Miocene), *Danea*? sp. (lowest and highest occurrences), *Labyrinthodinium truncatum* (lowest and highest occurrences), *Hystrichostrogylon* sp. (lowest occurrence), *Batiacasphaera* sp. I (highest occurrence), *Operculodinium* sp. of Jan du Chêne, 1977 (lowest occurrence), *Invertocysta tabulata* n. gen., n. sp. (lowest occurrence), *Invertocysta lacrymosa* n. gen., n. sp. (lowest occurrence), Incertae sedis sp. I (lowest occurrence), *Fibrocysta*? *fusiforma* n. sp. (lowest occurrence), and *Pentadinium laticinctum* (highest occurrence).

In the upper Miocene, important species from Leg 81 sites include: *Fibrocysta*? *fusiforma* n. sp. (highest occurrence), Incertae sedis sp. I (highest occurrence), and Incertae sedis sp. II (lowest occurrence).

SYSTEMATIC DESCRIPTIONS

Division PYRROPHYTA Pascher, 1914
Class DINOPHYCEAE Fritsch, 1935
Order PERIDINIALES Haeckel, 1894
Genus *BATIACASPHAERA* Drugg, 1970

***Batiacasphaera sphaerica* Stover, 1977**
(Plate 1, Fig. 1)

***Batiacasphaera* sp. I**
(Plate 1, Fig. 2)

Remarks. This form has an apical archeopyle, accessory sutures suggesting six precingular paraplates, and a surface ornamented with raised bumps and irregular discontinuous ridges. Diameter ranges from about 40 to 70 μm. Deep in Hole 555, the specimens are larger than average and ornament is more irregular. A typical specimen is shown in Plate 1, Figure 2.

***Batiacasphaera* sp. II**
(Plate 1, Figs. 8A,B)

Remarks. This form is spherical with an apical archeopyle. The wall consists of a single spongy layer, often covered with numerous nontabular bumps 1–3 μm in height. Specimens average 37 μm in diameter (range 27–52 μm) and the wall thickness ranges from 1.5 to 4.5 μm. The form is very abundant in Sample 555-19-2, 45–47 cm.

Genus *CANNOSPHAEROPSIS* O. Wetzel, 1933

***Cannosphaeropsis*? sp.**
(Plate 1, Figs. 5A,B,C)

Remarks. Although only three specimens of this form were observed, the nature of the trabeculae warrants discussion. Here, the trabeculae do not represent extensions of the triradiate tips of gonal processes as in the typical *Nematosphaeropsis;* rather, they appear to represent normal parasutural septa that are incomplete or excavated to give the appearance of trabeculae. Pending reevaluation of the genera *Nematosphaeropsis* and *Cannosphaeropsis*, this form is questionably placed in *Cannosphaeropsis*.

?*Cannosphaeropsis* sp. b of Shimakura, Nishida, and Matsuoka, 1971
(Plate 1, Fig. 4)

?*Cannosphaeropsis* sp. b Shimakura, Nishida, and Matsuoka, 1971, pl. 1, fig. 15, *not* fig. 17.
Cannosphaeropsis sp. A Williams and Brideaux, 1975, pl. 17, fig. 10.
Impletosphaeridium sp. I Manum, 1976, pl. 6, figs. 8,9.
Impletosphaeridium sp. I of Manum 1976, Harland, 1978, pl. 2, figs. 6–8.
Impletosphaeridium sp. I, Manum, 1976, Costa and Downie, 1979, pl. 3, fig. 8.
Cannosphaeropsis sp. A of Williams and Brideaux, 1975, Bujak and Davies, 1981, pl. 1, figs. 7–9.

Remarks. This distinctive form has been reported from several high latitude locations in the North Atlantic, North Pacific, and Arctic oceans. Morphologic details have not been determined but this form is probably more closely related to *Melitasphaeridium* than to *Cannosphaeropsis*.

Genus *DANEA* Morgenroth, 1968

Danea? sp.
(Plate 4, Figs. 1A,B,C; Plate 5, Figs. 4–6)

Remarks. This form has a gonyaulacacean paratabulation and a 3″archeopyle. Paratabulation is expressed by penitabular ridges that are incomplete bordering the paracingulum. This form is questionably placed in *Danea* because of its spherical rather than elongate shape and because it lacks any sort of apical projection.

Genus *DAPSILIDINIUM* Bujak et al., 1980

Dapsilidinium pseudocolligerum (Stover, 1977) Bujak et al., 1980
(Plate 1, Fig. 6)

Genus *FIBROCYSTA* Stover and Evitt, 1978

Fibrocysta? *fusiforma* n. sp.
(Plate 4, Figs. 2, 3A,B)

Holotype. Plate 4, Figure 2, slide R 2712 BJ (2), 33.7 × 77.4, Sample 555-7-6, 44–48 cm.

Derivation of name. Latin, spindle shaped.

Diagnosis. Cyst fusiform, autophragm only; surface smooth with many (15–40), smooth nontabular processes; paratabulation presumably gonyaulacacean, indicated by pentagonal 3″ precingular archeopyle and faint alignment of processes in paracingular region; operculum free; dimensions of holotype, length 75 μm, width 47 μm, processes 10–13 μm.

Description. Cyst fusiform, with elongate rounded protrusion at apex, pointed nubbin, with or without additional spine at antapex; wall thin, autophragm only, surface smooth with 15–40 (typically 20–30) smooth nontabular processes; processes are typically acuminate, may be bifid, especially at paracingulum; processes hollow at bases, probably solid distally, paratabulation presumably gonyaulacacean, indicated by archeopyle and faint alignment of processes at paracingular region; archeopyle five-sided, type P, 3″ only, operculum free.

Dimensions. Length, average 73 μm, range 65–81 μm; width, average 41 μm, range 35–52 μm; length of spines, 7–13 μm; 16 specimens measured.

Remarks. This species is provisionally placed in *Fibrocysta* because the processes and the autophragm are smooth rather than fibrous.

Occurrence. Lower part of upper Miocene in Holes 555, 552A, and 554A.

Genus *HYSTRICHOKOLPOMA* Klumpp, 1953

Hystrichokolpoma sp.
(Plate 1, Fig. 3)

Remarks. A few specimens of a small delicate *Hystrichokolpoma* were found in the material from the Rockall Plateau.

Genus *HYSTRICHOSPHAEROPSIS* Deflandre, 1935

Hystrichosphaeropsis obscura Habib, 1972
(Plate 1, Fig. 10)

Genus *HYSTRICHOSTROGYLON* Agelopoulos, 1964

Hystrichostrogylon sp.
(Plate 1, Figs. 7A,B,C)

Remarks. Specimens from the Rockall Plateau show large ventral pericoels, often have spines on the periphragm wall, and may or may not have intergonal processes in addition to the typical gonal processes.

