30. LEG 27 CALCAREOUS NANNOPLANKTON

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INTRODUCTION

Sites 259-263 were drilled in the Eastern Indian Ocean during DSDP Leg 27, in November-December 1972, beginning and ending at Freemantle (Figure 1).

Calcareous nannofossils were recovered from all sites; ages range from Upper Jurassic to Quaternary, with Albian predominant except for Site 262. No calcareous nannoplankton associations of Upper Cretaceous age were encountered. A continuous succession of nannoplankton associations representing upper Paleocene and all the recognized lower Eocene zones was recorded at Site 259. Of the other sites, Paleogene is present but much reduced in turbidites at Sites 260 and 263. The Neogene is represented also in turbidite facies at Sites 260, 261, and 263. A thick section of Quaternary and upper Pliocene was drilled and continuously cored in the Timor Trough Site 262.

The light microscope (LM) was used to examine the calcareous nannoplankton assemblages. In addition, some selected samples were also investigated by the scanning electron microscope (SEM).

BIOSTRATIGRAPHY

The age determinations and zonation of the Quaternary and Tertiary samples is based on Hay and others (1967) and Martini (1970). The subdivision of the Cretaceous is based on the Lower Cretaceous calcareous nannoplankton biostratigraphy proposed by Thierstein (1973). The nannoplankton zones and the biostratigraphic data levels of Thierstein are the results of detailed investigations of the classical sections in southeastern France, Switzerland, Great Britain, and numerous samples from the Western and Central Atlantic, Venezuela, and Trinidad. His nannoplankton biostratigraphy is also correlated with that based on ammonites, calpionellids, and foraminifera.

The upper Oxfordian age of the sediments immediately overlying basalt at Site 261 is based on the evolution of *Stephanolithion* according to Rood and Barnard (1972). Table 1 shows the distribution of the most important nannoplankton index species for the Upper Jurassic and Lower Cretaceous stages. Table 2 lists in alphabetical order the species epithets of the nannofossil species listed in this report.

SITE 259

(Perth Abyssal Plain, 29°37.05'S, 112°41.78'E, water depth 4649 m, penetration 346 m, Cores 141)

Samples from Core 1 contain rich and well-preserved temperate to warm-water Pleistocene assemblages.

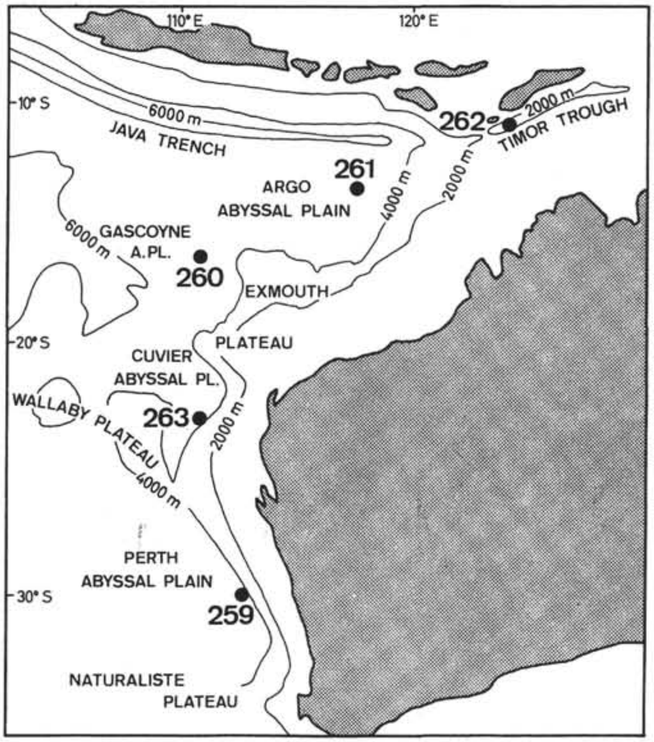


Figure 1. *Location of Leg 27 Sites 259-263.*

Markers of all Quaternary biozones occur together, hence a detailed biostratigraphic subdivision is not possible. Some Pliocene species are also present, but the bulk of the assemblage is Quaternary. Sections 3 and 4 also contain reworked middle and upper Eocene species. The assemblages show evidence of mixed preservation, the reworked specimen being calcified. The samples also contain sponge and ascidian spicules.

Core 2 has no recovery. Core 3 is barren of calcareous nannofossils. Cores 4-8 contain a complete sequence of lower Eocene and upper Paleocene nannoplankton zones. The uccession of biozones on the whole is regular, but some samples appear to be displaced, probably as a result of drilling disturbance. The assemblages appear to be residual, almost wholly composed of resistant taxa (*Discoaster, Fasciculithus,* and some *Coccolithus*). The *Discoaster* specimens show effects of calcite solution, particularly in the central part of the shield that is often pierced. The dissolution is strongest in Core 8. Cores 9 and 10 are lacking coccoliths.

Calcareous nannoplankton are again present in the section between Cores 11 to 17, where they are most abundant and best preserved in Samples 11, CC to 14, CC. In particular Core 14 contains a diversified and

TABLE 1
Distribution of Some Upper Jurassic and Lower Cretaceous Nannoplankton Stratigraphic Markers[a]

	Upper Jurassic					Lower Cretaceous						U. Cretaceous
	Bathonian	Callovian	Oxfordian	Kimmeridgian	Tithonian	Berriasian (L.U.)	Valanginian (L.U.)	Hauterivian (L.U.)	Barremian (L.U.)	Aptian (L.U.)	Albian (L.M.U.)	Cenomanian
Eiffellithus turriseiffeli											U	x
Tranolithus exiguus											M.U.	x
Podorhabdus orbiculofenestrus											M.U.	x
Cretarhabdus coronadventis											M.U.	x
Broinsonia signata											M.U.	x
Vagalapilla matalosa											M.U.	x
Prediscosphaera cretacea											x	x
Hayesites albiensis											x	
Cretarhabdus loriei										U	x	x
Lithastrinus floralis										U	x	x
Parhabdolithus angustus										U	x	x
Corollithion achylosum										U	x	x
Flabellites biforaminis										U	x	x
Braarudosphaera africana										U	x	
Chiastozygus litterarius										x	x	x
Podorhabdus decorus										x	x	x
Rucinolithus irregularis										x	x	
Tegumentum stradneri									x	x	x	x
Nannoconus bucheri								x	x	x		
Micula infracretacea							U	x	x	x		
Reinhardites fenestratus							x	x	x	x		
Tubodiscus verenae							x					
Micrantholithus hoschulzi						U	x	x	x	L		
Micrantholithus obtusus						U	x	x	x	L		
Cruciellipsis cuvillieri						x	x	x				
Parhabdolithus embergeri					x	x	x	x	x	x	x	x
Cretaturbella rothii					x	x	x	x	x	L		
Polycostella beckmanni					x	L						
Loxolithus armilla			x	x	x	x	x	x	x	x	x	x
Watznaueria manivitae			x	x	x	x	x	x				
Zygodiscus salillum			x	x	x	x	x					
Watznaueria britannica	x	x	x	x	x	x	x	x	x	x	x	x
Stephanolithion bigoti		x	x									

[a]According to Thierstein (1973) and Rood and Barnard (1972).

typical Albian assemblage. Based on the absence of *Eiffellithus turriseiffeli* and the presence of *Prediscosphaera cretacea*, the nannoplankton are referred to the *Prediscosphaera cretacea* Zone of Thierstein that covers the upper part of the lower and the middle Albian. The presence of *Cretarhabdus coronadventis* and *Vagalapilla matalosa* suggests a middle Albian age. Cores 15-17 contain progressively impoverished and badly preserved associations, probably of the same Albian age. The absence of markers is, most probably, due to poor preservation and, therefore, of no stratigraphic implication.

The age, zonation, and distribution of calcareous nannoplankton at Site 259 are shown in Table 3.

Scanning electron microscope investigations of Sample 259-14, CC have shown the presence of cristobalite spherules (Plate 8, Figure 4). According to Wise et al., (1972), this authigenic mineral denotes an early diagenetic phase in the silicification of carbonate sedimentation.

No calcareous nannofossils were found in Cores 18-34, which overlie basement. The examined samples contain some questionable small bag- or pot-shaped remains that could be of organic origin. Some of them possess a regular and symmetrical shape that seems unlikely to be casual and that suggests some affinity with Recent Tintinnida (Plate 10, Figure 1).

SITE 260

(Gascoyne Abyssal Plain, 16°8.67′S, 110°17.92′E, water depth 5702 m, penetration 331 m, Cores 1-20)

The upper part of the section (Cores 1-4) consists of Quaternary and Tertiary turbiditic sediments. Core 1 is

TABLE 2
Selected Nannofossil Species Considered in This Report

Sphenolithus abies Deflandre in Deflandre and Fert, 1954
Corollithion achylosum (Stover) Thierstein, 1971
Braarudosphaera africana Stradner, 1961
Hayesites albiensis Manivit, 1971 (Plate 3, Figures 21, 22; Plate 7, Figure 4)
Sphenolithus anarrhopus Bukry and Bramlette, 1969
Parhabdolithus angustus (Stradner) Stradner, 1968 (Plate 3, Figures 29, 30)
Cyclolithella annulus (Cohen) McIntyre and Be, 1967 (Plate 8, Figure 8)
Oolithotus antillarum (Cohen) Reinhardt in Cohen and Reinhardt, 1968
Loxolithus armilla (Black in Black and Barnes) Noel, 1965 (Plate 6, Figure 6)
Parhabdolithus asper (Stradner) Reinhardt, 1967 (Plate 5, Figures 17, 18) + (Plate 7, Figures 10-12)
Discoaster asymmetricus Gartner, 1969
Discoaster barbadiensis Tan Sin Hok, 1927
Polycostella beckmanni Thierstein, 1971 (Plate 4, Figures 18-20, 25)
Watznaueria barnesae (Black, 1959) (Plate 4, Figure 27) + Plate 7, Figure 1)
Flabellites biforaminis Thierstein, 1973 (Plate 3, Figures 31, 32) + (Plate 7, Figure 9)
Stephanolithion bigoti Deflandre, 1939 (Plate 6, Figures 15-19)
Braarudosphaera bigelowi (Graan and Braarud) Deflandre, 1947)
Discoaster binodosus Martini, 1959 (Plate 1, Figures 17-19)
Watznaueria biporta Bukry, 1969 (Plate 4, Figure 31)
Prinsius bisulcus (Stradner) Hay and Mohler, 1967
Tribrachiatus bramlettei (Bronnimann and Stradner) (Plate 1, Figure 26)
Watznaueria britannica (Sradner) Reinhardt, 1964 (Plate 4, Figures 28-30)
Discoaster brouweri Tan Sin Hok, 1927 (Plate 1, Figure 16)
Nannoconus bucheri Bronnimann, 1955 (Plate 6, Figures 4, 5)
Scyphosphaera campanula Deflandre, 1942
Lithraphidites carniolensis Deflandre, 1963 (Plate 6, Figures 10, 11)
Gephyrocapsa carribeanica Boudreaux and Hay in Hay et al., 1967 (Plate 1, Figures 3, 4)
Markalius circumradiatus (Stover) Perch-Nielsen, 1968 (Plate 6, Figures 7-9, 13)
Rhabdosphaera clavigera Murray and Blackmann, 1898
Watznaueria communis Reinhardt, 1964 (Plate 4, Figures 21, 22, 26)
Cretarhabdus conicus Bramlette and Martini, 1964 (Plate 3, Figures 16-18)
Biscutum constans (Gorka) Black, 1959 (Plate 4, Figures 11-14)
Chiasmolithus consuetus (Bramlette and Sullivan) Hay & Mohler, 1967
Tribrachiatus contortus (Stradner) Bukry 1972 (Plate 1, Figure 27)
Cretarhabdus coronadventis Reinhardt, 1966 (Plate 3, Figure 9) + (Plate 7, Figure 7)
Cretarhabdus crenulatus Bramlette and Martini, 1964 emend. Thierstein, 1971 (Plate 3, Figures 10, 14, 15)
Prediscosphaera cretacea (Arkhangelsky) Gartner, 1968 (Plate 3, Figures 26-28) + (Plate 7, Figures 5, 6)
Ceratolithus cristatus Kamptner, 1950 (Plate 1, Figure 13)
Discoaster cruciformis Martini, 1958
Cruciellipsis cuvillieri (Manivit) Thierstein, 1971 (Plate 5, Figures 13-15)
Podorhabdus decorus (Deflandre) Thierstein in Roth and Thierstein, 1972 (Plate 6, Figure 14)
Discoaster delicatus Bramlette and Sullivan, 1961
Discoaster diastypus Bramlette and Sullivan, 1961 (Plate 1, Figures 20, 21)
Podorhabdus dietzmanni (Reinhardt) Reinhardt, 1967 (Plate 4, Figures 5, 10)
Zygodiscus diplogrammus (Deflandre and Fert) Gartner, 1968 (Plate 4, Figures 6, 7) + (Plate 7, Figure 15)
Pontosphaera discopora Schiller, 1925
Gephyrocapsa doronicoides (Black and Barnes) (Plate 1, Figure 12)
Zygodiscus elegans Gartner, 1968, emend. Bukry, 1969 (Plate 4, Figures 8, 9) + (Plate 7, Figure 13)

