15. REMARKS ON LATE CRETACEOUS TO PLEISTOCENE COCCOLITHS FROM THE NORTH ATLANTIC

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BASIS FOR COCCOLITH AGE DETERMINATIONS LEG 12, DSDP

This report contains the results of the study of the coccoliths and related forms with the light-microscope. Most samples were studied as smear slides only. However, for some samples, preparations were made for the scanning electron microscope (SEM) in concentrating the coccoliths by treatment with ultrason and centrifuging. SEM-pictures from Leg 12 material are presented in Perch-Nielsen (1971a, b and c); most of the material comes from the very well-preserved Paleocene of Site 119. Some forms discussed in the text are illustrated on Plates 1 to 22.

Two ways were open for the zonation with coccoliths of the high latitude sediments investigated. The one chosen in this report is an attempt to use as much as possible of the zonations proposed for lower latitudes. Another possibility was to set up a new zonation for high latitudes, independent from the zonations of low latitudes. The first way was chosen because by using these zones and the scheme by Berggren (Chapter 2) it was possible to get the approximate absolute age of the sediments and thus calculate sedimentation rates. However, in doing so, one has to bear in mind that the real content of a zone and the time span it represents might be slightly different from the ones in lower latitudes. As a working base it proved useful in most holes drilled. However, often the definition or limitations of a zone had to be taken in a broader sense than originally defined. More emphasis was put on the assemblage than on the presence of a single species.

Table 1 gives the stratigraphic position and the radiometric age adapted in this report for the coccolith zones; these were used as the base for calculating sedimentation rates when only coccoliths were available for an age assignment. The sequence adapted for the zones is stated and commented upon below.

Emiliania huxleyi Zone

The presence of *E. huxleyi* defines this zone also in high latitudes. *E. huxleyi*, however, can be difficult to recognize in the light-microscope.

Gephyrocapsa oceanica Zone

Interval from the first occurrence of *Gephyrocapsa oceanica* to the first appearance of *Emiliani huxleyi*. Only small forms of *Cyclococcolithus leptoporus* are present.

"Coccolithus jaramillensis" Zone[1]

The presence of *C. jaramillensis* defines this zone. Also present in the lower part of the zone: *Cyclococcolithus macintyrei* ("big *C. leptoporus*") and *Pseudoemiliania lacunosa.*

Pseudoemiliania lacunosa Zone

Interval from the last occurrence of *Discoaster brouweri* to the first occurrence of *"Coccolithus jaramillensis"*. *Pseudoemiliania lacunosa* as determined in the light-microscope includes probably several species. It is present throughout the zone, however, in slightly different shapes and dimensions, and is more or less common.

Discoaster brouweri Zone

The only discoaster present in this zone is *Discoaster brouweri*. The zone seems to be very small. Also present are *Pseudoemiliania lacunosa* and *Cyclococcolithus macintyrei.* The zone is defined from the last occurrence of *Discoaster pentaradiatus* to the last occurrence of *Discoaster brouweri*.

Remarks: The sites drilled in the Labrador sea all include a "planktonic sediment heavily diluted by glacial detritus" in the Late Pliocene and the Pleistocene. Discoasters are very rare in this sediment and the top of the *Discoaster brouweri* Zone was set above the uppermost occurrence of the species. The possibility, however, cannot be excluded that the species is present also higher up and could be found when searched after for many hours.

Discoaster pentaradiatus Zone

Interval from the last occurrence of *Discoaster surculus* to the last occurrence of *Discoaster pentaradiatus*. This zone seems considerably longer than the *Discoaster brouweri* Zone; otherwise, it contains the same assemblage.

Discoaster surculus Zone

Interval from the last occurrence of *Reticulofenestra pseudoumbilica* to the last occurrence of *Discoaster surculus*. This zone might be difficult to recognize in high latitudes, due to the scarcity of discoasters.

Reticulofenestra pseudoumbilica Zone

Interval from the last occurrence of *Ceratolithus tricorniculatus* to the last occurrence of *Reticulofenestra pseudoumbilica*. The ceratoliths were rare in most samples studied, thus the recognition of zones based on their absence or presence is uncertain. In this zone, *Sphenolithus abies* has its last occurrence.

