14. CENOZOIC CALCAREOUS NANNOFOSSILS FROM DEEP SEA DRILLING PROJECT LEG 75, SOUTHEAST ATLANTIC OCEAN[1]

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ABSTRACT

Sediments from the three DSDP Leg 75 sites in the southeast Atlantic Ocean collectively contain a calcareous nannofossil record of almost the entire Cenozoic. Two rotary-cored holes and six hydraulic piston-cored holes were drilled. The youngest sediment recovered is Recent from the *Emiliania huxleyi* Zone, and the oldest sediment is at the Cretaceous/Tertiary boundary in Hole 530A. The nannofossils are generally common to abundant and moderately well-preserved. One new species is described, *Biantholithus astralis* nov. spec.

INTRODUCTION

Cenozoic sediments were recovered on Deep Sea Drilling Project (DSDP) Leg 75 at all three sites occupied in the Angola Basin and on the Walvis Ridge in the southeast Atlantic Ocean (Fig. 1). Only two of the eight holes were rotary-cored; the remainder were hydraulic piston cored (HPC). The oldest Cenozoic sediments recovered are basal Paleocene in age in Hole 530A. Cenozoic sediments generally contain common to abundant, moderately well-preserved nannofossils. Species assemblages are relatively diverse, permitting use of low-latitude zonations for biostratigraphy. Reworked older taxa were rarely encountered.

METHODS

Smear slides of samples were prepared employing commonly accepted techniques suggested by Bramlette and Sullivan (1961) and Hay (1961, 1965). The slides were examined under both cross-polarized and phase-contrast light at ×1200 magnification. The scanning electron microscope was used to confirm the presence of *Emiliania huxleyi* in cores where it was suspected. The Cenozoic nannofossils considered in this chapter are listed in the Appendix along with an index to the plates. The presence and abundance of all nannofossils observed were recorded in range charts (see Tables 1 through 4). Abundance estimates of the total number of taxa present and of individual taxa in the assemblage were made according to the method introduced by Hay on Leg 4 (1970). The abundance is estimated by the order of magnitude of its frequency per field of view at ×1200. This is expressed in terms of an exponent to the base ten. Table 5 lists the frequency estimate designations used and their meanings. The overall preservation of nannofossil assemblages was recorded using one of three letter designations instituted on Leg 49 (Steinmetz, 1979).

G = Good preservation. Fossils lack evidence of dissolution or overgrowth.

M = Moderately good preservation. A majority of the specimens are slightly etched. Fine structures are missing, but no diagnostic changes of form are evident in light microscopy. Rim margins of placoliths are slightly serrate. All taxa may be easily identified. Diversity is normal.

P = Poor preservation. A majority of the specimens are deeply etched. Identity of many centerless and fragmented specimens is questionable. Diversity is low.

NANNOPLANKTON ZONATION

Three nannoplankton zonations were employed to make zonal and geological age assignments of the samples. The Standard Nannoplankton Zonation of Martini (1971) was used for the shipboard and site reports. After closer inspection of the samples in shore-based studies, we found that Bukry's (1973, Leg 15; 1975, Leg 32) and Ellis' (1979; 1982, Leg 60) zonations offered higher resolution. Okada and Bukry (1981) introduced code numbers to the low-latitude zonation of Bukry (1973, 1975). Table 6 shows a correlation of the calcareous nannoplankton zonation schemes proposed by Martini (1971), Bukry (1973, 1975), and Ellis (1979, 1982), as well as their respective code numbers which are used throughout this report. Table 6 also shows the geologic age and nannofossil zone assignments of Leg 75 cores correlated with the zonations.

Site 530

Site 530 (19°11.26′S, 9°23.15′E; water depth, 4629 m) is located in the southeastern corner of the Angola Basin, about 20 km north of the Walvis escarpment, near the eastern end of the Walvis Ridge. Three holes were drilled at Site 530. Hole 530 was drilled using a standard rotary coring assembly, but was terminated (115 m below the seafloor) by technical failure. Hole 530A (1121 m penetration) was drilled using a standard rotary coring assembly. Hole 530B (180 m penetration) was cored using the hydraulic piston coring (HPC) device first employed on Leg 65.

Four sedimentary units were described in the Cenozoic sediments at Site 530. Unit 1 consists of Holocene to early Pleistocene diatom nannofossil ooze, marl, and debris-flow deposits to a depth of 110.0 m sub-bottom. Unit 2 consists of early Pleistocene to late Miocene nannofossil clay, marl, ooze, and debris-flow deposits from 110.0 to 277.0 m sub-bottom. Unit 3 consists of late Miocene to Oligocene red and green muds from 277.0 to 467.0 m sub-bottom. Unit 4 consists of Eocene to Danian multicolored mudstone, marlstone, chalk, and clastic limestones from 467.0 to 592.6 m sub-bottom.

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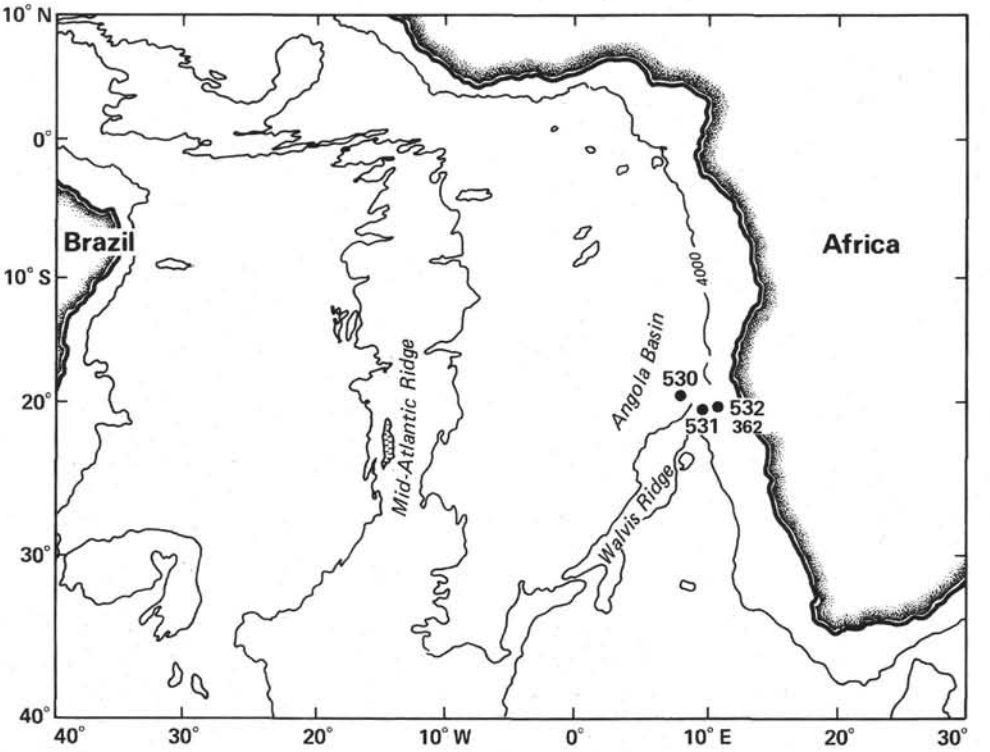

Figure 1. Location of Sites 530–532, Leg 75.

In Holocene through late Miocene sediments, nannofossils are generally common to abundant in number and show moderate to good preservation. The early and middle Miocene is largely unzoned because of repeated barren sections. The remainder of the Tertiary record is well-zoned using common to abundant numbers of moderately to poorly preserved nannofossils.

Hole 530. Only two cores were recovered from Hole 530. The presence of *Emiliania huxleyi* in Core 1 (0.0 m to 1.5 m sub-bottom) indicates the Holocene *E. huxleyi* Zone (NN21, CN15, WPN32). Core 2 (taken after washing to 115.5 m sub-bottom) contains an assemblage characteristic of the early Pliocene *Discoaster asymmetricus* Subzone (upper NN15, CN11b, WPN28b): *Calcidiscus macintyrei, D. brouweri, D. pentaradiatus, D. surculus, D. tamalis*, and *Sphenolithus abies. Gephyrocapsa caribbeanica* is present as a Pleistocene contaminant.

Hole 530A. Coring in Hole 530A was begun after washing to 125.0 m sub-bottom. Core 1 to Core 4, Section 4 (125.0 m to 158.7 m) are latest early Pliocene age, *Reticulofenestra pseudoumbilica* Zone (NN15, CN11, WPN28). *Discoaster asymmetricus* Subzone (upper NN15, CN11b, WPN28b) is delimited on the top by the last occurrences of *Sphenolithus abies* and *R. pseudoumbilica*, and on the bottom by the first occurrence of *D. tamalis*, not by the acme of *D. asymmetricus* as proposed by Bukry (1973). The *S. neoabies* Subzone (lower NN15, CN11a, WPN28a) occurs from 4-4 to 5,CC (158.7 m to 172.5 m) and is delimited on the top and bottom, respectively, by the first occurrence of *D. tamalis* and the last occurrence of *Amaurolithus tricorniculatus.*

Only one distinct subzone is discernable in the *A. tricorniculatus* Zone (NN12-14, CN10, WPN27). The *Ceratolithus rugosus* Subzone (NN13-14, CN10c, WPN27c) occurs between the last occurrence of *A. tricorniculatus* at 5,CC (172.5 m) and the first occurrence of *C. rugosus* at 7-4 (187.2 m). Below this is a section with mixed subzone indicators (NN12, CN10a-10b, WPN27a-27b) which extends down to the last occurrence of *D. quinqueramus* at 8,CC (201.0 m).

The late Miocene *D. quinqueramus* Zone (NN11, CN9, WPN26) occurs from 8,CC to 15,CC (201.0 m to 267.5 m) and is divisable into two subzones: the *A. primus* Subzone (upper NN11, CN9b, WPN26b) and the *D. berggrenii* Subzone (lower NN11, CN9a, WPN26a). The first occurrence of *A. primus* (13,CC, 248.5 m) separates the two subzones. From 15,CC to 18-4 (267.5 m to 291.7 m) the middle to late Miocene interval is compressed, and individual zones or subzones are not resolvable. Indicators of Subzones CN5b to CN8b (NN7 to NN10, WPN22b to WPN25b) are absent. Much of the middle Miocene is barren and unzoned from Sections 18-5 to 21-5 (293.2 m to 321.7 m). Only one sample, Sample 530A-21-4, 70–71 cm (310.7 m), of the 22 samples taken in this interval, contains a poorly preserved assemblage of *C. macintyrei, Coccolithus eopelagicus, C. pelagicus, D. bollii, D. exilis, D. kugleri, D. variabilis, R. pseudoumbilica, S. abies*, and *Triquetrorhabdulus rugosus*, suggesting the *D. exilis* Zone (NN6 to NN7, CN5, WPN22).

The *S. heteromorphus* Zone (NN5, CN4, WPN21) is found from Section 21-6 (323.0 m) down to at least 24-2 (345.2 m), and may extend farther down, but the section

is barren through 31-1 (410.7 m). The interval from Sections 31-2 to 34-6 (412.3 m to 446.7 m) is largely barren, but a few samples contain moderately well-preserved assemblages indicating the *Dictyococcites bisectus* Subzone of the *Sphenolithus ciperoensis* Zone (NP25, CP19b, WPN17b). This is underlain by a short, but better-represented, interval of the *Cyclicargolithus floridanus* Subzone (NP24, CP19a, WPN17a) from 35-1 to 37-1 (448.7 m to 467.0 m).

Core 37 (467.0 to 476.5 m) contains a relatively well-represented, unusually compressed section. The late Oligocene *C. floridanus* Subzone (NP24, CP19a, WPN17a) is found in Sample 530A-37-1, 1–2 cm. From 37-1, 63–64 cm to 37-2, 2–3 cm, the *S. distentus* Zone, *S. predistentus* Zone, and *R. hillae* Subzone (NP23 to NP22, CP18 to CP16c, WPN16 to WPN14c) are indicated. This interval is characterized by the *Braarudosphaera bigelowi* ooze, which has been reported at DSDP Holes 14, 17, 19, 20, 22, 362A, and 363 in the South Atlantic Ocean (Maxwell et al., 1970; Bolli et al., 1978). This is a particularly thin section of *Braarudosphaera* ooze, and is likely an erosional remnant of a much thicker section. It is bounded on either end by barren intervals of unknown duration, and nearby Holes 362A and 363 on the Walvis Ridge contain as many as 42 m of *Braarudosphaera* ooze or chalk (Bolli et al., 1978).

Samples 37-2, 52–53 cm and 37-2, 81–82 cm are earliest Oligocene (NP21, CP16a and 16b, WPN14a and 14b) and are bounded by the last occurrence of *Calcidiscus formosus* and *Discoaster saipanensis* on the top and bottom, respectively. The latest Eocene, *Isthmolithus recurvus* Subzone (NP19/20, CP15b, WPN13b) is indicated by the assemblage in Sample 37-2, 87–88 cm. Present in rare to few numbers are *R. dictyoda, I. recurvus, D. saipanensis, D. tanii*, and *R. umbilica.* Martini's (1971) *D. tanii nodifer* Zone (NP16, CP13/14) is suggested in Sample 530A-37-2, 105–106 cm with the lowest occurrence of *D. tanii.* Section 8 of Core 37 is middle Eocene (NP15, CP13b).

The early–mid Eocene *D. sublodoensis* Zone (NP14, CP12), bounded on the top by the first occurrence of *Nannotetrina alata* in 37,CC and by the first occurrence of *D. sublodoensis* in 38-2, 1–2 cm, is found between 476.5 and 478.0 m sub-bottom. The early Eocene (NP13 to NP10, CP11 to CP9) is well defined from 38-2, 133–134 cm to 41-1, 75–76 cm (479.3 m to 505.8 m). The *D. lodoensis* Zone (NP13, CP11) is bounded on the bottom by the last occurrence of *Tribrachiatus orthostylus* in 39-2, 19–20 cm. The *T. orthostylus* Zone (NP12, CP10) is bounded on the bottom by the first occurrence of *D. lodoensis* in 40-3, 122–123 cm. Subzones in the *D. diastypus* Zone (NP10/11, CP9) are not resolvable; the zone is bounded on the bottom by the first occurrence of *T. bramlettei* in Sample 530A-41-1, 75–76 cm.

The top of the Paleocene, *D. multiradiatus* Zone (NP9, CP8), occurs from 41-1, 141–142 cm to 42-2, 63–64 cm (506.4 m to 516.6 m); its base is determined by the first occurrence of *D. multiradiatus.* The two subzones are not distinguished. The first occurrences of both *D. nobilis* and *Heliolithus riedeli* in 43,CC (533.5 m) established the base of the *H. riedeli* Zone (NP8) of Martini (1971), and the base of the *D. nobilis* Zone (CP7) of Bukry (1973). *H. riedeli* is usually not used because of its rare and sporadic occurrence in oceanic assemblages (Bukry, 1973), but in this case both zonal markers occur at the same level.

The *D. mohleri* Zone (NP7, CP6) is short, restricted to only one section, Section 44-1 (533.5 to 535.0 m). Its base is defined by the first occurrence of *D. mohleri.*

The *H. kleinpellii* Zone (NP6, CP5) extends from 42-2, 75-76 cm to 46,CC (535.7 to 562.0 m), the first occurrence of *H. kleinpellii.* The *Fasciculithus tympaniformis* Zone (NP5, CP4) is present in only two samples, 47-1, 18–19 cm and 47-1, 70–71 cm. The first occurrence of *F. involutus* in the lower sample defines the base of this zone.

The *Ellipsolithus macellus* Zone (NP4, CP3) is not distinguished and may be missing. Assemblages of the *Chiasmolithus danicus* Zone (NP3, CP2) and the *Cruciplacolithus tenuis* Zone (NP2) (Martini, 1971), or Subzone (CP1b) (Bukry, 1973), are found mixed together from 47-1, 143–144 cm to 48,CC (563.4 to 581.0 m). *Chiasmolithus danicus*, the first occurrence of which separates these two zones, is found only in the first of ten samples downcore. Poor preservation obscures the true first occurrence datum. Core 49 and part of Core 50 (581.0 to 590.7 m), down to 50-1, 16–17 cm, the first occurrence of *Cruciplacolithus tenuis*, are in the *C. tenuis* Zone.

The lowermost Paleogene, or Danian (NP1, CP1a), occurs in a 142 cm interval from 50-1, 30–31 cm down to 50-2, 22–23 cm. The bottom of the Paleogene, or the Cretaceous/Tertiary boundary, is defined here by the first occurrence of *Biantholithus sparsus* (592.2 m sub-bottom).

Obtaining a section across the Cretaceous/Tertiary boundary was one of the objectives of Leg 75. The boundary is well represented in this unit, documented by poorly to moderately preserved, common to abundant nannofossils in Core 50, Section 2 (592.0 m). Table 2H shows the occurrences of nannofossils at intervals sampled close to the boundary. They reveal that the boundary, as far as can be judged by calcareous nannoplankton, lies between 23 and 28 cm in Core 50, Section 2. The high relative abundance of *Micula staurophora* across the boundary is a reflection of both the dissolution resistance of *M. staurophora* (Thierstein, 1980), as well as the generally poor preservational record of the other nannofossils in the assemblage (Thierstein, 1981). The boundary is not a sharp break between Maestrichtian and Paleocene assemblages, and there may be some interlayering or mixing. Paleomagnetic studies (Keating, this volume) show a shift in polarity just below the paleontologic boundary, from normal above to reversed below 63 cm.

Hole 530B. A complete Holocene–Pleistocene record is present from the mudline to 28,CC (113.2 m sub-bottom). The presence of the Holocene *Emiliania huxleyi* Zone (NN21, CN15, WPN32) was confirmed using the scanning electron microscope. A typical assemblage down to 2-1, 10-11 cm (2.5 m) consists of *Calcidiscus leptoporus, Coccolithus carteri, C. pelagicus, Crenalith-*

us doronicoides, E. huxleyi, Gephyrocapsa caribbeanica, G. oceanica, Helicosphaera carteri, and *Umbilicosphaera sibogae*. Four Pleistocene subzones of Bukry (1975) and Ellis (1979) are discernable. The *G. oceanica* Zone of Martini (1971), or the *Ceratolithus cristatus* Subzone of Bukry (1975) and Ellis (1979, 1982) (NN20, CN14b, WPN31b), extends from Samples 2-2, 113–114 cm, below the first occurrence of *E. huxleyi*, down to 7-1, 55-56 cm (5.0 to 24.0 m), just above the last occurrence of *E. ovata*.

From the last occurrence of *E. ovata* in 7,CC (27.8 m) to the first occurrence of *G. oceanica* in 13,CC (954.2 m), the *E. ovata* Subzone (CN14a, WPN31a) is present. Two other datums of potential biostratigraphic importance are present in this subzone: the last occurrences of *Calcidiscus macintyrei* in 11,CC (45.4 m) and *Discolithina japonica* in 13,CC.

The *G. caribbeanica* Subzone (mid NN19, CN13b, WPN30b) is present from 14,CC to the first occurrence of *G. caribbeanica* in 18,CC (58.2 to 76.2 m). The earliest Pleistocene *E. annula* Subzone (early NN19, CN13a, WPN30a) extends down to 28,CC (113.2 m). The last occurrences of *D. brouweri* and *D. variabilis* in 29,CC (116.2 m) indicate that the Pleistocene lies unconformably upon the earliest late Pliocene *Discoaster tamalis* Subzone (lower NN16, CN12a, WPN29a). From 30,CC to 40,CC (118.2 to 154.6 m) the *D. asymmetricus* Subzone (upper NN15, CN11b, WPN28b) is indicated, bounded on top by the last occurrence of *Sphenolithus abies* and on the bottom by the first occurrence of *D. tamalis*. Below this, the *S. neoabies* Subzone (lower NN15, CN11a, WPN28a) continues from 41,CC to 44,CC (158.0 to 167.5 m) and lies unconformably upon the late Miocene.

The top of the late Miocene begins between 44,CC and 45,CC with the last occurrence of *D. berggrenii* and *D. quinqueramus* in 45,CC (170.8 m). This defines the top of the *Amaurolithus primus* Subzone (upper NN11, CN9b, WPN26b) which continues to the bottom of the cored section in 48,CC (180.6 m).

Site 531

Site 531 (19°38.40′S, 9°35.47′E; water depth, 1267 m) is located on the eastern end of the Walvis Ridge. Two holes were attempted at Site 531, but in each case the bottom was found to be firm and could not be penetrated. Hole 531 yielded only a core catcher filled with foraminiferal ooze. Hole 531A was 1000 feet west and yielded only 27 cm of foraminiferal ooze.

Holes 531/531A. The following well-preserved, abundant calcareous nannofossils, typically found in the Holocene *Emiliania huxleyi* Zone (NN21, CN15, WPN32), were observed in 531-1,CC (1284 m): *Calcidiscus leptoporus, Coccolithus pelagicus, E. huxleyi, Geophyrocapsa oceanica, Helicosphaera carteri, Pontosphaera syracusana, Syracosphaera pulchra*, and *Umbilicosphaera mirabilis*. In addition to these species, the following occur in Section 531A-1-1: *Ceratolithus cristatus, Rhabdosphaera clavigera*, and *Scapholithus fossilis*.

Site 532

Site 532 (19°41.61′S, 10°31.13′E; water depth, 1331 m) is located on the eastern part of the Walvis Ridge in a trough with relatively thick sediment fill, at a position close to Site 362 from Leg 40. The uppermost section at Site 362 was badly disturbed by rotary coring, and the HPC was employed at Site 532 in an attempt to recover an undisturbed upper section, close to the Walvis Bay zone of upwelling and high biotic productivity. Three holes were hydraulic piston cored (HPC) at Site 532. Hole 532 yielded 61 cores reaching a depth of 250.8 m. Hole 532A was offset about 50 m to the SSW. Forty-seven cores were taken to reach a depth of 199.6 m. This set of cores was taken for the JOIDES Sedimentary Petrology and Physical Properties Panel; the cores were sealed and not opened for examination and sampling aboard ship. Hole 532B was offset about 30 m to the south. Seventy-four cores were taken, reaching a depth of 291.3 m. Cores 1 to 56 were not opened, but were frozen to be examined later for geochemical studies. The remainder of the cores were studied in the usual manner. Control from the rig floor was so exact, that Cores 532-61 and 532B-61 correlate within 0.4 m and can be considered to have been taken at the same level. Hence, coring is continuous from the mudline to the total depth of 291.3 m in Core 532B-74.

A thick (291.3 m) Holocene to late Miocene unit of nannofossil marl and ooze was encountered at Site 532. The section was divided into three subunits: 1a, foram-nannofossil marl and ooze (Cores 1–12, 0 to 49.5 m, Pleistocene), 1b, diatom-nannofossil marl (Cores 12–26, 49.5 to 114.0 m, late Pliocene), and 1c, nannofossil marl (Cores 27–74, 114.0 to 291.3 m, late Pliocene to late Miocene). Calcareous nannofossils are common to abundant, showing moderate to good preservation in all samples studied. No barren intervals were encountered.

Figure 2 shows a comparison between the calcareous nannofossil biostratigraphy of Hole 362 (Bukry, 1978; Proto Decima, 1978) and Holes 532 and 532B. Immediately evident is the fact that the epoch boundaries in both sections are within 10 m of each other. The zonal boundaries, however, do not correlate as well. The higher zonal resolution in Holes 532 and 532B is the result of the diminished core disturbance with the HPC used in obtaining that core. The low resolution in the Early Pliocene sections of both Holes 362 and 532/532B is likely the result of slumping in the sediment.

Holes 532 and 532B. The Holocene *Emiliania huxleyi* Zone is detected from the mudline to Sample 1-2, 62–63 cm (2.1 m sub-bottom). A complete Pleistocene section, including the four subzones of Bukry (1975) and Ellis (1979, 1982), is present from 1-3, 65–66 cm down to 17,CC (74.4 m). The *E. ovata* datum occurs in 5,CC (21.6 m); the *Gephyrocapsa oceanica* datum occurs in 11,CC (48.0 m); and the *G. caribbeanica* datum occurs in 15,CC (65.6 m).

The last occurrence of *Discoaster brouweri*, defining the Pliocene/Pleistocene boundary, occurs in 18-1,

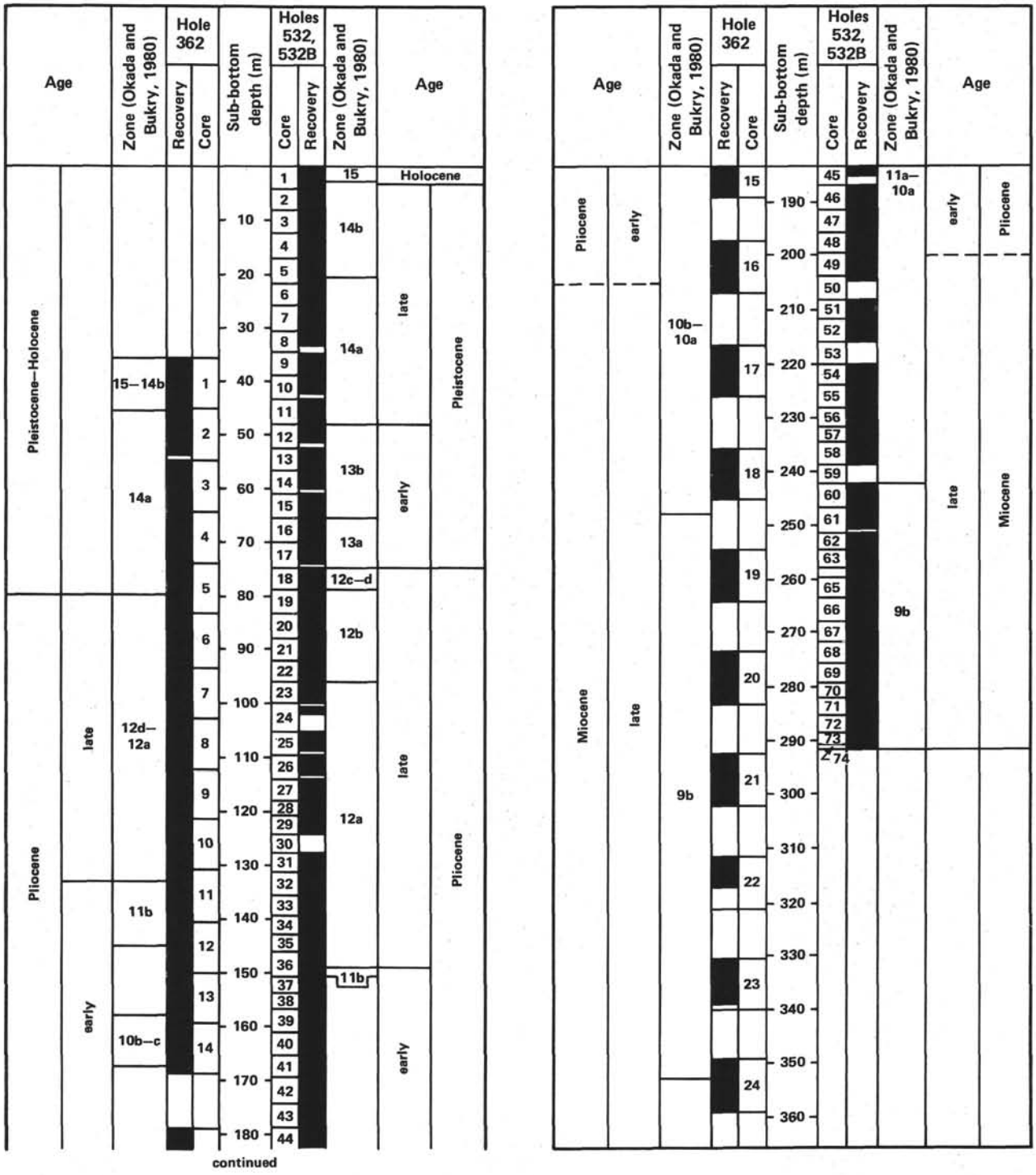

Figure 2. Comparison between the calcareous nannofossil biostratigraphy of Hole 362 and Holes 532 and 532B. Nannofossil zones and subzones are numbered according to the scheme proposed by Okada and Bukry (1980) and shown in Table 6.

125–126 cm (75.6 m). Three of four late Pliocene subzones of Bukry (1973, 1975) and Ellis (1979, 1982) are detectable; the upper two appear to be mixed together from 18-1, 125–126 cm to 18-3, 121–122 cm. The last occurrences of both *D. pentaradiatus* and *D. surculus* in 18,CC (78.8 m) indicate the top of the *D. surculus* Subzone (CN12b, WPN29b). This subzone extends down to 22-3, 80–81 cm (95.8 m). The last occurrence of *D. tamalis* in 22,CC (96.4 m) indicates the top of the *D. tamalis* Subzone. This extends down to 36-2, 107–108 cm (149.1 m).

Ellis' (1982) *D. asymmetricus* Subzone (WPN28b) is found in only one sample examined: 36,CC (150.6 m). This sample contains the two datums defining this subzone: the first occurrence of *D. tamalis* and the last occurrence of *Sphenolithus abies*. Bukry's (1973, 1975) *D.*

asymmetricus Subzone (CN11b) is defined on the bottom of the acme of *D. asymmetricus*. This is not detectable in Hole 532.

The zones or subzones of the early Pliocene are not resolvable. From 37,CC to 60-3, 31–32 cm (153.8 to 241.1 m), an early Pliocene assemblage (NN12–NN15, CN10a–CN11a, WPN27a–WPN28a) is present, but none of the datums is present in any meaningful order.

The late Miocene *Amaurolithus primus* Subzone (upper NN11, CN9b, WPN26b) occurs from 60,CC to the bottom of the cored interval, 74B,CC (246.8 to 291.3 m). The first occurrence of *A. primus*, defining the bottom of this subzone, was not reached.

TAXONOMY

***Biantholithus astralis* Steinmetz and Stradner nov. spec.**
(Plate 52, Figs. 1, 4; Plate 53, Figs. 1, 2)

Description: This new species consists of seven to eight segments radiating from a common center. The segments are slightly imbricate and slightly tilted, as are the blades of a windmill. Each segment is in contact with adjacent segments for a little more than half its length. Beyond the point of contact, the segments taper slightly and end with rounded tips. A small hole is present in the center where the segments meet.

Remarks: *Biantholithus sparsus* Bramlette and Martini differs from *Biantholithus astralis* nov. spec. in that it has eight to twelve segments which are in contact for almost their entire length.

Holotype: Plate 53, Figure 1. Negative 2/92/007, Elmi-Lab, Geological Survey of Austria, Vienna.

Type locality and level: Southeast Atlantic Ocean, Angola Basin, DSDP 530A-50-1, 6–7 cm, *Cruciplacolithus tenuis* Zone (Martini, 1971), *Cruciplacolithus tenuis* Subzone (Bukry, 1973, 1975).

Known range: Danian.

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APPENDIX

Cenozoic Calcareous Nannofossils Considered in This Chapter and Index to Plates (in alphabetical order by species epithets)

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Table 1. Distribution of Holocene-Pliocene calcareous nannofossils, Hole 530.

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Sphenolithus abies*	*Emiliania annula*	*Discoaster asymmetricus*	*Discoaster brouweri*	*Gephyrocapsa caribbeanica*	*Coccolithus carteri*	*Helicosphaera carteri*	*Rhabdosphaera clavigera*	*Ceratolithus cristatus*	*Amaurolithus delicatus*	*Crenalithus doronicoides*	*Thoracosphaera ellipsoidea*	*Thoracosphaera heimii*	*Emiliania huxleyi*	*Discolithina japonica*	*Calcidiscus leptoporus*	*Calcidiscus macintyrei*	*Discolithina multipora*	*Gephyrocapsa oceanica*	*Coccolithus pelagicus*	*Discoaster pentaradiatus*	*Reticulofenestra pseudoumbilica*	*Syracosphaera pulchra*	*Thoracosphaera saxea*	*Helicosphaera sellii*	*Umbilicosphaera sibogae*	*Aspidolithus stylifera*	*Discoaster surculus*	*Discoaster tamalis*	*Discoaster variabilis*	Zone (Ellis, 1982)	Zone (Okada and Bukry, 1980)	Zone (Martini, 1971)	Age
0.25	1-1, 25–26	C	M					C	C	F							R	R	C			C	F				F								
	1-1, 60–61	A	M					C	C	F		F			R			R	C			C	F			R	F	R					WPN32	CN15	NN21	Holocene
	1-1, 125–126	C	M					C	C	F								F	C			C	F		r		F	R								
1.5	1,CC	C	M					C	C	F	F	R				R	F	F	C		R	C	F			F	F	F								
117.7	2-2, 71–72	C	M			R	R	F	F	F				F					F	F		F	F		F					R						
	2-3, 72–73	A	M	F		R	F	C	F	F				C				F	F	F			C		C				R	R	R					
	2-5, 62–63	A	M	F			F	C	F	F				C				F	F	F			C		C					R		F	WPN28b	CN11b	upper NN15	early Pliocene
	2-6, 117–118	A	M	F			F		F	F			R	C		R		F	F	F			C		C			F			R					
125.0	2,CC	A	M	F	F	R	F	F	F	F			R	C				R	F	F			F	R	C					R	R					

Note: Abundance: A = abundant; C = common; F = few; R = rare; B = barren; lower case letter = reworked older fossils. Preservation: G = good; M = moderate; P = poor.

Table 2. Distribution of calcareous nannofossils, Hole 530A
2A. Early Pliocene to Late Miocene.

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Sphenolithus abies*	*Ceratolithus acutus*	*Discoaster altus*	*Helicosphaera ampliaperta*	*Amaurolithus amplificus*	*Emiliania annula*	*Discoaster asymmetricus*	*Discoaster auloskos*	*Sphenolithus belemnos*	*Discoaster bellus*	*Discoaster berggrenii*	*Braarudosphaera bigelowi*	*Reticulofenestra bisecta*	*Discoaster blackstockae*	*Discoaster bollii*	*Discoaster brouweri*	*Discoaster calcaris*	*Discoaster calculosus*	*Catinaster calyculus*	*Coccolithus carteri*	*Helicosphaera carteri*	*Discoaster challengeri*	*Catinaster coalitus*	*Minilithina convallis*	*Ceratolithus cristatus*	*Discoaster decorus*	*Discoaster deflandrei*	*Amaurolithus delicatus*	*Crenalithus doronicoides*	*Discoaster druggi*	*Discoaster exilis*	*Cyclicargolithus floridanus*	*Micrantholithus flos*	*Discoaster formosus*	*Reticulofenestra gartneri*	*Discoaster hamatus*	*Thoracosphaera heimii*	*Sphenolithus heteromorphus*	*Discoaster icarus*	*Thoracosphaera imperforata*	*Discoaster intercalaris*	*Discolithina japonica*
	1-1, 75-76	A	M	R			R		F	F				R				F				F	F							A	F						R				
	1-4, 67-68	C	M	F					F									R				F	C							C											
	1-5, 9-10	C	M						R						R			R				F	F							C											
134.5	1,CC	C	M	R					F									R				C	C	R						C											R
	2-1, 70-71	A	M						F	R				R				F				C	C					r		C											
	2-2, 70-71	C	M	F					C									R				F	F							C											
	2-3, 70-71	A	M	F						F								F				F	F							C											
144.0	2,CC	A	M						F	R							R	R				F	F					r		C			F	r							
153.5	3,CC	A	G	F													F	F				F	F	F						C			F								
	4-2, 77-78	A	G							F								F				F	F				R			C			F								
	4-3, 77-78	A	G							F								F				C	R							A											
	4-4, 77-78	C	M	F						F								F				R	C				R			C											
	4-5, 77-78	A	G							R								F				C	C							A											
163.0	4,CC	A	G	F											R			F				C	F	R						C											
172.5	5,CC	A	G	F													R	F				F	F						F	A		R	r							R
	6-1, 72-73	A	G															F				F	F							A											
	6-2, 72-73	A	G															F				F								C											
	6-3, 12-13	F	P																				F																		
182.0	6,CC	A	M		R												R	F				F	F	F					F	F		F						R		
	7-1, 77-78	A	G	F																			F			F		r		C											
	7-2, 77-78	A	M	F													F	F					F							F											
	7-3, 77-78	A	M	F														F					F						F	F											
	7-4, 77-78	A	M	F																			F				R			F											
	7-5, 77-78	A	G				R								R	R			F				F					R		F											F
	7-6, 77-78	A	G	F													F		F			R	R					R	R	F											
191.5	7,CC	A	M	F											R		F	F					R						F	F		F								
	8-1, 77-78	A	G	F													F	F					F					F	R	F											
	8-2, 77-78	A	G	F													F	F			F		F					F	R	F											
	8-3, 77-78	A	M				F										F						F					F	F	F											
	8-4, 77-78	A	G	F	F												F	F			F		F	F				F	F	F							R				
	8-5, 77-78	A	M				R										F	F					F					F	F	F		F								
	8-6, 77-78	A	G	F													F	F			F		F					F	F	F											
201.0	8,CC	A	M	F													F	F			R		R					F	R												
	9-1, 77-78	A	M														F	R					F					F				F									
	9-2, 77-78	A	G												R			F	R				F	F				F	F			F									
210.5	9,CC	A	M	F															R				R	F								F									
	10-1, 77-78	A	G															F					R					R													
	10-2, 77-78	A	G	F													R						F	F					R												
	10-3, 77-78	A	G																				R						R			F								
	10-4, 77-78	A	G	F														F	F				F	F				R		R							F				
	10-5, 77-78	A	G	F																			R					R				F								
	10-6, 77-78	A	G	R														F														F								
220.0	10,CC	A	M	F													F	F					F							R		F						R		R
	11-1, 77-78	A	G	R			R																							R		C								
	11-2, 77-78	A	G	F											R									F	R			R		R		F									

Note: Abundance: A = abundant; C = common; F = few; R = rare; B = barren; lower case letter = reworked older fossils. Preservation: G = good; M = moderate; P = poor.

Table 2A. (Continued).

Discoaster kugleri	*Calcidiscus leptoporus*	*Discoaster loeblichii*	*Calcidiscus macintyrei*	*Triquetrorhabdulus milowii*	*Coccolithus miopelagicus*	*Discolithina multipora*	*Discoaster musicus*	*Sphenolithus neoabies*	*Discoaster neohamatus*	*Discoaster neorectus*	*Coronocyclus nitescens*	*Coccolithus orangensis*	*Emiliania ovata*	*Discoaster pansus*	*Coccolithus pelagicus*	*Discoaster pentaradiatus*	*Hayaster perplexus*	*Discoaster prepentaradiatus*	*Amaurolithus primus*	*Reticulofenestra pseudoumbilica*	*Discoaster pseudovariabilis*	*Discoaster quadramus*	*Discoaster quinqueramus*	*Calcidiscus rotula*	*Ceratolithus rugosus*	*Triquetrorhabdulus rugosus*	*Pontosphaera scutellus*	*Helicosphaera sellii*	*Discoaster stellulus*	*Aspidorhabdus styliferа*	*Discoaster surculus*	*Discoaster tamalis*	*Amaurolithus tricorniculatus*	*Discoaster trinidadensis*	*Discoaster variabilis*	*Micrantholithus vesper*	Zone (Ellis, 1982)	Zone (Okada and Bukry, 1980)	Zone (Martini, 1971)	Age
F	F		F					R			C			A	F			C										R			R				F				
F	F		F											F	R			F										R											
F	F		F											C	R													F											
F	F		F											C	R			F										F			R								
F	F		F											C				F										F											
F	C		F											C				F										R			R					WPN28b	CN11	NN15	
F	F		C											C	F			C										F											
F	F		F											C	F			F										R				R		r					
F					R					F				C	F			C										R			F				F				
F	F													C	F			C						R							R	F							
F	F													C	F												F				F	F							
F	F													F				C													F	F							
F	F									R				F	F			C										F			R				F				
F	F		F							R				C	R			C													R	F	R		F				
F	F		F											C				C													C				F				
F	F		F											F	R			C													F				F				
F	F		F											F				C										R			F				F				
F	F		F											F	F			A						R				R			A				F				
F	F		F											F	F			A							R						R				F				
F	F		F											C	F			A													F				F				
F	F		F											F	F			A													F				F				
F	F		F											F	F			A						R				R			F				F				
F	F		F		R									F	R			A													A		F		F				
F	F		F											F	F			A													F				R				
F	F		F											C	F			A													F				F				
F	F		F											F	F			A													F				R				
F	F		F											A	R			C						R							F			R	F				
F	F		F		R								R	F	R			A													A				F				
F	F		F											F	F			A						F							R				F				
F	F		F											F	F			C						F							R				F				
F	F		F											F	F			A													A				F				
F	F		F											F	F			A	R						R	F	R												
R	F		F											F	F			A						F							A			R	F				
F	F		F											R	F			A	R					C							A				C				
F	F		F											C	F			A						F		R									F				
R	F		F					R						R	F			A						F			R								F				
F	F		F		R									R	F			A						F											C				
F	F		F					R		F				F	F			A	R					F				R							F	R			

Table 2B. Late Miocene–middle Miocene. Hole 530A (Continued).