TABLE 2 – *Continued*

Parhabdolithus embergeri (Noel) Stradner, 1963 (Plate 5, Figures 19, 20, 24; Plate 7, Figure 14)
Coccolithus eopelagicus (Bramlette and Riedel) Bramlette and Sullivan, 1961
Tranolithus exiguus Stover, 1966 (Plate 3, Figure 8)
Discoaster falcatus Bramlette and Sullivan, 1961
Reinhardites fenestratus (Worsley) Thierstein in Roth and Thierstein, 1972 (Plate 5, Figures 9, 12, 16)
Lithastrinus floralis Stradner, 1962 (Plate 3, Figures 33-35) + (Plate 7, Figures 2, 3)
Scapholithus fossilis Deflandre in Deflandre and Fert, 1954
Thoracosphaera heimi (Lohman) Kamptner, 1941
Syracosphaera histrica Kamptner, 1941 (Plate 8, Figure 7)
Micrantholithus hoschulzi (Reinhardt) Thierstein, 1971 (Plate 6, Figures 20, 21)
Emiliania huxleyi (Lohmann) Hay and Mohler in Hay et al., 1967 (Plate 9, Figures 3, 6)
Micula infracretacea Thierstein, 1973 (Plate 4, Figures 16, 17)
Markalius inversus (Deflandre) Bramlette and Martini, 1964
Rucinolithus irregularis Thierstein, 1972 (Plate 4, Figures 1, 2)
Pontosphaera jonesi (Boudreaux and Hay, 1969) n. comb.
Helicopontosphaera kamptneri Hay and Mohler in Hay et al., 1967 (Plate 1, Figures 14, 15)
Discoasteroides kuepperi (Stradner) Bramlette and Sullivan, 1961
Pseudoemiliania lacunosa (Kamptner) Gartner, 1969
Stephanolithion laffittei Noel, 1957 (Plate 4, Figure 15)
Discoaster lenticularis Bramlette and Sullivan, 1961
Cyclococcolithina leptopora (Murray and Blackmann) Wilcoxon, 1970 (Plate 8, Figure 6)
Chiastozygus litterarius (Gorka) Manivit, 1971
Discoaster lodoensis Bramlette and Riedel, 1954 (Plate 2, Figures 1, 2)
Cretarhabdus loriei Gartner, 1968 (Plate 5, Figures 1-3)
Cyclococcolithina macintyrei (Bukry and Bramlette) Wilcoxon, 1970
Watznaueria manivitae (=*Coccolithus deflandrei* auct.) (Plate 5, Figures 21-23; Plate 9, Figure 1)
Cyclagelosphaera margereli Noel, 1965 (Plate 4, Figures 32-34)
Vagalapilla matalosa (Stover) Thierstein, 1973 (Plate 3, Figures 23-25) + (Plate 7cf., Figure 20) + (Plate 8, Figure 1 cf.)
Discoasteroides megastypus Bramlette and Sullivan, 1961
Sphenolithus moriformis (Bronnimann and Stradner) Bramlette and Wilcoxon, 1967
Discoaster multiradiatus Bramlette and Riedel, 1954 (Plate 2, Figure 4)
Micrantholithus obtusus Stradner, 1963 (Plate 6, Figures 22, 23)
Gephyrocapsa oceanica Kamptner, 1943 (Plate 1, Figures 5-11) + (Plate 8, Figures 9, 11; Plate 9, Figures 2, 4, 5, 7)
Podorhabdus orbiculofenestrus (Gartner) Thierstein, 1971
Tribrachiatus orthostylus Shamrai, 1963 (Plate 2, Figures 2,3)
Coccolithus pelagicus (Wallich) Schiller, 1930
Manivitella pemmatoidea (Deflandre ex Manivit) Thierstein, 1971 (Plate 5, Figures 5-7)
Discoaster pentaradiatus Tan Sin Hok, 1927
Discoaster perplexus Bramlette and Riedel, 1954
Gephyrocapsa protohuxleyi (McIntyre) (Plate 8, Figure 12)
Syracosphaera pulchra Lohmann, 1902
Cyclolithella robusta (Bramlette and Sullivan) Stradner, 1969
Cretaturbella rothii Thierstein, 1971 (Plate 6, Figures 1-3)
Zygodiscus salillum (Noel) (Plate 4, Figure 35)
Discoaster salisburgensis Stradner, 1961 (Place 2, Figures 3, 4)
Pontosphaera scutellum Kamptner, 1952
Helicopontosphaera sellii Bukry and Bramlette, 1969
Umbilicosphaera sibogae (Weber-Van Bosse) Gaarder, 1970 (Plate 8, Figure 5)
Broinsonia signata (Noel) Noel, 1970 (Plate 3, Figures 19, 20) + (Plate 7, Figure 16)
Parhabdolithus splendens (Deflandre) Noel, 1969 (Plate 5, Figures 4, 8)
Biantholithus sparsus Bramlette and Martini, 1964 (Plate 1, Figures 24, 25)
Tegumentum stradneri Thierstein, 1972 (Plate 4, Figures 3, 4) + (Plate 7, Figure 8)

TABLE 2 – *Continued*

Vagalapilla stradneri (Rood, Hay and Barnard) Thierstein, 1973 (Plate 4, Figures 23, 24) + (Plate 7, Figures 17-19)
Discoaster surculus Martini and Bramlette, 1963
Cretarhabdus surirellus (Deflandre) Reinhardt, 1970 (Plate 3, Figures 11-13)
Ceratolithus tricorniculatus Gartner, 1967
Eiffellithus turriseiffeli (Deflandre) Reinhardt, 1965 (Plate 3, Figures 5?, 6, 7)
Fasciculithus tympaniformis Hay and Mohler in Hay et al., 1967
Discoaster variabilis Martini and Bramlette, 1963
Tubodiscus verenae Thierstein, 1973
Helicopontosphaera wallichii (Lohmann) Boundreaux & Hay, 1969

very rich in calcareous nannoplankton in Section 1, barren in Sections 2-4 which are radiolarian clays, and very poor in the core-catcher sample.

The following species were recognized:

1) Sample 1-1, 54-55 cm: *Gephyrocapsa oceanica, Cyclococcolithina leptopora, Rhabdosphaera clavigera, Helicopontosphaera kamptneri, Coccolithus pelagicus, Thoracosphaera heimi, T. saxea, Pseudoemiliania lacunosa, Sphenolithus moriformis, Ceratolithus cristatus, Umbilicosphaera sibogae, Syracosphaera histrica, Discoaster brouweri, D. pentaradiatus, D. variabilis, D. challengeri, D. surculus, D. deflandrei,* and in addition older reworked Paleogene and Cretaceous species are frequent. Such a mixed association suggests a turbiditic sedimentation.

2) Sample 1, CC: contains only a few specimens of *Gephyrocapsa oceanica,* but is very rich in siliceous skeletal remains. Age of Core 1: Quaternary, *Gephyrocapsa oceanica* Zone.

3) Sample 2-2, 85-86 cm: *Discoaster brouweri, D. variabilis, D. pentaradiatus, D. surculus, D. asymmetricus, D. challengeri, D. hamatus, D. deflandrei, Helicopontosphaera kamptneri, Pseudoemiliania lacunosa, Reticulofenestra pseudoumbilica, Scyphosphaera apsteini, Ceratolithus cristatus,* and *Catinaster calyculus.*

4) Sample 2-3, 101-102 cm: *Discoaster brouweri, D. variabilis, D. quinqueramus, D. asymmetricus, D. pentaradiatus, D. deflandrei, D. surculus, Ceratolithus cristatus, C. tricorniculatus, Catinaster coalithus, Helicopontosphaera kamptneri, Reticulofenestra pseudoumbilica,* and *Sphenolithus abies.*

5) Sample 2, CC: *Discoaster brouweri, D. variabilis, D. pentaradiatus, D. asymmetricus, D. surculus, Helicopontosphaera kamptneri, Pontosphaera discopora, Scyphosphaera apsteini, Reticulofenestra pseudoumbilica, Catinaster calyculus,* and *Sphenolithus abies.* Age of Core 2: not older than lower Pliocene.

Samples examined in Sections 1-5 of Core 3 are either barren or contain poorly preserved nannofloras.

6) Sample 3-6, 3-4 cm: *Discoaster dilatus, D. exilis, D. signus, D. challengeri, D. deflandrei, D. calcaris, D. perplexus, D. barbadiensis, Cyclococcolithus leptoporus, Helicopontosphaera granulata, Sphenolithus belemnos, S. distentus, S. moriformis,* and in addition, older and reworked Paleogene and Cretaceous species are frequent.

7) Sample 3, CC: *Discoaster brouweri, D. variabilis, D. challengeri, D. dilatus, D. signus, Cyclococcolithus leptoporus* and in addition, older and reworked Paleogene and Cretaceous species are frequent. Age of Core 3: middle-upper Miocene.

8) Sample 4-1, 97-98 cm: *Discoaster deflandrei, D. druggi, Sphenolithus ciperoensis, S. moriformis,* and in addition, older and reworked Paleogene and Cretaceous species are frequent.

9) Sample 4-5, 97-98 cm: *Discoaster deflandrei, D. elegans, Reticulofenestra umbilica, R. bisecta, Sphenolithus ciperoensis, Coccolithus eopelagicus,* and in addition, older and reworked Paleogene and Cretaceous species are frequent. Age of Core 4: not older than middle Oligocene.

Cores 5-8 are lacking calcareous nannoplankton.

The interval from Core 9 to the sediment-basement contact in Core 18 contains nannoplankton assemblages of *Prediscosphaera cretacea* Zone, middle Albian. The recognized species and their distribution are reported in Table 4. The stratigraphic conclusions are the same as for the Albian at Site 259. Minor differences in assemblage composition, chiefly the presence or absence of poorly represented species, exist between Site 260 and 259. The presence of *Braarudosphaera africana* in Sample 12-2, 22-23 cm could indicate a shallower water or near-coast environment, but it is too rare to be taken as a conclusive paleoenvironmental indicator. The same sample shows evidence of mixed preservation, some specimen of *Parhabdolithus embergeri* and large *Watznaueria* are overgrown by a calcite crust and could be reworked. *Reinhardites fenestratus* and *Micula infracretacea* become extinct according to their known stratigraphic ranges at the end of the Aptian and are therefore also considered as reworked. This suggests the presence of older sediments that are subject to erosion and redeposition. Cores 9-12 are rich in nannofossils. The nannoplankton associations lose their specific diversity in Cores 13-18 where they consist of *Watznaueria* floods together with *Parhabdolithus embergeri, Vagalapilla matalosa,* and *Cretarhabdus* spp. The specimens show evidence of calcite solution and breakage in many of the examined samples. Some samples are barren or contain only the taxon *Watznaueria.* The above observations suggest that changes in the assemblages reflect solution rather than climatic changes. The assemblages from Cores 13-18, with their very reduced specific diversity, are considered residual. Most of the examined samples contain the same questionable fossils as reported from Site 259, which consist of small bag- or pot-shaped and spherical remains (Plate 10, Figures 4, 9).

SITE 261

(Argo Abyssal Plain, 12°56.83'S, 117°53.56'E, water depth 5667 m, penetration 579.5 m, Cores 1-39)

Cores 1-4 are Quaternary to late Tertiary turbidites.

1) Sample 1, CC: *Gephyrocapsa oceanica, Emiliania huxleyi?, Pseudoemiliania lacunosa, Helicopontosphaera kamptneri, Discoaster brouweri, D. calcaris,* and *Reticulofenestra pseudoumbilica.* Age of Core 1: Quaternary, *?Emiliania huxleyi* Zone.

TABLE 3
Age, Zonation, and Distri bution of Calcareous Nannoplankton in Cores 1-17, Site 259 (Cores 18-33 are barren)

Age	Zone	Sample (Interval in cm)	Depth (m)	*Emiliania huxleyi*	*Gephyrocapsa oceanica*	*Pseudoemiliania lacunosa*	*Rhabdosphaera clavigera*	*Cyclococcolithina leptopora*	*Helicopontosphaera kamptneri*	*Coccolithus pelagicus*	*Thoracosphaera saxea*	*Discoaster variabilis*	*D. pentaradiatus*	*D. brouweri*	*Ceratolithus tricorniculatus*	*Cyclolithella annulus*	*Syracosphaera pulchra*	*Pontosphaera discopora*	*P. scutellum*	*Ceratolithus cristatus*	*Thoracosphaera heimi*	*Umbilicosphaera sibogae*	*Helicopontosphaera wallichi*	*Gephyrocapsa carribeanica*	*Scyphosphaera intermedia*	*S. campanula*	*Syracosphaera histrica*
Quaternary	*Emiliania huxleyi* to *Pseudoemiliania lacunosa* (mixed association)	1-1, 130-131	1.3	×	×	×	×	×	×	×	×	×	×	×	×												
		1-2, 87-88	2.3	×	×	×	×	×	×	×	×				×	×	×	×	×	×							
		1-3, 53-54	3.5	×	×	×	×	×	×	×	×				×		×	×	×	×	×	×	×				
		1-4, 47-48	5.0	×	×	×	×	×	×	×				×	×			×	×	×		×		×	×	×	
		1-5, 95-96	6.9	×	×	×	×	×	×	×				×	×	×	×										
		1, CC	8.0	×	×	×	×	×	×	×	×	×															×
Lower Eocene	*Discoaster lodoensis*	4-1, 94-95	27.9																								
		4-2, 65-66	29.1																								
	Tribrachiatus orthostylus	4-3, 86-87	30.8																								
		4-4, 131-132	32.8																								
	Discoaster binodosus	4-5, 124-125	34.2																								
	Tribrachiatus contortus	4-6, 110-111	35.6																								
		4, CC	36.5																								
	Discoaster binodosus	5-2, 107-108	37.5																								
		5-3, 90-91	40.4																								
	Tribrachiatus contortus	5-4, 45-46	41.4																								
Upper Paleocene	*Discoaster multiradiatus*	5-5, 100-101	43.5																								
		5, CC	46.0																								
		6-1, 66-67	46.6																								
	Tribrachiatus contortus	6-2, 108-109	48.5																								
	Discoaster multiradiatus	6-3, 83-84	49.8																								
		6-4, 94-95	51.4																								
		6-5, 90-91	52.9																								
		6-6, 90-91	54.5																								
		7-1, 84-85	56.3																								
		7-2, 54-55	57.5																								
		7-3, 33-34	58.8																								
		7-5, 36-37	61.8																								
		7, CC	65.0																								
		8-5, 130-131	73.3																								
		8-6, 38-39	73.8																								
Lower Cretaceous Middle Albian	*Prediscosphaera cretacea*	11, CC	103.0																								
		12-6, 79-80	111.2																								
		12, CC	112.5																								
		13-5, 98-99	119.4																								
		13-6, 102-103	121.0																								
		13, CC	122.0																								
		14-2, 104-105	124.5																								
		14, CC	131.5																								
		15, CC	141.0																								
		16, CC	150.5																								
		17, CC	160.0																								

Sample (Interval in cm)	Depth (m)	*Discoaster barbadiensis*	*D. lodoensis*	*D. cruciformis*	*Discoasteroides kuepperi*	*Discoaster binodosus*	*D. diastypus*	*Tribrachiatus orthostylus*	*Coccolithus eopelagicus*	*Sphenolithus radians*	*S. anarrhopus*	*Fasciculithus involutus*	*Markalius inversus*	*Discoaster salisburgensis*	*D. falcatus*	*D. lenticularis*	*Tribrachiatus contortus*	*Discoaster multiradiatus*	*Tribrachiatus bramlettei*	*Chiasmolithus consuetus*	*C. danicus*	*Transversopontis obliquipons*	*Discoaster mohleri*	*D. delicatus*	*Discoasteroides megastypus*	*Cyclolithella robusta*	*Biantholithus sparsus*	*Fasciculithus tympaniformis*	*Heliolithus reidelii*	*Pronsius bisulcus*
1-1, 130-131	1.3																													
1-2, 87-88	2.3																													
1-3, 53-54	3.5																													
1-4, 47-48	5.0																													
1-5, 95-96	6.9																													
1, CC	8.0																													
4-1, 94-95	27.9	×																												
4-2, 65-66	29.1	×	×	×	×	×																								
4-3, 86-87	30.8	×	×	×	×		×	×	×	×	×	×																		
4-4, 131-132	32.8		×		×	×	×	×	×				×	×																
4-5, 124-125	34.2	×			×	×	×	×			×		×	×	×	×														
4-6, 110-111	35.6						×	×				×		×	×		×	×	×	×	×									
4, CC	36.5						×		×						×	×		×	×	×	×	×								
5-2, 107-108	37.5					×	×	×						×	×															
5-3, 90-91	40.4					×	×	×						×	×															
5-4, 45-46	41.4						×										×	×												
5-5, 100-101	43.5								×					×				×		×										
5, CC	46.0					×			×			×						×		×			×	×	×	×	×			
6-1, 66-67	46.6					×										×		×												
6-2, 108-109	48.5					×		×								×		×	×											
6-3, 83-84	49.8																													
6-4, 94-95	51.4																													
6-5, 90-91	52.9							×										×												
6-6, 90-91	54.5																	×												
7-1, 84-85	56.3											×			×			×					×					×		
7-2, 54-55	57.5											×			×			×					×					×		
7-3, 33-34	58.8											×			×			×					×					×		
7-5, 36-37	61.8														×	×		×							×					
7, CC	65.0								×			×						×					×	×						
8-5, 130-131	73.3						×		×			×						×												×
8-6, 38-39	73.8								×			×						×											×	
11, CC	103.0																													
12-6, 79-80	111.2																													
12, CC	112.5																													
13-5, 98-99	119.4																													
13-6, 102-103	121.0																													
13, CC	122.0																													
14-2, 104-105	124.5																													
14, CC	131.5																													
15, CC	141.0																													
16, CC	150.5																													
17, CC	160.0																													

