23. CALCAREOUS NANNOFOSSILS – LEG 17, DEEP SEA DRILLING PROJECT

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INTRODUCTION

During Leg 17, eight holes were drilled in the central Pacific basin. Calcareous nannofossils were recovered at all the sites. Of the 247 cores recovered, 178 contained nannofossils ranging in age from the Late Jurassic or earliest Cretaceous to the Quaternary. Because the Neogene part of sections was usually intermittently cored, this interval is incompletely represented. Due to unconformities, lower Eocene and upper Paleocene were not recovered. Site 167 provided an excellent opportunity to study changes of nannofossil preservation (see also Schlanger et al., this volume). All samples were examined by light microscope, and selected ones were viewed in a scanning electron microscope.

PRESERVATION

Dissolution and secondary overgrowth are differential and thus strongly affect the composition of nannofossil assemblages. Most of the dissolution takes place when the nannofossils are exposed to the bottom water at the ocean floor. It seems to continue after the burial of coccoliths and furnishes some of the calcite which is deposited on other nannofossils as overgrowths. Coccoliths with small elements (especially lath-shaped ones), deeply indented sutures, many exposed edges, and perforations are most susceptible to solution. Holococcoliths composed of loosely joined rhombohedra are rarely preserved in open-ocean sediments, and none were encountered in Leg 17 samples. The most easily dissolved genera are *Pontosphaera, Scyphosphaera, Syracosphaera* (Plate 3, Figures 1, 2), and *Rhabdosphaera* which are composed of small laths. Also very susceptible to solution are *Zygodiscus, Vagalapilla,* and *Kamptnerius.* The last mentioned genus occurs in cores from the shallow Site 171 but is missing in cores from the deeper Site 167. More solution resistant are placoliths with nonimbricate elements, like *Gephyrocapsa, Crenalithus, Cyclicargolithus, Reticulofenestra,* and many species of *Chiasmolithus.* Moderately solution resistant are the Cretaceous genera *Prediscosphaera, Podorhabdus, Eiffellithus,* and *Arkhangelskiella.* Placoliths with strongly imbricate elements belonging to the genera *Coccolithus, Cyclococcolithina, Markalius, Watznaueria, Cyclagelosphaera,* and *Cruciellipsis* and strongly built species of *Cretarhabdus* are very resistant to solution. The most resistant forms are composed of few large elements and belong to the genera *Discoaster, Ceratolithus, Tribrachiatus, Marthasterites, Tetralithus, Rucinolithus*, and *Micula.* Secondary calcite overgrowths tend to accumulate preferentially on large exposed surfaces of crystals. Members of the genera *Discoaster* and *Marthasterites* are often strongly overgrown in samples with little overgrowth or even signs of solution on other coccoliths (Plate 10, Figure 1). In more advanced stages of diagenesis more delicate species are covered with secondary calcite to such a degree that they are unrecognizable. Placoliths with strongly overlapping elements and nannoconids are most resistant to diagenetic changes and are often found in fine-grained limestones where all other forms are destroyed.

Preservation Scale

The preservation scale is similar to the one used in Roth and Thierstein (1972). The following categories of preservation are used on the range charts.

X – Excellent preservation, no etching or overgrowth.

Etching:

- E-1 – Slight etching, Coccoliths with serrate outlines; central holes somewhat enlarged. *Pontosphaera, Scyphosphaera, Rhabdosphaera,* and other delicate species are preserved.
- E-2 – Moderate etching. More delicate species dissolved. Delicate central structures like crosses and grilles are destroyed. *Helicopontosphaera* and *Sphenolithus* are preserved but the most delicate species are absent. There are some isolated shields of placoliths. Relative abundance of discoaster is increased.
- E-3 – Strong dissolution. Only solution-resistant species are left. Placoliths exist mostly as isolated shields. Discoasters or similar forms are dominant and placoliths with strongly imbricate elements exist in smaller number.

Overgrowth:

- O-1 – Slight overgrowth. There is thickening of the arms of *Discoaster, Marthasterites,* and *Tetralithus.* There are some secondary calcite deposits on elements of coccoliths and thickening of central structures (e.g., cross-bars in *Chiasmolithus*).
- O-2 – Moderate overgrowth. Arms of discoaster are strongly thickened. Delicate ornamentation on discoasters and central structures of placoliths are completely obscured.
- O-3 – Strong overgrowth. Discoasters and similar species are so overgrown that original species are difficult to recognize. Delicate species are so much overgrown that identification is difficult.

Combinations of slight-to-moderate etching and slight-to-moderate overgrowth are frequently observed in the same sample. In these cases etching is usually most pronounced in small coccoliths whereas overgrowth occurs on the discoasters and similar forms. This indicates that larger ortholiths grow at the expense of smaller coccoliths.

Glossary of Preservation and Morphologic Ultrastructure Terminology

Block. Cubical or tabulate coccolith element.

Crystal. Regular polyhedral form bounded by plane surfaces. The structural units of hoococcoliths are referred to as crystals. Structural units of heterococcoliths lack the true crystal form of calcite and should be called element and not crystal.

Crystallite. Structural unit of coccolith acting as single crystallographically homogenous domain. This term is identical with the term element which is preferred.

Cycle. Concentric ring of elements.

Diagenesis. Chemical and physical modifications undergone by a sediment after its initial deposition. Most important processes for nannofossil preservation are dissolution and reprecipitation of calcite (i.e., etching and overgrowth formation), finally leading to cementation.

Element. Ultrastructural unit of coccolith shield, wall, and central structures. More descriptive ultrastructural terms used for elements are: lath, tabular plate, granule, block, wedge, lamina, lamella, etc. Other more or less identical terms: crystallite and segment.

Etching. Partial removal of calcite as the result of calcite dissolution. The term corrosion is sometimes used for this process.

Imbrication. Overlapping of elements in the shields of coccoliths. The degree of imbrication of coccolith shields seems to be an important factor in determining the resistance to dissolution.

Lath. Element with one short, one intermediate, and one long dimension.

Overgrowth. Secondary calcite deposited on elements of coccoliths during diagenesis. Overgrowth formation is often incorrectly referred to as recrystallization (= formation of new crystalline mineral grains under the influence of metamorphic processes).

Ray. Element of discoasters, sometimes also called arm.

Shield. Part of coccolith which is more or less horizontal (i.e., parallel to cell surface of the coccolithophorid). Identical term: rim.

Solution. Dissolution and removal of calcite from elements of coccoliths (and other calcareous fossils) in the water column, at the water-sediment interface and in the sediment after burial. Calcite dissolution is species preferential and leads to various degrees of etching and total destruction of coccoliths.

Suture. Boundary between elements of coccoliths.

Tabular Plate. Element with two large and one small dimension.

Wall. Part of coccolith which is more or less vertical (i.e., perpendicular to cell surface of coccolithophorid). In placoliths the wall is sometimes called central tube.

Wedge. Element of coccolith with two dimensions subequal, the third small at one edge, →0 at the other.

LOWER CRETACEOUS ZONATION AND SELECTION OF MARKER SPECIES

Earlier investigators based their biostratigraphic subdivisions of the Lower Cretaceous mainly on nannoconids (Brönnimann, 1955; Stradner, 1963; Bouche, 1965). Worsley (1971) proposed seven nannofossil zones using seven samples from the western Atlantic (Deep Sea Drilling Project Leg 1, Sites 4 and 5). Some of the markers for his zones are rare or missing in other sections. Manivit (1971) introduced a new zonation for the Albian and Aptian of the Aquitaine and for some type sections of European stages. Thierstein (1971) described nine zones for the Lower Cretaceous based on a study of long sections from southeastern France and samples from the western Atlantic. He correlated his nannofossil zones with the classic European stages and the cephalopod, foraminiferal, and the calpionellid zonations of southeastern France. Unfortunately, none of the zonations proposed so far is applicable for the central Pacific because diagenesis has destroyed many of the important markers used by Thierstein (1971) and Worsley (1971). Therefore, a zonation based on species that are resistant to recrystallization is proposed here. This new zonal system may be of regional value because some of the ranges of species are not only a function of the age of the sediments but also of the degree of diagenesis.

Diagenesis, or recrystallization, is selective as is calcite solution in the ocean. A slight degree of secondary calcite overgrowth is found in most carbonate oozes that have been buried under about 100 meters of sediment (see Roth and Thierstein, 1972). In somewhat lithified chalks, secondary overgrowths can make certain species difficult to recognize. In lithified limestones, only the more resistant groups are preserved. Site 167 provides an excellent section for the study of progressive lithification and the disappearance of more delicate species. In the Lower Cretaceous, the genera *Rucinolithus, Lithastrinus,* and *Tetralithus,* together with placoliths constructed of large and strongly imbricate elements (genera *Watznaueria, Cyclagelosphaera, Diazomatolithus, Cruciellipsis, Manivitella*), and the species *Cretarhabdus crenulatus* and *Parhabdolithus embergeri* are most resistant to recrystallization. *Eiffelithus turriseiffeli, Prediscosphaera cretacea, Stephanolithion laffittei, Parhabdolithus angustus, P. splendens, Rhagodiscus asper,* and *Lithraphidites carniolensis* show an intermediate resistance to recrystallization. *Calcicalathina oblongata, Vagalapilla matalosa, Broinsonia bevieri* and most species of *Chiastozygus, Zygodiscus, Vagalpilla, Corollithion, Diadorhombus, Cribrosphaera,* and *Podorhabdus* seem to be least resistant to recrystallization. They are not suitable as markers in sections of recrystallized limestones having a low clay content. Fairly indurated rocks with a high clay content show less recrystallization than pure limestones. The more solution-resistant forms (e.g., placoliths with strongly imbricate elements and ortholithids like *Rucinolithus* and *Tetralithus*) are also least affected by recrystallization. Delicate species composed of laths or with fragile central structures or perforations are easily dissolved and recrystallized.

Nannoconus colomii Zone

The base of this zone is defined by the first occurrence of *Nannoconus colomii Watznaueria britannica, W. barnesae, W. communis, Cyclagelosphaera margareli,* and *Diazomatholithus lehmani* are the dominant species of the assemblage. *Cruciellipsis cuvillieri* seems to be restricted to the upper part of the zone. The assemblages from the

Magellan Rise are similar to the ones in southern France, but they are less diversified. Age: Early Berriasian.

Watznaueria britannica Zone

The base of this zone is defined by the first occurrence of *Cretarhabdus crenulatus*. Its top is marked by the first occurrence of *Tubodiscus jurapelagicus*. In the section cored on the Magellan Rise, *Watzaueria britannica* ranges only slightly higher than the first occurrence of *Tubodiscus jurapelagicus*. However, in southern France it seems to range as high as the Albian. At Site 167, nannoconids disappear within this zone, but in France, Cuba, and the western Atlantic they range throughout the Lower Cretaceous, and some species are found in beds as young as the Campanian. This zone is of about the same age as the *Cretarhabdus crenulatus* Zone of Thierstein which has an identical base but its upper boundary is based on the first occurrence of *Calcicalathina oblongata*, which is too rare in the section on Magellan Rise to be used stratigraphically. Age: Late Berriasian to Early Valanginian.

Tubodiscus jurapelagicus Zone

The base is defined by the first occurrence of *Tubodiscus jurapelagicus*. The disappearance of *Tubodiscus jurapelagicus* marks the top of this zone. *Calcicalathina oblongata* was found only in one sample near the top of the zone. This zone is probably roughly identical in age with the *Calcicalathina oblongata* Zone of Thierstein (1971). Age: Late Valanginian to Early Hauterivian.

Cruciellipsis cuvillieri Zone

The base of this zone is defined by the last occurrence of *Tubodiscus jurapelagicus* and its top is marked by the disappearance of *Cruciellipsis cuvillieri*. *Lithraphidites bollii* was not observed in any of the samples and, therefore, the zone proposed by Thierstein (1971) based on that marker cannot be used in this section. *Cyclagelosphaera deflandrei* disappears close to the top of this zone. Age: Late Hauterivian.

Tetralithus malticus Zone

The base of this zone is defined by the last occurrence of *Cruciellipsis cuvillieri*; its top by the first occurrence of *Parhabdolithus angustus*. *Tetralithus malticus* is always present in samples from this zone, but it is never very abundant. This zone can probably be correlated with Thierstein's *Micrantolithus hoschulzii* and the *Chiastozygus litterarius* zones. Age: Barremian to Early Aptian.

Parhabdolithus angustus Zone

The base of this zone is marked by the first occurrence of *Parhabdolithus angustus* and *Lithastrinus floralis*; its top by the first occurrence of *Prediscosphaera cretacea*. *Assipetra infracretacea* disappears at the top of this zone. The assemblages are similar to the ones observed in southern France (Thierstein, 1971) but contain no nannoconids. Age: Late Aptian.

Prediscosphaera cretacea Zone

The base of this zone is marked by the first occurrence of *Prediscosphaera cretacea*; its top by the first occurrence of *Eiffellithus turriseiffeli*. The assemblages observed are not as diversified as the ones from southern France (Thierstein, 1971), which is probably a result of diagenetic effects. Age: Early to Middle Albian.

Eiffellithus turriseiffeli Zone

The base of this zone is marked by the first occurrence of *Eiffellithus turriseiffeli*. The top of the zone is more difficult to define. *Chiastozygus cuneatus* and *Lithraphidites alatus* appear for the first time near the Albian/Cenomanian boundary, but both species are rare in open-ocean sediments. Age: Late Albian.

UPPER CRETACEOUS ZONATION AND SELECTION OF MARKER SPECIES

Diagenesis was mainly responsible for the fact that existing zonations could not be used for the Lower Cretaceous. In the Upper Cretaceous species, preferential solution and, probably, paleoecologic factors reducing the diversity of the assemblages, make it difficult to use most of the published zonations. Cepek and Hay (1969) and Manivit (1971) propose different zonations for the Upper Cretaceous, but both schemes make use of *Kamptnerius* and perforate species of *Arkhangelskiella* as zonal markers. *Kamptnerius* seems to be restricted to shallower parts of the ocean. It was found in sediments from Horizon Guyot but was absent in the cores from Magellan Rise. Perforate species of *Arkhangelskiella* were not found in any of the samples from the central Pacific. A somewhat less refined zonation is used in this report. It combines zones proposed by Manivit (1971) and Bukry and Bramlette (1970) with some newly proposed ones.

Lithraphidites alatus Zone

The base of this zone is marked by the first occurrence of *Lithraphidites alatus;* its top by the first occurrence of *Corollithion exiguum*. *Chiastozygus cuneatus* also first appears near the base of this zone but is a less reliable marker. Thierstein (1971) considers it a synonym of *Eiffellithus trabeculatus,* which makes its first occurrence in the Albian. Excellent assemblages belonging to this zone were recovered from Site 137, Leg 14 of the Deep Sea Drilling Project (assigned to the *Chiastozygus cuneatus* Zone in Roth and Thierstein, 1972). Age: Cenomanian.

Corollithion exiguum Zone

Interval from the first occurrence of *Corollithion exiguum* to the first occurrence of *Micula decussata*. Sediments belonging to this zone have not been recovered in the central Pacific but are known from southern France (Manivit, 1971). Age: Early Turonian.

Micula decussata Zone

The base of this zone is defined by the first occurrence of *Micula decussata*; its top by the first occurrence of *Marthasterites furcatus*. *Microrhabdulus decoratus* makes its first occurrence in this zone, and *Cribrosphaera ehrenbergi* becomes distinctly more abundant. The *Micula decussata* Zone seems to be of the same age as the *Tetralithus pyramidus* Zone of Cepek and Hay (1969). Age: Late Turonian.

Marthasterites furcatus Zone

This interval is defined by the total range of *Marthasterites furcatus.* The zone as defined here covers a longer interval than the zone as used by Cepek and Hay (1969). The absence of *Arkhangelskiella ethmopora* from open-ocean sediments precludes its use as marker for the top of this zone. Age: Santonian to Coniacian.

Gartnerago obliquum Zone

Interval from the last occurrence of *Marthasterites furcatus* to the first occurrence of *Broinsonia parca. Gartnerago obliquum* is quite common in this zone but ranges above and below this interval. Age: Santonian.

Eiffellithus eximius Zone

Interval from the first occurrence of *Broinsonia parca* to the last occurrence of *Eiffellithus eximius* (=*Eiffellithus augustus* of Bukry). Age: Early Campanian.

Broinsonia parca Zone

Interval from the last occurrence of *Eiffellithus eximius* to the first occurrence of *Tetralithus trifidus.* Age: Early Campanian.

Tetralithus trifidus Zone

The base of this interval is defined by the first occurrence of *Tetralithus trifidus;* its top by the last occurrence of *Tetralithus trifidus*. Age: Late Campanian to Early Maestrichtian.

Lithraphidites quadratus Zone

Interval from the last occurrence of *Tetralithus trifidus* to the first occurrence of *Micula mura. Lithraphidites quadratus* is very rare in the sediments from the central Pacific, and this interval is often difficult to recognize. Age: Middle Maestrichtian.

Micula mura Zone

Interval from the first occurrence of *Micula mura* to the level of disappearance of most Cretaceous species. Age: Late Maestrichtian.

CENOZOIC NANNOPLANKTON ZONES

The zonation used in this report incorporates zones first proposed by Bramlette and Wilcoxon (1967), Bukry and Bramlette (1970), Bukry (1971a, 1971b), Gartner (1969), Hay et al. (1967), Martini and Worsley (1970), Martini (1970), and Milow (1970). Detailed descriptions of the Tertiary and Quaternary zones have been published in Bukry (1971a), Martini (1971), and Roth and Thierstein (1972). Only short definitions of the zonal boundaries are given below, together with some remarks where zones are used in a different sense from the original definition. Figures 1 and 2 show the correlation of the zones used in this paper with the zonation of Martini (1970), Martini and Worsley (1970), and Hay et al. (1967).

Age		Zonation in this Paper	Zonation of Martini and Worsley 1970	
Quaternary		*Emiliani huxleyi*	NN21	*E. huxleyi*
		Gephyrocapsa oceanica	NN20	*G. oceanica*
		Pseudoemiliania lacunosa	NN19	*P. lacunosa*
Pliocene	Late	*Cyclococcolithina macintyrei*	NN18	*Discoaster brouweri*
		Discoaster pentaradiatus	NN17	*D. pentaradiatus*
		Discoaster tamalis	NN16	*D. surculus*
	Early	*Reticulofenestra pseudoumbilica*	NN15 NN14	*R. pseudoumbilica* *D. asymmetricus*
		Ceratolithus rugosus	NN13	*C. rugosus*
		Ceratolithus amplificus	NN12	*C. tricorniculatus*
Miocene	Late	*Ceratolithus tricorniculatus*		
		Ceratolithus primus	NN11	*D. quinqueramus*
		Discoaster berggrenii		
		Discoaster neohamatus	NN10	*D. calcaris*
		Discoaster bellus		
	Middle	*Discoaster hamatus*	NN9	*D. hamatus*
		Catinaster coalitus	NN8	*C. coalitus*
		Discoaster kugleri	NN7	*D. kugleri*
		Discoaster exilis	NN6	*D. exilis*
		Sphenolithus heteromorphus	NN5	*S. heteromorphus*
	Early	*Helicopontosphaera ampliaperta*	NN4	*H. ampliaperta*
		Sphenolithus belemnos	NN3	*S. belemnos*
		Discoaster druggii	NN2	*D. druggii*
		Triquetrorhabdulus carinatus	NN1	*T. carinatus*
		Reticulofenestra abisecta		

Figure 1. *Correlation of Neogene nannoplankton zones used in this report with the zonation of Martini and Worsley (1970).*

Age		Zonation Used in this Paper	Zonation of Martini, 1970		Zonation of Hay et al., 1967
Oligocene	Late	*Reticulofenestra abisecta*	NN1	*Triquetrorhabdulus carinatus*	
		Sphenolithus ciperoensis	NP25	*S. ciperoensis*	
		Sphenolithus distentus	NP14	*S. distentus*	
	Early	*Sphenolithus predistentus*	NP23	*S. predistentus*	
		Helicopontosphaera reticulata	NP22	*H. reticulata*	*Reticulofenestra laevis*
					Cyclococcolithus margaritae
		Ericsonia subdisticha	NP21	*E. subdisticha*	*Ellipsolithus subdistichus*
Eocene	Late	*Discoaster barbadiensis*	NP20	*Sphenolithus pseudoradians*	*Isthmolithus recurvus*
			NP19	*Isthmolithus recurvus*	
			NP18	*Chiasmolithus oamaruensis*	*D. tani nodifer*
	Middle	*Chiasmolothus grandis*	NP17	*D. saipanensis*	
		Chiasmolithus solitus	NP16	*D. tani nodifer*	
		Nannotetrina fulgens	NP15	*Chiphragmalithus alatus*	*Chiphragmalithus quadratus*
		Chiasmolithus gigas			
		Discoaster sublodoensis	NP14	*D. sublodoensis*	*D. sublodoensis*
	Early	*Discoaster lodoensis*	NP13	*D. lodoensis*	*D. lodoensis*
		Tribrachiatus orthostylus	NP12	*Marthasterites tribrachiatus*	*M. tribrachiatus*
		Discoaster diastypus	NP11	*D. binodosus*	*D. binodosus*
			NP10	*Marthasterites contortus*	*M. contortus*
Paleocene	Late	*Discoaster multiradiatus*	NP9	*D. multiradiatus*	*D. multiradiatus*
		Discoaster nobilis	NP8	*Heliolithus riedeli*	*H. riedeli*
		Discoaster mohleri	NP7	*Discoaster gemmeus*	*D. gemmeus*
		Heliolithus kleinpellii	NP6	*H. kleinpellii*	*H. kleinpellii*
		Fasciculithus tympaniformis	NP5	*F. tympaniformis*	*F. tympaniformis*
	Early	*Cruciplacolitnus tenuis*	NP4	*Ellipsolithus macellus*	*Cruciplacolithus tenuis*
			NP3	*Chiasmolithus danicus*	
			NP2	*Cruciplacolithus tenuis*	
			NP1	*Markalius inversus*	*M. astroporus*

Figure 2. *Correlation of Paleogene nannoplankton zones used in this report with the zonations of Martini (1970) and Hay et al. (1967).*

Emiliania huxleyi Zone

Interval from the first occurrence of *Emiliania huxleyi* to the present.

Gephyrocapsa oceanica Zone

Interval from the last occurrence of *Pseudoemiliania lacunosa* to the first occurrence of *Emiliania huxleyi.*

Pseudoemiliania lacunosa Zone

Interval from the last occurrence of *Discoaster brouweri* to the last occurrence of *Pseudoemiliania lacunosa.*

Cyclococcolithina macintyrei Zone

Interval from the last occurrence of *Discoaster pentaradiatus* to the last occurrence of *Discoaster brouweri.*

Discoaster pentaradiatus Zone

Interval from the last common occurrence of *Discoaster tamalis* to the last occurrence of *Discoaster pentaradiatus.*

Reticulofenestra pseudoumbilica Zone

Interval from the last occurrence of *Ceratolithus tricorniculatus* to the last occurrence of *Reticulofenestra pseudoumbilica.*

Ceratolithus rugosus Zone

Interval from the first occurrence of *Ceratolithus rugosus* to the last occurrence of *Ceratolithus tricorniculatus.*

Ceratolithus amplificus Zone

Interval from the first occurrence of *Ceratolithus amplificus* to the first occurrence of *Ceratolithus rugosus.*

Ceratolithus tricorniculatus Zone

Interval from the first occurrence of *Ceratolithus tricorniculatus* to the first occurrence of *Ceratolithus amplificus.* This zone is identical with the *Triquetrorhabdulus rugosus* Subzone of Bukry (1973).

Ceratolithus primus Zone

Interval from the first occurrence of *Ceratolithus primus* to the first occurrence of *Ceratolithus tricorniculatus.*

Discoaster berggrenii Zone

Interval from the first occurrence of *Discoaster berggrenii* to the first occurrence of *Ceratolithus primus.*

Discoaster neohamatus Zone

Interval from the last common occurrence of *Discoaster bellus* to the first occurrence of *Discoaster berggrenii. Discoaster neorectus* occurs in this zone. This zone is identical with the *Discoaster neorectus* Subzone of Bukry (1973).

Discoaster bellus Zone

Interval from the last occurrence of *Discoaster hamatus* to the last common occurrence of *Discoaster bellus.*

Discoaster hamatus Zone

Interval from the first to the last occurrence of *Discoaster hamatus.*

Catinaster coalitus Zone

From the first occurrence of *Catinaster coalitus* to the first occurrence of *Discoaster hamatus.*

Discoaster kugleri Zone

Interval from the first occurrence of *Discoaster kugleri* to the first occurrence of *Catinaster coalitus.*

Discoaster exilis Zone

Interval from the last occurrence of *Sphenolithus heteromorphus* to the first occurrence of *Discoaster kugleri.*

Sphenolithus heteromorphus Zone

Interval from the last occurrence of *Helicopontosphaera ampliaperta* to the last occurrence of *Sphenolithus heteromorphus.*

Helicopontosphaera ampliaperta Zone

Interval from the last occurrence of *Sphenolithus belemnos* to the last occurrence of *Helicopontosphaera ampliaperta.*

Sphenolithus belemnos Zone

Interval from the last occurrence of *Triquetrorhabdulus carinatus* to the last occurrence of *Sphenolithus belemnos.*

Discoaster druggii Zone

Interval from the first occurrence of *Discoaster druggii* to the last occurrence of *Triquetrorhabdulus carinatus.*

Triquetrorhabdulus carinatus Zone

Interval from the last occurrence of *Reticulofenestra abisecta* to the first occurrence of *Discoaster druggii.* This zone represents only the upper part of the *Triquetrorhabdulus carinatus* Zone of Bramlette and Wilcoxon (1967). It is identical with the *Discoaster deflandrei* Subzone of Bukry (1971).

Reticulofenestra abisecta Zone

Interval from the last occurrence of *Sphenolithus ciperoensis* to the last occurrence of *Reticulofenestra abisecta.* This zone represents the lower part of the *Triquetrorhabdulus carinatus* Zone of Bramlette and Wilcoxon (1967). It is of latest Oligocene age.

Sphenolithus ciperoensis Zone

Interval from the last occurrence of *Sphenolithus distentus* to the last occurrence of *Sphenolithus ciperoensis.*

Sphenolithus distentus Zone

Interval from the first occurrence of *Sphenolithus ciperoensis* to the last occurrence of *Sphenolithus ciperoensis.*

Sphenolithus predistentus Zone

Interval from the last occurrence of *Reticulofenestra umbilica* to the first occurrence of *Sphenolithus ciperoensis.*

Helicopontosphaera reticulata Zone

Interval from the last occurrence of *Cyclococcolithina formosa* to the last occurrence of *Reticulofenestra umbilica.*

Ericsonia subdisticha Zone

Interval from the last occurrence of *Discoaster saipanensis* to the last occurrence of *Cyclococcolithina formosa.*

Discoaster barbadiensis Zone

Interval from the last occurrence of *Chiasmolithus grandis* to the last occurrence of *Discoaster saipanensis.* So far all attempts to subdivide this zone have failed. *Reticulofenestra reticulata* seems to be restricted to the lower part of this interval.

Chiasmolithus grandis Zone

Interval from the last occurrence of *Chiasmolithus solitus* to the last occurrence of *Chiasmolithus grandis.* This zone represents the upper part of the *Reticulofenestra umbilica* Zone of Bukry and Bramlette (1970), and it is almost identical with the *Discoaster saipanensis* Zone of Martini (1970).

Chiasmolithus solitus Zone

Interval from the first occurrence of *Reticulofenestra umbilica* to the last occurrence of *Chiasmolithus solitus.* This zone covers a similar interval as the *Discoaster nodifer* Zone as used by Martini (1971).

Nannotetrina fulgens Zone

Interval from the last occurrence of *Chiasmolithus gigas* to the first occurrence of *Reticulofenestra umbilica.*

Chiasmolithus gigas Zone

Interval from the first occurrence of *Nannotetrina fulgens* to the last occurrence of *Chiasmolithus gigas.*

Discoaster sublodoensis Zone

Interval from the first occurrence of *Discoaster sublodoensis* to the first occurrence of *Nannotetrina fulgens.*

Discoaster lodoensis Zone

Interval from the last occurrence of *Tribrachiatus orthostylus* to the first occurrence of *Discoaster sublodoensis.*

Tribrachiatus orthostylus Zone

Interval from the first occurrence of *Discoaster lodoensis* to the last occurrence of *Tribrachiatus orthostylus.*

Discoaster diastypus Zone

Interval from the first occurrence of *Discoaster diastypus* to the first occurrence of *Discoaster lodoensis.*

Discoaster multiradiatus Zone

Interval from the first occurrence of *Discoaster multiradiatus* to the first occurrence of *Discoaster diastypus.*

Discoaster nobilis Zone

Interval from the first occurrence of *Discoaster nobilis* to the first occurrence of *Discoaster multiradiatus.*

Discoaster mohleri Zone

Interval from the first occurrence of *Discoaster mohleri* to the first occurrence of *Discoaster nobilis.*

Heliolithus kleinpelli Zone

Interval from the first occurrence of *Heliolithus kleinpellii* to the first occurrence of *Discoaster mohleri.*

Fasciculithus tympaniformis Zone

Interval from the first occurrence of *Fasciculithus tympaniformis* to the first occurrence of *Heliolithus kleinpellii.*

Cruciplacolithus tenuis Zone

Interval from the last occurrence of *Arkhangelskiella cymbiformis* (or other Cretaceous species) to the first occurrence of *Fasciculithus tympaniformis.*

CALCAREOUS NANNOFOSSILS AT DRILL SITES

SITE 164
(lat 13°12.1′N, long 161°31.1′W, depth 5513 meters)

The sediments recovered at this site consist mainly of zeolitic brown clay with radiolarians. Nannofossil distribution is shown in Table 1. In the core catcher of Core 8 rare specimens of *Micula decussata* were found, indicating a Late Cretaceous age. In Core 25 there are very poor assemblages of strongly etched coccoliths with *Cyclagelosphaera margareli* and *Discorhabdus biradiatus.* Accurate age assignment is impossible, but a Barremian to Aptian age seems most likely.

SITE 165
(lat 8°10.7′N, long 164°51.6′W, depth 5025 m)

This site is located 50 km from the Line Island chain. The upper part of the section consists of lower Tertiary calcareous turbidites interbedded with radiolarian ooze, the middle part of limestone and chert sections of Eocene to Late Cretaceous age, and the lower part of volcanogenic turbidites, with basalt flows of Late Cretaceous age. Distribution of nannofossils at this site is shown in Table 2 (Hole 165) and in Tables 3A and 3B (both 165A).

Core 1 of Hole 165 contains well-preserved Quaternary (*Gephyrocapsa oceanica* Zone) resting on upper Oligocene (*Reticulofenestra abisecta* Zone) with moderately etched and overgrown nannofossils. Core 2 is highly mixed Quaternary and Tertiary with some reworked Cretaceous.

A new Hole 165A was started without moving the vessel, and the interval of Core 2 (14-25 m below sea floor) was redrilled (165A, Core 1). It contains nannofossils typical of the late Oligocene *Reticulofenestra abisecta* Zone with abundant *Triquetrorhabdulus carinatus* and common *Reticulofenestra abisecta.* Core 2 recovered assemblages belonging to the *Sphenolithus ciperoensis* Zone with rare *Triquetrorhabdulus carinatus* and common *Sphenolithus ciperoensis.* Cores 3 and 4 contain common *Sphenolithus distentus* and few specimens of *S. ciperoensis* and are thus assigned to the *Sphenolithus distentus* Zone. *Sphenolithus predistentus* is the dominant sphenolith in Core 5, together with rare *S. distentus,* and thus Core 5 is assigned to the *Sphenolithus predistentus* Zone of early Oligocene age.

The uppermost part of Core 6 contains *Reticulofenestra umbilica* and *R. hillae* but lacks *Cyclococcolithina formosa*; therefore, it belongs to the *Helicopontosphaera reticulata* Zone. The lower part of Core 6 (Sections 2-6 and core catcher) and the upper part of Core 7 (Sections 1-4) are assigned to the *Ericsonia subdisticha* Zone of the early Oligocene; common species include *Cyclococcolithina formosa, Ericsonia subdisticha, Reticulofenestra umbilica, R. bisecta, R. hillae,* and *Discoaster nodifer.* The lower part of Core 7 contains *Discoaster saipanensis, D. barbadiensis, Reticulofenestra reticulata,* and *Chiasmolithus altus* and belongs to the upper Eocene. Core 8 and the upper part (Sections 1-5) of Core 9 belong to the *Chiasmolithus grandis* Zone. *Chiasmolithus oamaruensis* and *Chiasmolithus grandis* occur together in the uppermost two sections of Core 8, and *Chiasmolithus expansus* ranges into the lowermost part of this interval. Sections 5 and 6 of Core 9 and Cores 10 and 11 belong to the *Chiasmolithus solitus* Zone of middle Eocene age with *Chiasmolithus grandis, C. solitus, C. expansus,* and *Reticulofenestra umbilica* occurring together. Core 12 recovered the *Nannotetrina fulgens* Zone with *Nannotetrina fulgens, N. mexicana,* and *Cruciplacolithus staurion.* Cores 13 through 15 yield only poorly preserved assemblages including *Chiasmolithus gigas* and *Nannotetrina fulgens* typical of the middle Eocene *Chiasmolithus gigas* Zone.

TABLE 1
Distribution of Nannofossils at Site 164

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation		*Micula decussata*	*Watznaueria barnesae*	*Cretarhabdus crenulatus*	*Parhabdolithus embergeri*	*Manivitella pemmatoidea*	*Discorhabdus* cf. *D. biradiatus*	*Cyclogelosphaera margareli*
Late Cret.	?	8 CC	R	P	E-3	R						
Early Cret.	?	25-1, 115-117	R	P	E-3		F	R				
		25 CC	C	P	E-3		C	C	F	F	F	C

Core 16 and Section 1 of Core 17 recovered the late Maestrichtian *Micula mura* Zone with rare specimen of the zonal marker. The core catchers of Core 17, Core 18, and Section 1 of Core 19 contain poorly to moderately preserved assemblages typical of the *Tetralithus trifidus* Zone. The lower part of Core 19 and Section 3 of Core 20 belongs to the *Broinsonia parca* Zone (late Campanian). The core catcher of Core 20, Core 21, and Core 25 recovered the *Eiffellithus eximius* Zone with *Eiffellithus eximius* and *Broinsonia parca.* Cores 22 through 24 lack calcareous nannofossils.

Preservation: The assemblages from the calcareous turbidites (Cores 1 through 12) are slightly to moderately etched (E-1 to E-2) and slightly overgrown. The limestones (Cores 14 through 17) in the middle of the drilled section contain moderately to strongly etched assemblages with considerable fragmentation. In the volcanogenic sediments at the base of the cored sections, nannofossils are less abundant than in the upper part and show moderate etching and slight overgrowth.

SITE 166
(lat 3°45.7′N, long 175°04.9′W, depth 4962 m)

At this site the upper 195 meters consist of radiolarian ooze with nannofossils, which are late Eocene-Quaternary in age and are overlying about 30 meters of chert and brown clay of middle Eocene age and about 90 meters of Lower Cretaceous volcanogenic marls and basalt. Distribution of nannofossils at this site are shown in Tables 4A and 4B.

Cores 1 and 2 lack nannofossils. Core 3 contains rare, fairly long-ranging species like *Discoaster brouweri* and *Discoaster variabilis* together with *Gephyrocapsa oceanica.* This assemblage is mixed and is probably of Miocene to Pliocene age with downmixed Quaternary. Cores 4 and 5 contain strongly etched assemblages including *Discoaster exilis* and *D. kugleri* and are assigned to the *Discoaster kugleri* Zone (middle Miocene). Core 6 belongs to the *Sphenolithus heteromorphus* Zone. Poor assemblages with *Discoaster druggii, D.* sp. cf. *D. calculosus* and *Triquetrorhabdulus carinatus* occur in Core 7 and in the upper part of Core 8. This interval probably represents the *Discoaster druggii* Zone of the early Miocene. The lower parts of Core 8 and Cores 9 and 10 contain mostly long-ranging species and cannot be assigned to any zone but are of late Oligocene age. Core 11 contains common *Reticulofenestra umbilica* and could therefore be of an early Oligocene age. Cores 12 and 15 recovered poorly preserved assemblages lacking characteristic markers; a late Eocene age is most probable. Cores 13, 14, and 16 through 25 lack calcareous nannofossils. Cores 26 through 27 contain moderately well preserved assemblages with *Assipetra infracretacea, Tetralithus malticus,* and many long-ranging species. A late Hauterivian to early Aptian age is most probable for these cores.

Preservation: All the assemblages recovered from the Miocene to Eocene radiolarian oozes are strongly etched. Discoasters and placoliths with strongly imbricate elements are the only groups of nannofossils which are fairly common. Members of the genera *Reticulofenestra, Cyclicargolithus,* and *Chiasmolithus* are rare or absent because they are less solution resistant. The Lower Cretaceous assemblages are moderately etched and slightly overgrown.

HOLE 166A

A rich Quaternary assemblage with *Gephyrocapsa oceanica* was found in the top 10 cm of Core 1. The lower part of this core does not contain calcareous nannofossils.

SITE 167
(lat 07°04.1′N, long 176°49.5′W, depth 3176 m)

This site is located on the Magellan Rise. The sedimentary column consists of 200 meters of ooze, 600 meters of chalk, with chert in the lower part, and about 350 meters of limestone resting on basalt. Distribution of nannofossils is shown in Tables 5A-D.

Core 1 recovered the *Gephyrocapsa oceanica* Zone in the upper part and the *Pseudoemiliania lacunosa* Zone in the lower part. Core 2 also belongs to the *Pseudoemilania lacunosa* Zone. Core 3 contains *Discoaster brouweri* but lacks other species of *Discoaster* and is thus assigned to the *Cyclococcolithina macintyrei* Zone (Late Pliocene). The

TABLE 2
Distribution of Nannofossils at Site 165

Legend:
Abundance/distribution:
- A – abundant
- C – common
- F – few
- R – rare

Preservation:
- G – good
- M – moderate
- P – poor

(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Gephyrocapsa oceanica*	*Ceratolithus cristatus*	*Cyclolithella annula*	*Umbilicosphaera sibogae*	*Coccolithus pelagicus*	*Cyclococcolithina leptopora*	*Helicopontosphaera kamptneri*	*Cyclococcolithina macintyrei*	*Helicopontosphaera sellii*	*Discoaster brouweri*	*Discoaster pentaradiatus*	*Discoaster surculus*	*Reticulofenestra pseudoumbilica*	*Ceratolithus rugosus*	*Ceratolithus tricorniculatus*	*Discoaster exilis*	*Discoaster divaricatus*	*Discoaster deflandrei*	*Sphenolithus heteromorphus*	*Coccolithus miopelagicus*	*Cyclicargolithus floridanus*	*Triquetrorhabdulus carinatus*	*Reticulofenestra abisecta*	*Sphenolithus belemnos*	*Sphenolithus dissimilus*	*Sphenolithus moriformis*	*Sphenolithus capricornutus*	*Coronocyclus serratus*	*Reticulofenestra bisecta*	*Reticulofenestra scrippsae*	*Reticulofenestra hillae*	*Reticulofenestra umbilica*	*Coccolithus eopelagicus*	*Discoaster woodringii*	*Cyclococcolithina formosa*	*Chiasmolithus grandis*	*Markalius inversus*	*Cribrosphaera ehrenbergii*	*Prediscosphaera cretacea*	*Cretarhabdus crenulatus*
Pleistocene	*G. oceanica*	1-1, 6-8	A	A E-1 O-1	A	F	F	C	F	A	C			F	F	F	C			F			C	F	F					F	R		R	R	R	F	F	F		F	R	R		
Late Oligocene	*R. abisecta*	1-1, 109-111	C	M E-2 O-2																	C			F	A	C	C		F	C							C	C						
		1-2, 109-111	C	M E-2 O-2																	C			F	A	C	C		F	C							C	C						
		1-3, 61-63	C	M E-2 O-1																	C			F	A	C	C		F	C							C	C						
		1 CC	C	M E-21 O-1																	C	F		F	A	C	C			A							C	C						
Mixed Quat. and Tert.	?	2-1, 52-54	C	G E-1 O-1	C	F			F	C		C		F									F		C							R	F			F		F		R		R		
		2-2, 88-90	C	G E-1 O-1	C	F		C	C	F				C				R	R						C	F							F				F						R	
		2 CC	C	G E-1 O-1	F	F				C			F	F									F	R	C	C							F				R	C	R					

TABLE 3A
Distribution of Nannofossils at Site 165A

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Reticulofenestra abisecta*	*Reticulofenestra bisecta*	*Reticulofenestra scrippsae*	*Reticulofenestra umbilica*	*Reticulofenestra hillae*	*Reticulofenestra coenura*	*Reticulofenestra reticulata*	*Chiasmolithus oamaruensis*	*Chiasmolithus altus*	*Chiasmolithus titus*	*Chiasmolithus grandis*	*Chiasmolithus solitus*	*Chiasmolithus expansus*	*Chiasmolithus gigas*	*Coccolithus eopelagicus*	*Ericsonia subdisticha*	*Cruciplacolithus staurion*	*Cyclococcolithina kingii*	*Cyclococcolithina formosa*	*Cyclicargolithus floridanus*	*Coronocyclus serratus*	*Pedinocyclus larvalis*	*Helicopontosphaera bramlettei*	*Helicopontosphaera reticulata*	*Helicopontosphaera compacta*	*Helicopontosphaera seminulum*	*Bramletteius serraculoides*	*Triquetrorhabdulus carinatus*	*Triquetrorhabdulus inversus*	*Discoaster divaricatus*	*Discoaster deflandrei*	*Discoaster woodringii*	*Discoaster nodifer*	*Discoaster barbadiensis*	*Discoaster saipanensis*	*Discoaster* cf. *wemmelensis*	*Nannotetrina fulgens*	*Nannotetrina mexicana*	*Sphenolithus moriformis*	*Sphenolithus belemnos*	*Sphenolithus dissimilis*	*Sphenolithus ciperoensis*	*Sphenolithus distentus*	*Sphenolithus predistentus*	*Sphenolithus pseudoradians*	*Sphenolithus radians*	*Sphenolithus obtusus*	*Sphenolithus furcatolithoides*
Late Oligocene	*R. abisecta*	1-1, 143-145	C	M E-1 O-1	C														A					A								A		F		C							A	C	C							
		1-2, 143-145	C	M E-2 O-1	C														A					A								A		F		C							C	F	F							
		1-3, 119-121	A	M E-2 O-1	C														C					A								A		C		C							A	F	F							
		1-4, 52-54	C	M E-2 O-1	C														C					A								A		C		C							A	F	F							
		1-5, 105-107	C	M E-2 O-1	C	R													C					A								A		C		C							A		F	R						
		1-6, 95-97	C	M E-2 O-1	C														C					A								A		C		C							A		F							
		1 CC		E-1 O-2	C														C					A								A		C		C							A		F	R						
	Sphenolithus ciperoensis	2-1, 114-116	A	M E-2 O-2	C														C					A								F				C							A			C						
		2-2, 100-102	A	M E-1 O-1	C														C					A								F				C							A			C						
		2-3, 85-87	A	M E-2 O-1	C	F													C					A								R				C							A			C						
		2-4, 80-82	A	M E-2 O-1	C	F													C					A								R				C							A			C						
		2-5, 83-85	A	M E-2 O-1	A	C													C					A								R				F							A			C						
		2-6, 30-32	A	M E-2 O-1	A	C													C					A								R				F							A			C						
		2 CC	A	M E-2 O-2	C	C													C					A								R				F							C			C						
	Sphenolithus distentus	3-2, 42-44	A	M E-2 O-1	R	C									R				C				R	A	F				R					F	F	C		R					A			F	C	R				
		3-3, 44-46	A	M E-2 O-1	R	C													C					A	F									F	F	C							A			F	C	R				
		3-4, 42-44	A	M E-2 O-1	R	C													C					A	F									F	F	C							A			F	C	R				
		3 CC	A	M E-2 O-1	F	C		R											C					A	F										F	C							A				C	R				
		4 CC	A	M E-2 O-1	F	A													C					A	F									F	F	C							A				C	F	R			
Early Oligocene	*Sphenolithus predistentus*	5-2, 97-99	C	M E-2 O-1		C													F					C										F	F	F							A				F	C				
		5-3, 108-110	C	M E-2 O-1		C													F					C										F	F	F							A				F	C				
		5-4, 105-107	C	M E-2 O-1		C													F					C										F	F	F							A				R	C				
		5-5, 36-38	C	M E-2 O-1		A													C					A		F	F								C	C							A				R	C	R			
		5 CC	C	M E-2 O-1		C													C					C											F	F							A					C	R			
	Helico reticulata	6-1, 22-24	C	M E-2 O-1		A		F	F										C					C				R							C		C						A					F				
		6-2, 46-48	C	M E-2 O-1		A		F	F										C	C			F	C											C		C						A					F	R			
		6-3, 28-30	C	M E-2 O-1		C		C	C										C	C			F	A											C		C	R					A					F				

	Ericsonia subdisticha	6-4, 10-12	C	M	E-2	O-1		C		C	F										C	C			F	A		R		R			R				C		C						A					F				
		6-5, 123-125	C	M	E-2	O-1		C		C	F										C	C			F	A				R			R				C		C						A					F				
		6-6, 111-113	C	M	E-2	O-1		C		C	F										C	F			F	A							F				F		C						C					C				
		6 CC	C	M	E-2	O-1		C		A	C										C	F			C	C											F		F	R	R				C					F				
		7-1, 89-91	C	M	E-2	O-1		C		A	C										C	F			A	C											F		F						C					F				
		7-2, 21-23	C	M	E-2	O-1		C		A	C										C	F			A	C											F		F						C					F				
		7-4, 21-28	C	M	E-2	O-1		C		A	C										C	F			A	C											C		C						C					F				
Late Eocene	*Discoaster barbadiensis*	7-5, 70-72			E-2	O-1		F		A	C				R	F	R				C	C			A	C					R		F				F		C	F	F				C					R	R			
		7-6, 17-19	C	M	E-2	O-1		C		A	C					F	R				C	R			C	A		R					C						F	C	C				C					F	R			
		7 CC	C	M	E-2	O-1		C		A			C		R	F					C	R		R	C	A				F	F	R	F						F	C	C				C					R	R			
Middle Eocene	*Chiasmolithus grandis*	8-1, 94-96	C	M	E-2	O-1		C		C		C		F			F				C	F		F	C	C				R			R						F	C	C				C					R				
		8-2, 3-5	C	M	E-2	O-2		C	F	C		C		F			F				C	F		F	C	C				R			F		F				F	C	C				C					R				
		8-3, 97-99	C	M	E-2	O-1		C	F	C		C					C				C	F		F	C	C				F		F	C		F				C	C	C				C							R	R	
		8-4, 18-21	C	M	E-2	O-1		C	F	C		C					C				C	F		F	C	C				F		F	C		F				C	C	C				C							R	R	
		8-5, 28-30	C	M	E-2	O-1		C	F	C		C					C				C				C	C							C		F				C	C	C				C									
		8-6, 40-42	C	M	E-2	O-1		C	F	C		C					C				C				C	C							C		F				C	C	C				C									
		8 CC	C	M	E-2	O-1		C	F	C		C					C				C				C	C							C		F				C	C	C				C									
		9-1, 110-112	C	M	E-2	O-1		C	F	C		C					C				C				C	C							R		F				C	C	C				C									
		9-2, 120-122	C	M	E-2	O-1		C	F	C		C					C		F		C				C	C							R		F				C	C	C				C									
		9-3, 35-37	C	M	E-2	O-1		C	C	C		C					C		F		C				C	F									F				C	C	C				C							F		F
		9-4, 115-117	C	M	E-2	O-1		C	C	C		C					C		F		C				C	F									F				C	C	C	F			C									
		9-5, 25-27	C	M	E-2	O-1		F	C	C		C					C		F		C				C	F									F				C	C	C	F			C					R				
	Chiasmolithus solitus	9-6, 112-114	C	M	E-2	O-1		F	C	C		C					C	F	F		C				C	F									C				C	C	C			R	C					R			R	F
		9 CC	C	M	E-2	O-1			C	C		C					C	C	F		C				C	F									C				F	C	C				C									
		10-1, 110-112	C	M	E-2	O-1			C	C		C					C	C	F		C				C	F									F				F	C	F				C							R		F
		10-2, 70-72	C	M	E-2	O-1			C	C		C					C	C	F		C				C	F									F				F	C	F				C							R		R
		10-3, 100-102	C	M	E-2	O-1			C	C		C					C	C	F		C				C	F									F				F	C	F				C							R		F
		10-4, 80-82	C	M	E-2	O-1			C	C		C					C	C	F		C				C	F						R			C				F	C	F				C							F		F
		10-5, 60-62	C	M	E-2	O-1			C	C		C					C	C	F		C				C	F									C				F	C	F				C							R		F
		10-6, 60-62	C	M	E-2	O-1			C	F		C					C	C	C		C				C	F									C				F	C	F				C							F		F
		10 CC	C	M	E-2	O-1			F	F		C					C	C	C		C				C	F									C				F	C	F				C									F
		11-1, 30-32	C	M	E-2	O-1				F		C					C	C	C		C				F										C					C	F		R		C									
		11-2, 130-132	C	M	E-2	O-1				F		C					C	C	C		C				F										C					C	F				F							F		
		11-3, 105-107	C	M	E-2	O-1				F		C					C	C	C		C				F					R					C					C	F				F							R		
		11-4, 90-92	C	M	E-2	O-1				F		C					C	C	C		C				F					R					C					C					F							R		
		11-5, 80-82	C	M	E-2	O-1				F		C					C	C	C		C				C										C					C					F							F		F
		11-6, 30-32	C	M	E-2	O-1				F		C					C	C	C		C				C					R		R			C					C					F							F		R
		11 CC	C	M	E-2	O-1				F		C					C	C	C		C				C								R		C				F	C	F				F							F		F

TABLE 3A – *Continued*

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Reticulofenestra abisecta*	*Reticulofenestra bisecta*	*Reticulofenestra scrippsae*	*Reticulofenestra umbilica*	*Reticulofenestra hillae*	*Reticulofenestra coenura*	*Reticulofenestra reticulata*	*Chiasmolithus oamaruensis*	*Chiasmolithus altus*	*Chiasmolithus titus*	*Chiasmolithus grandis*	*Chiasmolithus solitus*	*Chiasmolithus expansus*	*Chiasmolithus gigas*	*Coccolithus eopelagicus*	*Ericsonia subdisticha*	*Cruciplacolithus staurion*	*Cyclococcolithina kingii*	*Cyclococcolithina formosa*	*Cyclicargolithus floridanus*	*Coronocyclus serratus*	*Pedinocyclus larvalis*	*Helicopontosphaera bramlettei*	*Helicopontosphaera reticulata*	*Helicopontosphaera compacta*	*Helicopontosphaera seminulum*	*Bramletteius serraculoides*	*Triquetrorhabdulus carinatus*	*Triquetrorhabdulus inversus*	*Discoaster divaricatus*	*Discoaster deflandrei*	*Discoaster woodringii*	*Discoaster nodifer*	*Discoaster barbadiensis*	*Discoaster saipanensis*	*Discoaster* cf. *wemmelensis*	*Nannotetrina fulgens*	*Nannotetrina mexicana*	*Sphenolithus moriformis*	*Sphenolithus belemnos*	*Sphenolithus dissimilis*	*Sphenolithus ciperoensis*	*Sphenolithus distentus*	*Sphenolithus predistentus*	*Sphenolithus pseudoradians*	*Sphenolithus radians*	*Sphenolithus obtusus*	*Sphenolithus furcatolithoides*
Middle Eocene	*N. fulgens*	12-1, 100-102	C	M E-2 O-1						F					C	C	C		C				F										C					C	F		F		F							F		F
		12-2, 85-87	C	M E-2 O-1						F					C	C	C		C				F										C					C			F	F	F									F
		12-3, 112-114	C	M E-2 O-1						F					C	R	F		C		F		F										C					C	F		F		F									F
		12-4, 20-22	C	M E-2 O-1						F					C	R	F		C		F		F										C					C	F		F		F									
		12-5, 80-82	C	M E-2 O-1						F					C	F	F		C		F		F										C					C	F		F		F									
		12-6, 23-25	C	M E-2 O-1						F					C	R	F		C		F		F										C					C	F		F		F							R		
	C. gigas	13-1, 79-81	C	M E-2 O-1						F					C	C	F	F	C				F										C					C			F	F	C									
		13-2, 90-92	C	M E-3											C	F	F		C				F										C					C					F									
		13 CC	R	P E-3																																							F									
		14 CC	C	M E-2 O-1						C					C	C	F																C					C			F	F	F									
		15 CC	R	P E-2 O-2													F																					F					F									

assemblages in Core 4 show moderate calcite overgrowths, especially on discoasters. The presence of *Discoaster neohamatus, D. calcaris,* and *D. bellus* indicates a late Miocene age (*Discoaster bellus* Zone). Core 5 contains abundant *Discoaster exilis* and therefore belongs to the middle Miocene *Discoaster exilis* Zone. In Cores 6 and 7, *Sphenolithus heteromorphus* occurs together with common *Discoaster exilis;* the overlap of these two species indicates the *Sphenolithus heteromorphus* Zone (middle Miocene).