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Sphenolithus abies*	*Ceratolithus acutus*	*Discoaster altus*	*Helicosphaera ampliaperta*	*Amaurolithus amplificus*	*Emiliania annula*	*Oolithotus antillarum*	*Gephyrocapsa aperta*	*Scyphosphaera apsteini*	*Discoaster asymmetricus*	*Discoaster aulakos*	*Sphenolithus belemnos*	*Discoaster bellus*	*Discoaster bergrenii*	*Braarudosphaera bigelowi*	*Reticulofenestra bisecta*	*Discoaster blackstockae*	*Discoaster bollii*	*Discoaster brouweri*	*Discoaster calcaris*	*Discoaster calculosus*	*Catinaster calyculus*	*Gephyrocapsa caribbeanica*	*Coccolithus carteri*	*Helicosphaera carteri*	*Discoaster challengeri*	*Rhabdosphaera clavigera*	*Catinaster coalitus*	*Minylithina convallis*	*Ceratolithus cristatus*	*Discoaster decorus*	*Amaurolithus delicatus*	*Sphenolithus delphix*	*Coccolithus eopelagicus*	*Discoaster exilis*	*Cyclicargolithus floridanus*	*Micrantholithus flos*	*Discoaster formosus*	*Reticulofenestra gartneri*	*Discoaster hamatus*	*Thoracosphaera heimii*	*Sphenolithus heteromorphus*	*Syracosphaera histrica*	*Emiliania huxleyi*	*Discoaster icarus*	*Thoracosphaera imperforata*	*Discoaster intercalaris*	*Scyphosphaera intermedia*	*Discolithina japonica*	*Cricolithus jonesii*
	11-3, 77-78	A	M	F	R																F	F												R		F					R						
	11-4, 77-78	A	M																		F													F		F											
	11-5, 77-78	A	M					R													R													R		C											
	11-6, 77-78	A	M																		R															C											
229.5	11,CC	A	M	P				R												R	F	R						R	R							F					R						
	12-1, 72-73	A	M	F																	F							R								F											
	12-2, 72-73	A	P					R													F	R														C											
	12-3, 72-73	A	M	F																F	C	F					R	F			C				F											
	12-4, 72-73	A	P																		F							R																		
	12-5, 72-73	A	M					R													F							R								F											
	12-6, 72-73	A	M																		F															F											
239.0	12,CC	A	M											R							R	R						R	R							F											
	13-1, 77-78	A	M																		R															F											
	13-2, 78-78	A	M																		R															F											
	13-3, 77-78	A	P	R													R	R		R	R	F						F								R											
	13-4, 77-78	A	M	R																	R							R								R											
	13-5, 77-78	A	M																		F	R												R												
248.5	13,CC	A	M														R			F	F	R						R								R											
	14-1, 77-78	A	M																		F											R														
	14-2, 77-78	A	M																		F							R						R											
	14-3, 77-78	A	M																		F																									
258.0	14,CC	A	M	F													F			F	F	F						F								R											
	15-1, 77-78	A	M	F																	F										R												F		F		
	15-2, 77-78	A	M	F																	F										R												R		R		
	15-3, 77-78	C	P	F																	F	F						R															R			
	15-4, 77-78	B																																												
	15-5, 77-78	A	M	F																	C	F						R	F							F							R			
	15-6, 77-78	A	P	F		R									R						F							F	F			R					F						R			
267.5	15,CC	C	P																		C							F	F	R			R			F						R			
277.0	16,CC	A	M															F		R	F							F	F	R						F							R			
286.5	17,CC	C	P												F					R	R							F		R															
	18-1, 73-74	A	M	F											R						F							R	F	C						R	F				F				
	18-2, 73-74	C	M												R					R	F	R	R					F	F						R	F				R		F			
	18-3, 22-23	A	M	F														R		R								C	R						F									
	18-3, 73-74	A	M																	R								F	R				R											
	18-4, 73-74	C	P	R																R		F						R	R						F									
	18-5, 73-74	B																																											
296.0	18,CC	B																																											
	19-1, 73-74	B																																											
	19-2, 73-74	B																																											
	19-3, 73-74	B																																											
	19-4, 73-74	B																																											
	19-5, 73-74	B																																											
	19-6, 73-74	B																																											
305.5	19,CC	B																																											

Table 2B. (Continued).

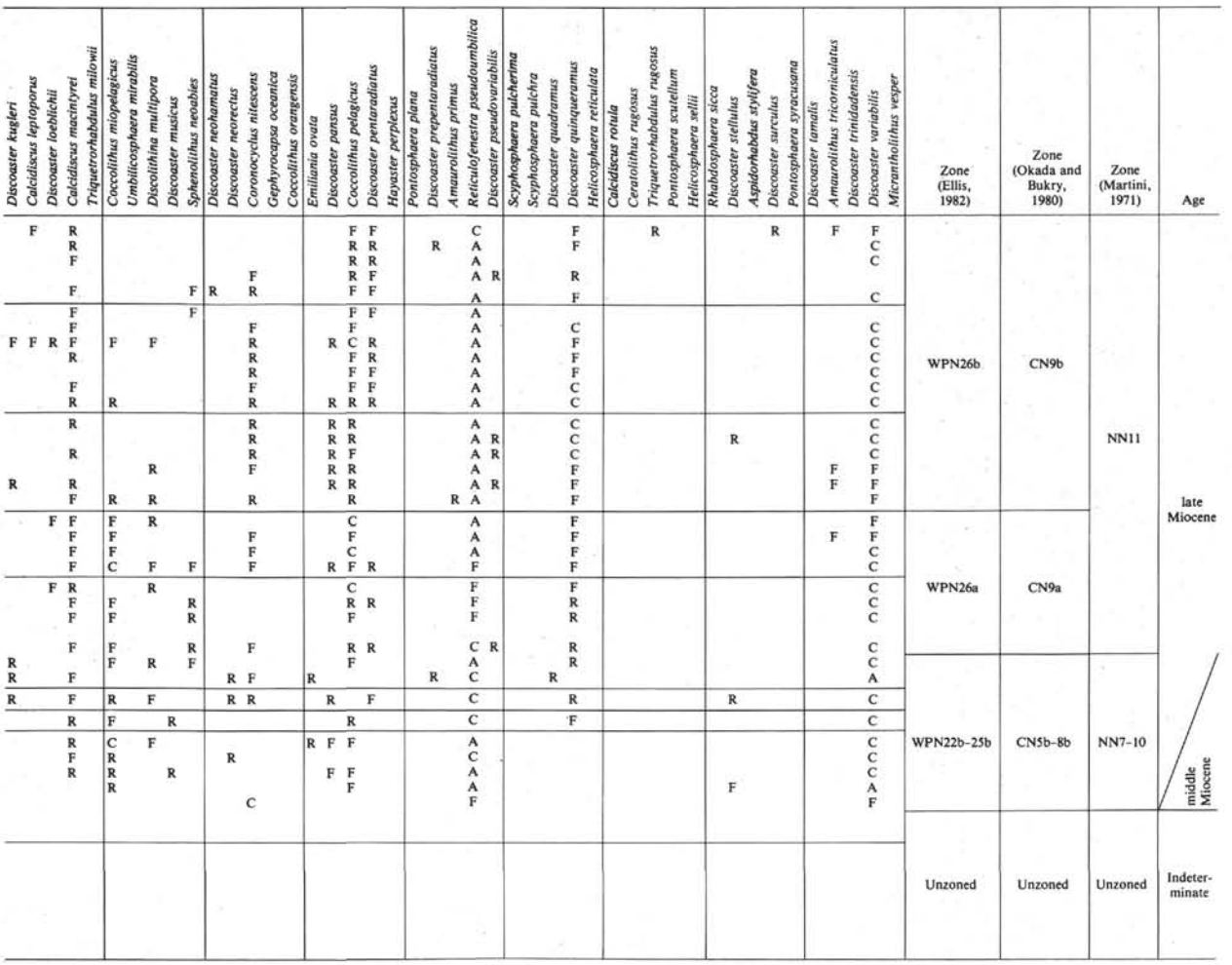


Table 2C. Middle Miocene. Hole 530A (continued).

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Sphenolithus abies*	*Ceratolithus acutus*	*Discoaster alus*	*Helicosphaera ampliaperta*	*Amaurolithus amplificus*	*Emiliania annula*	*Oolithotus antillarum*	*Gephyrocapsa aperta*	*Scyphosphaera apsteini*	*Discoaster asymmetricus*	*Discoaster aulakos*	*Sphenolithus belemnos*	*Discoaster bellus*	*Discoaster bergrenii*	*Braarudosphaera bigelowi*	*Reticulofenestra bisecta*	*Discoaster blackstockae*	*Discoaster bollii*	*Discoaster brouweri*	*Discoaster calcaris*	*Discoaster calculosus*	*Catinaster calyculus*	*Gephyrocapsa caribbeanica*	*Triquetrorhabdulus carinatus*	*Helicosphaera carteri*	*Discoaster challengeri*	*Rhabdosphaera clavigera*	*Catinaster coalitus*	*Minilithina convallis*	*Ceratolithus cristatus*	*Discoaster decorus*	*Discoaster deflandrei*	*Sphenolithus delphix*	*Discoaster druggii*	*Coccolithus eopelagicus*	*Discoaster exilis*	*Cyclicargolithus floridanus*	*Micrantholithus flos*	*Discoaster formosus*	*Reticulofenestra garinerii*	*Discoaster hamatus*	*Thoracosphaera helmii*	*Sphenolithus heteromorphus*	*Syracosphaera histrica*	*Emiliania huxleyi*	*Discoaster icarus*	*Thoracosphaera imperforata*	*Discoaster intercalaris*	*Scyphosphaera intermedia*	*Discolithina japonica*	*Cricolithus jonesii*
	20-1, 78-79	B																																																
	20-2, 78-79	B																																																
	20-3, 93-94	B																																																
	20-4, 70-71	A	M	F																R																	F	F												
	20-5, 47-48	B																																															
	20-6, 59-60	B																																															
315.0	20,CC	B																																															
	21-1, 77-78	B																																															
	21-2, 77-78	B																																															
	21-3, 77-78	B																																															
	21-4, 77-78	B																																															
	21-5, 77-78	B																																															
	21-6, 53-54	A	M	F																								F							F				F	A										
	21-6, 77-78	C	P																																					F											
324.5	21,CC	B																																															
	22-1, 51-52	B																																															
	22-2, 51-52	B																																															
	22-3, 61-62	A	P																									F							F				A				F						
	22-4, 61-62	B																																															
	22-5, 61-62	B																																															
	22-6, 61-62	B																																															
334.0	22,CC	C	P																																				F	R										
	23-1 Top	B																																															
	23-1, Cement	R	P																																											R				
	24-1, 83-84	A	G	F																				R			F							C		R			A					F					F	
	24-1, 149-150	A	M	F																							F							C		R	F			C					F					F	
	24-2, 10-11	A	M												R												F													C					F						
	24-2, 28-29	A	G	F											F									R			F							C			F	F		C					R						
	24-3, 22-23	B																																															
353.0	24,CC	B																																															
	25-1, 68-69	B																																															
	25-3, 68-69	B																																															
	25-5, 68-69	B																																															
362.5	25,CC	B																																															
	26-1, 28-29	B																																															
	26-3, 28-29	B																																															
	26-5, 28-29	B																																															
372.0	26,CC	B																																															
	27-1, 73-74	B																																															
	27-4, 73-74	B																																															
	27-6, 73-74	B																																															
381.5	27,CC	B																																															
	28-1, 59-60	B																																															
	28-3, 59-60	B																																															
	28-7, 59-60	B																																															

Table 2C. (Continued).

Discoaster kugleri	*Calcidiscus leptoporus*	*Discoaster loeblichii*	*Calcidiscus macintyrei*	*Triquetrorhabdulus milowii*	*Coccolithus miopelagicus*	*Umbilicosphaera mirabilis*	*Discolithina multipora*	*Discoaster musicus*	*Sphenolithus neoabies*	*Discoaster neohamatus*	*Discoaster neorectus*	*Coronocyclus nitescens*	*Cephyrocapsa oceanica*	*Coccolithus orangensis*	*Emiliania ovata*	*Discoaster pansus*	*Coccolithus pelagicus*	*Discoaster peniaradiatus*	*Hayaster perplexus*	*Pontosphaera plana*	*Discoaster prepentaradiatus*	*Amaurolithus primus*	*Reticulofenestra pseudoumbilica*	*Discoaster pseudovariabilis*	*Scyphosphaera pulcherima*	*Syracosphaera pulchra*	*Discoaster quadramus*	*Discoaster quinqueramus*	*Helicosphaera reticulata*	*Calcidiscus rotula*	*Ceratolithus rugosus*	*Triquetrorhabdulus rugosus*	*Pontosphaera scutellum*	*Helicosphaera sellii*	*Rhabdosphaera sicca*	*Discoaster stellulus*	*Aspidorhabdus styliferа*	*Discoaster surculus*	*Pontosphaera syracusana*	*Discoaster tamalis*	*Amaurolithus tricorniculatus*	*Discoaster trinidadensis*	*Discoaster variabilis*	*Micrantholithus vesper*	Zone (Ellis, 1982)	Zone (Okada and Bukry, 1980)	Zone (Martini, 1971)	Age
F		C		F			R									F						C							F																			
F		R R									R					C C						A C						F R															C F			middle Miocene
F R		F R		C			F R								C							C F	R																		C F	WPN21–WPN22b	CN4–CN5b	NN5–NN7	
				R							F					R						R																									
		F F		R R R	C C C F		R R				F F F F					C C C C	F F F			R R		A A A A												R						F	C C C C							
																																														Unzoned	Unzoned	Unzoned	Indeter-minate

Table 2D. Late Oligocene–late Eocene. Hole 530A (continued).

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	Cyclicargolithus abisectus	Nannotetrina alata	Markalius astroporus	Discoaster araneus	Discoaster barbadiensis	Chiasmolithus bidens	Braarudosphaera bigelowi	Zygrhablithus bijugatus	Discoaster binodosus	Reticulofenestra bisecta	Prinsius bisulcus	Tribrachiatus bramlettei	Ericsonia cava	Neochiastozygus chiastus	Sphenolithus ciperoensis	Helicosphaera compacta	Chiasmolithus consuetus	Tribrachiatus contortus	Coccolithus crassus	Toweius craticulus	Nannotetrina cristata	Chiasmolithus danicus	Discoaster deflandrei	Campylosphaera dela	Discoaster delicatus	Discoaster diastypus	Reticulofenestra dictyoda	Braarudosphaera discula	Sphenolithus distentus	Ellipsolithus distichus	Discoaster distinctus	Neococcolithites dubius	Toweius eminens	Coccolithus eopelagicus	Chiasmolithus expansus	Discoaster falcatus	Heliorthus fallax	Ericsonia fenestrata	Cyclicargolithus floridanus	Micrantholithus flos	Calcidiscus formosus	Scapholithus fossilis	Calcidiscus gammation	Reticulofenestra gartneri	Chiasmolithus gigas	Chiasmolithus grandis	Discoaster helianthus	Reticulofenestra hillae	Helicosphaera intermedia	Markalius inversus	Triquetrorhabdulus inversus	Fasciculithus involutus	Neochiastozygus junctus	Heliolithus kleinpellii	Discoasteroides kuepperi	Discoaster lodoensis
391.0	28,CC	B																																																									
	29-1, 97–98	B																																																									
	29-3, 97–98	B																																																									
	29-5, 97–98	B																																																									
400.5	29,CC	B																																																									
	30-1, 101–102	B																																																									
	30-3, 101–102	B																																																									
	30-6, 101–102	B																																																									
410.0	30,CC	B																																																									
	31-1, 71–72	B																																																									
	31-2, 87–88	C	P	F									C													R																																	
	31-3, 72–73	B																																																										
	31-5, 75–76	C	M	C						R			F													F																					R													
419.5	31,CC	B																																																									
	32-2, 77–78	B																																																									
	32-3, 77–78	B																																																									
429.0	32,CC	B																																																									
	33-1, 67–68	B																																																									
	33-3, 67–68	B																																																									
438.5	33,CC	B																																																									
	34-1, 41–42	B																																																									
	34-3, 61–62	B																																																									
	34-6, 14–15	C	M	C						R			F													F																F					F												
	34-6, 77–78	A	M	A									F					R								F											R										F					F							
448.0	34,CC	B																																																									
	35-1, 70–71	C	G	A								R								R						F						R					R																						
	33-2, 70–71	A	M	A						R	R		C							R						C						R					R																						
	35-3, 127–128	C	P	C						R			F													R											R																						
457.4	35,CC	B																																																									
	36-1, 5–6	B																																																									
467.0	36,CC	B																																																									
	37-1, 1–2	A	M	C						R	F		C					r								C				F		R					R																						
	37-1, 25–26	B																																																									
	37-1, 50–51	B																																																									
	37-1, 63–64	A	P	A						A			A													C						F																											
	37-1, 70–71	A	P	A						C			A													C						R																											
	37-1, 80–81	A	M	A						F	F		C													A						F		R			F																						
	37-1, 96–97	A	P	A						A	F		C													F						F		R			F														R								
	37-1, 115–116	A	P	A						C	F		C													C						R					F														R								
	37-1, 131–132	A	M	A						R	R		C													C						F					F														F								
	37-2, 1–2	A	P							A	F		C																	A		F					F						R																
	37-2, 8–9	R	P										R																																														
	37-2, 52–53	C	P										C													F				C							F							R															
	37-2, 81–82	A	P										C													R				A							F							C															
	37-2, 87–88	F	M										F																	R							R																						

[a] WPN13b
[b] WPN14a-14b
[c] CP15b
[d] CP16a-16b
[e] NP19-20
[f] NP21
[g] late Eocene–early Oligocene

Table 2D. (Continued).

Ellipsolithus macellus	*Coccolithus magnicrassus*	*Discoaster mediosus*	*Discoaster megastypus*	*Lanternithus minutus*	*Discoaster mirus*	*Discoaster mohleri*	*Sphenolithus moriformis*	*Discolithina multipora*	*Discoaster multiradiatus*	*Discoaster nobilis*	*Chiasmolithus oamaruensis*	*Discoaster okadai*	*Thoracosphaera operculata*	*Coccolithus orangensis*	*Tribrachiatus orthostylus*	*Coccolithus pelagicus*	*Blackites perlonga*	*Fasciculithus pileatus*	*Sphenolithus predistentus*	*Thoracosphaera prolata*	*Sphenolithus pseudoradians*	*Discolithina pulchra*	*Sphenolithus radians*	*Isthmolithus recurvus*	*Cyclagelosphaera reinhardtii*	*Helicosphaera reticulata*	*Heliolithus riedeli*	*Cyclolithina robusta*	*Biscutum romeinii*	*Braarudosphaera rosa*	*Discoaster saipanensis*	*Discoaster salisburgensis*	*Thoracosphaera saxea*	*Helicosphaera seminulum*	*Zygodiscus sigmoides*	*Bianholithus sparsus*	*Discoaster splendidus*	*Discoaster sublodoensis*	*Discoaster surculus*	*Nannotetrina swasticoides*	*Discoaster tanii*	*Discoaster tanii nodifer*	*Cruciplacolithus tenuis*	*Braarudosphaera turbinea*	*Fasciculithus tympaniformis*	*Reticulofenestra umbilica*	*Markalius variabilis*	*Micrantholithus vesper*	Zone (Ellis, 1982)	Zone (Okada and Bukry, 1980)	Zone (Martini, 1971)	Age
																																																	Unzoned	Unzoned	Unzoned	Indeterminate
																R								r																	R					f						
							R							R		R												R																				R				
																																																	WPN17b	CP19b	NP25	
							F	R								F			R																																late Oligocene
							F									C												R																								
																												R																								
													R			F																															R				
							F									F			R																																
																																																	WPN17a	CP19a	NP24	
																C					C										r										F					f						
											R					C					C																									R						
																C					F																				F					C						
													R			C					C																				F	R				C						
													R			C					F			R																	F	R				F						
																C					C			R																	F	R				F			WPN14c, 15, 16	CP16c, 17, 18	NP22–23	early Oligocene
													R			C			F		C																				F	R				F						
													R			C			F		C			R																						F						
																F																									F					C						
																F								R																	F	F				C			b	d	f	g
																R								R							R										R					F			a	c	e	

Table 2E. Middle Eocene–late Paleocene. Hole 530A (continued).

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Cyclicargolithus abisectus*	*Nannoteirina alata*	*Markalius astroporus*	*Discoaster araneus*	*Discoaster barbadiensis*	*Chiasmolithus bidens*	*Braarudosphaera bigelowi*	*Zygrhablithus bijugatus*	*Discoaster binodosus*	*Reticulofenestra bisecta*	*Prinsius bisulcus*	*Tribrachiatus bramlettei*	*Ericsonia cava*	*Neochiastozygus chiastus*	*Sphenolithus ciperoensis*	*Helicosphaera compacta*	*Chiasmolithus consuetus*	*Tribrachiatus contortus*	*Coccolithus crassus*	*Toweius craticulus*	*Nannoteirina cristata*	*Chiasmolithus danicus*	*Discoaster deflandrei*	*Campylosphaera dela*	*Discoaster delicatus*	*Discoaster diastypus*	*Reticulofenestra dictyoda*	*Braarudosphaera discula*	*Sphenolithus distentus*	*Ellipsolithus distichus*	*Discoaster distinctus*	*Neococcolithites dubius*	*Toweius eminens*	*Coccolithus eopelagicus*	*Chiasmolithus expansus*	*Discoaster falcatus*	*Heliorthus fallax*	*Ericsonia fenestrata*	*Cyclicargolithus floridanus*	*Micrantholithus flos*	*Calcidiscus formosus*	*Scapholithus fossilis*	*Calcidiscus gammation*	*Reticulofenestra gartneri*	*Chiasmolithus gigas*	*Chiasmolithus grandis*	*Discoaster helianthus*	*Reticulofenestra hillae*	*Helicosphaera intermedia*	*Markalius inversus*	*Triquetrorhabdulus inversus*	*Fasciculithus involutus*	*Neochiastozygus junctus*
	37-2, 105–106	C	M		R			F		R			C						R						R			C						R															
	37-2, 148–149	B																																																	
	37-3, 15–16	C	P		F			F											F									C																							
	37-3, 25–30	A	P		R			C																																				F	C						
	37-3, 40–41	R	P																																									R							
476.5	37,CC	C	P		R			C			F								F																															F		
	38-1, 39–40	F	P					F											R																R																
	38-1, 74–75	C	P							R	C								F									F	F					F							F										
	38-1, 86–87	B																																																	
	38-1, 134–135	B																																																	
	38-2, 1–2	A	P								C																															F								
	38-2, 50–51	B																																																	
	38-2, 105–106	B																																																	
	38-2, 133–134	F	P					F																																											
486.0	38,CC	C	P					C																																											
	39-1, 8–9	C	P					F											F								R																R	R							
	39-1, 48–49	C	P					F																																											
	39-1, 85–86	A	P					C											F																																
	39-1, 110–111	C	P					C																																						R						
	39-2, 5–6	B																																																	
	39-2, 19–20	C	P					C			C																																		F		F					
	39-2, 42–43	A	P					C			F																																								
	39-2, 80–81	C	P					C			F																																			R						
	39-2, 120–121	A	P					C																																						F		F					
495.5	39,CC	C	P					F																																												
	40-1, 10–11	B																																																	
	40-1, 75–76	C	P					C			F																																								
	40-1, 140–141	C	P																																																
	40-2, 13–14	B																																																	
	40-2, 80–81	A	P					C			F																																	R							
	40-2, 140–141	A	P					A																																											
	40-3, 8–9	A	P			F		C																																											
	40-3, 68–69	A	P					C													F																								F							
	40-3, 122–123	A	P								C			A	R																																				
	40-4, 9–10	A	P						F	R	F			A															C																						
	40-4, 72–73	A	P						R					A							F									F																						
	40-4, 92–93	A	P						R					A																	F																					
505.0	40,CC	A	P											A	R						R																																
	41-1, 33–34	A	P							R				A																																						
	41-1, 75–76	A	P											A	R						R																																
	41-1, 90–91	B																																																	
	41-1, 141–142	C	P											R									C														R														
	41-2, 10–11	A	P											C									F														C														
	41-2, 70–71	A	P											C									F														F														
	41-2, 110–111	A	P											C									F														C														

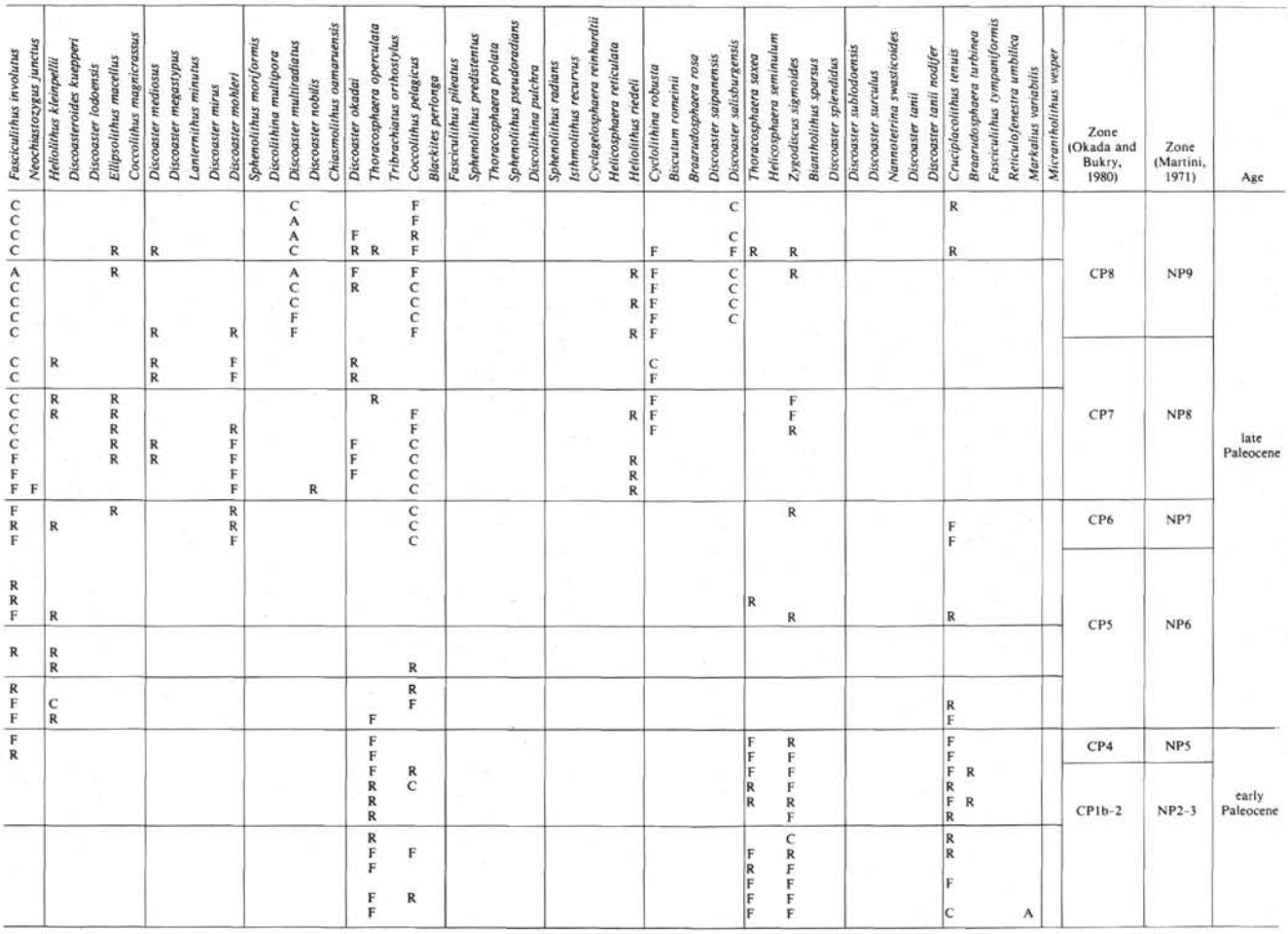
Table 2E. (Continued).

Heliolithus kleinpellii	*Discoasteroides kuepperi*	*Discoaster lodoensis*	*Ellipsolithus macellus*	*Coccolithus magnicrassus*	*Discoaster mediosus*	*Discoaster megastypus*	*Lanternithus minutus*	*Discoaster mirus*	*Discoaster mohleri*	*Sphenolithus moriformis*	*Discolithina multipora*	*Discoaster multiradiatus*	*Discoaster nobilis*	*Chiasmolithus oamaruensis*	*Discoaster okadai*	*Thoracosphaera operculata*	*Tribrachiatus orthostylus*	*Coccolithus pelagicus*	*Blackites perlonga*	*Fasciculithus pileatus*	*Sphenolithus predistentus*	*Thoracosphaera prolata*	*Sphenolithus pseudoradians*	*Discolithina pulchra*	*Sphenolithus radians*	*Isthmolithus recurvus*	*Cyclagelosphaera reinhardtii*	*Helicosphaera reticulata*	*Heliolithus riedeli*	*Cyclolithella robusta*	*Biscutum romeinii*	*Braarudosphaera rosa*	*Discoaster saipanensis*	*Discoaster salisburgensis*	*Thoracosphaera saxea*	*Helicosphaera seminulum*	*Zygodiscus sigmoides*	*Bianthalithus sparsus*	*Discoaster splendidus*	*Discoaster sublodoensis*	*Discoaster surculus*	*Nannotetrina swasticoides*	*Discoaster tanii*	*Discoaster tanii nodifer*	*Cruciplacolithus tenuis*	*Braarudosphaera turbinea*	*Fasciculithus tympaniformis*	*Reticulofenestra umbilica*	*Markalius variabilis*	*Micrantholithus vesper*	Zone (Ellis, 1982)	Zone (Okada and Bukry, 1980)	Zone (Martini, 1971)	Age
																																											R					F			WPN12a	CP13/14	NP16	middle Eocene
																																																F			(no zonation published)	CP13b	NP15	
		F																A																																				
																		C							F																	R						R						
																		R																								R										CP12	NP14	
																		C							R															C		R												
		C														F		C							F															C														
	R	F																																																		CP11	NP13	early Eocene
		C																F																																				
	R	C														F		F																																				
		C																																																				
								F										C							C																													
		C										R						C																																				
		C										R					F	C							C																											CP10	NP12	
		A																							C																													
		F															R	F							F																													
		A															C	C							F																													
		C										R				F	F	C							F																													
		C																																																				
		C															C	F							F																													
																	C																																					
		C															C	C							C																													
																	A	A							C																													
																F	C	U							C																													
																	C	C							C																													
		R										R	F			F	A	C							C									A																					
												F	F				C	C																C																				CP9	NP10-11	
												A	F					C				R												C																				
												C						C																C																				
												C				F	R	C				R												C																				
												C	R					C																C																				
												C	R					C																C																				
			R									C	F					R																R																			CP8	NP9	late Paleocene
												A	F					C																F																				
			R									A	F					P																F																				
												A	F					C																F																				

Table 2F. Late Paleocene–early Paleocene. Hole 530A (Continued).

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Cyclicargolithus abisectus*	*Nannotetrina alata*	*Markalius astroporus*	*Discoaster araneus*	*Discoaster barbadiensis*	*Chiasmolithus bidens*	*Braarudosphaera bigelowi*	*Zygrhablithus bijugatus*	*Discoaster binodosus*	*Reticulofenestra bisecta*	*Prinsius bisulcus*	*Tribrachiatus bramlettei*	*Heliolithus cantabriae*	*Ericsonia cava*	*Neochiastozygus chiastus*	*Sphenolithus ciperoensis*	*Helicosphaera compacta*	*Chiasmolithus consuetus*	*Tribrachiatus contortus*	*Coccolithus crassus*	*Toweius craticulus*	*Nannotetrina cristata*	*Chiasmolithus danicus*	*Discoaster deflandrei*	*Campylosphaera dela*	*Discoaster delicatus*	*Discoaster diastypus*	*Reticulofenestra dictyoda*	*Braarudosphaera discula*	*Sphenolithus distentus*	*Ellipsolithus distichus*	*Discoaster distinctus*	*Neococcolithites dubius*	*Cruciplacolithus edwardsii*	*Toweius eminens*	*Coccolithus eopelagicus*	*Chiasmolithus expansus*	*Discoaster falcatus*	*Heliorthus fallax*	*Ericsonia fenestrata*	*Cyclicargolithus floridanus*	*Micrantholithus flos*	*Calcidiscus formosus*	*Scapholithus fossilis*	*Calcidiscus gammation*	*Reticulofenestra gartneri*	*Chiasmolithus gigas*	*Chiasmolithus grandis*	*Discoaster helianthus*	*Reticulofenestra hillae*	*Helicosphaera intermedia*	*Markalius inversus*	*Triquetrorhabdulus inversus*
	41-3, 8-9	A	P											C																								C																		
	41-3, 80-81	A	P						F					C																								C	R																	
	41-3, 140-141	A	M						R					C				R																				C																		
514.5	41,CC	A	M						R	R				F																								C	R																	
	42-1, 17-18	A	P						F					F																				R				C																		
	42-1, 61-62	A	P						F					F																								C			R															
	42-1, 140-141	A	P						F					C																R								C			R															
	42-2, 20-21	A	P						R					A										F														C			R															
	42-2, 63-64	A	P						R					A										C														C			R															
	42-2, 140-141	B																																																						
	42-3, 10-11	A	P						R					A										C																	F											R				
524.0	42,CC	A	P						R					A										C														C			F											R				
	43-1, 14-15	A	M									F		A				R						C														C														F				
	43-1, 57-58	C	P									F		A										C														C														F				
	43-1, 110-111	A	P									F		A							F																	C														F				
	43-2, 20-21	A	M											C										C														C														F				
	43-2, 76-77	A	M						F					A				R			R			C										R				F																		
	43-2, 122-123	A	P						F					A							R			F																																
533.5	43,CC	C	P						F					C				R			R			F																																
	44-1, 19-20	A	P											A				R						R																																
	44-1, 69-70	A	P											A				R			R																	F																		
	44-1, 113-114	A	M											C							R			F														F																		
	44-1, 129-130	B																																																					
	44-2, 15-16	B																																																						
	44-2, 75-76	R	P											R																																										
	44-2, 115-116	R	P																																																					
543.0	44,CC	C	P											C				R			R			F																																
	45-1, 43-44	B																																																						
	45-1, 57-58	R	P											R			R																																							
552.5	45,CC	R	P											R																																										
	46-1, 34-35	R	P																					R																																
	46-1, 50-51	A	P														C																					R																		
562.0	46,CC	C	P											C			C							F														R																		
	47-1, 18-19	A	P													F	A							C																																
	47-1, 70-71	A	M														A				R			C		R											R																			
	47-1, 143-144	A	P														A									R											R																			
	47-2, 25-26	A	P														A																				R																			
	47-2, 75-76	C	P														C																				R																			
571.5	47,CC	F	P			R											F																				R																			
	48-1, 40-41	A	P														C																				F																			
	48-1, 79-80	C	P														F																				R																		R	
	48-1, 127-128	A	P														A																				F																			
	48-2, 1-2	A	P														A																				F																			
	48-2, 43-44	A	P														A																				F																		F	
581.0	48,CC	A	P														A																				F																		F	

Table 2F. (Continued).



2G. Early Paleocene. Hole 530A (Continued).

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Markalius astroporus*	*Ericsonia cava*	*Thoracosphaera operculata*	*Coccolithus pelagicus*	*Cruciplacolithus primus*	*Biscutum romeinii*	*Thoracosphaera saxea*	*Zygodiscus sigmoides*	*Biantholithus sparsus*	*Cruciplacolithus tenuis*	Zone (Okada and Bukry, 1980)	Zone (Martini, 1971)	Age
	49-1, 30-32	A	P	R		C					F			CP1b	NP2	
	49-1, 45-46	A	P	R	A	C				F	F		C			
	49-1, 73-74	A	P		A						F		C			
	49-1, 136-137	A	P		A						F		F			
	49-2, 40-41	B														
590.5	49,CC	A	P	F	A	F				F	F		F			
	50-1, 6-7	C	P	R		C	R	R		R	R	R	R			
	50-1, 11-12	F	P			R					R	R	R			
	50-1, 16-17	A	M		R	C				R	R		R			
	50-1, 30-31	A	P	F		C					R			CP1a	NP1	Early Paleocene
	50-1, 33-34	C	P	R		C				R	R					
	50-1, 47-48	F	M	R		F				R	R	R				
	50-1, 49-50	F	P	R	R	F										
	50-1, 60-61	F	P	R					R							
	50-1, 67-68	F	P						R							
	50-1, 69-70	R	P													
	50-1, 78-79	F	P						R							
	50-1, 82-83	B														
	50-1, 90-91	B														
	50-1, 101-102	B														
	50-1, 110-111	C	P			R					R					
	50-1, 122-123	F	P			R			R	R						
	50-1, 124-125	F	P			R										
	50-1, 130-131	F	M													
	50-1, 134-135	C	P						R							
	50-1, 136-137	F	P						R							
	50-1, 141-142	C	P								R					
	50-2, 3-4	C	M			R			R		R					
	50-2, 13-14	C	M			R			R	F	R	R				
	50-2, 22-23	A	M	R					R	R	R	R				
	50-2, 28-29	A	P							R						
	50-2, 31-32	A	P													
	50-2, 37-38	A	P													
	50-2, 49-50	A	P													
	50-2, 52-53	A	P													
	50-2, 62-63	A	P													
	50-2, 95-96	A	P													
	50-2, 123-124	A	P													
	50-2, 145-146	A	P													
	50-3, 50-51	A	P													
	50-3, 94-95	A	P											*Micula mura*	*Micula mura*	late Maestrichtian
	50-3, 132-133	A	P													
	50-4, 7-8	A	P													
	50-4, 17-18	A	P													
	50-4, 24-25	A	P													

Note: The following species were not found: *Cyclicargolithus abisectus, Biantholithus astralis, Discoaster araneus, Discoaster barbadiensis, Chiasmolithus bidens, Braarudosphaera bigelowi, Zygrhablithus bijugatus, Discoaster binodosus, Reticulofenestra bisecta, Prinsius bisulcus, Tribrachiatus bramlettei, Neochiastozygus chiastus, Sphenolithus ciperoensis, Helicosphaera compacta, Chiasmolithus consuetus, Tribrachiatus contortus, Coccolithus crassus, Toweius craticulus, Nannotetrina cristata, Chiasmolithus danicus, Discoaster deflandrei, Campylosphaera dela, Discoaster delicatus, Discoaster diastypus, Reticulofenestra dictyoda, Braarudosphaera discula, Sphenolithus distentus, Ellipsolithus distichus, Discoaster distinctus, Neococcolithites dubius, Toweius eminens, Coccolithus eopelagicus, Chiasmolithus expansus, Discoaster falcatus, Heliorthus fallax, Ericsonia fenestrata, Cyclicargolithus floridanus, Micrantholithus flos, Calcidiscus formosus, Scapholithus fossilis, Cyclococcolithus gammation, Calcidiscus gammation, Chiasmolithus gigas, Chiasmolithus grandis, Discoaster helianthus, Reticulofenestra hillae, Helicosphaera intermedia, Markalius inversus, Triquetrorhabdulus inversus, Fasciculithus involutus, Neochiastozygus junctus, Heliolithus kleinpellii, Discoaster kuepperi, Discoaster lodoensis, Ellipsolithus macellus, Coccolithus magnicrassus, Discoaster mediosus, Discoaster megastypus, Lanternithus minutus, Discoaster mirus, Discoaster mohleri, Sphenolithus moriformis, Discolithina multipora, Discoaster multiradiatus, Discoaster nobilis, Chiasmolithus oamaruensis, Discoaster okadai, Tribrachiatus orthostylus, Blackites perlonga, Fasciculithus pileatus, Sphenolithus predistentus, Thoracosphaera prolata, Sphenolithus pseudoradians, Discolithina pulchra, Sphenolithus radians, Isthmolithus recurvus, Cyclagelosphaera reinhardtii, Helicosphaera reticulata, Heliolithus riedeli, Cyclolithina robusta, Braarudosphaera rosa, Discoaster saipanensis, Discoaster salisburgensis, Helicosphaera seminulum, Discoaster splendidus, Discoaster subladoensis, Discoaster surculus, Nannotetrina swasticoidea, Discoaster tanii, Discoaster tanii nodifer, Braarudosphaera turbinea, Fasciculithus tympaniformis, Reticulofenestra umbilica, Markalius variabilis, Micrantholithus vesper.*

Table 2H. Tertiary/Cretaceous boundary. Hole 530A (Continued).

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	Tertiary species: *Markalius astroporus*	*Ericsonia cava*	*Coccolithus pelagicus*	*Biscutum romeinii*	*Thoracosphaera saxea*	*Zygodiscus sigmoides*	*Bianthholithus sparsus*	*Cruciplacolithus tenuis*	Cretaceous species: *Markalius inversus*	*Ceratolithoides kampineri*	*Reinhardtites levis*	*Chiastozygus litterarius*	*Micula murus*	*Ahmuellerella octoradiata*	*Micula prinsii*	*Quadrum quadratum*	*Prediscosphaera spinosa*	*Zygodiscus spiralis*	*Micula staurophora*	*Microrhabdulus stradneri*	*Eiffellithus turriseiffeli*	Zone (Okada and Bukry, 1980)	Zone (Martini, 1979)	Age
	49-1, 30-32	A	P	R					F																		
	49-1, 45-46	A	P	R	A			F	F		C					R								R	CP1b	NP2	
	49-1, 73-74	A	P		A				F		C					R											
	49-1, 136-137	A	P		A				F		F																
	49-2, 40-41	B																									
590.5	49,CC	A	P	F	A			F	F		F											F					
	50-1, 6-7	C	P	R			R	R	R	R	R										R	F					
	50-1, 11-12	F	P						R	R	R					R	R					F					
	50-1, 16-17	A	M		R			R	R		R					F					R	C		R			
	50-1, 30-31	A	P	F					R							R						C					
	50-1, 33-34	C	P	R				R	R							R					R	F					
	50-1, 47-48	F	M	R				R	R	R											R	F					
	50-1, 49-50	F	P	R	R																	R					
	50-1, 60-61	F	P	R			R															R					
	50-1, 67-68	F	P				R											R		R		F					Early Paleo-cene, Danian
	50-1, 69-70	R	P																			R					
	50-1, 78-79	F	P				R					R								R		F					
	50-1, 82-83	B																									
	50-1, 90-91	B																									
	50-1, 101-102	B																							CP1a	NP1	
	50-1, 110-111	C	P						R																		
	50-1, 122-123	F	P				R	R								R			R			C					
	50-1, 124-125	F	P													R						F					
	50-1, 130-131	F	M													R						F					
	50-1, 134-135	C	P				R						R					R				F		R			
	50-1, 136-137	F	P				R															C					
	50-1, 141-142	C	P						R							R		R									
592.0	50-2, 3-4	C	M				R		R			R	R								R	C					
	50-2, 13-14	C	M				R	F	R	R		R	R					R			R	C	R				
	50-2, 22-23	A	M	R			R	R	R	R		R				R					R	C		R			
	50-2, 28-29	A	P					R					R		F	F	R				F	A	R	R			
	50-2, 31-32	A	P									R			R				R			A	R				
	50-2, 37-38	A	P											F		R				F	R	A					
	50-2, 49-50	A	P													F					R	A	R	R			
	50-2, 52-53	A	P													F		R				A					
	50-2, 62-63	A	P									R						R		R		A					
	50-2, 95-96	A	P													F						R					
	50-2, 123-124	A	P													F				R		A			*Micula mura*	*Micula mura*	late Maes-trichtian
	50-2, 145-146	A	P															R	F	R		A					
594.0	50-3, 50-51	A	P													R			R			A					
	50-3, 94-95	A	P													R			R		R	A					
	50-3, 132-133	A	P													R						A					
595.5	50-4, 7-8	A	P													R						C					
	50-4, 17-18	A	P													F					R	A					
	50-4, 24-25	A	P													F						A					
	50-4, 54-55	A	P													R						A					

Table 3. Distribution of Holocene–late Miocene calcareous nannofossils, Hole 530B.