Sample (Interval in cm)	Depth (m)	*Cribrosphaerella ehrenbergi*	*Podorhabdus orbiculofenestrus*	*Cretarhabdus coronadventis*	*Vagalapilla matalosa*	*Prediscosphaera cretacea*	*Hayesites albiensis*	*Cretarhabdus loriei*	*Lithastrinus floralis*	*Parhabdolithus angustus*	*Flabellites biforaminis*	*Chiastozygus litterarius*	*Tegumentum stradneri*	*Parhabdolithus splendens*	*Zygodiscus diplogrammus*	*Podorhabdus dietzmanni*	*Cretarhabdus crenulatus*	*C. surirellus*	*Manivitella pemmatoidea*	*Lithraphidites carniolensis*	*Biscutum constans*	*Watznaueria biporta*	*Zygodiscus elegans*	*Markalius circumradiatus*	*Parhabdolithus asper*	*Stephanolithion laffittei*	*Parhabdolithus embergeri*	*Watznaueria barnesae*	*W. communis*
1-1, 130-131	1.3																												
1-2, 87-88	2.3																												
1-3, 53-54	3.5																												
1-4, 47-48	5.0																												
1-5, 95-96	6.9																												
1, CC	8.0																												
4-1, 94-95	27.9																												
4-2, 65-66	29.1																												
4-3, 86-87	30.8																												
4-4, 131-132	32.8																												
4-5, 124-125	34.2																												
4-6, 110-111	35.6																												
4, CC	36.5																												
5-2, 107-108	37.5																												
5-3, 90-91	40.4																												
5-4, 45-46	41.4																												
5-5, 100-101	43.5																												
5, CC	46.0																												
6-1, 66-67	46.6																												
6-2, 108-109	48.5																												
6-3, 83-84	49.8																												
6-4, 94-95	51.4																												
6-5, 90-91	52.9																												
6-6, 90-91	54.5																												
7-1, 84-85	56.3																												
7-2, 54-55	57.5																												
7-3, 33-34	58.8																												
7-5, 36-37	61.8																												
7, CC	65.0																												
8-5, 130-131	73.3																												
8-6, 38-39	73.8																												
11, CC	103.0								×										×									×	
12-6, 79-80	111.2																		×									×	
12, CC	112.5							×	×			×			×		×		×	×							×	×	
13-5, 98-99	119.4					×		×	×				×		×			×	×	×						×	×	×	×
13-6, 102-103	121.0		×	×		×		×	×	×			×		×			×	×	×			×				×	×	×
13, CC	122.0	×			×	×		×	×	×			×		×			×	×	×	×	×			×	×		×	×
14-2, 104-105	124.5							×	×						×				×									×	×
14, CC	131.5	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
15, CC	141.0											×			×													×	×
16, CC	150.5								×			×			×				×	×						×		×	×
17, CC	160.0																											×	×

[a]Nannoplankton poorly preserved.

TABLE 4
Age, Zonation and Distribution of Calcareous Nannoplankton in the Cretaceous, Site 260

Age	Lower Cretaceous Middle Albian														
Zone	*Prediscosphaera cretacea*														
Sample (Interval in cm)	9, CC	10, CC	11, CC	12-1, 75-76	12-2, 22-23	13-1, 62-63	13, CC	15-2, 63-64	15-3, 86-87	15-4, 120-121	15, CC	17-1, 37-38	17, CC	18-1, 135	18-2, 123
Depth (m)	243.5	253.0	262.5	263.2	264.2	272.6	281.5	293.1	294.8	296.7	300.5	310.3	319.5	320.8	322.2
Cribrosphaerella ehrenbergi	X	X	X												
Cretarhabdus coronadventis			X											X	
Vagalapilla matalosa	X		X		X							X	X	X	X
Prediscosphaera cretacea					X										
Cretarhabdus loriei			X												
Lithastrinus floralis	X		X												
Corollithion achylosum	X		X		X										
Braarudosphaera africana					X										
Chiastozygus litterarius									X						
Rucinolithus irregularis	X	X	X		X					X					
Tegumentum stradneri			X		X										
Parhabdolithus splendens	X	X			X										
Zygodiscus diplogrammus			X									X	X		
Micula infracretacea				X	X		X	X	X	X	X	X			
Reinhardites fenestratus	X		X		X										
Cretarhabdus crenulatus	X	X	X		X			X				X	X		
C. surirellus			X		X	X		X			X	X	X	X	X
Manivitella pemmatoidea	X	X	X		X	X		X	X		X	X	X		
Lithraphidites carniolensis	X	X	X		X										
Biscutum constans			X		X										
Watznaueria biporta	X		X		X									X	
Zygodiscus elegans			X		X			X				X			
Markalius circumradiatus			X		X			X				X	X		
Parhabdolithus asper	X		X		X			X	X		X				
Stephanolithion laffittei	X		X		X										
Parhabdolithus embergeri	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Vagalapilla stradneri		X	X												
Watznaueria barnese	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
W. communis	X		X					X	X	X		X	X	X	
Cyclagelosphaera margereli				X	X										
Watznaueria britannica	X		X												

No calcareous nannoplankton are present in Core 2 which is very rich in Radiolaria.

2) Core 3-1, 140-141 cm: *Discoaster brouweri, D. variabilis, D. pentaradiatus, D. exilis, D. quinqueramus, D. challengeri, D. surculus, Cyclococcolithina leptopora, Helicopontosphaera kamptneri, Reticulofenestra pseudoumbilica, Ceratolithus rugosus, C. tricorniculatus, Thoracosphaera heimi, T. saxea, Coccolithus pelagicus, Scyphosphaera apsteini,* and in addition, small coccoliths which seem to belong to primitive *Gephyrocapsa* are also abundant.

3) Sample 3, CC: *Discoaster brouweri, D. variabilis, D. surculus, D. challengeri, D. pentaradiatus, D. asymmetricus, Cyclococcolithina leptopora, Helicopontosphaera kamptneri, Pontosphaera discopora, Thoracosphaera saxea, Sphenolithus abies, Coccolithus pelagicus,* and *Ceratolithus rugosus.* Age of Core 3: Pliocene, probably *Reticulofenestra pseudoumbilica* Zone.

4) Sample 4-2, 133-134 cm: *Discoaster brouweri, D. pentaradiatus, D. signus, D. variabilis, D. challengeri, D. surculus, D. quinqueramus, D. hamatus, D. asymmetricus, D. druggi, Helicopontosphaera kamptneri, Catinaster coalitus, C. calyculus, Cyclococcolithina leptopora, C. macintyrei, Sphenolithus abies, Umbilicosphaera sibogae,* and *Gephyrocapsa oceanica.*

5) Sample 4, CC: *Discoaster brouweri, D. surculus, D. variabilis, D. quinqueramus, D. pentaradiatus, D. challengeri, D. calcaris, D. druggi, Ceratolithus cristatus, C.*

tricorniculatus, Helicopontosphaera kamptneri, Thoracosphaera saxea, and *Sphenolithus abies.*

The nannofloras of Core 4 are composed of Miocene, Pliocene, and Quaternary species. The Quaternary species could be contamination from above. The admixture of Miocene and Pliocene species is interpreted as a result of turbidity current sedimentation. Age of Core 4: not older than lower Pliocene.

Cores 5-10 are practically barren of calcareous nannofossils. The rare coccoliths present there are, in all probability, to be regarded as contamination from above.

Cores 11-27, except for some very rare *Watznaueria* in Samples 20-2, 22-23 cm; 25-3, 117-118 cm; and 27, CC, are lacking calcareous nannofossils.

Cores 28-33 contain Lower Cretaceous and Upper Jurassic assemblages. The recognized species and their distribution are reported in Table 5. Core 28 is considered Valanginian or Hauterivian, because of *Cruciellipsis cuvillieri* that ranges from Berriasian to Hauterivian, *Reinhardites fenestratus,* and *Micula infracretacea* that first appear in the Valanginian. Samples 29, CC; 30-3, 120-121 cm; and 31-2,130-131 cm contain assemblages indicative of a Valanginian age. The presence in Sample 29, CC of *Tubodiscus verenae,* whose range is restricted to the Valanginian, and the first appearance of *Rheinhardites fenestratus* in Sample 31-2, 130-131 cm support this age assignment. The nannofossils of Sample 31-3, 10-11 cm still indicate a Lower Cretaceous age. The presence of a questionable specimen of *Polycostella beckmanni* suggests a possible Berriasian age.

The nannoplankton of Samples 31-4, 127-128 cm; 31, CC; and 32-2, 134-135 cm indicate an Upper Jurassic Tithonian age, based on *Parhabdolithus embergeri,* which first occurs in the lower Tithonian. Lower Cretaceous species are absent.

The remaining examined samples (32-3, 135-136 cm; 32-4, 70-71 cm; and 32, CC) contain very abundant *Watznaueria manivitae* (*Coccolithus deflandrei auct.*), *W. britannica, Watznaueria* spp., and *Discolithus salillum.* They occur below the *Parhabdolithus embergeri*

TABLE 5
Age and Distribution of Calcareous Nannoplankton in the Mesozoic, Site 261

	Lower Cretaceous								Upper Jurassic						
Age	?	not younger than Hauterivian			Valanginian			Berriasian ?	Tithonian			Kimmeridgian			Upper Oxfordian
Sample (Interval in cm)	27, CC	28-2, 136-137	28-3, 77-78	28-4	29, CC	30.3, 120-121	31-2, 130-131	31-3, 10-11	31-4, 127-128	31, CC	32-2, 134-135	32-3, 135-136	32-4, 70-71	32, CC	33-1, 0-20
Depth (m)	446.5	449.3	450.2	451.1	475.0	488.7	506.3	506.6	509.2	513.0	525.3	526.8	527.7	532.0	532.2
Micula infracretacea		X	X	X	X	X	X								
Reinhardites fenestratus		X	X	X			X								
Tubodiscus verenae					X										
Cretarhabdus crenulatus		X	X	X	X		X	X							
C. surirellus		X	X	X	X		X	X							
Manivitella pemmatoidea		X					X	X							
Lithraphidites carniolensis		X													
Biscutum constans		X				X	X	X							
Watznaueria biporta											X	X	X	X	
Parhabdolites asper						X				X					
Zygodiscus diplogrammus		X													
Cruciellipsis cuvillieri		X			X	X	X								
Parhabdolithus embergeri		X	X			X	X	X		X	X				
Polycostella beckmanni								X							
Watznaueria barnesae	X	X	X	X	X	X				X	X		X	X	X
W. communis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyclagelosphaera margereli		X		X	X					X					
Loxolithus armilla					X	X	X			X					
Watznaueria manivitae							X		X	X	X	X	X	X	X
Zygodiscus salillum							X	X						X	X
Stephanolithion bigoti															X
Watznaueria britannica			X	X		X	X	X		X		X		X	X

appearance and above the extinction of *Stephanolithion bigoti.* According to the known data levels based on nannoplankton, their age is intermediate between upper Oxfordian and lower Tithonian and in terms of European stratigraphic stages could correspond to the Kimmeridgian.

Sample 33-1, 0-20 cm, immediately above basement, contains the same assemblage as Core 32, but with *Stephanolithion bigoti.* The central area, diagnostic for the species, is lacking in all but one of the encountered four or five specimens. Nevertheless, all specimens seem co-specific, and no other species of this genus is apparently present in this sample. Based on he ranges of *Stephanolithion* species, the age of this level could be upper Oxfordian. The sediment color and the presence of limonite or hematite suggest an oxidizing environment.

SITE 262

(Timor Trough, 10°52.19'S, 123°50.78'E, water depth 2298 m, penetration 442 m, Cores 1-47)

Calcareous nannoplankton are abundant throughout most of the section. Only in the basal part where a rapid shallowing takes place do they become scarce to absent. The nannoplankton are associated with abundant siliceous skeletal remains from Cores 1 to 29 and with Ascidian spicules (Plate 10, Figures 2, 3) throughout the section. Distribution of the recognized species, age, and zonation are shown in Table 6.

The distribution of *Emiliania huxleyi* was found to be restricted to Cores 1-9 by SEM examination carried out by H. E. Franz. An interesting evolutionary sequence of *Gephyrocapsa* is observed from Sample 45, CC to the top of the section. Changes in the size of the specimens and the size of central openings (Plate 1, Figures 1-11) are visible under the light microscope. Higher evolved *Gephyrocapsa* species appear beginning with Core 36. Below this level the genus is represented only by more primitive forms. This evolutionary change coincides with the Pliocene-Pleistocene boundary based on the first occurrence of *Globorotalia truncatulinoides truncatulinoides.* The occurrence of *Emiliania protohuxleyi* was noted in Sample 23-1, 81-82 cm (Plate 8, Figure 12). Additional studies with the SEM will be needed to follow the evolutionary trends in more detail and establish individual taxa of *Gephyrocapsa.*

The *Pseudoemiliania lacunosa-Gephyrocapsa oceanica* Zone boundary is placed between Cores 29 and 30 at the level where the frequency of *Pseudoemiliania lacunosa* decreases abruptly.

The Pliocene-Pleistocene boundary is based on the extinction of *Discoaster brouweri* in Core 44. Table 7 shows the frequency of this species below and above this boundary. The absence of the species from the bottom to Sample 45, CC is explained by adverse facies conditions. The boundary is placed between Core 44, Section 3 and Core 44, Section 2, where an abrupt reduction in specimens takes place. Above Core 44, Section 2 the species re-appear only sporadically and in small quantities. These occurrences may be interpreted as a result of reworking.