Cores 8, 9, and the upper part of Core 10 contain *Triquetrorhabdulus carinatus* without *Reticulofenestra abisecta.* They belong to the lower Miocene *Triquetrorhabdulus carinatus* Zone. The lower part of Core 10 and Core 11 recovered the late Oligocene *Reticulofenestra abisecta* Zone with common *Triquetrorhabdulus carinatus* and *Reticulofenestra abisecta.* Typical specimens of *Sphenolithus ciperoensis* together with *Triquetrorhabdulus carinatus* are found in Core 12, which therefore belongs to the *Sphenolithus ciperoensis* Zone of late Oligocene age. Cores 13 through 16 recovered the late Oligocene *Sphenolithus distentus* Zone, and Cores 17 through 20 and the upper part of Core 21, the early Oligocene *Sphenolithus predistentus* Zone. In the lower part of Core 21 and in Core 22 *Reticulofenestra umbilica* occurs without *Cyclococcolithina formosa;* this is typical of the *Helicopontosphaera reticulata* Zone as used here. The lowest zone of the Oligocene, the *Ericsonia subdisticha* Zone, was recovered in Cores 23 through 24. The Eocene/Oligocene boundary lies between Cores 24 and 25. Cores 25 through 29 belong to the *Discoaster barbadiensis* Zone. *Reticulofenestra reticulata* is restricted to the lower part of this interval and *Chiasmolithus* is very rare. Cores 30 through 32 belong to the middle Eocene *Chiasmolithus grandis* Zone. Cores 33 through 36 contain *Chiasmolithus grandis* together with *C. solitus* and *C. expansus*, which is typical for the *Chiasmolithus solitus* Zone. Core 37 recovered the middle Eocene *Chiasmolithus gigas* Zone with *Chiasmolithus gigas* and *Nannotetrina mexicana.* Core 38 belongs to the upper Paleocene *Discoaster mohleri* Zone. Cores 39 through 40 contain *Fasciculithus tympaniformis* and *F.* sp. cf. *F. ulii* indicating the *Fasciculithus tympaniformis* Zone. Core 41 recovered the late Maestrichtian *Micula mura* Zone with rare rather short-armed *Micula mura.* Cores 42 and 43 are assigned to the *Lithraphidites quadratus* Zone, although the marker species was not found. Cores 44 through 48 contain rich assemblages of the *Tetralithus trifidus* Zone.

Cores 49 and 50 contain *Broinsonia parca* but lack *Eiffellithus eximius.* They belong to the *Broinsonia parca* Zone. Cores 51 through 57 and the top of Core 58 recovered the Campanian *Eiffellithus eximius* Zone with assemblages including *Eiffellithus eximius, Broinsonia parca*, and *Tetralithus aculeus.* The lower part of Core 58 and Core 59 are assigned to the *Marthasterites furcatus* Zone. Core 60 contains poor assemblages which probably belong to the Turonian *Micula decussata* Zone. Core 61 contains rare specimens of *Lithaphridites alatus* and is therefore assignable to the Cenomanian *Lithraphidites alatus* Zone. The Lower Cretaceous assemblages recovered from Cores 62 through 94 were strongly affected by diagenesis, and only the more robust species are preserved. Cores 62 to 67 lack Cenomanian markers like *Lithraphidites alatus* but still contain *Eiffellithus turriseiffeli* and are thus assigned to the late Albian *Eiffellithus turriseiffeli* Zone. The core catchers of Cores 67 and 68 belong to the early Albian *Prediscosphaera cretacea* Zone. Cores 69 and 70 recovered the *Parhabdolithus angustus* Zone (Aptian). Cores 71 and 72 contain assemblages including *Tetralithus malticus, Rucinolithus irregularis,* and *Assipetra infracretacea*; they are assigned to the Barremian *Tetralithus malticus* Zone. Cores 73, 74, and the top of Core 75 belong

TABLE 3B
Distribution of Nannofossils at Site 165A

Legend:
Abundance/distribution:
- A – abundant
- C – common
- F – few
- R – rare

Preservation:
- G – good
- M – moderate
- P – poor

(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Arkhangelskiella cymbiformis*	*Broinsonia parca*	*Watznaueria barnesae*	*Watznaueria biporta*	*Biscutum melaniae*	*Markalius circumradiatus*	*Manivitella pemmatoidea*	*Cylindralithus gallicus*	*Cylindralithus serratus*	*Cribrosphaera ehrenbergi*	*Prediscosphaera cretacea*	*Prediscosphaera spinosa*	*Cretarhabdus crenulatus*	*Cretarhabdus conicus*	*Parhabdolithus splendens*	*Parhabdolithus embergeri*	*Eiffellithus turriseiffeli*	*Eiffellithus eximius*	*Eiffellithus anceps*	*Zygodiscus pseudanthophorus*	*Vagalapilla octoradiata*	*Parhabdolithus regularis*	*Chiastozygus litterarius*	*Eiffellithus trabeculatus*	*Glaukolithus diplogrammus*	*Tranolithus orionatus*	*Microrhabdulus decoratus*	*Lithraphidites carniolensis*	*Lithraphidites quadratus*	*Micula decussata*	*Tetralithus gothicus*	*Tetralithus trifidus*	*Tetralithus pyramidus*	*Tetralithus aculeus*	*Tetralithus ovalis*	*Micula mura*
Late Maestr.	*Micula mura*	16 CC	C	P E-2 O-2			A					C					F														R		R	A						R
		17-1, 130-132	F	P E-2 O-1			A						F				F																	A	F	F	F			R
		17 CC	C	M E-2 O-1	R		A						C	F	R		C																	A	F	F	F			R
Early Maestr.-Late Campanian	*Tetralithus trifidus*	18-1 Top	C	M E-2 O-1	R		A						R	C	R		C														F			A	F	F	F	R		
		18-1, 85-87	C	P E-2 O-1			A				F		R	F	F		R														R			A	F	C	F	R		
		18-2, 17-19	C	M E-2 O-1			A						F	F	F		F								F	F					F			A	F	C	C	F		
		18-3, 20-22	C	M E-2 O-1	R		A	R			F		R	F	F		C												F		F			C	F	C	F	F		
		19-1, 68-70	C	M E-2 O-1	F		A						F	F	F		C	F										R	R	F	F			A	C	C	F	F		
	Br. parca	19-2, 41-44	C	M E-2 O-1		R	A						F	C	F		F	F			R								F	F	F			C	F	F	R	F		
		19 CC	C	M E-2 O-1	F	F	A		F		F		F	F	F		C	C					R						F	F	F	F		A	F	F	R	F		
Middle to Early Campanian	*Eiffelithus eximus*	20-3, 140-142	C	P E-2 O-1		F	A						F	F	F		C	R											F	F				A	F		F	F		
		20 CC	C	P E-2 O-1	F	F	A						R	C	F		F	F			F	F							F					A	F		F			
		21-1, 96-96	C	P E-2 O-1	F	C	A			R	F		R	F	F		C	R				F												A	F		F	F		
		21-2, 48-50	C	P E-2 O-1	R	F	A	F		F	F		F	F	F		F	F		F		F	R							R		R		A	F		F	F	R	
		21-3, 107-109	C	P E-2 O-1		F	A							F	F		C	F				F								F				A	F		F	C	R	
		21 CC	C	P E-2 O-1	F	F	A				F			F	F		F	F	R			C					F		F	F	F	C		A	R		F	F	F	
		25 CC	F	M E-2 O-2	F	F	A							F	R		C					F										F		A	F				F	

TABLE 4A
Distribution of Nannofossils at Site 166

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	Gephyrocapsa oceanica	Reticulofenestra pseudoumbilica	Reticulofenestra bisecta	Reticulofenestra scrippsae	Reticulofenestra umbilica	Reticulofenestra hillae	Chiasmolithus grandis	Chiasmolithus solitus	Coccolithus pelagicus	Coccolithus miopelagicus	Coccolithus eopelagicus	Cyclococcolithina leptopora	Cyclococcolithina macintyrei	Cyclococcolithina formosa	Cyclicargolithus floridanus	Ceratolithus cristatus	Triquetrorhabdulus carinatus	Discoaster brouweri	Discoaster variabilis	Discoaster braarudii	Discoaster adamanteus	Discoaster exilis	Discoaster divaricatus	Discoaster kugleri	Discoaster deflandrei	Discoaster druggii	Discoaster woodringii	Discoaster cf. calculosus	Discoaster nodifer	Sphenolithus moriformis	Sphenolithus heteromorphus	Sphenolithus radians
Pleistocene	G. oceanica	A-1-1, 8-10	A	M E-2	A											A				F																
Mio. to L. Mio.	?	3 CC	R	P E-2	F								C			F						F	F													
Middle Miocene	Discoaster kuglieri	4-1, 80-82	F	P E-3									F	F									C	F		C										
		4-2, 75-77	F	P E-3									F	F									C	F		C										
		4-3, 90-92	F	P E-3		F							F	F		F							C			C		F								
		4-4, 30-32	F	P E-3									F	F									C			C										
		4-5, 30-32	F	P E-3		F										F							C			C		F								
		4-6, 40-42	R	P E-3																			F			F										
		4 CC	R	P E-3																			R	R		R										
		5-1, 90-92	F	P E-3		F							C	C									C			C		C								
		5-2, 55-57	F	P E-3		F							C	C					C				C			C		C								
		5-3, 30-32	F	P E-3		F							F	C		F	F		R				C		F	C		C								
		5-4, 40-42	F	P E-3									F	C		F	F						F	F	F	C		F								
		5-5, 10-12	F	P E-3		F							F	C		F	F						C	F		C		C								
		5 CC	F	P E-3									F	C		F	F						C	F		C		C								
	S. hetero.	6 CC	F	P E-2 O-1									F	C					C					F		C	C		C					F	F	
Early Miocene	?Discoaster druggii	7-1, 60-62	F	P E-3 O-2																									C	C	C					
		7-2, 20-22	F	P E-3 O-2																									C		C	F				
		7-4, 20-22	F	P E-3 O-2																									C		C	F				
		7-5, 43-45	F	P E-3 O-2																									C		C	F				
		7-6, 35-37	F	P E-3																									C		C			R		
		7 CC	F	P E-3 O-1										F					F		F					F			C		C			R	R	
		8-1, 15-17	F	P E-3 O-1																	F				F				C	F	C					
		8-2, 55-57	F	P E-3																	F								C	F	C					
Late Oligocene	?	8-4, 59-61	F	P E-3																	F								C		C					
		8-5, 32-34	F	P E-3																	F								C		C					
		8-6, 24-26	F	P E-3																									C		C					
		8 CC	F	P E-3															F		F					F			C	F	C					
		9-5, 91-93	F	P E-3																									F		F					
		9-6, 34-36	F	P E-3																									F		F					
		9 CC	F	P E-3											F						F								C		C					
		10-2, 21-23	F	P E-3											F				C										C		C		R	F		
		10-3, 122-123	F	P E-3					F		R	R			C			F	F															F		R
		10-4, 112-114	F	P E-3			F								C				C										C				F	C		
		10-5, 42-44	F	P E-3					R						C				C										C				C	F		
		10 CC	F	P E-3											C				C										C							
E. Oligocene	?	11 CC	C	P E-3			C	C	C	C					F				C										C				R			
Late Eocene		12-1, 54-56	F	M E-2 O-1			C	C	C	C					F			F											E				F			
		12-2, 77-79	R	P E-3			F		F						F														F				F			
		12-3, 40-42	R	P E-3			F																										R			
		12-4, 31-33	R	P E-3			R																										R			
		12-5, 70-72	R	P E-3			R								R														R				R			
		12-6, 37-39	R	P E-3			R								R																		R			
		12 CC	R	P E-3			R		R																				R							
?	?	15 CC	R	P E-3			F		C																	R			C							

TABLE 4B
Distribution of Nannofossils at Site 166

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Watznaueria barnesae*	*Watznaueria communis*	*Watznaueria biporta*	*Watznaueria britannica*	*Biscutum melaniae*	*Biscutum supracretaceum*	*Cyclagelosphaera margareli*	*Markalius circumradiatus*	*Manivitella pemmatoidea*	*Cruciellipsis chiasta*	*Stephanolithon laffittei*	*Cretarhabdus crenulatus*	*Parhabdolithus splendens*	*Parhabdolithus embergeri*	*Rhagodiscus asper*	*Zygodiscus* cf. *salillum*	*Chiastozygus* cf. *garrisonii*	*Glaukolithus diplogrammus*	*Lithraphidites carniolensis*	*Assipetra infracretacea*	*Tetralithus malticus*	*Discorhabdus* cf. *biradiatus*	*Rucinolithus* cf. *irregularis*	*Cretaturbella rothii*	*Nannoconus* sp.
Late Hauterivian–Early Aptian	?	26 CC	C	M E-2 O-1	A	C	F	C		F	C	F	F	C	R	A	R	C	C	F			C	F	R	C			F
		27-1, 80-82	C	M E-2 O-1	A	F	C	C		F	C	F	F	F		C		C	C	F		F	C	F	R	C			
		27-2, 50-52	C	M E-2 O-1	A	C	F	C	F	F	C	F	F	F		C	R	C	C	F		R	C	F	R	C	F		
		27 CC	C	M E-2 O-1	A	C	F	C	F	F	C	F	F	F		C	R	C	C		R		C	F	R	C			
		28-2, 140-142	F	M E-2 O-1	C	C						F			R	C		F	F				F	F		C			
		28 CC	C	M E-2 O-1	A	C		C	R			F	F	F	F	A	R	C	F				C	F				R	

to the Hauterivian *Cruciellipsis cuvillieri* Zone, characterized by the occurrence of the zonal marker without *Tubodiscus jurapelagicus.* The core catcher of Cores 75 and 84 recovered the *Tubodiscus jurapelagicus* Zone of late Valanginian to early Hauterivian age. A single specimen of *Calcicalathina oblongata* was observed in Core 75. Cores 86 through 92 and the upper part of Core 93 contain common *Watznaueria britannica, Cretarhabdus crenulatus,* and rare *Rucinolithus wisei*; they belong to the *Watznaueria britannica* Zone (early Valanginian to late Berriasian). The lower part of Core 93 and Core 94 contain *Nannoconus colomii* and *Polycostella beckmannii.* These assemblages are typical of the early Barremian to late Tithonian *Nannoconus colomi* Zone.

SITE 168
(lat 10°42.2'N, long 173°35.9'E, depth 5430 m)

The predominate sediment type in the cores is brown radiolarian zeolitic clay. The only core containing nannoplankton is Core 5 (Table 6). It belongs to the middle Eocene *Chiasmolithus solitus* Zone with an assemblage including *Chiasmolithus grandis, C. solitus, Triquetrorhabdulus inversus,* and *Sphenolithus furcatolithoides.*

SITE 169
(lat 10°40.2'N, long 173°33.0'E, depth 5415 m)

The upper 95 meters was not cored at this site but probably consists of brown zeolitic clay with interbedded cherts. This overlies a unit comprising 122 meters of zeolitic claystone and chert. Distribution of nannofossils is shown in Table 7.

Core 1 contains a fairly rich assemblage with *Arkhangelskiella cymbiformis* and *Ceratolithoides kamptneri* and probably belongs to the *Lithraphidites quadratus* Zone. Core 2 lacks nannofossils. Core 3 contains *Broinsonia parca* and *Eiffellithus eximius*; it is assigned to the *Eiffellithus eximius* Zone (middle to early Campanian). Cores 4 and 5 are barren of nannofossils, and Cores 6 and 7 contain only long-ranging nondiagnostic forms. Cores 8 and 9 are assigned to the *Lithraphidites alatus* Zone because rare specimens of the marker species are present. Core 10 contains poorly preserved assemblage with *Eiffellithus turriseiffeli* and *Lithastrinus floralis* and therefore belongs to the late Albian *Eiffellithus turriseiffeli* Zone.

The preservation of the assemblages is poor to moderate with moderate-to-strong etching and slight overgrowth.

SITE 170
(lat 11°48.0'N, long 177°37.0'E, depth 5792 m)

At this site, the sedimentary column consists of 20 meters of Oligocene to Quaternary brown radiolarian zeolitic ooze overlying 172 meters of upper Albian to Oligocene nannofossil ooze, chalk, and limestone resting on basalt. Nannofossil distribution at this site is shown in Table 8.

Core 1 contains mixed Quaternary and Cretaceous nannofossils, and Core 2 lacks calcareous nannoplankton completely. Cores 3, 4, and 5 recovered the *Tetralithus trifidus* Zone of early Maestrichtian to late Campanian age. Cores 6, 7, and 8 contain *Eiffellithus eximius* and *Broinsonia parca* and are thus assigned to the middle to early Campanian *Eiffellithus eximius* Zone. Core 9 yields only a few specimens of long-ranging species *Watznaueria barnesae,* and Core 10 is completely barren of calcareous nannofossils. Core 11 contains mostly solution-resistant forms like *Marthasterites furcatus, Lithastrinus floralis,* and *Micula decussata* and is assigned to the *Marthasterites furcatus* Zone (Santonian to Coniacian). Core 12 recovered the late Turonian *Micula decussata* Zone. Cores 13 and, probably, also Core 14 belong to the Cenomanian *Lithaphridites alatus* Zone. Core 15 contains *Eiffellithus turriseiffeli* and *Cretarhabdus coronadventis* and is assigned

TABLE 5A
Distribution of Nannofossils at Site 167

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Gephyrocapsa oceanica*	*Gephyrocapsa caribbeanica*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*Reticulofenestra abisecta*	*Crenalithus bisecta*	*Crenalithus doronicoides*	*Coccolithus pelagicus*	*Coccolithus miopelagicus*	*Coccolithus eopelagicus*	*Ericsonia subdisticha*	*Cyclococcolithina leptopora*	*Cyclococcolithina macintyrei*	*Cyclococcolithina cf. rotula*	*Cyclicargolithus floridanus*	*Oolithotus antillarum*	*Umbilicosphaera sibogae*	*Coronocyclus serratus*	*Helicopontosphaera kamptneri*	*Helicopontosphaera sellii*	*Helicopontosphaera reticulatus*	*Pontosphaera discopora*	*Pontosphaera scutellum*	*Scyphosphaera apsteinii*	*Scyphosphaera pulcherrima*	*Rhabdosphaera clavigera*	*Syracosphaera cf. histrica*	*Ceratolithus cristatus*	*Ceratolithus rugosus*	*Triquetrorhabdulus rugosus*	*Triquetrorhabdulus carinatus*	*Rhabdothorax serratus*	*Discoaster brouweri*	*Discoaster surculus*	*Discoaster variabilis*	*Discoaster berggrenii*	*Discoaster neohamatus*	*Discoaster calcaris*	*Discoaster bellus*	*Discoaster braarudii*	*Discoaster perplexus*	*Discoaster challengeri*	*Discoaster exilis*	*Discoaster divaricatus*	*Discoaster deflandrei*	*Discoaster woodringii*	*Sphenolithus abies*	*Sphenolithus moriformis*	*Sphenolithus heteromorphus*	*Sphenolithus belemnos*	*Sphenolithus ciperoensis*	*Sphenolithus distentus*	*Sphenolithus predistentus*	*Sphenolithus pseudoradians*
L. Pleistocene	*G. oceanica*	1-3, 50-52	A	G X	A											A					C		F									F																											
		1-4, 50-52	A	G X	A											C					C		F			R	R			F	R	F																											
Early Pleistocene	*Psuedo-emiliania lacunosa*	1-5, 50-52	A	G X	A	A	A				C					C					C		C									F																											
		1-6, 50-52	A	G X	C	C	A				C					C					C		C			R						F																											
		1 CC	A		C	C	A				C					C					F		C			R						F																											
		2-2, 51-53		G X	C	C	A				C					C					R		F									F																											
		2-3, 50-52	A	G X	C	C	A				C					C					R		F									F																											
		2-4, 50-52	A	G X	F	F	C				C					C					F		C									F																											
		2-5, 50-52	A	G X	F	F	A				C					C					C		F									F																											
		2-6, 50-52	A	G X	F	F	A				C					C					C		F					F				F																											
		2 CC	A	G X	F	F	A				C					C					C		C			F						F																											
Late Pliocene	*C. macintyrei*	3-1, 52-54	A	G X			C				C	C				C	F			F			C	F									F				C																						
		3-2, 50-52	A	G X			C				C	C				C	F						C	F									F				C																						
		3-3, 50-52	A	G X			C				C	C				C	C						C										F				C																						
		3-5, 50-52	A	G X			C				C	C				C	C						F	F									R				C																						
		3 CC	A	G X			F					C				C	C						C	F									C				A																						
Late Miocene	*D. bellus*	4-1, 50-52	A	M E-1 O-1				C				C				C	C	F					C														C	F	C	F	C	F	C	C							C							
		4-3, 47-49	A	M E-1 O-1				F				C				C	C						C														C	R	C	F	C	R	C	C		C					A							
		4-5, 50-52	A	M E-1 O-1				F				C				C	C						C				F										C	R	C	R	C	F	C	C							C							
		4CC	A	M E-1 O-1				F				C				C	C						F					F									C	F	C	F	C	F	C	C							A							
Middle Miocene	*L. exilis*	5-2, 50-52	A	M E-1 O-2				C				C	A			C	C	F	C			F	C					F						F		F			C						F		A	C				C						
		5-5, 50-52	A	M E-1 O-2				C					A			C	C		C			F	C											F					C								A	C				C						
		5 CC	A	M E-1 O-2				C					A			C	C		C			F	C											F													A	C				C						
	Sphenolithus heteromorphus	6-3, 90-92	A	G E-1 O-1				C					C			F	F		C			F	F					R	R																		C	C				C	C					
		6-4, 50-52	A	G E-1 O-1				C					C			F	F		C			F	F																								C	C				C	C					
		6-6, 60-62	A	G E-1 O-1				C					C			F	F		C			R	C											F		F											C	C				C	C					
		6 CC	A	M E-1 O-2				C					C			F	F		C			R	F																								C	C				C	C					
		7-1, 50-52	A	M E-1 O-1				C					C			F	F		C			F																									C	C				C	C					
		7-2, 50-52	A	M E-1 O-2				C					C			F	F		C			C																									C	C				C	C					
		7-3, 80-82	A	M E-1 O-2				C					C				F		C			F																									C	C				C	C					

		7-5, 50-52	A	M	E-1	O-2									C				F		C			F																											C	C				C	C							
		7 CC	A	M	E-1	O-2									C				F		C			F																								R		C	C				C	C							
Early Miocene	*Triquetrorhabdulus carinatus*	8-1, 50-52	A	M	E-1	O-1										C					C			F													C																C	C	C		C								
		8 CC	A	M	E-1	O-2										C					C			R													C																C	C	C		C								
		9-1, 48-50	A	M	E-1	O-2										C					C			F													C																C	C	C		C								
		9-3, 50-52	A	M	E-1	O-2										C					C			F													C																	C	C		C								
		9-5, 50-52	A	M	E-1	O-2										C					C			F													C																	C	C		C								
		9 CC	A	M	E-1	O-2										C					C			F			R										C																	C	C		C		R						
		10-2, 50-52	A	M	E-1	O-2										C					C			F													C																	C	C		C								
Late Oligocene	*R. abisecta*	10-3, 50-52	A	M	E-1	O-2					F					C					C			F													C																	C	C		C								
		10-5, 50-52	A	M	E-1	O-2					F					C					C			F													A																	C	C		C								
		10 CC	A	M	E-1	O-2					C					C					C			R													A																	C	C		C								
		11-1, 50-52	A	G	E-1	O-1					C					C	R				C																A																	C	C		C								
		11-3, 50-52	A	G	E-1	O-1					C					C					C																A																	C	C		C								
		11-5, 50-52	A	G	E-1	O-1					C					C					C																C																	C	C		C			R				
		11 CC	A	M	E-1	O-2					C					C					C																C																	C	C		C			R				
	Sphenolithus ciperoensis	12-1, 50-52	A	G	E-1	O-1					C	R				C	F				C																C																	C	C		C			C				
		12-3, 50-52	A	M	E-1	O-2					C	F				C					C																F																	C	C		C			C				
		12-5, 50-52	A	G	E-1	O-1					C	C				C					C			F													F																	C	C		C			C				
		12 CC	A	G	E-1	O-1					C	C				C					C			F													F																	C	C		C			C				
	Sphenolithus distentus	13-1, 50-52	A	G	E-1	O-1					C	C				C					C																																	C	C		C			F	C			
		13-3, 50-52	A	G	E-1	O-1					C	C				C					C																																	C	C		C			R	C			
		13-5, 30-32	A	G	E-1	O-1					C	C				C					C																																	C	C		C			R	C			
		13 CC	A	G	E-1	O-1					C	C				C					C																																	C	C		C			R	C			
		14-1, 80-82	A	M	E-1	O-1					C	C				C	F				C																																	C	C		C			R	C			
		14-3, 30-32	A	M	E-1	O-1					C	C				C					C																																	C	C		C			R	C			
		14-5, 50-52	A	M	E-1	O-1					C	C				C					C																																	C	C		C			R	C			
		14-CC	A	M	E-1	O-1					C	C				C	R				C																																	F	F		C			R	C	R	R	
		15-1, 50-52	A	M	E-1	O-1					C	C				C					C																																	C	C		A			R	C	F		
		15-3, 50-52	A	M	E-1	O-1					C	C				C	F				C																																	C	C		A			R	C	R		
		15-5, 50-52	A	M	E-1	O-1					C	C				C					C																																	C	C		A			R	C	R		
		15 CC	A	M	E-1	O-1					C	C				C					C		F				R																											C	C		A			R	C	R		
		16 CC	A	M	E-1	O-1					C	C				C					C																																	C	C		A			R	C	R		

TABLE 5B
Distribution of Nannofossils at Site 167

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Reticulofenestra bisecta*	*Reticulofenestra scrippsae*	*Reticulofenestra umbilica*	*Reticulofenestra hillae*	*Reticulofenestra reticulata*	*Reticulofenestra coenura*	*Prinsius bisulcus*	*Toweius craticulus*	*Toweius eminens*	*Chiasmolithus oamaruensis*	*Chiasmolithus titus*	*Chiasmolithus grandis*	*Chiasmolithus solitus*	*Chiasmolithus expansus*	*Chiasmolithus gigas*	*Chiasmolithus californicus*	*Chiasmolithus bidens*	*Chiasmolithus danicus*	*Chiasmolithus consuetus*	*Coccolithus eopelagicus*	*Coccolithus cavus*	*Ericsonia subdisticha*	*Ericsonia fenestrata*	*Cruciplacolithus tenuis*	*Cyclococcolithina kingii*	*Cyclococcolithina formosa*	*Cyclicargolithus floridanus*	*Markalius inversus*	*Ericsonia subperta*	*Coronocyclus serratus*	*Helicopontosphaera reticulata*	*Ellipsolithus macellus*	*Bramletteius serraculoides*	*Triquetrorhabdulus inversus*	*Heliolithus kleinpellii*	*Zygodiscus plectopons*	*Discoaster deflandrei*	*Discoaster woodringii*	*Discoaster nodifer*	*Discoaster tani*	*Discoaster barbadiensis*	*Discoaster saipanensis*	*Discoaster mohleri*	*Nannotetrina mexicana*	*Sphenolithus moriformis*	*Sphenolithus distentus*	*Sphenolithus predistentus*	*Sphenolithus pseudoradians*	*Sphenolithus radians*	*Sphenolithus obtusus*	*Sphenolithus furcatolithoides*	*Sphenolithus anarrhopus*	*Fasciculithus tympaniformis*	*Fasciculithus* cf. *ulii*	*Bomolithus elegans*
Early Oligocene	*Sphenolithus predistentus*	17-3, 50-52	A	M E-1 O-1	F																			C							C			R							C		F						A	R	C	R							
		17-5, 80-82	A	M E-1 O-1	F																			C							C										C		F						C	R	C								
		17 CC	A	M E-1 O-1	F																			C							C										F		F						A	R	C								
		18-1, 50-52	A	M E-1 O-1	C																			C							C										C		F						A	R	C								
		18-2, 50-52	A	M E-1 O-1	C																			C							C										C		C						C	R	C								
		18 CC	A	M E-1 O-1	C																			C							C										C	F	C						A	R	C								
		19-2, 48-50	A	M E-1 O-1	C																			C							C										C		C						C	R	C								
		19 CC	A	M E-1 O-1	C																			C							C										C		F						A		C								
		20-2, 48-50	A	M E-1 O-1	C																			C							C										C		C						A		C								
		20 CC	A	G E-1 O-1	C	F		F																C							C										C		C						A										
		21-1, 50-52	A	G E-1 O-1	C	F		F																C							C										C		C						A		C								
		21-3, 50-52	A	G E-1 O-1	C	F		F																C							C										C		C						C		C								
		21-5, 50-52	A	G E-1 O-1	C	F		F																C							C										C		C						C		C								
	Helicopontosphaera reticulata	21-6, 50-52	A	G E-1 O-1	C	F	F	C																C							C										C		C						C		C								
		21 CC	A	G E-1 O-1	C	F	C	C																C							C										C	F	C						C		F								
		22-1, 50-52	A	G E-1 O-1	C	F	C	C																C		F					C				R						C		C						C		C			R					
		22 CC	A	G E-1 O-1	C	F	C	C																C		F					C										C	F	C						C		C								
	Ericsonia subdisticha	23-2, 50-52	A	M E-1 O-1	C	F	C	C																C		C				C	C										C		F						C		R								
		23-4, 50-52	A	G E-1 O-2	C	F	C	C																C		C				C	C										F		F						C		F								
		23 CC	A	M E-1 O-1	C	F	C	C																C		C	R			C	C										F	F	F						C		C								
		24-1, 50-52	A	M E-1 O-2	C	F	C	F																C		C	R			C	C										C		C						C		R								
		24 CC	A	M E-1 O-1	C	F	C	F																C		C				C	C										F		F						A										
Late Eocene	*Discoaster barbadensis*	25 CC	A	M E-1 O-1	C	F	C	F																C		F				C	C				R		F				C		C		F				C										
		26 CC	A	M E-1 O-1	C	F	C	F																C						C	C				R						F		C	F	C	C			C		R								
		27 CC	A	M E-1 O-2	F	C	C	F						F										C						C	C										F		F	F	C	C			C				F						
		28-1, 50-52	A	M E-1 O-2	F	C	C	F	F															C						C	C										C		F	F	C	C			C				F						
		28-4, 50-52	A	M E-1 O-2	F	C	C	F	C															C						C	C				R		R				C		C	F	C	C			C				F						
		28 CC	A	M E-1 O-2	F	C	C	F	C															C					C	C	C						F				F		R	F	C	C			C				F						
		29-1, 50-52	A	M E-1 O-2	F	C	C	F	F															C					F	C	C				R						R		R	R	C	C			C				F						
		29 CC	A	M E-1 O-2	F	C	C	F	F						R									C						C	C						F				F		R	F	C	C			C		R		F						

Middle Eocene	C. grandis	30-1, 50-52	A	M	E-1	O-2	F	C	C		C							F								C						C	C										F		R	R	C	C			C				F						
		30 CC	A	M	E-1	O-2	F	C	C									F								C						C	C										F		F	R	C	C			C				C						
		31 CC	A	M	E-1	O-2	F	C	C									C								C		F			F	C	C										F		C	F	C	C			C										
		32-2, 50-52	A	M	E-1	O-2	F	C	C									C								C						C	C										F		C	F	C	C			C										
		32 CC	A	M	E-1	O-2	F	C	C									C								C					F	C	C							F							C	C			C				F	F					
	C. solitus	33-1, 85-87	A	M	E-1	O-2	F	C	C			F						C	F							C						C	C							F							C	C			C		R								
		33 CC	A	M	E-1	O-2	F	C	C			F						C	F	C						C						C	C							F							C	C			C						F				
		34 CC	A	M	E-1	O-2		C	C			F						C	C	F						C						C	C							F							C				C						F				
		35 CC	R	P	E-3				F			C						C	C							C						C	C							F							C				C						F				
		36 CC	C	M	E-2	O-2																				R																																			
	N. fulgens	37 CC	C	M	E-1	O-2						C						C	C		F					C						C	C							C							C			R	C										
L. Paleo.	D. mohleri	38 CC	C	P	E-1	O-2							C	C	C							C					C			F				F				C			F	F							C		C							F	C	C	C
Early Paleo.	Fasc. tympaniform	39-1, 117-119	C	P	E-1	O-2							C	C	C							C	C				C							R				F				C																	C	C	
		39 CC	C	P	E-2	O-2							C	C	C							C	C	F			C			F				R								C																	R	C	
		40 CC																				F	F	F	F					F				R	F																								R	C	

to the *Eiffellithus turriseiffeli* Zone (late Albian). Signs of slight-to-moderate etching and slight overgrowth were observed in most assemblages except for Cores 8 through 11 where etching was so strong that only the more solution-resistant forms escaped total destruction.

SITE 171
(lat 19°07.9'N, long 169°27.6'W, depth 2295 m)

This site is located on a saddle in Horizon Guyot. The stratigraphic section consists of 143 meters of middle Eocene to middle Miocene calcareous ooze resting on Maestrichtian to Cenomanian chalk, volcanogenic sediments and detrital limestone. Nannofossil distribution is shown in Tables 9A-B.

Core 1 recovered the early Pleistocene *Pseudoemiliania lacunosa* at the top, the late Pliocene *Discoaster tamalis* Zone in the middle, and the early Pliocene *Ceratolithus amplificus* Zone in the lower part. The core catchers of Cores 1 and 2 belong to the middle Miocene *Sphenolithus heteromorphus* Zone. The top of Core 3 is assigned to the *Discoaster druggii* Zone and the lower part to the *Triquetrorhabdulus carinatus* Zone, both of early Miocene age. Core 4 recovered the *Sphenolithus ciperoensis* Zone (late Oligocene) with assemblages including *Sphenolithus ciperoensis, Triquetrorhabdulus carinatus, Reticulofenestra bisecta,* and *R. abisecta.* Core 5 belongs to the *Sphenolithus distentus* Zone with dominant *Sphenolithus distentus* and few *S. ciperoensis.* Core 6 is assigned to the *Sphenolithus predistentus* Zone based on assemblages including *Sphenolithus predistentus, S. pseudoradians,* and rare *S. distentus.* Core 7 contains assemblages typical of the *Ericsonia subdisticha* Zone including *Reticulofenestra umbilica, Cyclococcolithina formosa,* and *Ericsonia subdisticha* without Eocene discoasters. The upper Eocene is missing. Core 8 recovered the middle Eocene *Chiasmolithus grandis* Zone. The core catcher of Core 8 and Sections 1 to 3 of Core 9 are assigned to the *Chiasmolithus solitus* Zone. The top of Core 4 contains *Nannotetrina fulgens, Chiasmolithus gigas,* and *Reticulofenestra umbilica;* it probably belongs to the *Chiasmolithus gigas* Zone although the presence of *Reticulofenestra umbilica* indicates a younger age (*Chiasmolithus solitus* Zone). Sections 5, 6, and the core catcher of Core 9 and Cores 10 through 15 belong to the middle Maestrichtian *Lithraphidites quadratus* Zone. The marker species is very rare and poorly developed. *Kamptnerius magnificus* is quite common in the upper part of this zone and a form assigned to *Kamptnerius pseudopunctatus* occurs in the lower part. The genus *Kamptnerius* is absent from other Upper Cretaceous deposits in the central Pacific. It is probably not solution resistant and was only preserved at this relatively shallow site. Cores 16 through 21 recovered the *Tetralithus trifidus* Zone. The Maestrichtian and upper Campanian are thus very thick at this site. Cores 22 and 23 contain assemblages which are tentatively assigned to the Coniacian to Santonian. They contain *Gartnerago obliquum, Corollithion signum,* and rare *Lithastrinus grillii* (in the lower part). Cores 24 through 26 recovered the *Micula decussata* Zone (late Turonian) with assemblages including *Micula decussata, Corollithion signum,* rare *C. exiguum, Lithastrinus grillii,* and *C. floralis.*

TABLE 5C
Distribution of Nannofossils at Site 167

Legend:
Abundance/distribution:
- A – abundant
- C – common
- F – few
- R – rare

Preservation:
- G – good
- M – moderate
- P – poor

(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Arkhangelskiella cymbiformis*	*Broinsonia parca*	*Gartnerago obliquum*	*Kamptnerius magnificus*	*Watznaueria barnesae*	*Watznaueria biporta*	*Biscutum melaniae*	*Biscutum supracretaceum*	*Markalius circumradiatus*	*Manivitella pemmatoidea*	*Cruciellipsis chiasta*	*Cylindralithus serratus*	*Corollithion exiguum*	*Lithastrinus floralis*	*Cribrosphaera ehrenbergi*	*Prediscosphaera cretacea*	*Prediscosphaera spinosa*	*Cretarhabdus crenulatus*	*Cretarhabdus conicus*	*Podorhabdus decorus*	*Dodekapodorhabdus noelae*	*Parhabdolithus splendens*	*Parhabdolithus* cf. *angustus*	*Parhabdolithus angustus*	*Parhabdolithus embergeri*	*Eiffellithus turriseiffeli*	*Eiffellithus eximius*	*Eiffellithus anceps*	*Crepidolithus thiersteinii*	*Reinhardtites anthophorus*	*Reinhardtites* cf. *mirabilis*	*Zygodiscus spiralis*	*Zygodiscus pseudanthophorus*	*Vagalapilla octoradiata*	*Parhabdolithus regularis*	*Chiastozygus amphipons*	*Chiastozygus litterarius*	*Vagalapilla* cf. *imbricata*	*Vagalapilla matalosa*	*Cretarhabdus* cf. *schizobrachiata*	*Glaukolithus diplogrammus*	*Tranolithus orionatus*	*Microrhabdulus decoratus*	*Microrhabdulus stradneri*	*Lithraphidites carniolensis*	*Lithraphidites alatus*	*Micula decussata*	*Micula mura*	*Tetralithus gothicus*	*Tetralithus trifidus*	*Tetralithus pyramidus*	*Tetralithus aculeus*	*Tetralithus obscurus*	*Marthasterites furcatus*	*Rucinolithus* cf. *irregularis*	*Rucinolithus* cf. *hayi*
L. Maas	*Micula mura*	41-1, 119-121	A	M E-1 O-1	C	R			A		F			C		C			C	C	F	C	C	F						F						F	F	F	F	F					F		C	R	C		F	R								
		41 CC	A	M E-1 O-1	C				A		F			C		C			C	C	F	C	C				R			F						F	F			F						R	F	F	C		C	R								
Middle Maastrichtian	?*Lithraphadites quadratus*	42-1, 138-140	A	M E-1 O-1	C			F	A		F			C		C			C	C	F	C	C				R			F						F	F			F							C	C	C		C									
		42-2, 50-52	A	M E-1 O-1	C				A		C			C		C			C	C	F	C	C	F			R			F						F	F	F	F	F							C		C		C									
		42-3, 50-52	A	M E-1 O-1	C				A		C			C		C			C	C	F	C	C				R			C						F	F	F	F	R							C		C		C									
		42-4, 50-52	C	M E-1 O-1	C				A		C			C		C			C	C	F	C	C			F	F			C						F	F		R	R							C		C		C									
		42-5, 50-52	C	M E-1 O-1	C			R	A		C			C		C			C	C	R	C	C				F			F						F	C		R	R							C		C		C									
		42 CC	C	C E-1 O-1	C				A		C			C		C			C	C		C	C			R	R			F						F	F	R	F	R							C		C		C									
		43-2, 15-17	C	M E-1 O-1	C				A		C			C		C			C	C	R	C	C			F	F			F						F	F		R	R					C		C		C		C									
		43 CC	A	M E-1 O-1	C			R	A		C			C		C			C	C		C	C			F	F			F						F	C		R	R					C		C		C		C									
Early Maastrichtian	*Tetralithus trifidus*	44 CC	A	G E-1 O-1	C				A		C			C		C			C	C		C	C			R	F			F		F				F	F		F	R					C	F	C		C		C		F	F	F					
		45-3, 107-109	A	G E-1 O-1	C				A		C			C		C			C	A	R	C	C			R	F			C						C	F		R	F					C		C		C		C		F	F	F		F			
		45-6, 50-52	A	G E-1 O-1	C				A		C			C		C			C	A		C	C				F			C						F	F	F	R	R					C		C		C		C		F	F	F					
		45 CC	A	G E-1 O-1	C				A		C	F		C		F			C	A		C	C	R		R	F			F			F			F	F	F	F	R					C	F	C		C		C		F	F	F					
		46 CC	A	G E-1 O-1	C				A		C			C		F			C	A		C	C		R		C			C			F			F	F		R	R		F			C	F	C		C		C		F	F	F		F		R	
		47 CC	A	G E-1 O-1	C				A		C			C		F			C	A	F	C	C	F		F	C			C		F	F			F	F	F	C	R		F		F	C	F	C		C		C		F	F	F					
		48 CC	A	G E-1 O-1	C				A		C			C		F			C	A		C	C			F	C			C		C	F			F	F		R	R		F		F	C	F	C		C		C		F	F	R					
Late Campanian	*Broinsonia parca*	49-1, 50-52	A	M E-1 O-1	C	C			A		C			C		F			C	A		C	C				F			C		R	F			F	F	R	F	R	F	F		F	C	R	C		C		C		F	F	R					
		49 CC	A	M E-1 O-1	C	C			A		C			C		F			C	A		C	C			F	F			C		F	C			F	F		R	R					C	F	C		C		C		F	F	F	F			R	
		50-1, 90-92	A	A E-1 O-1	C	F			A		C			C		F			C	A	R	C	C	F			F		F	C		F	C			F	C	R	F	R					C	R	C		C		C		F	F	F	F				
		50 CC	A	G E-1 O-1	C	F			A		C	F		C		F			C	A		C	C				C		F	C		F	F	F		F	C	R	F	R				F	C	F	C		C		C		F	F	F	F			F	
		51-1, 50-52	A	G E-1 O-1	C	C			A		C	F		C		F			C	A	R	C	C	F			C		F	C	R	F	F	F		C	F		R	F					C	F	C		C		C		F	F	F	F				
		51 CC	A	G E-1 O-1	**C**	**C**			**A**	**F**	**C**	**F**		**C**		**F**			**C**	**A**		**C**	**C**	**F**		**F**	**F**		**C**	**C**	**R**	**F**	**R**	**R**		**C**	**F**	**F**	**C**	**F**	**F**				**C**	**R**	**C**		**C**		**C**		**F**	**F**	**F**	**F**				
Early to Middle Campanian	*Eiffellithus eximus*	52 CC	A	G E-1 O-1	C	C			A	F	C	F		C		F			C	A	R	C	C	F			R		C	F	C	C	C	R	F	C				R	C				C	C	C		C		C			R	F	F			F	
		53-1, 83-85	A	C E-1 O-1	C	C			A	F	C	F		C		F			C	A	F	C	C	F					C	F	C	F	F	F	F	C		R	F	F	F				C	F	C		C		C		F		F	F	F		F	
		53 CC	A	G E-1 O-1	F	C			A		C	F		C		F			C	A	F	C	C	F					C	F	C	C	F	F	C	F		C	R	R	C				C	C	F		C		C				F	F				C
		54-1, 128-133	A	G E-1 O-1	F	C			A		C	F	F	C		F			C	A	F	C	C						C	F	C	C	F		C	F		F		F	C				C	C	F		C		C				F	F				
		54 CC	A	G E-1 O-1	F	C			A		C			C		F			C	A	R	C	C			F			C	F	C	C	C		C	F		F		R	C				C	C	F		C		C				F	F				C
		55-1, 93-95	A	A E-1 O-1	F	C	F		A	F	C			C		F			C	A	F	C	C	F		F			C	F	C	C	C		F	F				F	C				C	C	F		C		C					F				
		55-2, 40-42	A	G E-1 O-1	F	C			A	R	C			C		F			C	A		C	C						C	F	C	F	C		F	F				R	C				C	F	F		C		C		F			F				
		55 CC	A	G E-1 O-1	F	C			A	F	C			C		F			C	A		C	F	F					C	F	C		C		C	F					C				C	F	F		F		C		F			F				

		56-1, 62-64	A	G E-1 O-1	F	C			A	R	C		F	C		F			C	A		C	F						C	F	C		F			F					C				C	C	C		C		C					F				
		56 CC	A	M E-1 O-1	F	F			A	F	C			C		F			C	A		C							C	F	F		F								F				C	C	C		F		C					C				
		57-1, 72-74	A	M E-1 O-1		C			A	F	F			C		F ‡			C	A		C							F	F	F		F								F				C	C	F		F		C									
		57 CC	A	M E-1 O-1		C			A		F			C					F	A		C							F	F	F		F								C				F				F		C									F
		58-1, 135-137	C	P E-2 O-1		R			A	F	F			C					F	A		C							F		R										F				F						C									
Coniacian to Santonian	*Marthasterites furcatus*	58-3, 111-113	C	P E-2 O-2					A	F				C				C		F		A									F																				A							A		
		58-4, 52-54	C	P E-2 O-2					A	F				C				C		R		A									F																				A							A		
		58 CC	C	P E-2 O-2					A					C				C		F		A																													A							A		F
		59-1, 102-104	C	P E-2 O-2		R			A	F				C				C		F		A																													A							A		
		59-2, 128-130	C	P E-2 O-2					A					C				C		C		A									F		R																		A							A		
		59-3, 17-19	C	P E-1 O-2					A					C				C		C		A											F																		A				F			A		
		59 CC	C	P E-1 O-2					A	F			F	C				C	R	C		C																								R				C				F			A		
Late Turonian	*Micula decussata*	60-2, 71-73	A	P E-1 O-2					A				F	C		F		C		A		A	F	F					F	F			F												C						C				F					
		60 CC	A	P E-1 O-2					A	F			F	C		F	R	C		A		A	F					F	F	F			F										F		C						F									
E. Cenomanian	*L. alatus*	61-1, 137-139	C	P O-2					A				F	C		F		C		C		A	F					F	C	C			F										F		C					R										
		61-2, 75-77	C	P O-2					A					C		F	R	C		C		C						F	F	F															F					R										
		61 CC	C	P O-3					A				F	C	F			F				C		F					R																F					R										

Cores 27 through 32 lack calcareous nannofossils. The preservation of nannofossils is good to moderate throughout the section. The Miocene through Eocene assemblages are moderately overgrown with secondary calcite. Slight overgrowths were observed in the Maestrichtian and slight etching combined with slight overgrowth in the Campanian samples.