Genus *IMPAGIDINIUM* Stover and Evitt, 1978

Impagidinium patulum (Wall, 1967) Stover and Evitt, 1978
(Plate 1, Figs. 11A,B)

Remarks. In the Rockall material, the size of this species is highly variable (length ranges from 40 to 110 μm). A typical specimen is shown in Plate 1, Figures 11A,B.

Impagidinium spp.
(Plate 1, Figs. 12A,B)

Remarks. Small specimens of *Impagidinium* (probably several species) were found in the Rockall material, typically 30 μm or less. Septa are high relative to cyst body size. No attempt was made in the present study to differentiate them. A typical specimen is illustrated in Plate 1, Figures 12A,B.

Genus *INVERTOCYSTA* n. gen.

Derivation of name. Latin, *invertere*, to turn inside out or upside down.

Diagnosis. Cyst cavate; endocyst ovoidal to ellipsoidal, often with a short apical boss; pericyst discoidal or bowl-shaped, meridionally placed, open towards dorsal side; endophragm and periphragm appressed midventrally, periphragm extended outward elsewhere; wall surfaces smooth except for parasutural ridges or thickenings of the periphragm indicating paratabulation; paratabulation gonyaulacacean, 4′, 6″, 4–6c, 5–6‴, 1p, 1⁗, ?3–5s for *Invertocysta tabulata*, probably similar formula for *I. lacrymosa* but incompletely expressed; archeopyle precingular, type P, 3″ only; distribution of periphragmal paraplates asymmetrical such that most or all of the dorsal surface represents 3″ and is absent, and the dorsal part of the paracingulum is displaced towards the antapex; up to five small paraplates may be distinguished in the parasulcal region.

Type species. *Invertocysta tabulata* n. sp.

Comparisons. In the genus *Invertocysta*, the bowl- or saucer-shaped periphragm opens toward the dorsal side and is appressed to the endophragm midventrally. In *Thalassiphora*, the "bowl" of the periphragm opens ventrally and is attached middorsally. *Stephodinium* has a periphragmal extension which is positioned equatorially, rather than meridionally as in *Invertocysta*. *Hystrichostrogylon* has gonal processes and the wall layers are appressed middorsally. *Invertocysta* is probably related to *Amiculosphaera*, although in *Amiculosphaera*, the periphragm is appressed to the endophragm over most of the hypocyst.

Invertocysta tabulata n. sp.
(Plate 3, Figs. 3A,B; Text-Fig. 6)

Forma A (="*Thalassiphora delicata*") Costa and Downie, 1979, pl. 3, fig. 9.

Holotype. Plate 3, Figures 3A,B, slide R 2712 BC (2), 35.5 × 103.3, sample 555-15-1, 50–52 cm.

Derivation of name. Latin, *tabulatus*, boarded, plated.

Diagnosis. Cyst cavate; endocyst ovoidal to ellipsoidal with apical boss; pericyst discoidal, meridionally placed, with endophragm and periphragm in contact midventrally; wall surface smooth or nearly smooth with well-developed parasutural ridges; paratabulation gonyaulacacean, 4′, 6″, 4–6c, 5–6‴, 1p, 1⁗, ?3–5s; archeopyle precingular, type P, 3″ only; distribution of paraplates such that nearly all of the dorsal area of the periphragm represents 3″ and is missing (see Fig. 6) and the dorsal part of the paracingulum is displaced to form the antapical margin of the pericyst; up to five small paraplates may be distinguished in the parasulcal region; dimensions of holotype, pericyst length 90 μm, pericyst width 92 μm, endocyst length 54 μm, endocyst width 37 μm.

Description. Cyst cavate; endocyst ovoidal to ellipsoidal with small but prominent apical protrusion; pericyst discoidal, meridionally located with endocyst centered within pericyst, and endophragm and periphragm in contact in the midventral region and separated elsewhere; wall surfaces smooth to shagreenate; paratabulation indicated by low parasutural ridges, gonyaulacacean, 4′, 6″, 4–6C, 5–6‴ 1p, 1⁗, ?3–5s, well expressed where periphragm extends out from endophragm, well to poorly expressed midventrally (with younger specimens showing less definition in the midventral area than older specimens); paratabulation asymmetrical such that all of the pericyst tabulation is expressed on the ventral surface and what would be the dorsal side is missing; paracingulum displaced antapically so that what would normally be in the middorsal portion lies along the antapical margin and the paracingulum forms a characteristic eccentric circle on the ventral hypocyst; archeopyle precingular, type P, 3″ only in endocyst, presumably the missing dorsal side of the pericyst also represents 3″; up to five small paraplates may be distinguished in the parasulcal region.

Dimensions. Outer diameter, average 89 μm, range 63–113 μm; endocyst length, average 46 μm, range 37–58 μm; endocyst width, average 37 μm, range 31–60 μm; 25 specimens measured.

Remarks. The discoidal shape, the prominent paratabulation, and the eccentric circle formed by the paracingulum distinguish this species from *I. lacrymosa*. This species only superficially resembles *Thalassiphora delicata* Williams and Downie, 1966, as emended by Eaton,

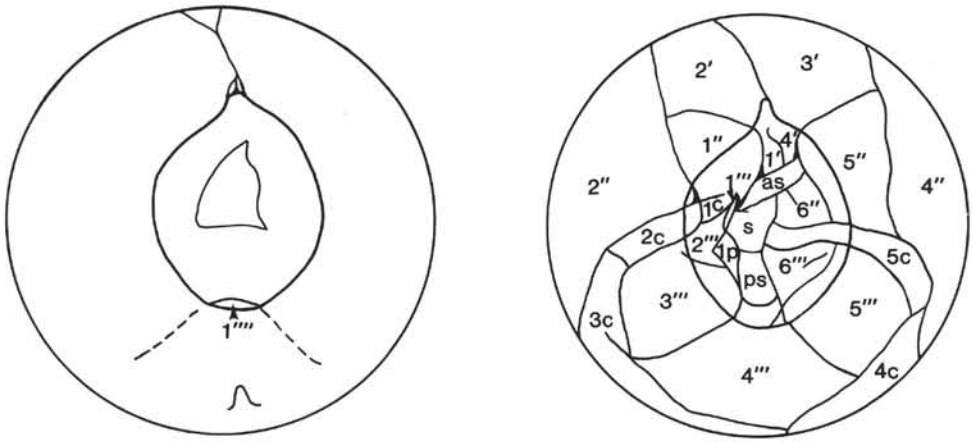

Figure 6. Paratabulation for *Invertocysta tabulata* n. gen., n. sp. (see Plate 3, Fig. 3). A. Dorsal surface. B. Dorsal view of ventral surface.

1976 (contrast Fig. 6 with Eaton's text-figs. 18, 20). In *T. delicata*, the wall layers are appressed middorsally and the large ventral opening represents paraplate 1″; in *I. tabulata* the wall layers are appressed midventrally, the large opening represents 3″, and the paracingulum is displaced antapically.

Occurrence. Middle to upper Miocene in Hole 555, upper Miocene in Holes 552A, 554.