Following Smith and Beard (1973, fig. 5), it is also possible that the abrupt decrease of *Discoaster brouweri* in Core 44 is due to cooling.

In this interpretation, the occasional and rare occurrences between Cores 44 and 34 (Table 7) would be the result of such a cooling period, and the weak increase in Cores 33 and 32 would represent a warmer period, just before extinction, shortly after the first occurrence of *Globorotalia truncatulinoides truncatulinoides.* The occasional and rare presence of *Discoaster brouweri* between Cores 30 and 5 would then be regarded as due to reworking.

Beginning with Core 36, and particularly between Core 29 and Core 1, frequent reworked *Discoaster* and Cretaceous taxa are present.

SITE 263

(Cuvier Abyssal Plain, 23°19.43'S, 110°57.81'E, water depth 5048 m, penetration 746 m, Cores 1-29)

Cores 1 and 2 contain abundant, partly reworked, moderately preserved nannofloras which are associated with ascidian spicules and rare holothurian sclerites.

1) Samples 1-1, 138-139 cm; 1-2, 88-89 cm; and 1, CC: *Gephyrocapsa oceanica, Cyclococcolithina leptopora, Helicopontosphaera kamptneri, Coccolithus pelagicus, Thoracosphaera heimi, T. saxea, Pontosphaera discopora, P. scutellum, Sphenolithus abies, S. moriformis, Umbilicosphaera sibogae, Pseudoemiliania lacunosa, Discoaster brouweri, D. pentaradiatus, D. variabilis, Ellipsodiscoaster lidzi, Rhabdosphaera clavigera,* and *Braarudosphaera bigelowi,* and in addition, reworked Paleogene and Cretaceous species are present. Age of Core 1: Quaternary.

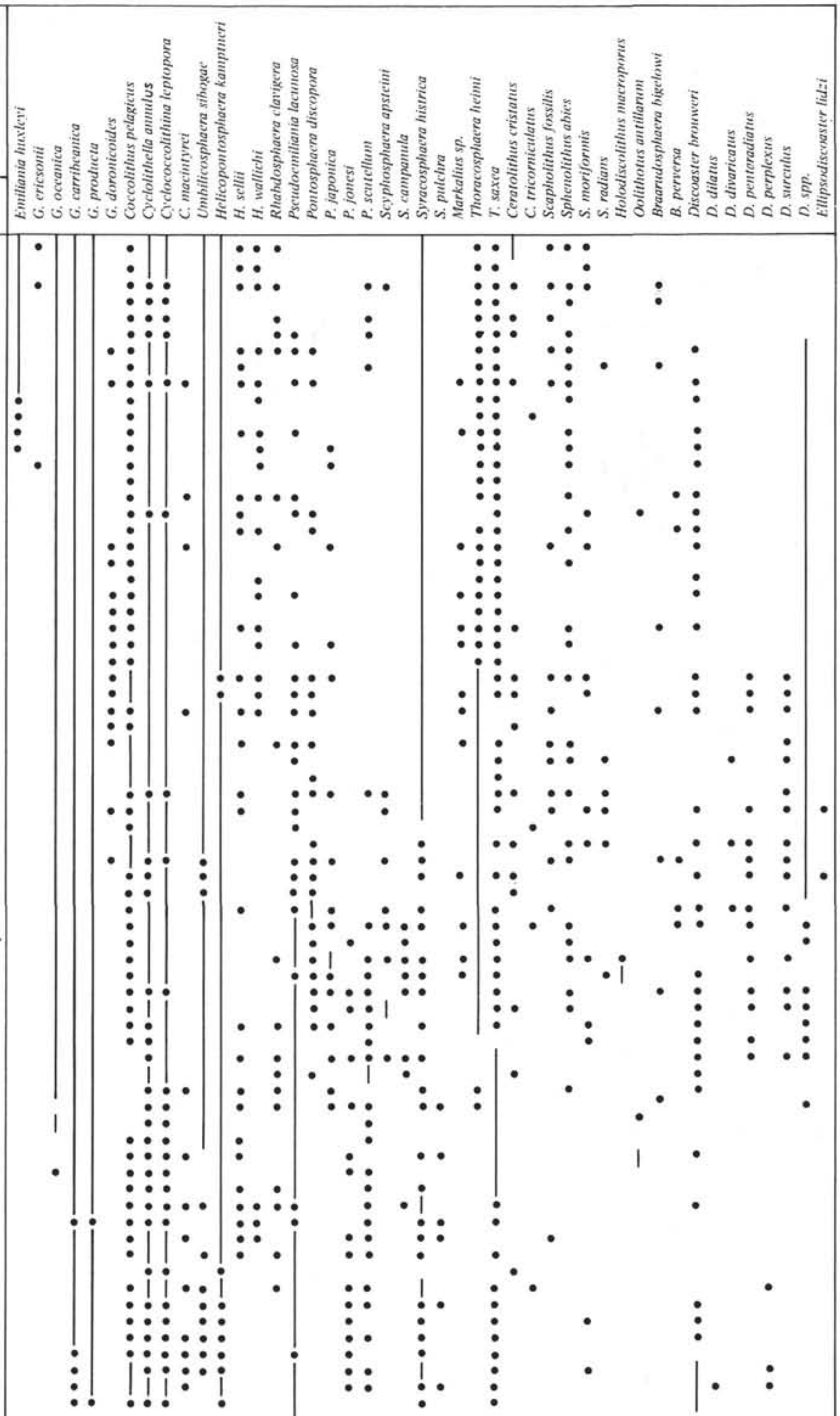
2) Samples 2-2, 80-81 cm; 2-4, 23-24 cm; and 2, CC: contain essentially the same nannoflora as Core 1. Age of Core 2: Quaternary.

The sediments of Cores 3-29 are, based on smear slides, very rich in organic matter and pyrite. The organic matter is represented by irregular brown fragments and bag-shaped membranes, both of chitinous appearance, and probably remains of microplankton (Plate 10, Figure 8). The bag- or pot-shaped forms of Sites 259 and 260 are also present (Plate 10, Figures 5, 6, 7). The pyrite has the shape of spherical concretions 4-20μ in diameter (Plate 8, Figures 2, 3), or of smaller cubical and octahedral crystals. The great abundance of organic remains and authigenic pyrite suggests a reducing sedimentary environment of euxinic type. The uniformity of the sediment facies from Cores 3 to 29 indicates a persistence of such environmental conditions. The calcareous nannoplankton are rarely abundant and show a low specific diversity. The recognized species and their distribution are reported in Table 8.

Sample 4-4, 55-57 cm contains, in addition to the dominantly Lower Cretaceous nannoflora, a number of species including *Cruciplacolithus* cf. *tenuis* (Plate 3, Figures 2-4), *Ellipsolithus* cf. *macellus* (Plate 3, Figure 1), and *Markalius inversus,* indicative of lower Paleocene. On this evidence the interval between Samples 3, CC

TABLE 6
Age, Zonation, and Distribution of Calcareous Nannoplankton, Site 262

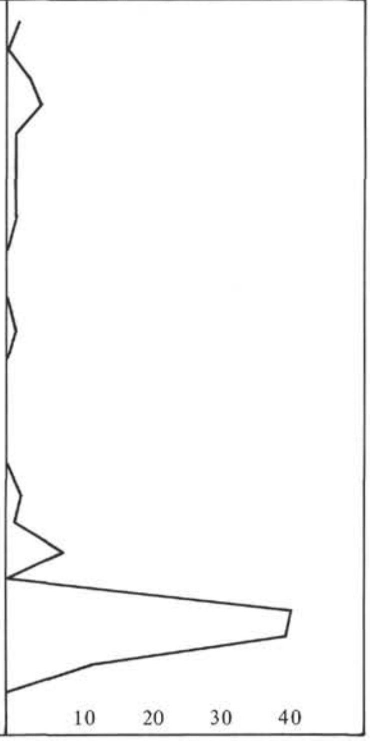
Age	Zone	Sample (Interval in cm)	Depth (m)
		1-2, 10-11	1.6
		1, CC	5.0
		2-4, 67-68	10.1
		2, CC	14.5
	Emiliania	3-4, 70-71	18.2
	huxleyi	4-4, 94-95	29.4
		5-4, 98-99	38.9
		5, CC	43.0
		6-4, 70-71	48.2
		7-3, 82-83	56.2
		7, CC	62.0
		8-5, 63-64	68.6
		9-5, 64-65	78.1
		10-5, 111-112	88.1
		10, CC	90.5
		11-5, 83-84	97.3
		12-5, 50-51	106.5
		13-5, 105-106	116.5
		14-5, 70-71	125.7
		14, CC	128.5
		15-5, 27-28	134.7
		16-6, 94-95	146.4
		16, CC	147.5
		17-6, 77-78	155.7
	Gephyrocapsa	18-6, 90-91	165.4
	oceanica	18, CC	166.5
		19-5, 92-93	173.4
		20-5, 77-78	182.7
		21-6, 96-97	193.9
		21, CC	195.0
		22-3, 82-83	198.8
		23-3, 80-81	208.3
		23, CC	214.0
		24-2, 96-97	216.4
		25-2, 89-90	225.8
		25, CC	233.0
		26-2, 60-61	235.1
		27-2, 86-87	244.8
		28-1, 72-73	252.7
		28, CC	261.5
Quaternary		29-1, 87-88	262.3
		30-2, 108-109	273.5
		30, CC	280.5
		31-4, 66-67	285.6
		32, CC	299.5
		33-4, 84-85	304.8
		33, CC	309.0
		34-3, 43-44	312.4
		34, CC	318.5
		35-1, 55-56	319.0
		35, CC	328.0
		36-1, 135-136	329.3
		37-5, 80-81	344.3
	Pseudoemiliania	37, CC	347.0
	lacunosa	38-5, 70-71	359.7
		39-2, 77-78	358.7
		39, CC	366.0
		40-1, 98-99	366.9
		40-5, 81-82	372.8
		41-3, 139-140	379.8
		41-6, 66-67	383.6
		42-1, 74-75	385.7
		42-5, 81-82	391.8
		42, CC	394.5
		43-1, 75-76	395.2
		43-2, 95-96	396.9
		43, CC	404.0
		44-2, 114-115	406.6
		44-3, 80-81	407.8
Upper	*Discoaster*	44, C	413.5
Pliocene	*brouweri*	45-1, 89-90	414.3
		45, CC	423.0



abundant to common ——— rare to few •

TABLE 7
Distribution of Discoaster brouweri in Cores 30-45 at Site 262

Sample (Interval in cm)	Depth (m)	Number of Specimens per 100 Fields (objectives 54 x, ocular 12.5 x)
30-2, 108-109	273.80	
31-4, 66-67	285.16	
32, CC	299.50	
33-4, 84-85	304.84	
34-3, 43-44	412.43	
35-1, 55-56	319.05	
36-1, 135-136	329.35	
37-5, 80-81	344.30	
38-5, 70-71	353.70	
39-2, 77-78	358.77	
40-1, 98-99	366.98	
40-5, 81-82	372.81	
41-3, 139-140	379.89	
41-6, 66-67	383.66	
42-1, 74-75	385.74	
42-5, 81-82	391.81	
42, CC	394.50	
43-1, 75-76	395.25	
43-2, 95-96	396.95	
43, CC	404.00	
44-2, 114-115	406.64	
44-3, 80-81	407.80	
44, CC	413.50	
45-1, 89-90	414.39	
45, CC	423.00	



and 4-4, 55-57 cm is dated lower Paleocene or younger.

Core 4, Section 5 to Core 27 are referred to the upper Albian, because they follow the first appearance of *Eiffellithus turriseiffeli* in Core 27 and are lacking in species appearing in the post-Albian.

Eiffellithus turriseiffeli was not observed in the interval between Cores 4 and 21, except for a single and doubtful specimen in Sample 4-4, 89-90 cm (Plate 3, Figure 5). It should be noted that the species is also absent in some of the samples examined between Cores 22-27. Many other species, generally frequent in the Albian and present at Sites 259 and 260, are also lacking, in particular from Cores 5 to 16. The presence of *Cretarhabdus coronadventis* and *Eiffellithus turriseiffeli* in Sample 4-4, 89-90 cm, and the uniformity in sediment facies suggest the same upper Albian age down to Core 27.

The low specific diversity of assemblages and the absence or the rarity of some common Albian species, present at Sites 259 and 260, could be explained by selective solution. This is supported by some correlation between diversity and abundance of coccoliths and $CaCO_3$ content of the sediments, the presence of etched nannofossils, and the existence of a depositional or post-depositional environment of euxinic type.

Sample 28-2, 95-96 cm contains *Vagalapilla matalosa* and hence it is not older than middle Albian.

No detailed stratigraphic dating is possible for Core 28, Section 3 to Sample 29, CC which only contain *Watznaueria* and very rare specimen of *Vagalapilla stradneri* and *Biscutum constans*.

According to their known stratigraphic ranges, some species are considered reworked. They are:

Nannoconus bucheri Sample 4-4, 89-90 cm
Cretaturbella rothii Sample 4-4, 89-90 cm
Micula infracretacea Samples 4-3, 70-71 cm and 5-1, 114-115 cm
Reinhardites fenestratus Samples 4-3, 70-71 cm and 5-1, 114-115 cm
Micrantolithus hoschulzi Sample 26-3, 124-125 cm
Micrantolithus obtusus Sample 26-3, 124-125 cm

No notable facies change was observed in the above samples, except for Sample 26-3, 124-125 cm which contains somewhat more detrital material and overgrown specimens of *Watznaueria* and *Vagalapilla matalosa*. The presence of reworked taxa implies the proximity of older sediments exposed to erosion and redeposition.

ACKNOWLEDGMENTS

The author wishes to thank H. M. Bolli (Zurich) for discussions and guidance in the preparation of this report. Aspects on the distribution and stratigraphic value of a number of Cretaceous taxa were discussed with H. R. Thierstein (Lamont). H. E. Franz (Zurich) kindly prepared most of the SEM micrographs and also aided in the determination of the range of *Emiliania huxleyi*. The problematic microfossils on Plate 10 were discussed with A. R. and Helen Loeblich Tappan (Los Angeles) and J. Remane (Neuchatel). F. Medizza and P. Grandesso (Padova) assisted in the preparation of the LM micrographs. JEOL (Milano) and Leitz Italiana (Milano) kindly allowed the author to make use of their scanning electron microscopes. Gratitude is expressed to the Padova University for having granted the necessary leave of absence to participate in Leg 27. Finally, thanks are expressed to G. Piccoli, Director of the Geological Institute, University of Padova, for making available the laboratory facilities.