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Sphenolithus abies*	*Emiliania annula*	*Discoaster asymmetricus*	*Sphenolithus belemnos*	*Discoaster berggrenii*	*Braarudosphaera bigelowi*	*Discoaster braarudii*	*Discoaster brouweri*	*Discoaster calcaris*	*Gephyrocapsa caribbeanica*	*Coccolithus carteri*	*Helicosphaera carteri*	*Discoaster challengeri*	*Rhabdosphaera clavigera*	*Ceratolithus cristatus*	*Discoaster decorus*	*Discoaster deflandrei*	*Amaurolithus delicatus*	*Discolithina discopora*	*Crenalithus doronicoides*	*Discoaster exilis*	*Thoracosphaera heimii*	*Emiliania huxleyi*	*Discolithina japonica*	*Discoaster kugleri*	*Calcidiscus leptoporus*	*Calcidiscus macintyrei*
	1-1, 37–38	A	M										F	F	F		F					C			F	R		C	
	1-2, 37–38	A	M										C	C	F						F	C				F			C	
2.4	1,CC	A	M										C	C	F		R					C		F	F				F	
2.5	2-1, 10–11	A	M										C	C	F		R				F	C			C				C	
	2-2, 113–114	A	M										C	C	F							C							C	
6.8	2,CC	A	M										C	C	F		R				F	C							C	
11.2	3,CC	A	M										C	C	F						F	C							F	
15.6	4,CC	A	M										C	C	F							A							F	
23.4	6,CC	A	M										C	F	F							A							F	
23.45	7-1, 55–56	A	M										C	F	F							A							F	
27.8	7,CC	A	M						R				C	F	F							F	A						F	
	8-3, 14–15	A	M										C	F	F								C						F	
32.2	8,CC	A	M					r					C	F	F								C						F	
36.6	9,CC	A	M										C	F	F							F	A						F	
41.0	10,CC	C	M										C	F	F								F						F	
45.4	11,CC	C	M										F	F	F					r			F						F	R
49.8	12,CC	C	P										C	F	F					r									F	R
54.2	13,CC	A	M										C	F	F							F	F				F		C	R
58.2	14,CC	C	M										F	F	F								F				F		F	F
63.0	15,CC	R	P																				F							
67.4	16,CC	F	M										F	F	F								F						F	F
71.8	17,CC	B																												
76.2	18,CC	C	M										F	F	F								F				F		F	F
80.6	19,CC	C	P											F	R								F						F	F
85.0	20,CC	C	M											F	F							F	C				F		F	F
88.0	21,CC	C	M		F									F	F							F	F						F	F
92.4	22,CC	R	P																				R							R
96.8	23,CC	F	P											F									F						F	F
99.6	24,CC	R	P																										R	R
102.9	25,CC	C	M		F									F	F							F	F						F	F
107.2	26,CC	R	P																				R							
110.2	27,CC	C	M		F									F	F		R						A				F		F	F
113.2	28,CC	C	M		F									F	F								A				F		F	F
116.2	29,CC	A	M							F	F			F	F			R				F	A						F	F
118.2	30,CC	A	M	R							F			F	F							F	A						F	F
122.6	31,CC	A	M	R	F				R	F	F			C	F							F	A					F	F	F
127.0	32,CC	A	M	F							F	R			F						R	F	A	F					F	R
131.9	33,CC	A	M			R					F			C	F							F	F					F	F	C
134.9	34,CC	A	M	F		R					F			C	F						R		F					R	F	F
138.9	35,CC	C	M	R		R								C	F							F	F	F				F	F	F
142.2	36,CC	A	M	F		F				F	F			C	F								F	F					F	F
145.2	37,CC	A	M	F		F			R		F				F								F	F					F	F
149.2	38,CC	A	M	F		F					F				F						R		F					F	F	F
153.0	39,CC	A	M	F		F					F			F	F			R			R		F					R	F	C
154.0	40,CC	A	M	F		F					F				F								F	F					F	F
158.0	41,CC	C	M								F				F								F					F	F	C
163.0	43,CC	C	M								R			F	F								F						F	C
167.4	44,CC	A	M	F							F			R	F									F					F	C
170.8	45,CC	A	M	R		R		R	R		F			F	F	R								F				R	F	F
174.2	46,CC	A	M	F					R	R	F			F	F						R			F				F	F	F
177.6	47,CC	A	M	F				R			F			F	F	R			R					F					F	F
180.6	48,CC	A	M	F		R					F			F	F													F	F	F

Note: Abundance: A = abundant; C = common; F = few; R = rare; B = barren; lower case letter = reworked older fossils. Preservation: G = good; M = moderate; P = poor.

Table 3. (Continued).

Coronocyclus nitescens	*Gephyrocapsa oceanica*	*Emiliania ovata*	*Coccolithus pelagicus*	*Discoaster pentaradiatus*	*Reticulofenestra pseudoumbilica*	*Discoaster pseudovariabilis*	*Syracosphaera pulchra*	*Discoaster quinqueramus*	*Ceratolithus rugosus*	*Thoracosphaera saxea*	*Pontosphaera scutellum*	*Helicosphaera sellii*	*Umbilicosphaera sibogae*	*Aspidorhabdus stylifera*	*Discoaster surculus*	*Discoaster tamalis*	*Amaurolithus tricorniculatus*	*Discoaster trinidadensis*	*Discoaster variabilis*	*Micrantholithus vesper*	*Scyphosphaera* sp.	Zone (Ellis 1982)	Zone (Okada and Bukry, 1980)	Zone (Martini, 1971)	Age
		F	F				F			R			F									WPN32	CN15	NN21	Holocene
		A	C										F												
		A	C				F				F		F												
		A	C										F												
		A	C																			WPN31b	CN14b	NN20	
		A	C							F															
		C	F							F															
		C	F									F													
	R	A	F				R				R	F													late Pleistocene
	F	C	F																						
	F	C	F		R													r							
	F	A	F		R					R	R											WPN31a	CN14a		
	F	C	F																						
	F	C	F		F					R															
	F	C	F																						
	F	A	F		F						F														
	F		F		F																				
			F																			WPN30b	CN13b	NN19	early Pleistocene
			F		F					R		R													
	F		F				F																		
R	F		F				F					F													
	F		F		F							F													
			F		F																	WPN30a	CN13a		
												F													
	F		F				F					F													
	F		F									F													
	F		F									F													
R			C									F						R		R					
R			C		F										R	R		R							
			C		F	R						F						R							
R			C	F	A					R						F			F						
			C		F				R			F				R	F								
R			C	R	C					R		R		R	R	R			F						
	R		C	F	C							R				R			F			WPN28b	CN11b	NN15	
R			C	R	C					R		F							F	r					early Pliocene
			F	F	C														F						
			F	F	C											F			F						
R			C	F	F									R	F	F									
R			C	F	F											F	R		F						
			F	R	C											F			F						
R			F	R	C											R			R			WPN28a	CN11a		
R			F	F	C		R							R	F				F						
			F	R	C			R								R		F	F						
			F	F	C			R				R				F		R	R			WPN26b	CN9b	NN11	late Miocene
			F	R	C			F				F							R						
			F	R	C											F		R	F						

Table 4. Distribution of Holocene–late Miocene calcareous nannofossils, Holes 532, 532B.

Sub-bottom depth (m)	Core-Section (interval in cm)	Abundance	Preservation	*Sphenolithus abies*	*Amaurolithus amplificus*	*Emiliania annula*	*Discoaster asymmetricus*	*Discoaster barbadiensis*	*Braarudosphaera bigelowi*	*Discoaster blackstockae*	*Discoaster brouweri*	*Gephyrocapsa caribbeanica*	*Coccolithus carteri*	*Helicosphaera carteri*	*Discoaster challengeri*	*Rhabdosphaera clavigera*	*Ceratolithus cristatus*	*Discoaster decorus*	*Discoaster deflandrei*	*Trochoaster deflandrei*	*Amaurolithus delicatus*	*Discolithina discopora*	*Crenalithus doronicoides*	*Discoaster druggii*	*Discoaster exilis*	*Cyclicargolithus floridanus*	*Thoracosphaera heimii*	*Emiliania huxleyi*	*Discolithina japonica*	*Discoaster kugleri*	*Calcidiscus leptoporus*	*Calcidiscus macintyrei*	*Sphenolithus moriformis*	*Discolithina multipora*	*Coronocyclus nitescens*	*Gephyrocapsa oceanica*	*Emiliania ovata*	*Discoaster pansus*	*Coccolithus pelagicus*	*Discoaster pentaradiatus*	*Amaurolithus primus*	*Reticulofenestra pseudoumbilica*	*Discoaster pseudovariabilis*	*Syracosphaera pulchra*	*Discoaster quinqueramus*	*Triquetrorhabdulus rugosus*	*Thoracosphaera saxea*	*Pontosphaera scutellum*	*Helicosphaera sellii*	*Umbilicosphaera sibogae*	*Aspidorhabdus stylifera*	*Discoaster surculus*	*Discoaster tamalis*	*Amaurolithus tricorniculatus*	*Discoaster variabilis*	Zone (Ellis, 1982)	Zone (Okada and Bukry, 1980)	Zone (Martini, 1971)	Age
	Hole 532																																																										
	1-1, 12-13	C	G									C	F	F									C				R	C			F					C			F																	WPN32	CN15	NN21	Holocene
2.1	1-2, 63-64	A	G									C	F	F									C					C			F					C			F											F									
	1-3, 65-66	A	G									C	F										C								F					C			F											F									
4.0	1,CC	A	G									A	F	F								F	A						F		F					C			F					F			R			F	R								
8.4	2,CC	A	G			R						C	C	F									C						R		F					C			C									R		R									
12.8	3,CC	A	G									A	C	F									A								F					F			C								R			R					R	WPN31b	CN14b	NN20	
17.2	4,CC	A	G									A	C	F									A								F					F			C								R			R									
	5-2, 68-69	A	M									A	C	F								F	A								F					F			C			R								R									
20.8	5-3, 59-60	A	G									A	C	F								F	A								F					C			C											R									
21.6	5,CC	A	G									A	C	F								F	A						R		F					C	F		C											R									late Pleistocene
26.0	6,CC	A	G									A	C	F								F	A						R		F	R				A	C		C											R	R								
30.4	7,CC	A	M			F						F	C	F								F	A				R		R		F	R				F	C		C			F		R							R								
34.8	8,CC	A	M									F		F								F	C						R		F	R					C					R					R									WPN31a	CN14a		
39.2	9,CC	A	G									C	C	F								F	A						F		F	F				C	C		C					R					F										
43.6	10,CC	A	M									C	C	F								F	C						F		F	R				C	C		C										R						R				
48.0	11,CC	A	G									C	C	F								F	A						F		F	F				F	C		C								R		F									NN19	
52.4	12,CC	C	M			F							F	F								F	C						F		F	F					C		F					R					F			R			R				
56.8	13,CC	A	G									C	C	F								F	A						F		F	F					A		C								R		F							WPN30b	CN13b		early Pleistocene
61.2	14,CC	A	G									C	C	F								F	A						F		F	F					A		C					R					F										
65.6	15,CC	A	M									F	C	F									A								F	F					A		C					R					F										
70.0	16,CC	C	M										F	F									C								F	F					C		F			R					R		F							WPN30a	CN13a		
74.4	17,CC	A	M			F							C										C								F	F					F		C			F					R												
	18-1, 125-126	A	M								R		C	F								R	C						R		F	F					F		C										F										
	18-2, 125-126	A	M								F		C	F									A								F	F					C		C										F							WPN29c–29d	CN12c–12d	NN17–18	
78.6	18-3, 121-122	A	M								R		C	F									A								F	F					C		C										F										
78.8	18,CC	A	M						R		R		C	F									A								F	F					C		C	R									F			R							
83.2	19,CC	A	M								F	F	C	R									A								F	F					A		C										R						R				
87.6	20,CC	A	M								R		C	R									A									F	r				A		C										F							WPN29b	CN12b		
92.0	21,CC	A	M								R		C	R								R	A						R		F	F			R		C		C												R								
	22-2, 81-82	A	G								R		F	F									C								F	F					F		C			F																
95.8	22-3, 80-81	C	G								R		F	R					R				C								F	F					R		C			C							R										
96.4	22,CC	A	M								F		C	F					R				A							R	F	F					C		C			F							F			F	R						
100.8	23,CC	A	M				R				F		C	F			R	F	R				A								F	F			R		C		C	R		C					R		F			R	R						
105.2	24,CC	C	M			R					R		F	R					R				C								F	F					C		C	R		F					R								R				
109.6	25,CC	A	M				R				F		F	F					R				A								F	F					F		C										F			R	R			WPN29a	CN12a		
114.0	26,CC	A	M				R		R		F		F	F			R						A						R		F	F					F		C			C		R					R						R				late Pliocene
117.4	27,CC	A	M				F				F		F	F									A								F	F					F		C			C							F			R	R		R			NN16	
120.8	28,CC	A	M				F		R		F		F	F					R				C								F	F					C		C			C							F				R		R				

Table 4. (Continued).

124.4	29,CC	A	M			R		r	R		F		C	R				R	R				A								F	C					F		C			C					R		R						R				
127.4	30,CC	A	M				R		R		F		F	F				F					A								F	C					F		C			C					R					R	R		R				
131.8	31,CC	A	M				R				F		F	F					R				A								F	F					R		C			C										R	F		F				
135.2	32,CC	A	M				R				F		C	F				F	R				A								C	C							C			C										R	F		R				
139.2	33,CC	A	G				R		R		F		C	F				F					A						R	R	C	C					F		C										F			R	R			WPN29a	CN12a		
142.6	34,CC	A	G				F				F		C	F				F				R	A								C	C							C										F			R	R						
146.6	35,CC	A	M				R						C	F				F				R	A								C	C							C			F						R	F			R			R				
	36-1, 37-38	A	M										F	F									A								F	F							F			C																	
149.1	36-2, 107-108	A	M								F		F	F									A								F	F			F				F			F						R	F				R						
150.6	36,CC	A	G	R			R				F		F	F									A								F	F			F				F			F										R	R		R	WPN28b			
153.8	37,CC	A	G				R				F		F	F				F	R				A								F	F			F			R	C			F							F		R	R							
156.8	38,CC	A	G	R							F		F	F				F				R	A								F	C			F				C			C							F			R			R				
160.8	39,CC	A	M	R									F	F									A								F	F			F				C			C							F			R							
165.2	40,CC	A	M								R		C	F									A	r		r			R		F	F							C			C						R	F						R				
169.6	41,CC	A	M	F							F		C	F				F					A						R		F	F			F		F	R	F	R		A					R					R							
174.0	42,CC	C	M	F							F		F	F			R	R	R				C						R		F	C			F				F			A						R							R				
178.4	43,CC	C	M	F							F		F	F								R	C								F	F			F			R	F			C							R			R			R				
182.8	44,CC	C	M	F							F		F	F								F	C								F	F			F			R	F			C										R			R				
186.8	45,CC	C	M	F							F		F	F									C								F	F					F		F			C													R				
191.2	46,CC	A	G	F							F		F	F					R			R	C								F	F			F			R	F	R		A					R					F			F				
195.6	47,CC	A	G	F									F	F									A							F	F	F			F			F	F	R		A	R						R			F			F				
	48-1, 106-107	A	M	F							F		F	F									A								F	F							F	R		C						R											
	48-3, 68-69	A	M	F							F		F	F								R	C								F	F							F			C						R				F				WPN27a-28a	CN10a-11b	NN12-15	early Pliocene
199.6	48,CC	A	G	F							F		F	F							R	R	C						R	F	F	F							F	R		C							R			F		R	R				
203.6	49,CC	A	M	F							F		F	F							R		C								F	F							F	R		A										F			F				
207.6	50,CC	A	M	F							F			F							R		F								F	F							F	F		A										F		R	F				
211.6	51,CC	A	M	F					R		F			F									C							F	F	F							F			A										F		R	F				
216.0	52,CC	A	M	F							F		F	F					F				C								F	F							F	F		A										F		R	F				
224.0	54,CC	A	G	F							F		F	F							R	F	F								F	F	R	F					F	F		A	R									F							
228.0	55,CC	A	G	F							F		C	F		R					F		F							F	F	F							C	F		A										F		R	R				
231.4	56,CC	A	G	F							F		C	F							F	F									F	F		F					C	F		A										F		R	F				
234.8	57,CC	A	G	F							F		C	F							F										F	F		F					C	F		A										R		R	F				
238.8	58,CC	A	M	F						R	F		C	F							F										F	F		F					C	F		A										R		R	F				
	60-1, 118-119	A	G	F							F		C	F																F	F	F		F					C			A													F				
	60-3, 31-32	A	M	F							F		C	F				R													F	F		F					C			A													F				
246.8	60,CC	A	G	F							F		C	F				R			F	F							R	F	F	F		F			F		C	F		A			F									F		R	F				
251.2	61,CC and 61B,CC	A	G	F					R		F			F					R		F	F									F	F		F					C	R	R	A			R									R			F				
	Hole 532B																																																										
	62-3, 22-23	A	M	F							F		F	F																	F	F		F					F	F		A			R									F			F				
254.7	62,CC	A	M	F							F		F	F							F										F	F		F				R	C	R		A			R									R			F				
	63-1, 50-51	A	M	F							F		F	F				R			F	R			F						F	F		F				R	C	F		A															F				
	63-2, 20-21	A	M	F							F		F	F				R													F	F							C			A			R												F				
	63-2, 120-121	A	M	F									F	F				R													F	F							C			A																			
257.7	63,CC	A	M	F							F		F	F							R										F	F							C	R		A			F												F				
259.7	64,CC	A	M	F					R		F		F	F	R						F										F	F							C	R		A			F		R										F	WPN26b	CN9b	upper NN11	late Miocene
263.7	65,CC	A	G	F							F			F							R										F	F	R	F					C	F	R	A			F												F				
267.1	66,CC	A	G	F							F			F							R										F	F		F					C	F	R	A			F	R											F				
271.5	67,CC	A	G	C							F			F							R				R							F	R	F					C	F		A			F	R								R			F				
275.5	68,CC	A	M	F									F	F		R					R				F					F		F		F					C	F	R	A			F									R			F				
279.3	69,CC	A	M	F							F			F							R				F						F	F		F					F	F		A			F												F				
282.3	70,CC	A	M	F							F			F							R				F						F	F							F	R	R	A			F												F				
285.3	71,CC	A	G	F	R						F		F	F							F				F				R			F		F					F	F	R	A			F												F				
288.3	72,CC	A	G	F							F			F							F				F							F	R	F					F	F		A			F												F				
290.3	73,CC	A	G	F	R								F	F							R				F							F		F					F	F		A			F												F				
291.3	74,CC	A	G	F										F						R		R			R									F					F	F	R	A			F			R									F				

Note: Abundance: A = abundant; C = common; F = few; R = rare; B = barren; lower case letter = reworked older fossils. Preservation: G = good; M = moderate; P = poor.

Table 5. Frequency estimate designations.

Abundance of specimens	Logarithm	Designation	Letter designation
10–100 specimens per field of view	+1	Abundant	A
1–10 specimens per field of view	0	Common	C
Single specimen in 1–10 fields of view	−1	Few	F
Single specimen in 10–100 fields of view	−2	Rare	R

Table 6. Geologic age and nannoplankton zone assignment of cores.

Series or subseries		Zone (Martini, 1971)	Zone or subzone (Okada and Bukry, 1980)	Zone or subzone (Ellis, 1982)	DSDP Holes (Core-Section)					
					530	530A	530B	531	531A	532/532B
Holocene		NN21	CN15	WPN32	1,CC	Washed	1-1 to 2-1	1,CC	1-1	1-2
Pleistocene	late	NN20	CN14b	WPN31b	Washed		2-2 to 7-1			1-3 to 5-3
		NN19	CN14a	WPN31a			7,CC to 13,CC			5,CC to 11,CC
	early		CN13b	WPN30b			14,CC to 18,CC			12,CC to 15,CC
			CN13a	WPN30a			19,CC to 28,CC			16,CC to 17,CC
Pliocene	late	NN18	CN12d	WPN29d			Missing			18-1 to 18-3
		NN17	CN12c	WPN29c						
		NN16	CN12b	WPN29b						18,CC to 22-3
			CN12a	WPN29a						22,CC to 36-2
	early	NN15	CN11b	WPN28b	2-2 to 2,CC	1-1 to 4-4	30,CC to 40,CC			36,CC
			CN11a	WPN28a		4-5 to 4,CC	41,CC to 44,CC			37,CC to 60-3
		NN14	CN10c	WPN27c		5,CC to 7-4	Missing			
		NN13								
		NN12	CN10b	WPN27b		7-6 to 8-6				
			CN10a	WPN27a						
Miocene	late	NN11	CN9b	WPN26b		8,CC to 13,CC	45,CC to 48,CC			60,CC to B74,CC
			CN9a	WPN26a		14,CC to 15-5				
		NN10	CN8b	WPN25b		15-6 to 18-4				
			CN8a	WPN25a						
	middle	NN9	CN7b	WPN24b						
			CN7a	WPN24a						
		NN8	CN6	WPN23						
		NN7	CN5b	WPN22b		20-4				
		NN6	CN5a	WPN22a		21-6 to 24-2				
		NN5	CN4	WPN21						
	early	NN4	CN3	WPN20		Barren				
		NN3	CN2	WPN19						
		NN2	CN1c	WPN18c						
		NN1	CN1b	WPN18b						
			CN1a	WPN18a						
Oligocene	late	NP25	CP19b	WPN17b		31-2 to 34-6				
		NP24	CP19a	WPN17a		35-1 to 37-1				
	early	NP23	CP18	WPN16		37-1 to 37-2				
			CP17	WPN15						
		NP22	CP16c	WPN14c						
		NP21	CP16b	WPN14b		37-2				
			CP16a	WPN14a						
Eocene	late	NP20	CP15b	WPN13b		37-2				
		NP19								
		NP18	CP15a	WPN13a		Missing				
	middle	NP17	CP14b	WPN12b						
		NP16	CP14a	WPN12a		37-2				
		NP15	CP13c	Unpublished		37-3 to 37,CC				
			CP13b							
			CP13a							
	early	NP14	CP12b			38-1 to 38-2				
			CP12a							
		NP13	CP11			38-2 to 39-1				
		NP12	CP10			39-2 to 40-3				
		NP11	CP9b			40-4 to 41-1				
		NP10	CP9a							
Paleocene	late	NP9	CP8b			41-1 to 42-2				
			CP8a							
		NP8	CP7			42-2 to 43,CC				
		NP7	CP6			44-1				
		NP6	CP5			44-2 to 46,CC				
	early	NP5	CP4			47-1				
		NP4	CP3			Missing				
		NP3	CP2			47-1 to 50-1				
		NP2	CP1b							
		NP1	CP1a			50-1 to 50-2				

NOTE ON THE PLATES

The following abbreviations are used in the captions to the plates: NL = normal light; (Al) = aluminum-shadowed; (Au) = gold-shadowed; (RP) = Reverse print; PHC = phase contrast; XN = crossed nicols; SEM = scanning electron microscope (Elmi-Lab of the Geological Survey of Austria); and SEM* = scanning electron microscope (Electron Microscopy Facility of the University of South Florida).

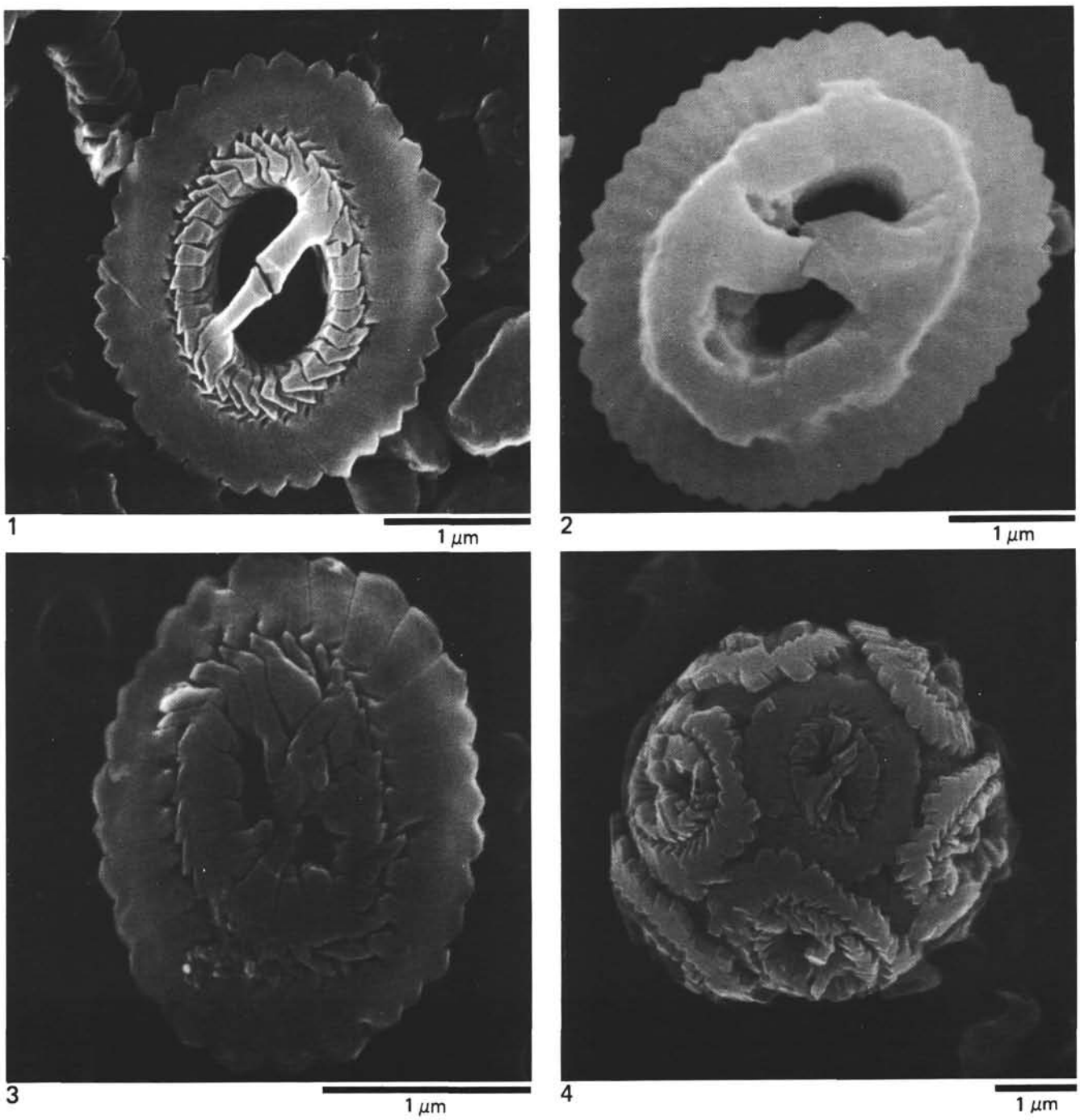


Plate 1. **1.** *Gephyrocapsa oceanica*, Sample 530B-4,CC, SEM*; **2.** *G. caribbeanica*, Sample 531A-1-1, 0–2 cm, SEM; **3.** *G. caribbeanica*, Sample 532-5,CC, SEM*; **4.** *G. caribbeanica* coccosphere, Sample 530B-4,CC, SEM*.

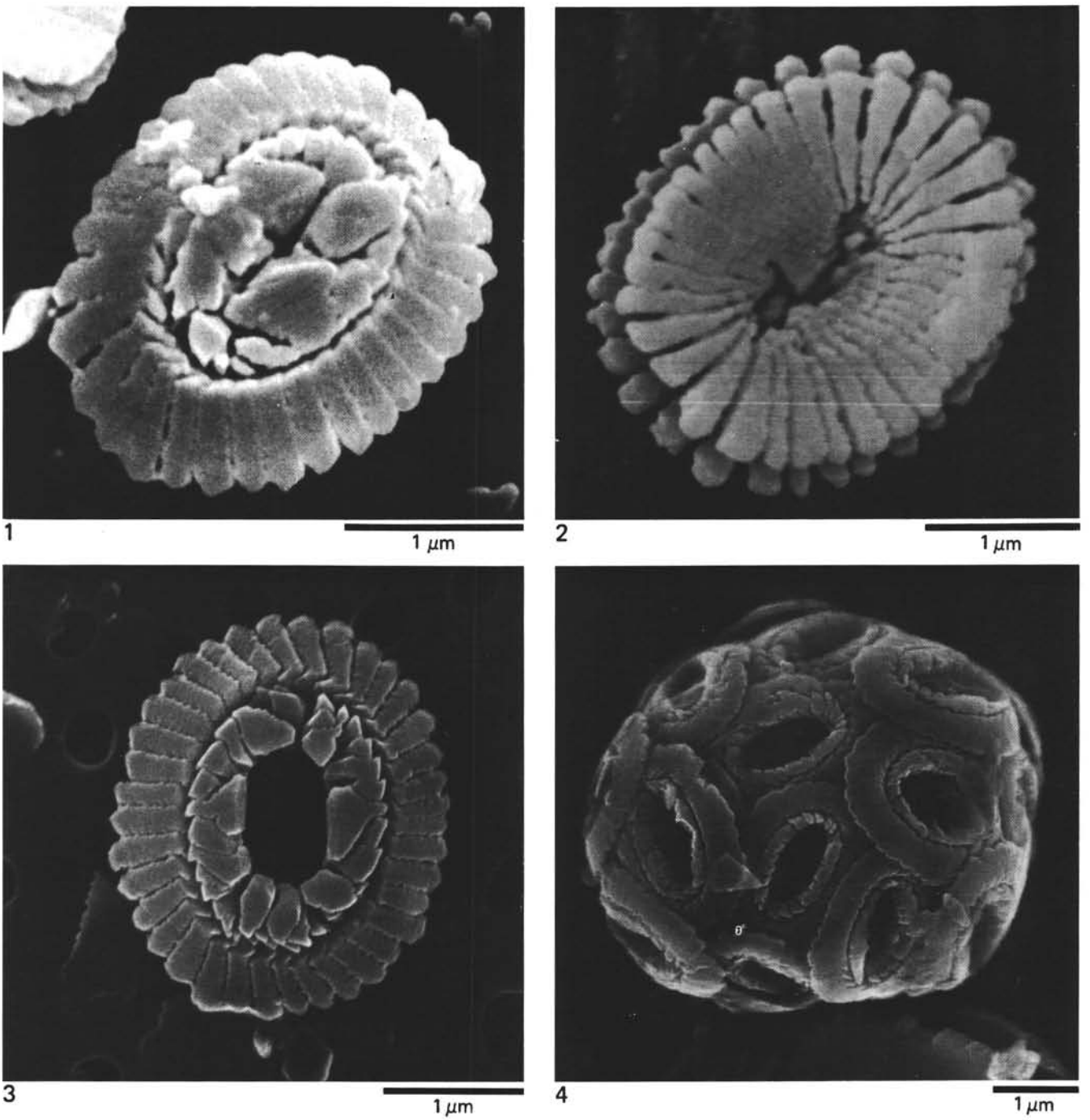


Plate 2. **1.** *Crenalithus productellus*, distal view, Sample 532-44,CC, SEM; **2.** *C. productellus*, proximal view, Sample 532-55,CC, SEM; **3.** *C. doronicoides*, distal view, Sample 530B-29,CC, SEM; **4.** *C. doronicoides*, coccosphere, Sample 530A-12-3-72/74 cm, SEM*.

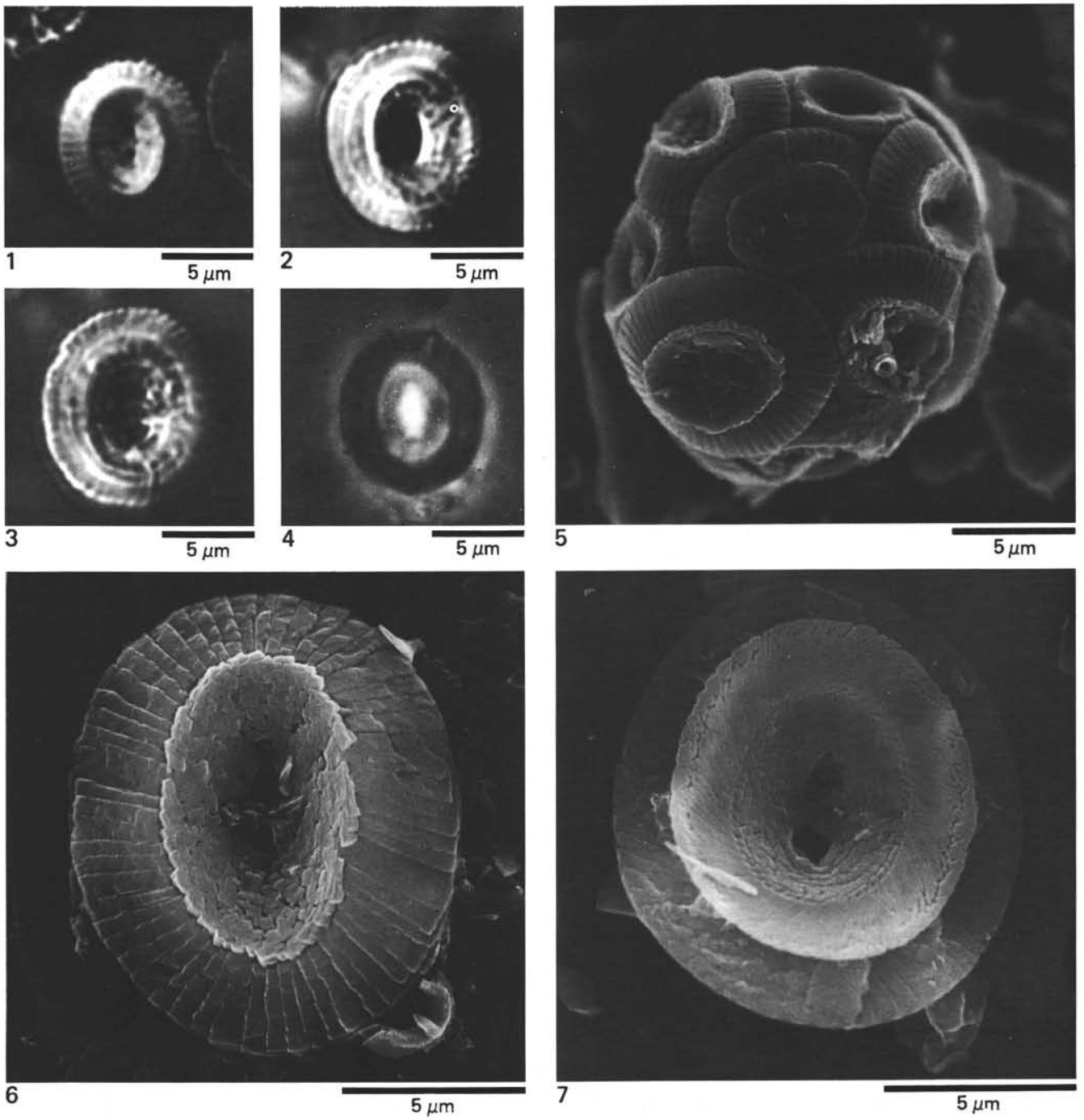


Plate 3. **1.** *Coccolithus carteri*, Sample 531A-1-1, 0–2 cm, NL (Al, RP); **2.** *C. pelagicus*, Sample 531A-1-1, 0–2 cm, NL (Al, RP); **3.** *C. carteri*, Sample 531A-1-1, 0–2 cm, NL (Al, RP); **4.** *C. pelagicus*, Sample 530A-35-1, 30–31 cm, PHC; **5.** *C. carteri* coccosphere, Sample 530B-38,CC, SEM*; **6.** *C. carteri*, distal view, Sample 530B-4,CC, SEM*; **7.** *C. carteri*, proximal view, Sample 530B-4,CC, SEM*.

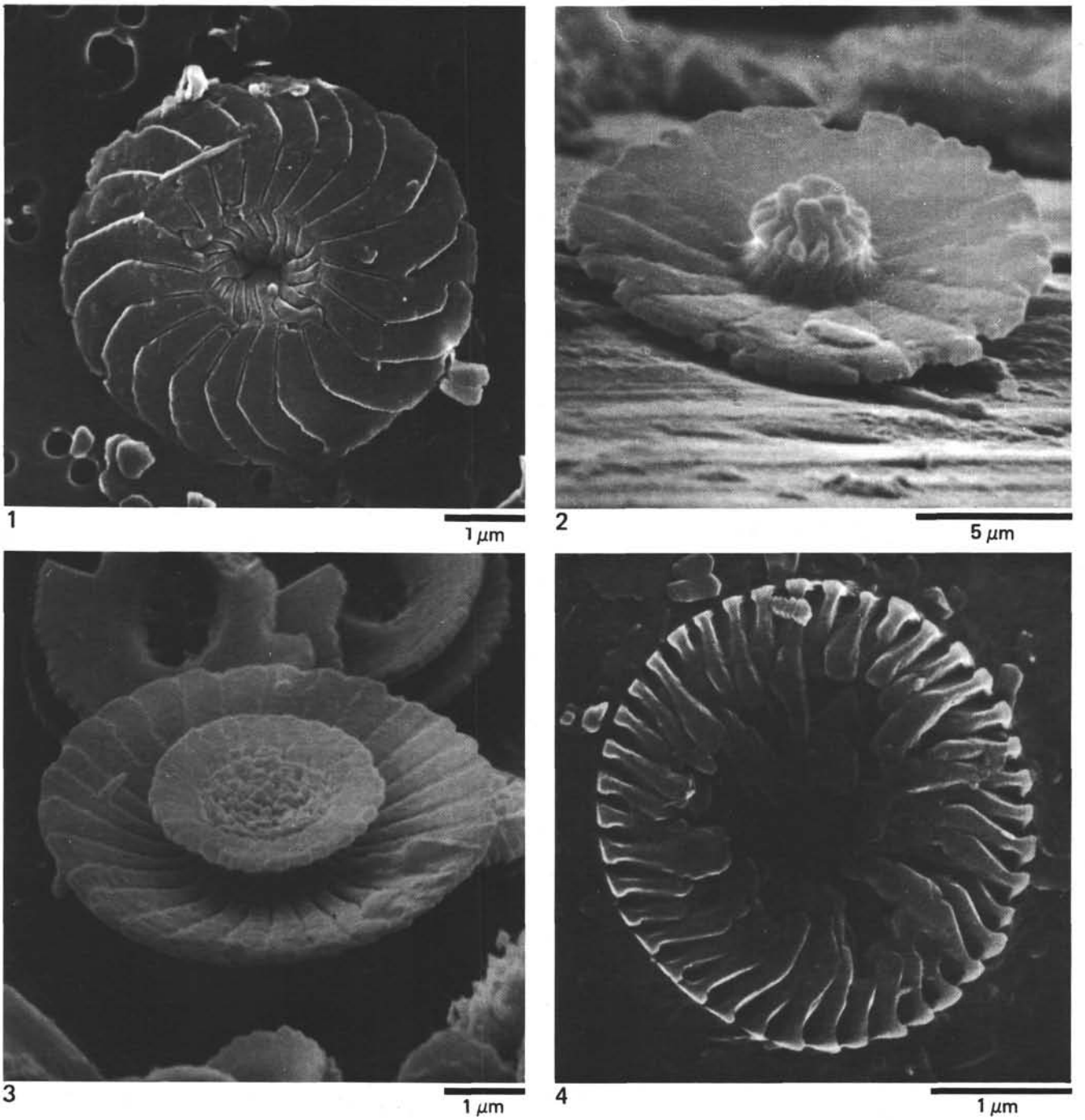


Plate 4. **1.** *Calcidiscus leptoporus*, distal view, Sample 530B-39,CC, SEM*; **2.** *C. leptoporus*, side view of proximal face, Sample 531A-1-1, 0–2 cm, SEM; **3.** *C. macintyrei*, side view of proximal face, Sample 532-55,CC, SEM; **4.** *C. macintyrei*, detail of center of proximal side of distal plate, Sample 532-5,CC, SEM*.