Invertocysta lacrymosa n. sp.
(Plate 3, Figs. 4A,B, 5)

Thalassiphora sp. cf. *T. pelagica* Habib, 1971, pl. 4, fig. 2.
"Thalassiphora delicata" Williams and Downie emend. Eaton, 1976, Harland, 1979, pl. 2, fig. 15.

Holotype. Plate 3, Figures 4 A,B, slide R 2712 BH (2), 19.0 × 79.1, Sample 555-9-1, 28–30 cm.

Derivation of name. Latin, *lacrimosus*, tearful.

Diagnosis. Cyst cavate; ovoidal endocyst connected at apical boss to lip of bowl-shaped pericyst; periphragm and endophragm appressed midventrally; periphragm turned inward on dorsal side around opening representing 3″; wall surfaces smooth to shagreenate with poorly to moderately developed parasutural ridges; paratabulation gonyaulacacean, exact formula undetermined; archeopyle precingular, type P, 3″ only; dimensions of holotype, pericyst length 79 μm, pericyst width 85 μm, endocyst length 52 μm, endocyst width 44 μm.

Description. Cyst cavate; endocyst ovoidal to ellipsoidal with apical boss connecting endocyst to inner lip of pericyst; pericyst bowl-shaped with inward-turning lip at opening of bowl on dorsal side; periphragm and endophragm appressed midventrally; opening on dorsal side variable in size, shape, and position, ranging from a small opening on the dorsal epicyst to an opening of approximately the same size and shape as the endocyst to an opening that is considerably larger and broader than the endocyst; wall surfaces smooth to shagreenate with faint to moderately well-developed parasutural ridges; paracingulum displaced antapically on dorsal side, outline of paracingulum is in the shape of a hemicircle with the flat side centered across the ventral side; paratabulation gonyaulacacean, exact formula undetermined but presumably similar to that of *I. tabulata*, paraplates analogous to 3″′, 4″′, 5″′ and 1″″ on *I. tabulata* are clearly visible on some specimens of *I. lacrymosa;* archeopyle precingular, type P, 3″ only on endocyst, large opening corresponding to 3″ on pericyst.

Dimensions. Pericyst length, average 76 μm, range 60–92 μm; pericyst width, average 77 μm, range 62–90 μm; endocyst length, average 44 μm, range 33–60 μm; endocyst width, average 36 μm, range 29–46 μm; dorsal opening length, average 58 μm, range 13–90 μm; dorsal opening width, average 56 μm, range 23–77 μm; 31 specimens measured.

Remarks. This form shows a wide range of variation in size, shape, degree of definition of paratabulation, and size, shape, and position of the dorsal opening. As a rough trend, the middle Miocene specimens have smaller openings than late Miocene specimens. The specimens illustrated here are typical of the Rockall material. The specimens illustrated by Habib (1971) and Harland (1979) are end members in the limits of variation.

I. lacrymosa differs from *I. tabulata* in possessing a bowl-shaped, as opposed to disc-shaped, pericyst, in having less definition of paratabulation and in having a less "droopy" paracingulum. It differs from *Thalassiphora delicata* Williams and Downie, 1966, as emended by Eaton, 1976, in that the wall layers of *I. lacrymosa* are appressed midventrally and the large dorsal opening represents 3″. In *T. delicata*, the wall layers are appressed middorsally and the large ventral opening represents 1″. *I. lacrymosa* is distinguished from *Amiculosphaera umbracula* Harland, 1979, by the appression of periphragm and endophragm in the hypocyst of the latter.

Occurrence. Upper part of middle Miocene to upper Miocene in Hole 555, upper Miocene in Holes 552A and 554.

Genus *LABYRINTHODINIUM* Piasecki, 1980

***Labyrinthodinium truncatum* Piasecki, 1980**
(Plate 1, Fig. 9)

Genus *LINGULODINIUM* Wall, 1967, emend. Wall and Dale, 1973

***Lingulodinium machaerophorum* (Deflandre and Cookson, 1955) Wall, 1967**
(Plate 2, Fig. 2)

Remarks. Specimens of *L. machaerophorum* were encountered with 3P, 5P, and epitractal archeopyles. Those with epitractal archeopyles, as shown in Plate 2, Figure 2, are by far the most common.

Genus *MELITASPHAERIDIUM* Harland and Hill, 1979

***Melitasphaeridium choanophorum* (Deflandre and Cookson, 1955) Harland and Hill, 1979**
(Plate 2, Fig. 8)

Genus *NEMATOSPHAEROPSIS* Deflandre and Cookson, 1955

***Nematosphaeropsis labyrinthea* (Ostenfeld, 1903) Reid, 1974**
(Plate 2, Figs. 7A,B)

***"Nematosphaeropsis" aquaeducta* Piasecki, 1980**
(Plate 5, Fig. 1)

Remarks. In their comparison of the genera *Cannosphaeropsis* and *Nematosphaeropsis*, Stover and Evitt (1978, p. 143) stated that *Cannosphaeropsis* differs from *Nematosphaeropsis* in having single parasutural trabeculae between gonal positions. In *Nematosphaeropsis*, ectophragmal trabeculae represent extensions of the triradiate tips of the gonal processes so that at least two trabeculae connect adjacent processes." Other workers (e.g., Williams and Downie, 1966; May, 1980) have come to different conclusions about the two genera. Pending resolutions of these differences, "*N.*" *aquaeducta*, which has single trabeculae between gonal positions, is considered a problematical species in "*Nematosphaeropsis.*"

Genus *OPERCULODINIUM* Wall, 1967

***Operculodinium centrocarpum* (Deflandre and Cookson, 1955) Wall, 1967**
(Plate 5, Fig. 2)

Remarks. This species is highly variable in size (60–135 μm including processes) and in degree of development of the processes. A typical specimen is shown in Plate 5, Figure 2.

***Operculodinium* sp. of Piasecki, 1980**
(Plate 5, Fig. 3)

Operculodinium sp. Piasecki, 1980, p. 70, pl. 3, fig. 6.
(?) ?*Pyxidiella* cf. *scrobiculata* (Deflandre and Cookson) Cookson and Eisenack, 1958, Harland, 1979, pl. 3, figs. 10,11.

Remarks. As stated by Piasecki (1980), this species is small, ovoid, and covered with short massive processes. The archeopyle is precingular, 3″, only. Processes may be cylindrical to truncated conical and may be interconnected at the bases to varying degrees. A typical specimen is shown in Plate 5, Figure 3. Harland's specimen is somewhat atypical in having poorly delimited processes.

***Operculodinium* sp. of Jan du Chêne, 1977**
(Plate 2, Figs. 3A,B)

Operculodinium sp. Jan du Chêne, 1977, p. 106, pl. 1, figs. 7,8.

Remarks. As noted by Jan du Chêne (1977), this species is subspherical to ovoid, has a simple precingular archeopyle and has short hollow spines, which are truncated and open at the ends.