Discoaster asymmetricus Zone

Interval from the first occurrence of *Discoaster asymmetricus* to the last occurrence of *Ceratolithus tricorniculatus*. This zone is hardly recognizable, due to scarcity of both discoasters and ceratoliths in the samples studied.

[1]Name proposed by A. McIntyre (oral communication, June 1970). *C. jaramillensis* corresponds with *C. doronicoides* Black and Barnes, 1961 in McIntyre *et. al.*, 1967; pl. 2:A.

TABLE 1
Calcareous Nannofossil Zones in the North Atlantic

Age m.y.	See Table	North Atlantic Holes																								Calcareous Nannofossil Zones	Duration m.y.	Age m.y.	Age
		Leg 1		2					3	4			12																
		6	7	8	9	10	11	12	13	26	27A	28	111	111A	112	112A	113	114	115	116	116A	117	117A	118	119				
Pleistocene Late				X	1-4								1								1					*Emiliania huxleyi*	0.3	0.0	Pleistocene Late
										1-5					1		1		1-8?		2,3			1	1?	*Geophyrocapsa oceanica*	0.5	0.3	
Early					5																3-5				2	*"Coccolithus jaramillensis*	0.8	0.8	Early
			1		6		1	1,2C					2	1-4		1	2-4	1,2			6,7			2		*Pseudoemiliania lacunosa*	0.2	1.6	
Pliocene Late			1				1	2C						4	2	1	4									*Discoaster brouweri*	0.2	1.8	Pliocene Late
	6		1					2C	1,2					4,5		1-4		3,4			7,8					*Discoaster pentaradiatus*	0.3	2.0	
		1A?				1		3C,4D 5D,4C						5,6		4				1				3	3	*Discoaster surculus*	0.7	2.3	
						1		4C	2					6		5	5-7?			1	8-10					*Reticulofenestra pseudoumbilica*	0.5	3.0	
Early					7		1							6							11?					*Discoaster asymmetricus*	0.8	3.5	Early
					8									6						2-3				4?		*Ceratolithus rugosus*	0.5	4.3	
						2	1							6			8-12	5-8						5?		*Ceratolithus tricorniculatus*	0.4	4.8	
Miocene Late														6						4?5						*Discoaster quinqueramus*	1.0	5.2	Miocene Late
														6	3?									6	4	*Discoaster neohamatus*	4.8	6.2	
														?6	3					6-8				7		*Discoaster hamatus*	1.7	11.0	
Middle							2A																			*Catinaster coalitus*	0.9	12.7	Middle
							4A																			*Discoaster kugleri*	0.6	13.6	
							5A								4?					9?				8-9?	5	*Discoaster exilis*	0.8	14.2	
																				10,11				10?	6	*Sphenolithus heteromorphus*	0.7	15.0	
Early																									6	*Helicopontosphaera ampliaperta*	1.1	16.3	Early
																				12-14		1		11	7	*Sphenolithus belemnos*	1.6	17.4	
Oligocene Late						2					3,4									15-18					8-11	*Discoaster druggi* *Triquetrorhabdulus carinatus*	5.0	19.0	
											5									19-22		2?			12-14	*Sphenolithus ciperoensis*	2.0	21.0	Oligocene Late
						3									5-7							3?	1		14,15	*Sphenolithus distentus*	3.5	26.0	
Early	5														8-11										16,17	*Sphenolithus predistentus*	4.5	29.5	Early
																									17,18	*Helicopontosphaera reticulatu*	1.5	34.0	
						4,5									12					23-25					18	*Ericsonia obruta*	2.0	35.5	
Eocene Late						5-7								6?												*Sphenolithus pseudoradians*	1.5	37.5	Eocene Late
														6	13					26-28						*Isthmolithus recurvus*	4.0	38.0	
														6	14											*Reticulofenestra umbilica*	1.0	42.0	
Mid	4										6,7	1-4													19	*Discoaster tani nodifer* s.l.	3.0	43.0	Eocene Mid
		3-	2																					12,13	19-22	*Nannotetrina fulgens*	3.0	46.0	
Early		6							1A?					6,7	15									14		*Discoaster sublodoensis*	1.0	49.0	Early
						8,9								8,9										14	23	*Discoaster lodoensis*	0.5	50.0	
														9,10	16?							3?	1-3		23	*Marthasterites tribrachiatus*	1.5	50.5	
																								14	24	*Discoaster binodosus*	0.5	52.0	
																							4,5	15-		*Marthasterites contortus*	1.0	52.5	
Paleocene Late														(12)									6-10	21	25-28	*Discoaster multiradiatus*	2.5	53.5	Paleocene Late
																									28-30	*Discoaster nobilis*	0.7	56.0	
																									30	*Discoaster gemmeus*	0.8	56.7	
	3																								31,32	*Heliolithus kleinpelli*	0.8	57.5	
																									33-38	*Fasciculithus tympaniformis*	1.2	58.3	
Early																									38-40	*Ellipsolithus macellus*	1.5	59.5	Early
																									40?	*Chiasmolithus danicus*	1.5	61.0	
																										Cruciplacolithus tenuis	1.5	62.5	
																										Biantolithus sparsus	1.0	64.0	
Late Cretaceous						10								11?												*Tetralithus murus-Nephrolithus*		65.0	Late Cretaceous
	2				2A	11							(3)	11												*Arkhangelskiella cymbiformis*			
														11												*Reinhardtites anthophorus*			
													4-7	12															