SYSTEMATICS

Cretaceous and Cenozoic species are treated separately. The synonymies are far from complete, and in most cases only the original reference and subsequent references which are important for the identification of the species are listed. Types of the new species will be deposited at the U.S. National Museum, Washington, D. C.

CRETACEOUS SPECIES

Family ARKHANGELSKIELLACEAE Bukry, 1969

Genus ARKHANGELSKIELLA Vekshina, 1959

Arkhangelskiella cymbiformis Vekshina
(Plate 19, Figures 1, 3, 5, 7; Plate 20, Figure 1)

Arkhangelskiella cymbiformis Vekshina, 1959, p. 66, pl. fig. 1, pl. 2, fig. 3a-c; Reinhardt, 1964, p. 752, figs. 1, 2, fig. 3; Shafik and Stradner, 1971, p. 80-81, pls. 5-7.

Remarks: All the specimen observed lack perforations. Specimens with pores seem to be restricted to near-shore deposits.

Range: Lower Campanian through Maestrichtian.

Genus BROINSONIA Bukry, 1969

Synonym ASPIDOLITHUS Noel, 1969

Broinsonia sp. cf. B. bevieri Bukry

Broinsonia bevieri Bukry, 1969, p. 21, pl. 1, figs. 8-12; Roth and Thierstein, 1972, p. 424, pl. 14, figs. 14-17, 22-29.

Aspidolithus angustus Noel, 1969, p. 196, pl. 1, figs. 1, 2.

Remarks: As indicated in Roth and Thierstein, 1972 (p. 429) it is not possible to distinguish the following species in the light microscope with certainty: *Broinsonia bevieri* Bukry, *B. lata* (Noel), and *B. orthocancellata* Bukry. Thus, all the forms related to *Broinsonia bevieri* Bukry with a rounded cross-like central structure in the light microscope are referred to *Broinsonia* sp. cf. *B. bevieri.*

Range: Cenomanian through Maestrichtian.

Broinsonia parca (Stradner) Bukry
(Plate 22, Figure 3)

Arkhangelskiella parca Stradner, 1963, p. 10, pl. 1, figs. 3, 3a.

Broinsonia parca (Stradner) Bukry, 1969, p. 23, pl. 3, figs. 3-10, Noel, 1970, p. 77-78, figs. 18, pl. 13, fig. 3.

Aspidolithus parcus (Stradner) Noel, 1969, p. 196, pl. 1, figs. 3, 4.

Remarks: This species is well developed in open-ocean assemblages of early to middle Campanian age and is a very useful marker.

Range Lower to middle Campanian.

Genus GARTNERAGO Bukry, 1969

Synonym LAFFITTIUS Noel, 1969

Gartnerago obliquum (Stradner) Noel
(Plate 22, Figure 1)

Arkhangelskiella obliquum Stradner, 1963, p. 10, pl. 1, figs. 2, 2a.

Discolithus decoratus Caratini, 1963, p. 18, pl. 1, figs. 7-9 (nomen alternatum pro *Discolithus ornamentatus*).

Discolithus ornamentatus Caratini, 1963, explanations to pl. 1.

Arkhangelskiella inclinata Reinhardt, 1965, p. 31, pl. 2, fig. 5.

Discolithus segmentatus Stover, 1966, p. 143, pl. 3, figs. 3, 6, pl. 8, fig. 19.

Arkhangelskiella obliqua Stradner, Reinhardt, 1967, p. 174, fig. 10.

Arkhangelskiella concava Gartner, 1968, p. 39, pl. 14, figs. 2, 3, pl. 16, figs. 5-7, pl. 18, figs. 22, 23, pl. 22, figs. 13-15.

TABLE 5D
Distribution of Nannofossils at Site 167

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Watznaueria barnesae*	*Watznaueria biporta*	*Watznaueria communis*	*Watznaueria britannica*	*Tubodiscus jurapelagicus*	*Biscutum supracretaceum*	*Cyclagelosphaera deflandrei*	*Cyclogelosphaera margareli*	*Markalius circumradiatus*	*Manivitella pemmatoidea*	*Diazomatholithus lehmani*	*Cruciellipsis chiasta*	*Cruciellipsis cuvillieri*	*Cruciellipsis* cf. *cuvillieri*	*Stephanolithion laffittei*	*Lithastrinus floralis*	*Cribosphaera ehrenbergii*	*Prediscosphaera cretacea*	*Cretarhabdus crenulatus*	*Cretarhabdus conicus*	*Parhabdolithus splendens*	*Parhabdolithis angustus*	*Parhabdolithus embergeri*	*Eiffelithus turriseiffeli*	*Rhagodiscus asper*	*Calcicalathina oblongata*	*Zygodiscus bussonii*	*Vagalapilla matalosa*	*Glaukolithus diplogrammus*	*Lithraphidites carniolensis*	*Assipetra infracretacea*	*Tetralithus malticus*	*Discorhabdus* cf. *D. biradiatus*	*Rucinolithus irregularis*	*Rucinolithus* cf. *wisei*	*Nannoconus colomii*	*Nannoconus* cf. *dolomiticus*	*Nannoconus* sp.	*Braarudosphaera turbinea*	*Micrantholithus hoschulzii*	*Polycostella beckmannii*
Late Albian to Early Cenomanian	*Eiffellithus turriseiffeli*	62-2, 103-105	C	P O-3	C									F						F		F	C				F	F																	
		62-3, 103-105	C	P O-3	C									F						F		R	C				F	F						F											
		62-4, 110-112	C	P O-3	C															F			C	F			F	F					F				F	F							
		62 CC	F	P O-3	C																		C																						
		63 CC	F	P O-3	C															F			C			F	F	F						F											
		64-1, 98-100	F	P O-3	C					F										F			C				F	F						F											
		64-5, 30-32	F	P O-3	C					F										F			C				F	F									F						F		
		64 CC	C	P O-3	C		F													F			C				F	F	F					F			F	R							
		65 CC	F	P O-3	C																		C				F	R																	
		66 CC	C	P O-3	C																R	F	C				R	F																	
		67-3, 12-14	C	P O-3	C								F							F		F	C		F	F	F	R						F		F	F								
Early Albian	*Prediscosphaera cretacea*	67 CC	C	P O-3	C						R		F	F		R						F	C	F		F	F		F			F		C			F	R							
		68-1, 18-20	C	P O-3	C		R						F	C						F		F	C	F	F	C	F		C				F	C			F								
		68 CC	C	P O-3	C																	R	C	F		F	C		F					C		F	F	F							
Aptian to Early Albian	*Parhabdolithus angustus*	69-1, 36-38	C	P O-3	C																		C	F		F	F		F					C	R		F								
		69-2, 48-50	C	P O-3	C																		F				C							C	R		F	F							
		69-4, 4-6	C	P O-3	C								F										F			R	F		F					C	R		F	F							
		69 CC	C	P O-3	C								F							F			F	F		R	C		F					C	R		F								
		70-1, 128-130	C	P O-3	C								R							F			F			R	C							C	R		F	F							
		70-2, 97-99	C	P O-3	C									F						F			F			F	C		R					C	R		F								
		70-3, 102-104	C	P O-3	C								F							F	R	R	F			R	C	R						C	R		F								
		70-4, 71-73	C	P O-3	C								F							R			F	F		R	C		F					C	R		F								
		70 CC	C	P O-3	C							F	F						R	F			C		F	F	C		F					F	R	F	F	F							
		71-1, 6-8	C	P O-3	C							F	F		F		R						C		F		C		R					C	R	F	R	R							

Barremian	*Tetralithus malticus*	71-1, 72-74	C	P	O-3	C							F	F		F								C				C		R					C	R	F	R	R							
		71-2, 54-56	C	P	O-3	C							F	F		F	R							C	F	F		C		F					C	R	F	R	R							
		71 CC	C	P	O-3	C					F		F	F		R								C				C		R					C	R	F	F	F							
		72-2, 42-44	C	P	O-3	C					F		C	F	R	F				R				C				F		F					C	R	F	F	F							
		72 CC	C	P	O-3	C							F	F	F	F								C				C		R					C	R		R	R							
Hauterivian	*Cruciellipsis cuvillieri*	73-2, 41-43	C	P	O-3	C		F					F		F	F		R						C		F		C		F					F	R		R	R							
		73 CC	C	P	O-3	C		F				F	C	F		F		F						C				C		F					F	R		F	F							
		74-2, 8-10	C	P	O-3	C		F			F	F	F	F		F		F						C				C		F					F	R		F								
		74 CC	C	P	O-3	C		F				F	F	F		F		R						F				F		F					F	R										
		75-1, 98-100	F	P	O-3	F		F				F	F			R		R						F				F		F					F	R										
Late Valanginian to Early Hauterivian	*Tubodiscus jurapelagicus*	75 CC	C	P	O-3	C		F		R		F	F			F		F						F				R		R	R				F	R										
		76-1, 34-36	C	P	O-3	C		C		F		F	F	R		F		F						F		F		R		F					F	R	R	F	F							
		76-2, 130-132	C	P	O-3	C		C		F		F	F			F		F						F		R		R		R					F	R	R									
		76 CC	C	P	O-3	C		C				F	F			F		R						F				R		F					F	R										
		77 CC	C	P	O-3	C		C				F	F	R		F	F	F		R				F		R		F		F					F	R										
		78 CC	C	P	O-3	C	R	C		R		C	F	R		F		F		R				F				F		R					F	R	R									
		81 CC	C	P	O-3	C	R	C				R	F			F		F						F				R		R					F	R										
		82 CC	C	P	O-3	C	R	C				R	F			F	F	F						F		R		F		R					F	R	R			F						
		83 CC	C	P	O-3	C	R	C	F	F		C	C			C		F						F				F		F					F	R										
		84 CC	C	P	O-3	C	R	C	F	F		F	C			C	F	F						F		R		F		R					F	R				R						
Early Valanginian to Late Berriasian	*Watznaueria britannica*	86 CC	F	P	O-3	C	R	C	F			F	F			F		R						F				F		R					R	R										
		87 CC	C	P	O-3	C	R	C	F			C	C			C	F	C						F				F		F		F			R	R										
		88 CC	C	P	O-3	C	R	C	F			F	C			F	F	F		R				F				F		F					R	R			F							
		89 CC	C	P	O-3	C	R	C	F			F	C			C		R						F				F		F					F	R										
		90 CC	C	P	O-3	C	R	C	F			F	C			C	F	F						F				F		R					F	R				R						
		92-1, 102-104	C	P	O-3	C		C	F			F	C			C	F	F						R				F		R					F						F					
		92 CC	C	P	O-3	C		C	F			F	C			C	F	F						R				F		R					F						F	F			R	
		93-1, 88-90	C	P	O-3	C		C	F			F	C			C	F	F						R				F		F					F											
		93-2, 24-26	C	P	O-3	C		C	F			F	C			C	R	F										F		F					F						F		F			R
L. Tithonian–E. Berri.	*Nannoconus colomii*	93 CC	C	P	O-3	C		C	C			F	C			C	R	F										F		F					R					F	F		F			
		94-1, 120-122	C	P	O-3	C		C	C			F	C			C	F		F									R		F					F						F		F			
		94-2, 56-58	C	P	O-3	C		C	C			F	C			C	F		F									F		F					F						F		F			R

TABLE 6
Distribution of Nannofossils at Site 168

Sample: Core 5, core catcher
Abundance: Common
Preservation: Moderate: E-2
Zone: *Chiasmolithus solitus*
Age: Middle Eocene

Species Present	Abundance
Reticulofenestra umbilica	C
Chiasmolithus grandis	C
Chiasmolithus solitus	F
Coccolithus eopelagicus	C
Cyclococcolithina formosa	F
Triquetrorhabdulus inversus	F
Discoaster nodifer	F
Discoaster tani	F
Discoaster barbadiensis	C
Discoaster saipanensis	C
Sphenolithus radians	F
Sphenolithus furcatolithoides	F

Arkhangelskiella costata Gartner, 1968, p. 37, pl. 8, figs. 1-3, pl. 11, fig. 2a-c.
Arkhangelskiella scapha Gartner, 1968, p. 39, pl. 14, fig. 1, pl. 20, figs. 1-3.
Arkhangelskiella ornamentatus (Caratini) Manivit, 1968, p. 278, pl. 1, fig. 2a, b.
Arkhangelskiella ornamentata (Caratini) Perch-Nielsen, 1968, p. 60.
Gartnerago concavum concavum (Gartner) Bukry, 1969, p. 24, pl. 4, figs. 2-6.
Gartnerago costatum costatum (Gartner) Bukry, 1969, p. 24, pl. 4, figs. 7-9.
Gartnerago costatum prolatum Bukry, 1969, p. 24-25, pl. 4, figs. 10-12.
Laffittius obliquus Noel, 1969, p. 197, text-fig. 3a-b, pl. 3, figs. 1-5.
Laffittius confossus Noel, 1969, p. 198-200, pl. 2, fig. 5, pl. 3, fig. 6a, b.
Gartnerago obliquus (Reinhardt) Noel, 1970, p. 78-79, figs. 19, 20, pl. 16, figs. 1a-d, 2-7.
Gartnerago inclinatum (Reinhardt) Reinhardt, 1970b, p. 65-66, figs. 55-57, 60.
Gartnerago obliquum (Stradner) Noel, Reinhardt, 1970b, p. 66-67, figs. 58-59.

Remarks: The presence or absence of perforations seems to depend on the state of preservation. A slight degree of overgrowth results in the formation of large crystals covering the perforations in the central area. Specimens from the central Pacific lack pores.

This species is quite common in the Coniacian to lower Santonian on Horizon Guyot.

Genus KAMPTNERIUS Deflandre, 1959

Kamptnerius magnificus Deflandre
(Plate 23, Figures 1, 2)

Kamptnerius magnificus Deflandre, 1959, p. 135, pl. 1, figs. 1-4; Noel, 1970, p. 82, pl. 27, fig. 2.

Remarks: Only the form with a widely flaring flange is included here; it is more abundant in the upper part of the *Lithraphidites quadratus* Zone and replaces a somewhat larger form with a narrow flange and small perforations assigned to *Kamptnerius pseudopunctatus* which occurs in the lower part of the *Lithraphidites quadratus* Zone and in the *Tetralithus trifidus* Zone. This species is not resistant to solution. It was found only at Site 171, Horizon Guyot but was absent in the thick Upper Cretaceous section of Magellan Rise.

Kamptnerius pseudopunctatus Cepek
(Plate 23, Figures 3-5)

Kamptnerius pseudopunctatus Cepek, 1970, p. 242-243, pl. 24, figs. 7-9.

Remarks: The specimens observed are somewhat larger than specimens of *Kamptnerius magnificus.* They have small perforations in the middle of the central area and agree well with the illustrations in Cepek (1970).

This species is also susceptible to solution and is only present at the relatively shallow Site 171 on Horizon Guyot.

Family COCCOLITHACEAE Kamptner, 1928

Genus WATZNAUERIA Reinhardt, 1964

Watznaueria barnesae (Black) Perch-Nielsen
(Plate 19, Figure 2, Plate 20, Figure 3, Plate 26, Figure 4)

Tremalithus barnesae Black, *in* Black and Barnes, 1959, p. 325, pl. 9, figs. 1, 2.
Watznaueria angustoralis Reinhardt, 1964, p. 753, pl. 2, fig. 2, text-fig. 4.
Ellipsagelosphaera frequens Noel, 1965, p. 117, pl. 11, figs. 7-10, pl. 12, figs. 1-10, text-figs. 3, 8.
Coccolithus paenepelagicus Stover, 1966, p. 139, pl. 1, figs. 10, 11, pl. 3, fig. 22, pl. 8, fig. 5.
Watznaueria barnesae (Black) Perch-Nielsen, 1968, p. 69-70, pl. 22, figs. 1-7, pl. 23, figs. 1, 4, 5, 16, text-fig. 32.

Remarks: This species is the most abundant form in all the Cretaceous samples. It is most resistant to solution and secondary

TABLE 7
Disposition of Nannofossils at Site 169

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Arkhangelskiella cymbiformis*	*Broinsonia parca*	*Watznaueria barnesae*	*Biscutum melaniae*	*Cylindralithus gallicus*	*Markalius circumradiatus*	*Manivitella pemmatoidea*	*Cruciellipsis chiasta*	*Cribrisphaera ehrenbergii*	*Prediscosphaera cretacea*	*Prediscosphaera spinosa*	*Cretarhabdus crenulatus*	*Cretarhabdus conicus*	*Cretarhabdus coronadventis*	*Cretarhabdus loriei*	*Podorhabdus orbiculofenestrus*	*Parhabdolithus splendens*	*Parhabdolithus angustus*	*Parhabdolithus embergeri*	*Eiffellithus turriseiffeli*	*Eiffellithus eximius*	*Rhagodiscus asper*	*Crepidolithus thiersteinii*	*Zygodiscus pseudanthophorus*	*Chiastozygus litterarius*	*Eiffellithus trabeculatus*	*Vagalapilla matalosa*	*Glaukolithus diplogrammus*	*Tranolithus orionatus*	*Lithastrinus floralis*	*Microrhabdulus decoratus*	*Lithraphidites carniolensis*	*Lithraphidites alatus*	*Ceratolithoides kamptneri*	*Micula decussata*	*Tetralithus* cf. *obscurus*	*Tetralithus aculeus*	*Tetralithus gothicus*	*Tetralithus* cf. *pyramidus*	*Discorhabdus* cf. *biradiatus*
Maest.	*L. quadratus*	1 CC	A	M E-1 O-1	C		A	F	C		C		C	A	F	A	F							F			F	F							C	C		F	A	R				
M-E Camp.	*E. eximius*	3 CC	F	P E-2		R	C	F			F		F	F		F	F				F				R		F									C			F		R	R		
?	?	6 CC	R	P E-3			F																													C								
Turon.-L. Alb.	?	7 CC	F	P E-2 O-1			C				F																							C		C						R		
Cenomanian	*L. alatus*	8 CC	C	M E-1 O-1			A	F	F		F			C		C	R	F		R	F		F	C			F		F	F	F	C	F	C		C	R							
Cenomanian	*L. alatus*	9 CC	A	M E-1 O-1			A	F	F	F	C			C		C			F		C	C	F	F		F					F	C	F	C		C	R							
Late Albian		10 CC	F	P E-2			C														F	F		F										F		C								F

TABLE 8
Distribution of Nannofossils at Site 170

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Gephyrocapsa oceanica*	*Coccolithus eopelagicus*	*Discoaster deflandrei*	*Sphenolithus moriformis*	*Chiasmolithus* sp.	*Arkhangelskiella cymbiformis*	*Broinsonia parca*	*Broinsonia bevieri*	*Watznaueria barnesae*	*Watznaueria biporta*	*Biscutum melaniae*	*Biscutum supracretaceum*	*Markalius circumradiatus*	*Manivitella pemmatoidea*	*Cruciellipsis chiasta*	*Cylindralithus serratus*	*Corollithion signum*	*Stephanolithion laffittei*	*Lithastrinus floralis*	*Cribrosphaera ehrenbergii*	*Prediscosphaera cretacea*	*Prediscosphaera spinosa*	*Cretarhabdus crenulatus*	*Cretarhabdus conicus*	*Cretarhabdus loriei*	*Cretarhabdus coronadventis*	*Podorhabdus decorus*	*Podorhabdus dietzmannii*
Mixed	?	1 CC	R	P E-3 O-1	R	R	R	R	R				R																			
E. Maas. to Late Campanian	*T. trifidus*	3 CC	A	M E-2						F			A							F				C	C	F	C	F				
		4 CC	C	M E-2						F			A					F		F				F	F	F	C	R				
		5 CC	A	M E-1 O-1						F			A					F		F				C	A	F	C	C			R	
Middle to Early Campanian	*Eiffellithus eximius*	6-4, 145-147	A	G E-1 O-1						F	F		A					F		F				C	A	F	A	C			F	
		6-5, 50-52	A	G E-1 O-1						C	F		A					C		F				C	A	F	A	C				
		6-6, 90-92	A	M E-1 O-1						F	F		A					C		F				C	A	F	A	C				
		6 CC	A	M E-1 O-1						F	F		A	F				C		F				C	A		C	C				
		7-2, 130-132	A	M E-1 O-1						C	F		A	F				C		F				C	A		A	C				
		7-3, 90-92	A	M E-1 O-1						F	F		A					C		F				C	A		C	C			F	
		7 CC	A	M E-1 O-1						F	F		A					F		F				C	A		C	C				
		8-1, 34-36	C	M E-1 O-1						F	F		A							F				C	A		C	C				
		8 CC	F	P E-1							F		C	F													F					
?	?	9 CC	R	P E-3									F																			
Sant. to Con.	*M. furcatus*	11 CC	C	P E-3									F										C									
L. Turon.	*M. decussata*	12 CC	C	M E-1 O-1								F	A					F	F	F			C		A		C					F
E. Cenomanian	*L. alatus*	13 CC	A	M E-1 O-1									A		C	F		C	F		F	F	C		A		C		F			F
		14 CC	A	M E-1 O-1									A		C	F			F		F		C		A		C		F			F
L. Albian	*E. turriseiffeli*	15-1, 106-108	F	M E-2									C		F		F	C	F				R				F					
		15-2, 143-145	A	M E-1 O-1									A	C	F	F		C	F			F	C				C		F	F		
		15 CC	A	M E-1 O-1									A	F	C	F	F	C	C				C		F		C			F		

Core, Section, Interval (cm)	*Parhabdolithus splendens*	*Parhabdolithus angustus*	*Parhabdolithus embergeri*	*Eiffellithus turriseiffeli*	*Eiffellithus eximus*	*Eiffellithus anceps*	*Rhagodiscus asper*	*Crepidolithus thiersteinii*	*Rheinhardites anthophorus*	*Zygodiscus pseudanthophorus*	*Vagalapilla octoradiata*	*Parhabdolithus regularis*	*Chiastozygus litterarius*	*Vagalapilla matalosa*	*Glaukolithus diplogrammus*	*Tranolithus orionatus*	*Microrhabdulus decoratus*	*Lithraphidites carniolensis*	*Lithraphidites alatus*	*Micula decussata*	*Tetralithus gothicus*	*Tetralithus trifidus*	*Tetralithus pyramidus*	*Tetralithus aculeus*	*Tetralithus obscurus*	*Marthasterites furcatus*	*Rucinolithus* cf. *hayi*	*Discorhabdus* cf. *D. biradiatus*	*Braarudosphaera turbinea*
1 CC																	R												
3 CC								F			F	F			C		F			C	F	F	F						
4 CC										F					C		F			C	F	F	F						
5 CC				F				F	F	F	F	F			C		C	C		C	F	F							
6-4, 145-147				F	F	F		F		F					C		C	C		A	F								
6-5, 50-52				C	F	F		F	F	F					C		C	C		A	F			F					R
6-6, 90-92				F	F	F		F		F					C		C	R		A	F			F					
6 CC					F			F		F					C		F	C		C	F		F	F			F		
7-2, 130-132	F			C	C			F		F					C		C	C		C	F			F					
7-3, 90-92				C	C			F		F					C		C	F		C	F			F			F		
7 CC	F			C	C	F		F		F			F		C	F	F	F		C	F			F					
8-1, 34-36				F	F	F		F	F	F					C		F			C				F			F		
8 CC																	C												
9 CC																													
11 CC																				C						A			
12 CC	C	F	F	C	F										C		F	F		C					F		R		
13 CC	C	F	F	C			F						C	F	C	F		F	F										
14 CC	C	F	C	C			F						C	F	C			C											
15-1, 106-108	F	F	F	F			F						C		F			F									F	F	
15-2, 143-145	C	C	F	C			C						C		C			F										F	
15 CC	C	C	F	C			C						C		C			C										F	

TABLE 9A
Distribution of Nannofossils at Site 171

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Gephyrocapsa oceanica*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*Reticulofenestra abisecta*	*Reticulofenestra bisecta*	*Reticulofenestra scrippsae*	*Reticulofenestra umbilica*	*Reticulofenestra hillae*	*Chiasmolithus oamaruensis*	*Chiasmolithus titus*	*Chiasmolithus grandis*	*Chiasmolithus solitus*	*Chiasmolithus gigas*	*Chiasmolithus consuetus*	*Crenalithus doronicoides*	*Coccolithus pelagicus*	*Coccolithus miopelagicus*	*Coccolithus eopelagicus*	*Ericsonia subdisticha*	*Cruciplacolithus staurion*	*Cyclococcolithina leptopora*	*Cyclococcolithina macintyrei*	*Cyclococcolithina protoannula*	*Cyclococcolithina formosa*	*Cyclicargolithus floridanus*	*Cyclolithella aprica*	*Coronocyclus serratus*	*Umbellosphaera irregularis*	*Helicopontosphaera kamptneri*	*Helicopontosphaera reticulata*	*Scyphosphaera apsteinii*	*Syracosphaera* cf. *S. pulchra*	*Rhabdosphaera clavigera*	*Bramletteius serraculoides*	*Ceratolithus cristatus*	*Ceratolithus amplificus*	*Ceratolithus tricorniculatus*	*Triquetrorhabdulus carinatus*
E. Pleistocene	*P. lacunosa*	1-2, 50-52	A	G X	C	C														R					C	F						C	C			F	R		F			
L. Pliocene	*D. tamalis*	1-4, 50-52	A	G X					R										C						C	C							F			F						
E. Pliocene	*S. amplificus*	1-6, 50-52	A	G X			C													C					C	C														F	C	
Middle Miocene	*Sphenolithus heteromorphus*	1 CC	A	G O-2			C		R						R						F				C	C			C						F							R
		2-1, 50-52	A	G O-2																	C				C	C			C		F											
		2-2, 50-52	A	G O-2																	C				C	C			C		F				F							
		2-3, 50-52	A	G O-2																	C				C	C			C		F											
		2-4, 48-50	A	G O-2					R												C				C	C			C		C											
		2-5, 50-52	A	G O-2																	C				C	C			C		C				F							
		2 CC	A	G O-2																	C				C	C			C		F											
Early Miocene	*D. drugii*	3-1, 50-52	A	G O-2																	C	F							C		F											C
	T. carinatus	3-2, 50-52	A	G O-2																	C	F							C		F											C
		3-3, 52-54	A	G O-2																	C	F							C		F											C
		3-4, 50-52	A	G O-2																	C	F							C		F											C
		3-5, 50-52	A	G O-2																	C	C							C		F											C
		3-6, 50-52	A	G O-2																	C	C							C		F											C
		3 CC	A	G O-2																	C	C							C		F											C
Late Oligocene	*Sphenolithus ciperoensis*	4-1, 50-52	A	G O-2				C	F													C							C		R											F
		4-2, 50-52	A	G O-2				C	F													C							C		R											F
		4-3, 48-50	A	G O-2				C	F													C							C		R											F
		4-4, 50-52	A	G O-2				C	F													C							C		R											F
		4-5, 50-52	A	G O-2				C	F													C							C		R											F
		4-6, 50-52	A	G O-2				C	F													C							C		R											F
		4 CC	A	G O-2				C	F													C							C		F											F
	Sphenolithus distentus	5-1, 50-52	A	G O-2				C	F													C	C						C													
		5-2, 50-52	A	G O-2				C	F													C	C						C		F											
		5-3, 50-52	A	G O-2				C	F													C	C						C		F											
		5-4, 50-52	A	G O-2				C	F													C	C						C		F											
		5-5, 50-52	A	G O-2				C	F													C	C						C		F											
		5-6, 50-52	A	G O-2				C	C													C	C						C		F											
		5 CC	A	G O-2				C	C													C	F						C													
E. Oligocene	*S. predistentus*	6-2, 50-52	A	G O-2					C	F												C							C													
		6 CC	A	G O-2					C													C							C									R				
	E. subd.	7 CC	A	G O-2					C		C	C										C	F					C	C									F				
Middle Eocene	*Chiasmolithus grandis*	8-3, 50-52	A	G O-2					C	C	C	C			F							C	F					C	C	F								C				
		8-4, 50-52	A	G O-2					C	C	C	F			F							C	F					C	C	F								C				
		8-5, 50-52	A	G O-2					C	C	C				F							C	F					C	C	F								C				
		8-6, 50-52	A	G O-2					C	C	C				F							C	F					C	C	F								C				
	Chiasmolithus solitus	8 CC	A	G O-2					C	C	C		R		F	F						C					F	F		F	F							F				
		9-1 Top	A	G O-1					C	C	C				F	R						C						F		F								R				
		9-2, 50-52	A	G O-1					C	C	C				F							C		F			F	F		F	F							F				
		9-3, 50-52	A	G O-1					C	C	C				C	R						C					F	C		R								C				
	N. fulgens	9-4 Top	A	G O-1					C	C	C			F	F		F					C					F	C						F				F				

TABLE 9A – *Continued*

Triquetrorhabdulus milowii	*Triquetrorhabdulus inversus*	*Discoaster brouweri*	*Discoaster pentaradiatus*	*Discoaster surculus*	*Discoaster tamalis*	*Discoaster triradiatus*	*Diacoaster asymmetricus*	*Discoaster variabilis*	*Discoaster braarudii*	*Discoaster challengeri*	*Discoaster exilis*	*Discoaster perplexus*	*Discoaster divaricatus*	*Discoaster deflandrei*	*Discoaster druggii*	*Discoaster woodringii*	*Discoaster nodifer*	*Discoaster tani*	*Discoaster barbadiensis*	*Discoaster saipanensis*	*Discoaster robustus*	*Discoaster multiradiatus*	*Catinaster coalitus*	*Nannotetrina fulgens*	*Sphenolithus abies*	*Sphenolithus moriformis*	*Sphenolithus heteromorphus*	*Sphenolithus conicus*	*Sphenolithus ciperoensis*	*Sphenolithus distentus*	*Sphenolithus predistentus*	*Sphenolithus pseudoradians*	*Sphenolithus obtusus*	*Sphenolithus radians*	*Sphenolithus furcatolithoides*	*Thoracosphaera saxea*	*Thoracosphaera prolata*	*Fasciculithus tympaniformis*	*Arkhangelskiella cymbiformis*	*Kamptnerius magnificus*	*Watznaueria barnesae*	*Biscutum melaniae*	*Cylindralithus serratus*	*Cribrosphaera ehrenbergii*	*Prediscosphaera cretacea*	*Prediscosphaera spinosa*	*Cretarhabdus crenulatus*	*Cretarhabdus conicus*	*Eiffellithus turriseiffeli*	*Reinhardtites anthophorus*	*Zygodiscus spiralis*	*Zygodiscus pseudanthophorus*	*Vagalapilla octoradiata*	*Parhabdolithus regularis*	*Vagalapilla cf. elliptica*	*Microrhabdulus decoratus*	*Lithraphidites quadratus*	*Micula decussata*
		R	R																																																							
		A	C	C	C	F	F																																																			
		C	C	C				A																	C																																	
								C	C	C	A		C										R			C	C			R																												
											C		C	C		C										F	F									C																						
											C		C	C		C										F	F									C																						
											C		C	C		C										F	F									C																						
											C		C	C		C										C	C									C																						
											C		C	C		C										C	C									C																						
											C	F	C	C		C										C	C									C																						
F														C	F	C										C										C																						
C														C		C										C										C																						
C														C		C										C		C																														
C														C		C										C		C																														
C														C		C										C		C																														
C														C		C										C		C																														
												F		C		C										C		C																														
														C		F										C		F	C	F																												
														C		F										C		F	C	F																												
														C		C										C			C	F																												
														C		C										C			C	F																												
														C		C										C			C	F																												
														C		C										C			C	F																												
														C		C										C			C	F																												
														C		C										C			F	C																												
														C		C										C			F	C																												
														C		C										C			F	C																												
														C		C										C			F	C																												
														C		C										C			F	C		R																										
														C		C										C			R	C	F	R																										
														C		C										C			R	C	F																											
														C		C										C				F	C	R																										
														C		C										C				F	C																											
																C	C									C					R	C																										
	F																C	F	C	C						C						F																										
	C																C	C	C	C						C					F	F																										
	C																C	C	C	C						C						F																										
	C																C	C	C	C						C						F																										
	C																F	F	C	C	R	R				C						F	F	F	F																							
	F																F	F	C	C						C						F				F			F	F	C	F		F	C		F	F	F		R	F	R	R	R	F		F
	C																F	F	C	C						C						F			F			R	F	F	C	F		F	C	R	F	F	F		R	F	F	R	R	F		F
	C																F	F	C	C						C						F	F						F	F	C	F	F	F	C		F	F	F		F	F	R	R	R	F		F
	F																F	F	C	C				F		C						R			F				F	F	C	F		F	C		F	F	F	F	F	F	R	R	R	F	R	F

TABLE 9B
Distribution of Nannofossils at Site 171

Legend:
Abundance/distribution:
A – abundant
C – common
F – few
R – rare
Preservation:
G – good
M – moderate
P – poor
(see text for explanation of preservation symbols: "X", "E–", and "O–".)

Age	Zone	Core, Section, Interval (cm)	Abundance	Preservation	*Arkhangelskiella cymbiformis*	*Broinsonia parca*	*Broinsonia* cf. *B. bevieri*	*Gartnerago obliquum*	*Kamptnerius magnificus*	*Kamptnerius pseudopunctatus*	*Watznaueria barnesae*	*Biscutum melaniae*	*Biscutum supracretaceum*	*Markalius circumradiatus*	*Manivitella pemmatoidea*	*Cylindralithus serratus*	*Cylindralithus coronatus*	*Corollithion exiguum*	*Corollithion signum*
Middle Maestrichtian	*Lithraphidites quadratus*	9-5, 90-92	A	G O-1	F				C		A	C			R	F			
		9-6 Top	A	G O-1	F				C		A	C	R		R	F			
		9 CC	A	G O-1	F				C		A	F			R	C			
		10-4, 4-6	A	G O-1	F				C		A	F			F	F			
		10-5, 50-52	A	G O-1	F				C		A	F			F	F			
		10CC	A	G O-1	C				C		A	F			F	F			
		11-4, 50-52	A	G O-1	F				C		A	F			F	F			
		11-5, 50-52	A	G O-1	F				F		A	F			F	R			
		11 CC	A	G O-1	F				F		A	C			F	R			
		12 CC	A	G O-1	C				F		A	C			F	R			
		13-4, 50-52	A	G O-1	C						A	C			F	F			
		13-5, 50-52	A	G O-1	C						A	C			C	F			
		13 CC	A	G O-1	C						A	C			C	F			
		14 CC	A	G O-1	F						A	C			C	F			
		15-2, 50-52	A	G O-1	F				F	F	A	C			F	F			
		15-3, 50-52	A	G O-1	F		F			F	A	C	F		F	F			
		15-4, 50-52	A	G O-1	F		F			F	A	C			C	C			
		15-5, 50-52	A	G O-1	F					F	A	C			C	C			
		15-6, 50-52	A	G O-1	F					F	A	C			C	F			
		15 CC	A	G O-1	F					F	A	C			C	F			
Late Campanian to Early Maestrichtian	*Tetralithus trifidus*	16-1, 50-52	A	G O-1	F						A	C			C	F			
		16-3, 90-92	A	G O-1	F						A	C			C	F			
		16-4, 50-52	A	G O-1	F						A	C			C	F			
		16-5, 50-52	A	G O-1	F						A	C			C	F			
		16-6, 50-52	A	G O-1	C						A	C			C	F			
		16 CC	A	G O-1	C						A	C			C	C			
		17-2, 50-52	A	G O-1	C						A	C			C	F			
		17-3, 50-52	A	G O-1	C						A	C			C	F			
		17-4, 50-52	A	G O-1	C						A	C			C	F			
		17-5, 50-52	A	G O-1	C						A	C			C	F			
		17-6, 50-52	A	G O-1	C						A	C			C	C			
		17 CC	A	M O-1	C						A	C			C	C			
		18 CC	C	M O-1	F						A	C			C	C			
		19-1, 50-52	C	M E-1 O-1	F						A	C			C	C			
		19-3, 50-52	C	M E-1 O-1	F						A	C	R		C	F			
		19-4, 50-52	C	M E-1 O-1	F			F			A	F			C	C			
		19-5, 48-50	C	M E-1 O-1	F	R		F			A	C			C	F			

Core, Section, Interval (cm)	*Stephanolithion laffittei*	*Lithastrinus floralis*	*Lithastrinus grillii*	*Cribrosphaera ehrenbergii*	*Prediscosphaera cretacea*	*Prediscosphaera spinosa*	*Cretarhabdus crenulatus*	*Cretarhabdus conicus*	*Cretarhabdus schizobrachiatus*	*Pedorhabdus decorus*	*Dodekapederhabdus noelae*	*Parhabdolithus splendens*	*Parhabdolithus angustus*	*Parhabdolithus* cf. *angustus*	*Parhabdolithus embergeri*	*Eiffellithus turriseiffeli*
9-5, 90-92				C	C		C	F								C
9-6 Top				C	C		C	F		F						C
9 CC				C	C		C	F								C
10-4, 4-6				C	C		C	F								C
10-5, 50-52				C	C	R	C	F								C
10CC				C	A	F	C	F		F						F
11-4, 50-52				C	A	R	C	F								C
11-5, 50-52				C	A	F	C	F								C
11 CC				C	A	F	C	F				F				C
12 CC				C	A	R	C	F		F	R	F				C
13-4, 50-52				C	A	F	C	F			R	F				C
13-5, 50-52				C	A	F	C	F				F				C
13 CC				C	A	F	C	F				F				C
14 CC				C	A	F	C	F				R				C
15-2, 50-52				C	A	R	C	C								C
15-3, 50-52				C	A	F	C	F		F						C
15-4, 50-52				C	A	F	C	C								C
15-5, 50-52				C	A	F	C	C								C
15-6, 50-52				C	C	F	C	C						F	F	C
15 CC				C	A	R	C	C						F	F	C
16-1, 50-52				C	A	R	C	C		F		F		F	F	C
16-3, 90-92				C	A	F	C	C				F		F	F	F
16-4, 50-52				C	A	F	C	C				F		R	F	C
16-5, 50-52				C	C	R	C	C						F	F	C
16-6, 50-52				C	C	R	C	C						F	F	C
16 CC				C	C	R	C	C		R				R	F	C
17-2, 50-52				C	C	F	C	C						F	F	C
17-3, 50-52				C	C	R	C	C						R	F	C
17-4, 50-52				C	C	R	C	C						R	F	C
17-5, 50-52				C	C	F	C	C						F	F	C
17-6, 50-52				C	C	F	C	C		R				F	F	C
17 CC				C	C	F	C	C		F				F	F	C
18 CC				C	A	F	C	C		F		F		F	F	F
19-1, 50-52				C	A	F	C	C						R	F	C
19-3, 50-52				C	A		C	C	F					R	F	F
19-4, 50-52				C	A	F	C	C						R	F	C
19-5, 48-50				C	A	F	C	C		F				F	F	F

Core, Section, Interval (cm)	*Eiffellithus eximius*	*Eiffellithus anceps*	*Eiffellithus trabeculatus*	*Crepidolithus thiersteini*	*Reinhardites anthophorus*	*Zygodiscus spiralis*	*Zygodiscus pseudanthophorus*	*Vagalapilla octaradiata*	*Parhabdolithus regularis*	*Chiastozygus amphipons*	*Chiastozygus litterarius*	*Chiastozygus cuneatus*	*Vagalapilla* cf. *elliptica*	*Vagalapilla imbricata*	*Vagalapilla matalosa*
9-5, 90-92						C	F	F	R	F			C		
9-6 Top						C	F	F	R	F			C		
9 CC						C	F	F	F	F			F		
10-4, 4-6						C	F	F	F	F			F		
10-5, 50-52						C	F	F	F	F	F		F		
10CC						C	F.	R	F	F	F		F		
11-4, 50-52						C	F	R	F	F	R		F		
11-5, 50-52						C	F	R	F.	R	R		F		
11 CC						C	F	R	F	R	R		F		
12 CC						C	F.	R	R	R	F		F		R
13-4, 50-52				F		C	F.	R	R	R	R		F		
13-5, 50-52				F		F	F	F	F	R			F		
13 CC				F		F	F	F	F	R			F		
14 CC						F	F	F	F	R			F		
15-2, 50-52						F	F	F	F	R			F		
15-3, 50-52					R	F	F	F	F	R			F		
15-4, 50-52					F	F	C	R	R	R			C		
15-5, 50-52					F	F	C	R	R	R			F		
15-6, 50-52						F	C	R	R	R			F		
15 CC						F	F	R	R	R			F		
16-1, 50-52						F	F	F	R	R			F		
16-3, 90-92					F	F	F	F	R	R			F		
16-4, 50-52					F	F	F	R	R	R			F		
16-5, 50-52						C	F		R				F		
16-6, 50-52					R	C	F		R	R			F		
16 CC					F	C	F		R				F		
17-2, 50-52					R	C	F		F	R			F		
17-3, 50-52					F	C	F		F				F		
17-4, 50-52					F	C	F		F				F		
17-5, 50-52					R	C	F	F	F	R			R		
17-6, 50-52					R	C	F	R	F	R			R		
17 CC					F	C	F	F	F	F	F		R	R	
18 CC					F	C	F	F	F	F			R	R	
19-1, 50-52					R	F	F		F	R	R		F		
19-3, 50-52		F			F	F	F	F	F	R	F		R	F	
19-4, 50-52				F	F	F	F	F	F	F			R	F	
19-5, 48-50				F	R	F	F	F	F	F			R		R

Core, Section, Interval (cm)	*Glaukolithus diplogrammus*	*Tranolithus orionatus*	*Tranolithus gabalus*	*Microrhabdulus decoratus*	*Microrhabdulus stradneri*	*Microrhabdulus belgicus*	*Lithraphidites carniolensis*	*Lithraphidites quadratus*	*Ceratolithoides kamptneri*	*Micula decussata*	*Tetralithus gothicus*	*Tetralithus trifidus*	*Tetralithus pyramidus*	*Tetralithus aculeus*	*Marthasterites* cf. *inconspicuus*
9-5, 90-92				C	C			R		C					
9-6 Top				C	F			R	R	C					
9 CC				F	F			R		C					
10-4, 4-6				F	F			R		C					
10-5, 50-52				F	F			R		C					
10CC				F	F		F	R		C					
11-4, 50-52				F	F					C					
11-5, 50-52				F	F					C					
11 CC				F	R		F	R		C					
12 CC	F			F	F		C	R		C					
13-4, 50-52	F			F	F		C	R		C					
13-5, 50-52	C			F	R		C	R		C					
13 CC	C			F	R		C	R		C					
14 CC	C			F	F		C	R		C					
15-2, 50-52	C			F	F		C			C					
15-3, 50-52	C			F			C	R		C					
15-4, 50-52	C			F			F			C					
15-5, 50-52	A			F			C			C					
15-6, 50-52	C			F			C			C					
15 CC	C			F			C			C					
16-1, 50-52	C	F		F			C			C	F				
16-3, 90-92	C			F			C			C	F	R			
16-4, 50-52	C			F			C			C	F	R			
16-5, 50-52	C			C			C			C	F	F			
16-6, 50-52	C			C			C			C	F	F			
16 CC	C			C			C			C	F	F			
17-2, 50-52	C			C			C			C	F	F			
17-3, 50-52	C			C			C			C	F	F			
17-4, 50-52	C			C			C			C	F	F			
17-5, 50-52	C	F		C			C			C	F	F			
17-6, 50-52	C			C			C			C	F	F			
17 CC	C			C			C			C	F	F			
18 CC	C			C			C			C	F	F			
19-1, 50-52	C			C			C			C	F	F			
19-3, 50-52	C	F		C			C			C	F	F			
19-4, 50-52	C		F	C			C			C	F	F			
19-5, 48-50	C			C			C			C	F	F			

		19-6, 50-52	C	M E-1 O-1	F			F		F	A	C			C	F							C	C		C	F						F	F	F				F	R	F	F		F	R			R	R		C			C			C			C	F	F	F		
		19 CC	C	M E-1 O-1	F			F			A	C			C	C							C	C	F	C	C		F				F	F	C						F	F		F	F			F	F		C			C			C			C	F	F		F	
		20 CC	C	M E-1 O-1	F			F			A	C			C	F							C	C		C	C		F					F	F						F	F	F	F					F		C			C			C			C	F	F	F		
		21-3 Top	C	M E-1 O-1	F			F			A	C			C	F							C	C	F	C	C		F					F	F		F			F	F	F		F		F					C			F			C			C	F	F			
		21 CC	C	M E-1 O-1	F			F			A	C			F	C							C	C	F	C	F	F						F	F		F		F	F	F	F	F	F	F						C			C			C			C	F	F			
Coniacian to Early Santonian	*G. obliquum* ?	22-2, 50-52	F	M E-1 O-1				F			C	F			F				F		F		F	C		C	F					F		F	C	F	F	F					F		F	F					C	F		F			R			C					
		22-3, 70-72	F	M E-1 O-1				F			C	R						R	F				F	C		C			F			F		R	C	F		F					F			C		F			C	R		F			F			C					
		22 CC	R	P. E-1 O-1				F			C	F											R	C		F			F			F		R	C	F	R	F					R					R			F	R		F			F								
		23-4, 72-74	F	M E-1 O-1							C	C							F				F	C	F	F						F		R	C	F		F	R							F		F			F	F		F			R								
		23-5, 50-52	R	M E-1 O-1				F			C	C							F			F	R	C	F	F			F		F	R		F	C	F		F					F			F					C	F		F			F								
		23 CC	R	M E-1 O-1				F			C	F			F				F		R	F	R	C	R	F			R		C	F		R	C	F		F								F					C	R		F		F	R								
Late Turonian	*Micula decussata*	24-1, 118-120	F	M E-1 O-1							C	F			F				F	F	F	F	F	C		F					F	F		F	C	F		F	F				F		F	C		F			C	F		F			F								
		24 CC	F	M E-1 O-1			R	F			C	F		R	C				F	F	F	R	R	C		F					C	C		F	C	F		F							F	F		F			C	F		F			F				R				
		25-2, 70-72	C	M E-1 O-1			F				C	F			R			R	F	R	F	F	F	C	F	F	F				C	F		F	C	F		F								C		C			C	F		F		R	F								
		25-3, 50-52	F	M E-1 O-1							C	F			F				F	R	F	R	F	C		F					C	F		F	C	F		F								F	R	C			C	R		F			F						R		
		25-4, 70-72	F	M E-1 O-1							C	F			F			R	F		F	R	F	C		F					F	F		R	C	F		F					R			F	R	F			C	R		F			F								
		25-5, 88-90	F	M E-1 O-1							C	F			F				R		F	F	R	C		F					F	F		F	F			R								F	F	F			C	R		R		R	F								
		25-6, 70-72	C	M E-1 O-1							C	F			F				C		F	F	F	C		F					C	C		F	C			R								C		C			C	F		R			C								
		26-1, 120	C	M E-1 O-1							C	C	F		F				F		F		R	C		F					C	C		F	C			C								C		C		F	C	F		F			C								
		26-2, 112-114	C	G E-1 O-1							C	C			C		F		F		C		R	C		C			F		C	C		F	C			C								C		C		C	C	F		F			C								R
		26-3, 112-114	C	M E-1 O-1							C	C			F		F		F	F	F		R	C	F	C					C	C		F	C			F								C				F	C	F		F			C								F
		26 CC		E-2							R																																																					

overgrowth. It has no stratigraphic value because it does not change from the Jurassic to the top of the Maestrichtian.

Watznaueria biporta Bukry

Watznaueria biporta Bukry, 1969, p. 32, pl. 10, figs. 8-10.
Watznaueria cynthae Worsley, 1971, p. 1314, pl. 2, figs. 23-25.

Remarks: Few to rare specimens of this species occur from the Berriasian to the Campanian.

Watznaueria britannica (Stradner) Reinhardt
(Plate 26, Figure 2)

Coccolithus britannicus Stradner, 1963, p. 176, pl. 1, figs. 7, 7a.
Watznaueria britannica (Stradner) Reinhardt, 1964, p. 753, pl. 2, fig. 3, pl. 5, fig. 5.
Ellipsagelosphaera lucasi Noel, 1965, p. 126, pl. 11, figs. 1-6, text-figs. 41-42.

Remarks: This species seems to disappear in the Valanginian in the samples studied. Thierstein (in press) reports younger occurrences from the south of France and the Blake Plateau (W. Atlantic).

Watznaueria communis Reinhardt

Watznaueria communis Reinhardt, 1964, p. 756, pl. 2, fig. 5.

Remarks: This species was found only in the Lower Cretaceous (Berriasian through Hauterivian). Its large central opening makes it conspicuous in the light microscope also.

Genus BISCUTUM Black, *in* Black and Barnes, 1959

Biscutum melaniae (Gorka) Reinhardt

Tremalithus melaniae Gorka, 1957, p. 245, 270, pl. fig. 12.
Discolithus constans Gorka, 1957, p. 257, 279, pl. 4, fig. 4.
Biscutum testudinarum Black, *in* Black and Barnes, 1959, p. 325, pl. 10, fig. 1.
Biscutum castorum Black, *in* Black and Barnes, 1959, p. 3, pl. 10, fig. 2.
Coccolithus oregus Stover, 1966, p. 139, pl. 1, figs. 8, 9, pl. 8, fig. 4.
Biscutum blacki Gartner, 1968, p. 18, pl. 1, fig. 7, pl. 6, fig. 2, pl. 8, figs. 8-10, pl. 11, fig. 8, pl. 15, fig. 2, pl. 16, fig. 8.
Biscutum melaniae (Gorka) Reinhardt, 1969, p. 936, pl. 1, fig. 5.

Remarks: More complete synonymy lists for this species are given *in* Reinhardt (1970a) and Noel (1970).

This species is common from the Turorian throughout the Maestrichtian.

Biscutum supracretaceum (Reinhardt) Perch-Nielsen

Coccolithites supracretaceus Reinhardt, 1965 p. 40, pl. 2, figs. 7-8.
Biscutum supracretaceum (Reinhardt) Perch-Nielsen, 1968, p. 80, pl. 23, figs. 9-12.