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TABLE 8
Age, Zonation, and Distribution of Calcareous Nannoplankton in the Cretaceous, Site 263

Age		Zone	Sample (Interval in cm)	Depth (m)	*Eiffellithus turriseiffeli*	*Tranolithus exiguus*	*Cretarhabdus coronadventis*	*Broinsonia signata*	*Vagalapilla matalosa*	*Prediscosphaera cretacea*	*Parhabdolithus angustus*	*Corollithion achylosum*	*Braarudosphaera africana*	*Podorhabdus decorus*	*Tegumentum stradneri*	*Nannoconus bucheri*	*Parhabdolithus splendens*	*Zygodiscus diplogrammus*	*Podorhabdus dietzmanni*	*Micula infracretacea*	*Reinhardites fenestratus*	*Cretarhabdus crenulatus*	*Cretarhabdus surirellus*	*Micrantholithus hoschulzi*	*Micrantholithus obtusus*	*Manivitella pemmatoidea*	*Lithraphidites carniolensis*	*Biscutum constans*	*Cretarhabdus conicus*	*Watznaueria biporta*	*Zygodiscus elegans*	*Discorhabdus rotatorius*	*Markalius circumradiatus*	*Parhabdolithus asper*	*Stephanolithion laffittei*	*Parhabdolithus embergeri*	*Cretaturbella rothii*	*Vagalapilla stradneri*	*Watznaueria barnesae*	*W. communis*	*Cyclagelosphaera margereli*	*Watznaueria britannica*	*Cruciplacolithus cf. tenuis*	*Ellipsolithus cf. macellus*	*Markalius inversus*
Teritiary	L. Paleocene or younger	*Cruciplacolithus tenuis* or younger	3, CC	100.0														X					X			X								X		X		X	X	X	X				
			4-1, 27-28	109.7			X							X				X					X			X	X							X		X		X	X	X					
			4-2, 90-91	111.9			X						X	X				X					X			X	X		X					X	X	X		X	X	X					
			4-3, 70-71	113.2			X			X				X				X	X	X			X			X	X		X					X		X		X	X	X					
			4-4, 55-57	114.6													X		X								X		X		X		X	X				X	X	X			X	X	X
Lower Cretaceous	Upper Albian	*Eiffellithus turriseiffeli*	4-4, 89-90	114.9			X							X	X	X	X		X			X	X			X	X	X	X					X		X	X	X	X	X		X			
			4-5, 102-103	116.5							X												X						X	X				X				X	X	X					
			5-1, 114-115	129.5														X		X	X		X			X								X		X			X	X					
			5, CC	138.0											X								X			X								X				X	X	X	X				
			6-3, 102-103	151.5																			X							X						X			X	X					
			6-5, 83-84	154.3																			X							X						X			X	X					
			17, CC	394.5					X																									X					X	X					
			18-4, 67-68	418.6				X										X												X				X				X	X	X					
			18, CC	423.0					X								X												X										X	X					
			19-6, 108-109	460.0		X		X							X													X			X			X		X		X	X	X		X			
			22-1, 30-31	556.3				X																															X	X	X				
			22-2, 71-72	558.2				X																															X	X	X				
			22, bottom	565.5	X			X							X			X					X			X		X		X								X	X	X	X				
			23-5, 61-62	600.6		X		X										X	X				X					X								X		X	X	X	X				
			23, CC	603.5	X			X										X					X															X	X	X					
			24-6, top	639.5																			X													X		X	X	X					
			24-6, 26-27	639.7				X	X						X													X								X			X	X					
			25, CC	679.5	X			X	X																													X	X	X	X				
			26-2, 19-20	700.1					X																			X											X	X					
			26-3, 124-125	702.7	X			X	X														X	X	X			X		X	X	X				X			X	X	X				
			26-4, 48-49	703.4																										X	X								X	X					
			26-5, 135-136	705.8	X			X			X	X											X					X								X			X	X					
			27, CC	717.5	X			X				X						X			X		X					X			X		X						X	X					
	not older than middle Albian		28-2, 95-96	729.4				X	X																					X									X	X	X				
			29-2, 21-22	738.2																																		X	X	X					
	?		29-4, 128-129	742.2																								X											X	X					
			29, CC	746.0																																			X	X					
			bit sample	746.0																								X										X	X	X					

PLATE 1

Figures 1, 2	*Gephyrocapsa producta*?, cross-polarized light, ×2600, Sample 262-44-3, 80-81 cm. 1. Long axis parallel. 2. Same specimen, long axis 45° inclined.
Figures 3, 4	*Gephyrocapsa caribbeanica*, cross-polarized light, ×2600. 3. Sample 262-40-1, 98-99 cm. 4. Sample 262-44-3, 80-81 cm.
Figures 5-11	*Gephyrocapsa oceanica*, cross-polarized light, ×2600. 5-8. Sample 262-36-1, 135-136 cm. 9, 10. Sample 262-3-4, 70-71 cm. 11. Sample 262-27-2, 86-87 cm.
Figure 12	*Gephyrocapsa doronicoides*?, cross-polarized light, ×2600, Sample 262-36-1, 135-136 cm.
Figure 13	*Ceratolithus cristatus*, transmitted light, ×2000, Sample 262-1-2, 10-11 cm.
Figures 14, 15	*Helicopontosphaera kamptneri*, Sample 262-44, CC. 14. Transmitted light, ×2000. 15. Phase contrast, ×2000.
Figure 16	*Discoaster brouweri*, transmitted light, ×2000, Sample 262-44, CC.
Figures 17-19	*Discoaster* cf. *binodosus*, Sample 259-4-5, 124-125 cm. 17. Transmitted light, ×2000. 18, 19. Phase contrast, ×2000.
Figures 20, 21	*Discoaster diastypus*, transmitted light, ×1200. 20. Sample 259-4-4, 131-132 cm. 21. Sample 259-4-5, 124-125 cm.
Figures 22, 23	*Discoaster* sp., transmitted light, ×1200, Sample 259-4-6, 110-111 cm.
Figures 24, 25	*Biantholithus sparsus* 24. transmitted light, ×2000 25. same specimen, cross polarized light, ×2000
Figure 26	*Tribrachiatus bramletteei* transmitted light, ×1200 Site 259-4-6, 110-111 cm
Figure 27	*Tribrachiatus contortus* transmitted light, ×2000 Site 259-5-4, 45-46 cm

PLATE 1

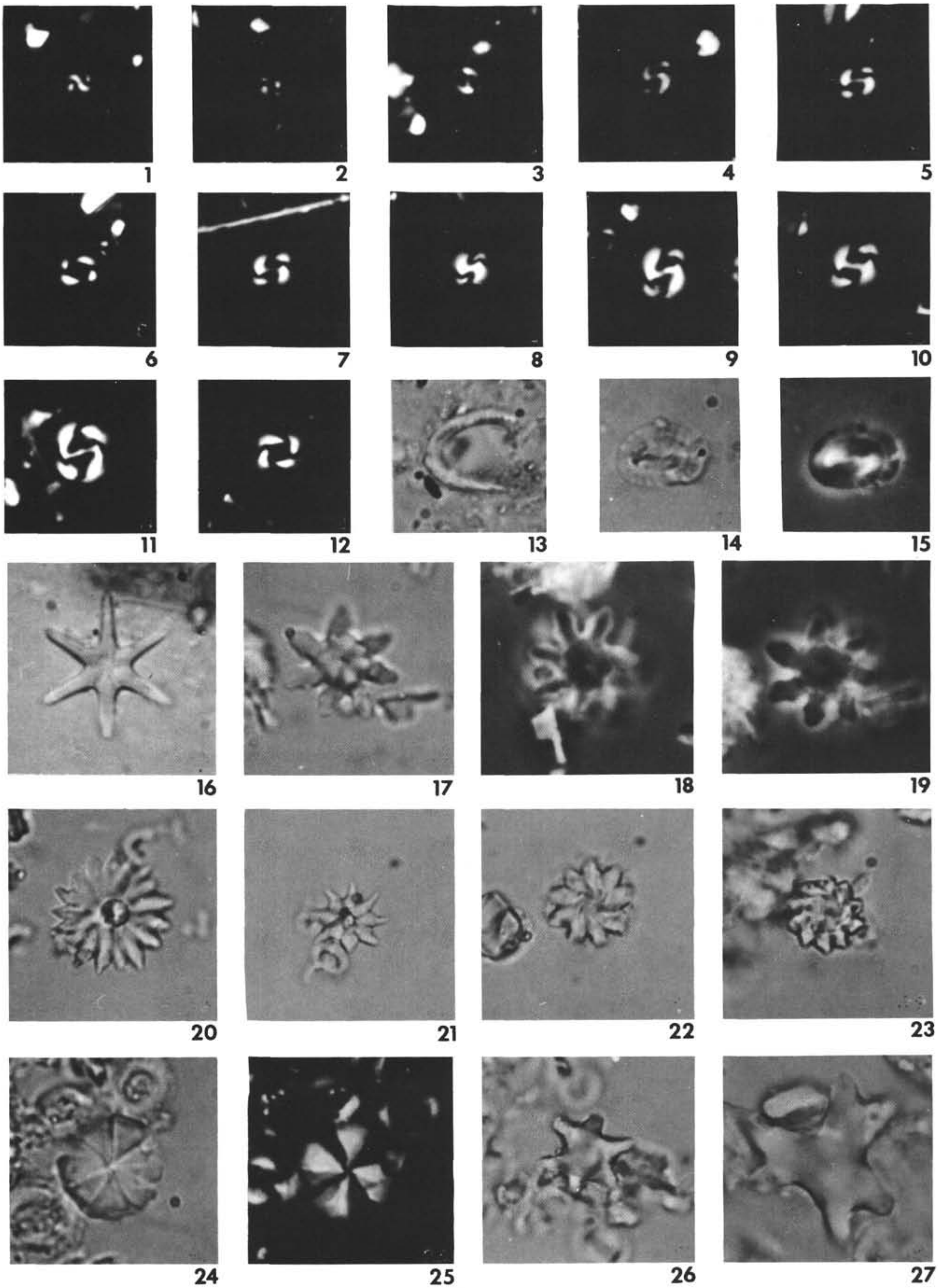
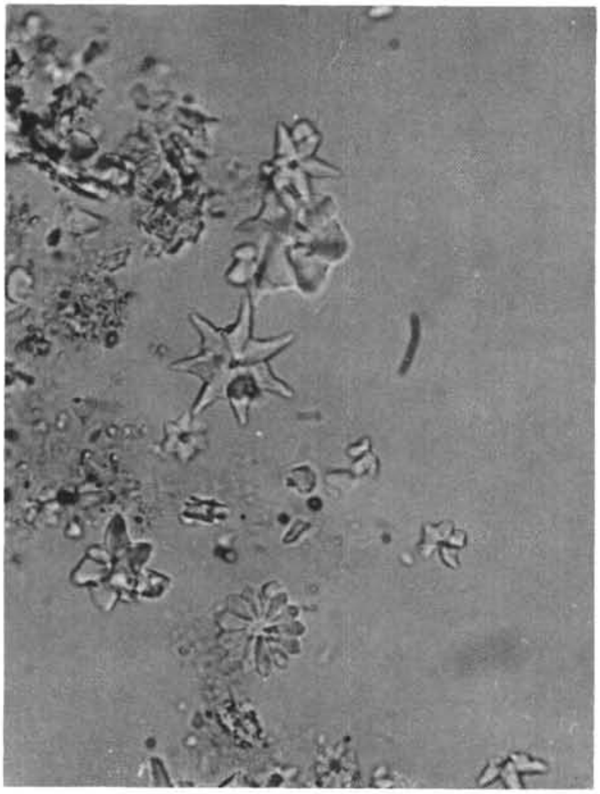


PLATE 2

Figure 1	*Discoaster lodoensis* and *D. barbadiensis*, transmitted light, ×850, *Discoaster lodoensis* Zone, Sample 259-4-2, 65-66 cm.
Figure 2	*Discoaster lodoensis* and *Tribrachiatus orthostylus*, transmitted light, ×850, *Tribrachiatus orthostylus* Zone, Sample 259-4-3, 86-87 cm.
Figure 3	*Discoaster salisburgensis* and *Tribrachiatus orthostylus*, transmitted light, ×850, *Discoaster binodosus* Zone, Sample 259-4-5, 124-125 cm.
Figure 4	*Discoaster multiradiatus*, *D. salisburgensis*, and *D. diastypus*, transmitted light, ×850, *Tribrachiatus contortus* Zone, Sample 259-4-6, 110-111 cm.

PLATE 2



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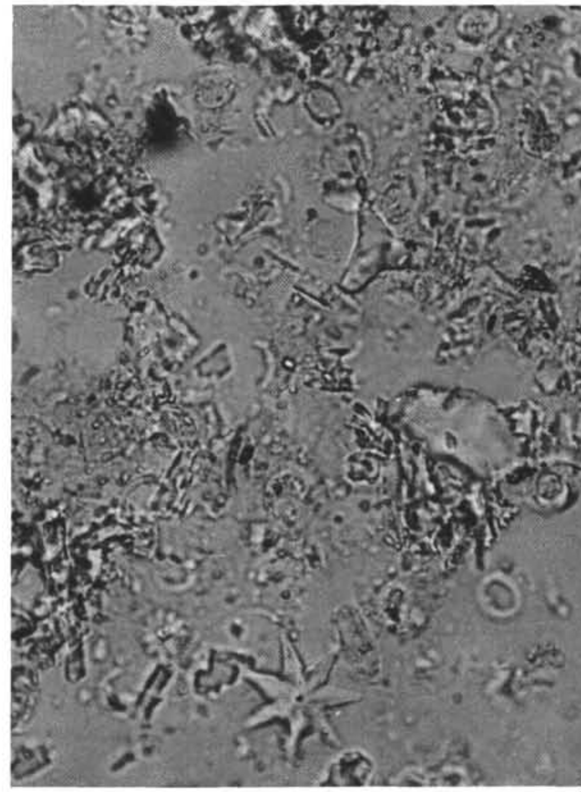

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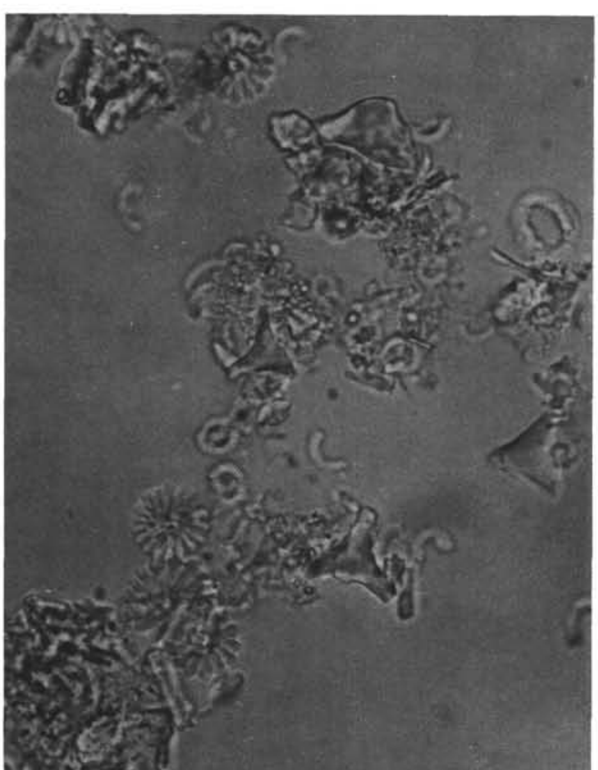