***Ceratolithus rugosus* Zone**

Interval from the first occurrence of *Ceratolithus rugosus* to the first occurrence of *Discoaster asymmetricus*. This zone is also difficult to recognize.

***Ceratolithus tricorniculatus* Zone**

Interval from the last occurrence of *Discoaster quinqueramus. Discoaster quinqueramus* itself appears some-The typical *Discoaster surculus* has its first occurrence at the base of this zone.

***Discoaster quinqueramus* Zone**

Interval from the first occurrence of *Ceratolithus tricorniculatus* to the last occurrence of *Discoaster quinqueramus*. *Discoaster quinqueramus* itself appears somewhat earlier than *Ceratolithus tricorniculatus. Triquetrorhabdulus rugosus* is also present.

***Discoaster neohamatus* Zone**

Interval where *Discoaster neohamatus* is present.

***Discoaster hamatus* Zone**

The zone is here defined by the presence of *Discoaster hamatus. Discoaster quinqueramus* is lacking. *Discoaster hamatus* is rare in the samples studied, as well as *Catinaster calyculus* and *Discoaster bollii*.

***Catinaster coalitus* Zone**

Catinaster coalitus was not found in the material studied, probably because the interval was not cored.

***Discoaster kugleri* Zone**

The zone should be recognizable by the presence of *Discoaster kugleri.* However, the sometimes severe calcification of the discoasters in the samples corresponding to about the Middle Miocene renders the differentiation between *Discoaster kugleri* and the older, long-ranging species *Discoaster druggi* uncertain. The presence of this zone is therefore questionable.

***Discoaster exilis* Zone**

Interval from the last occurrence of *Sphenolithus heteromorphus* to the first occurrence of *Discoaster kugleri*. This zone could only be recognized by the relative abundance of *Discoaster exilis* and the absence of younger, typical discoasters.

***Sphenolithus heteromorphus* Zone**

Interval from the last occurrence of *Helicopontosphaera ampliaperta* to the last occurrence of *Sphenolithus heteromorphus*. The zone was recognized only by the presence of *Sphenolithus heteromorphus* and the absence of *Helicopontosphaera ampliaperta*.

***Helicopontosphaera ampliaperta* Zone**

Interval from the last occurrence of *Sphenolithus belemnos* to the last occurrence of *Helicopontosphaera ampliaperta*. This zone was tentatively recognized by the presence of *Helicopontosphaera ampliaperta* together with *Sphenolithus heteromorphus. Cyclococcolithus leptoporus* s.l. has its first occurrence in this zone.