Genus *PALAEOCYSTODINIUM* Alberti, 1961

Palaeocystodinium golzowense* Alberti, 1961 *sensu lato
(Plate 2, Figs. 1,6)

Remarks. Several of Piasecki's (1980, p. 70–71) comments are applicable here. The size is variable, and specimens are often shorter than Alberti's holotype; horns may be faintly granular.

Genus *PENTADINIUM* Gerlach, 1961

***Pentadinium laticinctum* Gerlach, 1961**
(Plate 2, Fig. 4)

Remarks. As noted by Benedek et al. (1982) and Edwards (1982), there is no consistent criterion for separating *Pentadinium laticinctum* and *P. taeniagerum;* the latter is restricted to its holotype. The Rockall specimens are faintly granular and some show pericoel development in the apical region.

Genus *SPINIFERITES* Mantell, 1850

***Spiniferites mirabilis* (Rossignol, 1963) Sarjeant, 1970**
(Plate 2, Fig. 5)

Remarks. In the Rockall material, this species ranges in length from 60 to 120 μm. A typical specimen is shown in Plate 2, Figure 5.

***Spiniferites* spp.**
(Plate 2, Figs. 9,10,11)

Remarks. Numerous specimens of *Spiniferites* spp. were found in the Rockall material. Because of their variability and often poor preservation, no attempt was made to identify them at the species level. Three typical forms are shown in Plate 2, Figures 9,10,11.

***Spiniferites*-group sp. I**
(Plate 5, Fig. 9)

Remarks. This small equant form with high septa is common in several samples in the Rockall Plateau material. It lacks typical *Spiniferites*-type processes and appears intermediate between *Spiniferites* and *Impagidinium*.

***Spiniferites*-group sp. II**
(Plate 2, Fig. 12)

Remarks. This form is thin-walled and appears very faint. The truncated-tipped processes are atypical in *Spiniferites*.

Genus *SYSTEMATOPHORA* Klement, 1960

***Systematophora placacantha* (Deflandre and Cookson, 1955) Davey et al., 1969**
(Plate 3, Fig. 1)

Genus *TECTATODINIUM* Wall, 1967

***Tectatodinium pellitum* Wall, 1967**
(Plate 3, Fig. 2)

Remarks. This species shows varying thickness (1–4 μm) of the wall.

***Tectatodinium simplex* (Harland, 1979) n. comb.**
(Plate 5, Figs. 8A,B, 10A,B)

?*Pyxidiella* sp. nov. Harland, 1978, pl. 3, figs. 3,4.
?*Pyxidiella simplex* Harland, 1979, p. 537–538, pl. 3, fig. 12; *not* pl. 3, figs. 13,14,15.
(?) *Tectatodinium psilatum* Wall and Dale, 1973, Piasecki, 1980, pl. 4, figs. 2,3.

Remarks. As described by Harland, this species is ovoid (in dorsal–ventral view) and has a coarse positive ornament. The archeopyle, however, is precingular, not intercalary. The outline in lateral view is distinctive, showing a prominent dorso-antapical bulge and a protruding paracingular area (Plate 5, Figs. 10A,B), as does Harland's holotype. The species resembles *Tectatodinium psilatum* Wall and Dale, 1973, from which it differs in lateral profile and in the generally coarser ornament. The specimen figured by Piasecki as *T. psilatum* is most probably *T. simplex* n. comb.

Genus *TUBERCULODINIUM* Wall, 1967

***Tuberculodinium vancampoae* (Rossignol, 1962) Wall, 1967**
(Plate 5, Fig. 11)

Genus Unknown

"Gen. et sp. indet." of Piasecki, 1980
(Plate 5, Fig. 7)

Gen. et sp. indet. Piasecki, 1980, p. 71, pl. 3, fig. 3; pl. 6, figs. 5,6.

Remarks. As noted by Piasecki, this small form has a precingular archeopyle and is covered with discontinuous crests, which probably reflect paratabulation.

Gonyaulacacean cyst group
(Plate 4, Figs. 5A,B, 7A,B,C, 8)

Remarks. These forms are spherical with a precingular archeopyle, a "fuzzy" outline, and varying amounts of paratabulation expressed. More work, and more specimens, are required on this group.

Incertae sedis sp. I
(Plate 3, Figs. 7A,B, 8)

Remarks. This form has a five-sided archeopyle, which is therefore presumably 3″, and has six long blunt-tipped processes, which are triradiate in cross section. Eleven specimens were well-enough preserved to be measurable. For the cyst body, length averages 60 μm (range 52–79 μm), width averages 43 μm (range 31–56 μm). Processes range in length from 27 to 60 μm, with the average at 45 μm, but this may be too low because the processes often lie at an angle to the plane of the slide. The processes are consistently arranged: two on the epicyst, four on the hypocyst. On the epicyst, one process is on the dorsal surface, towards the right-lateral side; one is on the ventral surface, towards the left-lateral side. On the hypocyst, two processes are closely spaced and nearly symmetrical about the middorsal surface, and two processes are nearly symmetrical, more widely spaced about the ventral surface. A single, atypical specimen (Plate 3, Fig. 8) showed well-developed gonaulacacean paratabulation and prominent apical projection.

Incertae sedis sp. II
(Plate 3, Figs. 6A,B,C)

Remarks. This form resembles *Impagidinium strialatum* (Wall, 1967) Stover and Evitt, 1978, in size and in having weakly striate septa, but

differs in having septa outlining the archeopyle. The paratabulation is incompletely known.

Polykrikos? Bütschli, 1873
(Plate 4, Fig. 4)

Remarks. Specimens such as illustrated in Plate 4, Figure 4 are common in some samples of the Rockall material. They are probably cysts of *Polykrikos*.

Reworked Paleogene material
(Plate 4, Fig. 6)

Remarks. Specimens of *Apectodinium homomorphum* (Deflandre and Cookson, 1955) Lentin and Williams, 1977; *Wilsonidium tabulatum* (Wilson, 1967) Lentin and Williams, 1976 (Plate 4, Fig. 6); and *Wetzeliella* spp. were occasionally found in the Rockall material. These specimens presumably have been reworked from the Paleogene.