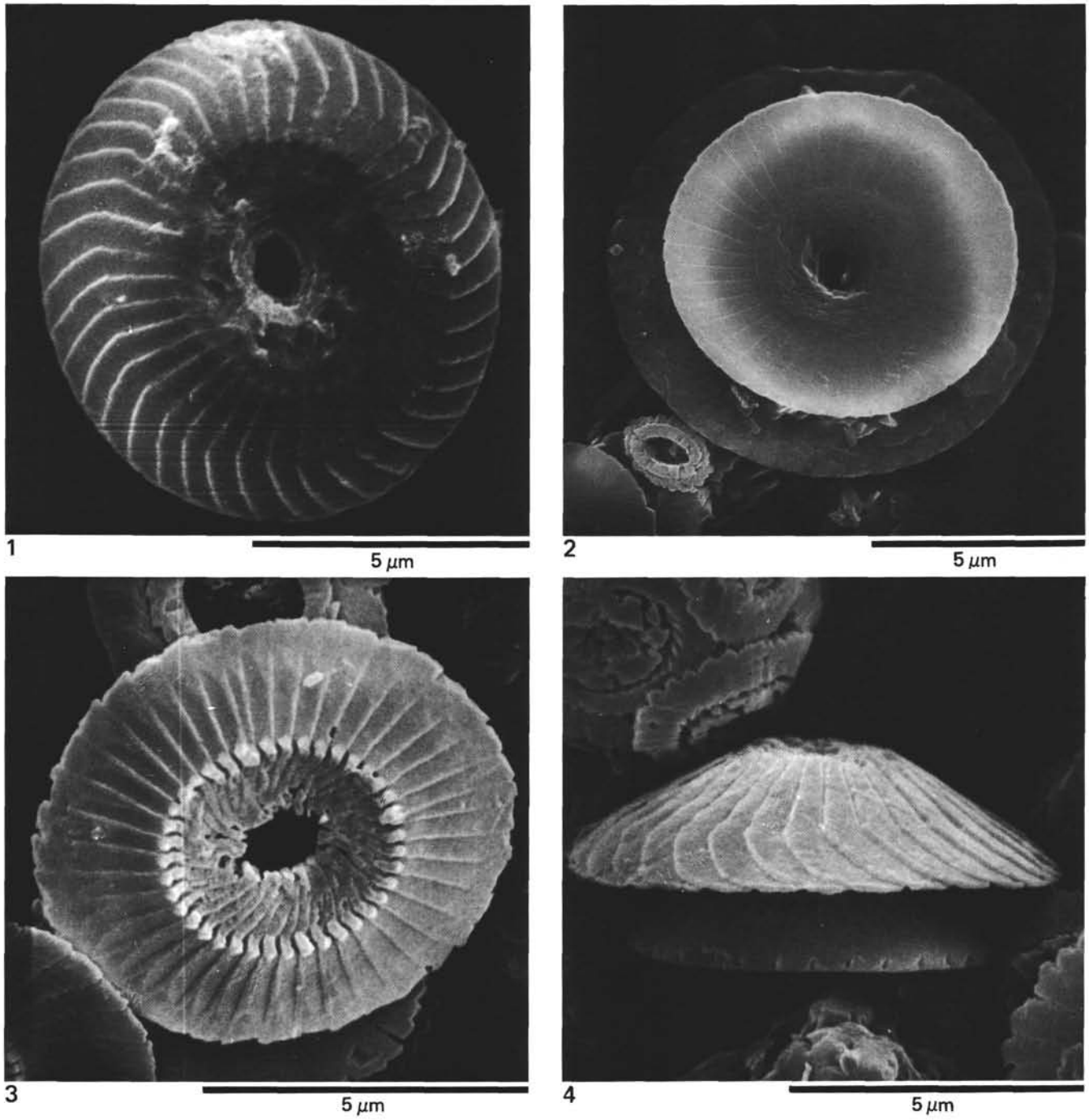


Plate 5. *Calcidiscus macintyrei.* **1.** Distal view, Sample 532-36,CC, SEM; **2.** Proximal view, Sample 530B-39,CC, SEM*; **3.** Distal side of proximal plate, Sample 532-33,CC, SEM; **4.** Side view, Sample 532-46,CC.

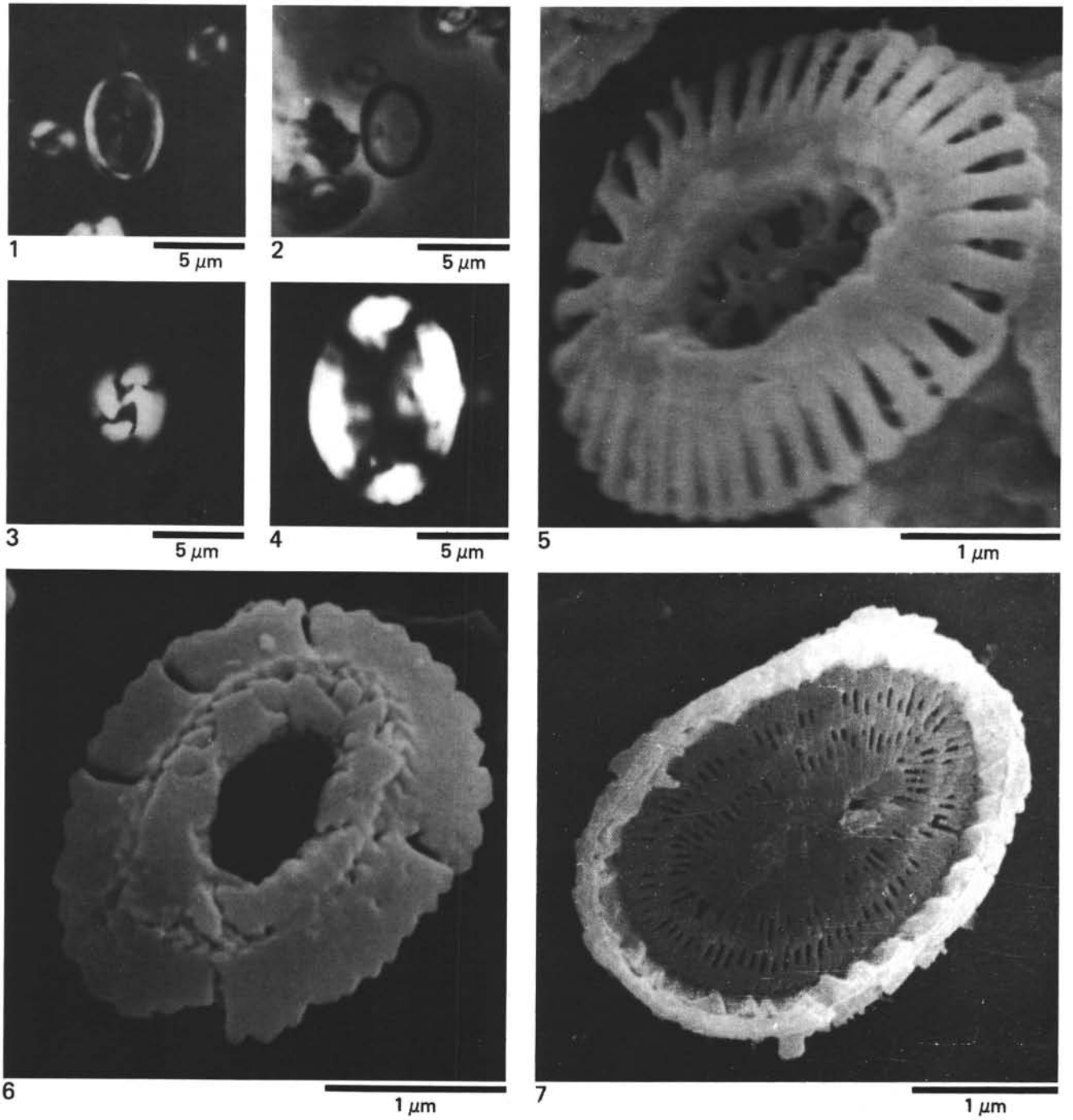


Plate 6. **1.** *Syracosphaera pulchra*, Sample 531-1,CC, XN; **2.** *Syracosphaera* cf. *S. pulchra*, Sample 531-1,CC, PHC; **3.** *Gephyrocapsa caribbeanica*, Sample 531-1,CC, XN; **4.** *Pontosphaera syracusana*, Sample 530A-1-1, 0–2 cm, XN; **5.** *Emiliania huxleyi*, distal view, Sample 531A-1-1, 0–2 cm, SEM; **6.** *Crenalithus doronicoides*, distal view, Sample 532-36,CC, SEM; **7.** *Syracosphaera pulchra*, distal view, Sample 531A-1-1, 0–2 cm, SEM.

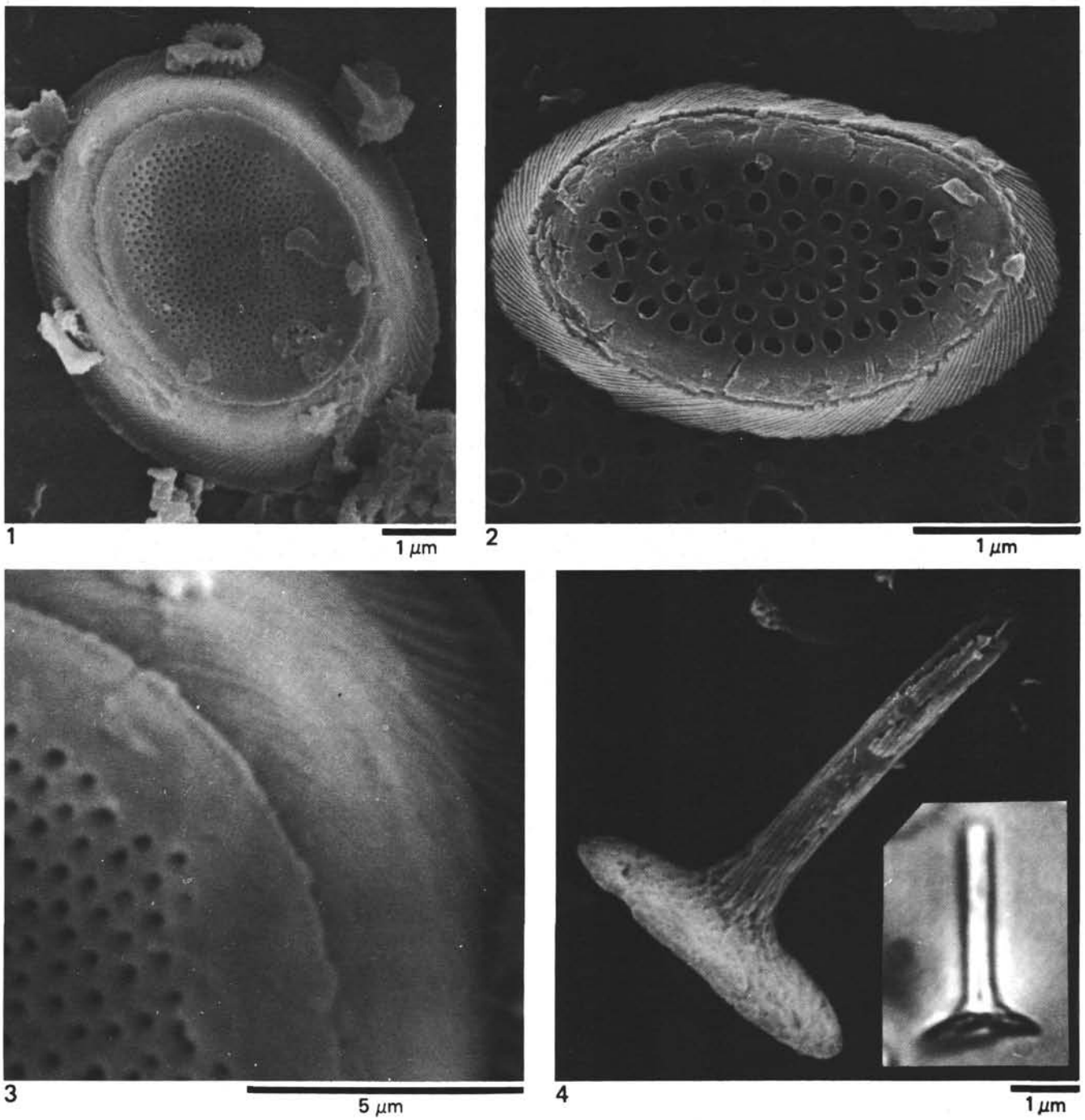


Plate 7. **1.** *Pontosphaera alboranensis*, proximal view, Sample 531A-1-1, 0–2 cm, SEM; **2.** *Pontosphaera* cf. *P. multipora*, proximal view, Sample 530B-29,CC, SEM*; 3. *P. alboranensis*, detail of Figure 1, SEM; **4.** *Rhabdosphaera sicca*, side view, Sample 532-46,CC, SEM (inset, NL).

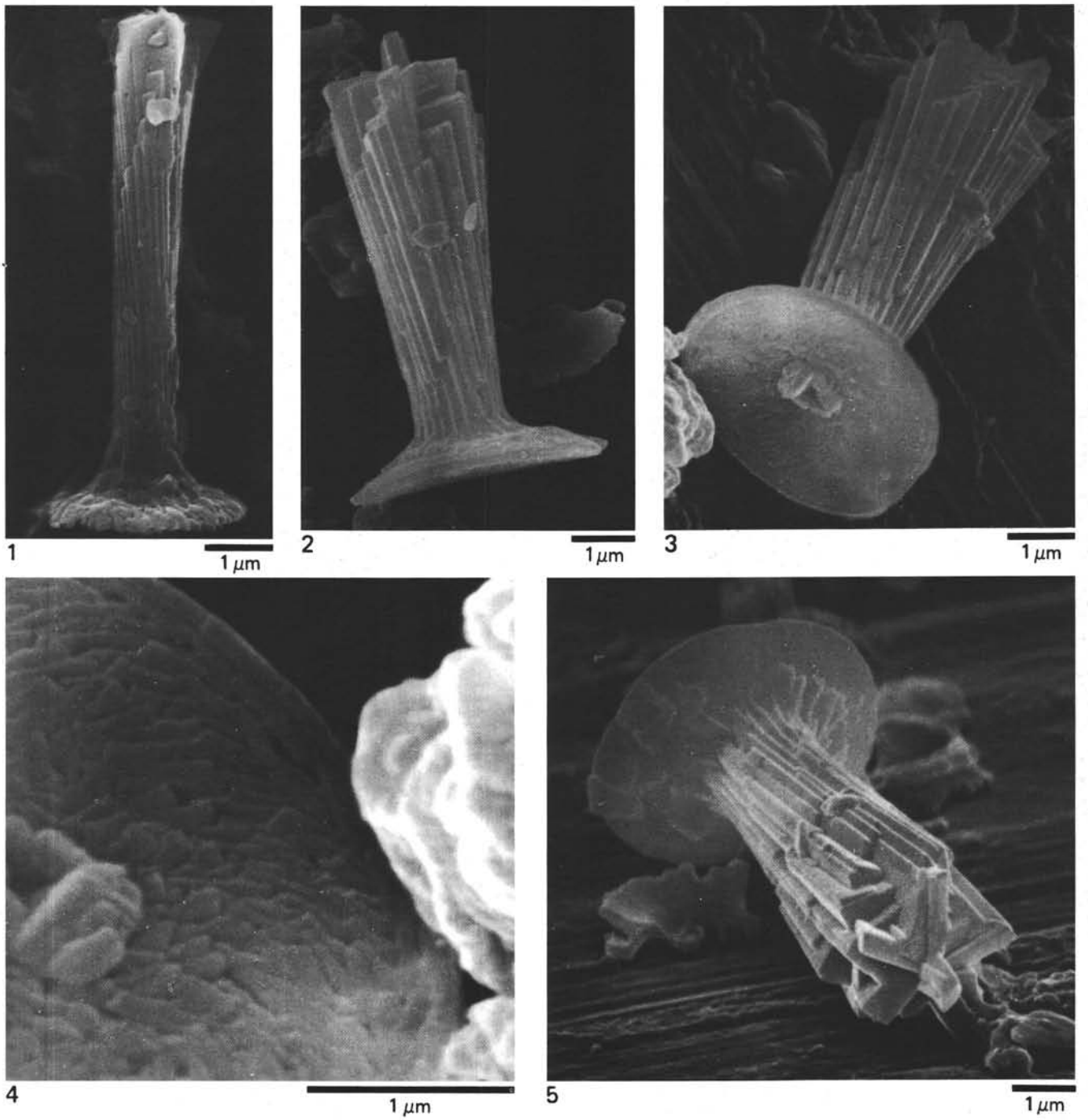


Plate 8. *Rhabdosphaera clavigera.* **1.** Side view, Sample 530B-39,CC, SEM*; **2.** Side view, Sample 531A-1-1, 0–2 cm, SEM. **3.** Oblique proximal view, Sample 531A-1-1, 0–2 cm, SEM; **4.** Proximal view of basal plate, Sample 531A-1-1, 0–2 cm, SEM; **5.** Distal view, Sample 531A-1-1, 0–2 cm, SEM.

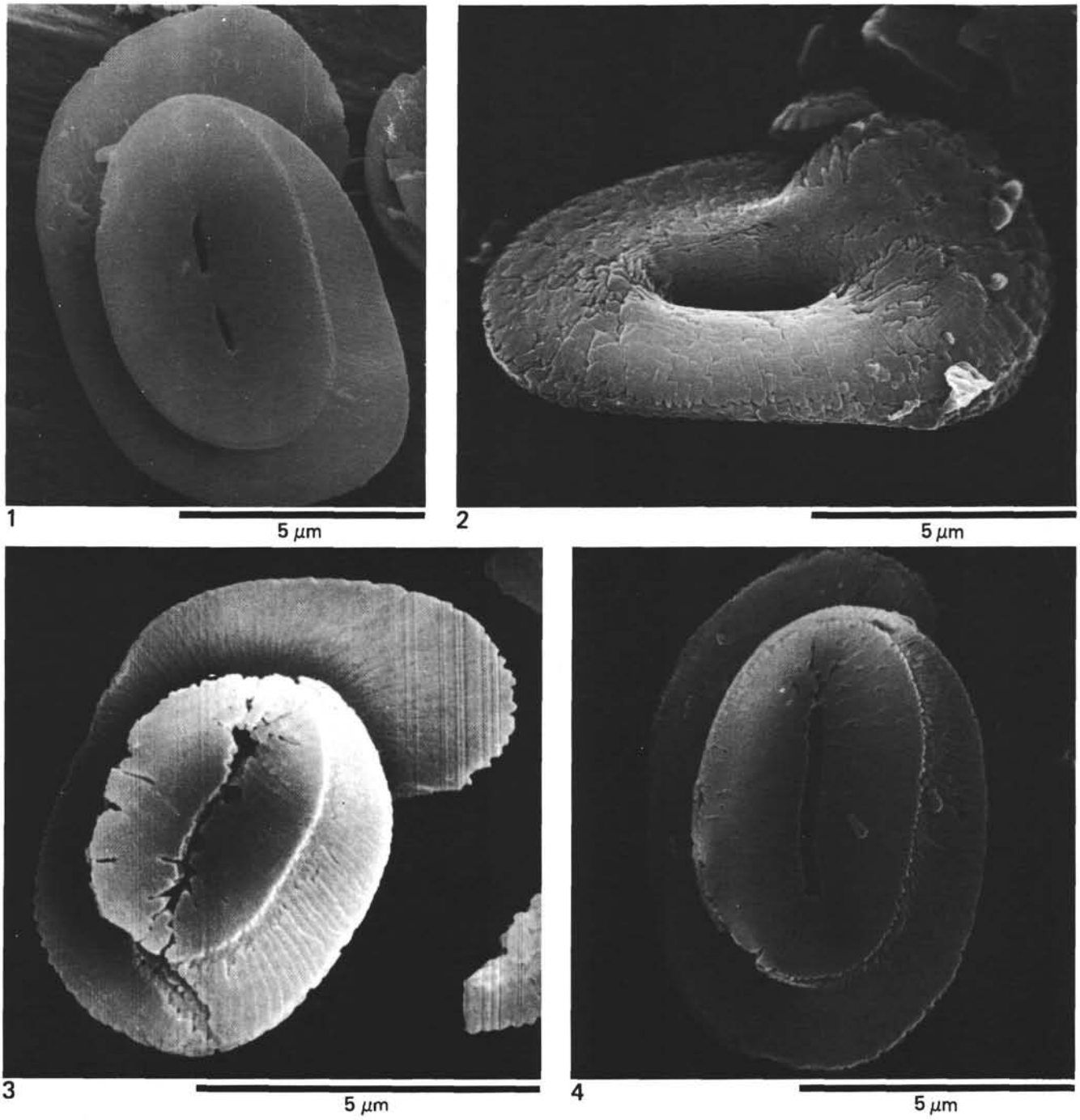


Plate 9. *Helicosphaera carteri.* **1.** Proximal view, Sample 531A-1-1, 0–2 cm, SEM; **2.** Distal view, Sample 530B-29,CC, SEM*; **3.** Proximal view, Sample 532-55,CC, SEM; **4.** Proximal view, Sample 530B-29,CC, SEM*.

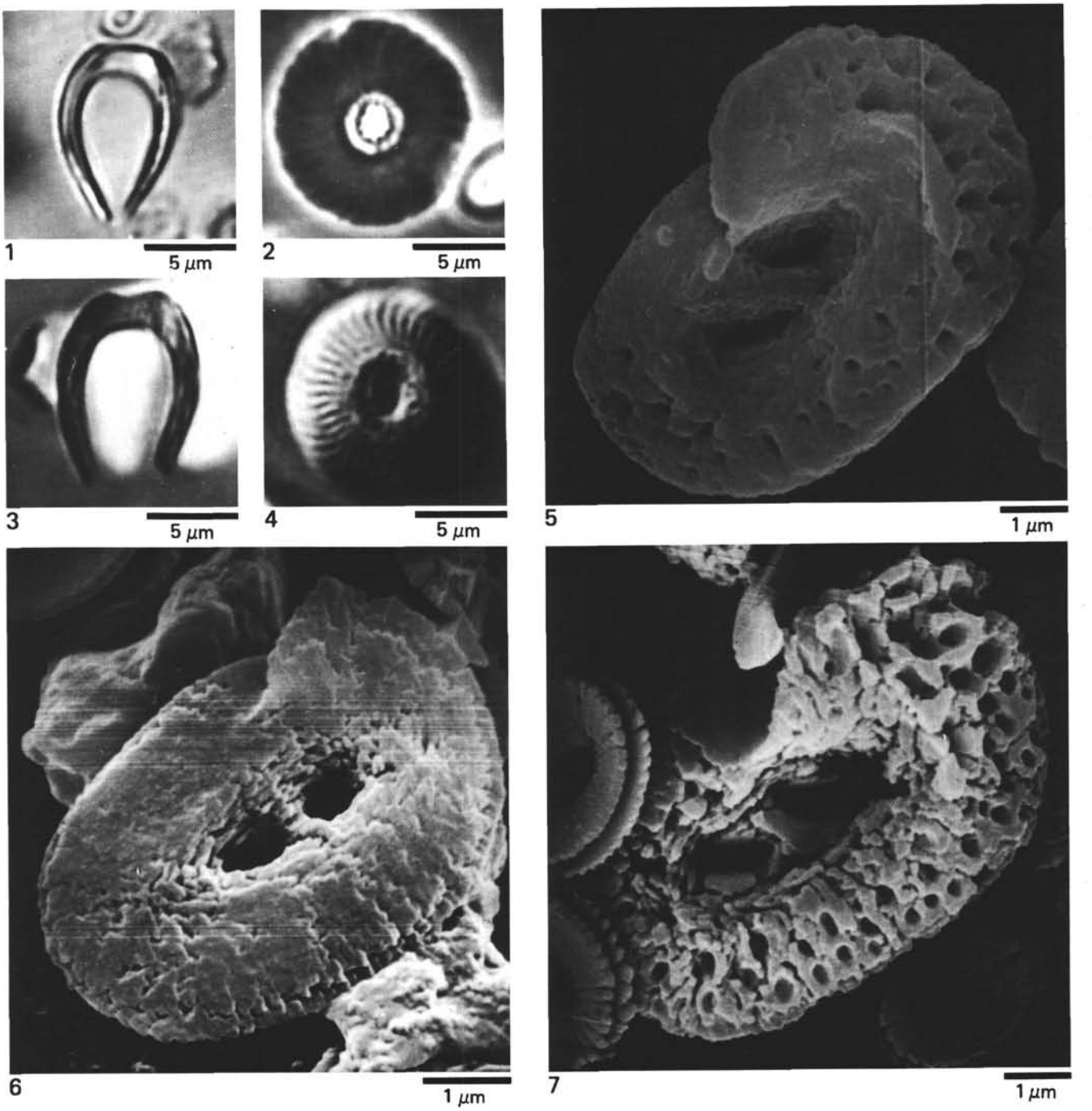


Plate 10. **1.** *Amaurolithus delicatus*, Sample 532-55,CC, NL.; **2.** *Calcidiscus macintyrei*, Sample 532-33,CC, PHC; **3.** *A. delicatus*, Sample 532-55,CC, NL (Al); **4.** *C. macintyrei*, Sample 532-33,CC, NL (Al, RP); **5–7.** *Helicosphaera sellii*, distal view, etched, Sample 532-55,CC, SEM.

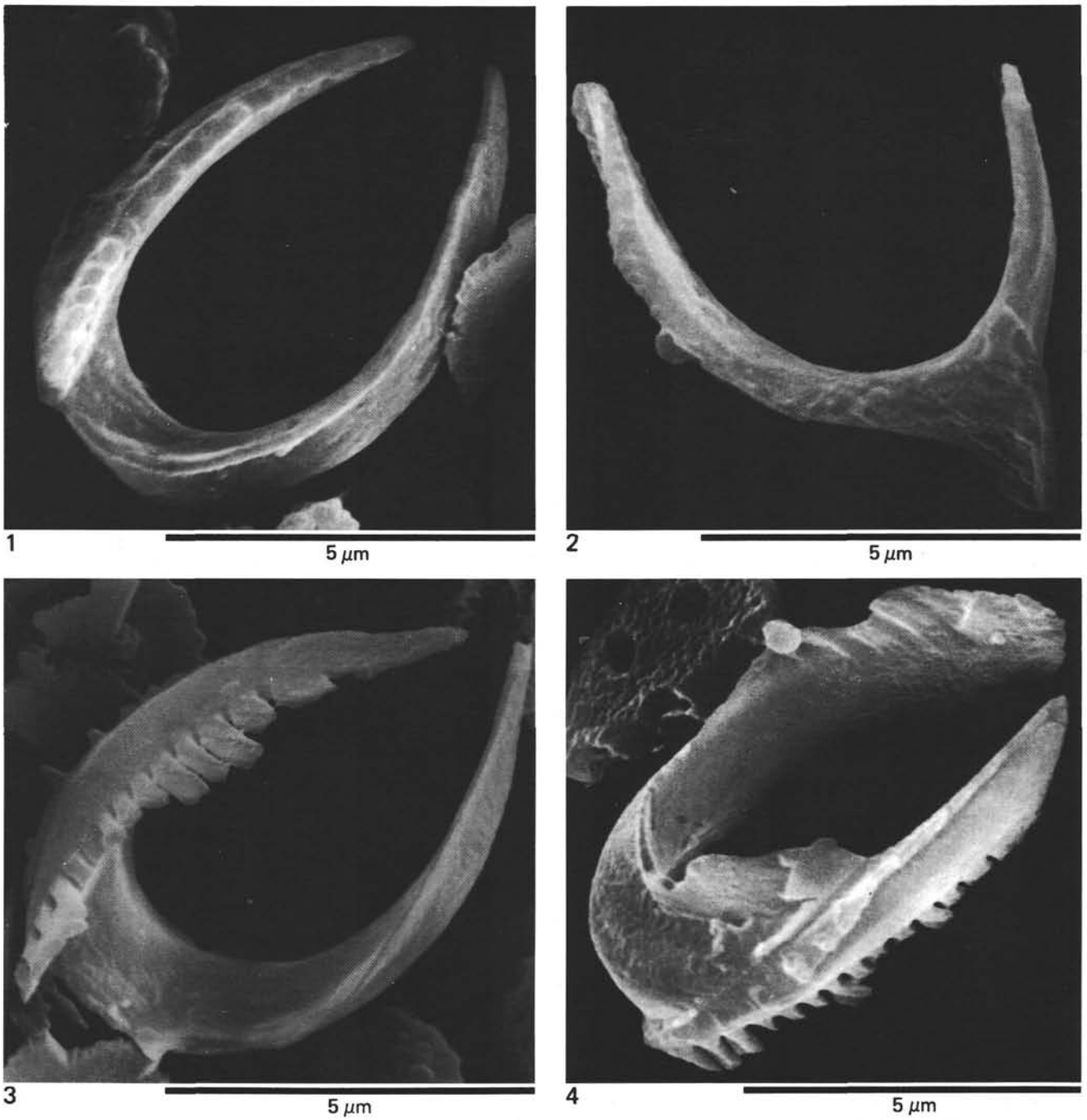


Plate 11. **1.** *Amaurolithus delicatus*, Sample 532-46,CC, SEM; **2.** *A. tricorniculatus*, Sample 532-55,CC, SEM; **3.** *A. tricorniculatus*, Sample 532-46,CC, SEM; **4.** *A.* cf. *A. tricorniculatus*, Sample 532-55,CC, SEM.

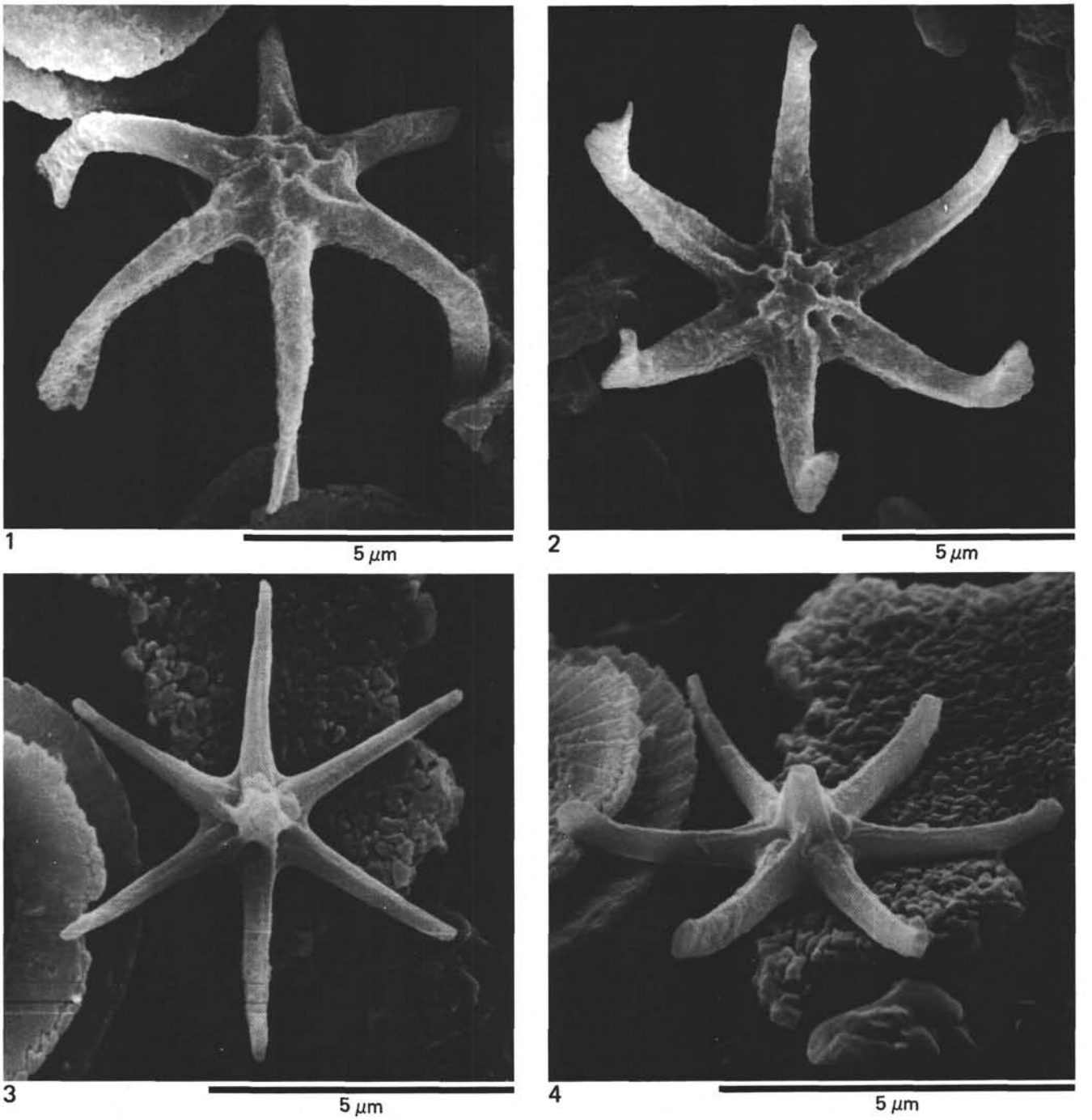


Plate 12. *Discoaster brouweri*. **1.** Distal view, Sample 532-36,CC, SEM; **2–3.** Proximal view, Sample 532-55,CC, SEM; **4.** Oblique proximal view, Sample 532-55,CC, SEM.

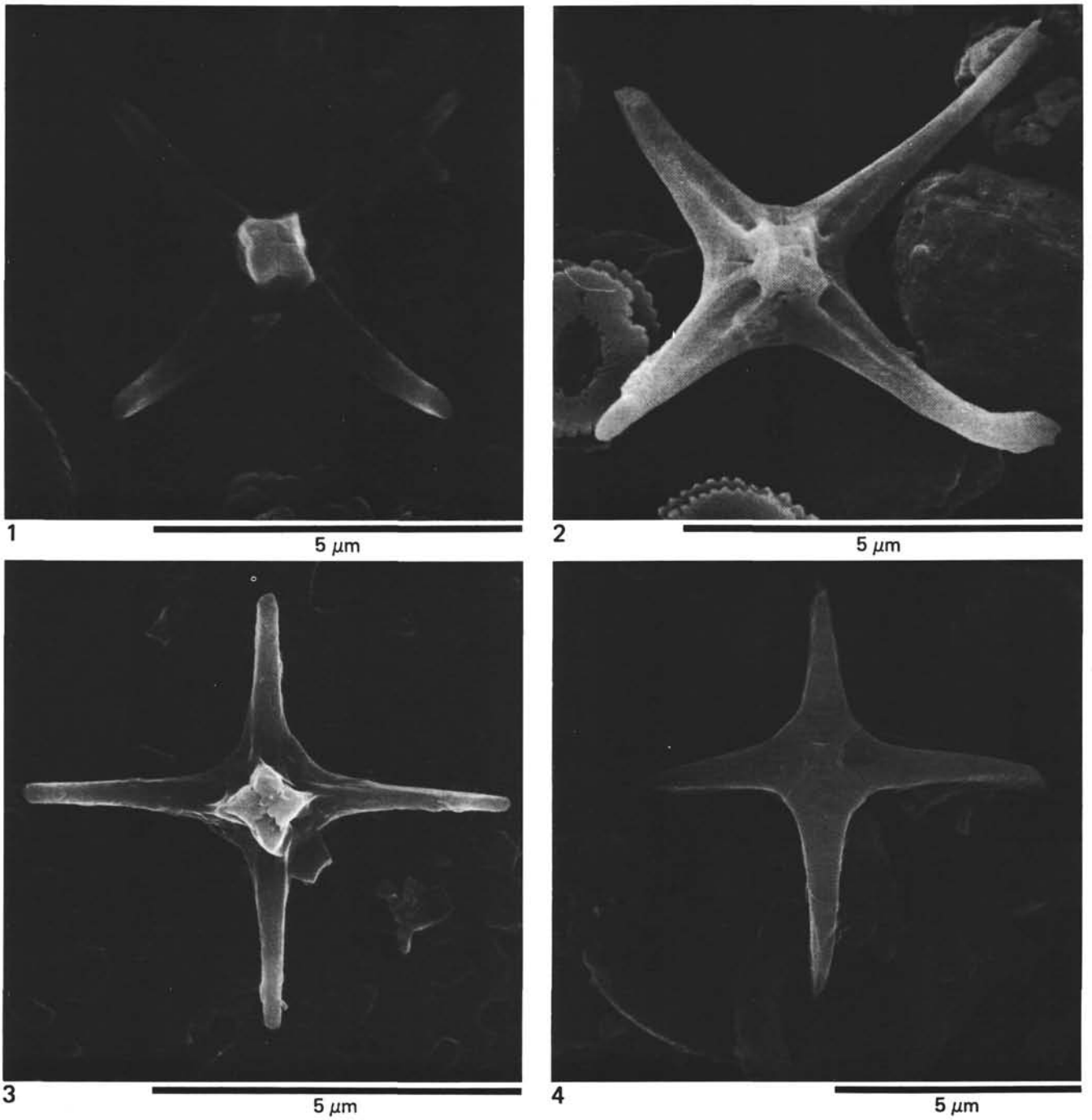


Plate 13. *Discoaster tamalis*. **1.** Proximal view, Sample 530B-38,CC, SEM*; **2.** Proximal view, Sample 532-36,CC, SEM; **3.** Proximal view, Sample 532-5,CC, SEM*; **4.** Distal view, Sample 530B-38,CC, SEM*.

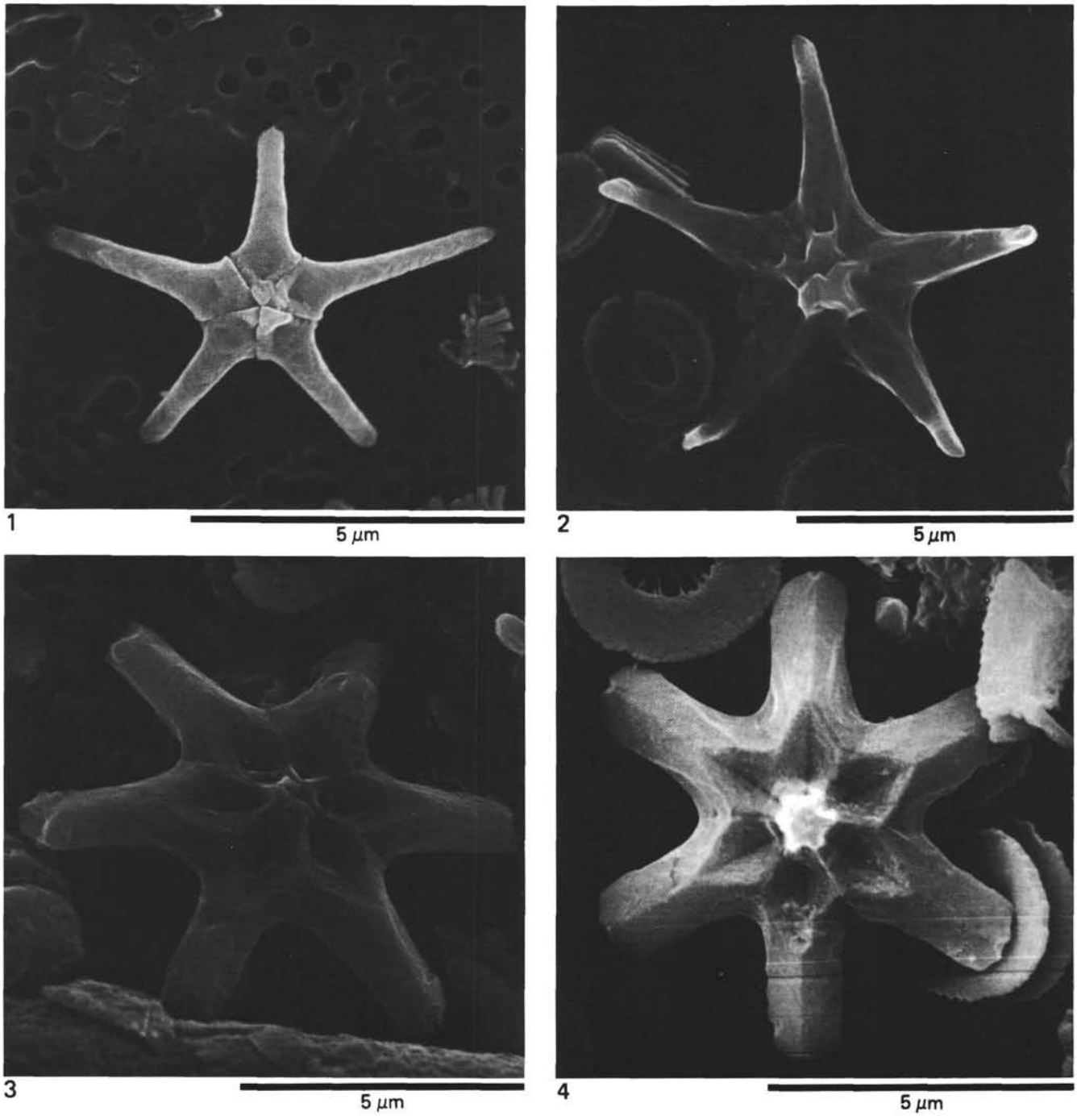


Plate 14. **1.** *Discoaster* cf. *D. pentaradiatus*, distal view, Sample 530B-29,CC, SEM*; **2.** *Discoaster* cf. *D. pentaradiatus*, proximal view, Sample 532-5,CC, SEM*; **3.** *D. intercalcaris*, distal view, Sample 530B-38,CC, SEM*; **4.** *D. intercalcaris*, distal view, Sample 532-55,CC, SEM.