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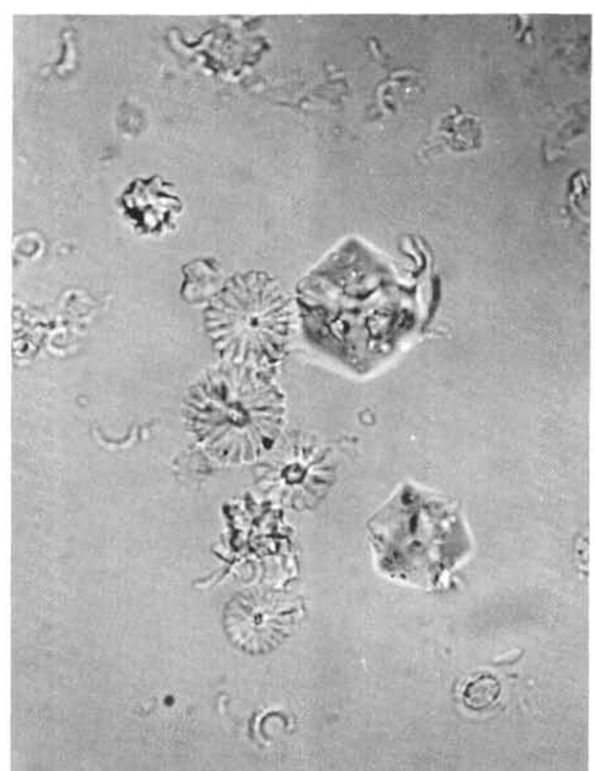

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PLATE 3

Figure 1	*Ellipsolithus* cf. *macellum*, cross-polarized light, ×2600, Sample 263-4-4, 55-57 cm.
Figures 2-4	*Cruciplacolithus* cf. *tenuis*, ×2000, Sample 263-4-4, 55-57 cm. 2. Transmitted light. 3. Phase contrast. 4. Cross-polarized light.
Figure 5	*Eiffellithus turriseiffeli*?, cross-polarized light, ×2000, Sample 263-4-4, 89-90 cm.
Figures 6, 7	*Eiffellithus turriseiffeli*, ×2600, Sample 263-26-3, 124-125 cm. 6. Cross-polarized light. 7. Transmitted light.
Figure 8	*Tranolithus exiguus*, cross-polarized light, ×2600, Sample 263-23-5, 61-62 cm.
Figure 9	*Cretarhabdus coronadventis*, cross-polarized light, ×2000, Sample 263-4-4, 89-90 cm.
Figures 10, 14, 15	*Cretarhabdus crenulatus*, ×2000, Sample 260-12-2, 22-23 cm. 10. Transmitted light. 14. Phase contrast. 15. Cross-polarized light.
Figures 11-13	*Cretarhabdus surirellus*, ×2000, Sample 260-12-2, 22-23 cm. 11. Phase contrast. 12. Transmitted light. 13. Cross polarized light.
Figures 16-18	*Cretarhabdus conicus*, ×2000, Sample 263-4-5, 102-103 cm. 16. Transmitted light. 17. Cross-polarized light. 18. Phase contrast.
Figures 19, 20	*Broinsonia signata*. 19. Phase contrast, ×2000, Sample 259-14-2, 104-105 cm. 20. Cross-polarized light, ×2000, Sample 260-17-1, 37-38 cm.
Figures 21, 22	*Hayesites albiensis*, ×2000, Sample 259-14-2, 104-105 cm. 21. Phase contrast. 22. Cross-polarized light.
Figures 23-25	*Vagalapilla matalosa*, ×2000, Sample 260-17-1, 37-38 cm. 23. Transmitted light, ×2000. 24. Cross-polarized light, ×2000. 25. Phase contrast, ×2000.
Figures 26-28	*Prediscosphaera cretacea*, ×2000, Sample 259-14-2, 104-105 cm. 26. Transmitted light. 27. Cross-polarized light. 28. Phase contrast.
Figures 29, 30	*Parhabdolithus angustus*, ×2000, Sample 259-14, CC. 29. Cross-polarized light. 30. Phase contrast.
Figures 31, 32	*Flabellites biforaminis*, ×2000, Sample 259-14-2, 104-105 cm. 31. Phase contrast. 32. Cross-polarized light.
Figures 33-35	*Lithastrinus floralis*, ×2000, Sample 259-14-2, 104-105 cm. 33. Transmitted light. 34. Cross-polarized light. 35. Phase contrast.

PLATE 3

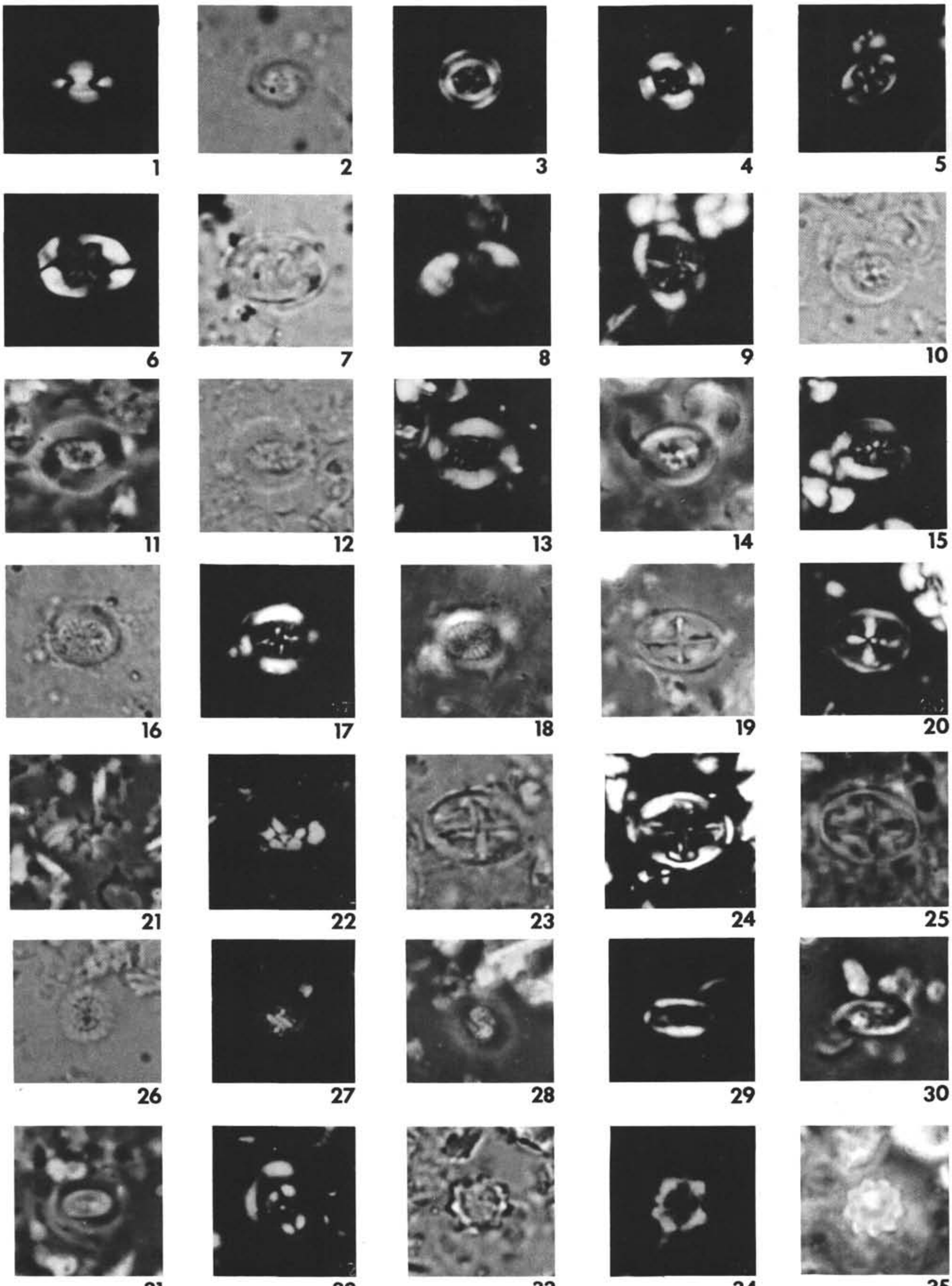

PLATE 4

Figures 1, 2	*Rucinolithus irregularis*, ×2600, Sample 260-12-2, 22-23 cm. 1. Cross-polarized light. 2. Phase contrast.
Figures 3, 4	*Tegumentum stradneri*, ×2000, Sample 263-19-6, 108-109 cm. 3. Cross-polarized light. 4. Transmitted light.
Figures 5, 10	*Podorhabdus dietzmanni*, ×2600, Sample 263-4-4, 55-57 cm. 5. Cross-polarized light. 10. Phase contrast.
Figures 6, 7	*Zygodiscus diplogrammus*, ×2000, Sample 259-14, CC. 6. Cross-polarized light. 7. Phase contrast.
Figures 8, 9	*Zygodiscus elegans*, ×2000, Sample 260-17-1, 37-38 cm. 8. Cross-polarized light. 9. Phase contrast.
Figures 11-14	*Biscutum constans*. 11. Transmitted light, ×2000, Sample 259-13, CC. 12. Cross-polarized light, ×2000, same specimen. 13. Phase contrast, ×2000, same specimen. 14. Cross-polarized light, ×2600, Sample 263-23-5, 61-62 cm.
Figure 15	*Stephanolithion laffittei*, phase contrast, ×2000, Sample 259-14-2, 104-105 cm.
Figures 16, 17	*Micula infracretacea*, ×1700, Sample 260-42-75-76 cm. 16. Transmitted light. 17. Cross-polarized light.
Figures 18-20, 25	*Polycostella beckmanni*?, ×2000, Sample 261-31-3, 10-11 cm. 18. Transmitted light. 19. Cross-polarized light. 20, 25. Phase contrast.
Figures 21, 22, 26	*Watznaueria communis*, ×2600. 21. Cross-polarized light, Sample 260-17, CC. 22. Phase contrast, Sample 260-17, CC. 26. Cross-polarized light, Sample 263-29, bit sample.
Figures 23, 24	*Vagalapilla stradneri*, ×2600, Sample 260-12-2, 22-23 cm. 23. Phase contrast. 24. Cross-polarized light.
Figure 27	*Watznaueria barnese*, cross-polarized light, ×2000, Sample 260-11, CC.
Figures 28-30	*Watznaueria britannica*, ×2000, Sample 261-33-1, 0-20 cm. 28. Cross-polarized light. 29. Cross-polarized light. 30. Transmitted light, same specimen as Fig. 29.
Figure 31	*Watznaueria biporta*, cross-polarized light, ×2000, Sample 260-11, CC.
Figures 32-34	*Cyclagelosphaera margereli*, ×2600, Sample 260-17, CC. 32. Transmitted light. 33. Cross-polarized light. 34. Phase contrast.
Figure 35	*Zygodiscus salillum*, cross-polarized light, ×2000, Sample 261-33-1, 0-20 cm.

PLATE 4

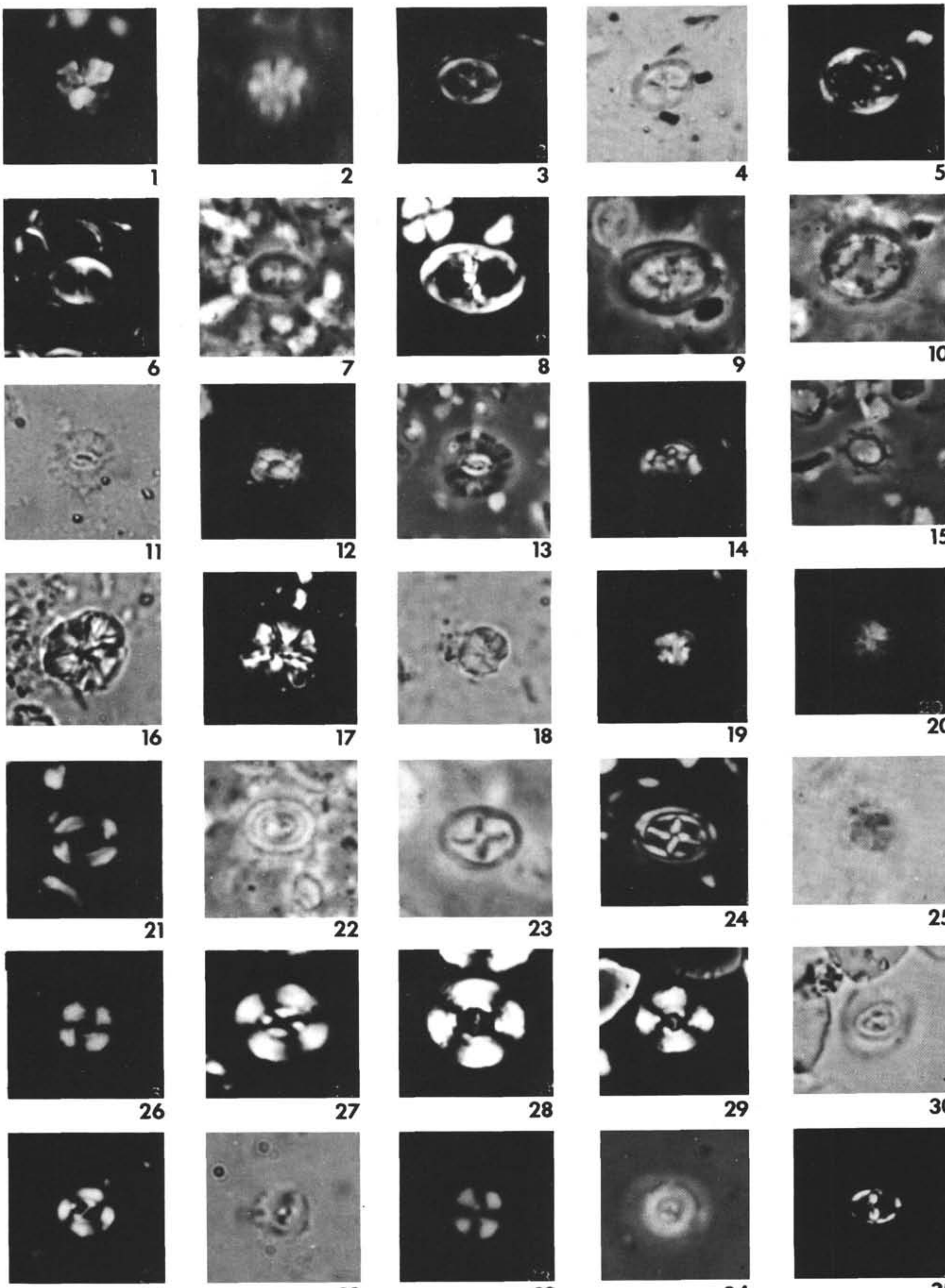
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PLATE 5

Figures 1-3	*Cretarhabdus loriei,* ×2000, Sample 259-14, CC. 1. Transmitted light. 2. Cross-polarized light. 3. Phase contrast.
Figures 4,8	*Parhabdolithus splendens,* ×2600, Sample 263-4-4, 55-57 cm. 4. Transmitted light. 8. Cross-polarized light.
Figures 5-7	*Manivitella pemmatoides,* ×2000, Sample 259-13-6, 102-103 cm. 5. Transmitted light. 6. Cross-polarized light. 7. Phase contrast.
Figures 9-12, 16	*Reinhardites fenestratus.* 9. Transmitted light, ×2600, Sample 260-17, CC. 10. Cross-polarized light, ×2600, same specimen as in Fig. 9. 11. Phase contrast, ×2600, same specimen as in Fig. 9. 12. Cross-polarized light, ×2000, distal side, Sample 261-31-2, 130-131 cm. 16. Transmitted light, ×2600, same specimen as in Fig. 12.
Figures 13-15	*Cruciellipsis cuvillieri,* ×2000, Sample 261-30-3, 120-121 cm. 13. Cross-polarized light. 14. Transmitted light. 15. Phase contrast.
Figures 17, 18	*Parhabdolithus asper,* ×2600, Sample 260-11, CC. 17. Cross-polarized light. 18. Phase contrast.
Figures 19, 20 24	*Parhabdolithus embergeri,* ×2000, Sample 259-14-2, 104-105 cm. 19. Transmitted light. 20. Phase contrast. 24. Cross-polarized light.
Figures 21-23	*Watznaueria manivitae,* ×2000, Sample 261-32-3, 135-136 cm. 21. Transmitted light. 22, 23. Cross-polarized light.