***Sphenolithus belemnos* Zone**

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

***Triquetrorhabdulus carinatus* Zone**

Interval from the last occurrence of *Helicopontosphaera truncata* to the last occurrence of *Triquetrorhabdulus carinatus*

***Sphenolithus ciperoensis* Zone**

Interval from the last occurrence of *Sphenolithus distentus* to the last occurrence of *Helicopontosphaera truncata*. *Triquetrorhabdulus carinatus* is also present in this zone, while *Sphenolithus ciperoensis* itself was not found in the samples studied.

***Sphenolithus distentus* Zone**

Interval from the first occurrence of *Sphenolithus ciperoensis* to the last occurrence of *Sphenolithus distentus*. Due to the absence of *Sphenolithus ciperoensis*, this zone was only recognized by the occurrence of *Coccolithus* aff. *bisectus* together with *Sphenolithus distentus.*

***Sphenolithus predistentus* Zone**

Interval from the last occurrence of *Reticulofenestra umbilica* to the first occurrence of *Sphenolithus ciperoensis.* This zone was only recognized by the absence of *Reticulofenestra umbilica* while *Sphenolithus distentus* and *Sphenolithus predistentus* are present.

***Helicopontosphaera reticulata* Zone**

Interval from the last occurrence of *Ericsonia obruta* to the last occurrence of *Reticulofenestra umbilica. Isthomolithus recurvus* is not present.

***Ericsonia obruta* Zone**

Interval from the last occurrence of *Discoaster saipanensis* or *Discoaster barbadiensis* to the last occurrence of *Ericsonia obruta. Isthmolithus recurvas* is present.

***Sphenolithus pseudoradians* Zone**

Interval from the first occurrence of *Sphenolithus pseudoradians* to the last occurrence of *Discoaster saipanensis* or *Discoaster barbadiensis. Isthmolithus recurvus* is present. *Sphenolithus pseudoradians* was not found in the samples investigated; the zone probably was not cored, or *Sphenolithus pseudoradians* is not present in high latitudes.

***Isthmolithus recurvus* Zone s.l.**

Interval from the first occurrence of *Isthmolithus recurvus* to the last occurrence of *Discoaster saipanensis* or *Discoaster barbadiensis*. This definition of the zone was useful, as *Sphenolithus pseudoradians* and other coccoliths that permit a further zonation of the interval in lower latitudes were not found.

***Reticulofenestra umbilica* Zone**

Interval from the first occurrence of *Reticulofenestra umbilica* to the first occurrence of *Istmolithus recurvus*. The presence of this zone was established by the occurrence of *Reticulofenestra umbilica* together with *Chiasmolithus grandis*, and *Sphenolithus furcatolithoides*, while *Coccolithus scissurus* is lacking. To my knowledge, *Reticulofenestra umbilica* or forms very similar to it appear already in the *Discoaster lodoensis Zone*. Coccoliths that permit further zonation of the interval in lower latitudes (*Pemma papillatum, Bramletteius serraculoides, Hayella situliformis* and *Clathrolithus spinosus*) are not present.

Discoaster tani nodifer Zone, s.l.

In the broad sense, this zone includes the interval from the first occurrence of *Discoaster tani nodifer* to the first occurrence of *Isthmolithus recurvus*, thus also including the *Reticulofenestra umbilica* Zone.

Nannotetrina fulgens Zone

Interval from the first occurrence of coccoliths of the genus *Nannotetrina* (*N. fulgens, N. cristata*), to the first occurrence of *Discoaster tani nodifer*

Discoaster sublodoensis Zone

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

Discoaster lodoensis Zone

Interval from the last occurrence of *Marthasterites tribrachiatus* to the first occurrence of *Discoaster sublodoensis.*

Marthasterites tribrachiatus Zone

Interval from the first occurrence of *Discoaster lodoensis* to the last occurrence of *Marthasterites tribrachiatus.*

Discoaster binodosus Zone

Interval from the last occurrence of *Marthasterites contortus* to the first occurrence of *Discoaster lodoensis.*

Marthasterites contortus Zone

Interval from the first occurrence of *Marthasterites bramlettei* to the last occurrence of *Marthasterites contortus*. In the absence of *Marthasterites bramlettei*, the zone was recognized only by the presence of *Marthasterites contortus*

Discoaster multiradiatus Zone

Interval from the first occurrence of *Discoaster multiradiatus* to the first occurrence of *Marthasterites bramlettei*. The zone was recognized by the presence of *D. multiradiatus* and the absence of *Marthasterites contortus* or younger discoasters.