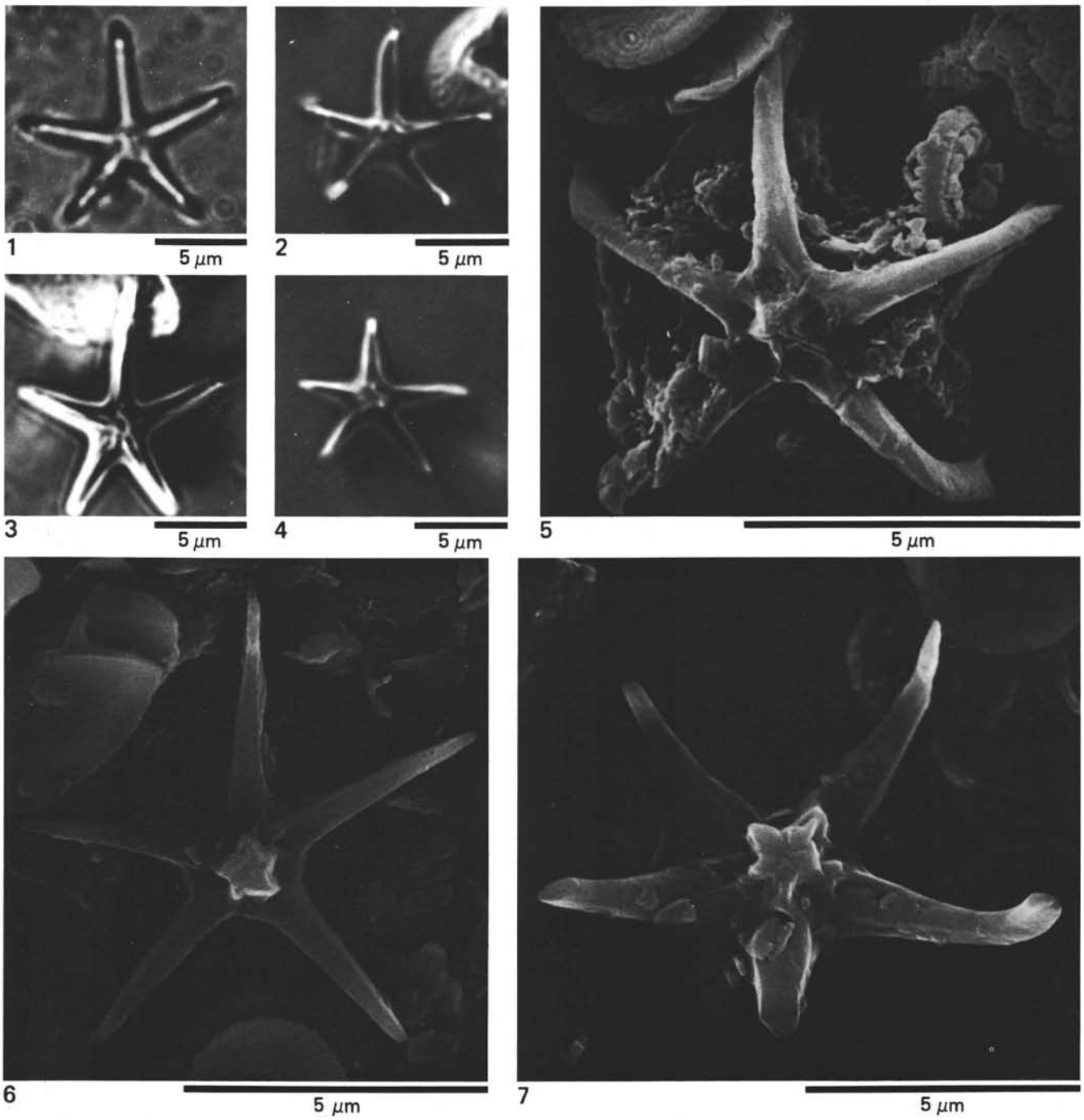


Plate 15. **1.** *Discoaster asymmetricus*, Sample 532-33,CC, NL; **2–4.** *D. asymmetricus*, Sample 532-33,CC, NL (Al); **5.** *D. pentaradiatus*, distal view, Sample 532-33,CC, SEM; **6.** *Discoaster asymmetricus*, proximal view, Sample 530B-38,CC, SEM*; **7.** *Discoaster* cf. *D. asymmetricus*, proximal view, Sample 530B-38,CC, SEM*.

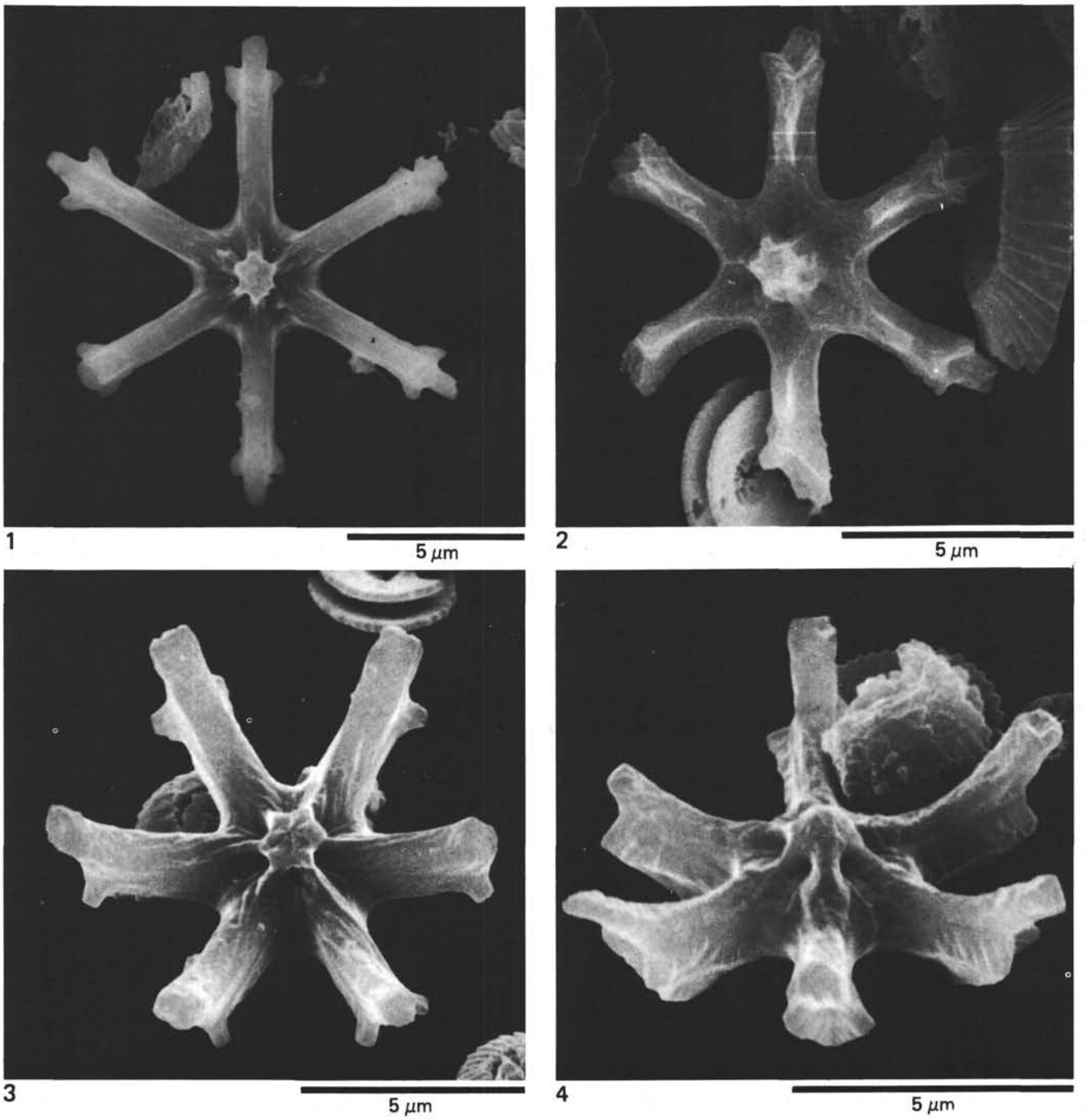


Plate 16. Proximal view, *Discoaster surculus*. **1.** Sample 532-46,CC, SEM; **2.** Distal view, Sample 532-55,CC, SEM; **3–4.** Proximal view, Sample 532-55,CC, SEM.

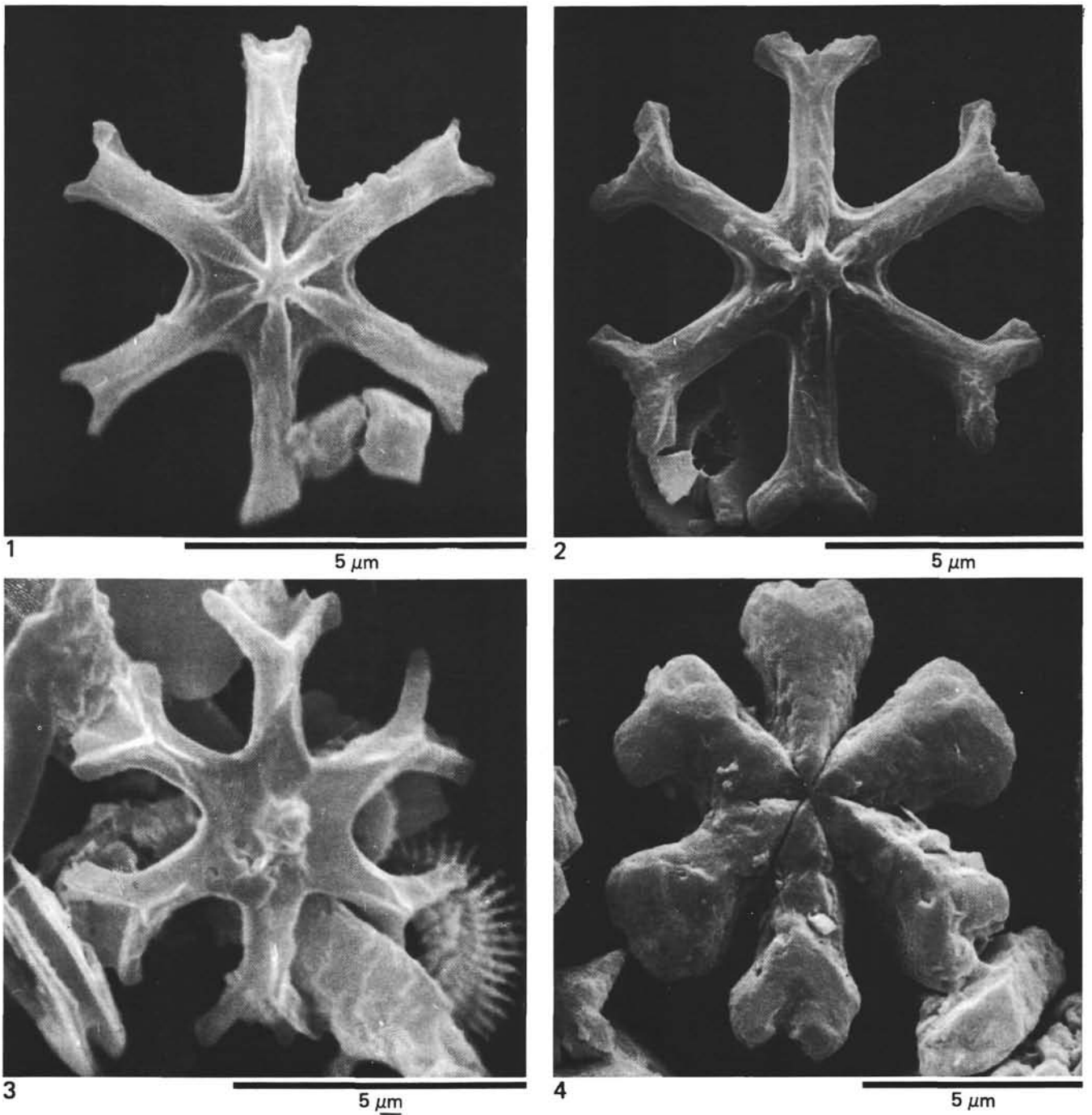


Plate 17. **1.** *Discoaster exilis*, Sample 532-46,CC, SEM. **2.** *D. challengeri*, Sample 532-55,CC, SEM; **3.** *D. icarus*, Sample 532-46,CC, SEM; **4.** *D. deflandrei*, heavily calcified, Sample 530A-37-1, 96–97 cm, SEM.

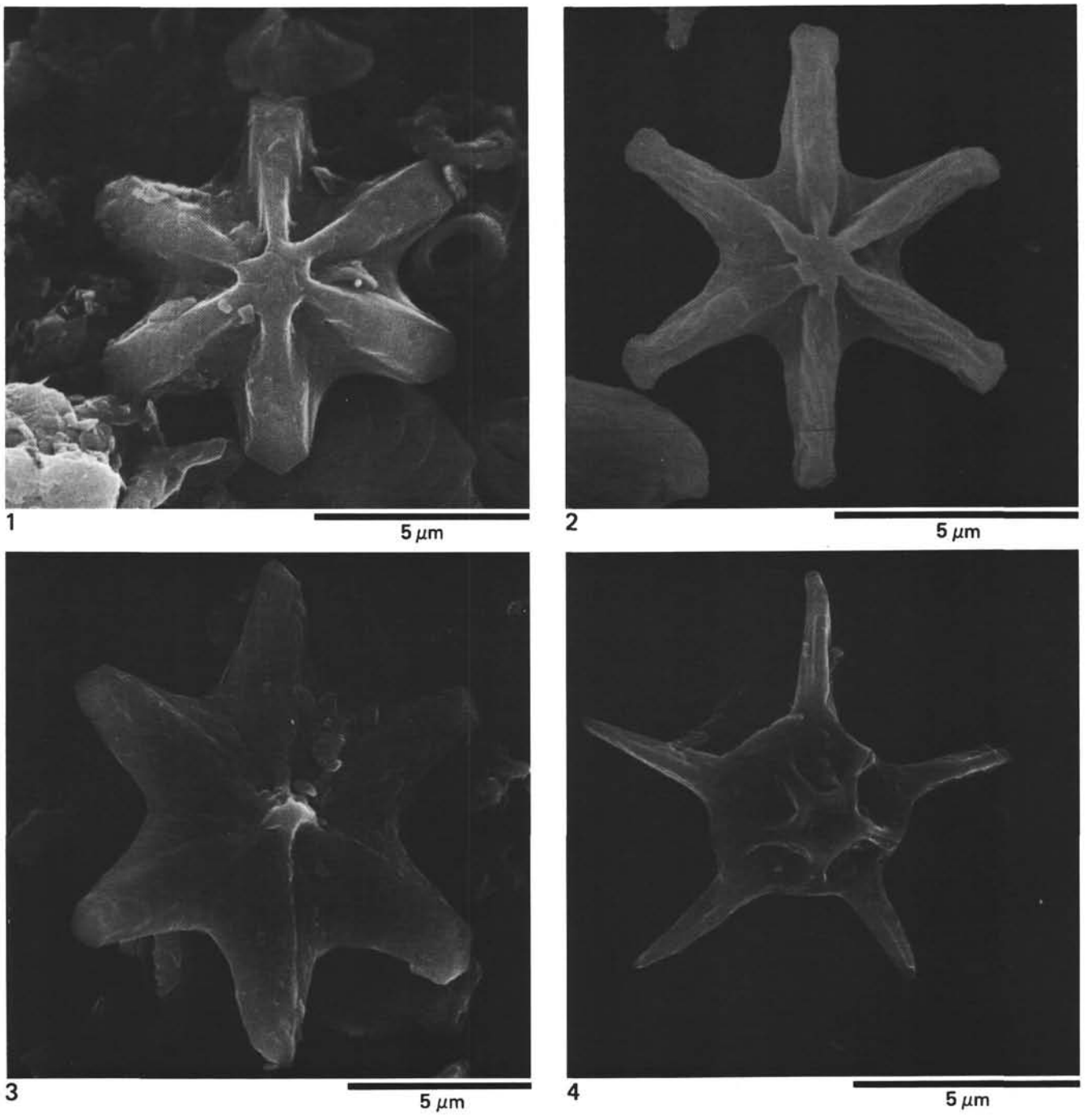


Plate 18. **1.** *Discoaster toralus*, Sample 530A-12-3, 72–73 cm, SEM*; **2.** *D. toralus*, Sample 532-33,CC, SEM; **3.** *D. kugleri*, Sample 530B-39,CC, SEM*; **4.** *D. berggrenii*, Sample 530A-12-3, 72–73 cm, SEM*.

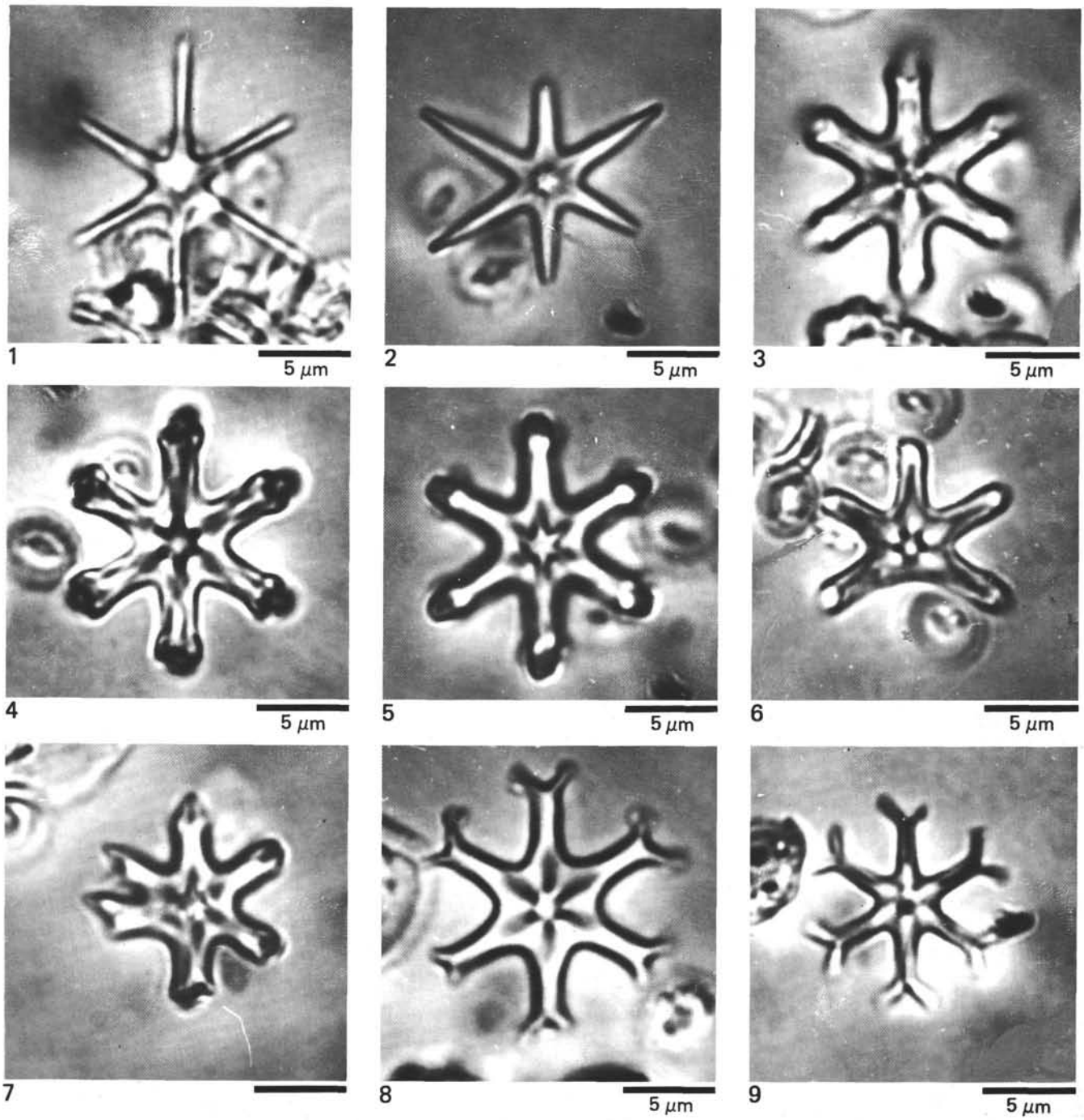


Plate 19. Sample 532-55,CC. **1–2.** *Discoaster brouweri*, NL; **3–7.** *D. surculus*, NL; **8.** *Discoaster variabilis*, NL; **9.** *D. loeblichii*, CC, NL.

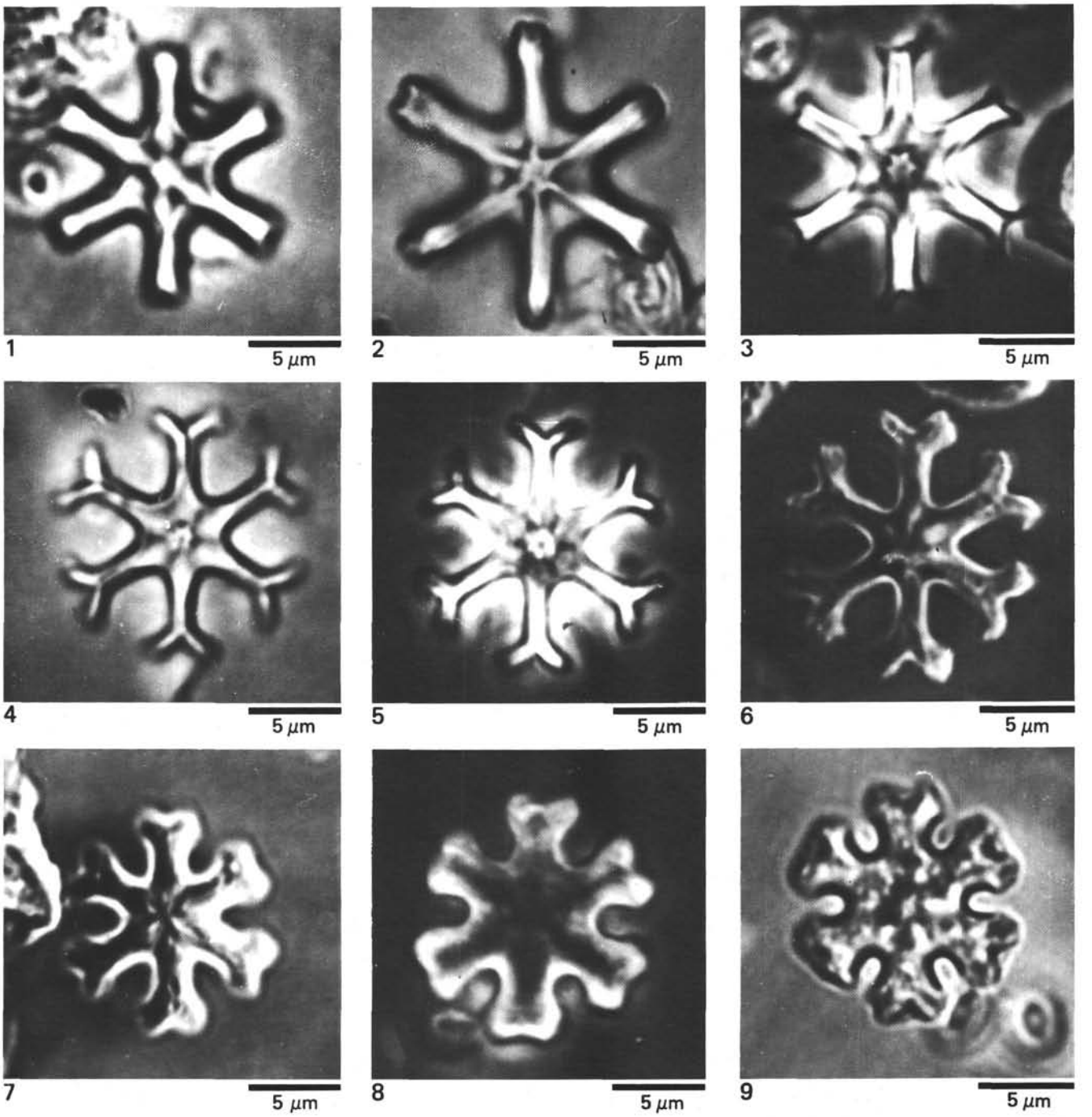


Plate 20. **1–2.** *Discoaster* cf. *D. surculus*, NL; **3.** *D. exilis*, PHC; **4.** *D. variabilis*, NL; **5.** *D. variabilis*, PHC; Sample 532-55,CC. **6.** *D. variabilis*, NL (Al); **7–8.** *D. pansus*, NL (Al); **9.** *D. pansus*, NL. Sample 532-33,CC.

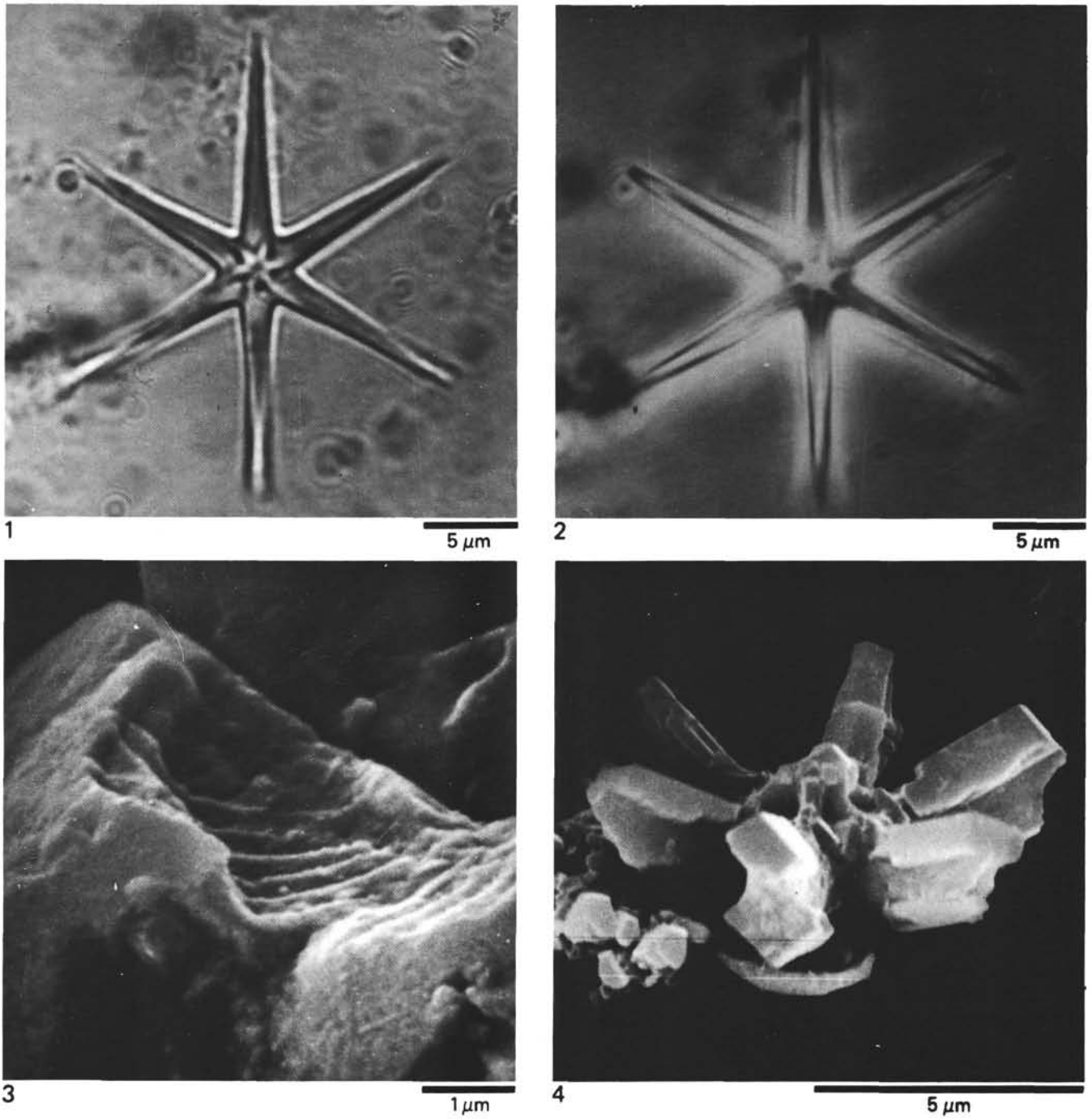


Plate 21. **1.** *Discoaster brouweri*, Sample 530A-15-5, 77–78 cm, NL; **2.** *D. brouweri*, Sample 530A-15-5, 77–78 cm, PHC; **3.** ***Braarudosphaera bigelowi***, corrosion etching, detail of Plate 25, Figure 2, Sample 530A-37-1, 96–97 cm, SEM; **4.** *Discoaster* sp., heavily calcified, Sample 532-55,CC, SEM.

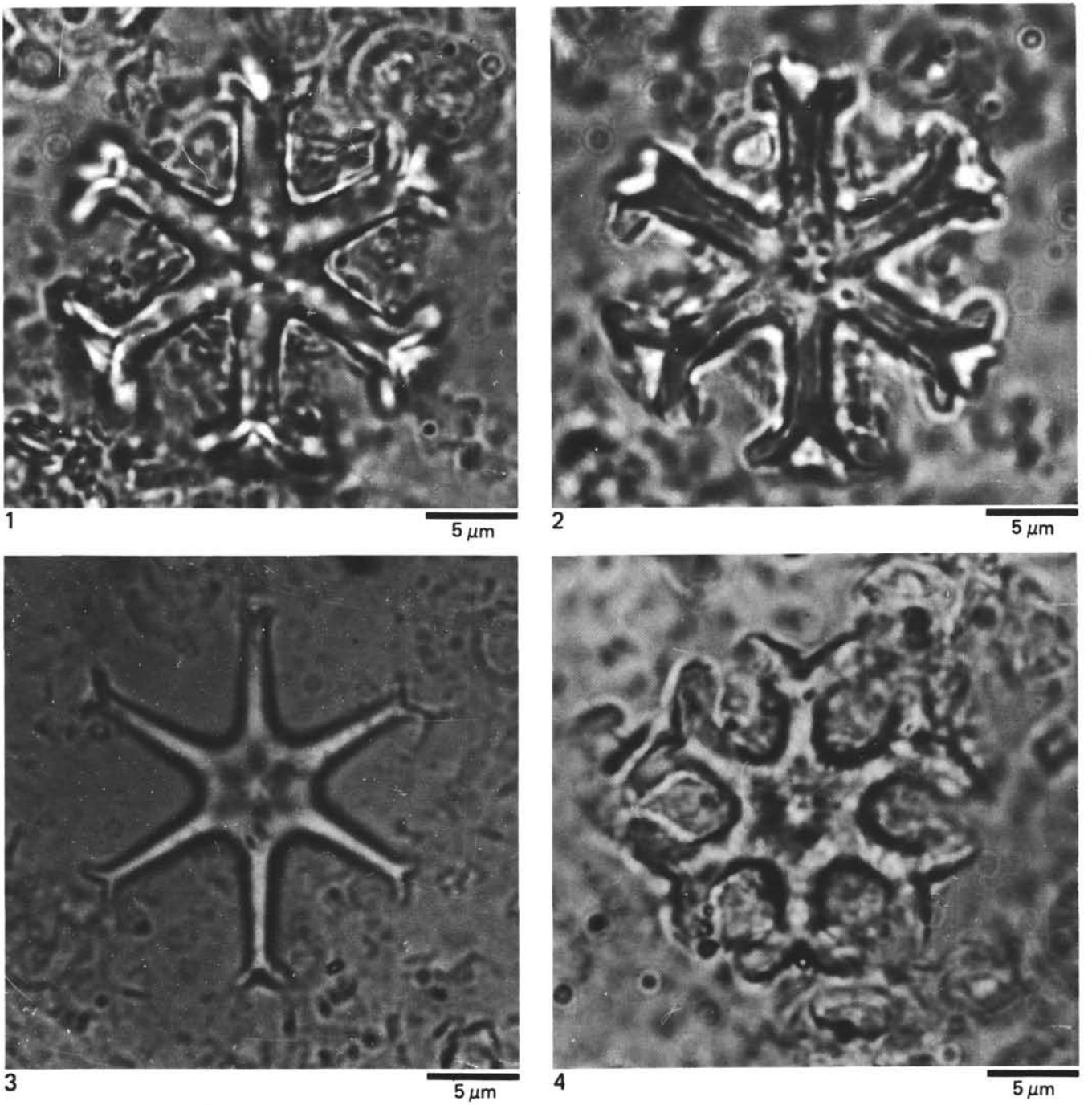


Plate 22. **1.** *Discoaster pseudovariabilis*, Sample 530A-15-6, 77–78 cm, NL, high focus; **2.** *D. pseudovariabilis*, Sample 530A-15-6, 77–78 cm, NL, low focus; **3.** *D. decorus*, Sample 530A-12-3, 72–73 cm, NL; **4.** *D. icarus*, Sample 530A-15-6, 77–78 cm, NL.

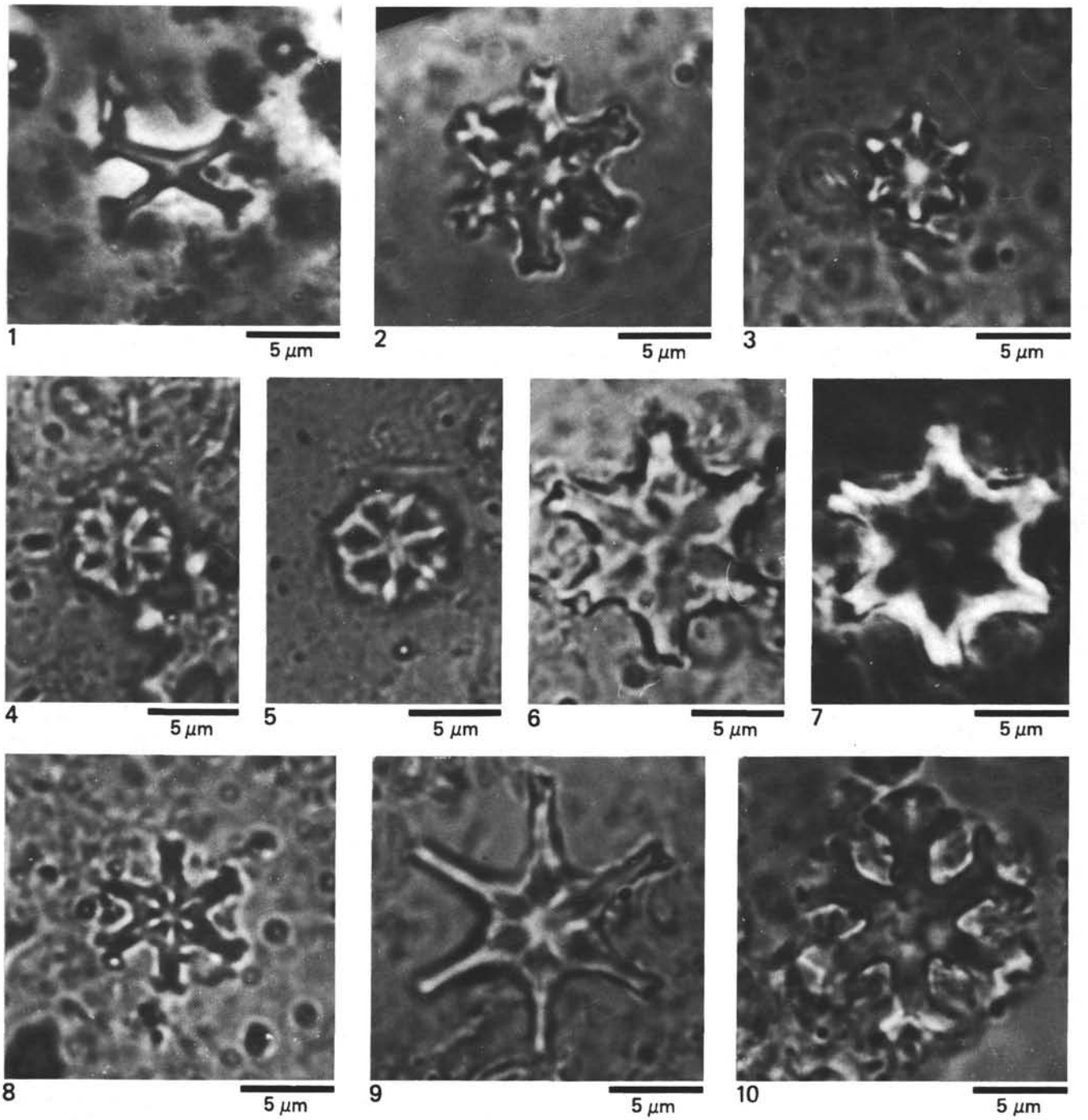


Plate 23. **1.** *Discoaster variabilis*, Sample 530A-20-4, 70–71 cm, NL; **2–3.** *D. musicus*, Sample 530A-20-4, 70–71 cm, NL; **4–5.** *Catinaster coalitus*, Sample 530A-18-3, 73–74 cm, NL; **6.** *D. kugleri*, Sample 530A-15-6, 77–78 cm, NL; **7.** *D. kugleri*, Sample 530A-15-6, 77–78 cm, PHC; **8.** *D. bollii*, Sample 530A-20-4, 70–71 cm, NL; **9.** *D. exilis*, Sample 530A-20-4, 70–71 cm, NL; **10.** *D. icarus*, Sample 530A-15-6, 77–78 cm, NL.

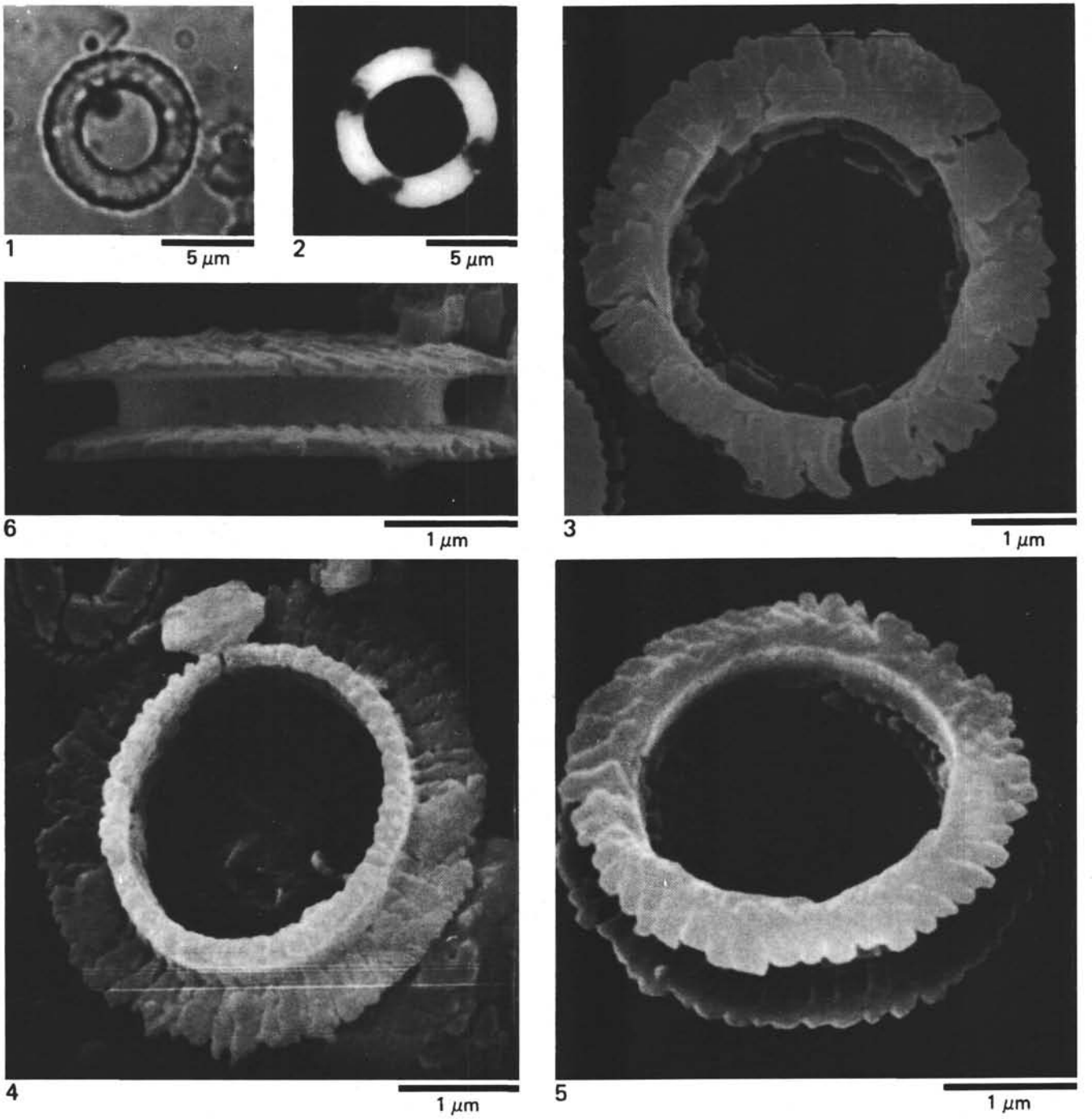


Plate 24. *Calcidiscus aequiscutum.* **1.** Sample 530A-24-2, 28–29 cm, NL; **2.** Sample 530A-24-2, 28–29 cm, XN; **3–4.** Sample 532-36,CC, SEM; **5.** Sample 532-55,CC, SEM; **6.** Sample 532-36,CC, side view, SEM.