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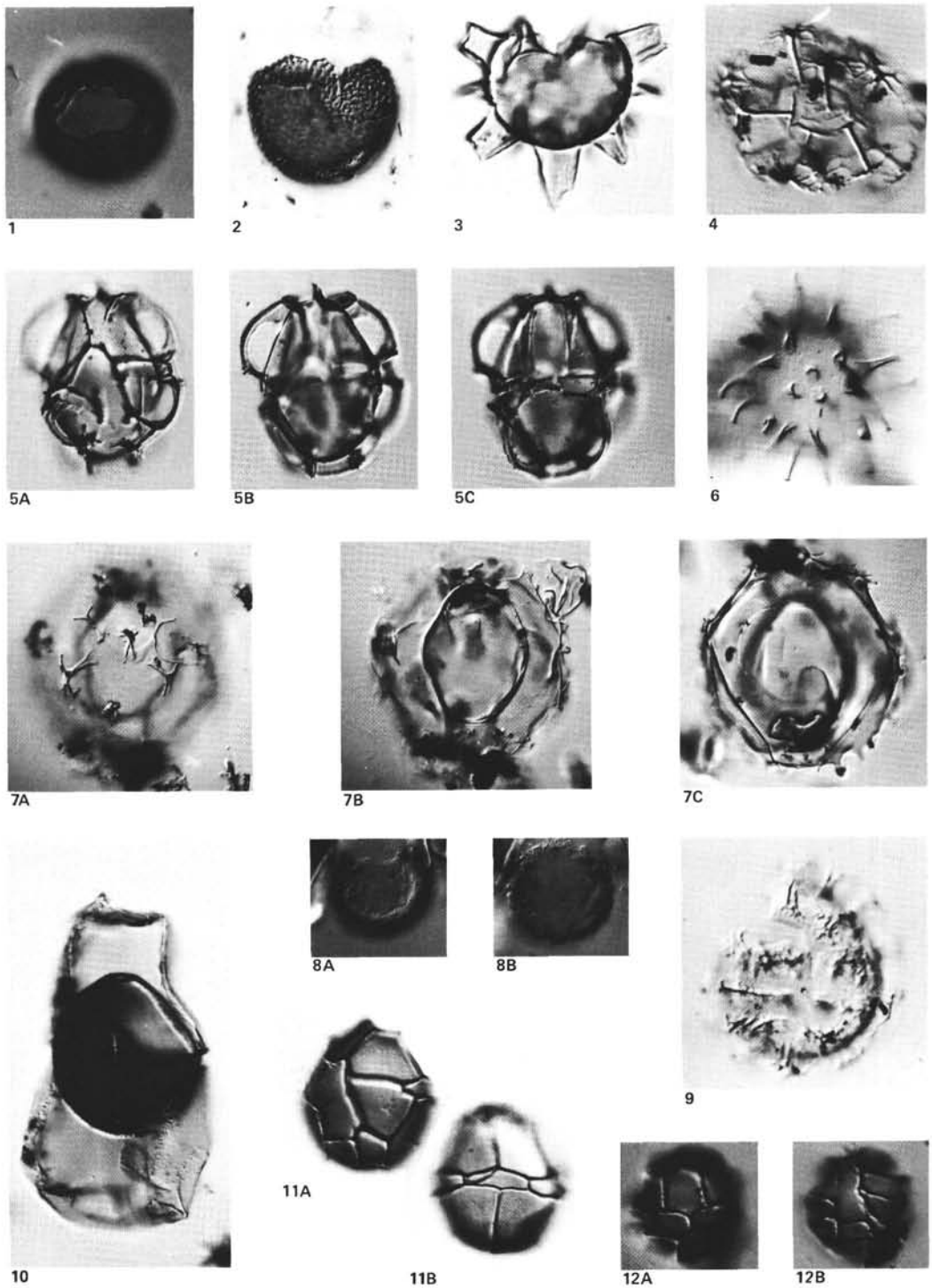


Plate 1. **1.** *Batiacasphaera sphaerica* Stover, 1977. Sample 555-21-2, 60–62 cm, R 2712 AW (1), 33.8 × 101.4, max. diam. 33 μm, apical view. **2.** *Batiacasphaera* sp. I. Sample 553A-7-3, 130–134 cm, R 2713 U (2), 36.8 × 97.8, length 38 μm, ?dorsal view of dorsal surface. **3.** *Hystrichokolpoma* sp. Sample 555-14-1, 20–22 cm, R 2712 BD (2), 21.0 × 79.2, length 47 μm, optical section (ventral view). **4.** ?*Cannosphaeropsis* sp. b of Shimakura et al., 1971. Sample 555-21-2, 60–62 cm, R 2712 AW (1), 35.2 × 77.4, max. diam. 54 μm, orientation unknown. **5.** *Cannosphaeropsis*? sp. Sample 555-8-6, 96–98 cm, R 2712 BI (2), 36.5 × 92.4, length 80 μm, ventral views, (A) ventral surface, (B) optical section, (C) dorsal surface. **6.** *Dapsilidinium pseudocolligerum* (Stover, 1977) Bujak et al., 1980. Sample 555-22-1, 107–109 cm, R 2712 AV (1), 36.7 × 80.0, diam. 57 μm, antapical view of antapical surface. **7.** *Hystrichostrogylon* sp. Sample 555-21-2, 60–62 cm, R 2712 AW (1), 29.7 × 76.1, length 85 μm, dorsal views, (A) dorsal surface, (B) optical section, (C) ventral surface. **8.** *Batiacasphaera* sp. II. Sample 555-19-2, 45–47 cm, R 2712 AY (2), 23.9 × 79.8, diam. 40 μm, orientation uncertain. **9.** *Labyrinthodinium truncatum* Piasecki, 1980. Sample 555-19-2, 45–47 cm, R 2712 AY (2), 32.6 × 80.1, length 54 μm, right-lateral view. **10.** *Hystrichosphaeropsis obscura* Habib, 1972. Sample 555-22-1, 107–109 cm, R 2712 AV (1), 36.9 × 96.7, length 135 μm, left-lateral view. **11.** *Impagidinium patulum* (Wall, 1967) Stover and Evitt, 1978. Sample 552A-28-3, 137–141 cm, R 2869 J (1) 29.4 × 91.5, length 70 μm, ventral views, (A) ventral surface, (B) dorsal surface. **12.** *Impagidinium* sp. Sample 554-6-6, 30–32 cm, R 2870 C (1), 29.0 × 78.9, length 29 μm, ventral views, (A) dorsal surface (B) ventral surface.