Remarks: This species closely resembles *Watznaueria bayacki* Worsley, which might be strongly overgrown *Biscutum supracretaceum.*

Biscutum supracretaceum becomes unrecognizable in recrystallized samples. It occurs in small numbers from the Albian to the Maestrichtian.

Genus CYCLAGELOSPHAERA Noel, 1965

Cyclagelosphaera margareli Noel
(Plate 26, Figure 3)

Cyclagelosphaera margareli Noel, 1965, p. 130, text-figs. 44-46, pl. 17, figs. 4-9, pl. 18, figs. 1, 2, pl. 20, figs. 2-4.

Remarks: This species is one of the more important constituents of Lower Cretaceous assemblages. It is resistant to recrystallization. It disappears in the lowermost Albian.

Cyclagelosphaera deflandrei n. comb.
(Plate 26, Figure 7)

Coccolithus deflandrei Manivit, 1966, p. 268, fig. 1a-c.

Remarks: *Cyclagelosphaera deflandrei* differs from *Markalius circumradiatus* in being much thicker and showing higher birefringence. Under crossed nicols *Markalius circumradiatus* looks gray with an indistinct dark cross whereas *Cyclagelosphaera deflandrei* shows a distinctive black cross on a bright yellowish white background. *Cyclagelosphaera deflandrei* has its first occurrence in the Berriasian and ranges up to the top of the Hauterivian.

Genus MARKALIUS Bramlette and Martini, 1964

Markalius circumradiatus (Stover) Perch-Nielsen
(Plate 27, Figure 5)

Coccolithites circumradiatus Stover, 1966, p. 138, pl. 5, figs. 2-4, pl. 9, fig. 10.
Markalius circumradiatus (Stover) Perch-Nielsen, 1968, p. 73, text-figs. 36, 37, pl. 25, figs. 2-7, pl. 26, figs. 1-7; Thierstein, 1971, p. 479, pl. 4, figs. 1-5.

Remarks: This species occurs from the Hauterivian through the Turonian; it is always quite rare and of little stratigraphic importance.

Genus MANIVITELLA Thierstein, 1971

Manivitella pemmatoidea (Deflandre) Thierstein

Cricolithus pemmatoideus Deflandre, *in* Manivit, 1965, p. 192, pl. 2, fig. 8.
Cyclococcolithus gronosus Stover, 1966, p. 140, pl. 1, figs. 1-3, pl. 8, fig. 1.
Apertapetra gronosa (Stover) Bukry, 1969, p. 26, pl. 6, figs. 6-9.
Manivitella pemmatoidea (Deflandre) Thierstein, 1971, p. 480, pl. 3, figs. 11-15.

Remarks: This species is fairly resistant to overgrowth. It is present from the Barremian through the Maestrichtian. There is quite a variability of forms, some with wider shields, some with narrower ones.

Genus TUBODISCUS Thierstein, 1973

Tubodiscus jurapelagicus n. comb.
(Plate 26, Figures 1, 6)

Watznaueria jurapelagica Worsley, 1971, p. 1315, pl. 2, figs. 29-31.

Remarks: *Tubodiscus jurapelagicus* is very similar to *Tubodiscus verenae* but has a lower central collar. This species is typical for the upper Valanginian to Hauterivian. The type level which Worsley (1971) assigned to the Upper Jurassic belongs to the late Valanginian according to Thierstein (1971).

Genus DIAZOMATOLITHUS Noel, 1965

Diazomatolithus lehmani Noel, 1965
(Plate 25, Figures 4, 6)

Diazomatolithus lehmani Noel, 1965, p. 96, text-figs. 25-27, pl. 6, figs. 6-10; Thierstein, 1971, p. 479, pl. 3, figs. 11-15.

Remarks: This species is very resistant to diagenesis and a common constituent of the Lower Cretaceous assemblages from the Berriasian through the Barremian.

Family PODORHABDACEAE Noel, 1965

Genus PODORHABDUS Noel, 1965

Podorhabdus dietzmannii (Reinhardt) Reinhardt

Ahmuellerella dietzmanni Reinhardt, 1965, p. 30, text-fig. 1, pl. 1, fig. 1.
Podorhabdus dietzmanni (Reinhardt) Reinhardt, 1967, p. 169, fig. 4; Thierstein, 1971, p. 478, pl. 8, figs. 1-8.

Remarks: This species was found in small numbers in Cenomanian to Santonian sediments at Site 170. Apparently it becomes unrecognizable if strongly overgrown because it was not seen in the Cretaceous chalks and limestones of Site 167.

Podorhabdus decorus (Deflandre) Thierstein

Rhadbolithus decorus Deflandre, *in* Deflandre and Fert, 1954, p. 159, pl. 13, figs. 4-6, text-fig. 87.
Ahmuellerella ? granulata Reinhardt, 1965, p. 39, pl. 1, fig. 4.
Podorhabdus decorus (Deflandre) Thierstein, *in* Roth and Thierstein, 1972, p. 437-438, pl. 4, figs. 7, 9, 10-13.

Remarks: This species occurs from the Cenomanian to the Maestrichtian in the central Pacific but it is always quite rare.

Podorhabdus orbiculofenestrus (Gartner) Thierstein

Prediscosphaera orbiculofenestra Gartner, 1968, p. 21, pl. 25, figs. 23-25, pl. 26, fig. 8.
Podorhabdus orbiculofenestrus (Gartner) Thierstein, 1971, p. 478, pl. 7, figs. 9-17.

Remarks: As pointed out by Thierstein (1971), this species is distinguished from the very similar species *Podorhabdus dietzmannii* by its bright central cross-bar structure when viewed under crossed nicols. *Podorhabdus orbiculofenestrus* was found only in Cenomanian at Site 169.

Podorhabdus coronadventis (Reinhardt) Reinhardt

Cretarhabdus coronadventis Reinhardt, 1966, p. 26, pl. 23, figs. 29, 30.
Cretarhabdus unicornis Stover, 1966, p. 140, pl. 5, figs. 6, 15, pl. 9, fig. 15; Bukry, 1969, p. 36, pl. 15, figs. 7-9.
Podorhabdus coronadventis (Reinhardt) Reinhardt, 1970, p. 86.

Remarks: This species is obviously susceptible to secondary overgrowth. It is rare in the central Pacific and was observed only in the Cenomanian at Site 169.

Genus DODEKAPODORHABDUS Perch-Nielsen, 1968

Dodekapodorhabdus noelae Perch-Nielsen

Dodekapodorhabdus noelii Perch-Nielsen, 1968, p. 47, pl. 8, figs. 1-5, pl. 9, figs. 1-3.
Dodekapodorhabdus noelae Perch-Nielsen, Noel, 1970, p. 61-63, pl. 12, figs. 1-3.

Remarks: This species occurs in the lower and middle Maestrichtian at Sites 167 and 171 but it is always rare.

Genus CRETARHABDUS Bramlette and Martini, 1964

Cretarhabdus loriei Gartner

Cretarhabdus loriei Gartner, 1968, p. 21, pl. 24, figs. 9, 10.

Remarks: Only a few specimens were observed in the upper Albian and the Cenomanian of Sites 169 and 170.

Cretarhabdus conicus Bramlette and Martini

Cretarhabdus conicus Bramlette and Martini, 1964, p. 299, pl. 3, figs. 5-8; Noel, 1970, p. 58-59, pl. 17, figs. 2, 4, text-fig. 14.

Remarks: This species is used as defined originally by Bramlette and Martini (1964) for coccoliths with a distinctive cross in a large central area. Typical specimens occur in the Campanian to Maestrichtian somewhat smaller forms with less well developed cross in the central area are found in sediments as old as late Barremian.

Cretarhabdus crenulatus Bramlette and Martini
(Plate 19, Figure 6)

Cretarhabdus crenulatus Bramlette and Martini, 1964, p. 300, pl. 2, figs. 21-24.
Coccolithus actinosus Stover, 1966, p. 138, pl. 1, figs. 15, 16, pl. 8, fig. 7.
Cretarhabdus surirellus (Deflandre and Fert) Reinhardt, 1970b, p. 50, pl. 1, figs. 6-8, pl. 2, figs. 1-6.

Remarks: Due to strong overgrowth in some of the samples and because of the limited stratigraphic usefulness of this species, no attempt was made to distinguish forms with eight struts from specimens with more than eight struts. The type specimen seems to have more than eight struts although it is difficult to make counts on the light micrographs provided. The lowest occurrence of this species lies in the Berriasian.

Below the first occurrence of typical *Cretarhabdus crenulatus* a form with smaller central area was found. It is here assigned to *Cretarhabdus* sp. cf. *C. crenulatus.*

Cretarhabdus schizobrachiatus (Gartner) Bukry

Vekshinella schizobrachiata Gartner, 1968, p. 31, pl. 13, figs. 10, 11, pl. 20, fig. 5.

Cretarhabdus schizobrachiatus (Gartner) Bukry, 1969, p. 36, pl. 15, figs. 4-6.

Remarks: Fairly large specimens with well-developed cross structure occur in the upper Campanian at Sites 167 and 171.

Genus PREDISCOSPHAERA Vekshina, 1959

Prediscosphaera cretacea (Arkhangelsky) Gartner
(Plate 21, Figures 4, 5)

Coccolithophora cretacea Arkhangelsky, 1912, p. 410, pl. 6, fig. 12, ? fig. 13.
Rhabdolithus intercisus Deflandre, *in* Deflandre and Fert, 1954, p. 159, pl. 13, figs. 12, 13, text-figs. 91, 92.
Prediscosphaera decorata Vekshina, 1959, p. 73, pl. 1, figs. 8, 9, pl. 2, fig. 13.
Prediscosphaera cretacea Gartner, 1968, p. 19, pl. 2, figs. 10-14, pl. 3, fig. 8. pl. 4, figs. 19-24, pl. 6, figs. 14, 15, pl. 9, figs. 1-4, pl. 12, fig. 1, pl. 14, figs. 20-22, pl. 18, fig. 8, pl. 22, figs. 1-3, pl. 23, figs. 4-6, pl. 25, figs. 12-14, pl. 26, fig. 2.

Remarks: The lowest occurrence of this species lies in the lowermost part of the Albian. Secondary overgrowth in the limestones at Site 167 makes it quite difficult to recognize this species.

Prediscosphaera spinosa (Bramlette and Martini) Gartner

Deflandrius spinosus Bramlette and Martini, 1964, p. 301, pl. 2, figs. 17-20.
Prediscosphaera spinosa (Bramlette and Martini), Gartner, 1968, p. 20, pl. 2, figs. 15, 16, pl. 3, figs. 9, 10, pl. 5, figs. 7-9, pl. 6, fig. 16, pl. 11, fig. 17.

Remarks: This species was observed only from the Campanian through the Maestrichtian. Stratigraphically older occurrences are known from the Atlantic (Cenomanian, see Roth and Thierstein, 1972) and from southern France (Thierstein, 1971).

Genus CRIBROSPHAERA Arkhangelsky, 1912

Cribrosphaera ehrenbergii Arkhangelsky
(Plate 20, Figure 3)

Cribrosphaera ehrenbergii Arkhangelsky, 1912, p. 412, pl. 6, figs. 19, 20.

Remarks: Noel (1970) gives a complete synonymy for this species. In the central Pacific this species occurs from the Turonian through the Maestrichtian. A single specimen was found in the upper Albian at Site 167.

Genus CRUCIELLIPSIS Thierstein, 1971

Cruciellipsis cuvillieri (Manivit) Thierstein
(Plate 25, Figure 1)

Coccolithus cuvillieri Manivit, 1966, p. 268, figs. 2, 3.
Cruciellipsis cuvillieri (Manivit) Thierstein, 1971, p. 478, pl. 5, figs. 4-8.

Remarks: This species is an excellent marker for the lower part of the Lower Cretaceous, i.e., Berriasian to the top of the Hauterivian. It is resistant to secondary overgrowth and can still be recognized in fairly strongly recrystallized carbonates. A small form with a less distinctive cross occurring below the base of typical *Cruciellipsis cuvillieri* is referred to as *Cruciellipsis* sp. cf. *C. cuvillieri*.

Cruciellipsis chiasta (Worsley) Thierstein

Helenea chiasta Worsley, 1971, p. 1310, pl. 1, figs. 42-44.
Cruciellipsis chiasta (Worsley) Thierstein *in* Roth and Thierstein, 1972, p. 437, pl. 6, figs. 8-13.

Remarks: It is difficult to identify this species in samples which have undergone strong recrystallization. This is probably the reason for its discontinuous range at Site 167 where it occurs from the Berriasian to the Albian.

Genus CALCICALATHINA Thierstein, 1971

Calcicalathina oblogata (Worsley) Thierstein

Schizosphaerella oblongata Worsley, 1971, p. 1312, pl. 2, figs. 32, 33.
Calcicalathina oblongata (Worsley) Thierstein 1971, p. 475, pl. 4, figs. 6-10.

Remarks: This species was found only in one sample. It is easily destroyed by diagenesis and therefore, cannot be used as a marker in sections where the rocks have undergone considerable diagenetic alteration.

Genus CREPIDOLITHUS Noel, 1965

Crepidolithus thiersteini n. sp.
(Plate 21, Figure 1, Plate 22, Figures 5, 6)

Description: Elliptic discolith with a rim consisting of about 40 steeply inclined laths and a rim cycle of about the same number of elements surrounding a central area composed of irregular interlocking crystals. The diameter of the central area is roughly half of the total diameter of the discoliths. Under crossed nicols the central area displays an irregular pattern of dark and light crystals indicating random orientation.

Remarks: This species is similar to *Rhagodiscus asper* (Stradner) but it has a much wider margin with elements visible even in the light microscope and a coarser structure of the central area.

Size: 10μ.

Distribution: Turonian (?)-Campanian-Maestrichtian.

Holotype: Plate 22, Figure 6 (USNM 188126).

Sample: 167-55-1, 93 cm. *Eiffellithus eximius* Zone.

Genus REINHARDITES Perch-Nielsen, 1968

Reinhardites anthophorus (Deflandre) Perch-Nielsen, 1968
(Plate 22, Figures 4a-c.)

Rhabdolithus anthophorus Deflandre, 1959, p. 137, pl. 1, figs. 21, 22.
Cretarhabdus ? anthophorus (Deflandre) Bramlette and Martini, 1964, p. 299, pl. 3, figs. 1-4.
Discolithus cryptochondrus Stover, 1966, pl. 2, figs. 8, 9, pl. 8, fig. 13.
Reinhardites anthophorus (Deflandre) Perch-Nielsen, 1968, p. 38-40, pl. 5, figs. 1-8, text-figs. 13, 14.

Remarks: The specimens observed in sediment from the central Pacific compare well with the holotype and the description and illustrations in Bramlette and Martini (1964). In general, specimens in open-ocean assemblages tend to be smaller than the ones from near-shore deposits.

Distribution: Campanian-early Maestrichtian.

Reinhardites cf. R. mirabilis Perch-Nielsen
(Plate 22, Figure 2a-d)

Reinhardites mirabilis Perch-Nielsen, 1968, p. 40-41, pl. 7, fig. 1, text-fig. 15.

Remarks: *Reinhardites mirabilis* has been illustrated in the electron microscope only. The specimens referred to this species are rather low discoliths with a somewhat raised granular central area. They show some indication of parabolic extinction figures under crossed nicols.

Range: Campanian.

Genus PARHABDOLITHUS Deflandre in Grassé, 1952

Parhabdolithus angustus (Stradner) Stradner, Adamiker and Maresch
(Plate 24, Figure 4a-d)

Rhabdolithus angustus Stradner, 1963, p. 178, pl. 5, figs. 6, 6a.
Parhabdolithus elongatus Stover, 1966, p. 144, pl. 6, figs. 16-19, pl. 9, fig. 18.
Parhabdolithus angustus (Stradner) Stradner, Adamiker and Maresch, 1968, p. 32, pl. 20, figs. 1-5.

Remarks: This species is fairly resistant to recrystallization and its lowest occurrence at the boundary between the lower and the upper Aptian is stratigraphically very useful.

Parhabdolithus sp. cf. P. angustus (Stradner)
(Plate 18, Figure 5)

Remarks: In the Campanian and Maestrichtian, specimens very similar to *P. angustus* but somewhat less elongated occur quite commonly. Typical *P. angustus* are restricted to the upper part of the Lower Cretaceous and the lower part of the Upper Cretaceous.

Parhabdolithus embergeri (Noel) Stradner
(Plate 25, Figure 2)

Discolithus embergeri Noel, 1959, p. 164, pl. 1, figs. 5-8.
Parhabdolithus embergeri (Noel) Stradner, 1963, p. 13, pl. 4, figs. 1, 1b.
Remarks: This species is very resistant to recrystallization and solution and occurs throughout the Cretaceous.

Parhabdolithus regularis (Gorka) Bukry

Tremalithus regularis Gorka, 1957, p. 246, pl. 2, fig. 4.
Rhabdolithus regularis (Gorka) Stradner, 1963, p. 180, pl. 5, figs. 5, 5a.
Actinozygus regularis (Gorka) Gartner, 1968, p. 23, pl. 3, fig. 12a-d, pl. 5, figs. 17, 18, pl. 6, fig. 17a-c, 18a-c, pl. 12, fig. 11a-c.
Parhabdolithus regularis (Gorka) Bukry, 1969, p. 53, pl. 30, figs. 8-10.
Remarks: This species is similar to *Vagalapilla octoradiata.* It has eight regularly spaced bars instead of four axially oriented bifurcating bars. It occurs in small numbers in the Campanian through Maestrichtian.

Parhabdolithus splendens (Deflandre), Noel

Rhabdolithus splendens Deflandre, 1953, p. 158, pl. 13, figs. 1-3, text-figs. 88, 89.
Parhabdolithus granulatus Stover, 1966, p. 144, pl. 6, figs. 11-15.
Parhabdolithus splendens (Deflandre) Noel, 1969, p. 476, pl. 1, figs. 1, 4.
Remarks: This species has a very long range; it was observed from the Hauterivian through the Maestrichtian. It seems to be fairly resistant to recrystallization and overgrowth.

Genus RHAGODISCUS Reinhardt, 1967

Rhagodiscus asper

Discolithus asper Stradner, 1963, p. 161, pl. 2, figs. 4, 4a, 5, 5a.
Discolithus vagus Stover, 1966, p. 144, pl. 3, figs. 10, 11, pl. 8, fig. 20.
Rhagodiscus asper (Stradner) Reinhardt, 1966, p. 161.
Remarks: This long-ranging species ranges from the Berriasian to the Albian. It is moderately resistant to recrystallization.

Family STEPHANOLITHIONACEAE Black, 1968

Genus COROLLITHION Stradner, 1961

Corollithion signum Stradner

Corollithion signum Stradner, 1963, p. 11, pl. 1, figs. 13, 13a.
Remarks: This species occurs in small numbers in the Turonian to Coniacian. Secondary overgrowths lead to a thickening of the crossbars.

Corollithion exiguum Stradner

Corollithion exiguum Stradner, 1961, p. 83, text-figs. 58-61.
Remarks: This small hexagonal coccolith is rare in the Turonian to Santonian at Sites 167 and 171.

Genus CYLINDRALITHUS Bramlette and Martini, 1964

Cylindralithus coronatus Bukry

Cylindralithus coronatus Bukry, 1969, p. 42, pl. 20, figs. 4-6.
Remarks: This small coccolith with a high wall occurs rarely in the Turonian at Site 171 (Horizon Guyot).

Cylindralithus gallicus (Stradner) Bramlette and Martini

Coccolithus gallicus Stradner, 1963, p. 10, pl. 1, figs. 8, 8a.
Cylindralithus gallicus (Stradner) Bramlette and Martini, 1964, p. 308, pl. 5, figs. 15-17.
Remarks: This species is restricted to the middle to upper Maestrichtian.

Cylindralithus serratus Bramlette and Martini

Cylindralithus serratus Bramlette and Martini, 1964, p. 310, pl. 5, figs. 18-20.
Remarks: This species is common from the Campanian through the Maestrichtian. Few specimens were observed in the upper Turonian at Site 170.

Genus STEPHANOLITHION Deflandre, 1939

Stephanolithion laffittei Noel

Stephanolion laffittei Noel, 1957, p. 318, pl. 2, fig. 5; Bramlette and Martini, 1964, p. 230, pl. 6, figs. 12-15.
Remarks: This species occurs rarely in the Lower Cretaceous. It is probably easily destroyed by recrystallization.

Genus LITHASTRINUS Stradner, 1962

Lithastrinus grilli Stradner

Lithastrinus grilli Stradner, 1962, p. 369, pl. 2, figs. 1-5.
Remarks: Slightly overgrown specimens occur in the Turonian to Coniacian at Site 171 (Horizon Guyot).

Lithastrinus floralis Stradner

Lithastrinus floralis Stradner, 1962, p. 370, pl. 2, figs. 6-11.
Polycyclolithus brotzeni Forchheimer, 1968, p. 41, pl. 6, figs. 6, 7.
Remarks: The first occurrence of this robust and easily recognizable species at the base of the upper Aptian is stratigraphically useful. *Lithastrinus floralis* was found from the upper Aptian through the Santonian.

Genus DISCORHABDUS Noel, 1965

Discorhabdus biradiatus (Worsley) Thierstein
(Plate 24, Figure 2)

Rucinolithus? biradiatus Worsley, 1971, p. 1311, pl. 1, figs. 51, 52.
Bidiscus canthus Wilcoxon, 1972, pp. 430-431, pl. 6, figs. 5, 6.
Discorhabdus biradiatus (Worsley) Thierstein, 1973, p. 42, pl. 6, figs. 7-11.
Remarks: Most specimens observed are somewhat recrystallized but they are easily recognized by their extinction pattern of alternating dark and light elements. The species ranges from the Hauterivian to the Albian.

Family EIFFELLITHACEAE Reinhardt, 1965

Genus EIFFELLITHUS Reinhardt, 1965

Eiffellithus anceps (Gorka) Reinhardt and Gorka
(Plate 18, Figures 2, 4; Plate 19, Figure 4)

Discolithus anceps Gorka, 1957, p. 252, pl. 3, fig. 4.
?Discolithus fessus Stover, 1966, p. 142-143, pl. 2, figs. 17-21.
Eiffellithus anceps (Gorka) Reinhardt and Gorka, 1967, p. 241, pl. 31, figs. 15, 16.
Helicolithus anceps (Gorka) Noel, 1970, pp. 41-43, pl. 8, figs. 1-5, pl. 9, figs. 1-2, text-fig. 6.
Remarks: This species has a very characteristic extinction pattern. At 45° to the polarizer, all four elements of the inner cycle light up, at 0° to the polarizer only two elements in opposite quadrants are bright, the other two are extinct. There is a small cross-shaped structure in the center.
This species ranges from the Campanian to the Maestrichtian.

Eiffellithus eximius (Stover) Perch-Nielsen
(Plate 18, Figure 1)

Clinorhabdus eximius Stover, 1966, p. 138, pl. 2, figs. 15, 16, pl. 8, fig. 15.

Eiffellithus eximius (Stover) Perch-Nielsen, 1968, p. 30, pl. 3, figs. 8-10.
Eiffellithus augustus Bukry, 1969, p. 51-52, pl. 28, figs. 10-12, pl. 29, fig. 1.
Remarks: This species has a central cross with arms in the axes of the ellipse. It occurs from the Santonian through the middle Campanian.

Eiffellithus trabeculatus (Gorka) Reinhardt and Gorka

Discolithus trabeculatus Gorka, 1957, p. 255, pl. 3, fig. 9.
Discolithus disgregatus Stover 1966, p. 142, pl. 2, figs. 11, 12, pl. 8, fig. 12.
Eiffellithus trabeculatus (Gorka) Reinhardt and Gorka, 1967, p. 241, pl. 31, figs. 19, 23, pl. 32, fig. 1, text-fig. 5.
Remarks: This species occurs in small numbers in the Cenomanian to Santonian of sediments from the central Pacific. Its total range is from the Albian to the Maestrichtian.

Eiffellithus turriseiffeli (Deflandre) Reinhardt

Zygolithus turriseiffeli Deflandre, in Deflandre and Fert, 1954, p. 149, pl. 13, figs. 15, 16.
Eiffellithus turriseiffeli turriseiffeli (Deflandre) Reinhardt, 1965, p. 36.
Remarks: The first occurrence of this easily recognizable species at the base of the upper Albian is stratigraphically important. The species ranges through the Maestrichtian.

Genus VAGALAPILLA Bukry, 1969

Vagalapilla sp. cf. V. elliptica (Gartner) Bukry

Vekshinella elliptica Gartner, 1968, p. 17, pl. 17, fig. 5a-d, pl. 25, figs. 26, 27, pl. 26, fig. 7a-d.
Vagalapilla elliptica (Gartner) Bukry, 1969, p. 57, pl. 32, figs. 9-12.
Remarks: Small coccoliths with a cross lying in the axes of the ellipse with a perforation in the center of the cross were tentatively assigned to this species. They occur from the Turonian to the Maestrichtian sediments Horizon Guyot (Site 171).

Vagalapilla imbricata (Gartner) Bukry

Vekshinella imbricata Gartner, 1968, p. 30, pl. 9, figs. 16, 17, pl. 13, figs. 8, 9.
Vagalapilla imbricata (Gartner) Bukry, 1969, pp. 57-58, pl. 33, figs. 1, 2.
Remarks: These small coccoliths with a central cross which lacks a perforation in the center occur in the Campanian at Sites 167 and 171.

Vagalapilla matalosa (Stover) Thierstein

Coccolithus matalosus Stover, 1966, p. 139, pl. 1, figs. 12-14, pl. 8, fig. 10.
Staurolithites matalosus (Stover) Cepek and Hay, 1969, p. 326.
Vagalapilla matalosa (Stover) Thierstein, 1973, p. 138, pl. 3, figs. 15-18.
Remarks: In the light microscope this species is difficult to distinguish from *Broinsonia signata* and *Broinsonia dentata.* It occurs rarely from the Albian to the Turonian.

Vagalapilla octoradiata (Gorka) Bukry

Discolithus octoradiata Gorka, 1957, p. 259, pl. 4, fig. 10.
Ahmuellerella octoradiata (Gorka) Reinhardt, 1966, p. 24, pl. 22, figs. 3, 4.
Vagalapilla octoradiata (Gorka) Bukry, 1969, p. 58, pl. 33, figs. 5-7.
Remarks: This small species with diverging cross-bars occurs from the Turonian to the Maestrichtian.

Genus CHIASTOZYGUS Gartner, 1968

Chiastozygus amphipons (Bramlette and Martini) Gartner

Zygodiscus amphipons Bramlette and Martini, 1964, p. 302, pl. 4, figs. 9, 10.
Chiastozygus amphipons (Bramlette and Martini) Gartner, 1968, p. 26, pl. 8, figs. 11-14, pl. 22, figs. 10, 11.
Remarks: This species has narrow and straight cross-bars which intersect the axis of the ellipse at 45°. It ranges from the Coniacian through the Maestrichtian.

Chiastozygus cuneatus (Lyul'eva) Čepek and Hay

Zygolithus cuneatus Lyul'eva, 1967, p. 94, pl. 1, fig. 13.
Chiastozygus cuneatus (Lyul'eva) Čepek and Hay, 1969, p. 325, fig. 2 (7).
Remarks: This species is characterized by an asymmetrical cross. It is possible that *Chiastozygus cuneatus* is identical with *Eiffellithus trabeculatus* (see Roth and Thierstein, 1972, pl. 12). In the central Pacific, *Chiastozygus cuneatus* occurs in small numbers in the Turonion (Site 171).

Chiastozygus sp. cf. C. garrisonii Bukry

Chiastozygus garrisoni Bukry, 1969, p. 49-50, pl. 27, figs. 5, 6.
Remarks: The X-shaped cross-structure and the rim are very slender. There are two large and two small perforations. Species tentatively assigned to this specie were found in the Hauterivian to Aptian at Site 166.

Chiastozygus litterarius (Gorka) Manivit

Discolithus litterarius Gorka, 1957, p. 274, pl. 3, fig. 3.
Chiastozygus litterarius (Gorka) Manivit, 1971, p. 90, pl. 4, figs. 1-5.
Remarks: This species was used in a broad sense and it includes *Tegumentum stradneri* Thierstein. Because of its fairly delicate structure, it is easily destroyed by secondary overgrowth and cannot be used to mark the base of the Aptian. It was found from the Turonian to the Campanian.

Genus GLAUKOLITHUS Reinhardt, 1964

Glaukolithus diplogrammus (Deflandre) Reinhardt

Zygolithus diplogrammus Deflandre, in Deflandre and Fert, 1954, p. 148, pl. 10, fig. 7, text-fig. 57.
Glaukolithus diplogrammus (Deflandre) Reinhardt, 1964, p. 40, text-fig. 15a-b.
Remarks: This species with a double bridge is quite variable. It occurs from the Albian through the Maestrichtian. Since it ranges down to the top of the Berriasian in southern France it is probably recrystallized beyond recognition in sediments older than Albian from the Magellan Rise.

Genus ZYGODISCUS Bramlette and Sullivan, 1961

Zygodiscus bonsonnii (Noel) Manivit

Zygolithus boussoni Noel, 1965, p. 321, pl. 2, figs. 13, 14.
Zygodiscus boussoni (Noel) Manivit, 1971, p. 78, pl. 29, figs. 4, 15, 16, pl. 13, fig. 1.
Remarks: This species with a slender single bridge occurs rarely in the Valanginian at Site 167. It is not resistant to diagenetic alterations and its range must have been much longer before it was destroyed by recrystallization.

Zygodiscus compactus Bukry
(Plate 20, Figure 6)

Zygodiscus compactus Bukry, 1969, p. 59, pl. 34, figs. 1, 2.
Remarks: This broad-rimmed species was only observed in the scanning electron microscope.

Zygodiscus pseudanthophorus Bramlette and Martini

Zygodiscus ? pseudanthophorus Bramlette and Martini, 1964, p. 303, pl. 3, fig. 17, pl. 4, figs. 17, 18.
Remarks: This robust species with a single cross-bar occurs in small numbers from the Campanian through the Maestrichtian.

Zygodiscus spiralis Bramlette and Martini

Zygodiscus spiralis Bramlette and Martini, 1964, p. 303, pl. 4, figs. 6-8.
Remarks: This species with its characteristic spiral bridge under crossed nicols was found in Campanian through Maestrichtian sediments in the central Pacific.

Zygodiscus sp. cf. Z. salillum (Noel) Wilcoxon

Discolithus salillum Noel, 1965, p. 72-74, pl. 1, figs. 8-12, text-figs. 5-6.
Zygodiscus salillum (Noel) Wilcoxon, 1972, p. 431, pl. 2, figs. 6, 7.
Remarks: This small species of Zygodiscus has a fairly wide bridge with a central knob. It occurs only in the Hauterivian-Aptian at Site 166.

Genus TRANOLITHUS Stover, 1966

Tranolithus gabalus Stover

Tranolithus gabalus Stover, 1966, p. 146, pl. 4, fig. 22, pl. 9, fig. 5.
Remarks: This species with a wide central bridge occurs in the Campanian at Site 171.

Tranolithus orionatus (Reinhardt) Reinhardt

Discolithus orionatus Reinhardt, 1966, pl. 42, pl. 23, figs. 22, 31, 33.
Tranolithus phacelosus Stover, 1966, p. 146, pl. 4, figs. 23-25.
Tranolithus orionatus (Reinhardt) Reinhardt, 1966, p. 522.
Remarks: The central area is almost completely filled by a double bridge. This species is found from the Cenomanian through the Maestrichtian.

Incertae sedis

Genus RUCINOLITHUS Stover, 1966

Rucinolithus irregularis Thierstein

Rucinolithus irregularis Thierstein *in* Roth and Thierstein, 1972, p. 438, pl. 2, figs. 10-19; Thierstein, 1973, p. 45, pl. 3, figs. 1-14.
Remarks: This species of *Rucinolithus* with 6 to 11 dextrally imbricate elements and a short central process occurs from the Barremian to the Albian. Forms similar to it were also found in the Campanian.

Rucinolithus sp. cf. R. hayi Stover

Rucinolithus hayi Stover, 1966, p. 156-157, pl. 7, fig. 21, pl. 9, fig. 22.
Remarks: This species has a more star-shaped outline than *Rucinolithus irregularis* and a usually perforated center. It occurs from the Santonian through the Campanian at Site 167.

Rucinolithus sp. cf. R. wisei Thierstein

Rucinolithus wisei Thierstein, 1971, p. 482, pl. 4, figs. 11-15.
Remarks: This species has six sinistrally imbricate elements of asymmetrical lanceolate shape. It is restricted to the Berriasian and Valanginian at Site 167.

Genus TETRALITHUS Gardet, 1955

Tetralithus aculeus (Stradner) Gartner
(Plate 18, Figure 3, Plate 20, Figure 2)

Zygrhablithus aculeus Stradner, 1961, p. 81, figs. 53-57.
Tetralithus sp. aff. *Tetralithus aculeus* (Stradner) Gartner, 1968, p. 43, pl. 9, fig. 5, pl. 13, fig. 5a-c.
Remarks: This arrowhead-shaped species ranges throughout the Campanian and can be used as a reliable marker for that stage.

Tetralithus gothicus Deflandre

Tetralithus gothicus Deflandre, 1959, p. 138, pl. 3, fig. 25.
Remarks: Forms with short arms seem to be more abundant in open-ocean sediments than long-rayed forms. This species occurs from the upper Campanian through the lower Maestrichtian.

Tetralithus malticus Worsley
(Plate 27, Figure 4)

Tetralithus malticus Worsley, 1971, p. 1313, pl. 2, figs. 9-11.
Remarks: This small species of *Tetralithus* usually has slightly curved suture lines. It seems to be most abundant in the Barremian and ranges from the Valanginian to the Albian.

Tetralithus obscurus Deflandre

Tetralithus obscurus Deflandre, 1959, p. 138, pl. 3, figs. 26-29.
Remarks: This elliptical species of *Tetralithus* with two small and two large segments is rare in the Campanian at Site 167 and in the Maestrichtian at Site 169.

Tetralithus ovalis Stradner

Tetralithus ovalis Stradner, 1963, p. 12, pl. 6, fig. 7.
Remarks: This species of *Tetralithus* is elliptical in shape and composed of four segments of roughly equal size. It occurs rarely in the Maestrichtian at Site 165A.

Tetralithus pyramidus Gardet

Tetralithus pyramidus Gardet, 1955, p. 521, pl. 7, fig. 66.
Remarks: This species of *Tetralithus* with short rays occurs in the Campanian to early Maestrichtian in the central Pacific.

Tetralithus trifidus (Stradner) Bukry
(Plate 18, Figures 6, 7)

Tetralithus gothicus trifidus Stradner, *in* Stradner and Papp, 1961, p. 124, fig. 23 (3a-3b).
Tetralithus trifidus (Stradner) Bukry, 1973, p. 680.
Remarks: The short-rayed form is more common in open-ocean sediments. It ranges from the upper Campanian through the lower Maestrichtian.

Genus MARTHASTERITES Deflandre, 1959

Marthasterites furcatus (Deflandre) Deflandre

Discoaster (?) furcatus Deflandre in Deflandre and Fert, 1954, pl. 13, fig. 14.
Marthasterites furcatus (Deflandre) Deflandre, 1959, p. 139, pl. 2, figs. 3-12, pl. 3, figs. 1, 5.
Remarks: Most of the specimens are strongly overgrown and resemble *Marthasterites furcatus* var. *crassus* which is considered an overgrowth stage of the typical form. This species is a good marker for Coniacian to Santonian and it is abundant in open-ocean sediments as well as in near-shore deposits. It was found at Site 167.

Marthasterites cf. M. inconspicuus Deflandre

Marthasterites inconspicuus Deflandre, 1959, p. 140, pl. 3, figs. 6-14.
Remarks: A small triradiate form similar to Deflandre's species was observed in the upper Turonian at Site 171. Čepek (1970) also described *M.* sp. cf. *M. inconspicuus* from the upper Turonian of northern Germany.

Genus NANNOCONUS Kamptner, 1938

Nannoconus colomii (de Lapparent) Kamptner

Lagena colomi de Lapparent, 1931, p. 223.
Nannoconus colomi (de Lapparent) Kamptner, 1938, p. 252.
Nannoconus steinmanni Kamptner, 1938, p. 289, text-figs. 1-3.
Remarks: This species is fairly common in the Berriasian sediments at Site 167. Its range is very much restricted since it only occurs in the Berriasian and does not range up into Aptian or Albian as in the south of France or the western Atlantic.

Nannoconus cf. N. dolomiticus Cita and Pasquaré

Nannoconus dolomiticus Cita and Pasquaré, 1959, p. 426, pl. 28, figs. 3-5, text-fig. 6 (7-10).
Remarks: A cylindric nannoconid with a narrow central canal occurs in the Berriasian limestones at Site 167. It is recrystallized and cannot be assigned to the above species with certainty.

Genus CRETATURBELLA Thierstein, 1971

Cretaturbella rothii Thierstein

Cretaturbella rothii Thierstein, 1971, p. 483, pl. 3, figs. 1-5.

Remarks: This species is very rare and was found only in one sample in the Hauterivian to Aptian at Site 166. It is probably easily destroyed by diagenesis because it is completely absent from the Lower Cretaceous limestones at Site 167.

Genus ASSIPETRA n. gen.

Description: These small rectangular prisms with rounded corners consist of two stacks of irregular rhomboidal plates. They are inclined towards the center where they interfinger. In the light microscope this species appears as a small rectangular to oval particle with four to six sutures. Under crossed nicols they are bright with V-shaped extinction patterns.

Remarks: Thierstein (1973) gives excellent scanning and light micrographs of the type species of this genus (as *Micula infracretacea)*.

Assipetra n. gen. differ from *Polycostella* by its rectangular outline and the lack of ridges. *Micula* is composed of fewer triangular plates which are inclined towards the center of the cube forming deep depressions in each side.

Type species: *Assipetra infracretacea* (Thierstein) n. comb.

Assipetra infracretacea (Thierstein) n. comb.
(Plate 25, Figures 5, 7)

Micula infracretacea Thierstein, 1973, p. 46, pl. 1, figs. 1-19.

Remarks: This is the only species which belongs to the genus *Assipetra*. The specimens illustrated here are somewhat recrystallized. Thierstein (1973) gives excellent scanning and light micrographs of this species. Its range is Valanginian to Aptian.

Genus POLYCOSTELLA Thierstein, 1971

Polycostella beckmannii Thierstein

Polycostella beckmannii Thierstein, 1971, p. 483-484, pl. 2, figs. 5-16.

Remarks: This species is a good marker for uppermost Tithonian to lowermost Berriasian. It is rare in the Berriasian to upper Tithonian limestones at Site 167.

Genus MICULA Vekshina, 1959

Micula decussata Vekshina

Micula decussata Vekshina, 1959, p. 71, pl. 1, fig. 6, pl. 2, fig. 11.
Micula staurophora (Gardet) Bramlette and Martini, 1964, p. 318, pl. 6, figs. 7-11.

Remarks: This species first occurs in the upper Turonian. The rare occurrence of *Micula decussata* in the Albian at Site 167 is caused by contamination.

Micula mura (Martini) Bukry

Tetralithus murus Martini, 1961, p. 4, pl. 1, fig. 6, pl. 4, fig. 42.
Micula mura (Martini) Bukry, 1973b, p. 679.

Remarks: Only the form with short extensions was observed in sediments from the central Pacific.

Genus MICROHABDULUS Deflandre, 1959

Microrhabdulus belgicus Hay and Towe

Microrhabdulus belgicus Hay and Towe, 1963, p. 95, pl. 1.
Microrhabdulus margaritatus Deflandre, 1963, p. 3486, figs. 12-18.
Microrhabdulus nodosus Stradner, 1963, p. 177, pl. 4, fig. 13.

Remarks: This species is rare in the upper Turonian at Site 171 (Horizon Guyot).

Microrhabdulus decoratus Deflandre

Microrhabdulus decoratus Deflandre, 1959, p. 141, pl. 4, figs. 1-5.

Remarks: Rare specimens of this species first occur in the Turonian but it does not become common until the Campanian.

Microrhabdulus stradneri Bramlette and Martini

Microrhabdulus stradneri Bramlette and Martini, 1964, p. 316, pl. 6, figs. 3, 4.

Remarks: In the central Pacific this species is restricted to the middle and upper Maestrichtian.

Genus LITHRAPHIDITES Deflandre, 1959

Lithraphidites alatus Thierstein

Lithraphidites alatus Thierstein, *in* Roth and Thierstein, 1972, p. 438, pl. 3, figs. 1-8.

Remarks: This species is a good marker for the Cenomanian although it is never very abundant.

Lithraphidites carniolensis Deflandre

Lithraphidites carniolensis Deflandre, 1963, p. 3486, figs. 1-8.

Remarks: This species occurs from the Tithonian/Berriasian throughout the Maestrichtian and has therefore no stratigraphic value.

Lithraphidites quadratus Bramlette and Martini

Lithraphidites quadratus Bramlette and Martini, 1964, p. 310, pl. 6, figs. 16, 17, pl. 7, fig. 8.

Remarks: This species is very rare and was either not solution resistant or preferred a near-shore environment.

Genus CERATOLITHOIDES Bramlette and Martini, 1964

Ceratolithoides kamptneri Bramlette and Martini

Ceratolithoides kamptneri Bramlette and Martini, 1964, p. 308, pl. 5, figs. 13, 14.

Remarks: This species is rare in the sediments from the central Pacific and was only found in the Maestrichtian at Sites 169 and 171.

Genus MICRANTHOLITHUS Deflandre
in Deflandre and Fert, 1954

Micrantholithus hoschulzii (Reinhardt) Thierstein

Braarudosphaera hoschulzi Reinhardt, 1966, p. 42, pl. 21, fig. 3.
Micrantholithus hoschulzi (Reinhardt) Thierstein, 1971, p. 482, pl. 1, figs. 12-15.

Remarks: This species is more common in near-shore deposits. It is very rare in the Valanginian-Berriasian at Site 167.

Genus BRAARUDOSPHAERA Deflandre, 1947

Braarudosphaera sp. cf. B. turbinea

Braarudosphaera turbinea Stradner, 1963, p. 10, pl. 6, fig. 8.

Remarks: This species is rare in the Albian of Site 167 (Magellan Rise).

CENOZOIC SPECIES

Family COCCOLITHACEAE Kamptner, 1928

Genus COCCOLITHUS Schwarz, 1894

Coccolithus cavus Hay and Mohler
(Plate 14, Figures 1, 2, 4, 5)

Coccolithus cavus Hay and Mohler, 1967, p. 1524, pl. 196, figs. 1-3, pl. 197, figs. 5, 7, 10, 12.

Remarks: This species is very similar to *Coccolithus eopelagicus* but has a larger central area. It is restricted to the Paleocene in the central Pacific sections.

Coccolithus eopelagicus (Bramlette and Riedel) Bramlette and Sullivan
(Plate 8, Figures 2, 4; Plate 9, Figures 3, 4, 6;
Plate 10, Figure 4; Plate 11, Figure 3)

Tremalithus eopelagicus Bramlette and Riedel, 1954, p. 392, pl. 38, fig. 2a, b.

Coccolithus eopelagicus (Bramlette and Riedel) Bramlette and Sullivan, 1961, p. 141.
Coccolithus muiri Black, 1964, p. 309, pl. 50, figs. 5, 6.
Ericsonia ovalis Black, 1964, p. 312, pl. 52, figs. 3, 4.
Ericsonia insolita Perch-Nielsen, 1971, p. 13, pl. 1, fig. 1, pl. 7, figs. 4, 6, pl. 61, figs. 14, 15.
Ericsonia femuricentrum Perch-Nielsen, 1971, p. 12, pl. 3, figs. 1-4, pl. 61, figs. 24, 25.

Remarks: A complete intergradation of small and large forms was observed and, therefore, this species is used in a broad sense. *Coccolithus eopelagicus* is common in the Eocene and Oligocene. It grades into *Coccolithus miopelagicus* in the lower Miocene.

Coccolithus miopelagicus Bukry
(Plate 6, Figure 5)

Coccolithus miopelagicus Bukry, 1971b, p. 310, pl. 2, figs. 6-9.

Remarks: This species differs from *Coccolithus eopelagicus* in having a relatively smaller central area.

Coccolithus pelagicus (Wallich) Schiller
(Plate 1, Figure 1; Plate 4, Figures 3, 6; Plate 5, Figure 3)

Coccosphaera pelagica Wallich, 1877, p. 348, pl. 17, figs. 1, 2, 5, 11, 12.
Coccolithus pelagicus (Wallich) Schiller, 1930, p. 246, figs. 123, 124.

Remarks: This species seems to have its lowest occurrence in the Upper Miocene. There is considerable variability in size and relative size and structure of the central area. The older (Miocene) forms seem to have coarser elements lining the central area than recent forms.

Genus ERICSONIA Black, 1964

Ericsonia fenestrata (Deflandre and Fert) Stradner

Discolithus fenestratus Deflandre and Fert, 1954, p. 25, pl. 11, fig. 25, text-figs. 18, 52.
Ericsonia fenestrata (Deflandre and Fert) Stradner, *in* Stradner and Edwards, 1968, p. 18, pl. 10, fig. 4, pl. 11, figs. 1-4 (*non* pl. 10, figs. 1-3, pl. 11, figs. 5-7).

Remarks: This species is used in the same sense as in Roth (1970), i.e., for specimens with 12 to 20 pores arranged on lines parallel to the long and short axis of the ellipse. This species is rare in the central Pacific and was only found in the lower Oligocene at Site 167. It is probably a species which prefers near-shore conditions.

Ericsonia subdisticha (Roth and Hay) Roth

Ellipsolithus subdistichus Roth and Hay *in* Hay et al., 1967, p. 446-447, pl. 6, fig. 7.
Ericsonia subdisticha (Roth and Hay) Roth, *in* Baumann and Roth, 1969, p. 319.

Remarks: This species was used in a fairly broad sense and includes *Ericsonia pauciperforata* which is difficult to distinguish from *Ericsonia subdisticha* in the light microscope. *Ericsonia subdisticha* seems to be more abundant in near-shore waters. It was found to be quite rare in the middle Eocene to lower Oligocene in the central Pacific.

Ericsonia subpertusa Hay and Mohler
(Plate 12, Figure 5)

Ericsonia subpertusa Hay and Mohler, 1967, p. 1531, pl. 198, figs. 11, 15, 18, pl. 199, figs. 1-3.

Remarks: This circular to subcircular species occurs in the Paleocene at Site 167. It is quite variable in size and shape.

Genus CYCLOCOCCOLITHINA Wilcoxon, 1970

Cyclococcolithina formosa (Kamptner) Wilcoxon
(Plate 8, Figure 1)

Cyclococcolithus formosus Kamptner, 1963, p. 163, pl. 2, fig. 8.
Coccolithus lusitanicus Black, 1964, p. 308, pl. 50, figs. 1-2.
Cyclococcolithus orbis Gartner and Smith, 1967, p. 4, pl. 4, figs. 1-3.
Cyclococcolithina formosa (Kamptner) Wilcoxon, 1970, p. 82.

Remarks: Circular to subcircular forms are common in the Eocene and lower Eocene from the central Pacific.

Cyclococcolithina kingi (Roth) n. comb.

Cyclococcolithus kingi Roth, 1970, p. 855, pl. 7, fig. 1 (*non* pl. 6, fig. 5).
Cyclococcolithus sp. cf. *C. kingi* Roth, *in* Roth Baumann and Bertolino, 1971, p. 1092-1093, figs. 11, 12.
Cyclococcolithina protoannula Gartner, 1971, p. 109, pl. 5, fig. 1a-c, 2.

Remarks: This species is quite rare in the middle and upper Eocene.

Cyclococcolithina leptopora (Murray and Blackman) Wilcoxon
(Plate 1, Figures 1-6; Plate 2, Figures 1-3; Plate 3, Figure 5; Plate 4, Figure 6; Plate 5, Figure 1)

Coccosphaera leptopora Murray and Blackman, 1898, p. 430, pl. 15, figs. 1-7.
Coccolithus leptoporus (Murray and Blackman) Schiller, 1930, *in* Rabenhorst, p. 245, text-fig. 10.
Cyclococcolithus leptoporus (Murray and Blackman) Kamptner, 1954, p. 23, fig. 20.
Cyclococcolithina leptopora (Murray and Blackman) Wilcoxon, 1970, p. 82.

Cyclococcolithina macintyrei (Bukry and Bramlette) Bukry
(Plate 3, Figure 5; Plate 4, Figure 1)

Cyclococcoccolithus macintyrei Bukry and Bramlette, 1969, p. 132, pl. 1, figs. 1-3.
Cyclococcolithina macintyrei (Bukry and Bramlette) Bukry, 1973a, p. 392.

Genus UMBILICOSPHAERA Lohman, 1902

Umbilicosphaera sibogae (Weber van Bosse) Gaarder
(Plate 2, Figure 4)

Coccosphaera sibogae Weber van Bosse, 1901, p. 137, 140, pl. 17, figs. 1, 2.
Umbilicosphaera mirabilis Lohmann, 1902, p. 139, pl. 5, figs. 66, 66a.
Umbilicosphaera sibogae (Weber van Bosse) Gaarder, 1970, p. 126.

Remarks: This species was only observed in the Pleistocene at Site 167 (Magellan Rise).

Genus MARKALIUS Bramlette and Martini, 1964

Markalius inversus (Deflandre) Bramlette and Martini

Cycloccolithus leptporus var. *inversus* Deflandre, *in* Deflandre and Fert, 1954, p. 150, pl. 9, figs. 4, 5.
Markalius inversus (Deflandre) Bramlette and Martini, 1964, p. 302, pl. 2, figs. 4-9, pl. 7, fig. 2a, b.

Remarks: This species was only found reworked into Pleistocene sediments in Hole 165.

Genus CYCLOLITHELLA Loeblich and Tappan, 1963

Cyclolithella annula (Cohen) McIntyre and Bé

Coccolithites annulus Cohen, 1964, p. 237-238, pl. 3, fig. 1a-e.
Cyclolithella annula (Cohen) McIntyre and Bé, 1967, p. 568, pl. 5a-c.