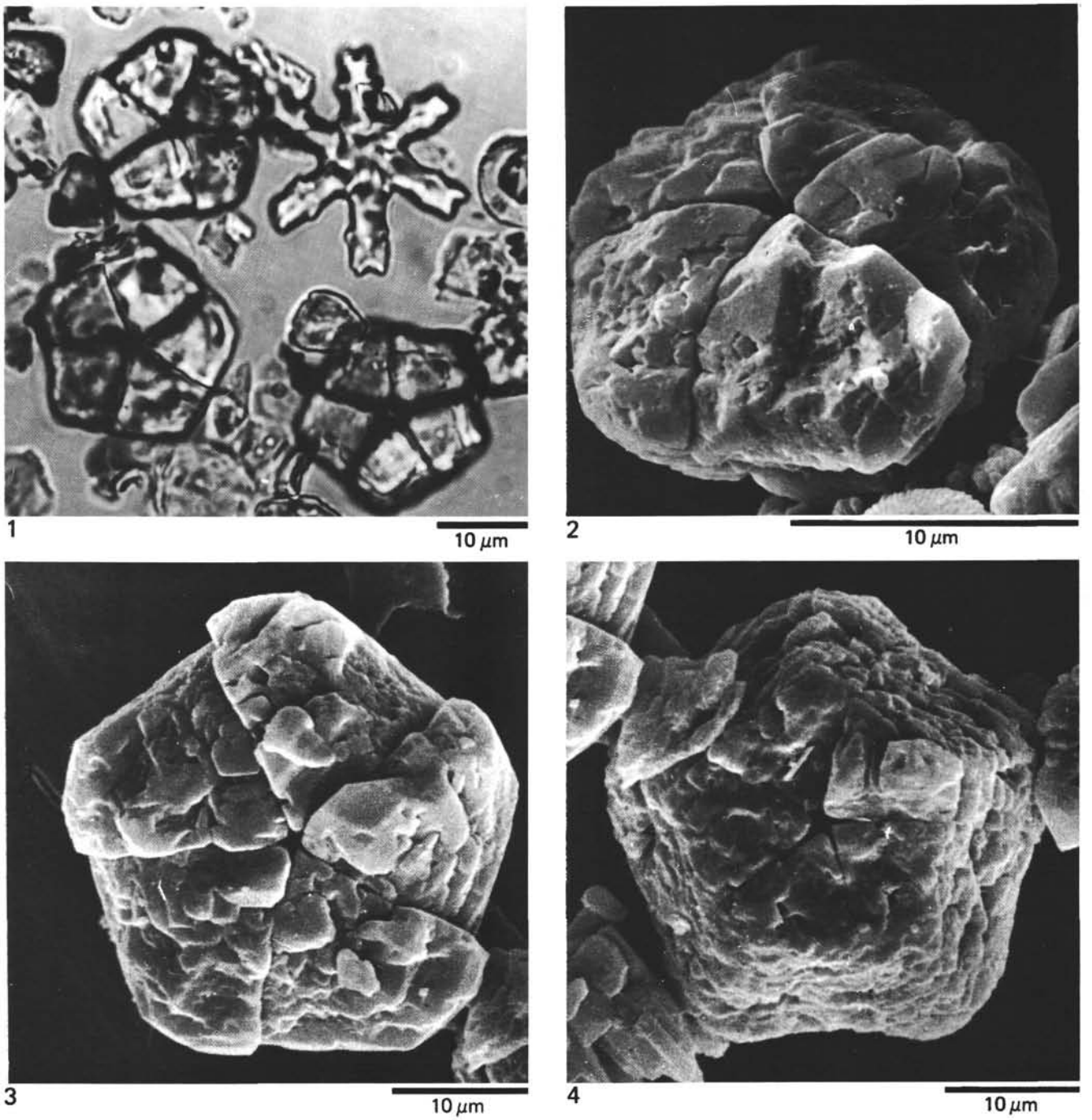


Plate 25. Sample 530A-37-1, 96-97 cm. **1.** *Braarudosphaera bigelowi* and *Discoaster tanii nodifer*, NL; **2-3.** *B. bigelowi*, distal view, SEM; **4.** *B. bigelowi*, proximal view, SEM.

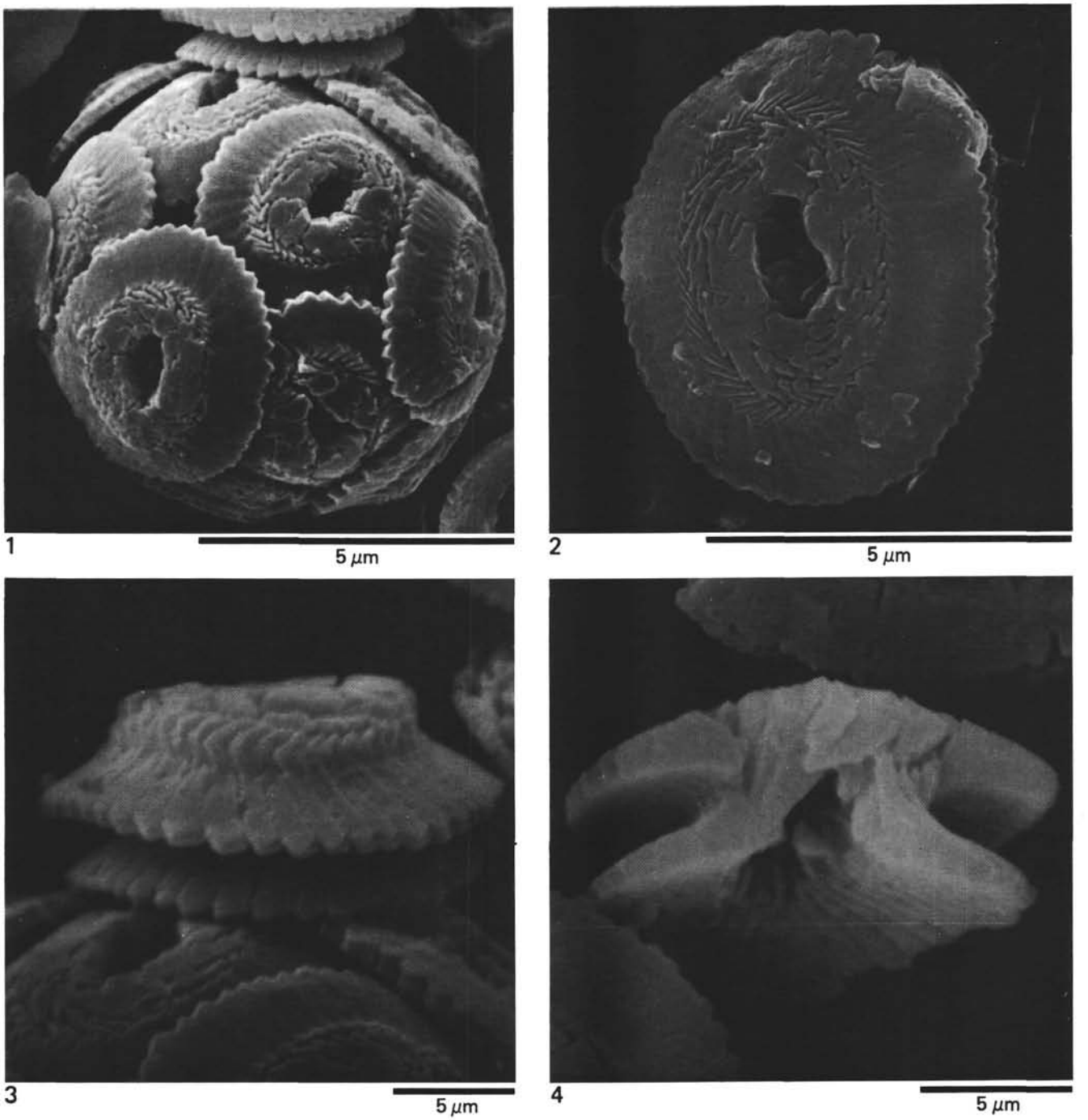


Plate 26. *Reticulofenestra pseudoumbilica.* **1.** Coccosphere, Sample 532-55,CC, SEM; **2.** Distal view, Sample 530B-29,CC, SEM*; **3.** Side view, Sample 532-55,CC, SEM; **4.** Fractured cross section, Sample 532-55,CC, SEM.

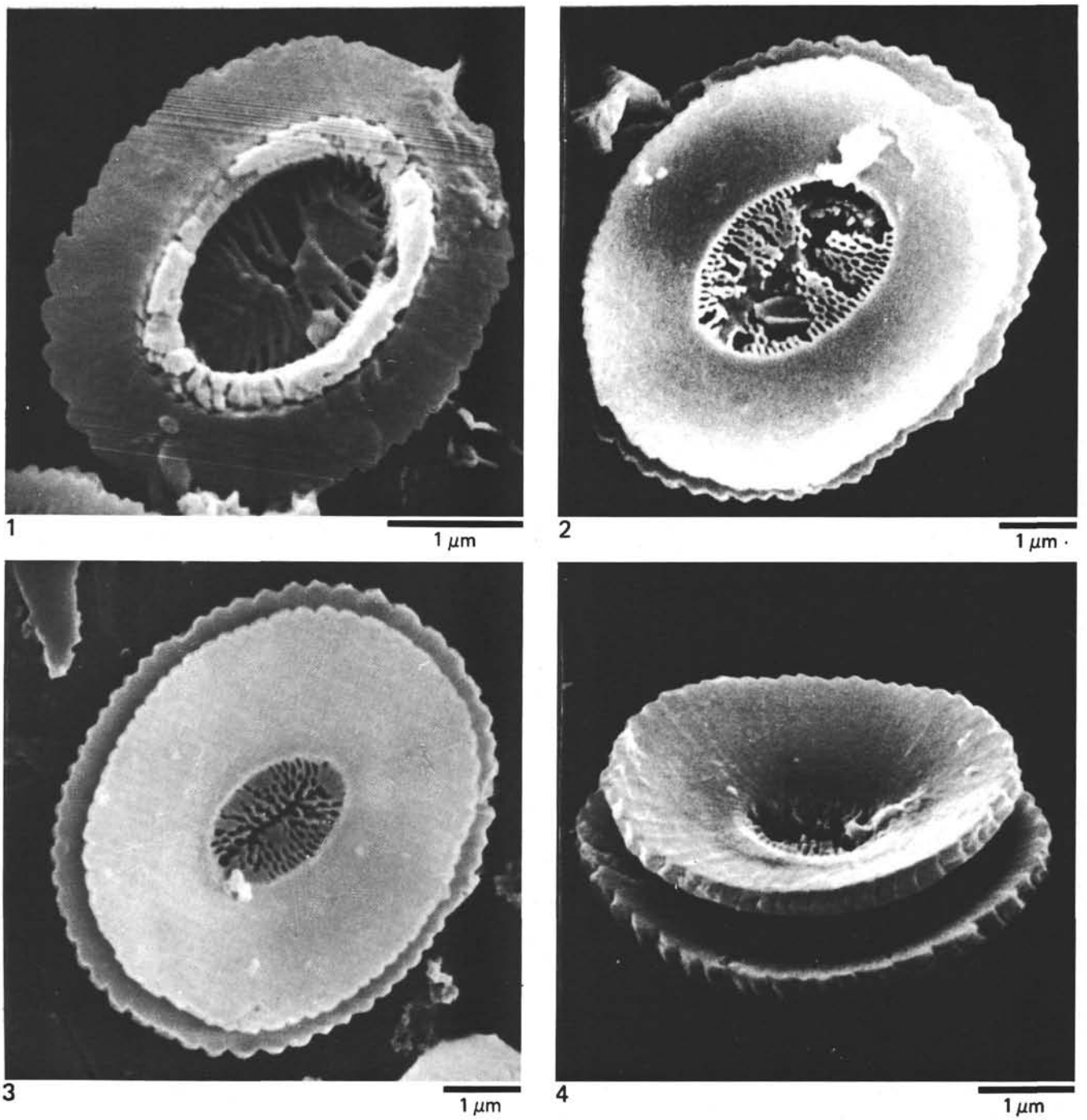


Plate 27. *Reticulofenestra pseudoumbilica.* **1.** Distal view of proximal plate, Sample 532-36,CC, SEM; **2.** Proximal view, Sample 532-55,CC, SEM; **3.** Proximal view, Sample 532-46,CC, SEM; **4.** Oblique proximal view, Sample 532-46,CC, SEM.

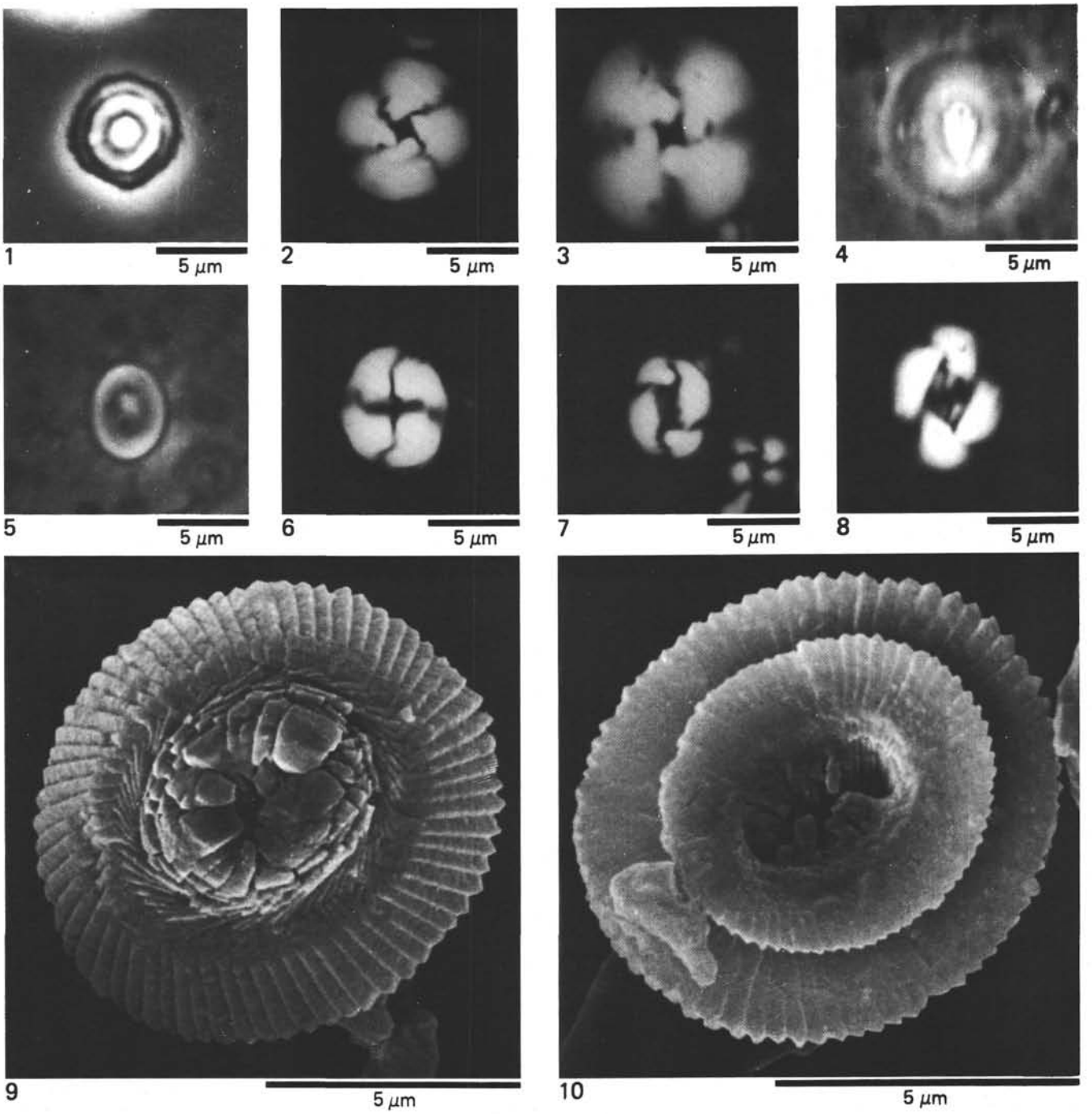


Plate 28. **1.** *Cyclicargolithus floridanus*, Sample 530A-49-1, 23–24 cm, PHC; **2.** *C. floridanus*, Sample 530A-35-1, 30–31 cm, XN; **3.** *C. abisectus*, Sample 530A-35-1, 30–31 cm, XN; **4, 5.** *C. orangensis*, Sample 530A-35-1, 30–31 cm, XN; **6.** *Reticulofenestra gartneri*, Sample 530A-35-1, 30–31 cm, PHC; **7.** *Coccolithus orangensis*, Sample 530A-35-1, 30–31 cm, PHC; **8.** *R. gartneri*, Sample 530A-35-1, 30–31 cm, XN; **9.** *R. bisecta*, distal view, Sample 530A-37-1, 96–97 cm, SEM; **10.** *R. bisecta*, proximal view, Sample 530A-37-1, 96–97 cm, SEM.

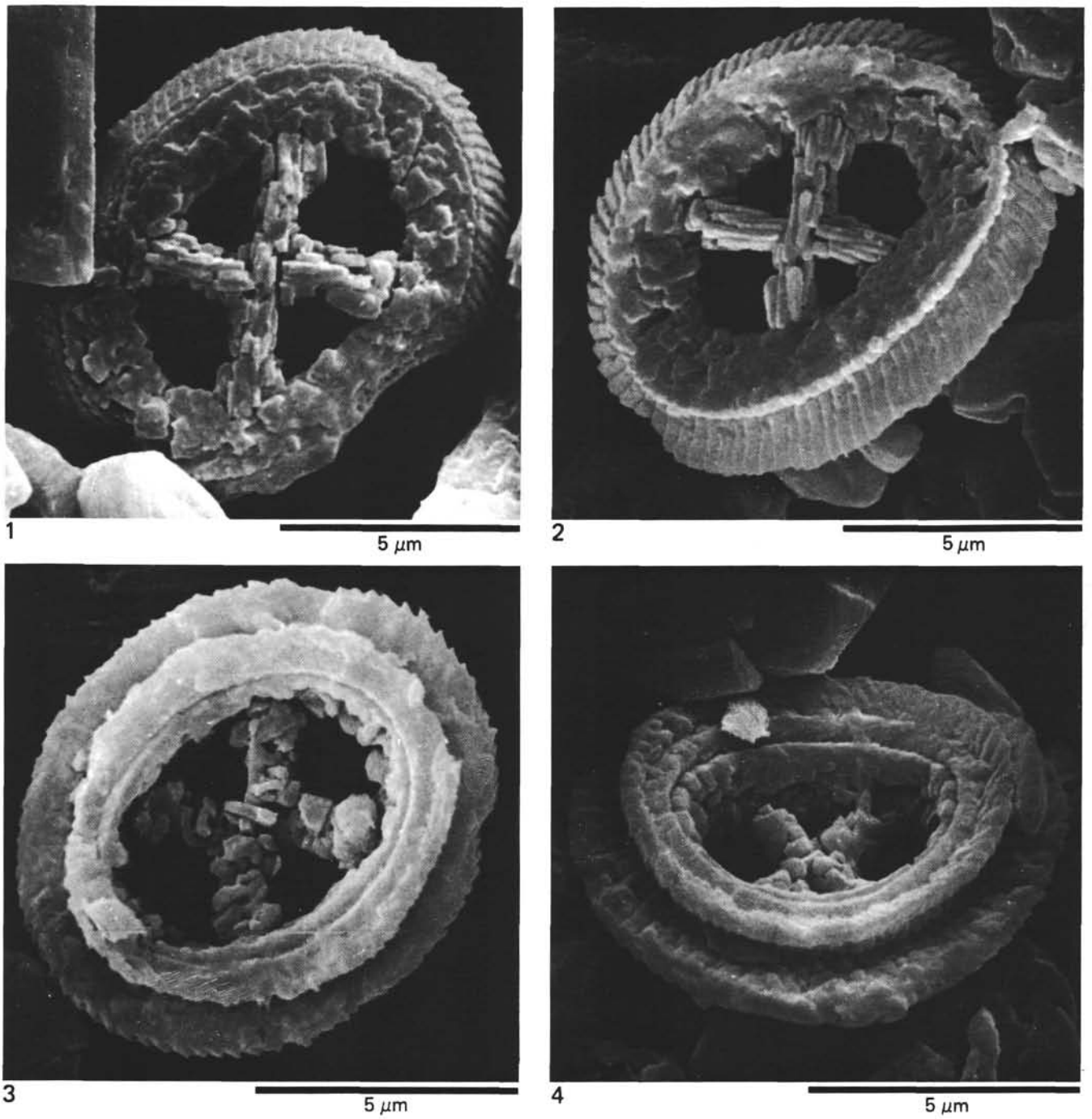


Plate 29. *Chiasmolithus altus*, Sample 530A-37-1, 96–97 cm, SEM. **1–2.** Distal view. **3.** Proximal view. **4.** Oblique proximal view.

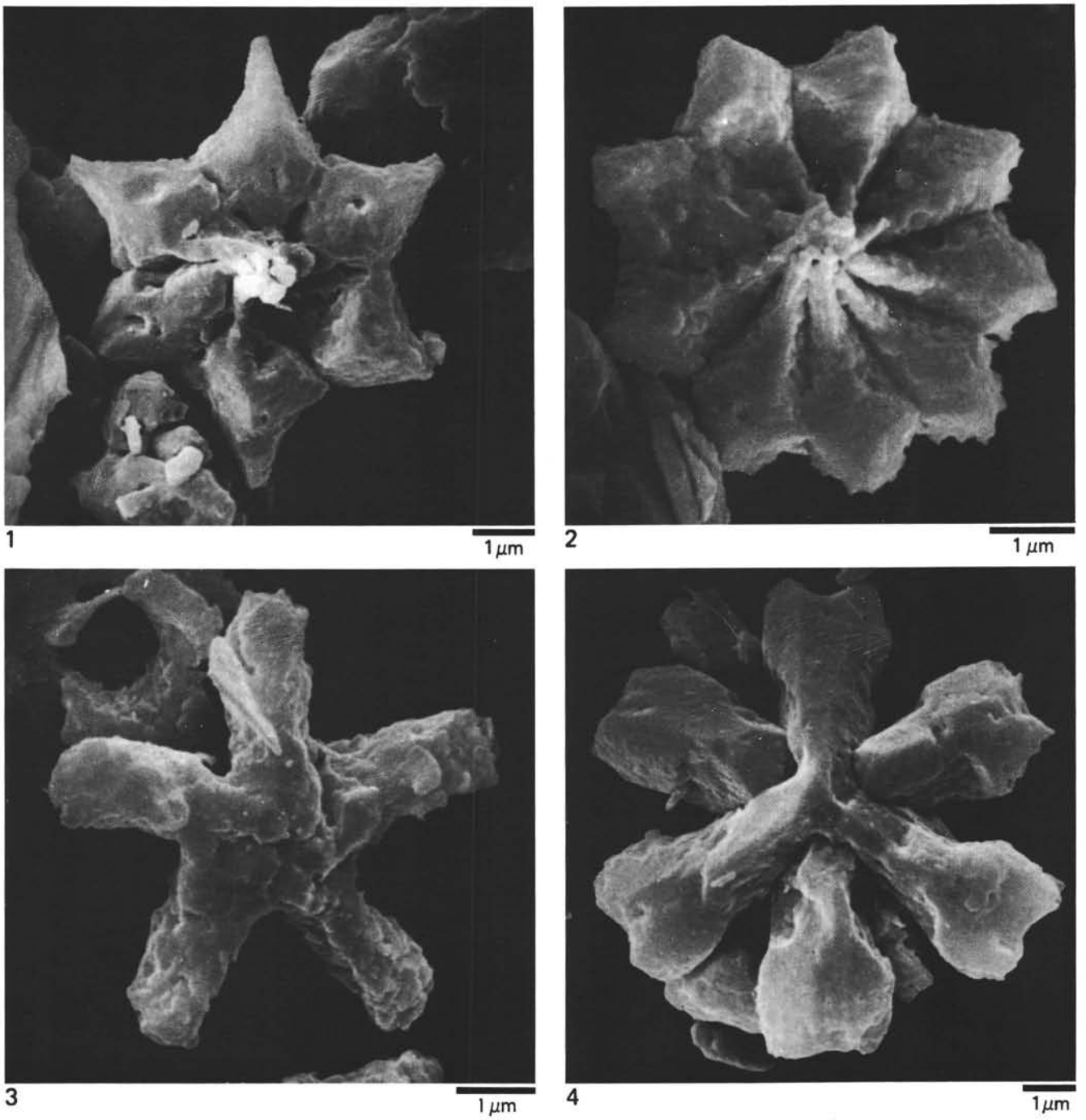


Plate 30. Sample 530A-37-1, 96–97 cm. **1.** *Discoaster saipanensis*, SEM; **2.** *D. barbadiensis*, SEM; **3.** *D. tanii*,SEM; **4.** *D. trinus*, heavily calcified, SEM.

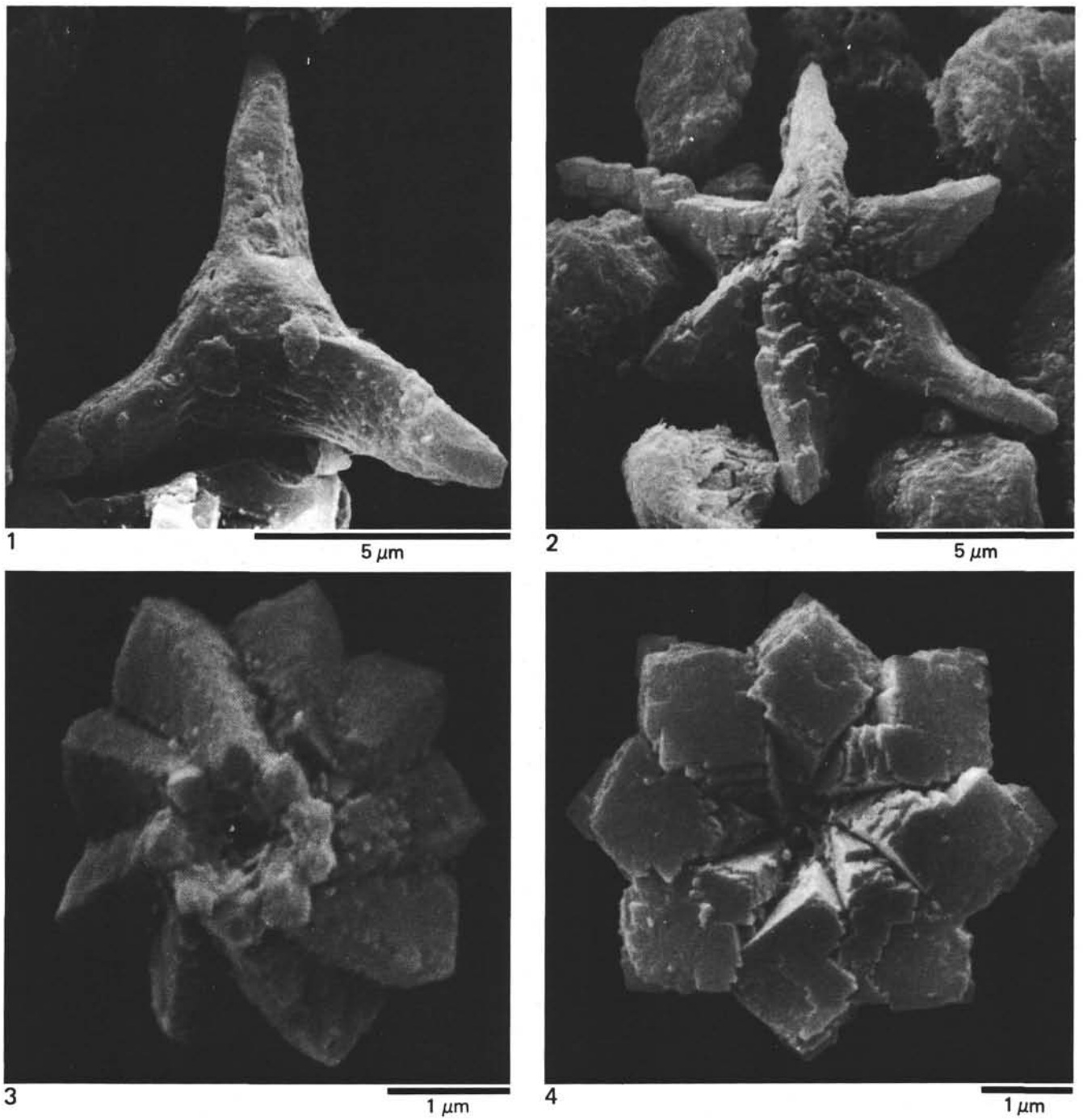


Plate 31. Sample 530A-39-2, 21–22 cm. **1.** *Tribrachiatus orthostylus*, SEM; **2.** *Discoaster lodoensis*, SEM; **3.** *Discoasteroides kuepperi*, proximal view, heavily calcified, SEM; **4.** *D. kuepperi*, distal view, heavily calcified, SEM.

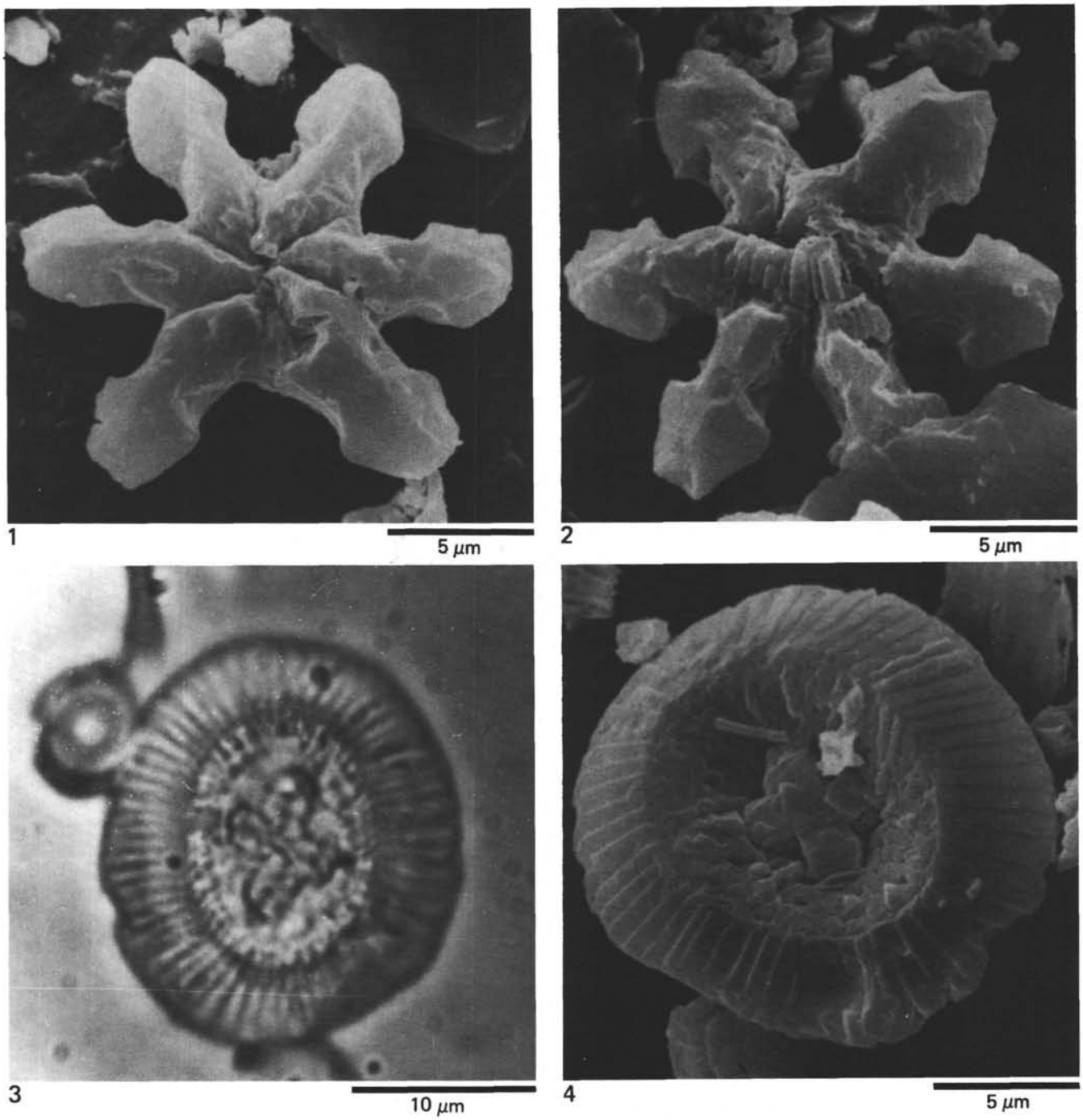


Plate 32. Sample 530A-43-2, 20–21 cm. **1–2.** *Discoaster binodosus*, SEM; **3.** *Chiasmolithus consuetus*, NL; **4.** *C. consuetus*, distal view, SEM.

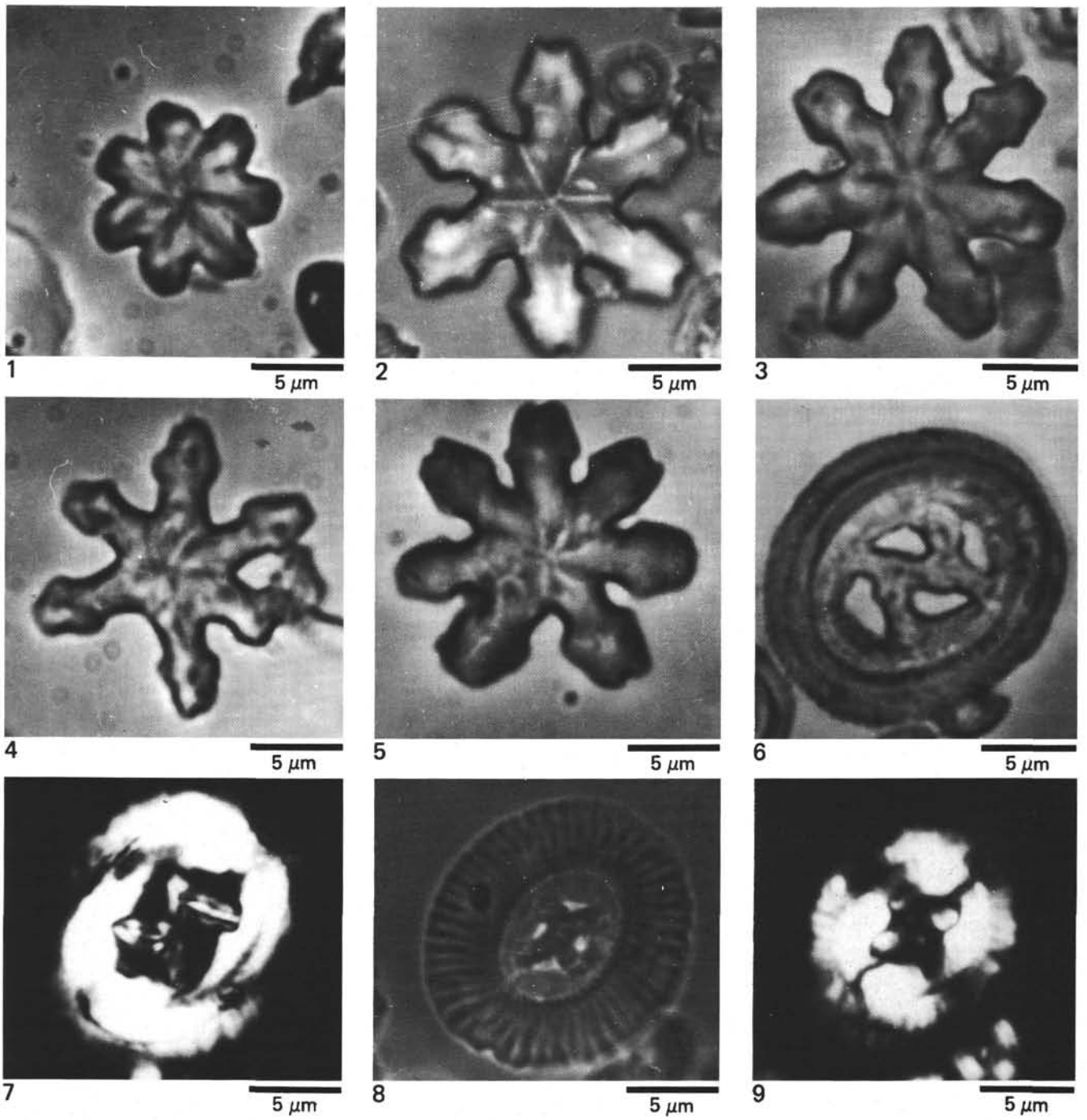


Plate 33. Sample 530A-43-2, 20–21 cm. **1.** *Discoaster* sp., NL; **2–4.** *D. binodosus*, NL; **5.** *D. binodosus*, NL (Au); **6.** *Chiasmolithus consuetus*, NL (Au). **7.** *C. consuetus*, XN; **8.** *C. consuetus*, NL, **9.** *C. consuetus*, XN.

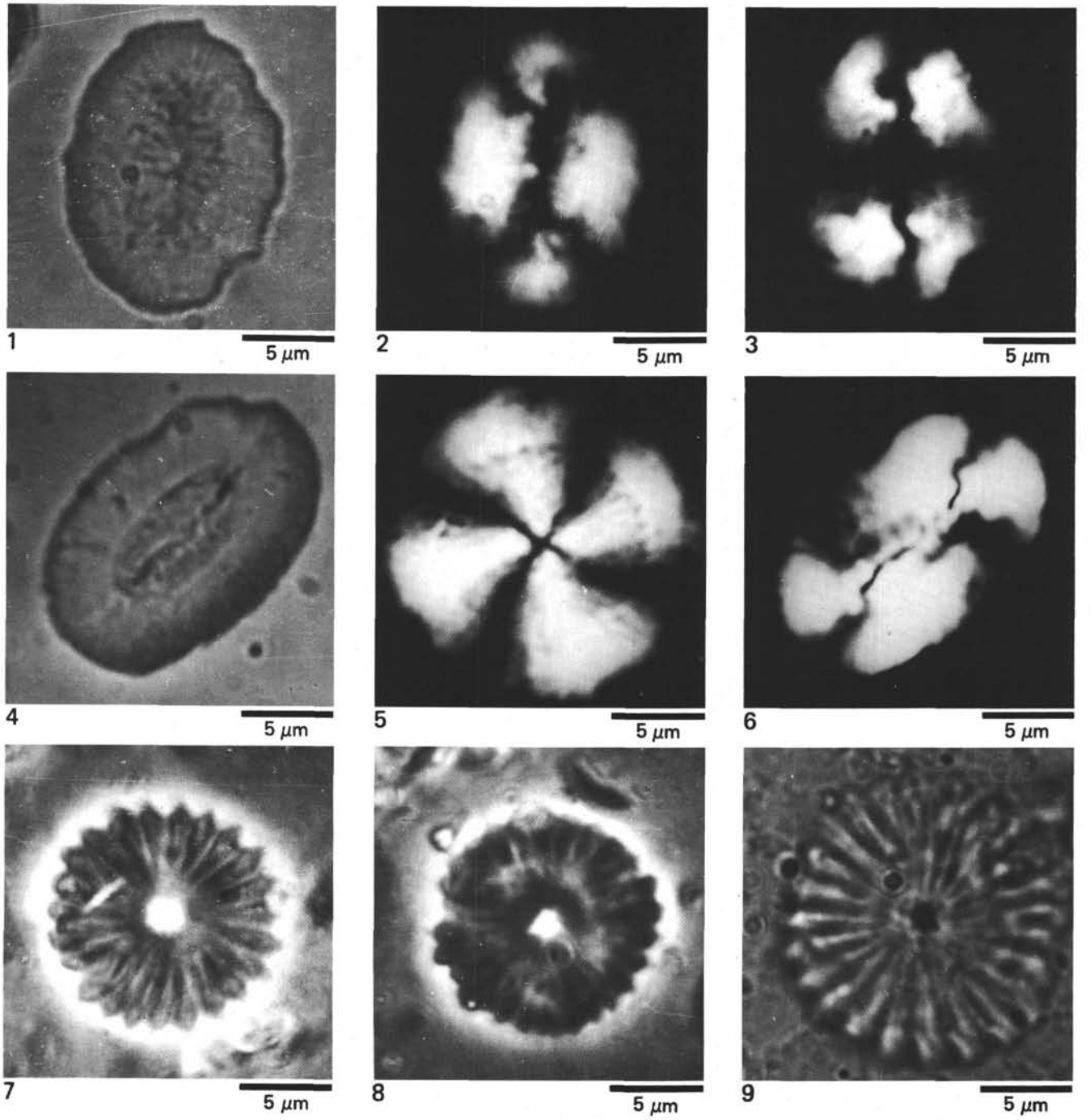


Plate 34. **1.** *Ellipsolithus macellus*, Sample 530A-43-2, 20–21 cm, NL (Au); **2–3.** *E. macellus*, Sample 530A-43-2, 20–21 cm, XN; **4.** *E. macellus*, Sample 530A-43-2, 20–21 cm, NL (Au); **5.** *Heliolithus kleinpellii*, Sample 530A-45-1, 57–58 cm, XN; **6.** *E. macellus*, Sample 530A-43-2, 20–21 cm, XN; **7.** *Discoaster lenticularis*, Sample 530A-41-1, 33–34 cm, NL; **8.** *D. lenticularis*, Sample 530A-41-1, 33–34 cm, PHC; **9.** *D. multiradiatus*, Sample 530A-41-1, 33–34 cm, NL.