Discoaster nobilis Zone

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

Discoaster gemmeus zone

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

Heliolithus kleinpelli Zone

Interval from the first occurrence of *Heliolithus kleinpelli* to the first occurrence of *Discoaster gemmeus*

Fasciculithus tympaniformis Zone

Interval from the first occurrence of *Fasciculithus tympaniformis* to the first occurrence of *Heliolithus kleinpelli*

Ellipsolithus macellus Zone

Interval from the first occurrence of *Ellipsolithus macellus* to the first occurrence of *Fasciculithus tympaniformis*. The presence of this zone was established by the occurrence of *Ellipsolithus macellus* and/or *Ellipsolithus distichus* and the absence of fasciculiths.

Chiasmolithus danicus Zone

Interval from the first occurrence of *Chiasmolithus danicus* to the first occurrence of *Ellipsolithus macellus*. This was the lowermost Tertiary Zone met with on Leg 12.

Tetralithus murus Zone

Interval from the first occurrence of *Tetralithus murus* to the extinction of most Cretaceous coccoliths. Only a few specimens of *T. murus* were found in the topwater of a sample at Site 111 (Hole A).

Arkhangelskiella cymbiformis Zone

Interval from the last occurrence of *Reinhardtites anthophorus* to the first occurrence of *Tetralithus murus* or *Nephrolithus frequens*. This zone probably includes part of the *Lithraphidites quadratus* Zone. *Lithraphidites quadratus* was only present in the uppermost samples belonging to this zone.

Reinhardtites anthophorus Zone

Presence of *Reinhardtites anthophorus*. Base was not cored on Leg 12.

CHECKLIST OF SPECIES USED IN THIS REPORT

The list of most coccolith species considered in this report is given below. An illustration of the species considered is also included. This was necessary since different coccoliths have been listed under the same species name, and the picture of the holotype is sometimes poor. The species mentioned in earlier reports of DSDP and other publications which are listed on the distribution charts (Tables 2 to 6) have not been included in the list below. No attempt was made to bring the taxonomy up to date.