Remarks: The delicate coccoliths assigned to this species in the upper Pleistocene at Site 165. It is distinguished from *Pseudoemiliania lacunosa* by its larger size and more delicate construction.

Cyclococcolithella aprica n. sp.
(Plate 11, Figures 4-6; Plate 12, Figures 1-4)

Description: This species has a circular shield composed of about 32 to 34 sinistrally imbricate elements. The outer margin is serrate. The central area is almost half the size of the whole coccolith. The inner margin of the shield is raised and consists of a cycle of laths with strongly clockwise inclined sutures. Due to secondary calcite overgrowths some of the elements of this inner rim cycle are completely fused to the elements of the shield. In the light microscope the individual elements in the shield can be distinguished. In cross-polarized light the extinction figure consists of four slightly flaring bars.

Remarks: This species differs from *Cyclolithella robusta* by its serrate margin and by the raised rim along the central area.

Size: 9 microns.

Holotype: Plate 11, Figure 4 (USNM 188113)

Paratypes: Plate 11, Figures 5, 6; Plate 12, Figures 1, 2, 4.

Type locality: Horizon Guyot, central Pacific Ocean, DSDP 171-8-3, 50 cm.

Distribution: Only observed in the middle Eocene.

Genus CORONOCYCLUS Hay, Mohler and Wade, 1966

Coronocyclus serratus Hay, Mohler and Wade

Coronocyclus serratus Hay, Mohler and Wade, 1966, p. 194, pl. 11, figs. 1-5.

Remarks: This species is rare in sediments of middle Eocene to middle Miocene age in the central Pacific.

Genus OOLITHOTUS Reinhardt in Cohen and Reinhardt, 1967

Oolithotus antillarum (Cohen) Reinhardt

Discolithus antillarum Cohen, 1964, p. 236, pl. 1, fig. 3a-e, pl. 2, fig. 2a, b.

Oolithotus antillarum (Cohen) Reinhardt, *in* Cohen and Reinhardt, 1968, p. 297, pl. 19, figs. 19, 23, pl. 21, figs. 1, 5, 7.

Remarks: This species is very rare in the sediments recovered from the central Pacific. It was only found in the uppermost Pliocene at Site 167.

Genus PEDINOCYCLUS Bukry and Bramlette, 1971

Pedinocyclus larvalis (Bukry and Bramlette) Loeblich and Tappan

Leptodiscus larvalis Bukry and Bramlette, 1971, p. 134, pl. 2, figs. 8-11.

Pedinocyclus larvalis (Bukry and Bramlette) Loeblich and Tappan, 1973, p

Remarks: This species is not solution resistant and usually more common in near-shore assemblages. The specimens observed in the Oligocene at Site 165 were probably transported from shallower areas.

Genus CRUCIPLACOLITHUS Hay and Mohler, 1967

Cruciplacolithus staurion (Bramlette and Sullivan) Gartner

Coccolithus staurion Bramlette and Sullivan, 1961, p. 141, pl. 2, figs. 5a, b, 6a-c.

Cruciplacolithus staurion (Bramlette and Sullivan) Gartner, 1971, p. 109.

Remarks: This species is restricted to the middle Eocene. It was observed in small numbers in samples from Sites 165 and 171.

Cruciplacolithus tenuis (Stradner) Hay and Mohler
(Plate 13, Figure 1; Plate 17, Figure 1)

Heliorthus tenuis Stradner, 1961, p. 84, text-figs. 64, 65.

Coccolithus helis Stradner *in* Gohrbrandt, 1963, p. 74, pl. 8, fig. 16, pl. 9, figs. 1, 2.

Cruciplacolithus tenuis (Stradner) Hay and Mohler, *in* Hay et al., 1967, p. 446.

Remarks: Somewhat overgrown specimens were found in the Paleocene at Site 167. In some specimen the crossbars do not coincide with the axes; these seem to be transitional between *Cruciplacolithus tenuis* and *Chiasmolithus danicus.*

Family GEPHYROCAPSACEAE Black, 1971

Genus GEPHYROCAPSA Kamptner, 1943

Gephyrocapsa caribbeanica Boudreaux and Hay

Gephyrocapsa caribbeanica Boudreaux and Hay, *in* Hay et al., 1967, p. 447, pl. 12, figs. 1-4, pl. 13, figs. 1-4.

Remarks: This species has a small central area and a bridge lying almost in the long axis of the ellipse. It was found in the lower Pleistocene at Site 167.

Gephyrocapsa oceanica Kamptner
(Plate 1, Figures 1-6; Plate 2, Figures 1, 2)

Gephyrocapsa oceanica Kamptner, 1943, p. 43-49.

Remarks: This species has its lowest occurrence stratigraphically higher than *Gephyrocapsa caribbeanica.* It makes its appearance within the *Pseudoemiliania lacunosa* Zone.

Genus CRENALITHUS n. g.

Description: Small elliptical placoliths with nonimbricate or only slightly overlapping elements. The margin of the shields is serrate. In cross-polarized light the distal shield is bright. Central area is open.

Remarks: This genus is very similar to *Gephyrocapsa* but lacks a bridge across the central area. *Cyclicargolithus* is circular to subcircular and usually larger. *Coccolithus* has strongly imbricate elements and the distal shield is dark in cross-polarized light.

Type species: *Crenalithus doronicoides* (Black and Barnes) n. comb.

Crenalithus doronicoides (Black and Barnes) n. comb.
(Plate 3, Figure 3)

Coccolithus doronicoides Black and Barnes, 1961, p. 142, pl. 25, fig. 3.

Remarks: These small elliptical placoliths first occur in the upper Pliocene and become abundant in the lowermost Pleistocene below the lowest occurrence of *Gephyrocapsa.*

Genus PSEUDOEMILIANIA Gartner, 1969

Pseudoemiliania lacunosa (Kamptner) Gartner
(Plate 3, Figures 5, 6; Plate 4, Figure 1)

Ellipsoplacolithus lacunosus Kamptner, 1963, p. 172, pl. 9, fig. 50.

Pseudoemiliania lacunosa (Kamptner) Gartner, 1969, p. 598, pl. 2, figs. 9, 10.

Remarks: This fairly variable species with circular and elliptical forms is not split up here because there seems to be intergradations between the various forms.

Genus CYCLICARGOLITHUS Bukry, 1971

Cyclicargolithus floridanus (Roth and Hay) Bukry

Coccolithus floridanus Roth and Hay, *in* Hay et al., 1967, p. 445, pl. 6, figs. 1-4.

Cyclococcolithus neogammation Bramlette and Wilcoxon, 1967, p. 104, pl. 1, figs. 1-3, pl. 4, figs. 3-5.

Cyclicargolithus floridanus (Roth and Hay) Bukry, 1971b, p. 312-313.

Remarks: This species is closely related to *Coccolithus marismontium* and *Coccolithus pseudogammation.* A careful study of topotype material is necessary before the relationship of these species can be completely understood.

Cyclicargolithus floridanus first occurs in the upper part of the middle Eocene. It seems to increase in size in the upper Oligocene and Miocene.

Genus RETICULOFENESTRA Hay, Mohler, and Wade, 1966

Reticulofenestra abisecta (Müller) Roth
(Plate 6, Figure 5; Plate 7, Figure 2)

Coccolithus aff. *C. bisectus* (Hay, Mohler, and Wade) Bramlette and Wilcoxon, 1967, p. 102, pl. 4, figs. 9, 10.

Coccolithus abisectus Müller, 1970a, p. 92, pl. 9, figs. 9, 10, pl. 12, fig. 1.

Reticulofenestra abisecta (Müller) Roth, *in* Roth and Thierstein, 1972, p. 436.
Remarks: This species is common in the late Oligocene and seems to disappear at the Oligocene Miocene boundary.

Reticulofenestra bisecta (Hay, Mohler, and Wade) Roth
(Plate 4, Figure 1; Plate 7, Figures 4, 5; Plate 9, Figures 1, 2; Plate 10, Figure 2)

Syracosphaera bisecta Hay, Mohler, and Wade, 1966, p. 393, pl. 10, figs. 1-6.
Reticulofenestra bisecta (Hay, Mohler, and Wade) Roth, 1970, p. 847, pl. 3, fig. 6.
Remarks: Typical specimens of this species first occur in the upper part of the middle Eocene. They seem to evolve from *Reticulofenestra scrippsae.*

Reticulofenestra coenura (Reinhardt) Roth

Coccolithus coenurus Reinhardt, 1966, pl. 1, fig. 7, text-fig. 6.
Reticulofenestra coenura (Reinhardt) Roth, 1970, p. 847.
Cribrocentrum coenurum (Reinhardt) Perch-Nielsen, 1971, p. 26, pl. 21, figs. 1-6.
Remarks: This species is left in the genus *Reticulofenestra. Cribrocentrum* does not seem to be sufficiently different from *Reticulofenestra* to warrant a separate genus. In the light microscope, *Reticulofenestra coenura* is very similar to *R. umbilica,* but it is considerably smaller (less than 15μ).

Reticulofenestra hillae Bukry and Percival

Reticulofenestra hillae Bukry and Percival, 1971, p. 136, pl. 6, figs. 1-3.
Remarks: This species is similar to *Reticulofenestra umbilica* but has a narrower central opening and with a more pronounced collar surrounding it. It is most abundant in the lower Oligocene but also occurs in the upper Eocene. It disappears at a higher level than *Reticulofenestra umbilica.*

Reticulofenestra pseudoumbilica (Gartner)Gartner

Coccolithus pseudoumbilicus Gartner, 1967, p. 4, pl. 6, fig. 3.
Reticulofenestra pseudoumbilica (Gartner) Gartner, 1969, p. 587-589.
Remarks: This species first occurs in the middle Miocene where it is quite rare. It becomes common in the upper Miocene and lower Pliocene.

Reticulofenestra reticulata (Gartner and Smith) Roth

Cyclococcolithus reticulatus Gartner and Smith, 1967, p. 4, pl. 5, figs. 1-4.
Reticulofenestra reticulata (Gartner and Smith) Roth, *in* Roth and Thierstein, 1972, p. 436.
Remarks: This species seems to be restricted to the lower part of the *Discoaster barbadiensis* Zone. More complete upper Eocene sections have to be studied to find out whether a separate zone can be based on the range of this species.

Reticulofenestra scrippsae (Bukry and Percival) n. comb.

Dictyococcites scrippsae Bukry and Percival, 1971, p. 128, pl. 2, figs. 7-8.
Remarks: This species occurs below the first occurrence of *Reticulofenestra bisecta,* is most common in the Eocene and ranges into the Oligocene.

Reticulofenestra umbilica (Levin) Martini and Ritzkowski
(Plate 7, Figures 1, 3; Plate 9, Figure 5)

Coccolithus umbilicus Levin, 1965, p. 265, pl. 41, fig. 2.
Reticulofenestra caucasica Hay, Mohler and Wade, 1966, p. 386, pl. 3, figs. 1, 2, pl. 4, figs. 1, 2.
Reticulofenestra umbilica (Levin) Martini and Ritzkowski, 1968, p. 245, pl. 1, figs. 11, 12.
Remarks: This is the largest species of *Reticulofenestra.* It appears in the upper part of the middle Eocene and ranges into lower Oligocene.

Genus PRINSIUS Hay and Mohler, 1967

Prinsius bisulcus (Stradner) Hay and Mohler
(Plate 17, Figure 2)

Coccolithus bisulcus Stradner, *in* Gohrbrandt, 1963, p. 72, pl. 8, figs. 3-6, text-fig. 3a, b.
Prinsius bisulcus (Stradner) Hay and Mohler, 1967, p. 1529-1530, pl. 196, figs. 10-13, pl. 197, fig. 6.
Remarks: This species was only observed in the Paleocene at Site 167.

Genus TOWEIUS Hay and Mohler, 1967

Toweius craticulus Hay and Mohler
(Plate 14, Figure 3)

Toweius craticulus Hay and Mohler, 1967, p. 1530-1531, pl. 196, figs. 7-9, pl. 197, figs. 2, 3.
Remarks: This species is used in a fairly broad sense to include small circular to subcircular placoliths with indications of numerous perforations in the central area. *Toweius craticulus* was observed in the Paleocene from Site 167.

Toweius eminens (Bramlette and Sullivan) Gartner

Coccolithus eminens Bramlette and Sullivan, 1961, p. 139, pl. 1, fig. 3a-d.
Toweius eminens (Bramlette and Sullivan) Gartner, 1971, p. 114, 116, pl. 5, figs. 4-6.
Remarks: This species is distinguished from *Toweius craticulus* by having only four pores in the center. It is also restricted to the Paleocene at Site 167.

Genus CHIASMOLITHUS Hay, Mohler and Wade, 1966

Chiasmolithus altus Bukry and Percival

Chiasmolithus altus Bukry and Percival, 1971, p. 126, pl. 2, figs. 1, 2.
Remarks: This species differs from *Chiasmolithus oamaruensis* by its relatively smaller central opening and the larger angle between the cross-bars. It was found only in the upper Eocene at Site 165.

Chiasmolithus bidens (Bramlette and Sullivan) Hay and Mohler

Coccolithus bidens Bramlette and Sullivan, 1961, p. 139, pl. 1, fig. 1.
Chiasmolithus bidens (Bramlette and Sullivan) Hay and Mohler, 1967, p. 1526, pl. 196, figs. 14, 15, 17, pl. 197, figs. 4, 9, 14.
Chiasmolithus eograndis Perch-Nielsen, 1971, p. 16, pl. 10, figs. 5, 6, pl. 13, figs. 1-4, pl. 60, figs. 17, 18.
Remarks: This species is restricted to the Paleocene at Site 167.

Chiasmolithus californicus (Sullivan) Hay and Mohler

Coccolithus aff. *C. gigas* Bramlette and Sullivan, 1961, p. 140, pl. 1, fig. 7a-d.
Coccolithus californicus Sullivan, 1964, p. 180, pl. 2, figs. 3a, b, 4a, b.
Chiasmolithus californicus (Sullivan) Hay and Mohler, 1967, p. 1527, pl. 196, figs. 18-20, pl. 198, fig. 5.
Remarks: This relatively large species of *Chiasmolithus* was observed in the Paleocene at Site 167.

Chiasmolithus danicus (Brotzen) Hay and Mohler
(Plate 13, Figure 3; Plate 17; Figures 3-5)

Cribrosphaerella danica Brotzen, 1959, p. 25, text-fig. 9.
Chiasmolithus danicus (Brotzen) Hay and Mohler, 1967, p. 1526 (*not* pl. 196, figs. 16, 21, 22, pl. 198, figs. 8, 12, 13).
Remarks: This large species is common in the Paleocene at Site 167. Most specimens are overgrown and it is difficult to see the detailed structure of the central cross.

Chiasmolithus expansus (Bramlette and Sullivan) Gartner

Coccolithus expansus Bramlette and Sullivan, 1961, p. 140, pl. 1, fig. 7a-d.
Chiasmolithus expansus (Bramlette and Sullivan) Gartner, 1971, p. 943, fig. 11 (1, 2a, b).

Chiasmolithus medius Perch-Nielsen, 1971, p[illegible]-19, *pro parte*, pl. 8, fig. 4, pl. 12, fig. 7, pl. 60, figs. 7, 8, (*non* pl. 11, fig. 4, pl. 8, fig. 3).

Remarks: This species has a narrow shield and a wide central area spanned by an x-shaped cross. Perch-Nielsen (1971) assigns forms with a slightly asymmetrical cross to *Chiasmolithus medius*. These forms are here considered an intraspecific variant of *Chiasmolithus expansus*. This species was found in the lower part of the middle Eocene.

Chiasmolithus gigas (Bramlette and Sullivan) Radomski

Coccolithus gigas Bramlette and Sullivan, 1961, p. 140, pl. 1, fig. 7a-d).

Chiasmolithus gigas (Bramlette and Sullivan) Radomski, 1968, p. 559, pl. 44, figs. 1, 2.

Remarks: This species is restricted to the lower part of the middle Eocene in the cores from the central Pacific.

Chiasmolithus grandis (Bramlette and Riedel) Radomski
(Plate 9, Figure 6)

Coccolithus grandis Bramlette and Riedel, 1954, p. 391, pl. 38, fig. 1a,b.

Chiasmolithus grandis (Bramlette and Riedel) Randomski, 1968, p. 560, pl. 44, figs. 3, 4.

Chiasmolithus medius Perch-Nielsen, 1971, pp. 18-19, *pro parte*, pl. 11, fig. 4, pl. 8, figs. 3 (*non* pl. 8, fig. 4, pl. 12, fig. 7, pl. 60, figs. 7,8).

Remarks: This large *Chiasmolithus* with tooth-like projections in the area between cross-bars disappears at the top of the middle Eocene.

Chiasmolithus oamaruensis (Deflandre) Hay, Mohler, and Wade

Tremalithus oamaruensis Deflandre, *in* Deflandre and Fert, 1954, p. 154, pl. 11, fig. 22, text-figs. 72-74.

Chiasmolithus oamaruensis (Deflandre) Hay, Mohler, and Wade, 1966, p. 388, pl. 7, fig. 1.

Remarks: This species is rare in the upper Eocene of the central Pacific. It is probably a cooler water form because it seems to be more common at high latitudes (New Zealand, Crimea).

Chiasmolithus solitus (Bramlette and Sullivan) Gartner

Coccolithus solitus Bramlette and Sullivan, 1961, p. 140, pl. 2, fig. 4a-c.

Chiasmolithus solitus (Bramlette and Sullivan) Gartner, 1970, p. 945, fig. 16.

Remarks: This species disappears in the upper part of the middle Eocene. This level can be used to subdivide the middle Eocene biostratigraphically.

Chiasmolithus titus Gartner

Chiasmolithus titus Gartner, 1970, p. 945-946, fig. 17.

Chiasmolithus minutus Perch-Nielsen, 1971, p. 19, pl. 14, figs. 2, 5.

Remarks: Only a few specimens were found in the Upper Eocene at Sites 165 and 167 and in the middle Eocene at Site 171.

Genus HELICOPONTOSPHAERA Hay and Mohler, 1967

Helicopontosphaera bramlettei Müller

Helicosphaera aff. *H. seminulum* Bramlette and Sullivan. Bramlette and Wilcoxon, 1967, p. 106, pl. 5, figs. 11,12.

Helicopontosphaera bramlettei Müller, 1970b, p. 114, pl. 5, figs. 4-6.

Helicopontosphaera wilcoxonii Gartner, 1971, p. 110, pl. 2.

Remarks: This species occurs in small numbers in the lower Oligocene at Site 165. Since most mid-Tertiary *Helicopontosphaera* are not solution resistant, they were probably transported from a shallower area.

Helicopontosphaera compacta (Bramlette and Wilcoxon) Hay

Helicosphaera compacta Bramlette and Wilcoxon, 1967, p. 105, pl. 6, figs. 5-8.

Helicopontosphaera compacta (Bramlette and Wilcoxon) Hay, 1970, p. 458.

Remarks: This is one of the more solution-resistant mid-Tertiary species of *Helicopontosphaera*. It occurs rarely in the upper Eocene and lower Oligocene at Site 165 (perhaps transported).

Helicopontosphaera kamptneri Hay and Mohler
(Plate 1, Figures 1, 3; Plate 4, Figures 2, 3)

Helicopontosphaera kamptneri Hay and Mohler, *in* Hay et al., 1967, p. 448, pl. 10, fig. 5, pl. 11, fig. 5.

Remarks: This Neogene species is more resistant to solution than the Eocene to Oligocene species. It is quite common in middle Miocene to Quaternary sediments of the central Pacific.

Helicopontosphaera reticulata (Bramlette and Wilcoxon) Roth

Helicosphaera reticulata Bramlette and Wilcoxon, 1967, p. 106, pl. 6, fig. 15.

Helicopontosphaera reticulata (Bramlette and Wilcoxon), Roth, 1970, p. 863, pl. 10, fig. 5.

Helicopontosphaera dinesenii Perch-Nielsen, 1971, p. 42-43, pl. 35, figs. 34, pl. 36, figs. 3, 6, 9, 11, pl. 61, figs. 6, 7.

Helicopontosphaera salebrosa Perch-Nielsen, 1971, p. 43-44, pl. 34, fig. 5, pl. 36, figs. 5, 10, pl. 61, figs. 8, 9.

Remarks: This species is quite variable. It can have one or two rows of perforations along the diagonal cross-bar in the central area. This species is rare in open-ocean assemblages. It was found in the lower Oligocene and middle to upper Eocene of Site 165 (perhaps transported from shallower areas) and in the upper Eocene to lower Oligocene at Site 167 and in the middle Eocene at Site 171.

Helicopontosphaera sellii Bukry and Bramlette

Helicopontsphaera sellii Bukry and Bramlette, 1969, p. 134, pl. 2, figs. 3-7.

Remarks: This species is rare in the Pliocene from the Magellan Rise (Site 167). According to Bukry (1972) there are indications that *Helicopontosphaera sellii* is more abundant at high latitude.

Helicopontosphaera seminulum (Bramlette and Sullivan) Stradner

Helicosphaera seminulum Bramlette and Sullivan, 1961, p. 144.

Helicopontosphaera seminulum (Bramlette and Wilcoxon) Stradner, 1969, p. 419, pl. 87, figs. 19, 20.

Remarks: This species was only seen in the middle to upper Eocene at Site 165 and was probably transported from shallower areas.

Family PONTOSPHAERACEAE Lemmermann *in* Brandt and Apstein, 1908

Genus PONTOSPHAERA Lohmann, 1902

Pontosphaera discopora Schiller

Pontosphaera discopora Schiller, 1925, p. 11, pl. 1, fig. 4.

Remarks: This species is not solution resistant. It occurs in small numbers in the Pleistocene at Site 167.

Pontosphaera scutellum Kamptner

Pontosphaera scutellum Kamptner, 1952, p. 234, fig. 1, p. 378, fig. 17a-f.

Remarks: This species was found sporadically in the Pleistocene sediments from Site 167. Like most pontosphaerids it is easily dissolved.

Genus SCYPHOSPHAERA Lohmann, 1902

Scyphosphaera apsteini Lohmann

Scyphosphaera apsteini Lohmann, 1902, p. 132, pl. 4, figs. 26-30.

Remarks: This species prefers warm water and is susceptible to solution. It occurs sporadically in the middle Miocene to Pleistocene at Site 167 and in the middle Miocene at Site 171.

Scyphosphaera pulcherrima Deflandre

Scyphosphaera pulcherrima Deflandre, 1942, p. 133, figs. 28-31.

Remarks: This species with a constricted neck and flaring distal ring occurs in small numbers in the middle Miocene at Site 167.

Genus ELLIPSOLITHUS Sullivan, 1964

Ellipsolithus macellus (Bramlette and Sullivan) Sullivan
(Plate 12, Figure 7)

Coccolithites macellus Bramlette and Sullivan, 1961, p. 152-153, pl. 7, figs. 11-13.

Ellipsolithus macellus (Bramlette and Sullivan) Sullivan, 1964, p. 184, pl. 5, fig. 3.

Remarks: Few and usually etched specimens belonging to this species were found in the Paleocene at Site 167.

Family SYRACOSPHAERACEAE Lemmermann *in* Brandt and Apstein, 1908

Genus SYRACOSPHAERA Lohmann, 1902

Syracosphaera sp. cf. S. histrica Kamptner

Syracosphaera histrica Kamptner, 1941, p. 84, pl. 6, figs. 65-68; Boudreaux and Hay, 1969, p. 279, pl. 8, figs. 10-19.

Remarks: Small syracosphaerids with the characteristic hourglass-shaped extinction figure were observed in the Quaternary of Site 167.

Syracosphaera sp. cf. S. pulchra Lohmann

Syracosphaera pulchra Lohmann, 1902, p. 134, pl. 4, figs. 33, 36, 36a, 37; Boudreaux and Hay, 1969, p. 279, pl. 8, figs. 1-9.

Remarks: Rare specimens very similar to *Syracosphaera pulchra* as illustrated by Boudreaux and Hay occur in the Quaternary of Site 171.

Family ZYGODISCACEAE Hay and Mohler, 1967

Genus ZYGODISCUS Bramlette and Sullivan, 1961

Zygodiscus plectopons Bramlette and Sullivan

Zygodiscus plectopons Bramlette and Sullivan, 1961, p. 148, pl. 4, fig. 12a-d.

Remarks: Common but overgrown specimens assigned to this species occur in the Paleocene at Site 167.

Family HELIOLITHACEAE Hay and Mohler, 1967

Genus HELIOLITHUS Bramlette and Sullivan, 1961

Heliolithus kleinpellii Sullivan

Heliolithus kleinpelli Sullivan, 1964, p. 193, pl. 12, fig. 5a,b.

Remarks: This is the only species of *Heliolithus* observed in the Paleocene at Site 167 where it occurs together with *Discoaster mohleri.*

Genus BOMOLITHUS n. gen.

Description: Circular coccolith consisting of three cycles of elements. The uppermost cycle is higher than the others and the elements slope towards a central depression. The two lower cycles are sinistrally imbricate and slope towards the periphery.

Remarks: *Heliolithus* differs from *Bomolithus* in having only two cycles of elements in the shape of two partial cones joined at truncate apices. *Fasciculithus* lacks the lower cycles which slope toward the periphery. *Toweius* has a much lower inner cycle of elements and is usually elliptical.

Type Species: *Bomolithus elegans* n. sp.

Bomolithus elegans n. sp.
(Plate 15, Figures 1-6)

Description: The upper cycle is the highest one and is composed of about 24 irregular wedge-shaped elements which slope towards a crater-like central depression. Not all the elements reach the center. There is an irregular hole in the center of the depression. The next lower cycle consists of about 24 tabular sinistrally imbricate elements which slope towards the periphery of the coccolith. The next lower cycle seems to be of the same basic construction. So far it has only been observed in side view. In the light microscope under cross-polarized light only the central part (i.e., the upper cycle) is bright with a dark cross with practically straight arms. The two lower cycles are extinct.

Remarks: *Heliolithus riedelii* Bramlette and Sullivan differs from *Bomolithus elegans* n. sp. in having two conical shields both of which are bright under crossed nicols. *Bomolithus elegans* n. sp. has a cylindrical upper cycle with two lower cycles attached to it and only the center is bright in cross-polarized light.

Diameter: 7.5μ

Holotype: Plate 15, Figure 1 (USNM 188118)

Paratypes: Plate 15, Figures 2-6 (USNM 188119–188123)

Type locality: DSDP Site 167-38 core catcher sample, Magellan Rise, central Pacific.

Type level: *Discoaster mohleri* Zone, Paleocene.

Distribution: Only observed in the *Discoaster mohleri* Zone, Magellan Rise, central Pacific.

Genus FASCICULITHUS Bramlette and Sullivan, 1961

Fasciculithus sp. cf. F. ulii Perch-Nielsen
(Plate 16, Figures 1, 2)

Fasciculithus ulii Perch-Nielsen, 1971, p. 350-351, pl. 2, figs. 1-4, pl. 14, figs. 17, 18.

Remarks: This species is used in a broad sense for *Fasciculithus* with a distal cycle which can be narrower or wider as the main column. It occurs in the Paleocene at Site 167.

Fasciculithus tympaniformis Hay and Mohler
(Plate 13, Figure 5; Plate 14, Figure 2; Plate 16, Figure 5)

Fasciculithus tympaniformis Hay and Mohler, in Hay et al., 1967, p. 447, pl. 8, 9, figs. 1-5.

Remarks: This species lacks a distal cycle and sculpture. It is common in the Paleocene at Site 167.

Family THORACOSPHAERACEAE Schiller, 1930

Genus THORACOSPHAERA Kamptner, 1927

Thoracosphaera prolata Bukry and Bramlette

Thoracosphaera prolata Bukry and Bramlette, 1969, p. 141, pl. 3, fig. 18.

Remarks: This large prolate *Thoracosphaera* is rare in the Middle Eocene at Site 171.

Thoracosphaera saxea Stradner

Thoracosphaera saxea Stradner, 1961, p. 84, fig. 71; Boudreaux and Hay, 1969, p. 265, pl. 4, figs. 2-5.

Remarks: Whereas *Thoracosphaera* is rare to absent from most sediments from the central Pacific studied for this report, this species occurs in fairly large numbers in the middle Miocene at Site 171.

Family RHABDOSPHAERACEAE Lemmermann *in* Brandt and Apstein, 1908

Genus RHABDOSPHAERA Haeckel, 1894

Rhabdosphaera clavigera Murray and Blackman

Rhabdosphaera clavigera Murray and Blackman, 1898, p. 438-439, pl. 15, figs. 13-15; Boudreaux and Hay, 1969, p. 266-267, pl. 4, figs. 6-10.

Remarks: This species was only observed in the Pleistocene at Sites 167 and 171.

Genus BRAMLETTEIUS Gartner, 1969

Bramletteius serraculoides Gartner

Bramletteius serraculoides Gartner, 1969, p. 31, pl. 1, figs. 1-3.

Remarks: This species is common in sediments of middle Eocene to early Oligocene age. *Bramletteius serraculoides* is most abundant in open-ocean deposits. Other mid-Tertiary Rhabdosphaeraceae (*Rhabdolithus, Blackites*) are usually restricted to near-shore deposits.

Family CERATOLITHACEAE Norris, 1965

Genus CERATOLITHUS Kamptner, 1950

Ceratolithus amplificus Bukry and Percival

Ceratolithus amplificus Bukry and Percival, 1971, p. 125-126, pl. 1, figs. 9-11.
Remarks: This species has a broadly pointed extension on the outer part of the arch and shows moderate birefringence in cross-polarized light. It occurs in the uppermost Miocene at Site 171.

Ceratolithus cristatus Kamptner

Ceratolithus cristatus Kamptner, 1954, p. 43, figs. 44, 45.
Remarks: This species has fairly slender arms and is bright in cross-polarized light. It occurs in the Quaternary at Sites 166, 167, and 171.

Ceratolithus rugosus Bukry and Bramlette

Ceratolithus rugosus Bukry and Bramlette, 1968, p. 152, pl. 1, figs. 5-9.
Remarks: This species has robust arms and shows high birefringence. It is common in the Pliocene at Sites 165 and 167.

Ceratolithus tricorniculatus Gartner

Ceratolithus tricorniculatus Gartner, 1967, p. 5, pl. 10, figs. 4-6.
Remarks: This species is used in its original sense for fairly slim ceratoliths with a horn-like projection. It is dark in cross-polarized light. It occurs in the basal Pliocene at Site 171.

Family TRIQUETRORHABDULACEAE Lipps, 1969

Genus TRIQUETRORHABDULUS Martini, 1965

Triquetrorhabdulus carinatus Martini

Triquetrorhabdulus carinatus Martini, 1965, p. 408, pl. 36, figs. 1-3.
Remarks: This species occurs in the upper Oligocene and lower Miocene at Sites 165, 166, 167, and 171. It can be very abundant in some layers.

Triquetrorhabdulus inversus Bukry and Bramlette

Triquetrorhabdulus inversus Bukry and Bramlette, 1969, p. 142, pl. 1, figs. 9-14.
Remarks: This species differs from *Triquetrorhabdulus carinatus* by having opposite crystallographic orientation of the keels (i.e., distinct outlines of the two side keels if parallel to polarizing direction). *Triquetrorhabdulus inversus* is restricted to the middle Eocene and was observed at Sites 165, 167, 168, and 171.

Triquetrorhabdulus milowii Bukry

Triquetrorhabdulus milowii Bukry, 1971, p. 325, pl. 7, figs. 9-12.
Remarks: This species differs from *Triquetrorhabdulus carinatus* by being much shorter and wider. It occurs in the lower Miocene at Site 171.

Triquetrorhabdulus rugosus Bramlette and Wilcoxon

Triquetrorhabdulus rugosus Bramlette and Wilcoxon, 1967, p. 128-129, pl. 9, figs. 17, 18.
Remarks: This species differs from other species of *Triquetrorhabdulus* in having two thick and rugose extended edges and a low but sharp median ridge. It occurs in the Middle Miocene at Site 167.

Family DISCOASTERACEAE Vekshina, 1959

Genus DISCOASTER Tan, 1927

Discoaster adamanteus Bramlette and Wilcoxon

Discoaster adamanteus Bramlette and Wilcoxon, 1967, p. 108, pl. 7, fig. 6.
Discoaster obtusus Gartner, 1967, p. 2-3, pl. 3, figs. 1-6.
Discoaster stellulus Gartner, 1967, p. 3, pl. 4, figs. 1-3.
Remarks: This species is used in a broad sense for small star-shaped discoasters with stubby rays with or without ridges. It occurs in the middle Miocene at Site 166.

Discoaster asymmetricus Gartner

Discoaster asymmetricus Gartner, 1969, p. 598, pl. 1, figs. 1-3.
Remarks: This five-rayed discoaster, which has unequal angles between adjacent rays, occurs in the Pliocene at Site 171.

Discoaster barbadiensis Tan
(Plate 10, Figure 3)

Discoaster barbadiensis Tan, 1927, p. 119; Bramlette and Riedel, 1954, p. 398, pl. 39, fig. 5.
Remarks: This discoaster with 10 to 18 rays and a central knob is common in the middle and upper Eocene at Sites 165, 167, 168, and 171.

Discoaster bellus Bukry and Percival
(Plate 5, Figure 3)

Discoaster bellus Bukry and Percival, 1971, p. 128, pl. 3, figs. 1, 2.
Remarks: This simple five-rayed discoaster lacks a knob and has straight rays that terminate in points.
It is common in the lowermost part of the upper Miocene; it occurs only at Site 167.

Discoaster berggrenii Bukry

Discoaster berggrenii Bukry, 1971, p. 45, pl. 2, figs. 4-6.
Remarks: This five-rayed discoaster with a relatively large central area with a knob was found in the upper Miocene at Site 167.

Discoaster braarudii Bukry
(Plate 4, Figure 4)

Discoaster braarudii Bukry, 1971, p. 45, pl. 2, fig. 10.
Remarks: This species is very similar to *Discoaster brouweri,* but its rays are straight and not bent down. *D. braarudii* is quite common in the middle and upper Miocene at Sites 166, 167, and 171.

Discoaster brouweri Tan
(Plate 5, Figure 5)

Discoaster brouweri Tan, 1927, p. 20, text-fig. 2 (8a, b); *emend.* Bramlette and Riedel, 1954, p. 402, pl. 39, fig. 12, text-figs. 3a,b.
Remarks: Only specimens with five and six strongly bent rays are assigned to this species. This species first occurs in the upper Miocene and disappears in the uppermost Pliocene. It was found at Sites 166, 167, and 171.

Discoaster calcaris Gartner

Discoaster calcaris Gartner, 1967, p. 2, pl. 2, figs. 1-3.
Remarks: This species usually has six slender rays which are bent downward near the tip. The end of the ray is bifurcated. *Discoaster calcaris* occurs in the upper Miocene at Site 167.

Discoaster sp. cf. D. calculosus Bukry

Discoaster calculosus Bukry, 1971, p. 46, pl. 2, figs. 7-9.
Remarks: Specimens assigned to this species have six rays with a short free length and broad bifurcations. The pebbly surface is not well developed in the specimens found in sediments from the central Pacific. It was observed in the lower Miocene at Site 166.

Discoaster challengeri Bramlette and Riedel

Discoaster challengeri Bramlette and Riedel, 1954, p. 401, pl. 39, fig. 10.
Remarks: This species has parallel sides of the rays and wide bifurcations. It occurs in the upper Miocene at Site 167 and in the middle Miocene at Site 171.

Discoaster deflandrei Bramlette and Riedel
(Plate 6, Figure 5; Plate 8, Figure 3)

Discoaster deflandrei Bramlette and Riedel, 1954, p. 399, pl. 39, fig. 6, text-fig. 1a-c.

Remarks: This species is used in a broad sense for usually six-rayed discoasters with wide bifurcating rays. Secondary calcite overgrowth changes the morphology of this species considerably. *Discoaster deflandrei* occurs in the Oligocene at Site 165, the upper Eocene to lower Miocene at Site 166, the middle Eocene to upper Oligocene at Site 167, and in the Oligocene to lower Miocene at Site 171.

Discoaster divaricatus Hay

Discoaster divaricatus Hay, in Hay et al., 1967, p. 451, pl. 3, figs. 7-9.

Discoaster aulakos Gartner, 1967, p. 2, pl. 4, figs. 4, 5.

Remarks: Discoasters with thick-ended rays, bifurcating or flat ray tips, and angular interray species are included in this species. It is fairly common in the Oligocene to lower Miocene at Sites 165, the lower to middle Miocene at Sites 167 and 171.

Discoaster druggii Bramlette and Wilcoxon

Discoaster extensus Bramlette and Wilcoxon, 1967, p. 110, pl. 8, figs. 2-8.

Discoaster druggi Bramlette and Wilcoxon, 1967, p. 220 (nom. subst. pro *D. extensus* Bramlette and Wilcoxon, 1967, *non* Hay, 1967).

Remarks: This species has a broad central area and six bluntly rounded, truncated or notched rays. It occurs in small numbers in the Lower Miocene at Sites 166 and 171.

Discoaster exilis Martini and Bramlette

Discoaster exilis Martini and Bramlette, 1963, p. 852, pl. 104, figs. 1-3.

Remarks: This discoaster is characterized by slender rays with faint ridges and a constriction below the short bifurcations. It occurs in the middle Miocene at Sites 166, 167, and 171.

Discoaster kugleri Martini and Bramlette

Discoaster kugleri Martini and Bramlette, 1963, p. 853, pl. 102, figs. 11-13.

Remarks: This discoaster has a large central area and many specimens have inclined rays resulting in a lack of radial symmetry of the asterolith. *Discoaster kugleri* is restricted to the upper part of the Middle Miocene.

Discoaster mohleri Bukry and Percival
(Plate 12, Figures 8, 9, 10; Plate 13, Figure 5)

Discoaster gemmeus Stradner, of Hay and Mohler, 1967, p. 1538, pl. 204, figs. 19-21, pl. 205, figs. 1-3, pl. 206, figs. 3, 5, 6, 8.

Discoaster mohleri Bukry and Percival, 1971, p. 128-129, pl. 3, figs. 3-5.

Remarks: These small asteroliths have 9 to 16 straight rays with broad points and virtually no free length. They occur in the Paleocene at Site 167.

Discoaster multiradiatus Bramlette and Riedel

Discoaster multiradiatus Bramlette and Riedel, 1954, p. 396, pl. 38, fig. 10.

Remarks: Only rare reworked specimens were found in the middle Eocene at Site 171.

Discoaster neohamatus Bukry and Bramlette
(Plate 5, Figure 2)

Discoaster neohamatus Bukry and Bramlette, 1969, p. 133, pl. 1, figs. 4-6.

Remarks: This species has six long slender rays which bend in one direction and terminate in points. It occurs in the upper Miocene at Site 167.

Discoaster nodifer (Bramlette and Riedel) Bukry

Discoaster tani nodifer Bramlette and Riedel, 1954, p. 397, pl. 39, fig. 2.

Discoaster nodifer (Bramlette and Riedel) Bukry, 1973b, p. 678.

Remarks: This species has six to eight rays with nodes. It was found in the middle Eocene to lower Oligocene at Sites 165, 167, and 171 and in the upper Eocene at Site 166.

Discoaster pentaradiatus Tan
(Plate 5, Figure 1; Plate 6, Figure 1)

Discoaster pentaradiatus Tan, 1927, p. 416, fig. 14.

Remarks: This discoaster has five long slender bifurcate rays. It occurs in the Pliocene at Site 171.

Discoaster perplexus Bramlette and Riedel

Discoaster perplexus Bramlette and Riedel, 1954, p. 400, pl. 29, fig. 9.

Remarks: This is probably not a real discoaster. It ranges from the lower Miocene to Holocene (only in sediments, it has not yet been found in the plankton). It was observed in the middle Miocene at Sites 167 and 171.

Discoaster robustus Haq
(Plate 9, Figure 6)

Discoaster robustus Haq, 1969, p. 12, pl. 5, fig. 7, text-fig. 1c.

Remarks: This small discoaster cone-shaped with short robust rays occurs rarely in the middle Eocene at Site 171.

Discoaster saipanensis Bramlette and Riedel
(Plate 9, Figure 6; Plate 10, Figure 5)

Discoaster saipanensis Bramlette and Riedel, 1954, p. 398, pl. 39, fig. 4.

Remarks: Asterolith with six to seven pointed rays and a short stem in the center. This species was found in the middle and upper Eocene at Sites 165, 167, and 171.

Discoaster surculus Martini and Bramlette
(Plate 5, Figure 5)

Discoaster surculus Martini and Bramlette, 1963, p. 854, pl. 104, figs. 10-12.

Remarks: This species has a third spine between the bifurcations at the tip of the ray. It occurs in the upper Miocene and Pliocene at Sites 167 and 171.

Discoaster tamalis Kamptner

Discoaster tamalis Kamptner, 1967, p. 166, pl. 24, fig. 131, text-fig. 28.

Remarks: This species has four rays which are strongly bent downwards. It is often assigned to *Discoaster brouweri* (four-rayed *D. brouweri*). *Discoaster tamalis* is most abundant in the lower part of the upper Pliocene. It was found at Site 171.

Discoaster tani Bramlette and Riedel

Discoaster tani Bramlette and Riedel, 1954, p. 397, pl. 39, fig. 2.

Remarks: This species has five to six thick rays with almost parallel sides and lacks the paired nodes present in *Discoaster nodifer*. It occurs in the middle Eocene at Site 171.

Discoaster triradiatus Tan

Discoaster triradiatus Tan, 1927, p. 417.

Remarks: This discoaster has three downward bent arms with pointed terminations. It is often assigned to *Discoaster brouweri* (as three-rayed form). It occurs in the Pliocene at Site 171.

Discoaster variabilis Martini and Bramlette
(Plate 5, Figure 4)

Discoaster variabilis Martini and Bramlette, 1963, p. 854, pl. 104, figs. 4-9.

Remarks: This species has usually five or six arms which have some taper outward and terminate in bifurcations. The subspecies *Discoaster variabilis decorus* and *D. variabilis pansus* are not distinguished in this report. *Discoaster variabilis* occurs in the middle Miocene to Pliocene at Sites 166, 167, and 171.

Discoaster sp. cf. D. wemmelensis Achuthan and Stradner

Discoaster wemmelensis Achuthan and Stradner, 1969, p. 5, pl. 4, figs. 3, 4, text-fig. 2.

Remarks: The specimens observed in the central Pacific are similar to the ones illustrated in Roth, Baumann, and Bertolino (1971). They have fewer rays and are thicker than the holotype. *Discoaster* sp. cf. *D. wemmelensis* was found in the middle Miocene at Site 165.

Discoaster woodringii Bramlette and Riedel

Discoaster woodringi Bramlette and Riedel, 1954, p. 40, pl. 39, fig. 8a,b.

Remarks: This "species" is used in a broad sense for thick discoasters with arms joined throughout their length. *Discoaster woodringii* was encountered in the Oligocene at Sites 165, 166, and 167 and in the Oligocene to middle Miocene at Site 171.

Genus CATINASTER Martini and Bramlette, 1963

Catinaster coalitus Martini and Bramlette

Catinaster coalitus Martini and Bramlette, 1963, p. 851, pl. 103, figs. 7-10.

Remarks: This small basket-like asteroliths was found only in the middle Miocene at Site 171. It occurs in a position which is stratigraphically too low, which is probably due to mixing during the drilling operation.

Family SPHENOLITHACEAE Vekshina, 1959

Genus SPHENOLITHUS Deflandre in Grassé, 1952

Sphenolithus abies Deflandre
(Plate 4, Figure 5)

Sphenolithus abies Deflandre, *in* Deflandre and Fert, 1954, p. 164, pl. 10, figs. 1-4.

Remarks: This sphenolith has some larger apical spines but is very similar to *S. moriformis.* It was observed in the Pliocene and upper Miocene at Sites 167 and 171.

Sphenolithus belemnos Bramlette and Wilcoxon

Sphenolithus belemnos Bramlette and Wilcoxon, 1967, p. 118, pl. 2, figs. 1-3.

Remarks: Only small specimens were observed in the lower Miocene at Sites 165 and 167.

Sphenolithus capricornutus Bukry and Percival

Sphenolithus capricornutus Bukry and Percival, 1971, p. 140, pl. 6, figs. 4-6.

Remarks: This species with two diverging spines occurs in small numbers reworked in the Pleistocene at Site 165.

Sphenolithus ciperoensis Bramlette and Wilcoxon

Sphenolithus ciperoensis Bramlette and Wilcoxon, 1967, p. 120, pl. 2, figs. 15-18.

Remarks: In cross-polarized light at 45° to the direction of polarization, the extinction lines do not cross. This species was found in the upper Oligocene at Sites 165, 167, and 171.

Sphenolithus conicus Bukry

Sphenolithus conicus Bukry, 1971, p. 320, pl. 5, figs. 10-12.

Remarks: This large triangular species of *Sphenolithus* shows an extinction cross which divides its base into quadrants when the long axis of the fossil is aligned with a polarization direction. This species is rare in the uppermost Oligocene and the lowermost Miocene at Site 171.

Sphenolithus dissimilis Bukry and Percival

Sphenolithus dissimilis Bukry and Percival, 1971, p. 140, 142, pl. 6, figs. 7-9.

Remarks: This small species consists of three parts: a fairly high basal cycle of inclined elements, a middle portion of elements perpendicular to the long axis and an upper portion of about three parallel large spines. It occurs in the lower Miocene at Site 165.

Sphenolithus distentus (Martini) Bramlette and Wilcoxon

Furcatolithus distentus Martini, 1965, p. 407, pl. 35, figs. 7-9.

Sphenolithus distentus (Martini) Bramlette and Wilcoxon, 1967, p. 122, pl. 1, fig. 5, pl. 2, figs. 4, 5.

Remarks: This species shows an incomplete extinction cross at 45° to the planes of polarization. It occurs in the upper Oligocene at Sites 165, 167, and 171.

Sphenolithus furcatolithoides Locker

Sphenolithus furcatolithoides Locker, 1967, p. 363, pl. 1, figs. 14-16, text-figs. 7, 8.

Remarks: This species has two long apical spines which are parallel in the lower part and bend away from the long axis. Under cross nicols the apical spines are bright when parallel to the direction of polarization of either polarizer. Members of the *Sphenolithus distentus* group have the apical spine bright when the long axis is at 45° to the direction of polarization. This species occurs in the middle Eocene at Sites 165, 167, and 171.

Sphenolithus heteromorphus Deflandre

Sphenolithus heteromorphus Deflandre, 1953, p. 1785, 1786, figs. 1, 2.

Remarks: This sphenolith with a large apical spine which acts optically as a single unit occurs in the middle Miocene at Sites 166, 167, and 171.

Sphenolithus obtusus Bukry

Sphenolithus obtusus Bukry, 1971, p. 321, pl. 6, figs. 1-9.

Remarks: This species has a large spine consisting of two elements and a short basal cycle. It occurs in the middle Eocene at Sites 165, 167, and 171.

Sphenolithus moriformis (Brönnimann and Stradner) Bramlette and Wilcoxon
(Plate 6, Figures 4, 5; Plate 10, Figure 5; Plate 13, Figures 2, 4, 6)

Nannoturbella moriformis Brönnimann and Stradner, 1960, p. 368, figs. 11-16.

Sphenolithus pacificus Martini, 1965, p. 407, pl. 36, figs. 7-10.

Sphenolithus moriformis (Brönnimann and Stradner) Bramlette and Wilcoxon, 1967, pp. 124, 126, pl. 3, figs. 1-6.

Remarks: This is the most abundant species of *Sphenolithus.* It occurs in from the Paleocene through the Miocene at Sites 165, 166, 167, and 171.

Sphenolithus predistentus Bramlette and Wilcoxon
(Plate 8, Figure 5)

Sphenolithus predistentus Bramlette and Wilcoxon, 1967, p. 126, pl. 1, fig. 6, pl. 2, figs. 10, 11.

Remarks: This species has a large apical spine and a low basal cycle. It occurs from the middle Eocene to the lower Oligocene at Sites 165, 167, and 171.

Sphenolithus pseudoradians Bramlette and Wilcoxon

Sphenolithus pseudoradians Bramlette and Wilcoxon, 1967, p. 126, 128, pl. 2, figs. 12-14.

Remarks: This large sphenolith with a wide-flaring distal spine occurs usually in small numbers from the middle Eocene to the lower Oligocene at Sites 165, 167, and 171.

Sphenolithus radians Deflandre

Sphenolithus radians Deflandre *in* Grassé, 1952, p. 466, figs. 343 J-K, 363 A-G.

Remarks: This sphenolith with a fairly large apical spine composed of four blades. Its morphology and size is quite variable. It occurs in the middle Eocene at Sites 165 and 171 and in the middle to upper Eocene at Site 167.

Incertae sedis

Genus NANNOTETRINA Achuthan and Stradner

Nannotetrina fulgens (Stradner) Achuthan and Stradner

Nannotetraster fulgens Stradner *in* Martini and Stradner, 1960, p. 268, figs. 10, 16.

Nannotetraster alatus Martini *in* Martini and Stradner, 1960, p. 268, figs. 9, 15.

Chiphragmalithus (?) *quadratus* Bramlette and Sullivan, 1961, p. 157, pl. 10, figs. 14, 15.

Nannotetrina fulgens (Stradner) Achuthan and Stradner, 1969, p. 7, pl. 5, figs. 4-6.

Remarks: This species has four usually pointed arms with a pronounced ridge which is offcenter. Secondary calcite overgrowth completely covers this ridge in most samples from the central Pacific. This species occurs in the middle Eocene at Sites 165 and 167.

Nannotetrina mexicana (Stradner) n. comb.

Trochaster mexicanus Stradner, 1959, p. 480-481, fig. 55.

Nannotetraster mexicanus (Stradner) Martini and Stradner, 1960, p. 266, 267.