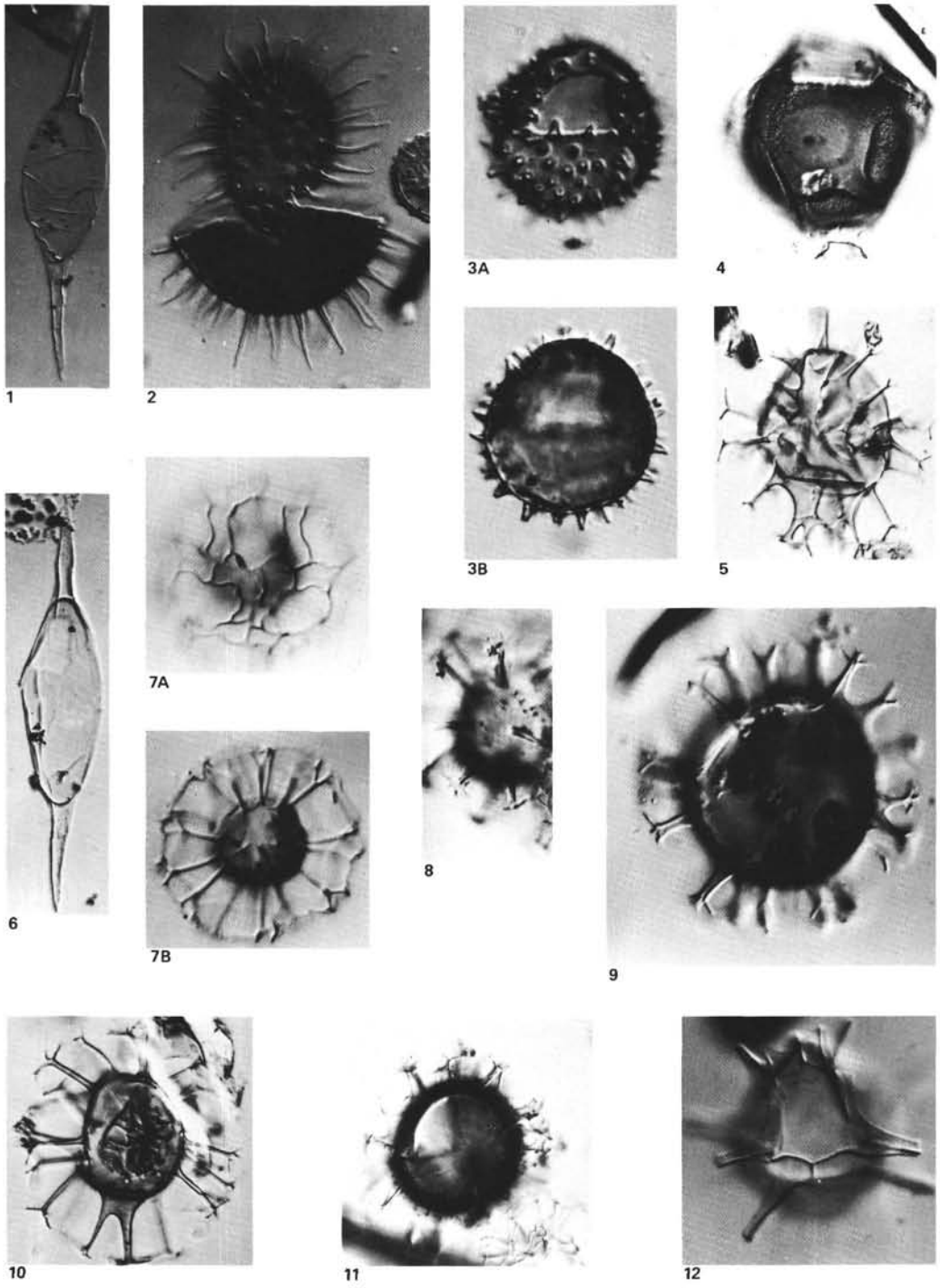


Plate 2. **1.** *Palaeocystodinium golzowense* Alberti, 1961. Sample 555-19-2, 45–47 cm, R 2712 AY (2), 30.0 × 87.1, length 134 μm, dorsal view of dorsal surface. **2.** *Lingulodinium machaerophorum* (Deflandre and Cookson, 1955) Wall, 1967. Sample 555-19-2, 45–47 cm, R 2712 AY (2), 21.8 × 109.1, length 127 μm, ventral view of ventral surface showing attached epitractal archeopyle. **3.** *Operculodinium* sp. of Jan du Chêne, 1977. Sample 555-15-1, 50–52 cm, R 2712 BC (2), 26.0 × 104.5, length 50 μm, dorsal views, (A) dorsal surface, (B) optical section. **4.** *Pentadinium laticinctum* Gerlach, 1961. Sample 555-16-5, 50–52 cm, R 2712 BB (2), 27.8 × 101.9, length 73 μm, dorsal view of dorsal surface. **5.** *Spiniferites mirabilis* (Rossignol, 1963) Sarjeant, 1970. Sample 555-5-6, 45–47 cm, R 2712 BL (2), 25.2 × 100.8, length 95 μm, dorsal view of dorsal surface. **6.** *Palaeocystodinium golzowense* Alberti, 1961. Sample 555-15-1, 50–52 cm, R 2712 BC (2), 27.0 × 74.6, length 156 μm, ventral view at mid-focus. **7.** *Nematosphaeropsis labyrinthea* (Ostenfeld, 1903) Reid, 1974. Sample 555-22-1, 107–109 cm, R 2712 AV (1), 37.0 × 99.4, length 53 μm, dorsal views, (A) high focus showing trabeculae, (B) dorsal surface. **8.** *Melitasphaeridium choanophorum* (Deflandre and Cookson, 1955) Harland and Hill,1979. Sample 555-9-1, 28–30 cm, R 2712 BH (2), 37.0 × 106.0, length from tip to tip of processes that are in focus 46 μm, detail of process tips, orientation unknown. **9.** *Spiniferites* sp. Sample 555-19-2, 45–47 cm, R 2712 AY (2), 35.2 × 109.4, length 73 μm, dorsal view of optical section. **10.** *Spiniferites* sp. Sample 555-5-6, 45–47 cm, R 2712 BL (2), 33.4 × 89.2, length 92 μm, right-lateral view. **11.** *Spiniferites* sp. Sample 555-16-5, 50–52 cm, R 2712 BB (2), 32.9 × 100.8, length 85 μm, right-lateral view. **12.** *Spiniferites*-group sp. II. Sample 555-20-1, 50–52 cm, R 2712 AX (2), 21.2 × 77.7, length 54 μm, ventral view of dorsal surface.