PLATE 5

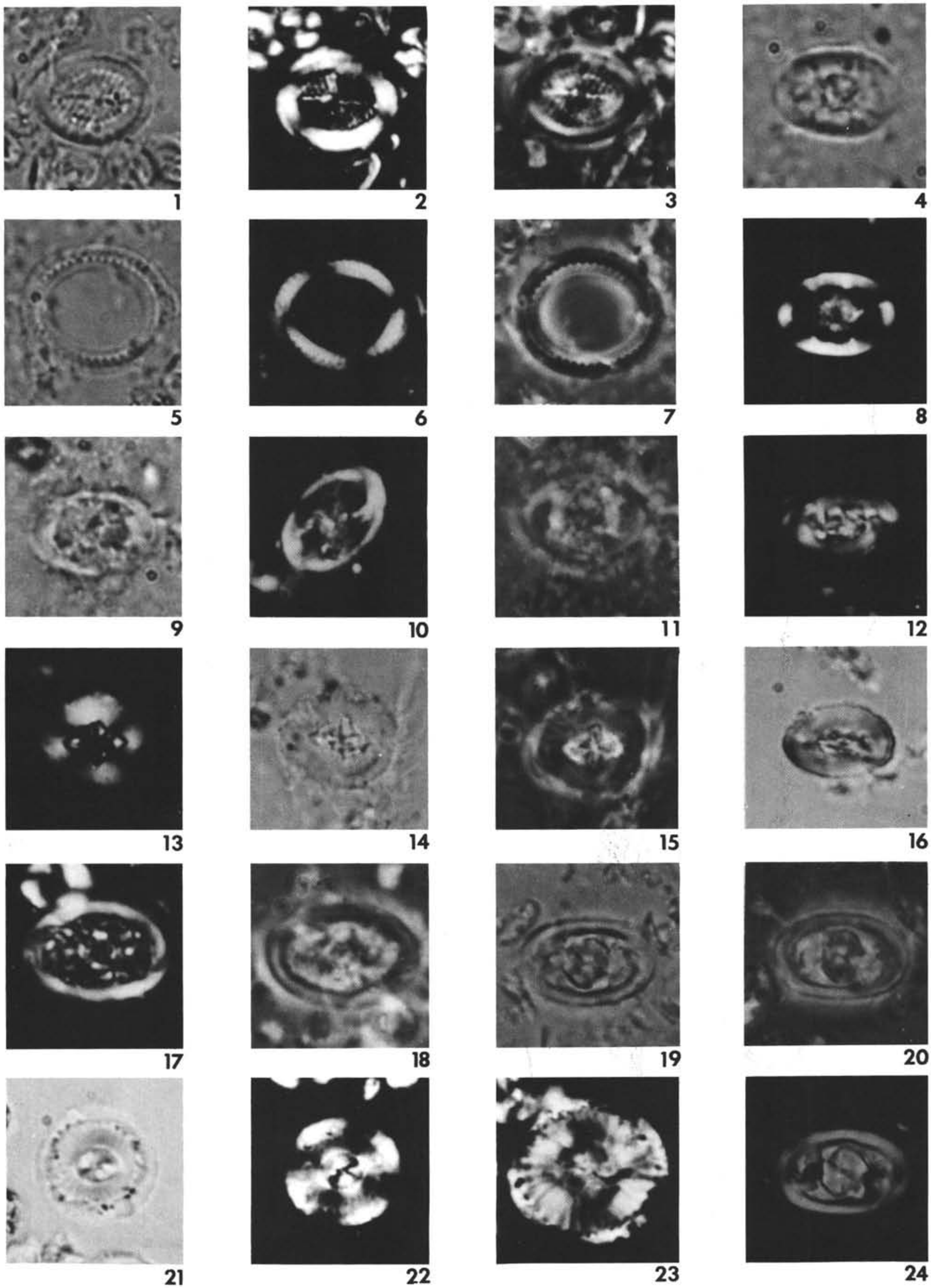


PLATE 6

Figures 1-3	*Cretaturbella rothii*, ×2000, Sample 263-4-4, 89-90 cm. 1. Transmitted light. 2. Cross-polarized light. 3. Phase contrast.
Figures 4, 5	*Nannoconus bucheri*, ×2000, Sample 263-4-4, 89-90 cm. 4. Transmitted light. 5. Cross-polarized light.
Figure 6	*Loxolithus armilla*?, cross-polarized light, ×2000, Sample 261-33-1, 0-20 cm.
Figures 7-9, 13	*Markalius circumradiatus*, ×2000, Sample 260-15-2, 63-64 cm. 7. Phase contrast. 8. Transmitted light. 9. Phase contrast, high focus. 13. Cross-polarized light.
Figures 10, 11	*Lithraphidites carniolensis*, ×2000, Sample 259-14-2, 104-105 cm. 10. Transmitted light. 11. Cross-polarized light.
Figure 12	*Thoracosphaera* sp., cross-polarized light, ×1600, Sample 263-27, CC.
Figure 14	*Podorhabdus decorus*, cross-polarized light, ×2000, Sample 263-4-4, 89-90 cm.
Figures 15-19	*Stephanolithion bigoti*, Sample 261-33-1, 0-20 cm. 15. Cross-polarized light, ×2000. 16, 18, 19. Phase contrast, ×2600. 17. Cross-polarized light, ×2600.
Figures 20, 21	*Micrantholithus hoschulzi*, ×2600, Sample 263-26-3, 124-125 cm. 20. Transmitted light. 21. Cross-polarized light.
Figures 22, 23	*Micrantholithus obtusus*, ×2000, Sample 263-26-3, 124-125 cm. 22. Transmitted light. 23. Cross-polarized light.

PLATE 6

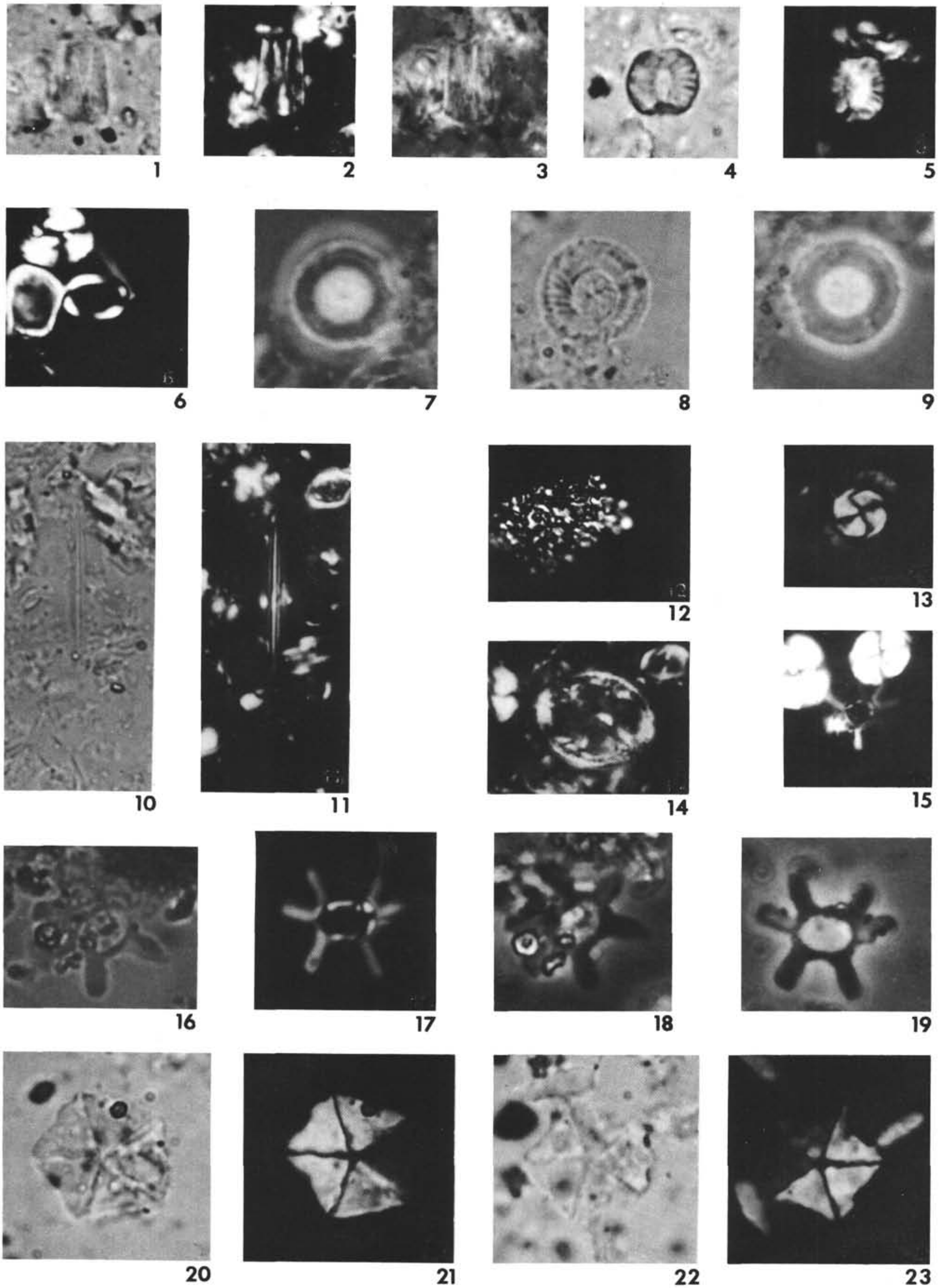


PLATE 7
SEM micrographs.

Figure 1	*Watznaueria barnesae*, ×5000, Sample 263-4-4, 89-90 cm.
Figure 2	*Lithastrinus floralis*, ×7000, Sample 259-14, CC.
Figure 3	*Lithastrinus floralis*, side view, ×7000, Sample 259-14, CC.
Figure 4	*Hayesites albiensis*, ×8000, Sample 259-14, CC.
Figures 5, 6	*Prediscosphaera cretacea*, Sample 259-14, CC. 5. ×9000. 6. ×5000, side view.
Figure 7	*Cretarhabdus coronadventis*, ×5000, Sample 263-4-4, 89-90 cm.
Figure 8	*Tegumentum stradneri*, ×7000, Sample 263-4-4, 89-90 cm.
Figure 9	*Flabellites biforaminis*, ×6000, proximal side, 259-14, CC.
Figures 10-12	*Parhabdolithus asper* 10. ×7000, proximal side. 11. ×7000, distal side. 12. ×6000, distal side.
Figure 13	*Zygodiscus elegans*, ×8000, proximal side, Sample 259-14, CC.
Figure 14	*Parhabdolithus embergeri*, ×4000, distal side, Sample 259-14, CC.
Figure 15	*Zygodiscus diplogrammus*, ×6500, proximal side, Sample 259-14, CC.
Figure 16	*Broinsonia signata*, ×7000, distal side, Sample 263-4-4, 89-90 cm.
Figures 17-19	*Vagalapilla stradneri*, Sample 263-4-4, 89-90 cm. 17. ×7000, proximal side. 18, 19. ×7000, distal side.
Figure 20	*Vagalapilla* cf. *matalosa*, ×7000, distal side, Sample 263-26-3, 124-125 cm.