Remarks: This species has four broad arms with ridges in the center. The specimens from the central Pacific are moderately to strongly overgrown with secondary calcite obscuring much of the detail structures. It occurs in the middle Eocene at Sites 165 and 167.

ACKNOWLEDGMENTS

I wish to thank M. N. Bramlette, Scripps Institution of Oceanography; David Bukry, Geological Survey; and Hans R. Thierstein, Swiss Federal Institute of Technology for stimulating discussions and valuable information on nannofossil biostratigraphy. I am grateful to David Bukry for his constructive review of this paper. Mrs. B. Murray, University of California at Riverside, provided some of the scanning-electron micrographs (Plates 1 and 2) and Miss E. Flentye helped with the scanning electron microscopy.

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PLATE 1

Scanning electron micrographs of Pleistocene nannofossils (*Gephyrocapsa oceanica* Zone); Sample 167-1-3

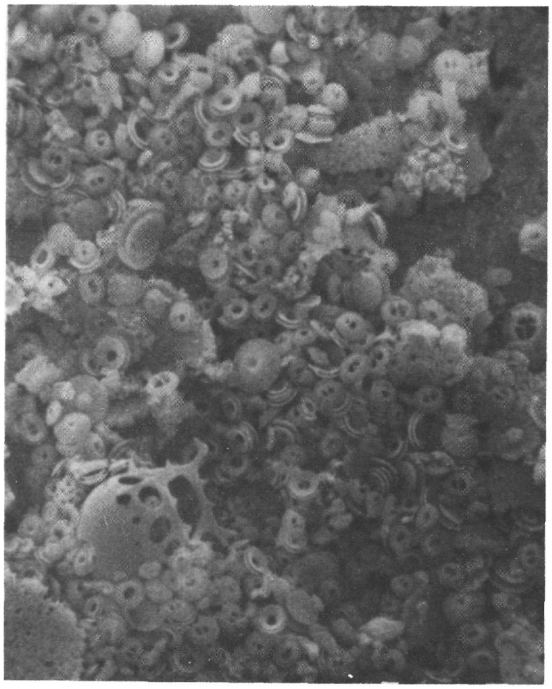
Figure 1 Flood of *Gephyrocapsa oceanica* with common *Cyclococcolithina leptopora* and few *Helicopontosphaera kamptneri.* Planktonic foraminiferal debris and radiolarian skeletons are also present. Magnification: 1000X.

Figure 2 Detailed view of the same assemblage. *Coccolithus pelagicus* (proximal) in the upper left and *Helicopontosphaera* sp. cf. *H. sellii* in the upper right, common *Gephyrocapsa oceanica,* and *Cyclococcolithina leptopora.* Magnification: 3000X.

Figure 3 Detailed view of the assemblage illustrated in Figure 1 with distal view of *Helicopontosphaera kamptneri* (displaying spirally arranged laths), *Cyclococcolithina leptopora, Gephyrocapsa oceanica* and a small undescribed species of *Crenalithus.* Magnification: 3000 X.

Figure 4 *Gephyrocapsa oceanica* (left) with a fairly wide bridge and proximal view of *Cyclococcolithina leptopora* with irregular elements resulting in jagged suture lines. Magnification: 10,000 X.

PLATE 1



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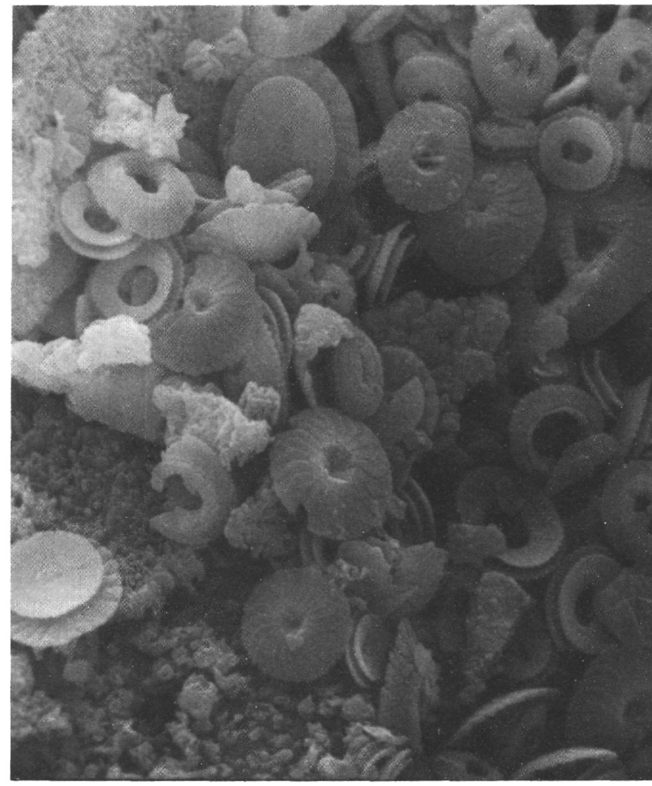

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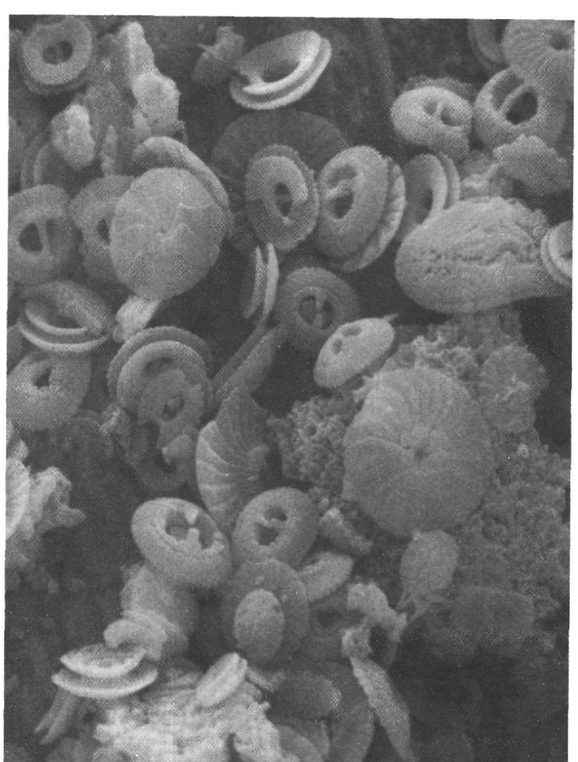

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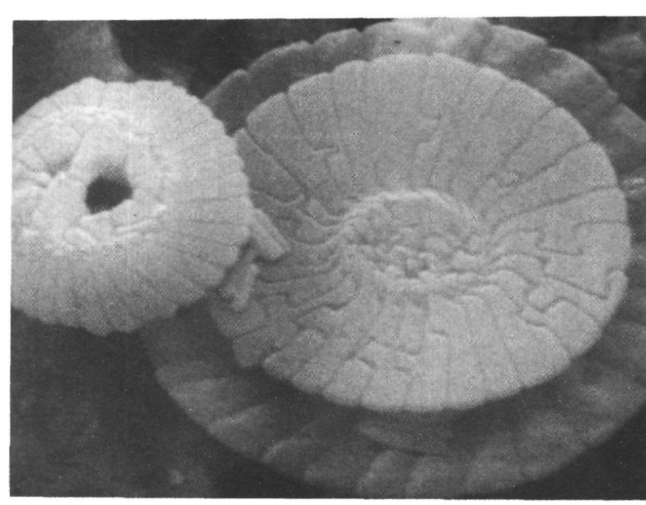


4

PLATE 2

Scanning electron micrographs of Pleistocene nannofossils (*Gephyrocapsa oceanica* Zone); Sample 167-1-3, Magellan Rise.

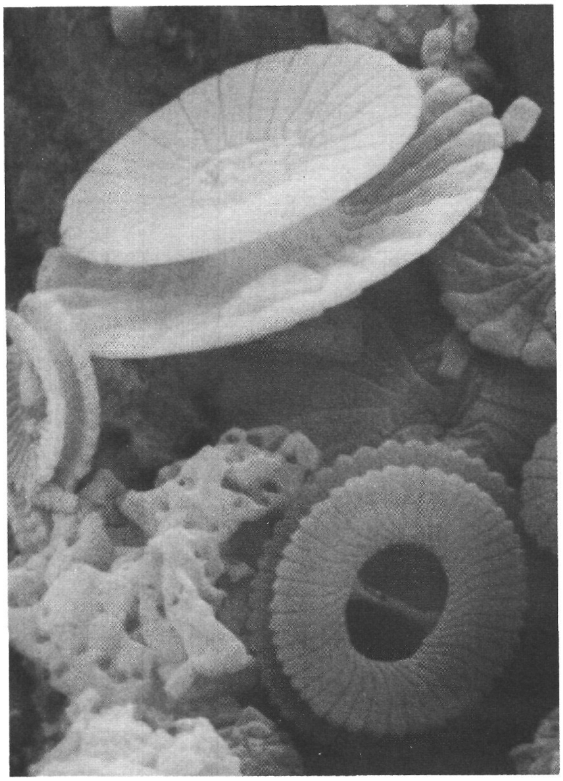
Figure 1 Oblique proximal view of *Cyclococcolithina leptopora* with almost straight radial sutures. Proximal view of a large specimen of *Gephyrocapsa oceanica* with the typical position of the bridge almost in the short axis of the ellipse. The bridge is very narrow. Magnification: 10,000X.

Figure 2 Proximal view of *Umiblicosphaera sibogae* with very irregular distal shield consisting of an outer cycle of elements of various shapes and sizes, a middle cycle of elongated pointed laths of varying length with intercalated elements and the innermost cycle of regular almost cubical elements surrounding a large central hole. In the right half of picture an oblique proximal view of *Cyclococcolithina leptopora* with jagged sutures and a small, undescribed *Crenalithus sp.* Note the lack of imbrication of the elements of both shields of *Gephyrocapsa oceanica* in the lower left. Magnification: 10,000X.

Figure 3 Proximal view of *Cyclococcolithina leptopora* with straight suture lines and very little imbrication. The elements of the distal shield (lower right) are strongly imbricate. Magnification: 20,000X.

Figure 4 Proximal view of a small specimen of *Umbilicosphaera sibogae*. Note the regular inner cycle, the pointed elements of the middle cycle and the irregular outer cycle in the proximal shield. The central hole is comparatively small for this species. Magnification: 18,000X.

PLATE 2



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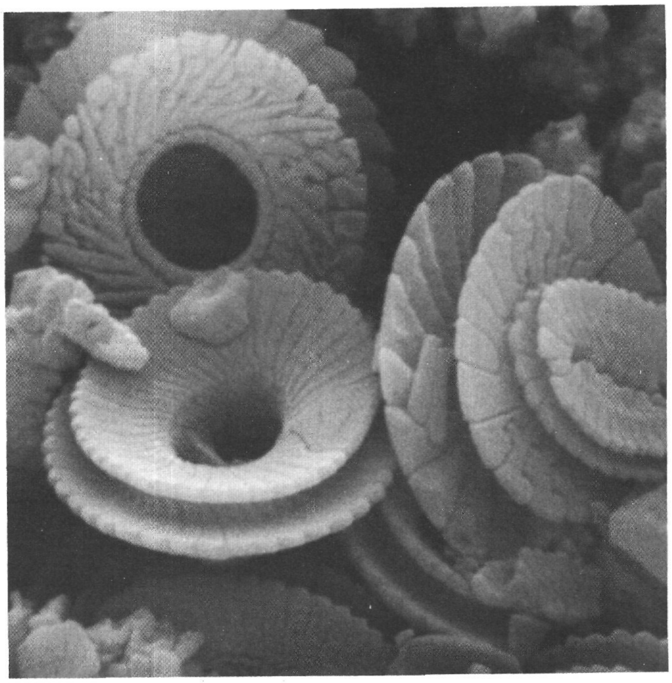

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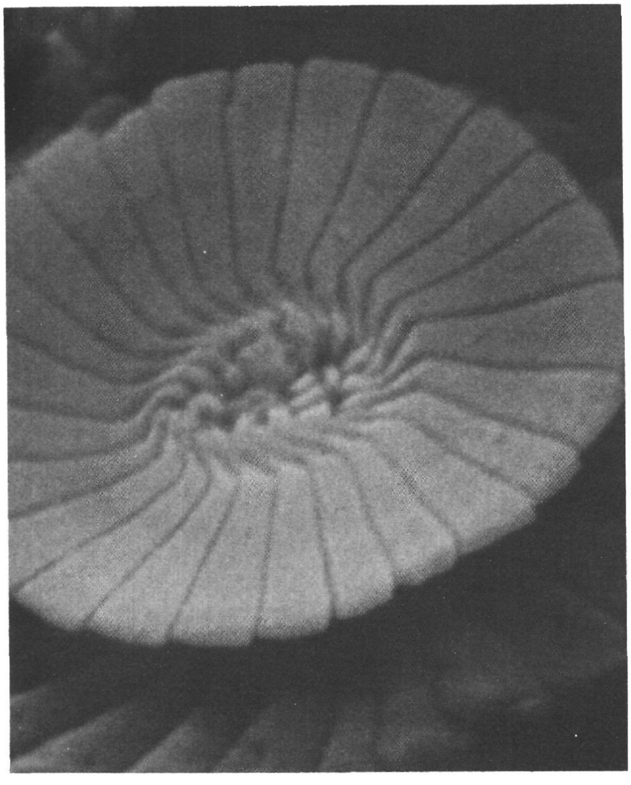

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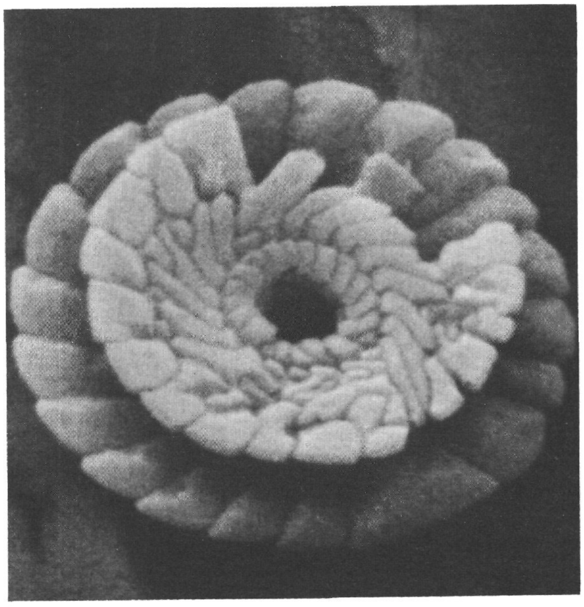

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PLATE 3

Scanning electron micrographs of lower Pliocene nannofossils; Sample 167-1-4, 50 cm

Figure 1 — Oblique proximal view of *Syracosphaera* sp. cf. *S. pulchra* showing the proximal shield, the almost complete median shield, and the remains of a proximal shield on the right-hand side. The central area is completely destroyed making identification difficult. Magnification: 10,000X.

Figure 2 — Distal view of *Syracosphaera* sp. cf. *S. pulchra* parts of the laths forming the central area preserved. The proximal shield consists of strongly imbricate elements.

Figure 3 — Distal view of *Crenalithus doronicoides* n. comb. (upper left) and proximal view (specimen in the lower right). The two shields are of almost the same size, the elements nonimbricate, and the outline of the shields crenulated. Proximal view of *Discoaster pentaradiatus* with irregular secondary growth on the arm. Magnification: 9900X.

Figure 4 — Proximal view of an almost circular specimen of *Pseudoemiliania lacunosa.* Only the distal shield has slits or indentations. Magnification: 10,000X.

Figure 5 — Distal view of *Cyclococcolithina macintyrei* (center), isolated proximal shield of *Cyclococcolithina leptopora* (lower right), proximal view of *Pseudoemiliania lacunosa* and *Discoaster pentaradiatus* (upper left). Magnification: 4800X.

Figure 6 — Distal view of an elliptical specimen of *Pseudoemiliania lacunosa* with a well-developed cycle of tabular imbricate elements surrounding the central area. Magnification: 9950X.

PLATE 3

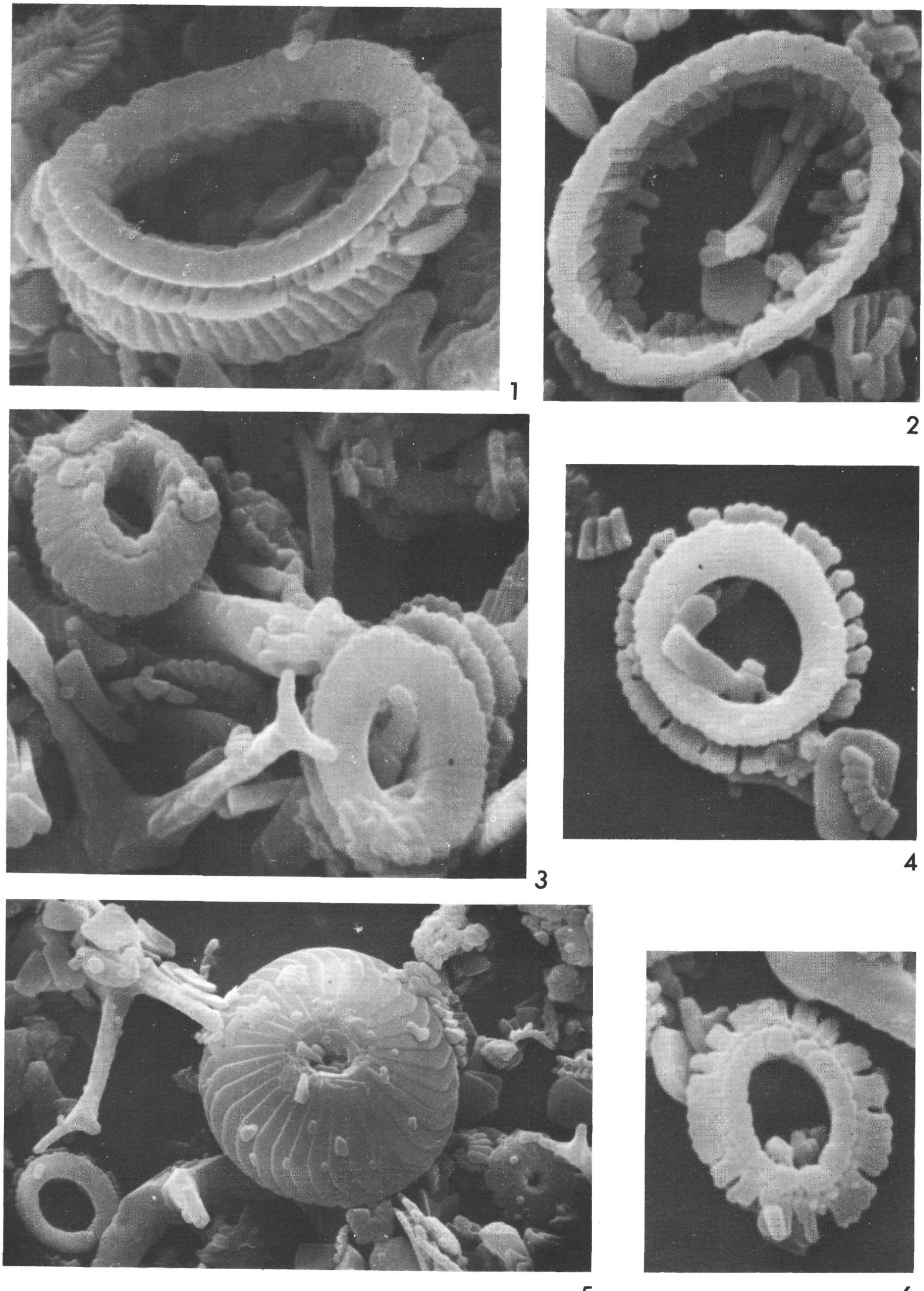


PLATE 4

Scanning electron micrographs of lower Pliocene (Figure 1) and upper Miocene (Figures 2-6) nannofossils; Samples: Figure 1: 171-1-4, 50 cm and Figures 2-6: 167-4-3, 47 cm

Figure 1	Distal view of *Reticulofenestra bisecta* (right of center) which is reworked from the upper Eocene to upper Oligocene. In the upper left-hand corner a proximal view of *Cyclococcolithina macintyrei* showing two cycles of imbricate tabular elements surrounding the central perforation. Distal view of an elliptical specimen of *Pseudoemiliania lacunosa* in the lower right-hand corner. Magnification: 4800X.
Figure 2	Proximal view of *Helicopontosphaera kamptneri*. The central area is slightly etched and shows signs of beginning disintegration. Magnification: 4800X.
Figure 3	Distal view of *Helicopontosphaera kamptneri*. The spirally arranged laths forming the distal layer are at least partly recrystallized and replaced by plates of irregular outline. The central area shows signs of etching. Proximal view of *Coccolithus pelagicus* with the proximal shield consisting of two cycles of elements separated by suture lines inclined in the opposite direction. Magnification: 4800X.
Figure 4	*Discoaster braarudii* with overgrowths on the arms. Magnification: 4800X.
Figure 5	Etched assemblage consisting of *Cyclococcolithina leptopora* with partly dissolved proximal shield (center) and isolated distal shield (upper right) of the same species. Three specimens of a small undescribed species of *Crenalithus*, two distal views (middle of lower margin and just above the center of the picture) and one oblique proximal view (upper left). This species seems to be identical to the one observed in the *Gephyrocapsa oceanica* Zone (Plate 1, Figure 2, center of picture). In the lower left *Sphenolithus abies*. Magnification: 10,000X.
Figure 6	*Coccolithus pelagicus*, distal view. The upper Miocene form of this species differs slightly from the recent ones. The edge of the crater-like depression is more angular not smooth and rounded as in recent specimens and the crystals lining the depression are much coarser. Magnification: 4800X.

PLATE 4

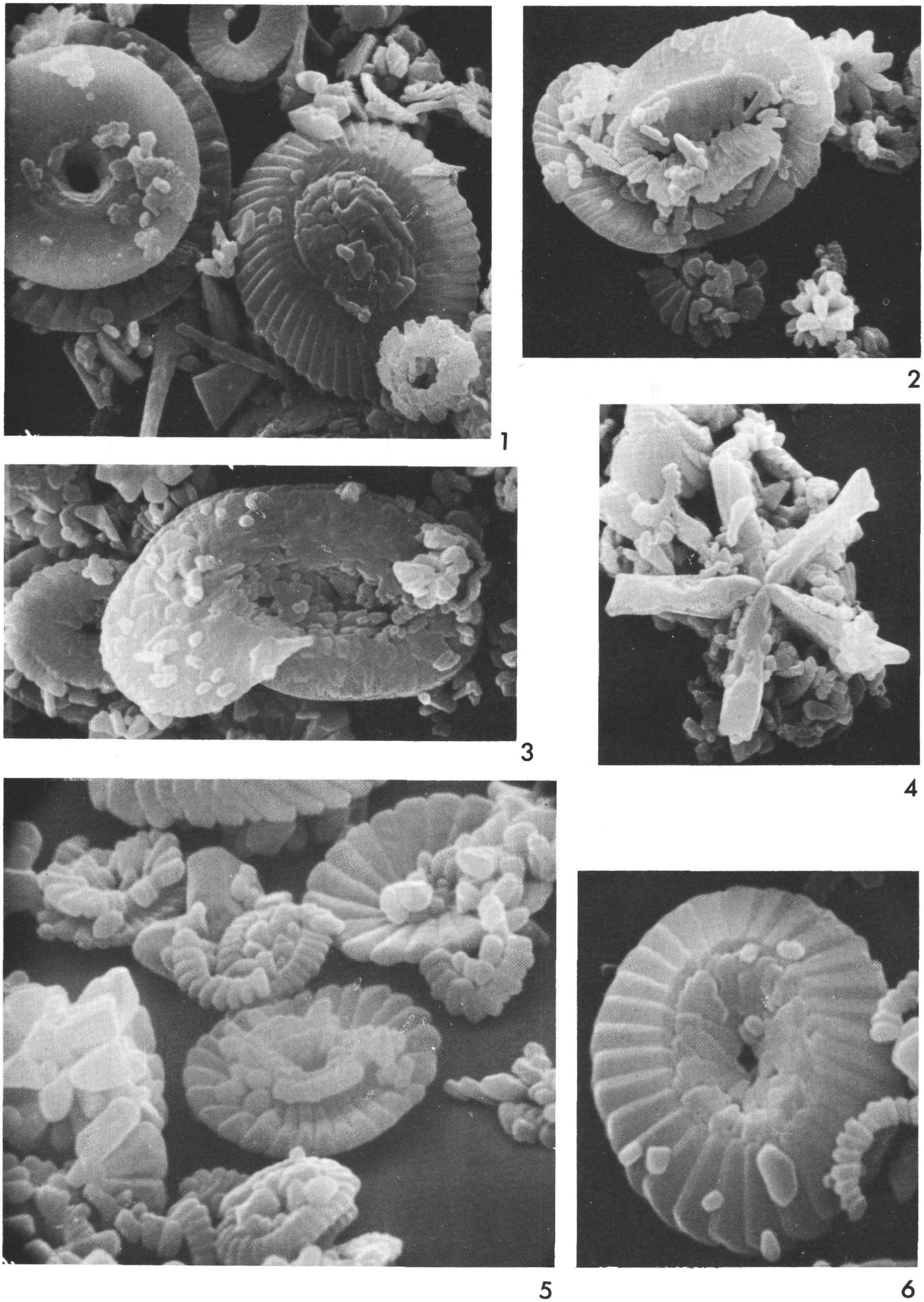


PLATE 5

Scanning electron micrographs of lower Pliocene and upper Miocene nannofossils

Figure 1 Three specimens of *Discoaster pentaradiatus* (distal views) with strongly bent arms but short (probably broken) bifurcations. Oblique side-views of *Syracosphaera sp.* in the lower left and in the interray area of the *Discoaster* to the right of the center. The distal view of *Cyclococcolithina leptopora* (upper right-hand quadrant) shows slight overgrowth leading to slightly jagged suture lines and irregular enlargement of some of the elements in the central crater. Magnification: 4800X. Sample 171-1-4, 50 cm, *D. tamalis* Zone.

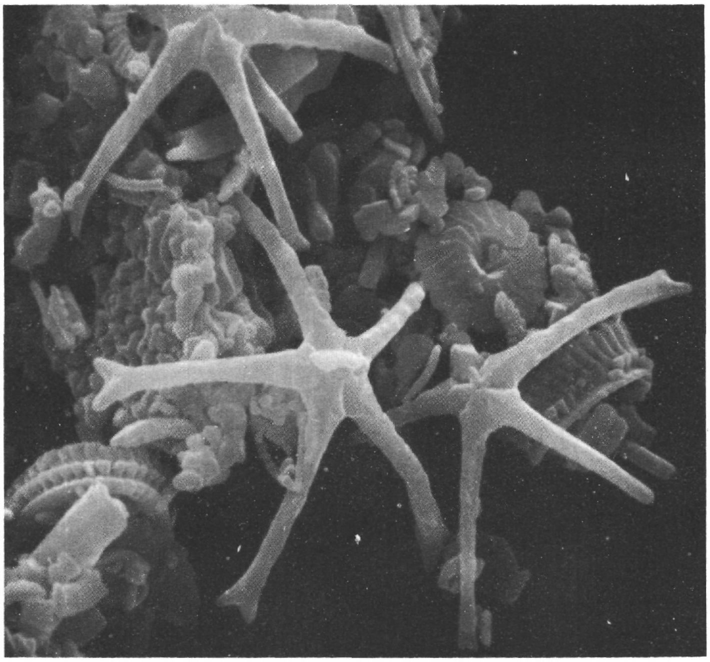
Figure 2 *Discoaster neohamatus* (distal view) with some overgrowths. Two small undescribed species of *Reticulofenestra* (?) lie on the two arms in the lower right-hand quadrant. Magnification: 4800X. Sample 167-4-3, 47 cm, *Discoaster bellus* Zone.

Figure 3 Distal view of *Discoaster bellus* with overgrowth resulting in distinctive crystal faces on the arms and extentions of three of the arms into the central area and coalescing in the center. The proximal shield of *Coccolithus pelagicus* to the right of the *Discoaster* shows three cycles of irregularly overgrown elements in the proximal shield. Magnification: 4800X. Sample 167-4-3, 47 cm.

Figure 4 Proximal view of *Discoaster variabilis* with slightly overgrown arms. Magnification: 4800X. Sample 171-1-4, 50 cm, *Discoaster tamalis* Zone.

Figure 5 Proximal view of *Discoaster surculus* (left), slightly overgrown and distal view of a small five-rayed specimen of *Discoaster brouweri*. Magnification: 4800X. Sample 171-1-4, 50 cm.

PLATE 5



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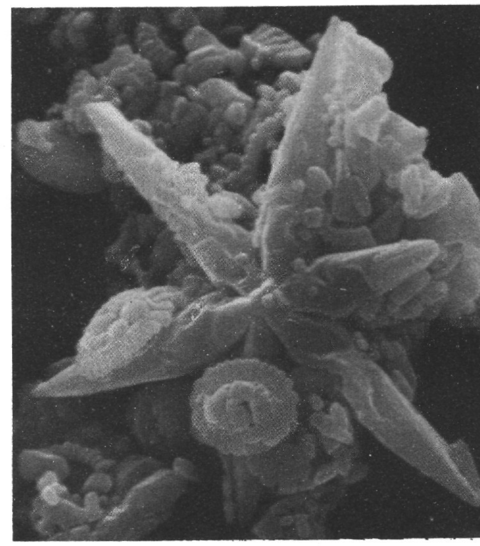

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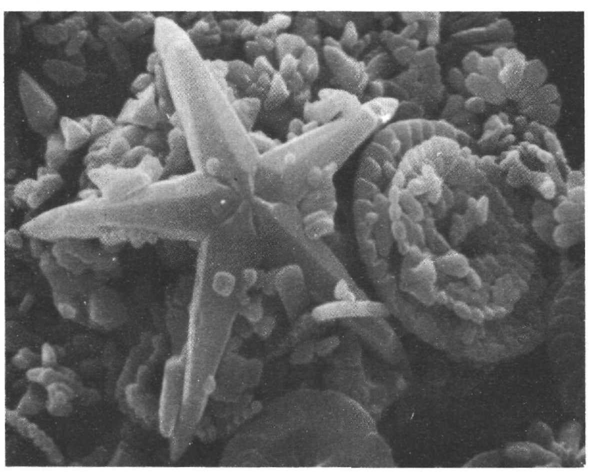

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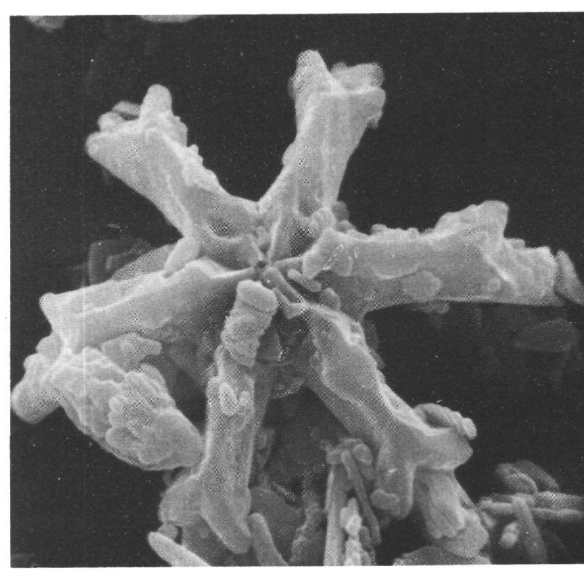

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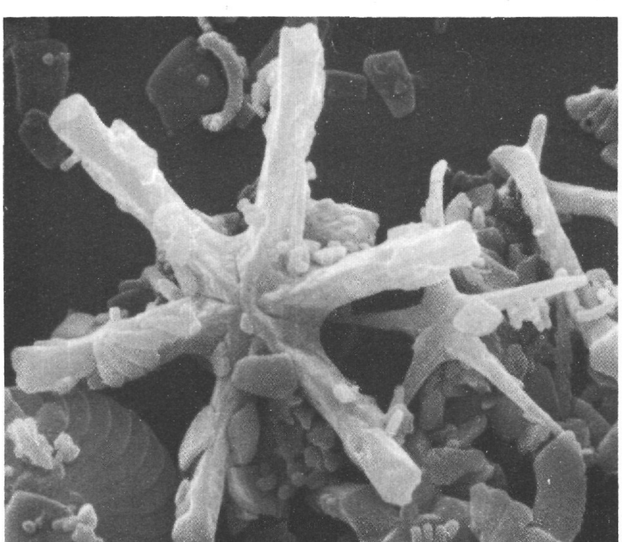

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PLATE 6

Scanning electron micrographs of upper Miocene and upper Oligocene nannofossils

Figure 1 — *Discoaster pentaradiatus* (distal view) with long bifurcating branches. In the lower right proximal view of *Pseudoemiliania lacunosa* and distal view of *Cyclococcolithina leptopora*. Magnification: 4800X. Sample 171-1-4, 50 cm, *D. tamalis* Zone.

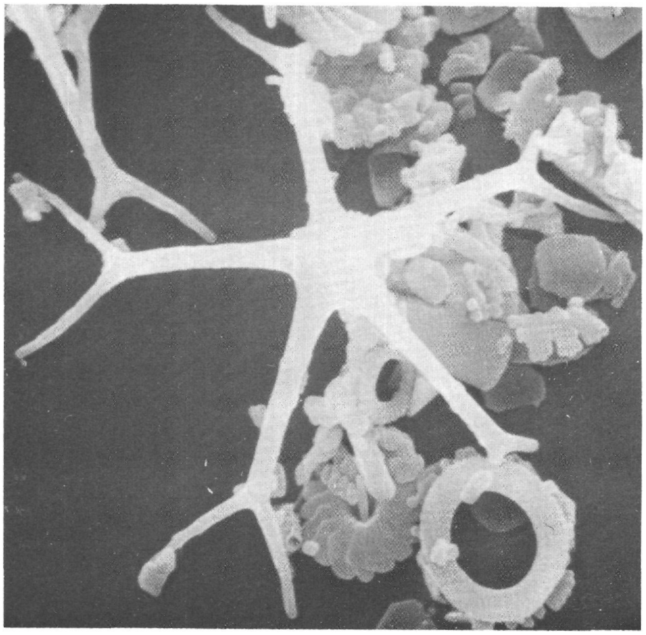
Figure 2 — *Cyclicargolithus floridanus* specimen in the upper left is a distal view, with an irregular cycle of imbricate tabular elements surrounding the center; the specimen in the lower right, seen from the proximal side, is etched and has an unusually large central opening. Magnification: 4800X. Sample 167-11-3, 50 cm, *R. abisecta* Zone.

Figure 3 — Side view of *Cyclicargolithus floridanus* showing that this species is fairly tall and the shield is well separated. Top view of *Sphenolithus moriformis*. Magnification: 5000X. Sample 167-11-3, 50 cm.

Figure 4 — Top view of the same specimen as illustrated in Figure 3. Note the slightly elliptical form of *Cyclicargolithus floridanus* with a well-developed cycle (two layers) of tabular elements around the center. Side view of a compact *Sphenolithus moriformis*. Magnification: 5000X. Sample 167-11-3, 50 cm.

Figure 5 — Typical assemblage belonging to the *Reticulofenestra abisecta* Zone with overgrown *Triquetrorhabdulus carinatus* in the center, strongly overgrown *Discoaster deflandrei* with diamond-shaped termination of the rays, displaying crystal faces and lacking bifurcation. The elliptical coccoliths belong to *Coccolithus miopelagicus* and the most common circular to slightly elliptical placolith is *Cyclicargolithus floridanus*. The coccolith which is seen in oblique proximal view in the center leaning against *Sphenolithus moriformis* is probably *Reticulofenestra abisecta* (center obscured by nannofossil debris. Magnification: 1900X. Sample 167-11-3, 50 cm.

PLATE 6



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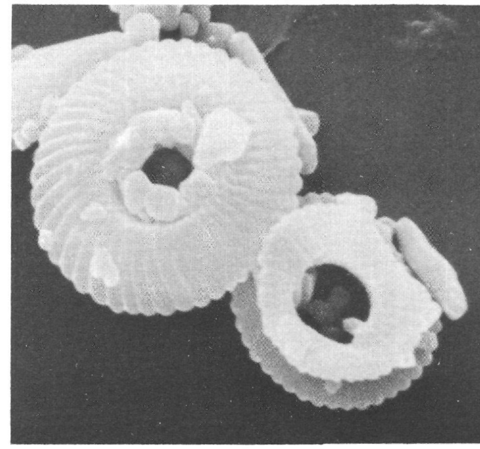

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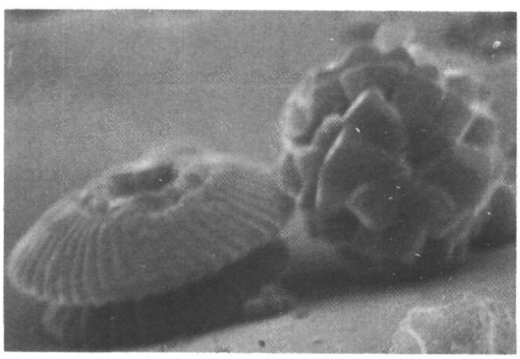

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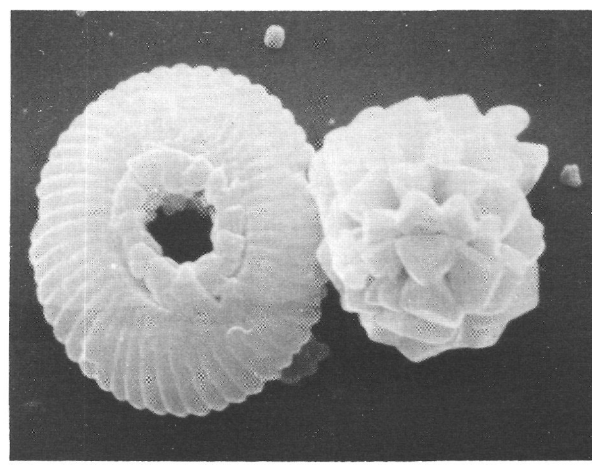

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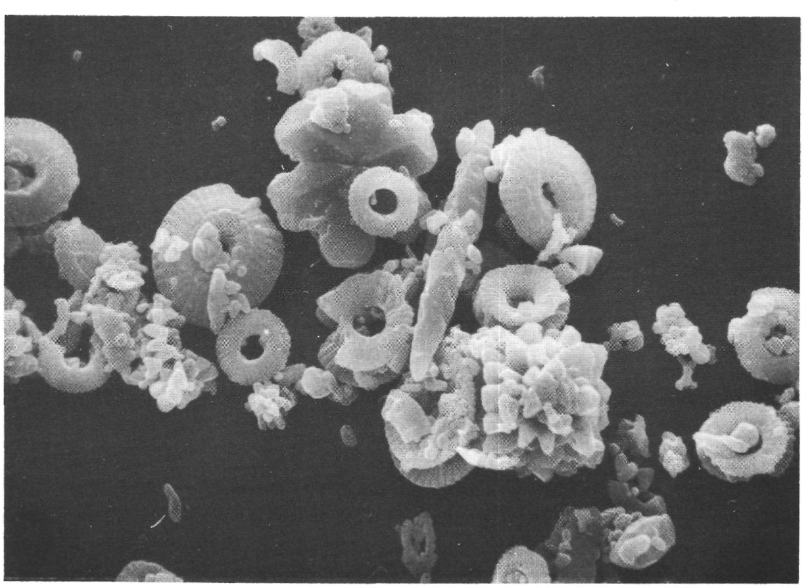

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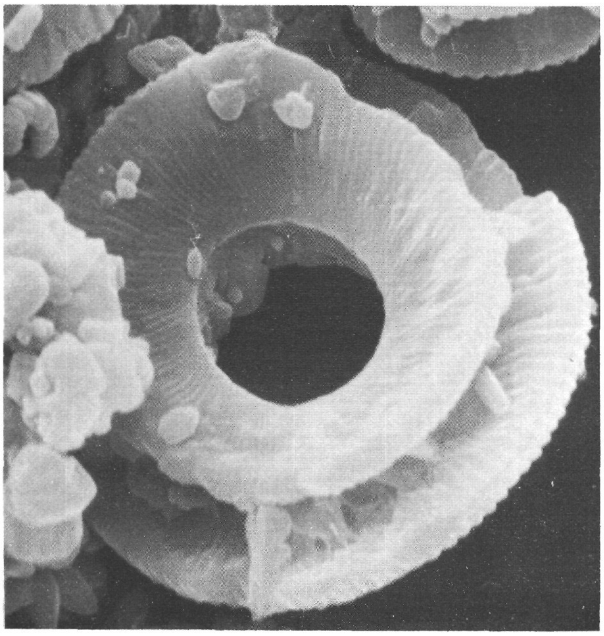
PLATE 7

Scanning electron micrographs of Oligocene nannofossils

Figure 1	Proximal view of *Reticulofenestra umbilica.* The central grill is missing completely probably due to etching and fragmentation. Some of the elements in both shields show irregular thickening due to overgrowth. Magnification: 4800X. Sample 167-23-4, 50 cm, *Ericsonia subdisticha* Zone.
Figure 2	Distal view of *Reticulofenestra abisecta* with well-developed cycle surrounding the central area consisting of a lower layer of narrow laths and an upper layer of tabular plates. Magnification: 4800X. Sample 167-11-3, 50 cm, *Reticulofenestra abisecta* Zone.
Figure 3	*Reticulofenestra umbilica,* distal view with cycle of imbricate tabular elements surrounging the central hole. Grill in the center destroyed by solution and/or fragmentation. Magnification: 4800X. Sample 167-23-4, 50 cm, *Ericsonia subdisticha* Zone.
Figure 4	Distal view of *Reticulofenestra bisecta* a cycle of two to three layers of imbricate tabular plates covers the central area. Magnification: 4800X. Sample 167-23-4, 50 cm.
Figure 5	Proximal view of *Reticulofenestra bisecta* with some overgrowth on the laths forming the central grill. Magnification: 4800X. Sample 167-23-4, 50 cm.

PLATE 7



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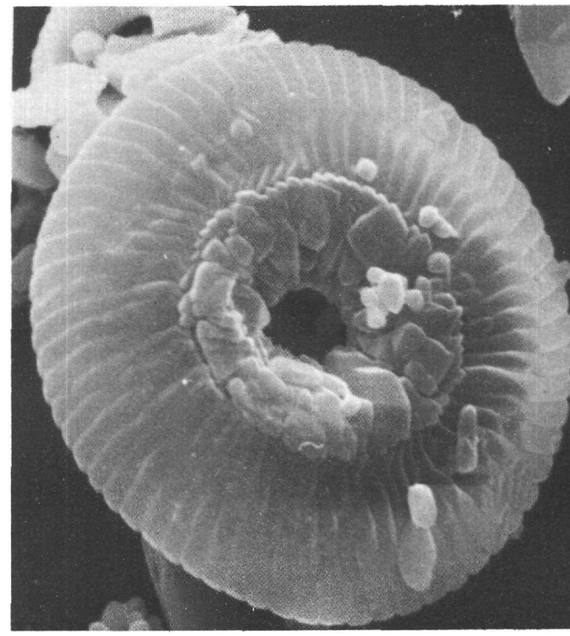

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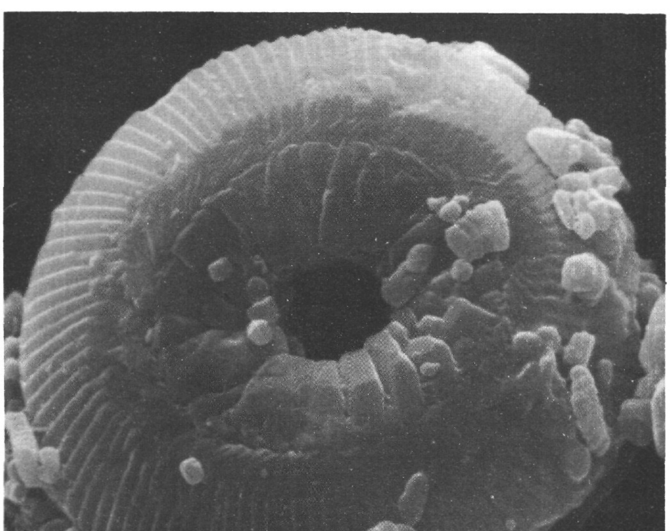

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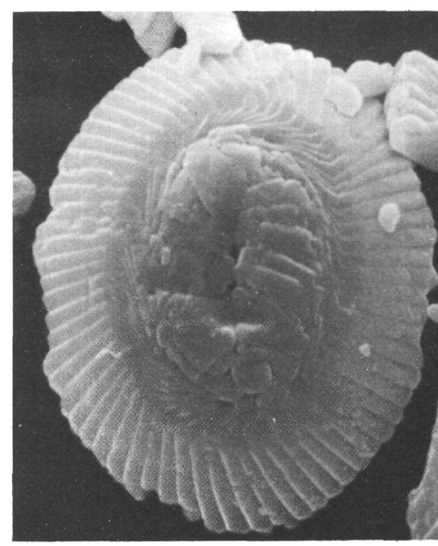

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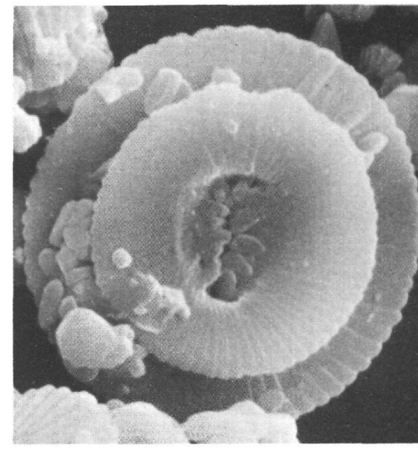

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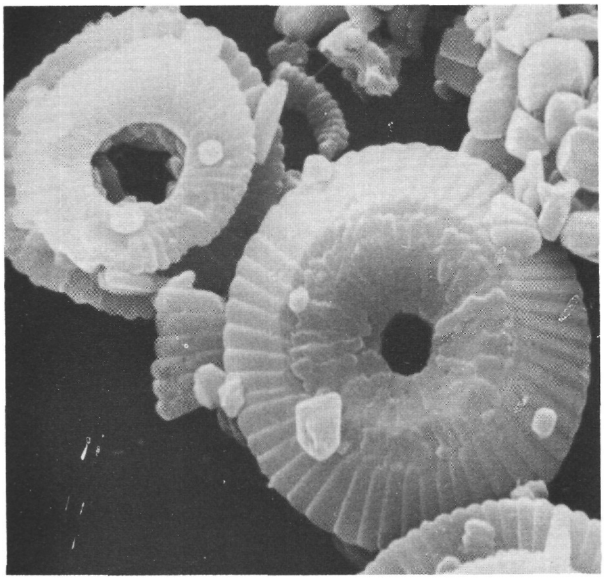
PLATE 8

Scanning electron micrographs of Oligocene nannofossils

Figure 1	Distal view of *Cyclococcolithina formosa* with a well-developed inner cycle consisting of elongate imbricate elements. In the upper left proximal view of *Cyclicargolithus floridanus* slightly etched and overgrown. Magnification: 4800X. Sample 167-23-4, 50 cm, *Ericsonia subdisticha* Zone.
Figure 2	Distal view of *Coccolithus eopelagicus*, well preserved. Magnification: 4800X. Sample 167-23-4, 50 cm.
Figure 3	*Discoaster deflandrei* strongly overgrown, with diamond shaped arms, delimited almost entirely by crystal faces. Magnification: 5000X. Sample 167-11-3, 50 cm, *Reticulofenestra abisecta* Zone.
Figure 4	Proximal view of *Coccolithus eopelagicus* with three well-developed cycles of elements (lower right), strongly overgrown discoaster of the *Discoaster deflandrei* group. *Cyclicargolithus floridanus* in the upper left, proximal view, strongly overgrown, with secondary crystals between the two shields; another specimen (proximal view also) in the lower right-hand corner. Magnification: 4800X. Sample 167-11-3, 50 cm.
Figure 5	*Sphenolithus predistentus* with overgrowths on the apical spine. Magnification: 9900X. Sample 167-23-4, 50 cm.