Check List of Species Used in This Report

Ahmuellerella octoradiata (Gorka)	Perch-Nielsen, 1968: Plate 2, Figure 2
Arkhangelskiella cymbiformis Vekshina	Perch-Nielsen, 1968: Plate 19, Figure 1
Aspidorhabdus stylifer (Lohmann)	Boudreaux and Hay, 1969: Plate 4, Figures 12-15
Biscutum constans (Gorka)	Perch-Nielsen, 1968: Plate 27, Figures 1-11
Braarudosphaera bigelowi (Gran and Braarud)	Holotype
Braarudosphaera discula Bramlette and Riedel	Holotype
Braarudosphaera turbinea Stradner	Holotype
Broinsonia parca (Stradner)	Holotype
Catinaster calyculus Martini and Bramlette	Holotype
Ceratolithus cristatus Kamptner	Holotype
Ceratolithus rugosus Bukry and Bramlette	Holotype
Ceratolithus tricorniculatus Gartner	Holotype
Chiphragmalithus armatus Perch-Nielsen	Holotype
Chiphragmalithus calatus Bramlette and Sullivan	Holotype
Chiasmolithus altus Bukry and Percival	Plate 3, Figure 5
Chiasmolithus bidens (Bramlette and Sullivan)	Holotype
Chiasmolithus consuetus (Bramlette and Sullivan)	Holotype
Chiasmolithus danicus (Brotzen)	Perch-Nielsen, 1969: Plate 1, Figures 1-4
Chiasmolithus eograndis Perch-Nielsen	Holotype
Chiasmolithus expansus (Bramlette and Sullivan)	Holotype
Chiasmolithus gigas (Bramlette and Sullivan)	Holotype
Chiasmolithus aff. *gigas* (Bramlette and Sullivan)	Holotype
Chiasmolithus grandis (Bramlette and Riedel)	Perch-Nielsen, 1971: Plate 10, Figure 4
Chiasmolithus solitus (Bramlette and Sullivan)	Holotype
Coccolithites ficula Stover	Holotype
Coccolithus bisectus (Hay *et. al.*)	Bramlette and Wilcoxon, 1967: Plate 4, Figures 11-13
Coccolithus aff. *C. bisectus* Hay *et al*	Bramlette and Wilcoxon, 1967: Plate 4, Figures 9-10
Coccolithus eopelagicus (Bramlette and Riedel)	Bramlette and Wilcoxon, 1967: Plate 4, Figures 6-8
Coccolithus pelagicus (Wallich)	Bramlette and Wilcoxon, 1967: Plate 3, Figures 13-15
Coccolithus aff. *C. scissurus* (Hay *et al.*)	Bramlette and Wilcoxon, 1967: Plate 4, Figures 1-2
Coronocyclus nitescens (Kamptner)	Bramlette and Wilcoxon, 1967: Plate 5, Figures 7-8
Coronocyclus prionion (Deflandre and Fert)	Holotype
Cretarhabdus conicus Bramlette and Martini	Holotype
Cretarhabdus crenulatus Bramlette and Martini	Holotype
Cretarhabdus decorus (Deflandre)	Bramlette and Martini, 1964: Plate 3, Figures 9-12
Cribrocentrum reticulatum (Gartner)	Perch-Nielsen, 1971: Plate 15, Figures 4-9
Cribrosphaerella ehrenbergi (Arkhangelsky)	Perch-Nielsen, 1968: Plate 17, Figures 1-8
Cruciplacolithus delus (Bramlette and Sullivan)	Holotype
Cruciplacolithus staurion (Bramlette and Sullivan)	Holotype
Cruciplacolithus tenuis (Stradner)	Perch-Nielsen, 1969: Plate 1, Figures 7, 8
Cruciplacolithus neohelis (McIntyre and Be)	Holotype
Cruciplacolithus inseadus Perch-Nielsen	Holotype
Cyclococcolithus leptoporus (Murray and Blackman)	Boudreaux and Hay, 1969: Plate 3, Figure 1
Cyclococcolithus macintyrei Bramlette and Bukry	Holotype
Cyclococcolithus neogammation Bramlette and Wilcoxon	Holotype
Cyclolithus robustus Bramlette and Sullivan	Holotype
Cylindralithus gallicus Bramlette and Martini	Holotype
Discoaster adamanteus Bramlette and Wilcoxon	Holotype
Discoaster asymmetricus Gartner	Holotype
Discoaster aulakos Gartner	Holotype
Discoaster barbadiensis Tan Sin Hok	Stradner, 1961: Plate 28, Figure 2
Discoaster bollii Martini and Bramlette	Holotype