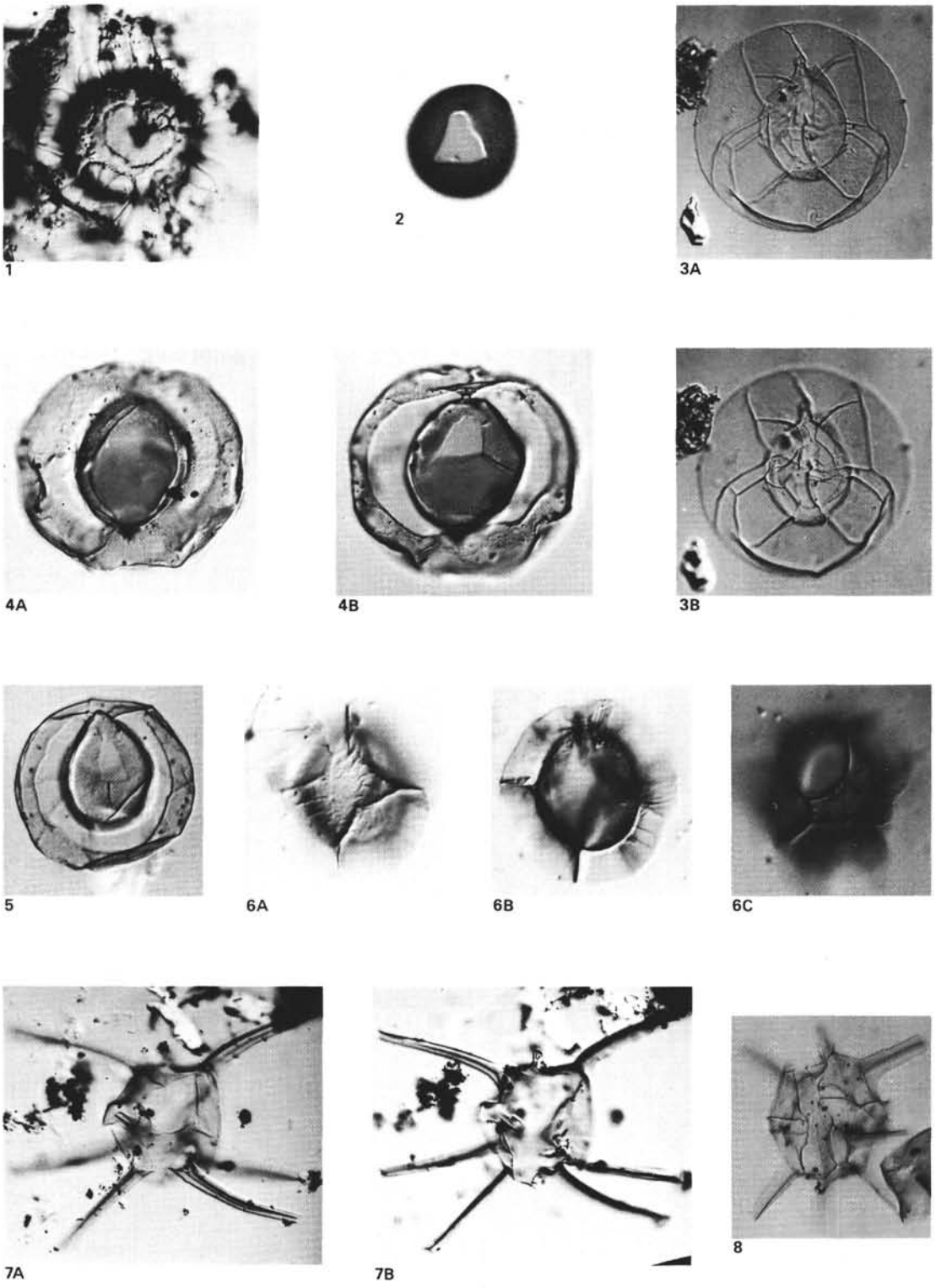
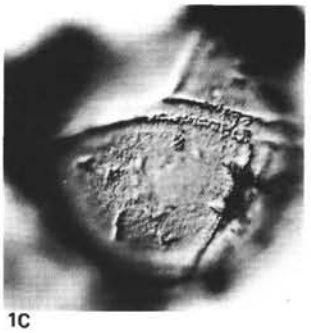
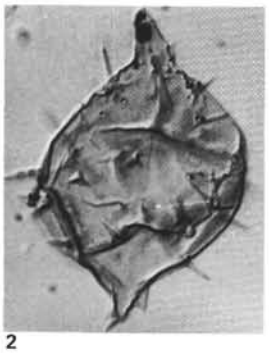


Plate 3. **1.** *Systematophora placacantha* (Deflandre and Cookson, 1955) Davey et al., 1969. Sample 555-24-3, 70–72 cm, R 2712 AU (1), 36.4 × 96.1, length 67 μm, apical view of antapical surface. **2.** *Tectatodinium pellitum* Wall, 1967. Sample 552A-26-2, 120–124 cm, R 2869 L (1), 23.6 × 98.6, diameter 28 μm, dorsal view of dorsal surface. **3.** *Invertocysta tabulata* n. gen., n. sp. Holotype. Sample 555-15-1, 50–52 cm, R 2712 BC (2), 35.5 × 103.3, length 90 μm, dorsal views, (A) dorsal surface, (B) ventral surface. **4.** *Invertocysta lacrymosa* n. gen., n. sp. Holotype. Sample 555-9-1, 28–30 cm, R 2712 BH (2), 19.0 × 79.1, length 80 μm, ventral views, (A) ventral surface, (B) dorsal surface. **5.** *Invertocysta lacrymosa* n. gen., n. sp. Paratype. Sample 555-5-6, 45–47 cm, R 2712 BL (2), 25.0 × 91.1, length 67 μm, ventral view of dorsal surface. **6.** Incertae sedis sp. II. Sample 552A-29-2, 124–128 cm, R 2869 I (1), 29.6 × 93.1, length 47 μm, ventral? views through specimen. **7.** Incertae sedis sp. I. Sample 555-10-5, 70–72 cm, R 2712 BG (1), 29.0 × 87.8, width from tips of spines 125 μm, dorsal views, (A) dorsal surface, (B) ventral surface. **8.** Incertae sedis sp. I. Sample 555-15-1, 50–52 cm, R 2712 BC (2), 29.1 × 99.4, length excluding spines 79 μm, ventral view of ventral surface.


1A


1B


1C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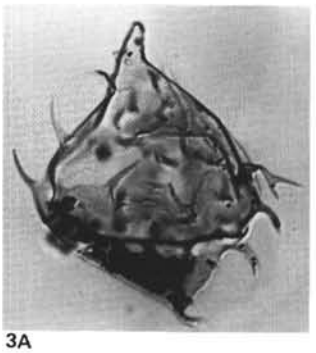
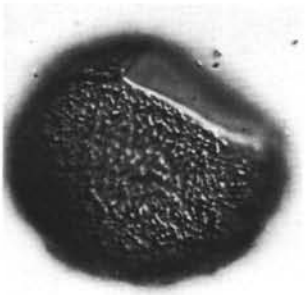

3A

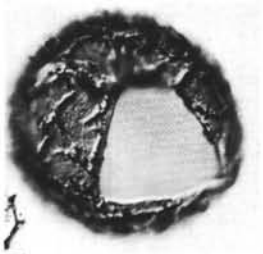

3B


4C

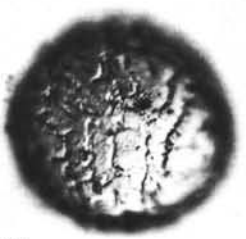

5A


5B


6C


7A


7B


7C


8

Plate 4. **1.** *Danea*? sp. Sample 555-21-2, 60–62 cm, R 2712 AW (1), 30.1 × 86.8, length 96 μm, ventral views, (A) ventral surface, high focus, (B) ventral surface, lower focus, (C) dorsal surface. **2.** *Fibrocysta*? *fusiforma* n. sp. Holotype. Sample 555-7-6, 44–48 cm, R 2712 BJ (2), 33.7 × 77.4, length 75 μm, ventral view of dorsal surface. **3.** *Fibrocysta*? *fusiforma* n. sp. Paratype. Sample 555-9-1, 28–30 cm, R 2712 BH (2), 30.9 × 103.5, length 71 μm, right lateral views, (A) upper surface, (B) lower surface. **4.** *Polykrikos*? Sample 555-15-1, 50–52 cm, R 2712 BC (2), 18.7 × 87.6, length 64 μm. **5.** Gonyaulacacean cyst group. Sample 555-16-5, 50–52 cm, R 2712 BB (2), 30.5 × 108.3, max. diam, 92 μm, dorsal views, (A) dorsal surface, (B) optical section. **6.** *Wilsonidium tabultaum* (Wilson, 1967) Lentin and Williams, 1976. Sample 555-3-7, 40–42 cm, R 2712 BN (1), 21.4 × 74.2, length 102 μm, dorsal view of dorsal surface, reworked. **7.** Gonyaulacacean cyst group. Sample 555-14-1, 20–22 cm, R 2712 BD (2), 33.3 × 78.7, max. diam. 81 μm, dorsal views, (A) dorsal surface, (B) optical section, (C) ventral surface. **8.** Gonyaulacacean cyst group. Sample 555-14-1, 20–22 cm, R 2712 BD (2), 16.9 × 103.7, length 47 μm, interior view of operculum.