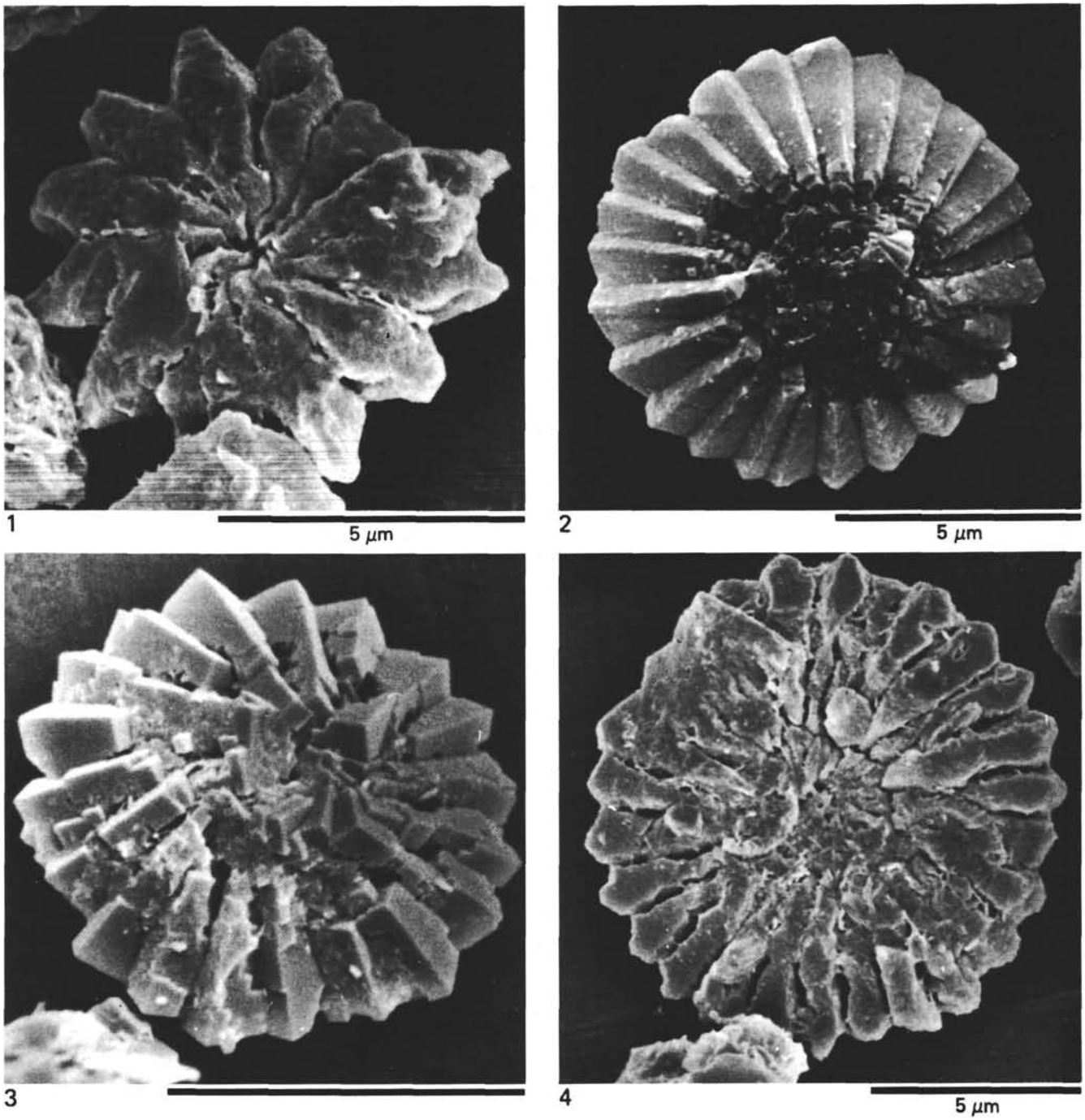


Plate 35. **1.** *Discoaster salisburgensis*, Sample 530A-41,CC, SEM; **2.** *D. multiradiatus*, Sample 530A-39-2, 21–22 cm, SEM; **3–4.** *D. multiradiatus*, Sample 530A-41,CC, SEM.

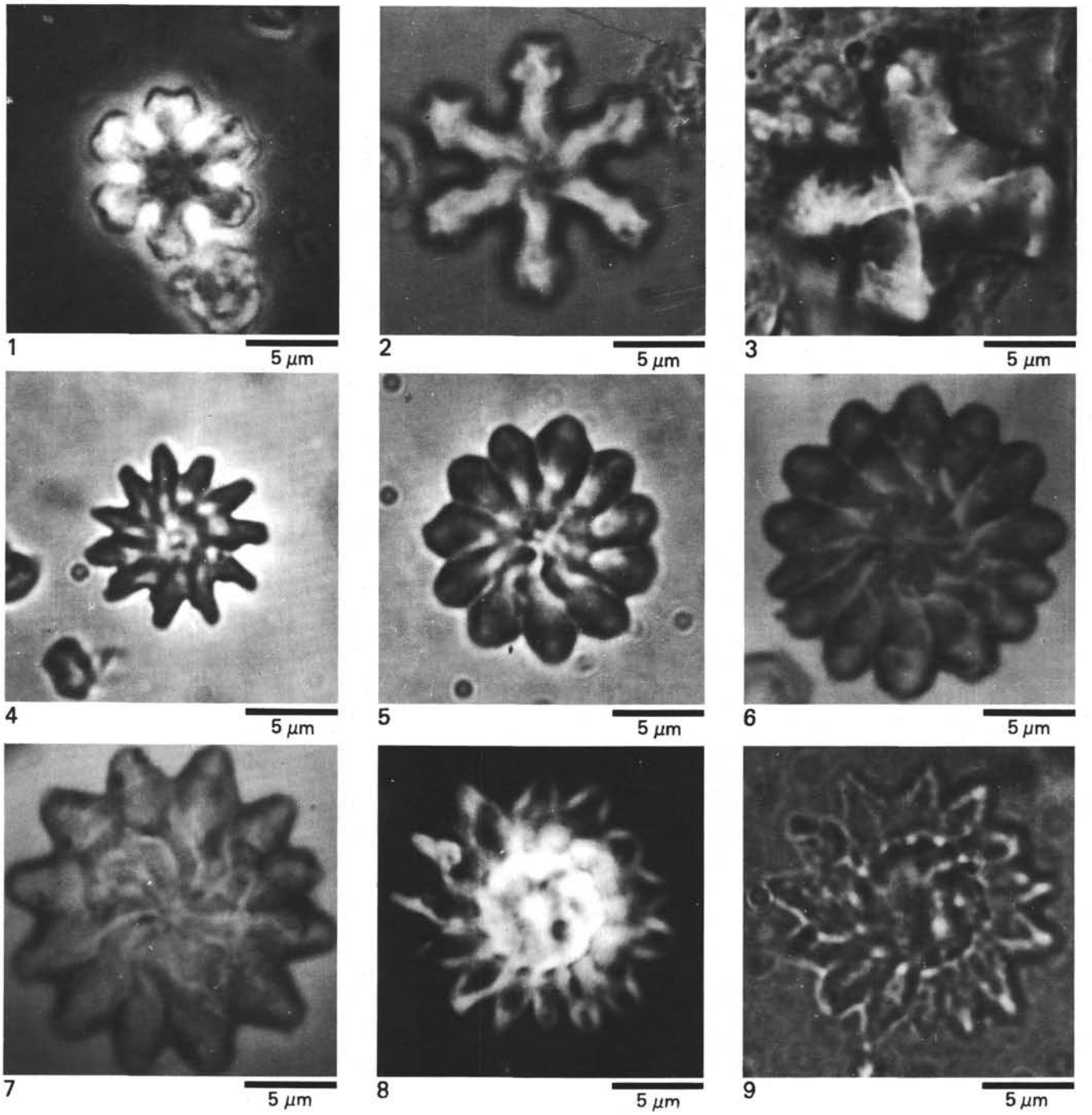


Plate 36. **1.** *Discoaster deflandrei*, Sample 530A-35-1, 30–31 cm, PHC; **2.** *D. distinctus*, Sample 530A-43-2, 20–21 cm, NL; **3.** *Nannotetrina swasticoides*, Sample 530A-38-1, 39–40 cm, NL; **4.** *Discoaster* sp., Sample 530A-43-2, 20–21 cm, NL (Au); **5–7.** *D. salisburgensis*, Sample 530A-43-2, 20–21 cm, NL (Au); **8.** *D. splendidus*, Sample 530A-43-1, 15–16 cm, XN; **9.** *D splendidus*, Sample 530A-43-1, 15–16 cm, NL.

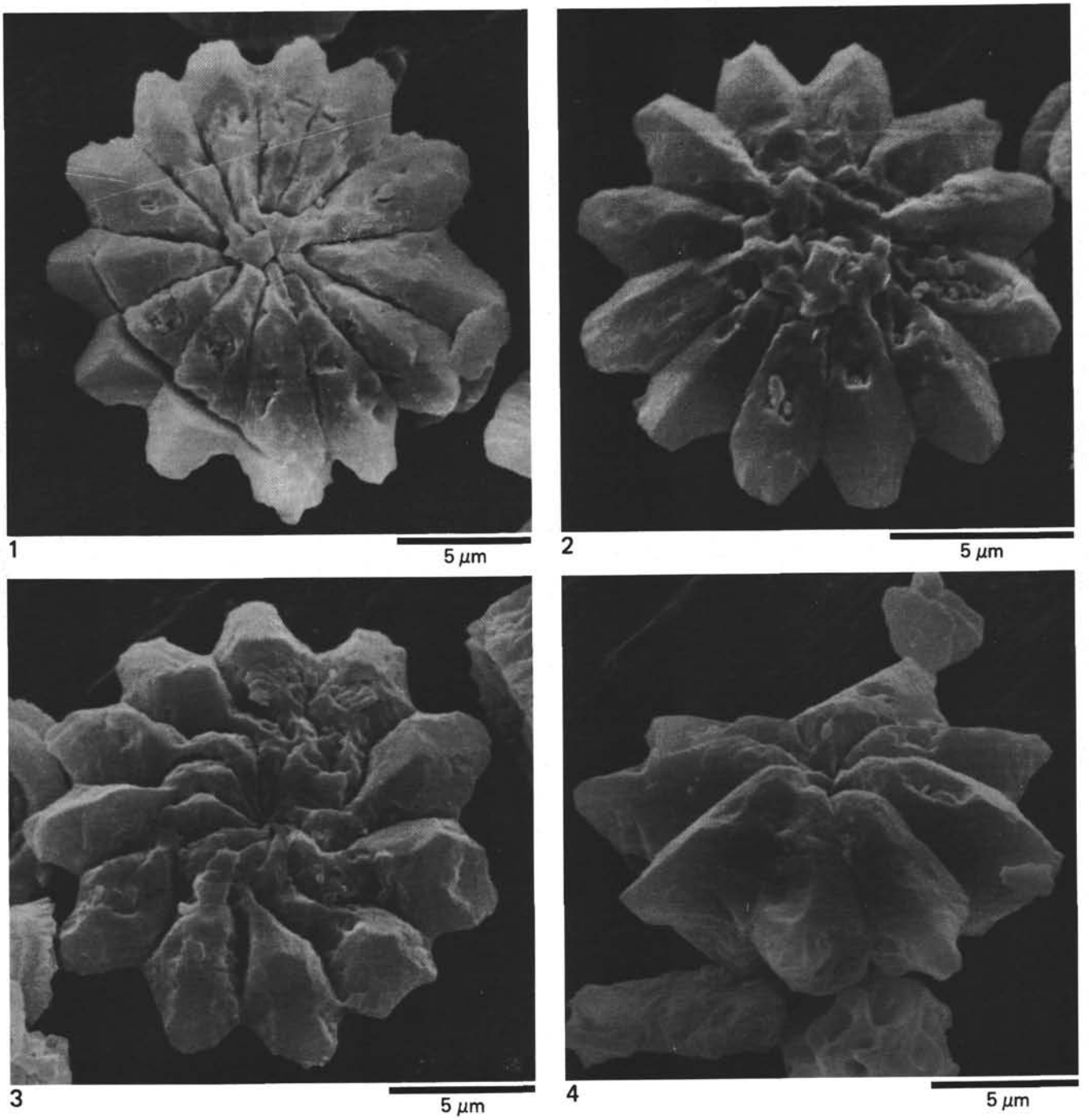


Plate 37. **1–3.** *Discoaster salisburgensis*, Sample 530A-43-2, 20–21 cm, SEM; **4.** *D. salisburgensis*, side view, Sample 530A-43-2, 20–21 cm, SEM.

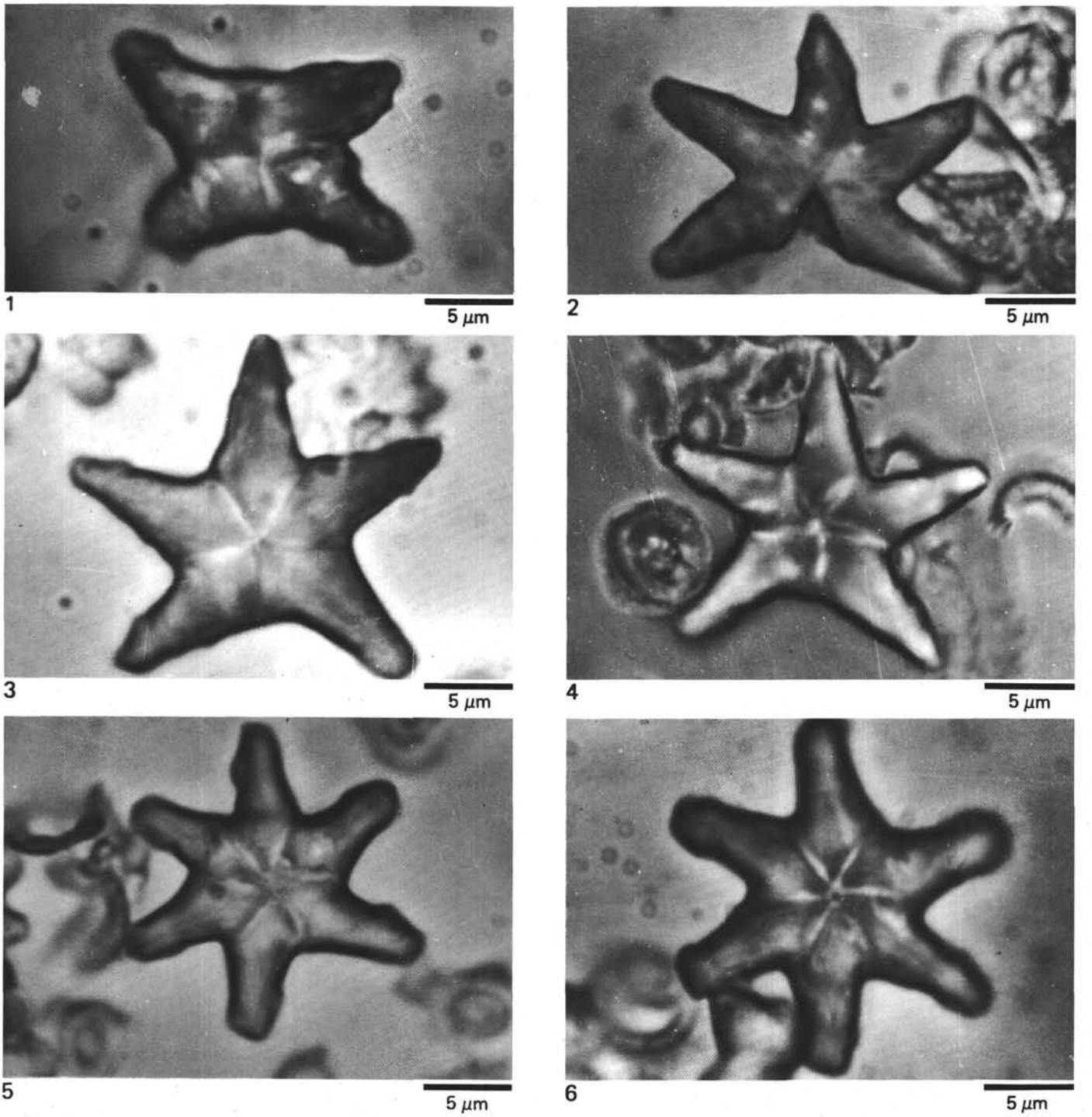


Plate 38. **1–6.** *Discoaster okadai*, Sample 530A-43-2, 20–21 cm, NL (Au).

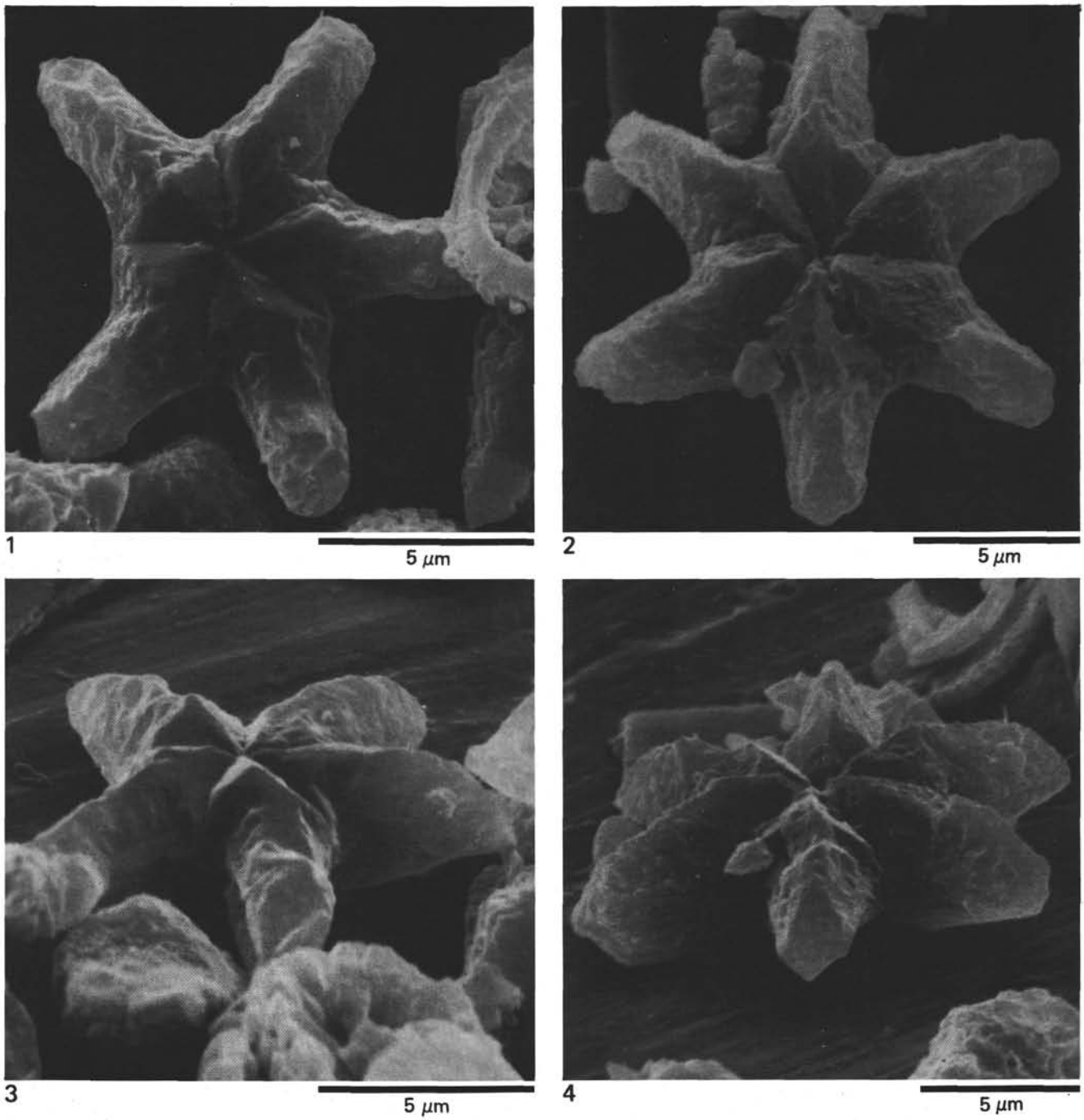


Plate 39. **1–4.** *Discoaster okadai*, Sample 530A-43-2, 20–21 cm, SEM.

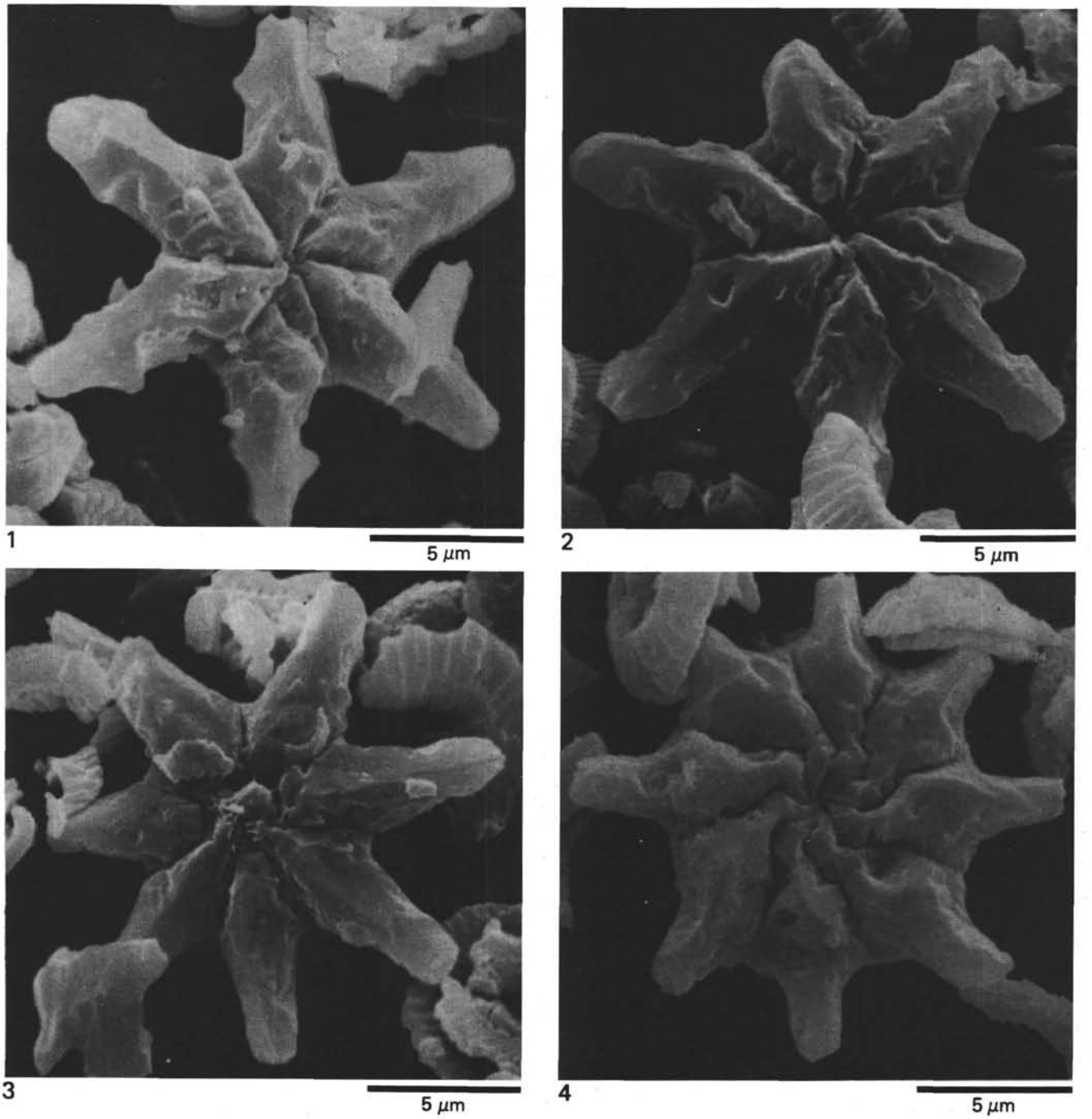


Plate 40. **1–3.** *Discoaster okadai*, Sample 530A-43-2, 20–21 cm, SEM; **4.** *D. mediosus*, Sample 530A-43-2, 20–21 cm, SEM.

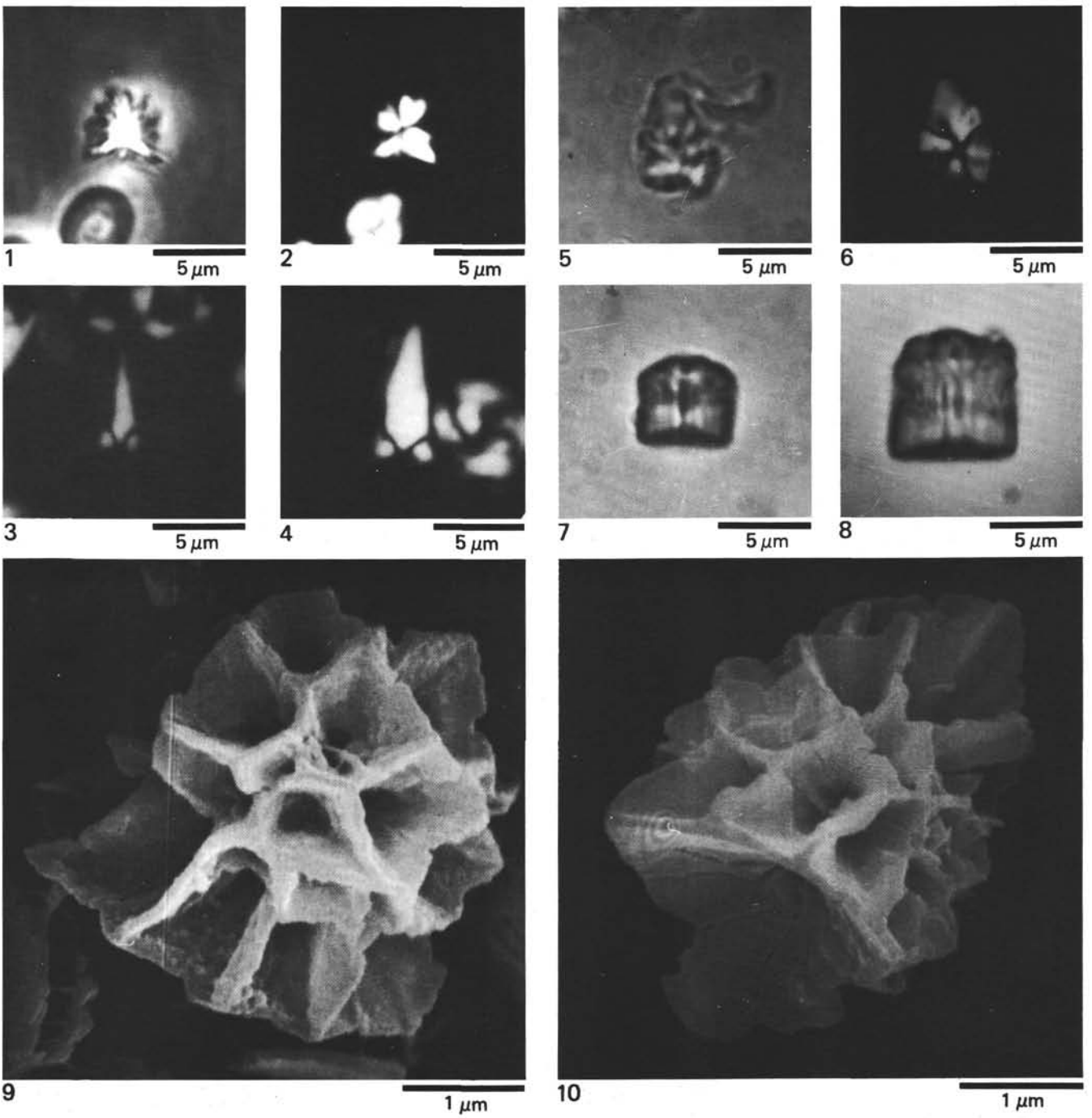


Plate 41. **1.** *Sphenolithus abies*, Sample 532-55,CC, PHC; **2.** *S. abies*, Sample 532-55,CC, XN; **3.** *S. distentus*, Sample 530A-37-2, 1–2 cm, XN; **4.** *S. distentus*, Sample 530A-37-1, 80–81 cm, XN; **5.** *S. radians*, Sample 530A-43,CC, NL; **6.** *S. radians*, Sample 530A-43,CC, XN; **7–8.** *Fasciculithus involutus*, Sample 530A-43-2, 20–21 cm, NL (Au); **9.** *S. abies*, Sample 532-55,CC, SEM; **10.** *S. abies*, Sample 532-46,CC, SEM.

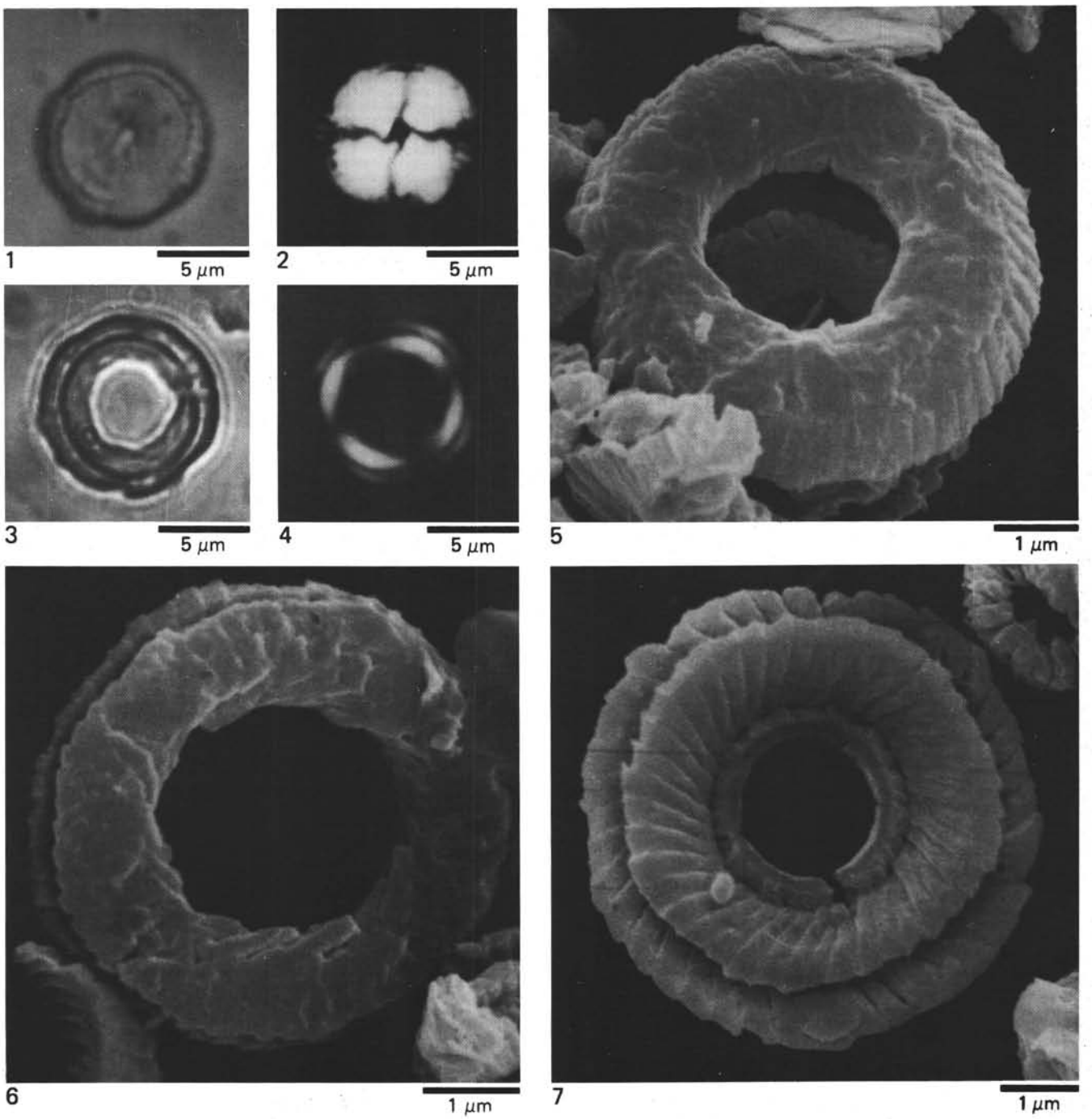


Plate 42. Sample 530A-43-2, 20–21 cm. **1.** *Coccolithus crassus*, NL (Au); **2.** *C. crassus*, XN; **3.** *Cyclolithella robusta*, NL (Au); **4.** *C. robusta*, XN; **5.** *C. robusta*, SEM; **6.** *C. robusta*, SEM; **7.** *Calcidiscus formosus*, proximal view, SEM.

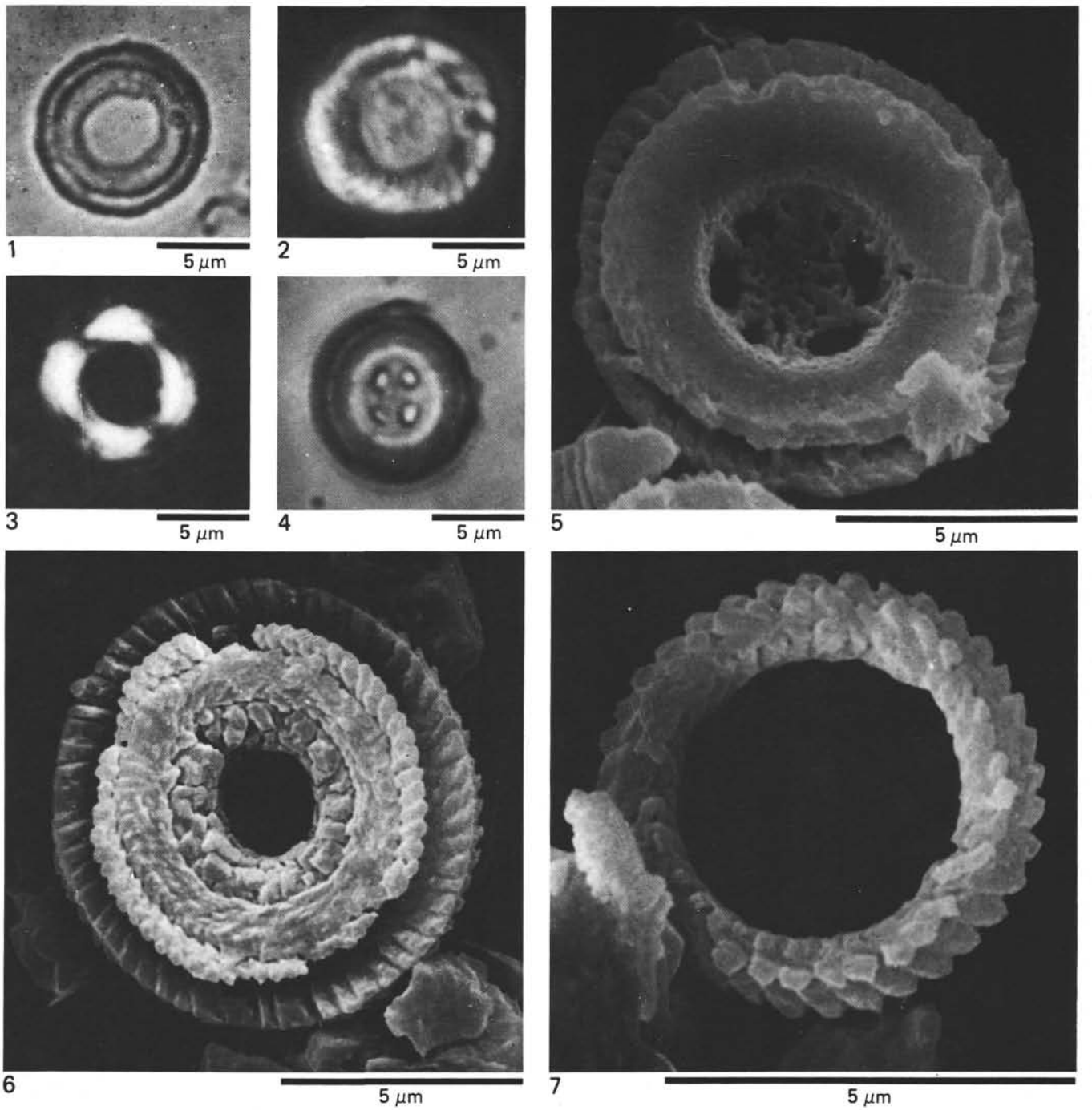


Plate 43. **1.** *Cyclolithella robusta*, Sample 530A-43-2, 20–21 cm, NL (Au); **2.** *C. robusta*, Sample 530A-43-2, 20–21 cm, PHC;**3.** *C. robusta*, Sample 530A-43-2, 20–21 cm, XN; **4.** *Toweius eminens*, Sample 530A-43-2, 20–21 cm, NL (Au); **5.** *Toweius* cf. *T. craticulus*, proximal view, Sample 530A-43-2, 20–21 cm, SEM; **6.** *Ericsonia cava*, proximal view, Sample 530A-37-1, 96–97 cm, SEM; **7.** *Cyclolithella prionion*, Sample 530A-37-1, 96–97 cm, SEM.

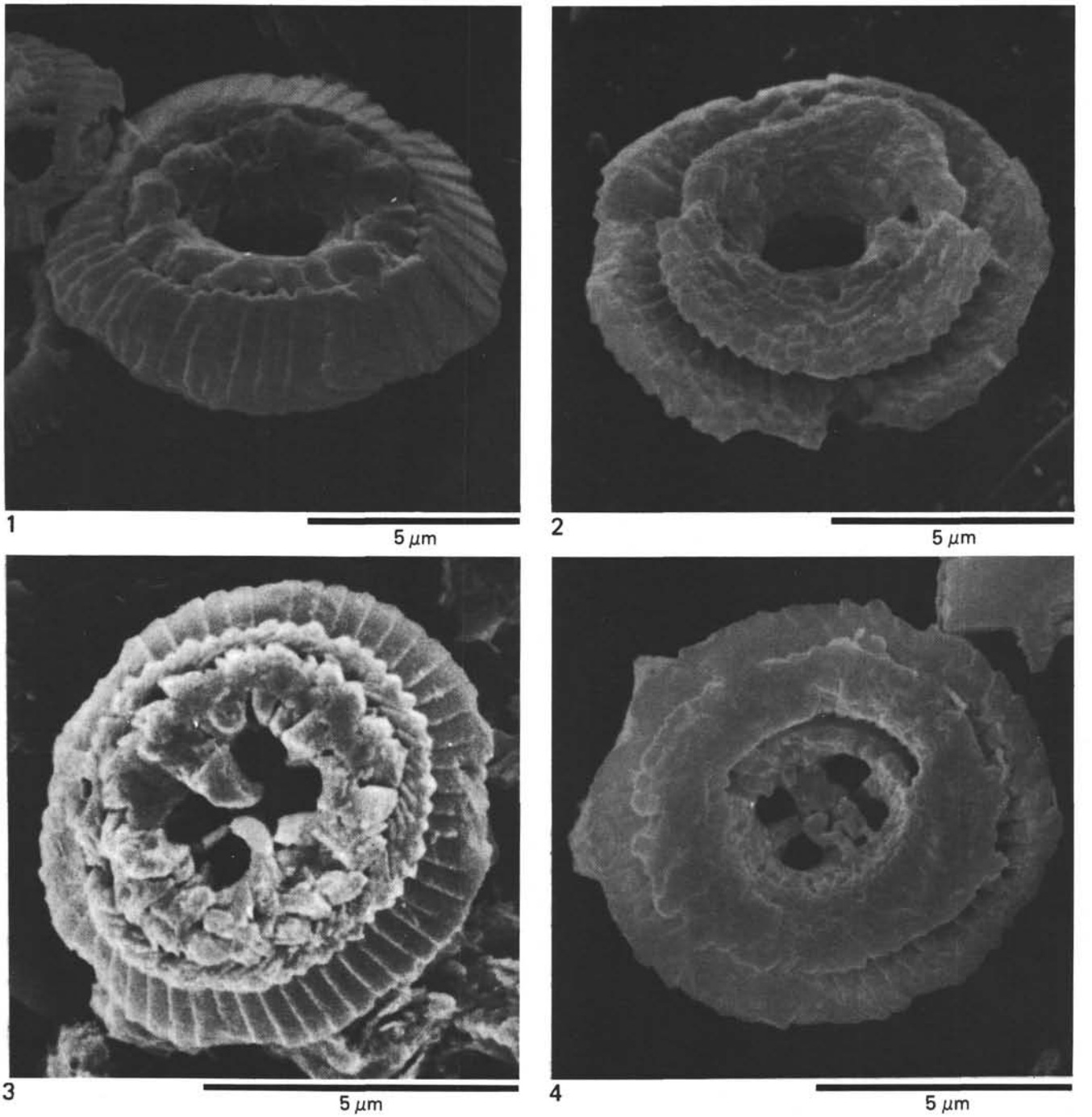


Plate 44. Sample 530A-43-2, 20–21 cm. **1.** *Ericsonia cava*, distal view, SEM; **2.** *E. cava*, proximal view, SEM; **3.** *Toweius eminens*, distal view, SEM; **4.** *T. eminens*, proximal view, SEM.