PLATE 8



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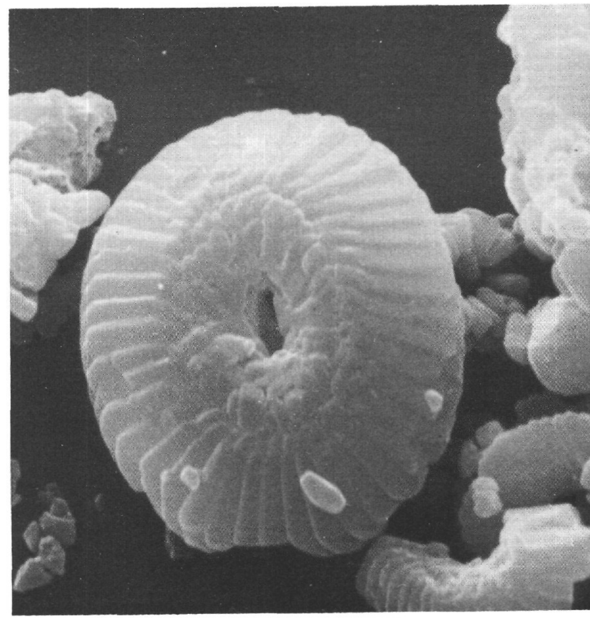

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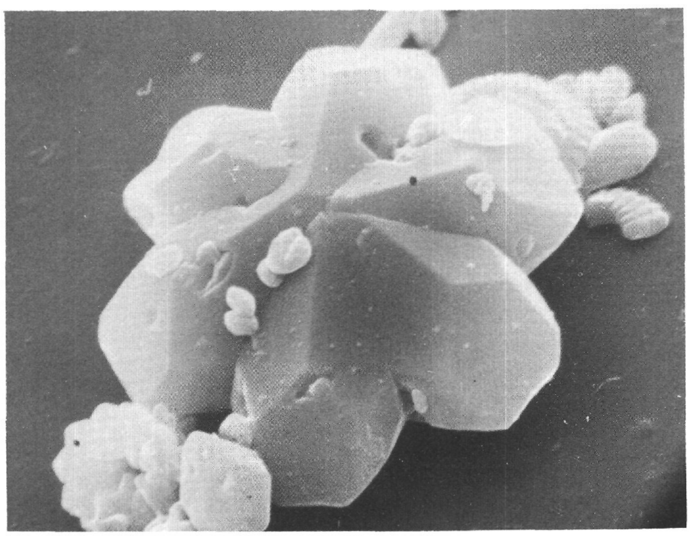

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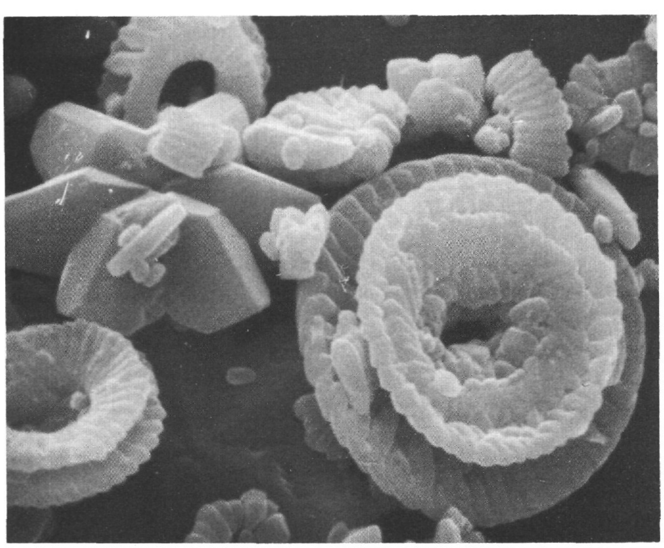

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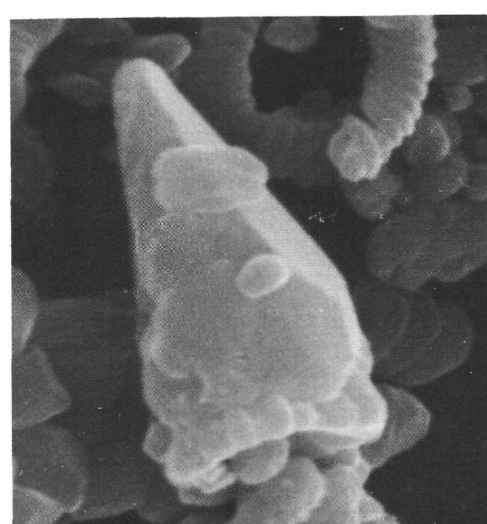

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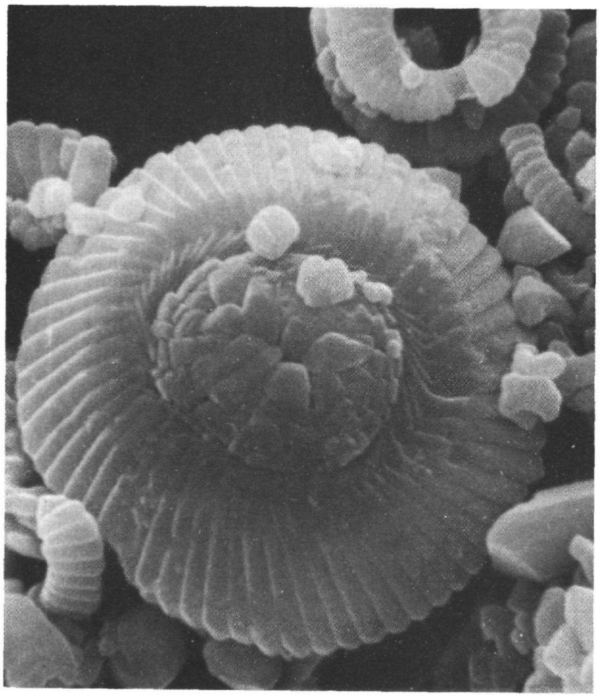
PLATE 9

Scanning electron micrographs of middle Eocene nannofossils (*Chiasmolithus grandis* Zone); Sample 171-8-3, 50 cm

Figure 1	*Reticulofenestra bisecta*, distal view. Magnification: 5000X.
Figure 2	*Reticulofenestra bisecta* oblique distal view, same specimen as Figure 1. Magnification: 5000X.
Figure 3	Distal view of *Coccolithus eopelagicus*, form with relatively wide central area. Magnification: 4400X.
Figure 4	Proximal view of *Coccolithus eopelagicus*, outermost cycle of proximal shield partly broken off. In the lower left-hand corner an isolated appendage of *Bramletteius serraculoides*. Magnification: 5400X.
Figure 5	Proximal view of *Reticulofenestra umbilica* with very small fragments of the grill still intact. Magnification: 5400X.
Figure 6	Assemblage consisting of *Chiasmolithus grandis* (distal view) in the lower left, *Discoaster saipanensis* (lower half of picture in center), *Discoaster robustus* (lower left-hand corner) *Cyclococcolithina formosa* (distal view, center of picture) and several specimens of *Coccolithus eopelagicus* (upper and lower left of picture). Magnification: 2200X.

PLATE 9



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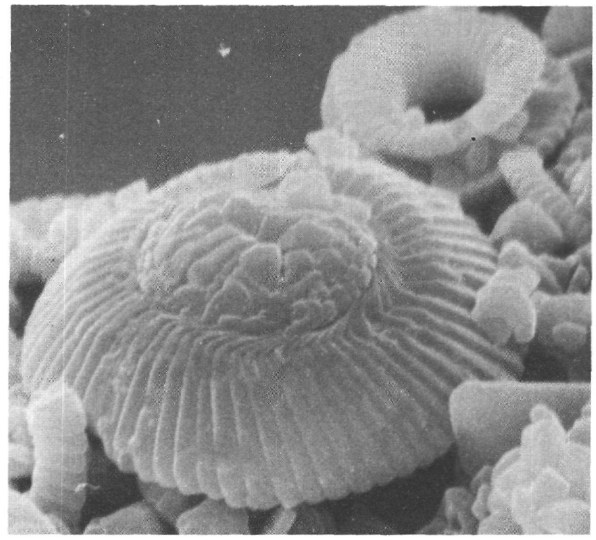

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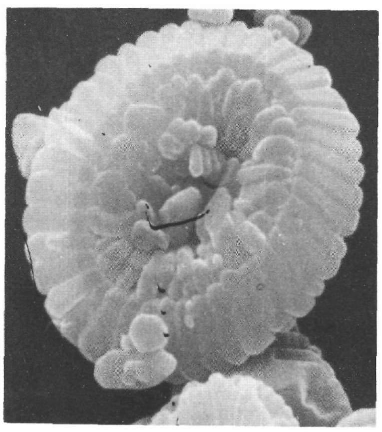

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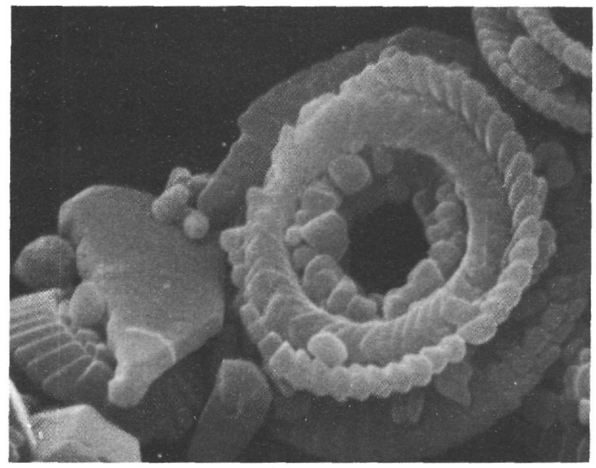

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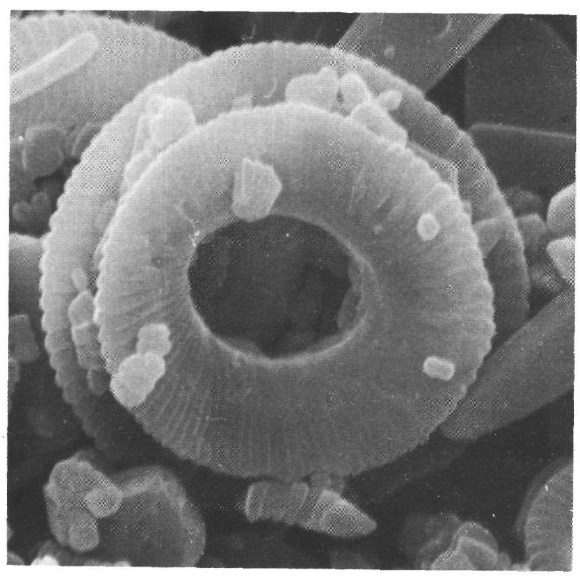

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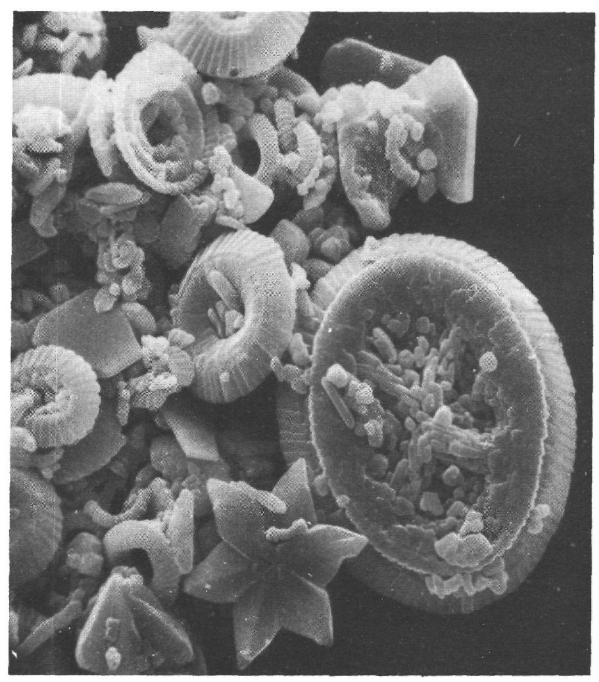

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PLATE 10

Scanning electron micrographs of middle Eocene nannofossils (*Chiasmolithus grandis* Zone); Sample 171-8-3, 50 cm

Figure 1 — Assemblage with strongly overgrown discoasters, probably *Discoaster saipanensis, Cyclicargolithus floridanus* and *Coccolithus eopelagicus.* Magnification: 2600X.

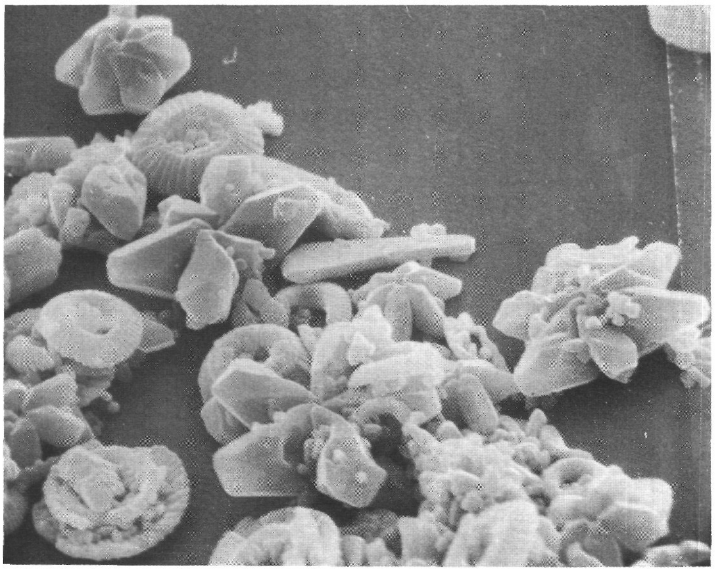
Figure 2 — *Reticulofenestra bisecta*, distal view. The central area is covered by three layers of tabular elements. Magnification: 5200X.

Figure 3 — *Discoaster barbadiensis*, distal view, slightly overgrown. Magnification: 5200X.

Figure 4 — Distal view of *Coccolithus eopelagicus* with a wide central area having dextrally imbricate laths. Magnification: 4200X.

Figure 5 — Assemblage with moderately well-preserved *Discoaster saipanensis* (center and upper right), strongly overgrown *Discoaster* sp. cf. *D. tani* (only half of the specimen visible in the upper left). Note the small *Discoaster* sp. in the upper right with a hole in the center; this is a very characteristic feature for etched assemblages. The center of the discoaster where the elements end in narrow extensions, often twisted or merged into a knob, seems to be the weakest spot in discoasters. In the center of the picture is a proximal view of *Coccolithus eopelagicus* and *Sphenolithus moriformis*; various specimens of *Cyclicargolithus floridanus* are seen, some well preserved, some etched and fragmented. Magnification: 2300X.

PLATE 10



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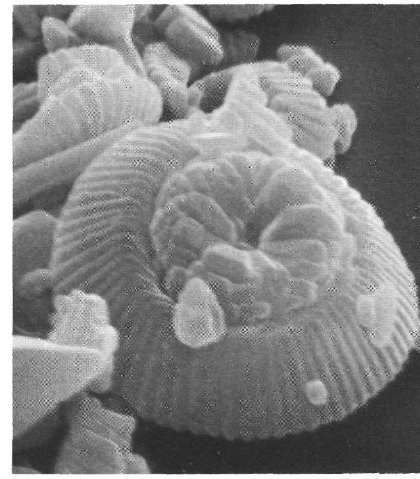

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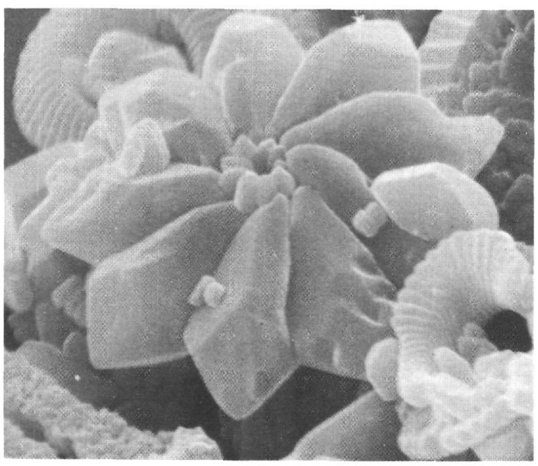

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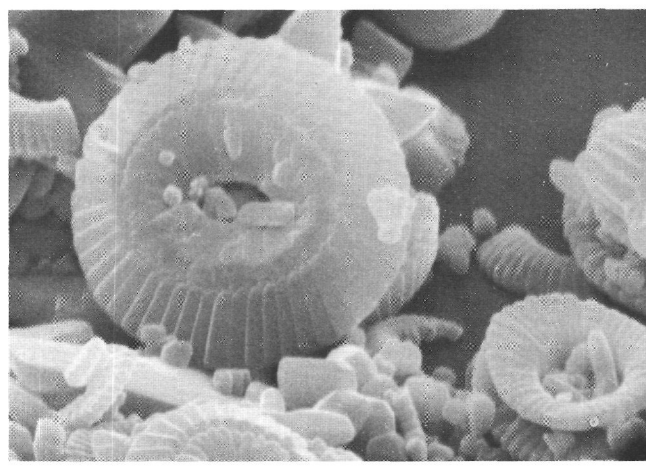

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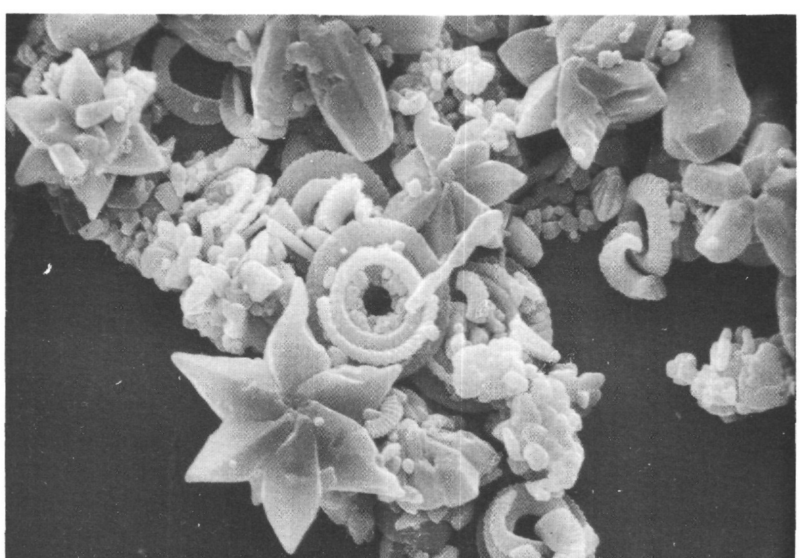

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PLATE 11

Scanning electron micrographs of lower Oligocene
and middle Eocene nannofossils

Figure 1 Proximal view of *Cyclicargolithus floridanus* with irregular overgrowths on some of the elements. Magnification: 9900X. Sample 167-23-4, 50 cm, *Ericsonia subdisticha* Zone.

Figure 2 Oblique proximal view of *Cyclicargolithus floridanus* strongly etched and overgrown. Irregular ridges of various height are deposited on some of the elements on the proximal side of the distal shield and along the wall. It can be seen quite clearly that the elements of the distal and proximal shield are actually one U-shaped piece as demonstrated for *Emiliania huxleyi* by Watabe (1967). Magnification: 10,000X. Sample 167-11-3, 50 cm, *Reticulofenestra abisecta* Zone.

Figure 3 Distal view of *Coccolithus eopelagicus*; the central area is lined with irregular granules and laths. Magnification: 4800X. Sample 167-11-3, 50 cm, *Reticulofenestra abisecta* Zone.

Figure 4 Distal view of *Cyclolithella aprica* n. sp. Due to overgrowth some of the elements of the inner cycle which forms the raised margin of the central hole are fused to the elements of the main shield. Holotype: USNM 188113. Magnification: 4800X. Sample 171-8-3, 50 cm.

Figure 5 *Cyclolithella aprica* n. sp., proximal view. Elements forming the shield are strongly sinistrally imbricate. A cycle of tabular plates lines the central hole; some of them are fused to the shield elements by secondary calcite. Paratype: USNM 188114. Magnification: 5200X. Sample 171-8-3, 50 cm.

Figure 6 Distal view of *Cyclolithella aprica* n. sp., same specimen as in Figure 4. The inner cycle is only well developed on the left-hand side whereas the elements seem to be fused to the elements of the outer cycle. Magnification: 4800X. Sample 171-8-3, 50 cm.

PLATE 11

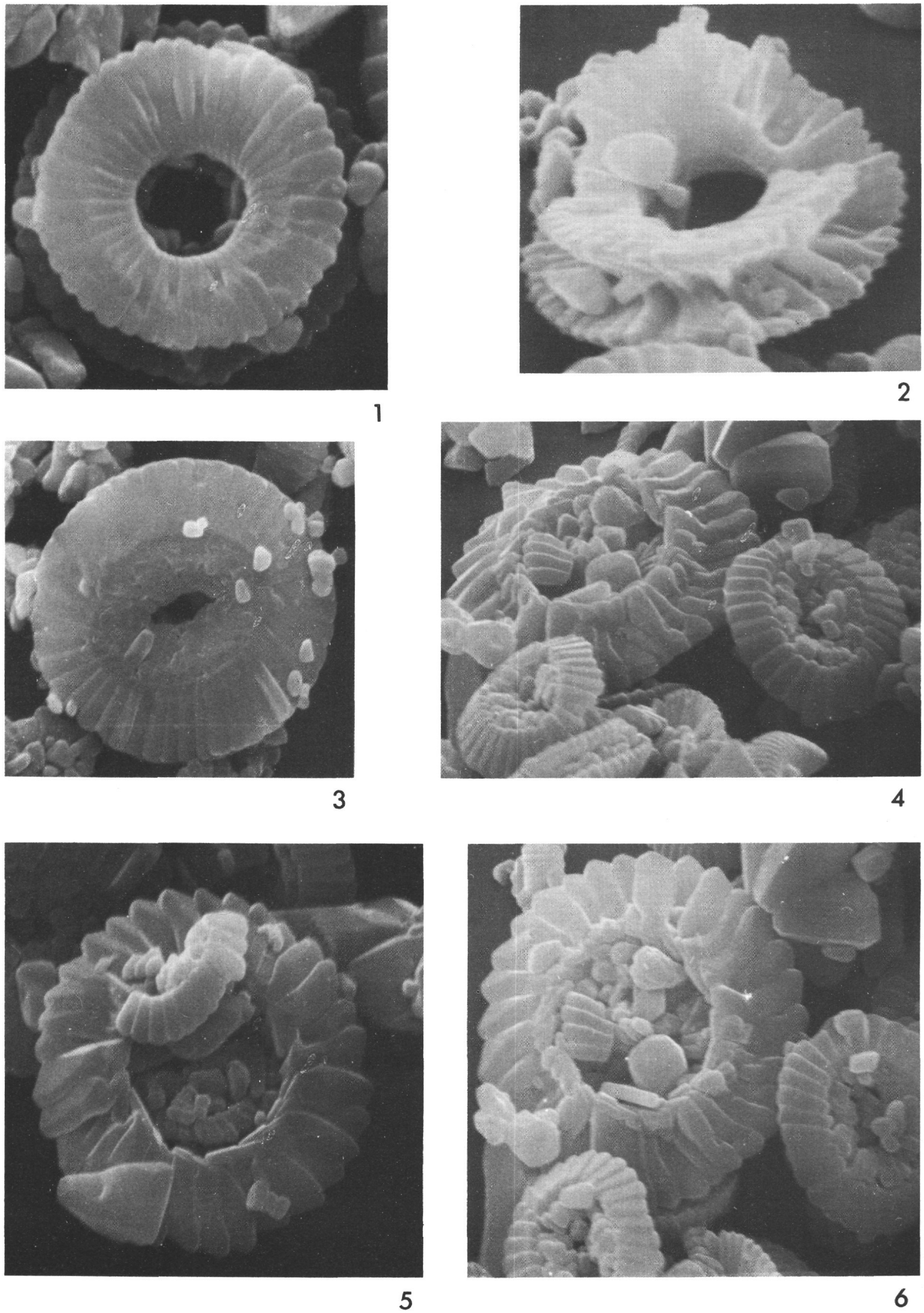

PLATE 12

Light micrographs of middle Eocene and upper Paleocene nannofossils; Magnification: 3000X

Figure 1	*Cyclolithella aprica* n. sp., (a) phase contrast, (b) crossed nicols. Paratype: USNM 188115. Sample 171-8-3, 50 cm, *Chiasmolithus grandis* Zone.
Figure 2	*Cyclolithella aprica* n. sp., (a) phase contrast, (b) crossed nicols. Paratype: USNM 188116. Sample 171-8-3, 50 cm.
Figure 3	*Prinsius bisulcus* (Stradner) (a) Phase contrast, (b) ordinary light, high focus, (c) ordinary light, low focus, (d) crossed nicols. Sample 167-38, CC, *Discoaster mohleri* Zone.
Figure 4	*Cyclolithella aprica* n. sp., (a) crossed nicols, (b) phase contrast, (c) ordinary light. Paratype: USNM 188117. Sample 171-8-3, 50 cm, *Chiasmolithus grandis* Zone.
Figure 5	*Ericsonia subpertusa*, (a) crossed nicols, (b) ordinary light, (c) Phase contrast. Sample 167-38, CC.
Figure 6	*Discoaster mohleri,* Phase contrast. Sample 167-38, CC.
Figure 7	*Ellipsolithus macellus,* (a) crossed nicols, (b) phase contrast. Sample 167-38,CC.
Figures 8,9 10	*Discoaster mohleri*, phase contrast. Sample 167-38, CC.

PLATE 12

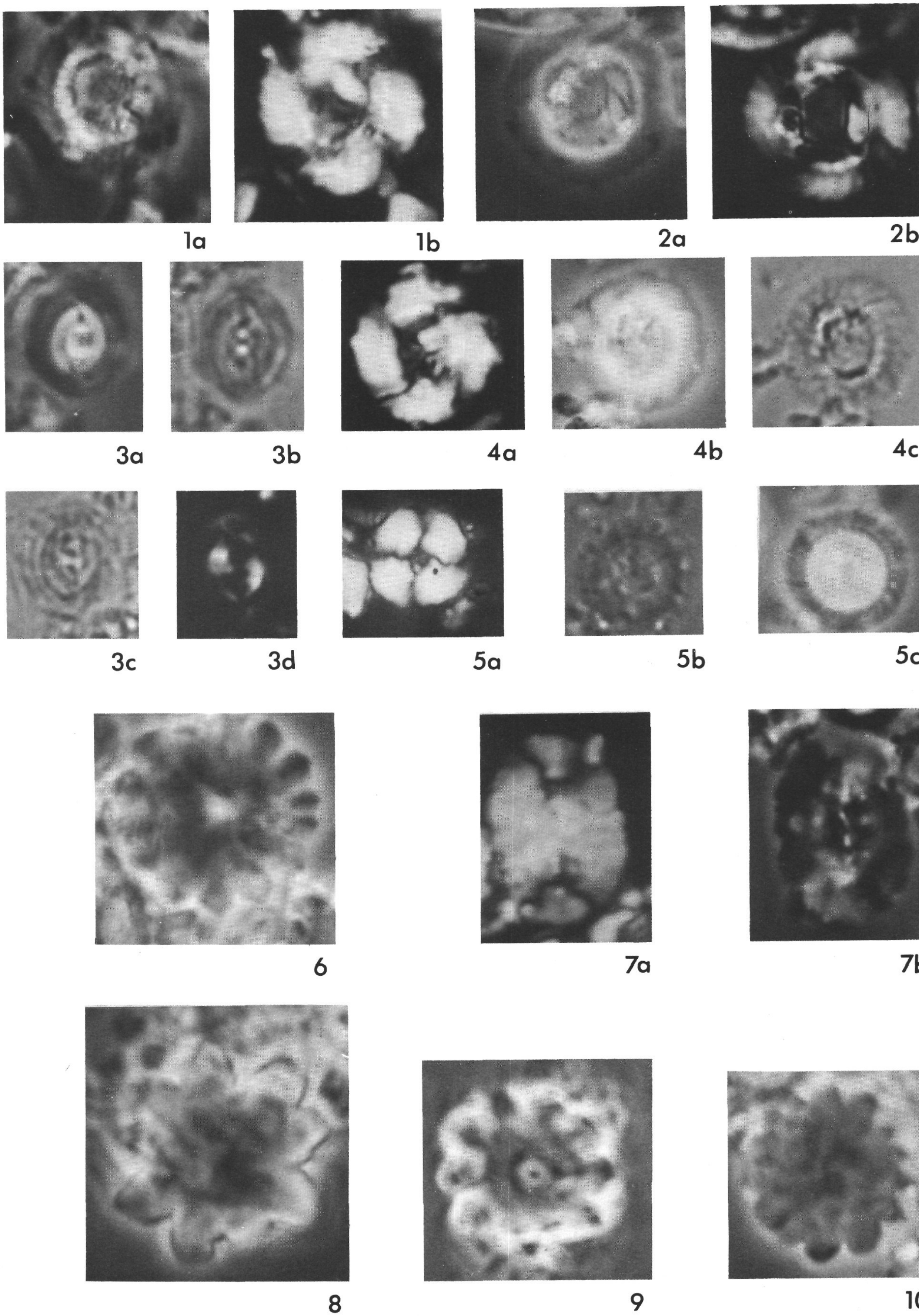

PLATE 13

Scanning electron micrographs of Paleocene nannofossils (*Discoaster mohleri* Zone); Sample 167-38, CC

Figure 1	Oblique distal view of *Ericsonia subpertusa*. Magnification: 11,700X.
Figure 2	Distal view of *Cruciplacolithus tenuis*. The arms of the cross do not lie exactly in the axis of the ellipse indicating a transition to *Chiasmolithus*. Early form of *Sphenolithus moriformis* in the lower left. Magnification: 4800X.
Figure 3	Proximal view of *Chiasmolithus danicus*. The proximal shield is composed of three cycles. The innermost one consists of irregular blocks lining the central hole, the elements of the middle cycle are arranged in a chevron pattern, and the outer cycle consists of irregular blocks again. The irregular appearance of the proximal shield is due to secondary overgrowth. Magnification: 5600X.
Figure 4	Top view of small specimen of *Sphenolithus moriformis*. Magnification: 9500X.
Figure 5	*Discoaster mohleri* with considerable secondary overgrowth which resulted in the development of many crystal faces. In the lower right side view of *Fasciculithus tympaniformis*. In the lower left oblique distal view of *Prinsius bisulcus*. Magnification: 6500X.
Figure 6	Side view of a large specimen of *Sphenolithus moriformis* (broken shield of coccolith sticking to it). Magnification: 9500X.

PLATE 13

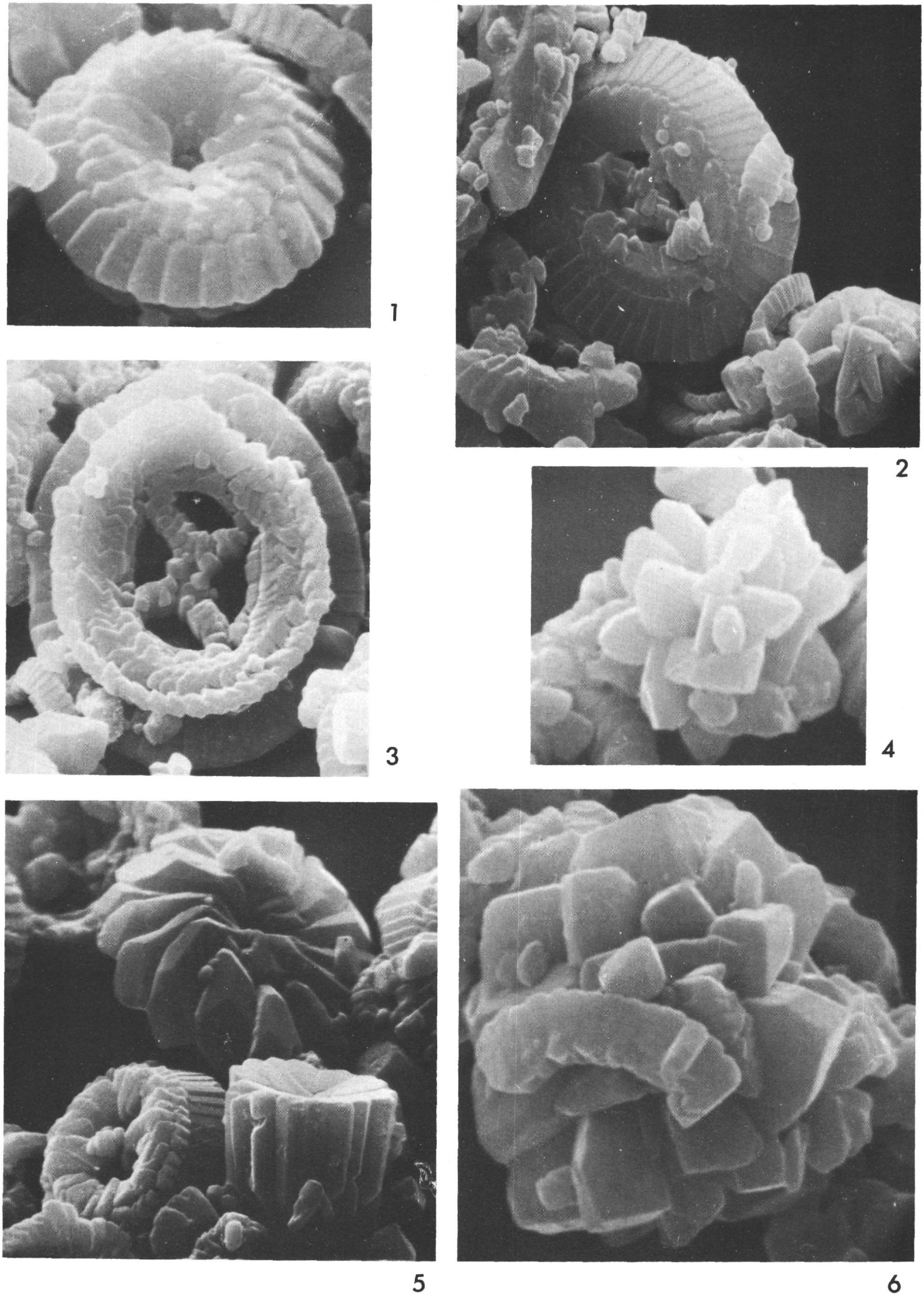

PLATE 14

Scanning electron micrographs of Paleocene nannofossils
(*Discoaster mohleri* Zone); Sample 167-38, CC

Figure 1 — Distal view of *Coccolithus cavus*. This specimen has a fairly narrow central depression which is filled with a double layer of irregular tabular elements. Magnification: 11,500X.

Figure 2 — Proximal view of *Coccolithus cavus*, moderately overgrown. The proximal shield consists of three cycles of elements. Side view of *Fasciculithus tympaniformis* in the lower left corner. Magnification: 4800X.

Figure 3 — Distal view of *Toweius craticulus*? the elements filling the central area are etched and overgrown giving them an irregular appearance. Magnification: 9500X.

Figure 4 — Strongly etched and overgrown specimen of (?) *Coccolithus cavus* in proximal view. A cycle of irregular elements is all that is left of the proximal shield. Magnification: 13,000X.

Figure 5 — Oblique proximal view of a strongly recrystallized specimen of *Coccolithus cavus*. The elements of the proximal side of the distal shield show a blocky appearance. The outer cycle of the proximal shield is thickened. Irregular blocky secondary crystals fill the center. Magnification: 11,500X.

PLATE 14

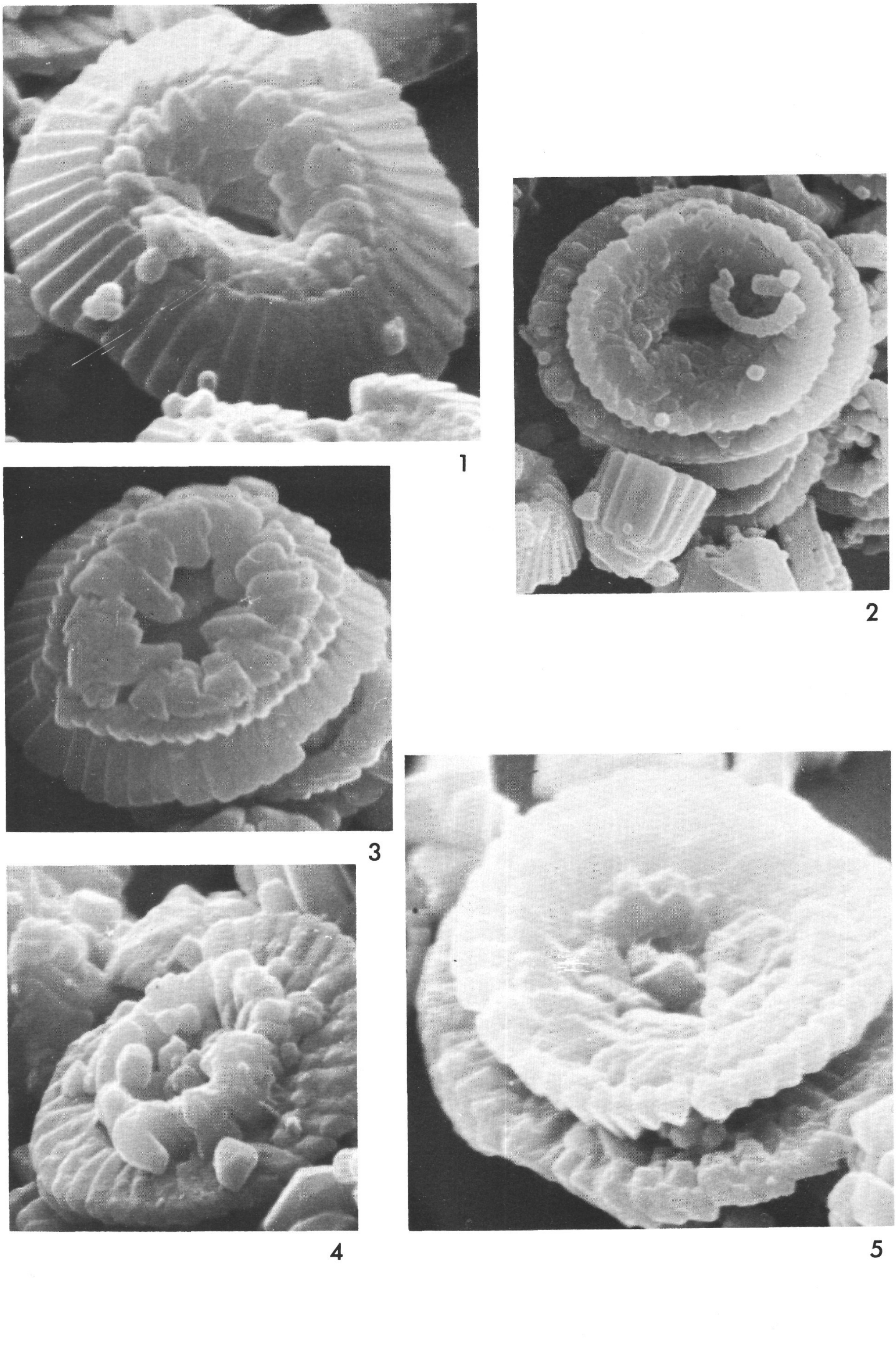

PLATE 15

Scanning electron and light micrographs of a new Paleocene nannofossil (*Discoaster mohleri* Zone); Sample 167-38, CC

Figure 1 Oblique distal view of *Bomolithus elegans* n. gen. n. sp., Holotype: USNM 188118. In the lower left side view of moderately overgrown *Fasciculithus tympaniformis*. Magnification: 5000X.

Figure 2 *Bomolithus elegans* n. gen., n. sp. Paratype: USNM 188119, (a) oblique distal view, (b) side view, (c) slightly oblique distal view. Magnification: 11,000X.

Figure 3 Light micrographs of *Bomolithus elegans* n. gen. n. sp. Paratype: USNM 188120. (a) ordinary light, high focus, (b) ordinary light, median focus (c) phase contrast, high focus. Magnification: 3000X.

Figure 4 *Bomolithus elegans* n. gen. n. sp. Paratype: USNM 188121. (a) ordinary light, high focus, (b) phase contrast, median focus. Magnification: 3000X.

Figure 5 Side view of *Bomolithus elegans* n. gen. n. sp. Paratype: USNM 188122, (a) ordinary light, (b) phase contrast, (c) crossed nicols. Magnification: 3000X.

Figure 6 *Bomolithus elegans* n. gen. n. sp. Paratype: USNM 188123, somewhat overgrown, (a) phase contrast, (b) crossed nicols (note that only the distal shield shows birefringence), (c) ordinary light, high focus, (d) crossed nicols, analyzer rotated 10°. Magnification: 3000X.

PLATE 15

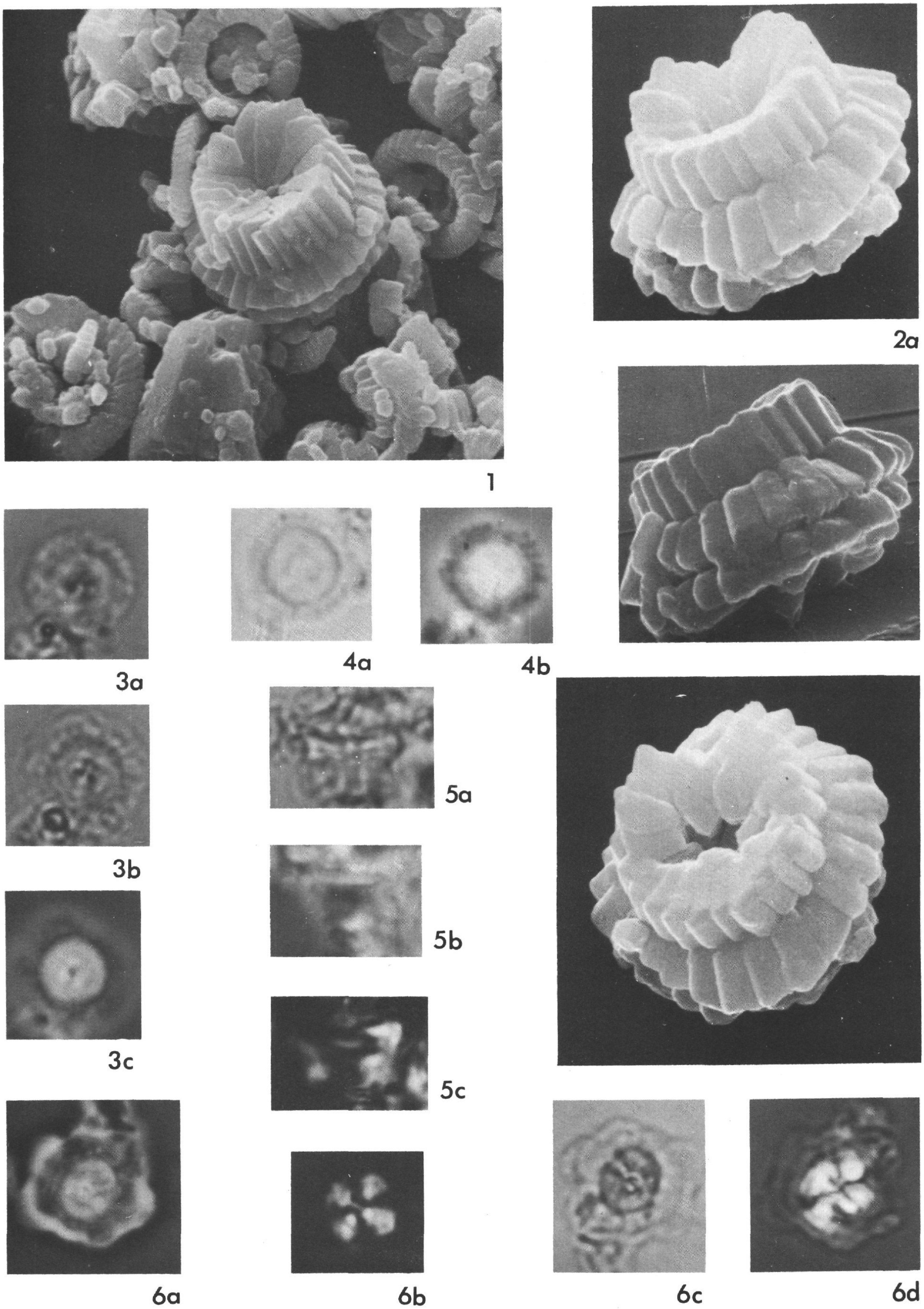

PLATE 16

Light micrographs of Paleocene nannofossils;
Magnification: 3000X

Figure 1 — *Fasciculithus* sp. cf. *F. ulii*, side view and (?) top view, (a) phase contrast, (b) ordinary light, (c) crossed nicols, (d) crossed nicols. Sample 167-40, CC, *Fasciculithus tympaniformis* Zone.

Figure 2 — *Fasciculithus* sp. cf. *F. ulii*, side view, (a) ordinary light, (b) crossed nicols. Sample 167-39-1, 117 cm, *Fasciculithus tympaniformis* Zone.

Figure 3 — Top view of *Fasciculithus*, probably *Fasciculithus* sp. cf. *F. ulii*, (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-40, CC, *Fasciculithus tympaniformis* Zone.

Figure 4 — *Heliolithus kleinpellii*, (a) Ordinary light, (b) phase contrast, (c) crossed nicols. Sample 167-38, CC, *Discoaster mohleri* Zone.

Figure 5 — *Fasciculithus tympaniformis*, (a) ordinary light, (b) phase contrast. Sample: 167-39-1, 117 cm, *Fasciculithus tympaniformis* Zone.

Figure 6 — Top (or basal) view of *Fasciculithus*, probably *Fasciculithus tympaniformis*, (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-40, CC, *Fasciculithus tympaniformis* Zone.

Figure 7 — Top (or basal) view of *Fasciculithus* sp., (a) ordinary light, (b) crossed nicols. Sample 167-40, CC, *Fasciculithus tympaniformis* Zone.

PLATE 16

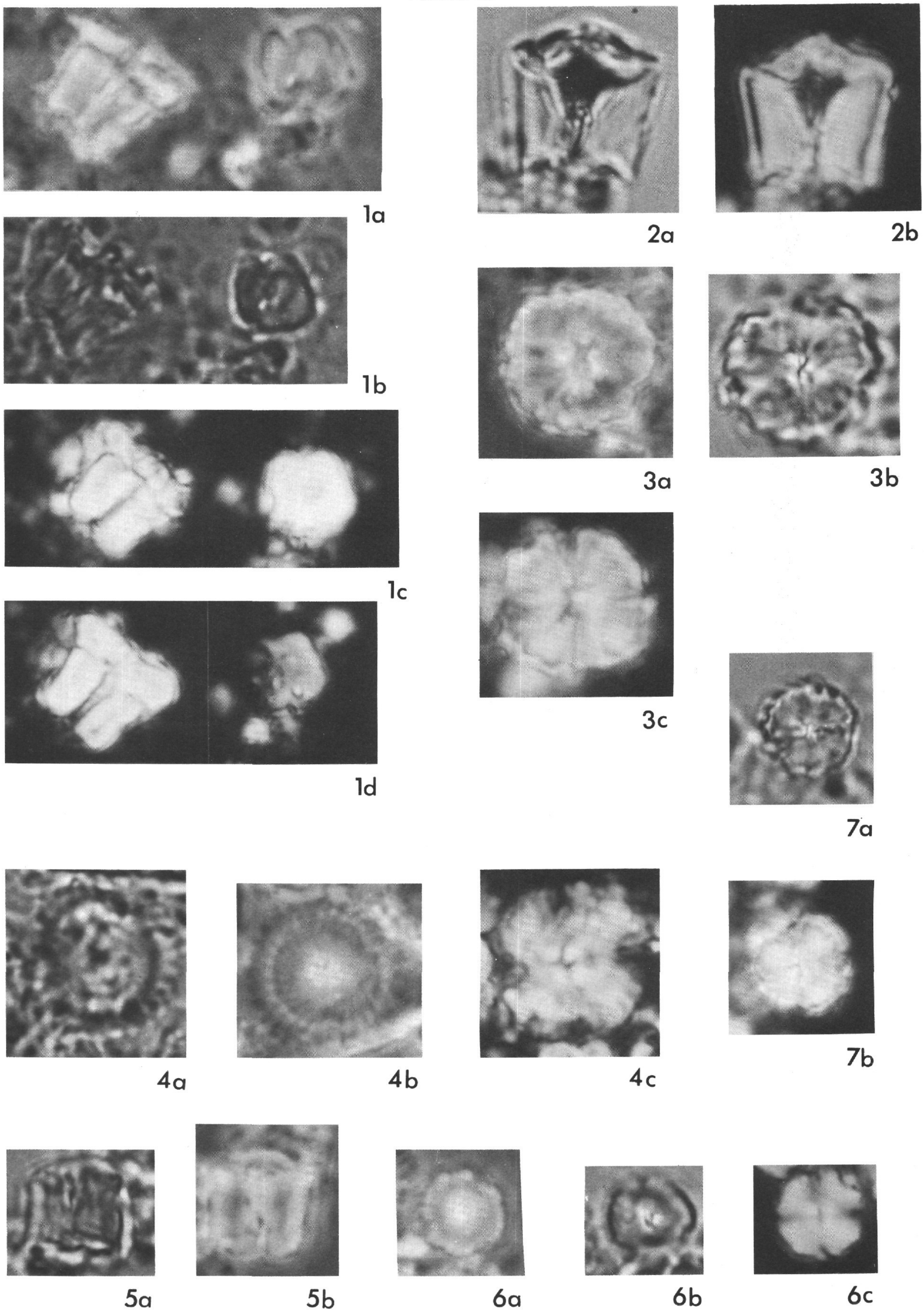

PLATE 17

Light micrographs of Paleocene nannofossils;
Magnification: 3000X

Figure 1 *Cruciplacolithus tenuis,* (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-40, CC, *Fasciculithus tympaniformis* Zone.

Figure 2 *Prinsius bisulcus,* (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-38, CC, *Discoaster mohleri* Zone.

Figure 3 *Chiasmolithus danicus*, form with arms of cross close to the axis of the ellipse, (a) long axis 45° to crossed nicols, (b) phase contrast, (c) ordinary light, (d) cross polarized light, long axis 0° to crossed nicols. Sample 167-38, CC, *Discoaster mohleri* Zone.

Figure 4 *Chiasmolithus danicus,* (a) phase contrast, (b) long axis 0° to crossed nicols, (c) long axis 45° to crossed nicols. Sample 167-38, CC, *Discoaster mohleri* Zone.

Figure 5 *Chiasmolithus danicus*, with cross bars almost diagonally, (a) phase contrast, (b) ordinary light, (c) long axis 45° to crossed nicols. Sample 167-38, CC, *Discoaster mohleri* Zone.