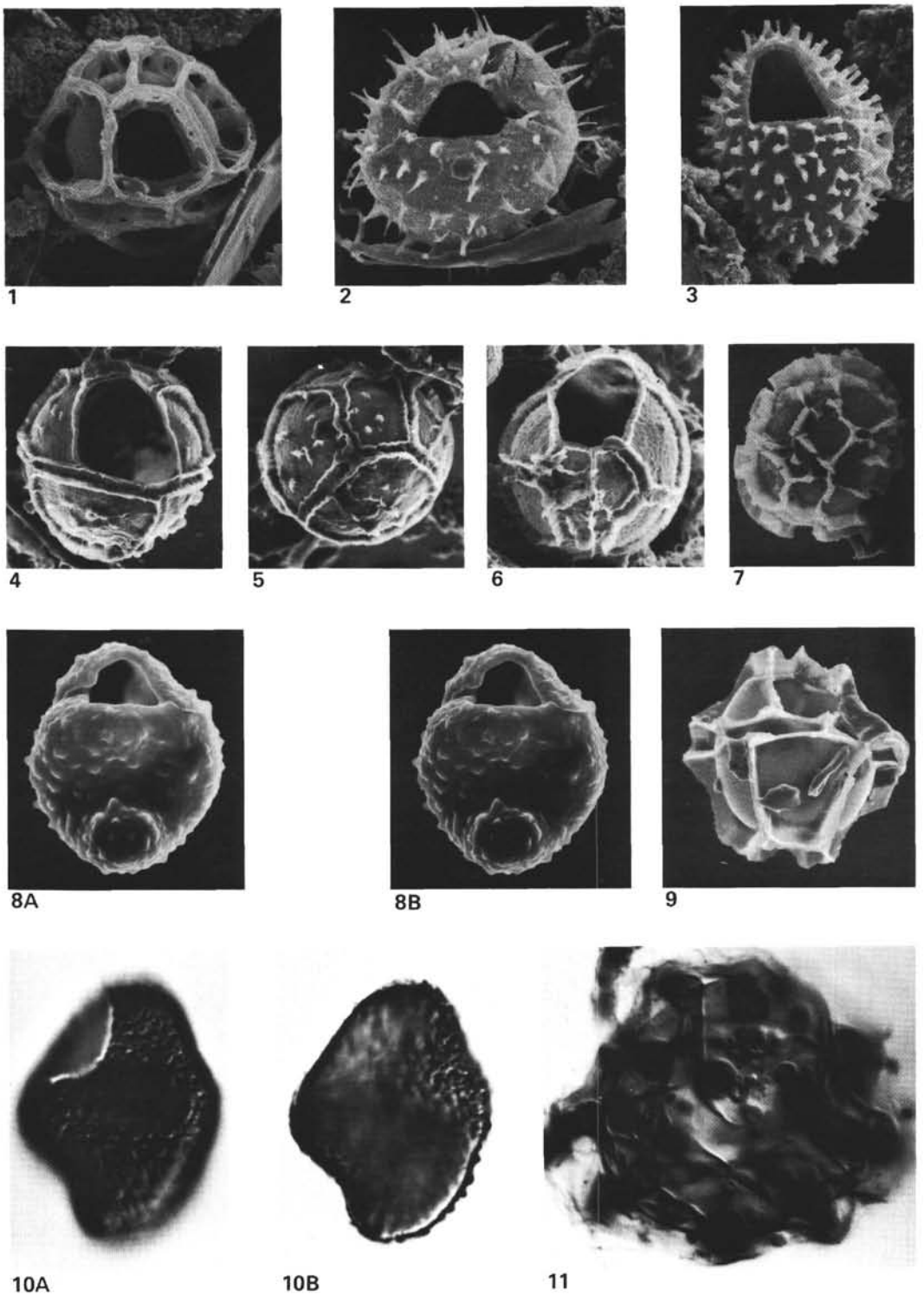


Plate 5. **1.** *"Nematosphaeropsis" aquaeducta* Piasecki, 1980. Sample 555-22-1, 107–109 cm, R 2712 AV, dorsal view, length 47 μm, SEM. **2.** *Operculodinium centrocarpum* (Deflandre and Cookson, 1955) Wall, 1967. Sample 555-22-1, 107–109 cm, R 2712 AV, dorsal view, max. diam. 70 μm, SEM. **3.** *Operculodinium* sp. of Piasecki, 1980. Sample 555-22-1, 107–109 cm, R 2712 AV, dorsal view, length 47 μm, SEM. **4.** *Danea*? sp. Sample 555-21-2, 60–62 cm, R 2712 AW, dorsal view, diam. 75 μm, SEM. **5.** *Danea*? sp. Sample 555-21-2, 60–62 cm, R 2712 AW, antapical view, same specimen as 4, diam. 75 μm, SEM. **6.** *Danea*? sp. Sample 555-21-2, 60–62 cm, R 2712 AW, apical view, diam. 73 μm, SEM. **7.** "Gen. et sp. indet." of Piasecki, 1980. Sample 555-22-1, 107–109 cm, R 2712 AV, orientation uncertain, diam. 36 μm, SEM. **8.** *Tectatodinium simplex* (Harland, 1979) n. comb. Sample 555-22-1, 107–109 cm, R 2712 AV, dorsal views, stereopair, length 45 μm, SEM. **9.** *Spiniferites*–group sp. I. Sample 555-22-1, 107–109 cm, R 2712 AV, dorsal view, length 67 μm, SEM. **10.** *Tectatodinium simplex* (Harland, 1979) n. comb. Sample 555-22-1, 107–109 cm, R 2712 AV (1), 30.4 × 78.6 length 52 μm, right-lateral views, (A) right-lateral surface, (B) optical section. **11.** *Tuberculodinium vancampoae* (Rossignol, 1962) Wall, 1967. Sample 555-22-1, 107–109 cm, R 2712 AV (1), 25.8 × 80.7, max. diam. 72 μm, ?antapical view.