PLATE 7

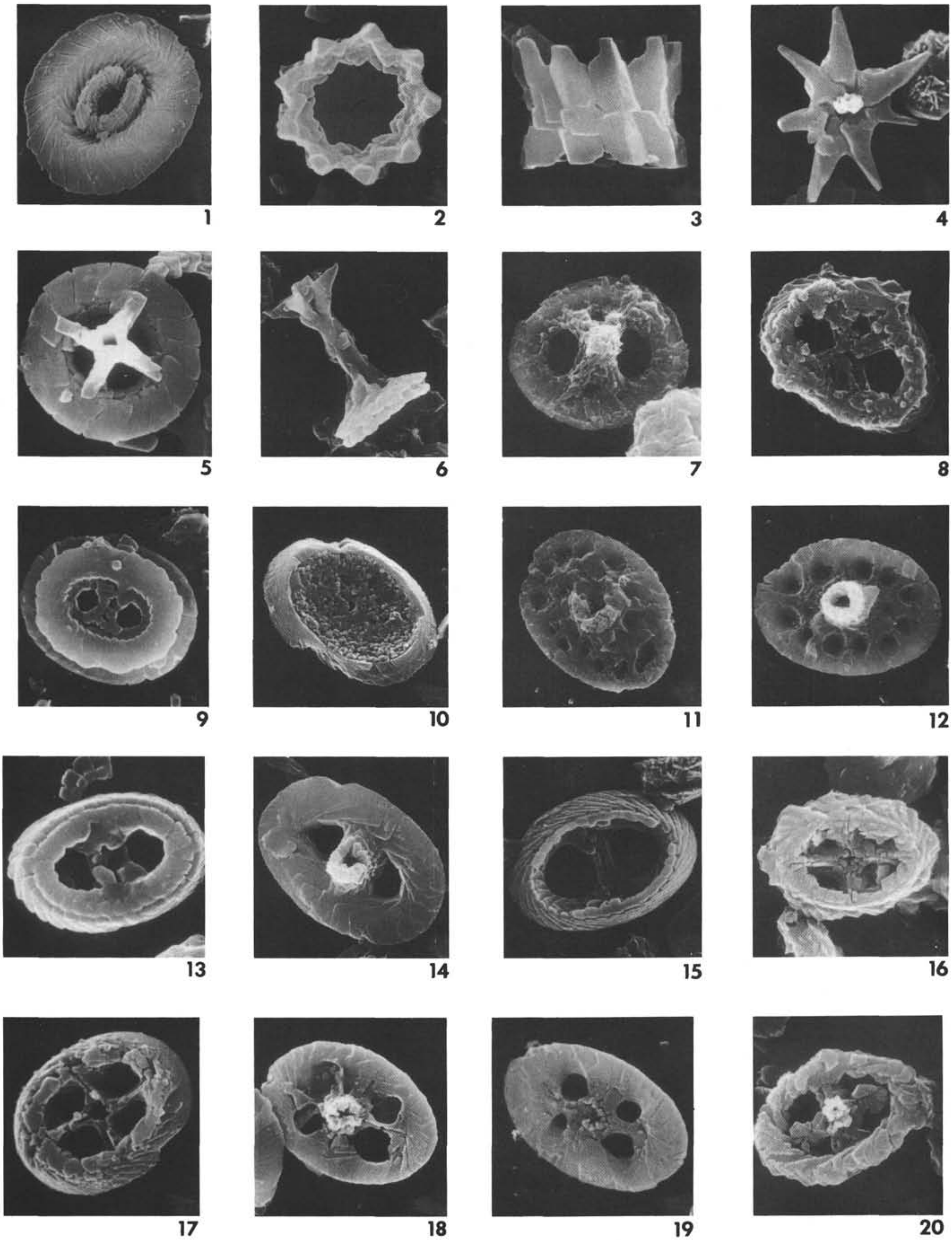


PLATE 8
SEM micrographs

Figure 1	*Vagalapilla* cf. *matalosa*, ×9000, overgrowth specimen, Sample 263-26-3, 124-125 cm.
Figures 2, 3	*Pyrite spherulus*, Sample 263-26-3, 124-125 cm. 2. ×4250. 3. ×4000.
Figure 4	*Cristobalite spherules*, ×17,500, Sample 259-14, CC.
Figure 5	*Umbilicosphaera sibogae*, ×10,000, Sample 262-17-2, 103-104 cm.
Figure 6	*Cyclococcolithina leptopora*, ×15,000, Sample 262-35-1, 55-56 cm.
Figure 7	*Syracosphaera* cf. *histrica*, ×10,000, Sample 262-6-6, 62-63 cm.
Figure 8	*Cyclolithella annulus*. ×10,000, Sample 262-35-1, 55-56 cm.
Figure 9	*Gephyrocapsa oceanica*?, ×10,000, Sample 262-29-2, 90-91 cm.
Figure 10	*Gephyrocapsa* sp., ×20,000, Sample 262-35-1, 55-56 cm.
Figure 11	*Gephyrocapsa oceanica*, ×10,000, Sample 262-17-2, 103-104 cm.
Figure 12	*Gephyrocapsa protohuxleyi*, ×30,000, Sample 262-23-1, 81-82 cm.

PLATE 8

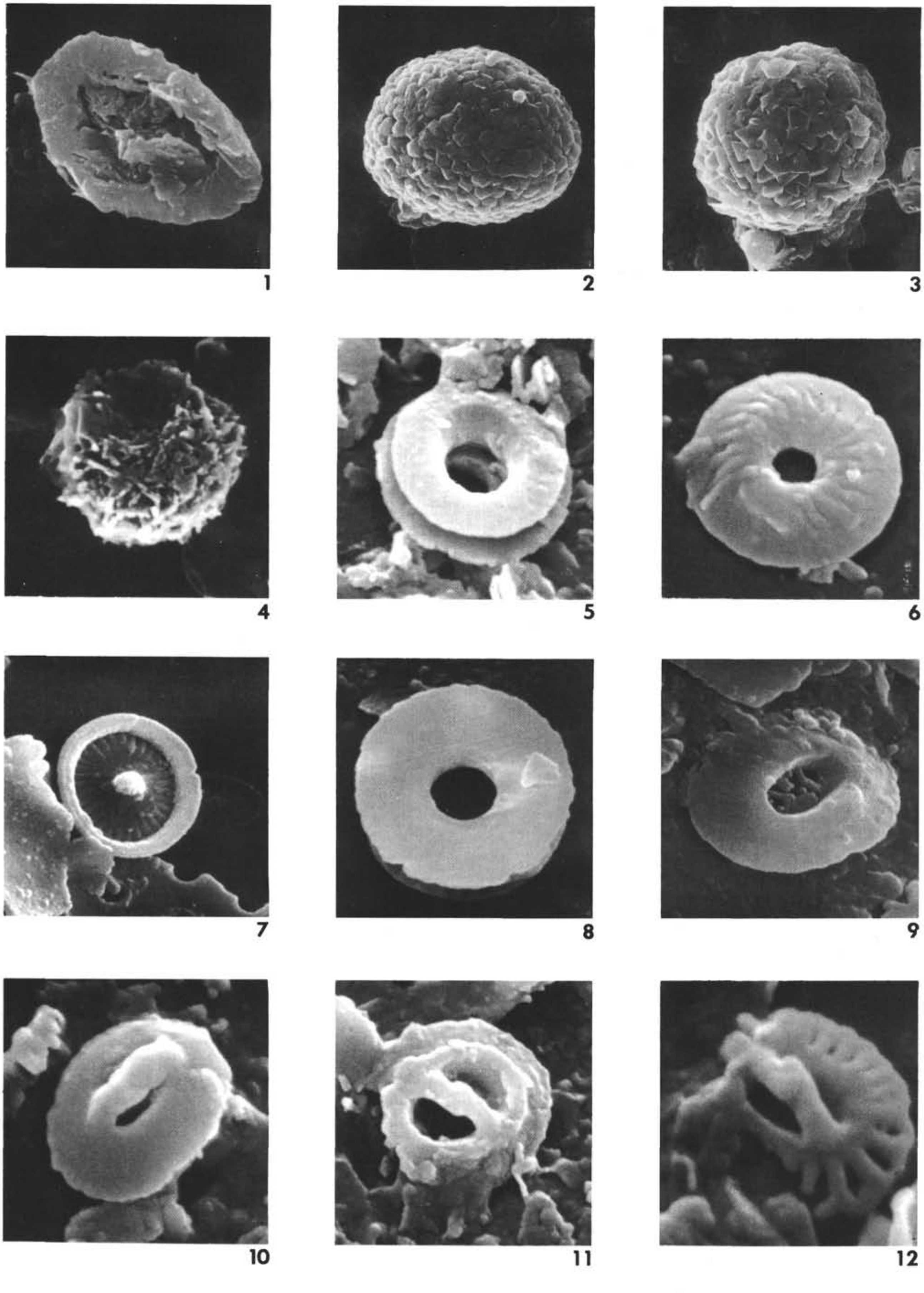
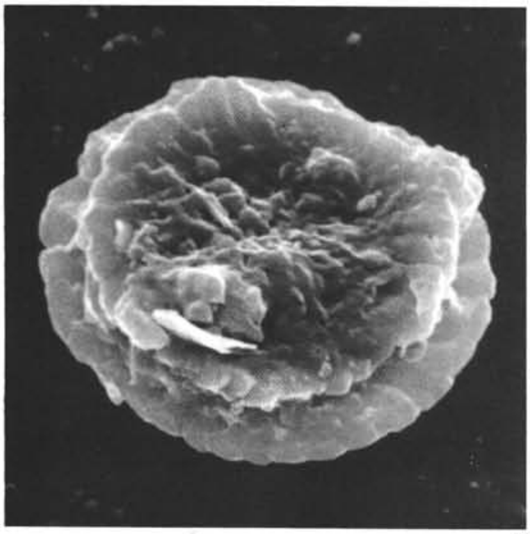


PLATE 9
SEM micrographs

Figure 1	*Watznaueria manivitae,* ×5000, proximal side, Sample 261-32-3, 135-136 cm.
Figure 2	*Gephyrocapsa oceanica,* ×10,000, distal side, Sample 262-2-4, 67-68 cm.
Figure 3	*Emiliania huxleyi,* ×10,000, Sample 262-2-4, 67-68 cm.
Figure 4	*Gephyrocapsa oceanica,* ×30,000 Sample 262-23-1, 81-82 cm.
Figure 5	*Gephyrocapsa oceanica,* ×30,000, Sample 262-23-1, 81-82 cm.
Figure 6	*Emiliania huxleyi* association, ×3000, Sample 261-6-6, 62-63 cm.
Figure 7	*Gephyrocapsa oceanica,* ×30,000, proximal side, Sample 262-23-1, 81-82 cm.

PLATE 9



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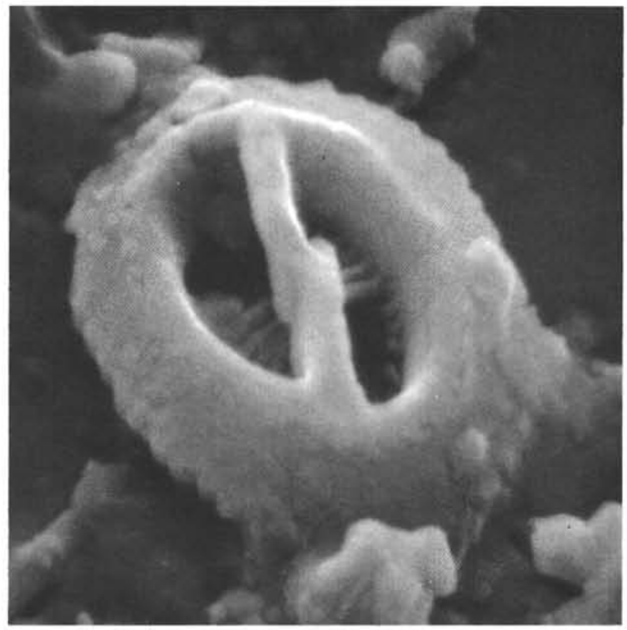

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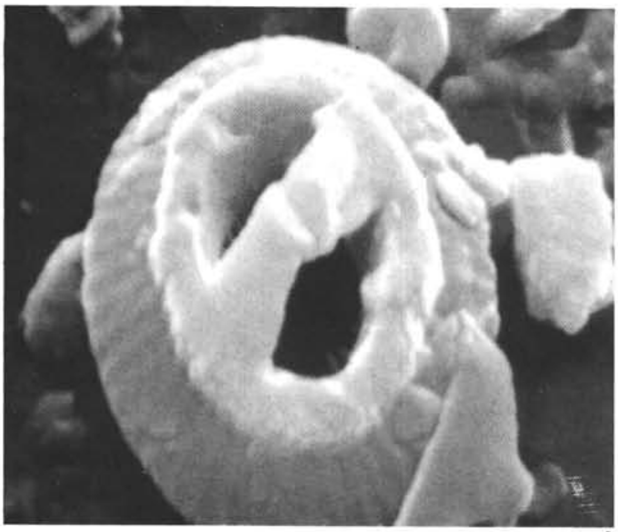

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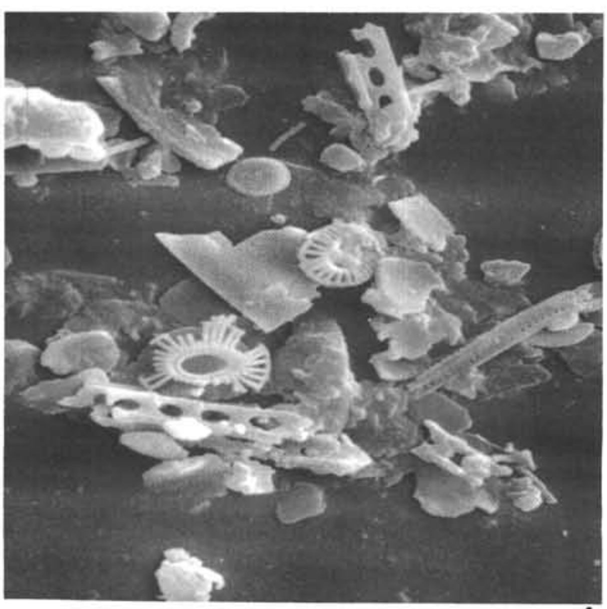

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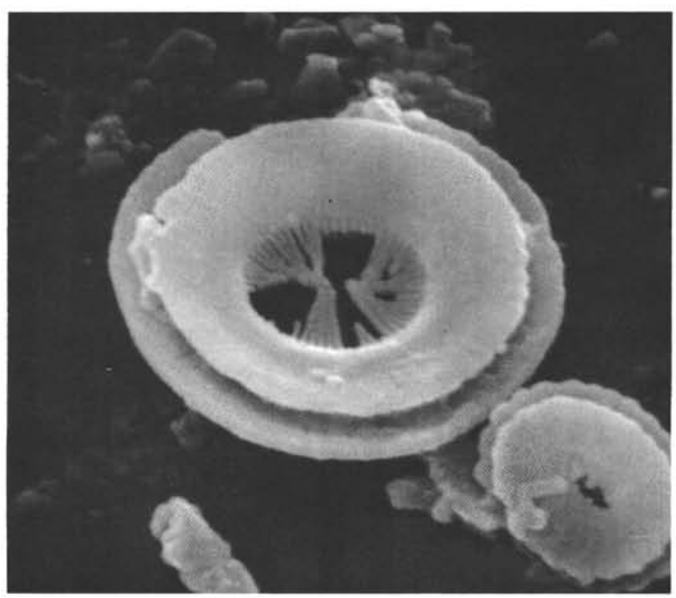

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PLATE 10

Figure 1	Problematic microfossil, transmitted light, ×1080, Sample 259-28, CC.
Figures 2, 3	Ascidian spicules, ×2000, Sample 262-32, CC. 2. Cross-polarized light, low focus. 3. Cross-polarized light, high focus.
Figure 4	Problematic microfossil, transmitted light, ×1600, Sample 260-16, CC.
Figure 5	Problematic microfossil, transmitted light, ×2000, Sample 263-24-2, 16-17 cm.
Figure 6	Achritarcha?, transmitted light, ×720, Sample 263-22, bottom.
Figure 7	Problematic microfossil, transmitted light, ×2000, Sample 263-28-2, 35-36 cm.
Figure 8	Problematic microfossil, transmitted light, ×2000, Sample 263-26-4, 48-49 cm.
Figure 9	Problematic microfossil, transmitted light, ×850, Sample 260-16-2, 56-57 cm.

PLATE 10