PLATE 17

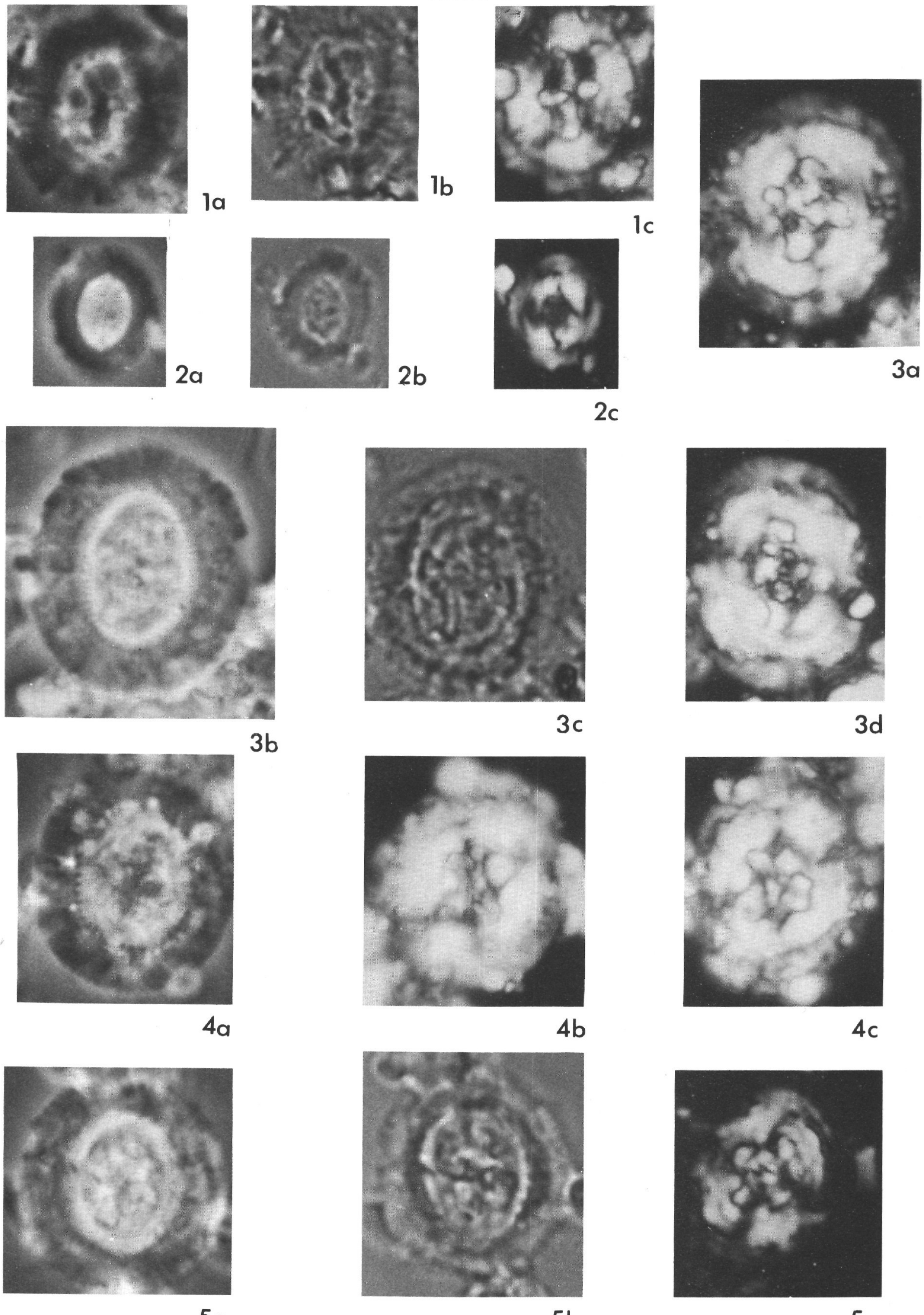

PLATE 18

Light micrographs of Upper Cretaceous nannofossils;
Magnification: 3000X

Figure 1	*Eiffellithus eximius*, (a) phase contrast, (b) ordinary light, (c) long axis 45° to crossed nicols, (d) long axis 0° to crossed nicols. Sample 167-54,CC, *Eiffellithus eximius* Zone.
Figure 2	*Eiffellithus anceps*, (a) phase contrast, (b) long axis 10° to crossed nicols, (c) long axis 0° to crossed nicols, (d) long axis 45° to crossed nicols. Sample 167-52, CC, *Eiffellithus eximius* Zone.
Figure 3	*Tetralithus aculeus,* (a) ordinary light, (b,c) crossed nicols. Sample 167-55-1, 93 cm, *Eiffellithus eximius* Zone.
Figure 4	*Eiffellithus anceps,* (a) phase contrast, (b) ordinary light, (c) long axis 45° to crossed nicols, (d) long axis 0° to crossed nicols. Sample 167-52, CC, *Eiffellithus eximius* Zone.
Figure 5	*Parhabdolithus cf. R. angustus,* (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-45, CC, *Tetralithus trifidus* Zone.
Figure 6	*Tetralithus trifidus* short-rayed form, (a) ordinary light, (b) crossed nicols. Sample 167-45, CC, *Tetralithus trifidus* Zone.
Figure 7	*Tetralithus trifidus*, long-rayed form, (a) ordinary light, (b) crossed nicols. Sample 167-45, CC, *Tetralithus trifidus* Zone.

PLATE 18

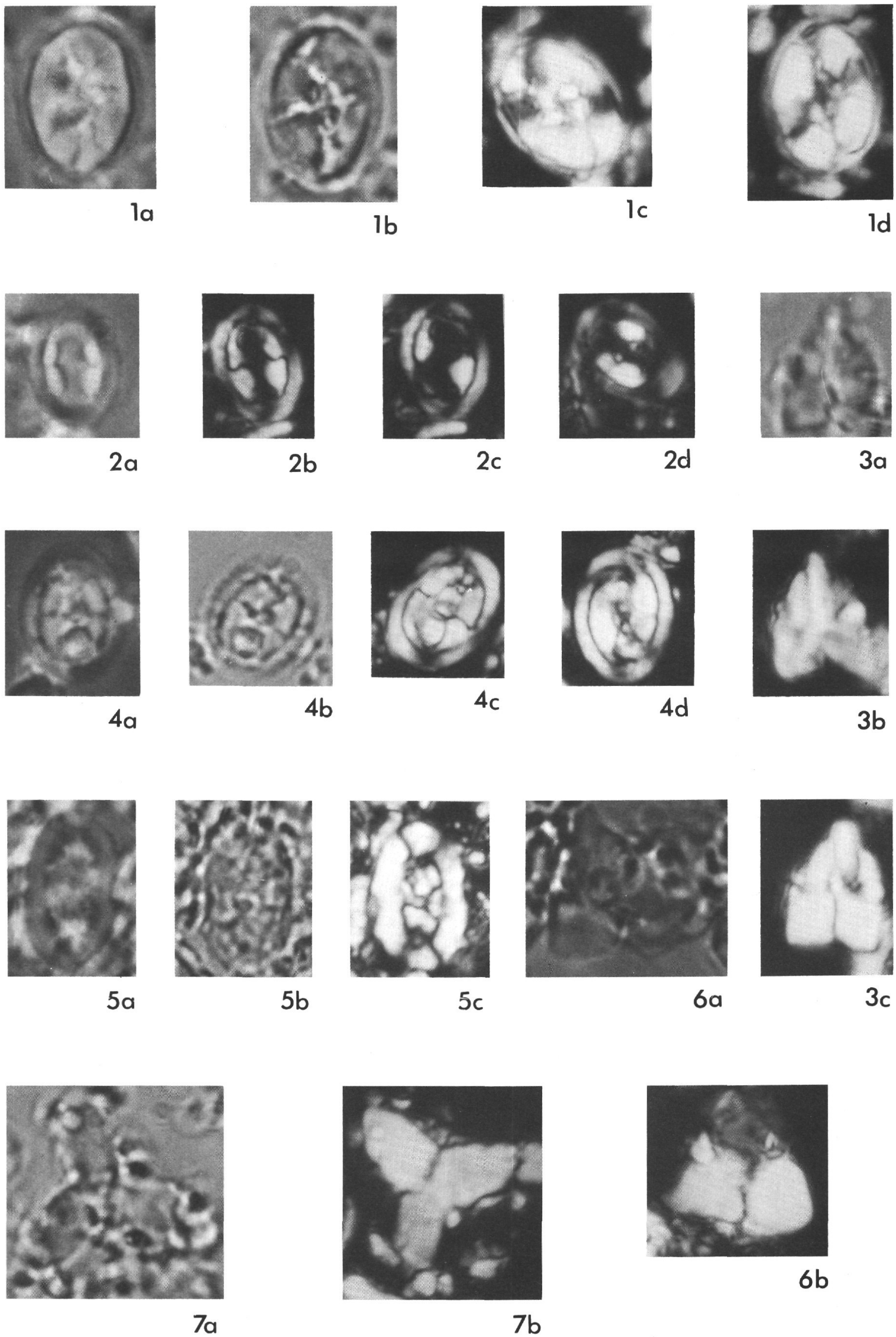

PLATE 19

Scanning and light micrographs of Upper Cretaceous nannofossils

Figure 1 *Arkhangelskiella cymbiformis* distal view. Magnification: 13,200X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.

Figure 2 Coccosphere of *Watznaueria barnesae*. Because the individual placoliths are interlocking complete coccospheres are occasionally preserved. Magnification: 4900X. Sample 167-55-1, 93 cm, *Eiffellithus eximius* Zone.

Figure 3 *Arkhangelskiella cymbiformis*, side view, same specimen as in Figure 1. The shield is composed of three tiers. Magnification 13,200X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.

Figure 4 *Eiffellithus anceps,* distal view, somewhat overgrown. Magnification: 6750X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.

Figure 5 *Arkhangelskiella cymbiformis*, distal view. Magnification: 10,000X. Sample 167-55-1, 93 cm, *Eiffellithus eximius* Zone.

Figure 6 *Cretarhabdus crenulatus*, distal view. Magnification: 5000X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.

Figure 7 *Arkhangelskiella cymbiformis*, (a) phase contrast, (b) crossed nicols. Magnification: 3000X. Sample 171-15-3, 50 cm, *Lithraphidites quadratus* Zone.

PLATE 19

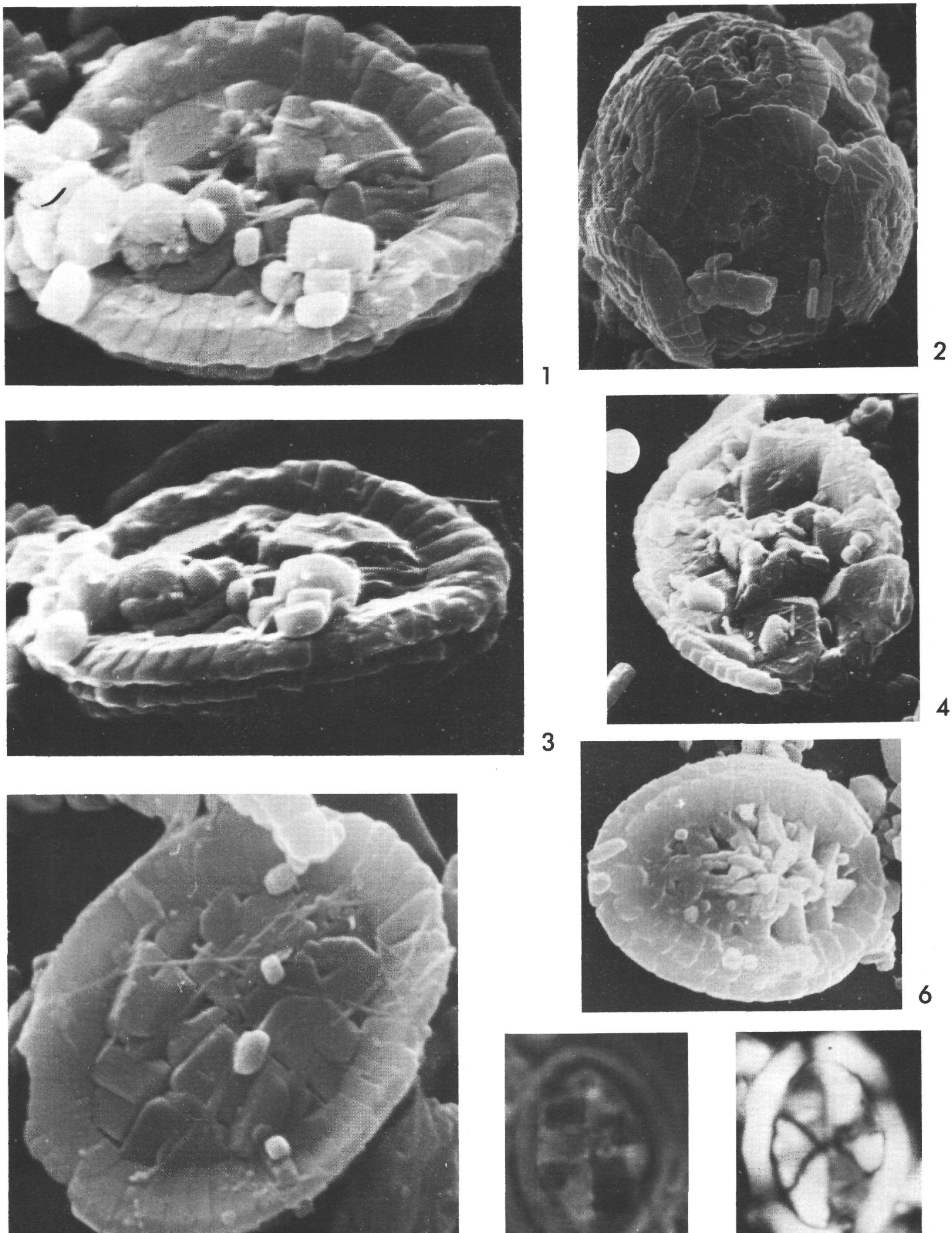

PLATE 20

Scanning electron micrographs of Cretaceous nannofossils

Figure 1	*Arkhangelskiella cymbiformis*, proximal view. Magnification: 13,000X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.
Figure 2	*Tetralithus aculeus* (upper left) and *Cylindralithus serratus* (?) (lower right). Both specimens show considerable overgrowth. Magnification: 4900X. Sample 167-55-1, 93 cm, *Eiffellithus eximius* Zone.
Figure 3	*Watznaueria barnesae* (upper left), *Cylindralithus serratus* (?) (lower left), and *Cribrosphaera ehrenbergi*. Magnification: 6750X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.
Figure 4	*Micula decussata*, oblique view. Magnification: 10,000X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.
Figure 5	*Zygodiscus* sp. cf. *Z. spiralis*, distal view. Magnification: 10,000X. Sample 171-11-4, 50 cm, *Lithraphidites quadratus* Zone.
Figure 6	*Zygodiscus compactus*, distal view. Magnification: 13,000X. Sample 171-15-4, 50 cm, *Lithraphidites quadratus* Zone.

PLATE 20

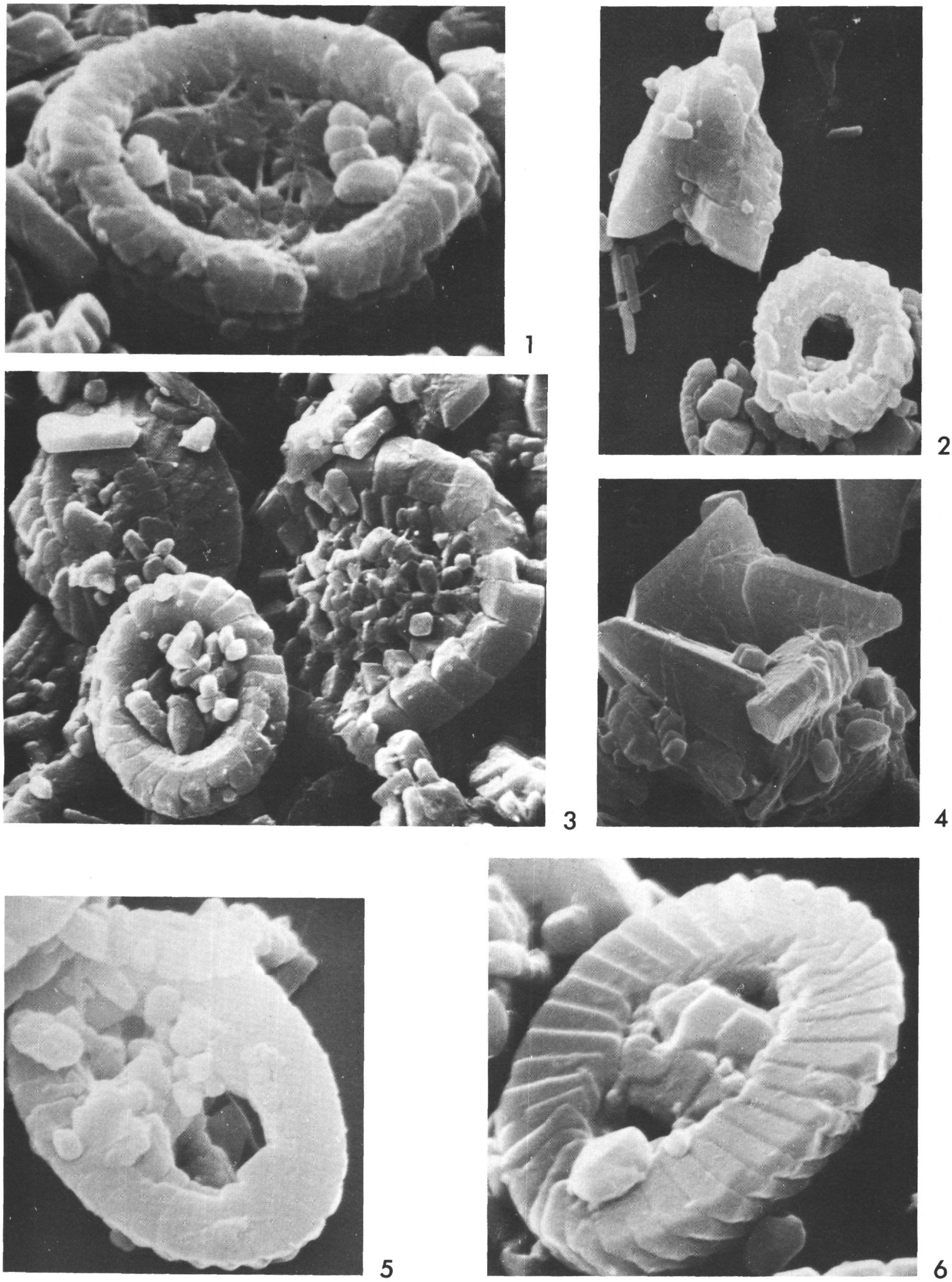

PLATE 21

Scanning electron and light micrographs of Cretaceous nannofossils

Figure 1	*Crepidolithus thiersteinii* n. sp. (lower left-hand corner), distal view, Paratype: USNM 188124, *Cribrosphaera ehrenbergi* (upper right), distal view. Magnification: 5000X. Sample 167-45-6, 50 cm.
Figure 2	*Kamptnerius pseudopunctatus,* ordinary light. Magnification: 3000X. Sample 171-15-3, 50 cm, *Lithraphidites quadratus* Zone.
Figure 3	*Kamptnerius pseudopunctatus,* (a) ordinary light, (b) crossed nicols. Magnification: 3,000X. Sample 171-15-3, 50 cm, *Lithraphidites quadratus* Zone.
Figure 4	*Prediscosphaera cretacea,* oblique distal view. Magnification: 10,000X. Sample 167-55-1, 93 cm, *Eiffellithus eximius* Zone.
Figure 5	*Prediscosphaera cretacea*, distal view. Magnification: 13,500X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.
Figure 6	*Cretarhabdus crenulatus*, oblique distal view. Magnification: 10,000X. Sample 167-45-6, 50 cm, *Tetralithus trifidus* Zone.

PLATE 21

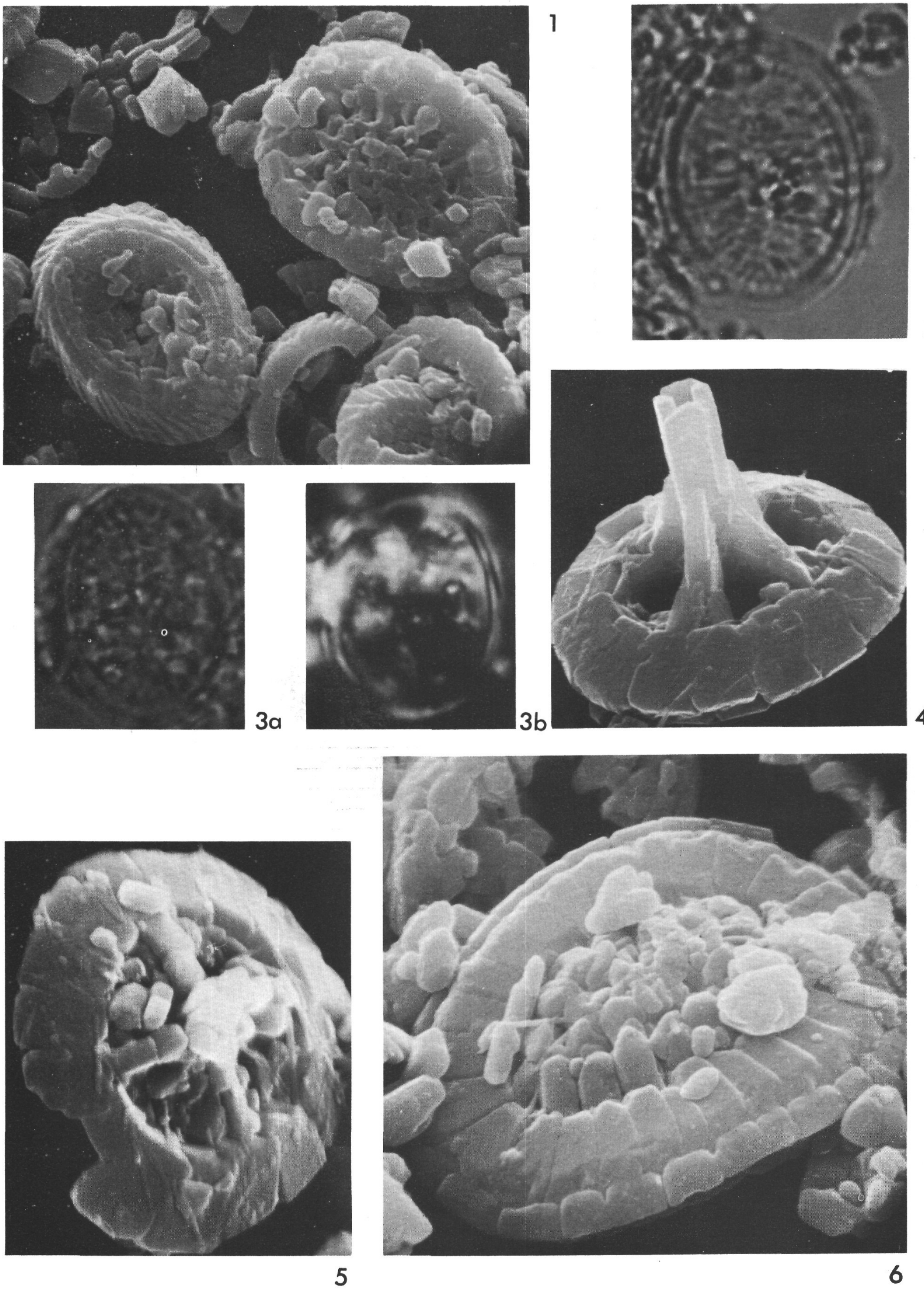

PLATE 22

Light micrographs of Cretaceous nannofossils;
Magnification: 3000X

Figure 1 *Gartnerago obliquum*, (a) phase contrast, (b) long axis at 0° to crossed nicols, (c) long axis at 45° to crossed nicols. Sample 171-22, CC, *Gartnerago obliquum* Zone.

Figure 2 *Reinhardites* sp. cf. *R. mirabilis*, (a) phase contrast, (b) ordinary light, (c) long axis at 45° to crossed nicols, (d) long axis at 0° to crossed nicols. Sample 167-55-1, 50 cm, *Eiffellithus eximius* Zone.

Figure 3 *Broinsonia parca*, (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-52, CC, *Eiffellithus eximius* Zone.

Figure 4 *Reinhardites anthophorus*, (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-51-1, 50 cm, *Eiffellithus eximius* Zone.

Figure 5 *Crepidolithus thiersteinii* n. sp., Paratype: USNM 188125, (a) phase contrast, (b) ordinary light, (c) long axis at 45° to crossed nicols, (d) long axis at 0° to crossed nicols. Sample 167-52, CC, *Eiffellithus eximius* Zone.

Figure 6 *Crepidolithus thiersteinii* n. sp., Holotype: USNM 188126, (a) ordinary light, (b) phase contrast, low focus, (c) phase contrast, high focus, (d) long axis 0° to crossed nicols. Sample 167-55-1, 93 cm, *Eiffellithus eximius* Zone.

PLATE 22

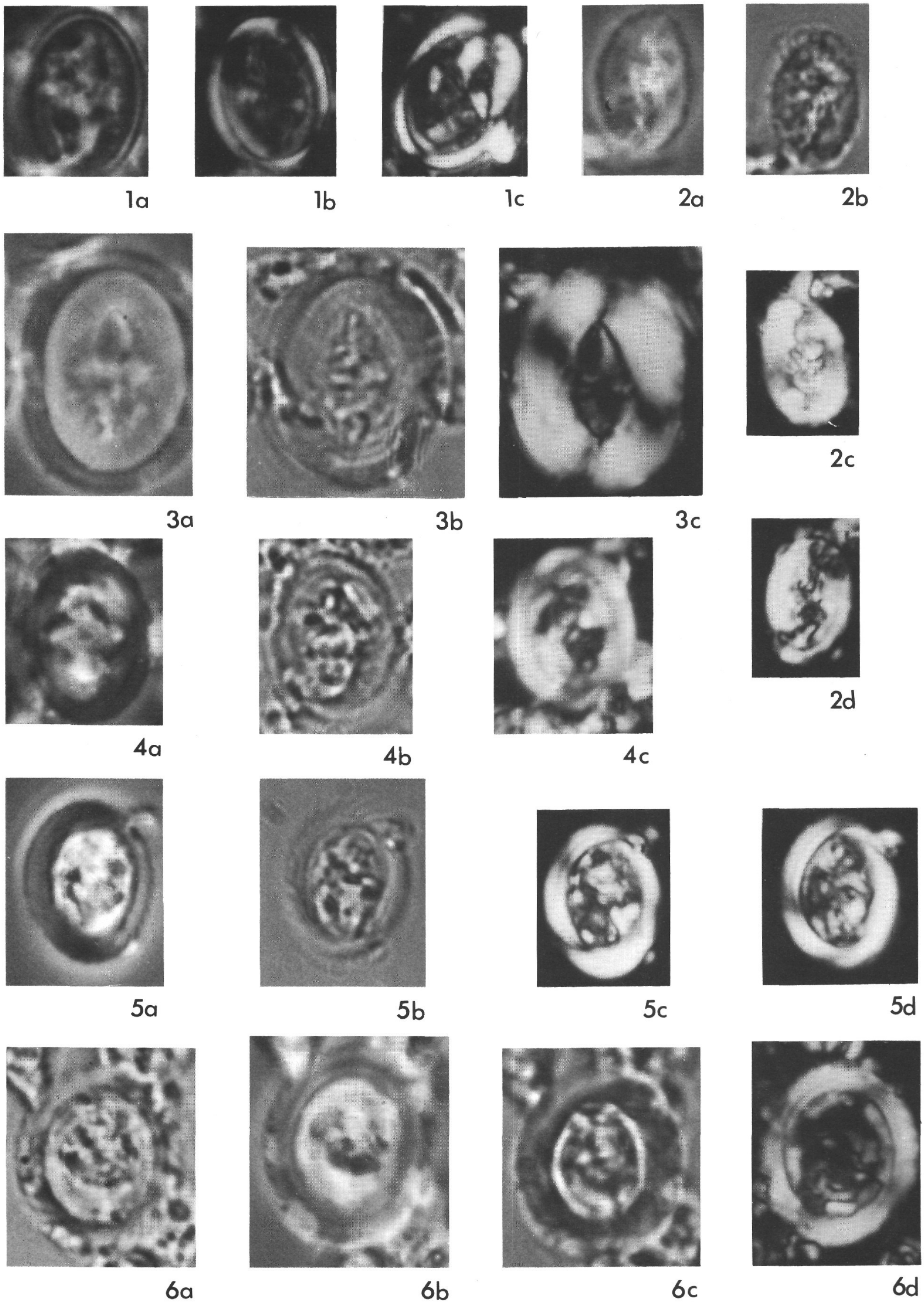

PLATE 23

Light micrographs of *Kamptnerius;* Magnification: 3000X

Figure 1	*Kamptnerius magnificus*, (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 171-9-6(top), *Lithraphidites quadratus* Zone.
Figure 2	*Kamptnerius magnificus*, (a) phase contrast, (b) crossed nicols, (c) ordinary light. Sample 171-9-6(top), *Lithraphidites quadratus* Zone.
Figure 3	*Kamptnerius pseudopunctatus,* (a) ordinary light, (b) crossed nicols. Sample 171-15-3, 50 cm, *Lithraphidites quadratus* Zone.
Figure 4	*Kamptnerius pseudopunctatus*, phase contrast. Note the perforations in the center. Sample 171-15-3, 50 cm.
Figure 5	*Kamptnerius pseudopunctatus*, (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 171-15-3, 50 cm.

PLATE 23

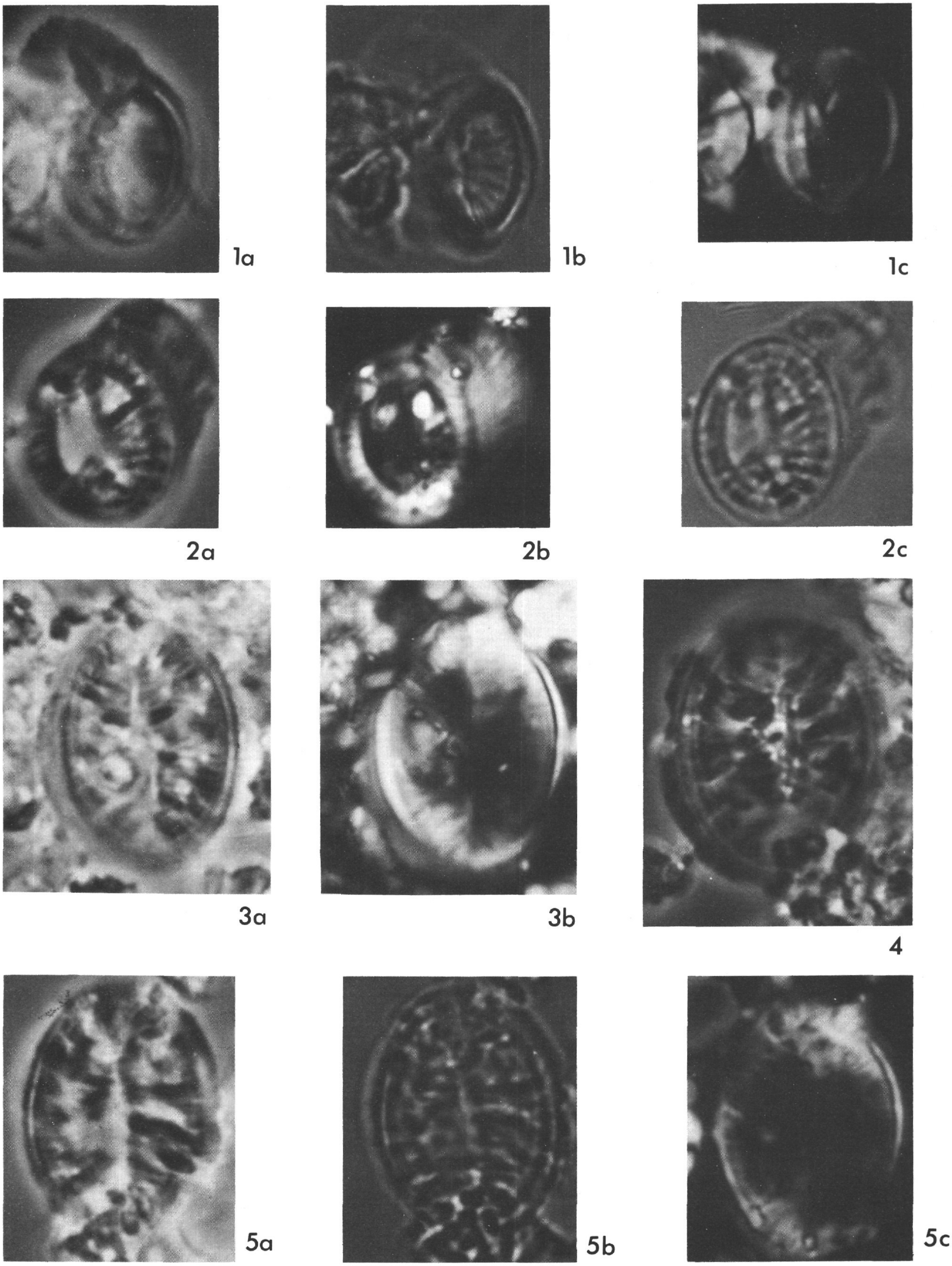

PLATE 24

Light micrographs of Cretaceous nannofossils;
Magnification: 3000X

Figure 1 *Rucinolithus irregularis*, (a) ordinary light, (b) phase contrast, (c) crossed nicols. Sample 167-72-2, 42 cm, *Tetralithus malticus* Zone.

Figure 2 *Discorhabdus biradiatus*, (a) crossed nicols, (b) ordinary light, (c) phase contrast, (d) crossed nicols. Sample 167-69, CC, *Parhabdolithus angustus* Zone.

Figure 3 *Parhabdolithus asper*, (a) ordinary light, (b) long axis 0° to crossed nicols, (c) long axis at 45° to crossed nicols. Sample 167-67, CC, *Prediscosphaera cretacea* Zone.

Figure 4 *Parhabdolithus angustus*, (a) ordinary light, (b) phase contrast, (c) long axis at 0° to crossed nicols, (d) long axis at 45° to crossed nicols. Sample 167-61-2-75, 77 cm, *Litraphidites alatus* Zone.

PLATE 24

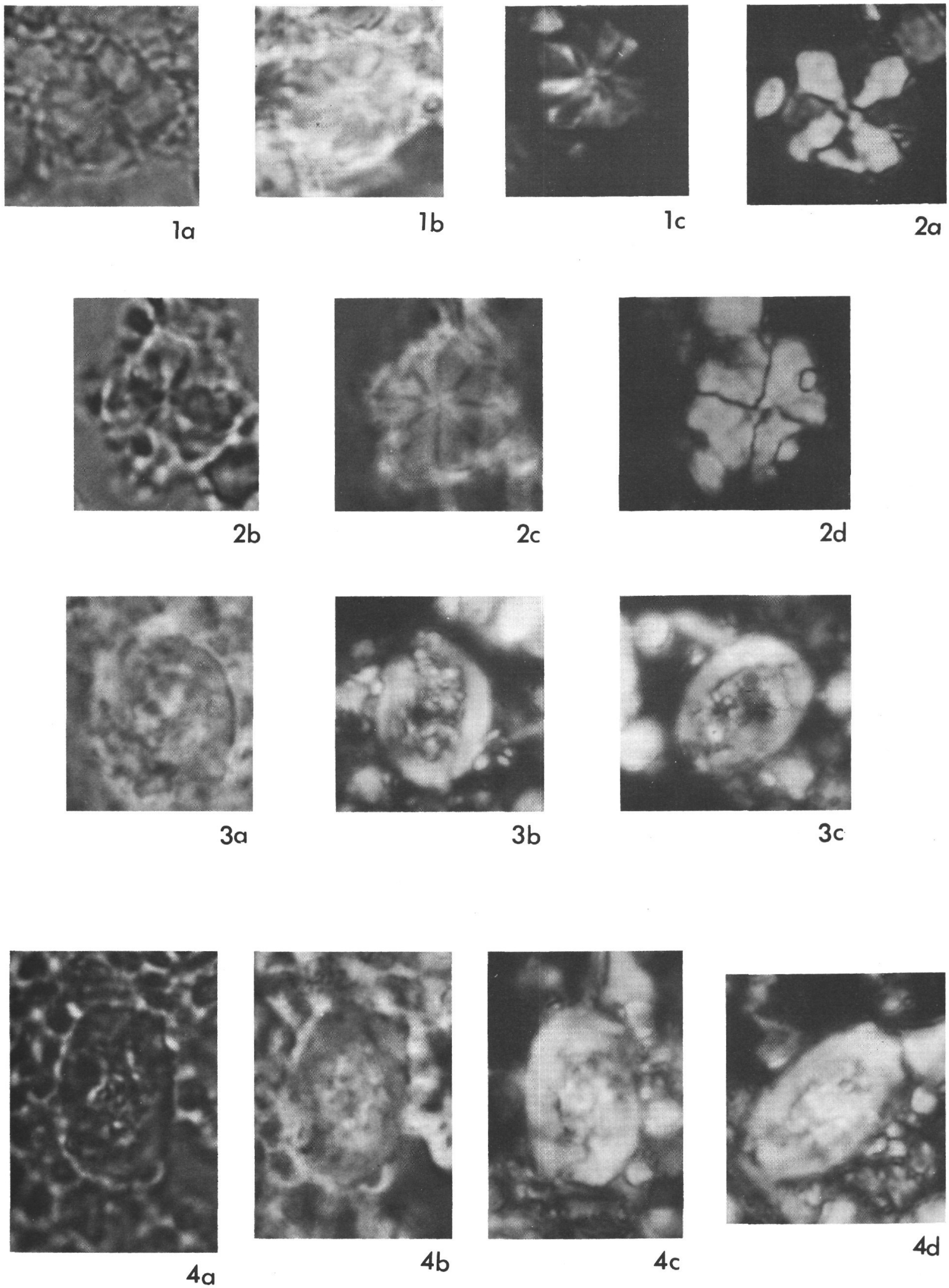

PLATE 25

Light micrographs of lower Cretaceous nannofossils;
Magnification: 3000X

Figure 1	*Cruciellipsis cuvillieri*, (a) ordinary light, (b) crossed nicols, (c) crossed nicols. Sample 167-87, CC, *Watznaueria britannica* Zone.
Figure 2	*Parhabdolithus embergeri*, (a) long axis at 0° to crossed nicols, (b) long axis at 45° to crossed nicols. Sample 167-87, CC.
Figure 3	*Cyclagelosphaera deflandrei* n. comb., (a) ordinary light, (b) crossed nicols. Sample 167-87, CC.
Figure 4	*Diazomatolithus lehmani*, (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-78, CC, *Tubodiscus jurapelagicus* Zone.
Figure 5	*Assipetra infracretacea* n. comb., (a) ordinary light, (b) crossed nicols, (c) crossed nicols. Sample 167-87, CC, *Watznaueria barnesae* Zone.
Figure 6	*Diazomatolithus lehmani*, (a) phase contrast, (b) crossed nicols, high focus, (c) crossed nicols low focus. Sample 167-78, CC, *Tubodiscus jurapelagicus* Zone.
Figure 7	*Assipetra infracretacea* n. comb., phase contrast. Sample 167-78, CC, *Tubodiscus jurapelagicus* Zone.
Figure 8	*Rucinolithus wisei*, phase contrast. Sample 167-83, CC, *Watznaueria britannica* Zone.
Figure 9	*Assipetra infracretacea* n. comb., (a) Ordinary light, high focus, (b) ordinary light, low focus, (c) phase contrast, (d) crossed nicols, (e) crossed nicols. Sample 167-70-1, 128 cm, *Parhabdolithus angustus* Zone.
Figure 10	*Polycostella beckmannii*, (a) ordinary light, (b) crossed nicols. Sample 167-94-2, 56 cm, *Nannoconus colomi* Zone.
Figure 11	*Polycostella beckmannii*, crossed nicols. Sample 167-94-2, 56 cm.

PLATE 25

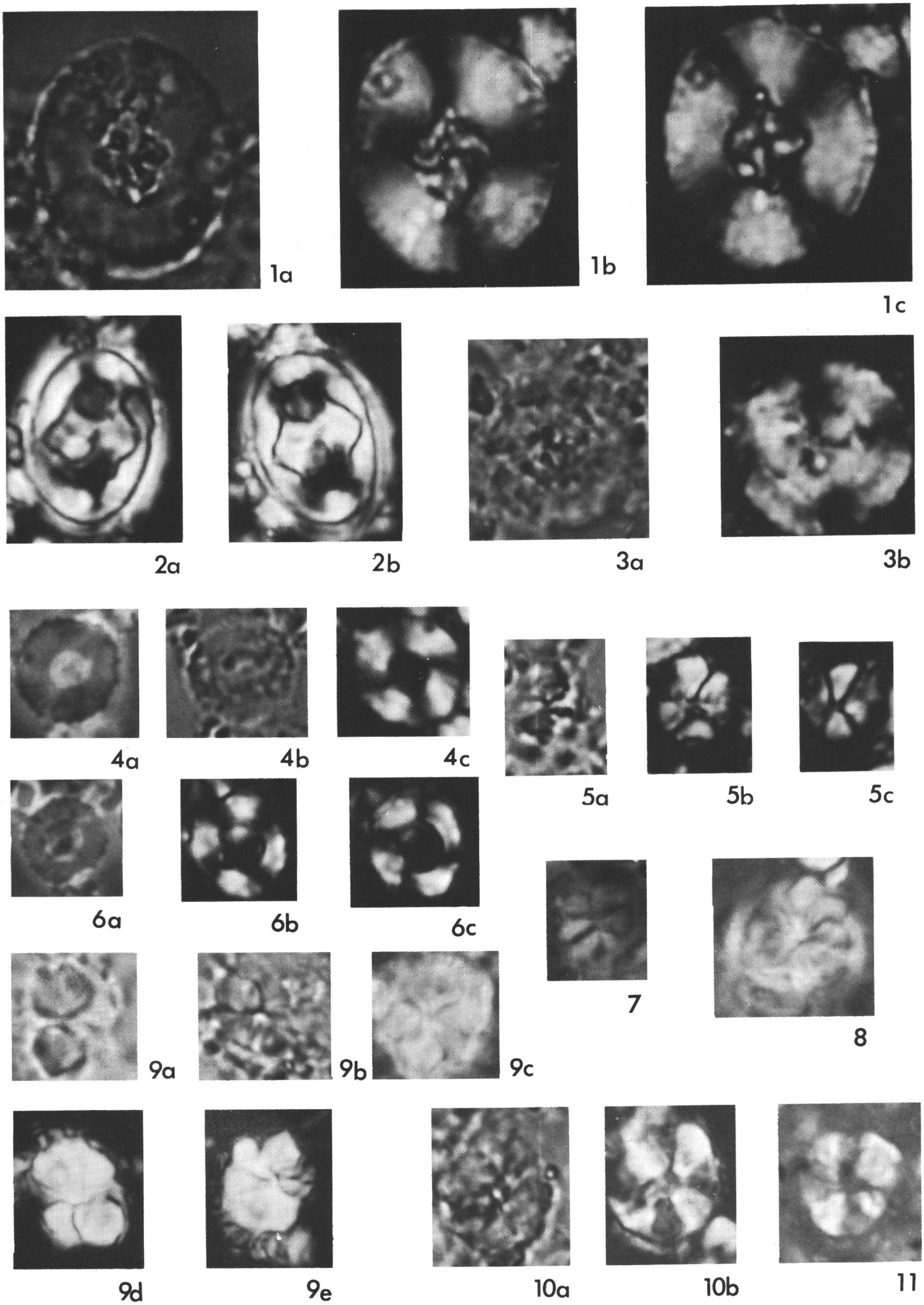
1a
1b
1c
2a
2b
3a
3b
4a
4b
4c
5a
5b
5c
6a
6b
6c
7
8
9a
9b
9c
9d
9e
10a
10b
11

PLATE 26

Light micrographs of lower Cretaceous nannofossils;
Magnification: 3000X

Figure 1 *Tobodiscus jurapelagicus* n. comb., (a) phase contrast, (b) ordinary light, (c,d) crossed nicols. Sample 167083, CC, *Tubodiscus jurapelagicus* Zone.

Figure 2 *Watznaueria britannica*, (a) phase contrast, (b) ordinary light, (c,d) crossed nicols. Sample 167-94-2, 56 cm, *Nannoconus colomi* Zone.

Figure 3 *Cyclagelosphaera margareli*, large specimen, (a) phase contrast, (b) crossed nicols. Sample 167-93-2, 24 cm, *Nannoconus colomi* Zone.

Figure 4 *Watznaueria barnesae* (small specimen), (a) ordinary light, (b) phase contrast, (c) crossed nicols. Sample 167-94-2, 56 cm, *Nannoconus colomi* Zone.

Figure 5 *Vagalapilla* cf. *V. stradneri* n. comb., phase contrast. Sample 167-94-2, 56 cm, Nannoconus colomi Zone.

Figure 6 *Tubodiscus jurapelagicus* n. comb., (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-83, CC, *Tubodiscus jurapelagicus* Zone.

Figure 7 *Cyclagelosphaera deflandrei* (Manivit) n. comb. (a) phase contrast, (b) ordinary light, (c) crossed nicols. Sample 167-70-1, 128 cm, *Parhabdoithus angustus* Zone.

Figure 8 *Vagalapilla* sp. cf. *V. stradneri*, n. comb., phase contrast. Sample 167-94-2, 56 cm, *Nannoconus colomi* Zone.

PLATE 26

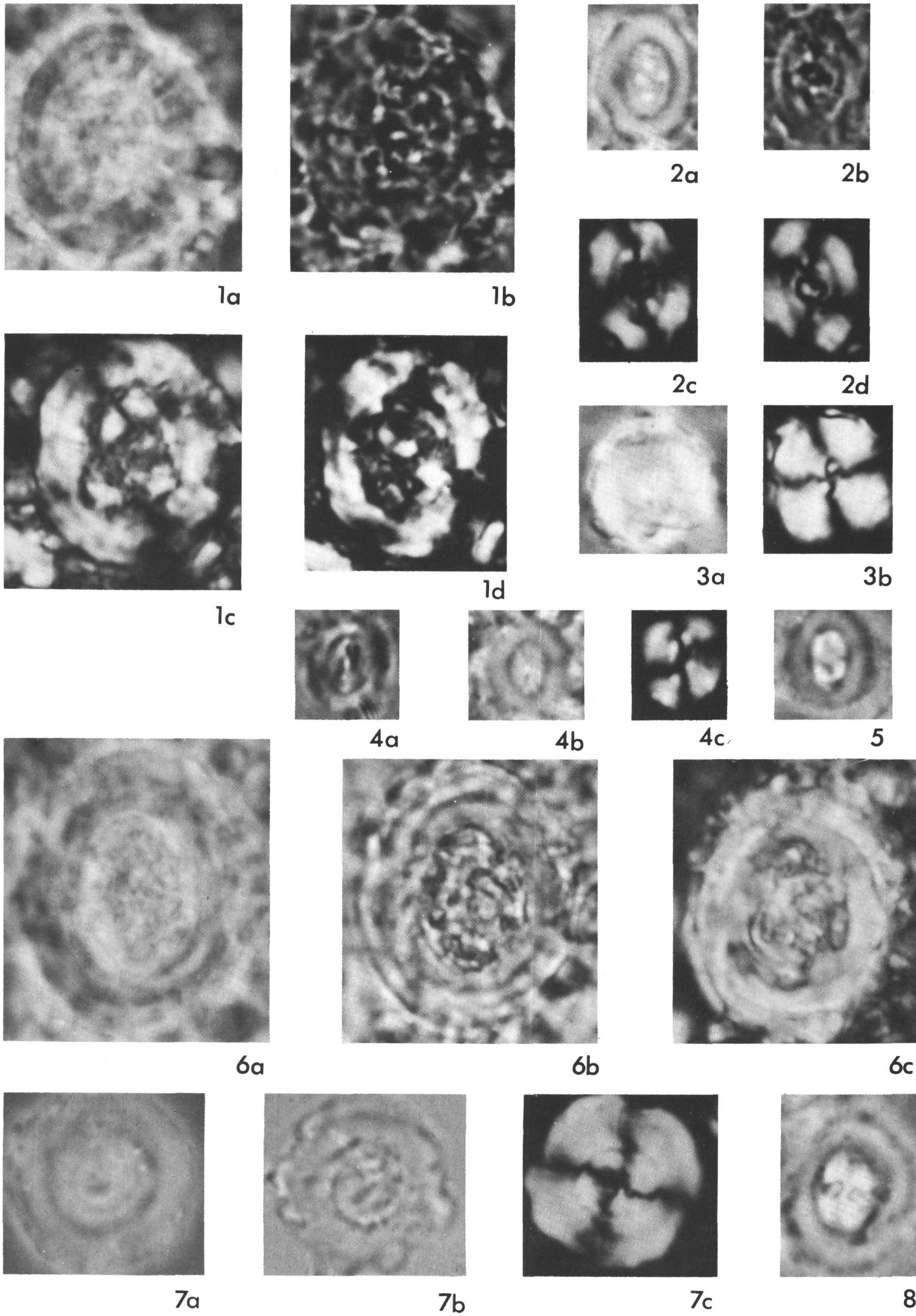

PLATE 27

Light micrographs of lower Cretaceous nannofossils;
Magnification: 3000X

Figure 1 *Nannoconus colomi*, (a) phase contrast, (b) ordinary light, (c) crossed nicols, (d) phase contrast. Sample 167-92, CC, *Nannoconus colomi* Zone.

Figure 2 *Nannoconus colomi*, (a) ordinary light, (b) phase contrast. Sample 167-92, CC.

Figure 3 *Rucinolithus irregularis*, (a) ordinary light, (b) phase contrast, (c) crossed nicols. Sample 167-92, CC.

Figure 4 *Tetralithus malticus,* (a) ordinary light, (b) phase contrast, (c) crossed nicols. Sample 167-72-2-42, cm, *Tetralithus malticus* Zone.

Figure 5 *Markalius circumradiatus,* (a) phase contrast, (b) crossed nicols. Sample 167-67, CC, *Prediscosphaera cretacea* Zone.

Figure 6 *Cyclagelosphaera deflandrei*, (Manivit) n. comb., crossed nicols. Sample 167-83, CC, *Watznaueria britannica* Zone.

PLATE 27