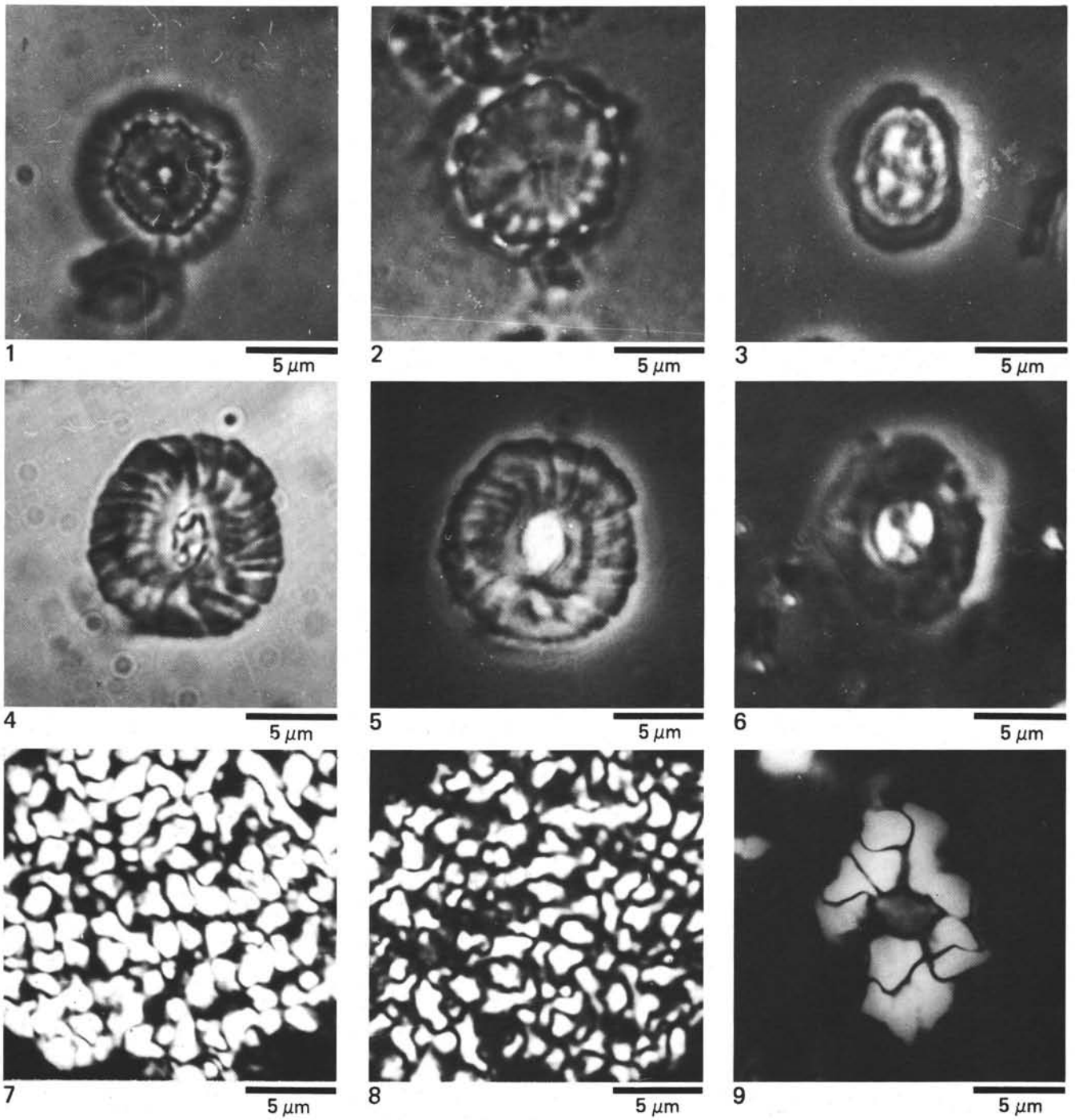


Plate 45. **1–2.** *Heliolithus cantabriae*, Sample 530A-43,CC, NL; **3.** *Chiasmolithus danicus*, Sample 530A-47-1, 142–143 cm, PHC; **4.** *Biscutum* cf. *B. castrorum*, Sample 530A-49-1, 73–74 cm, NL; **5.** *Biscutum* cf. *B. castrorum*, Sample 530A-49-1, 73–74 cm, PHC; **6.** *Markalius astroporus*, Sample 530A-50-1, 6–7 cm, PHC; **7–8.** *Thoracosphaera operculata*, Sample 530A-50-2, 13–14 cm, XN; **9.** *Thoracosphaera saxea*, Sample 530A-50-2, 13–14 cm, XN.

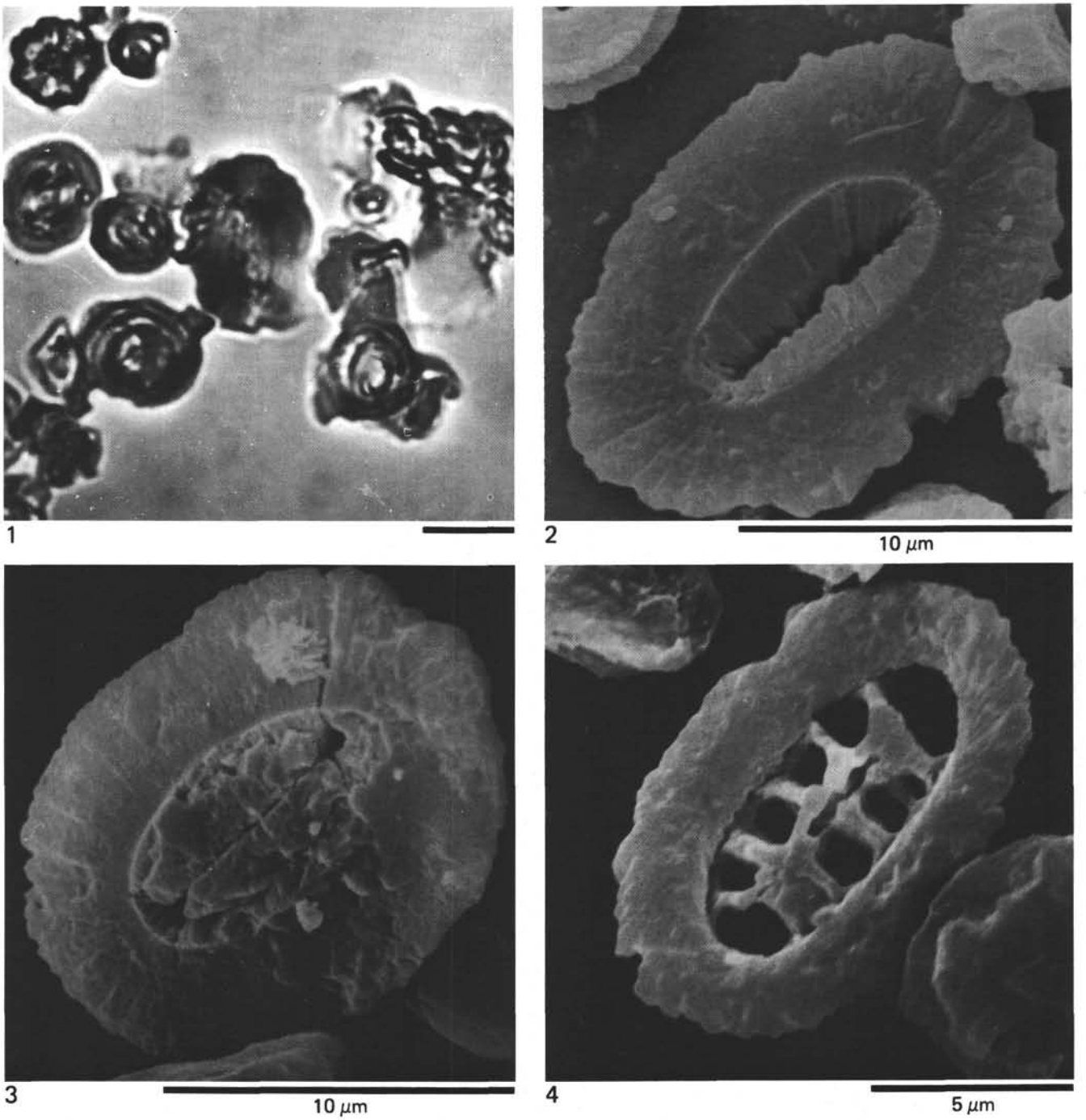


Plate 46. Sample 530A-43-2, 20–21 cm. **1.** *Ellipsolithus macellus*, partly polarized (Au); **2.** *E. macellus*, SEM; **3.** *E. macellus*, SEM; **4.** *E. distichus*, SEM.

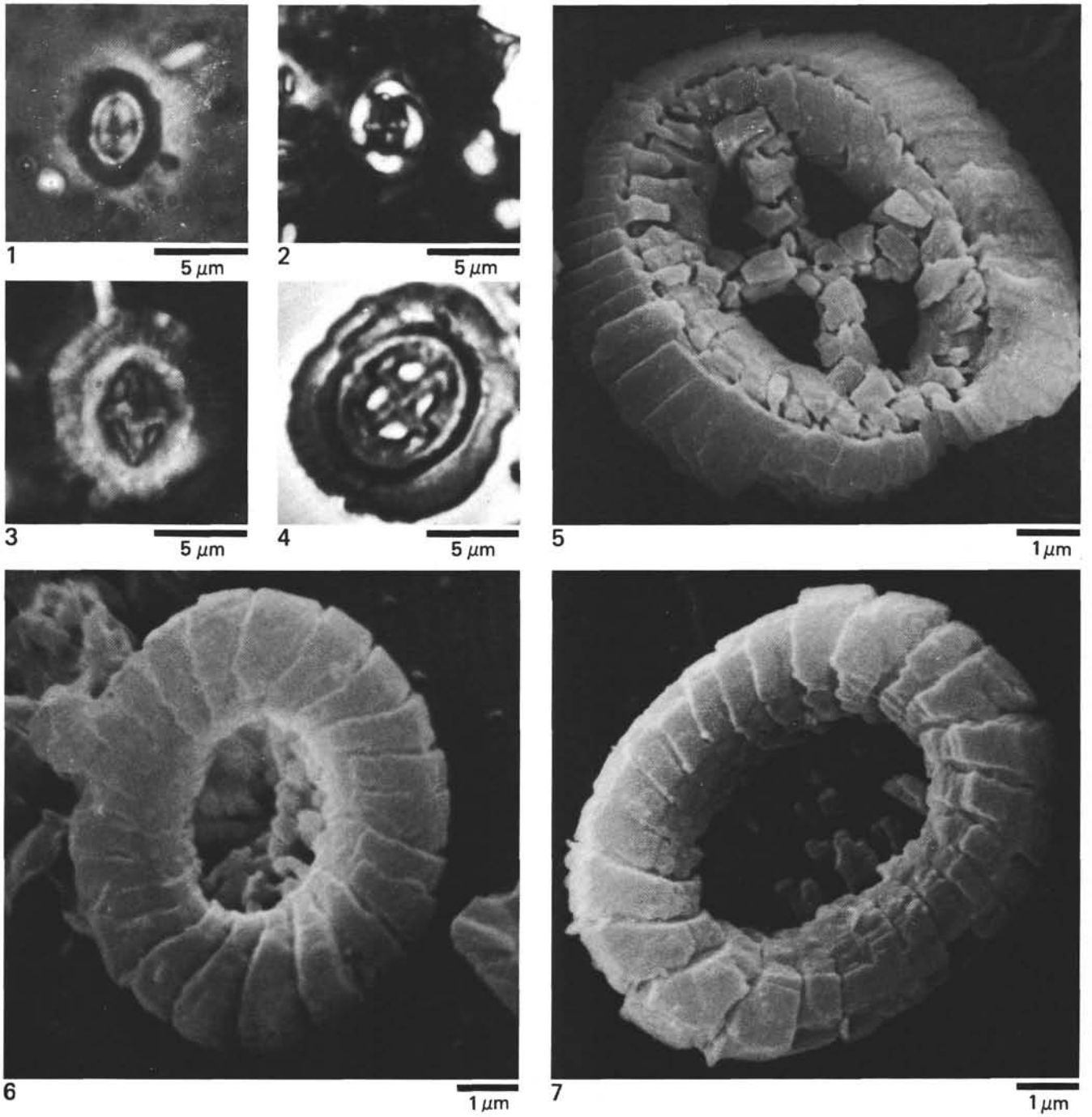


Plate 47. **1.** *Cruciplacolithus primus*, Sample 530A-50-1, 6–7 cm, PHC; **2.** *C. primus*, Sample 530A-50-1, 6–7 cm, XN; **3.** *C. tenuis*, Sample 530A-47-1, 142–143 cm, PHC; **4.** *C. tenuis*, Sample 530A-43-2, 20–21 cm, NL (Au); **5.** *C. edwardsii*, distal view, Sample 530A-50-1, 6–7 cm, SEM; **6–7.** *Biscutum* sp., Sample 530A-50-1, 6–7 cm, SEM.

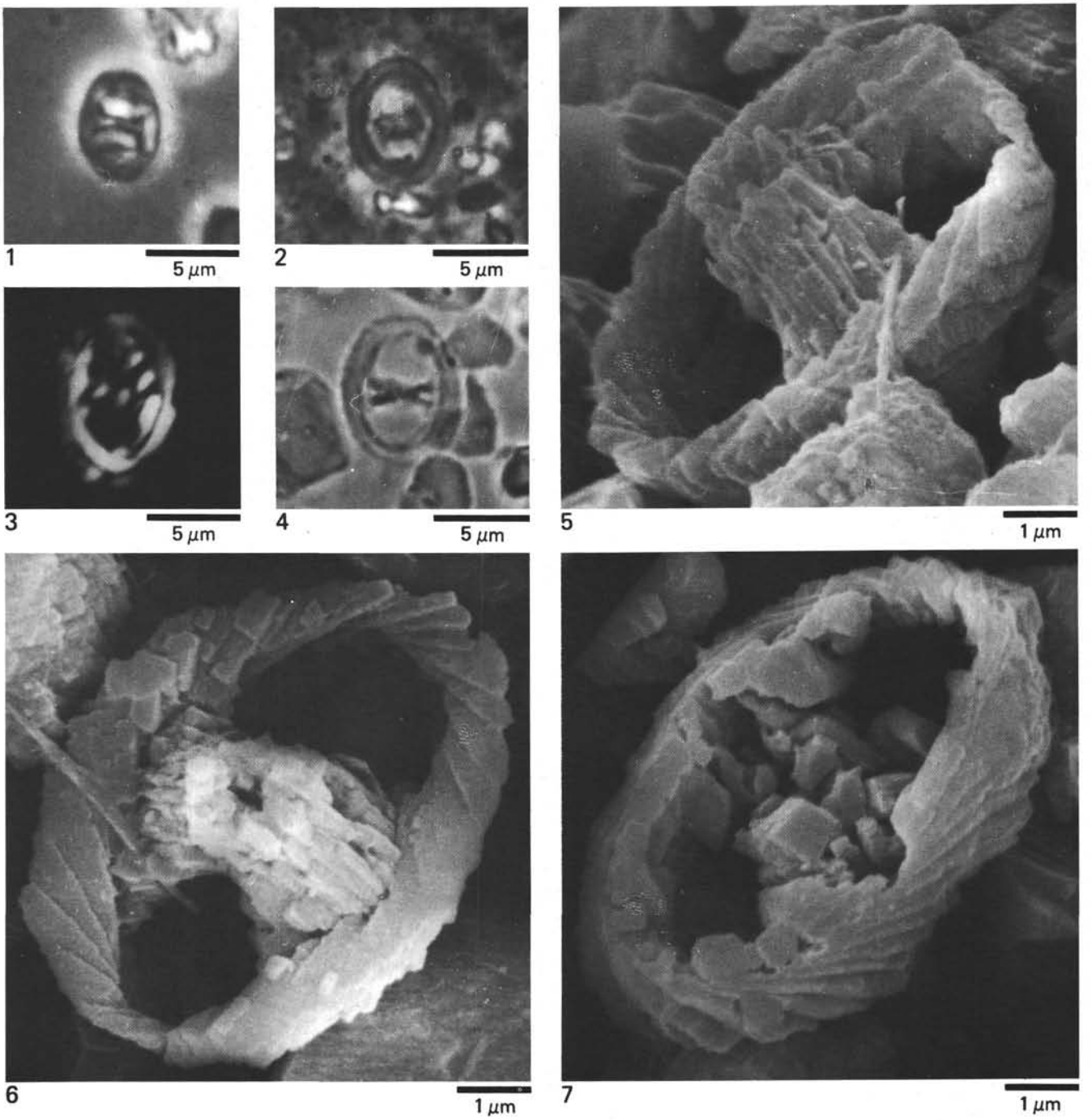


Plate 48. **1–2.** *Zygodiscus sigmoides*, Sample 530A-50-1, 6–7 cm, PHC; **3.** *Z. sigmoides*, Sample 530A-48-2, 43–44 cm, XN; **4.** *Neochiastozygus junctus*, Sample 530A-50-2, 13–14 cm, NL; **5–7.** *Zygodiscus sigmoides*, Sample 530A-50-1, 6–7 cm, SEM.

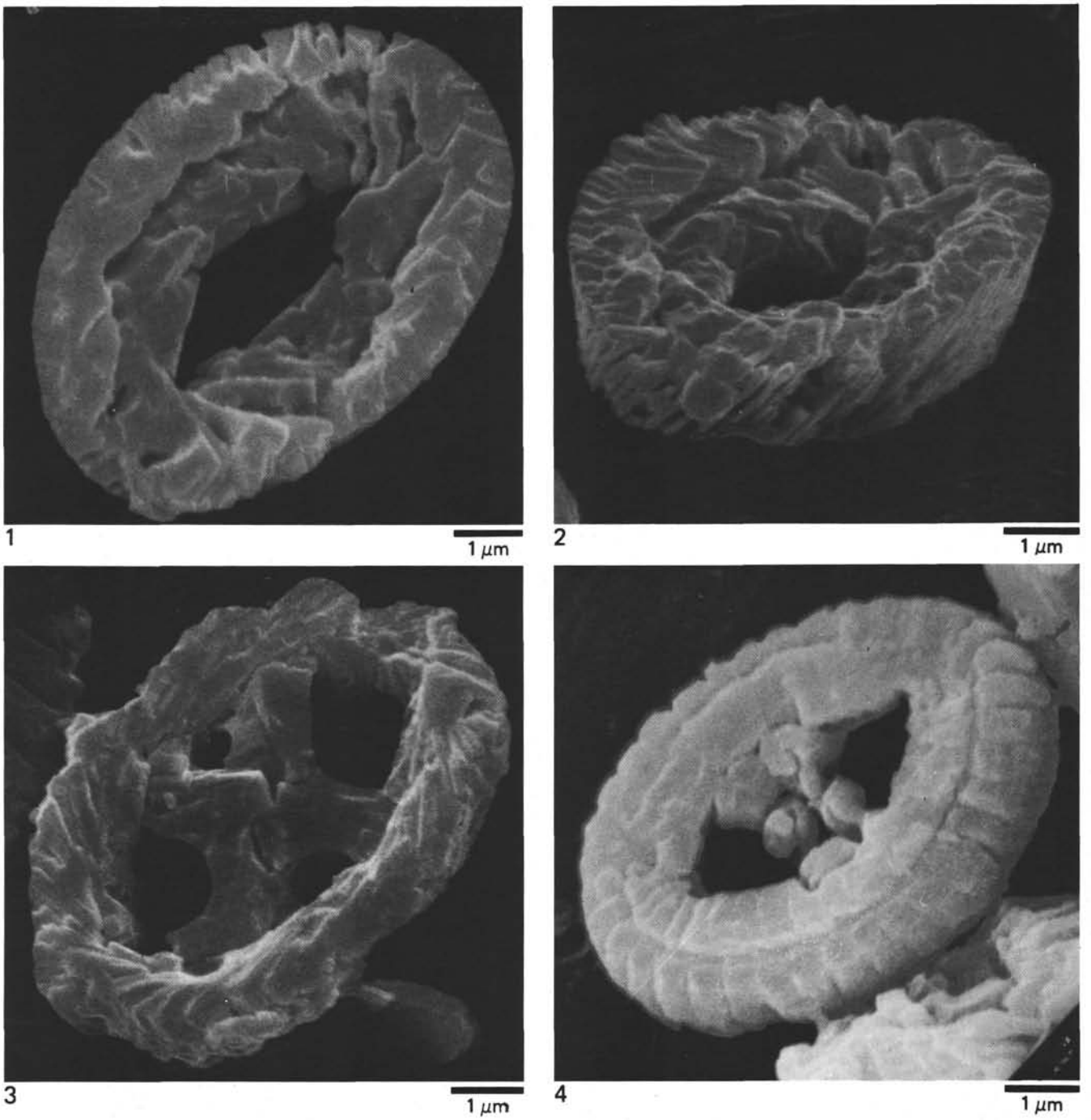


Plate 49. **1.** *Zygodiscus* sp., distal view, etched specimen, Sample 530A-43-2, 20–21 cm, SEM; **2.** *Zygodiscus* sp., side view, etched specimen, Sample 530A-43-2, 20–21 cm, SEM; **3.** *Neococcolithites protenus*, distal view, Sample 530A-43-2, 20–21 cm, SEM; **4.** *Zygodiscus* cf. *Z. spiralis*, proximal view, Sample 530A-50-2, 13–14 cm, ? reworked, SEM.

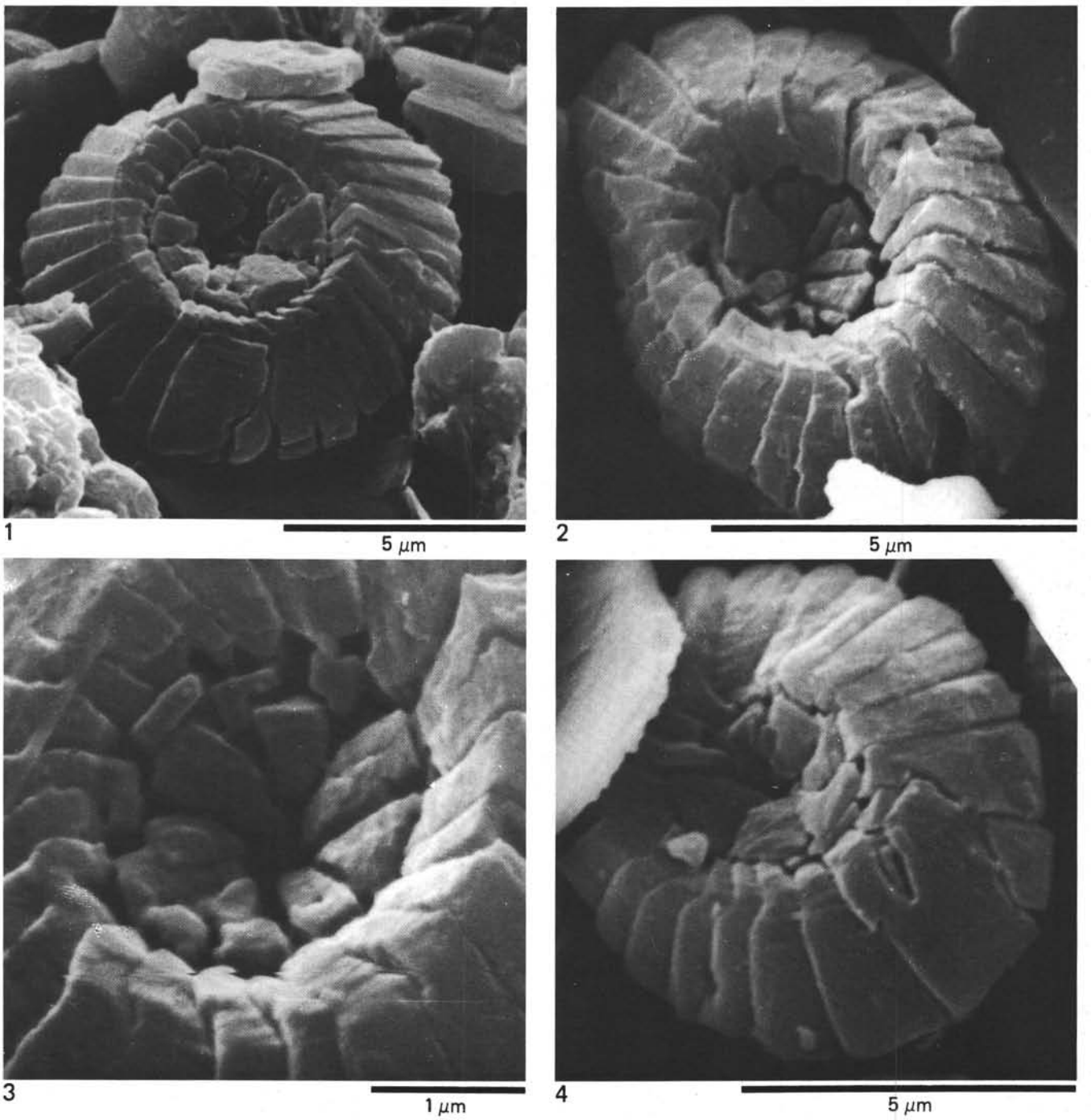


Plate 50. **1–4.** *Markalius astroporus*, Sample 530A-50-1, 6–7 cm, SEM. (1) distal view; (2) distal view; (3) central detail, distal view; (4) distal view.

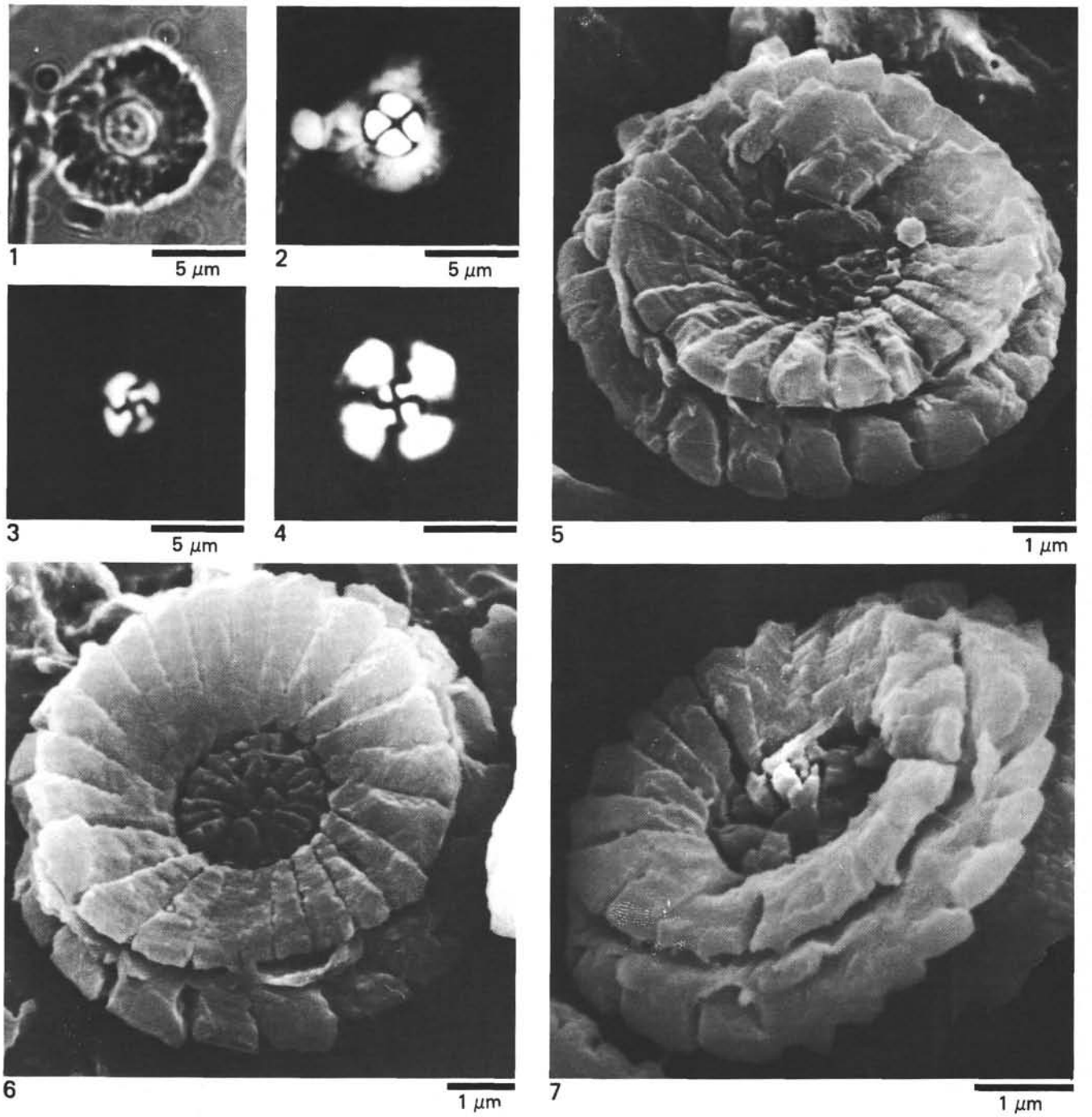


Plate 51. **1.** *Markalius astroporus*, Sample 530A-50-1, 6–7 cm, NL; **2.** *M. astroporus*, Sample 530A-47-1, 142–143 cm, XN; **3–4.** *Cyclagelosphaera reinhardtii*, Sample 530A-50-1, 6–7 cm, XN; **5–6.** *Markalius astroporus*, proximal view, Sample 530A-50-1, 6–7 cm, SEM; **7.** *M. astroporus*, oblique proximal view, Sample 530A-50-1, 6–7 cm, SEM.

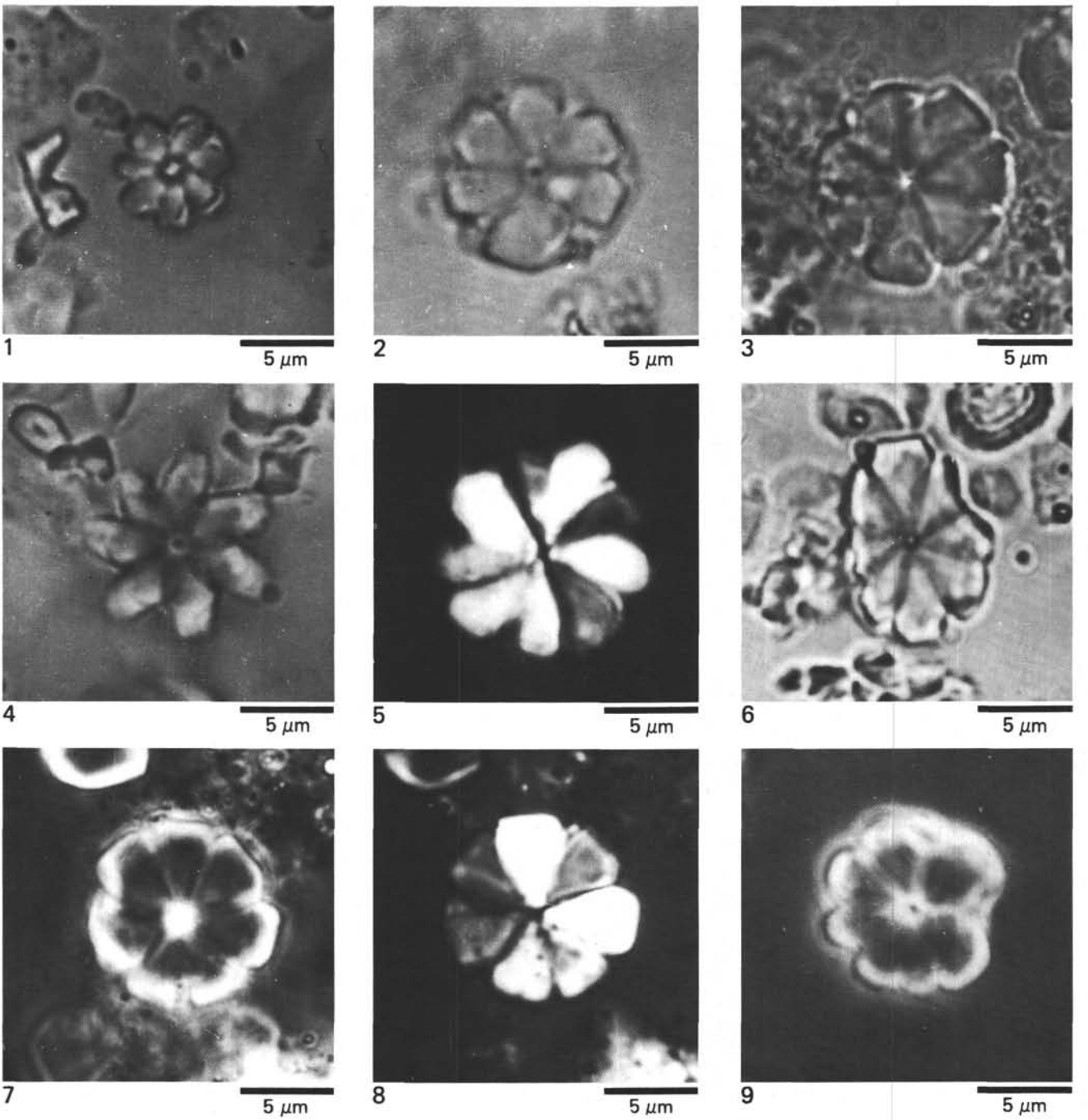


Plate 52. **1.** *Biantholithus astralis* nov. spec., Sample 530A-50-2, 13–14 cm, NL; **2–3.** *B. sparus*, Sample 530A-50-2, 13–14 cm, NL; **4.** *B. astralis* nov. spec., Sample 530A-50-2, 13–14 cm, NL; **5–9.** *B. sparsus*, (5) Sample 530A-50-1, 6–7 cm, XN, (6) Sample 530A-50-1, 6–7 cm, NL, (7) Sample 530A-50-2, 13–14 cm, PHC, (8) Sample 530A-50-2, 13–14 cm, XN, (9) Sample 530A-50-2, 13–14 cm, PHC.

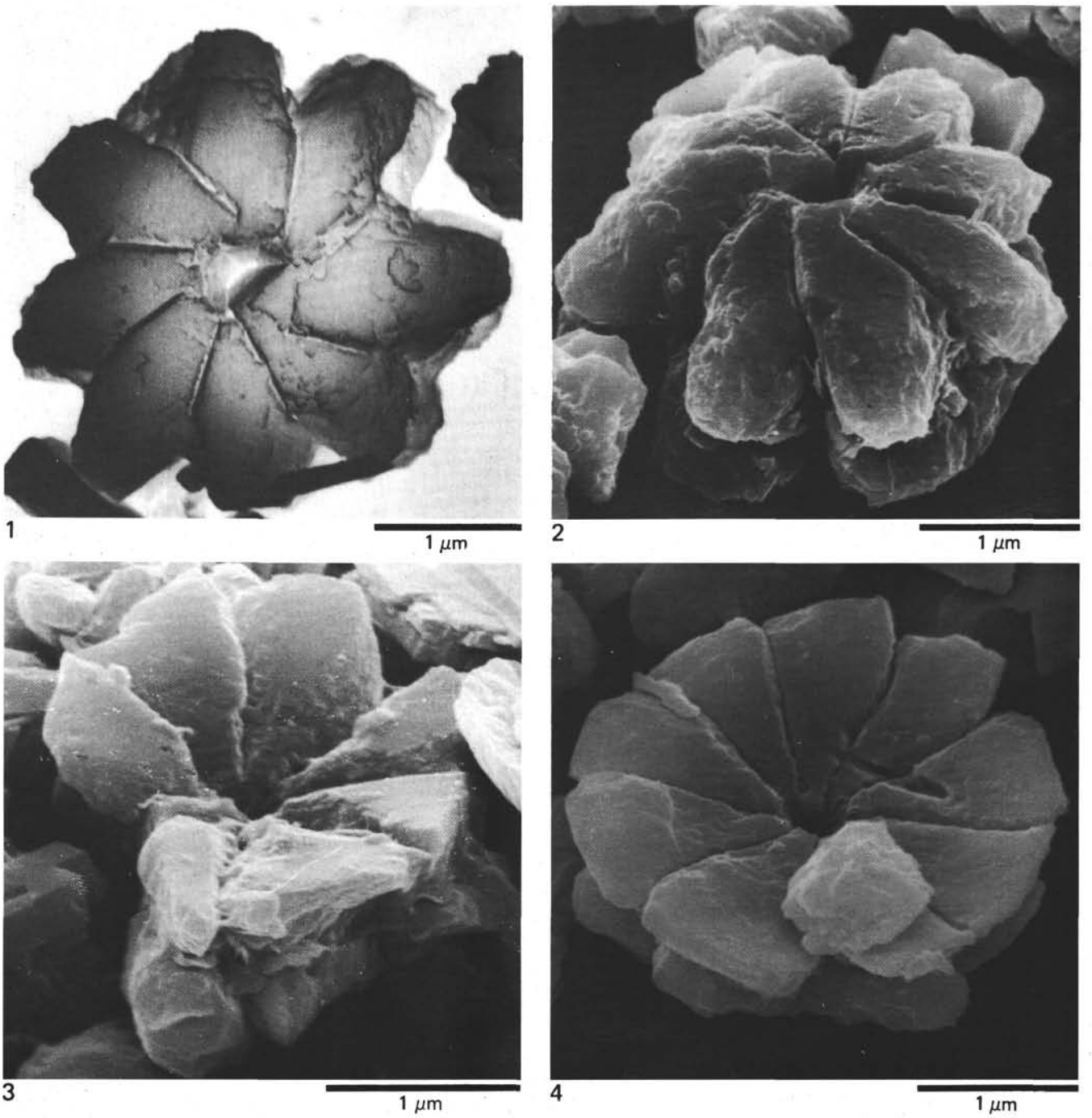


Plate 53. Sample 530A-50-1, 6–7 cm. **1.** *Biantholithus astralis* nov. spec., holotype, SEM; **2.** *B. astralis* nov. spec., SEM; **3–4.** *B. sparus*, SEM.

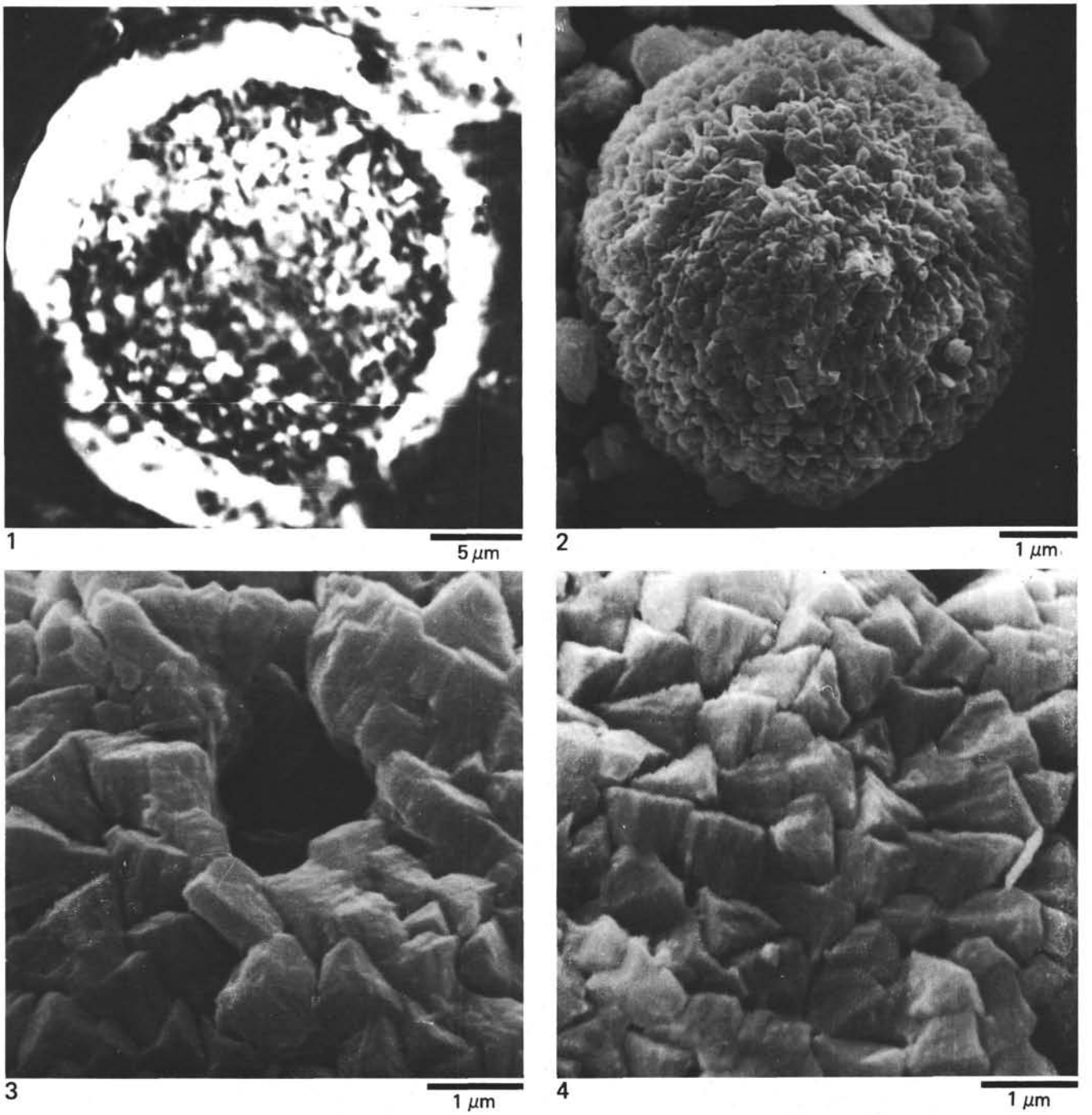


Plate 54. *Thoracosphaera* cf. *T. operculata*. **1.** Complete cyst, Sample 530A-50-2, 13–14 cm, XN; **2.** Complete cyst, Sample 530A-50-1, 6–7 cm, SEM; **3.** Closeup detail of outer wall surface of specimen shown in Figure 2; **4.** Closeup detail of outer wall surface of specimen shown in Figure 2.