Discoaster brouweri Tan Sin Hok	Martini and Bramlette, 1963: Plate 102, Figures 9, 10
Discoaster Calcaris Gartner	Holotype
Discoaster challengeri Bramlette and Riedel	Martini and Bramlette, 1963: Plate 103, Figure 12
Discoaster deflandrei Bramlette and Riedel	Bramlette and Wilcoxon, 1967: Plate 7, Figure 4
Discoaster distinctus Martini	Holotype
Discoaster druggi Bramlette and Wilcoxon	Holotype
Discoaster elegans Bramlette and Sullivan	Holotype
Discoaster exilis Martini and Bramlette	Holotype
Discoaster gemmeus Stradner	Holotype
Discoaster hamatus Martini and Bramlette	Holotype
Discoaster kuepperi Stradner	Holotype
Discoaster lenticularis Bramlette and Sullivan	Holotype
Discoaster lodoensis Bramlette and Riedel	Holotype
Discoaster multiradiatus Bramlette and Riedel	Holotype
Discoaster neohamatus Bukry and Bramlette	Holotype
Discoaster nobilis Martini	Holotype
Discoaster pentaradiatus Tan Sin Hok	Martini and Bramlette, 1963: Plate 105, Figure 5
Discoaster quinqueramus Gartner	Holotype
Discoaster saipanensis Bramlette and Riedel	Holotype
Discoaster salisburgensis Stradner	Holotype
Discoaster sublodoensis Bramlette and Sullivan	Holotype
Discoaster surculus Martini and Bramlette	Holotype
Discoaster tani nodifer Bramlette and Riedel	Holotype
Discoaster tani ornatus Bramlette and Wilcoxon	Holotype
Discoaster variabilis Martini and Bramlette	Holotype
Discoaster wemmelensis Achutan and Stradner	Holotype
Discolithina multipora Kamptner	Holotype
Discolithina plana (Bramlette and Sullivan)	Holotype
Discolithina segmenta Bukry and Percival	Plate 21, Figure 1
Discosphaera tubifera (Murray and Blackman)	Boudreaux and Hay, 1969: Plate 5, Figures 4-7
Dodekapodorhabdus noelae Perch-Nielsen	Holotype
Eiffellithus eximius (Stover)	Holotype
Eiffellithus turriseiffeli (Deflandre)	Holotype
Ellipsodiscoaster lidzi Boudreaux and Hay	Holotype
Ellipsolithus distichus (Bramlette and Sullivan)	Holotype
Ellipsolithus macellus (Bramlette and Sullivan)	Holotype
Emiliania huxleyi (Lohmann)	Gartner, 1969: Plate 2, Figure 5
Ericsonia alternans Black	Holotype
Ericsonia obruta Perch-Nielsen	Holotype
Ericsonia ovalis Black	Holotype
Ericsonia cava (Hay and Mohler)	Holotype
Ericsonia cribellum (Bramlette and Sullivan)	Holotype
Ericsonia subpertusa Hay and Mohler	Holotype
Fasciculithus billii Perch-Nielsen	Holotype
Fasciculithus involutus Bramlette and Sullivan	Perch-Nielsen, 1971: Plate 4, Figures 1-10
Fasciculithus janii Perch-Nielsen	Holotype
Fasciculithus schaubi Hay and Mohler	Perch-Nielsen, 1971: Plate 7, Figures 6, 9:1
Fasciculithus tympaniformis Hay and Mohler	Perch-Nielsen, 1971: Plate 1, Figures 1-5
Fasciculithus ulii Perch-Nielsen	Holotype
Geophyrocapsa aperta Kamptner	Gartner, 1969: Plate 2, Figure 8
Gephyrocapsa oceanica Kamptner	Gartner, 1969: Plate 2, Figure 7
Glaukolithus fessus (Stover)	Holotype
Helicopontosphaera ampliaperta (Bramlette and Wilcoxon)	Holotype
Helicopontosphaera compacta (Bramlette and Wilcoxon)	Holotype
Helicopontosphaera kamptneri Hay and Mohler	Boudreaux and Hay, 1969: Plate 6, Figures 10-15
Helicopontosphaera lophota (Bramlette and Sullivan)	Holotype

Helicopontosphaera parallela (Bramlette and Wilcoxon)	Holotype
Helicopontosphaera reticulata (Bramlette and Wilcoxon)	Holotype
Helicopontosphaera sellii Bukry and Bramlette	Holotype
Helicopontosphaera seminulum (Bramlette and Sullivan)	Holotype
Helicopontosphaera wallichii (Lohmann)	Plate 18, Figures 1-3, 8, 11
Heliolithus kleinpelli Sullivan	Holotype
Heliolithus riedeli Bramlette and Sullivan	Holotype
Isthmolithus recurvus Deflandre	Holotype
Kamptnerius magnificus Deflandre	Holotype
Koczyia scissura Perch-Nielsen	Holotype
Lithraphidites quadratus Bramlette and Martini	Holotype
Lithraphidites carniolensis Deflandre	Holotype
Lophodolithus nascens Bramlette and Sullivan	Holotype
Lucianorhabdus cayeuxi Deflandre	Holotype
Markalius inversus (Deflandre)	Perch-Nielsen, 1969: Plate 3, Figures 5, 6
Marthasterites contortus (Stradner)	Holotype
Marthasterites inconspicuus Deflandre	Holotype
Marthasterites obscurus Martini	Perch-Nielsen, 1968: Plate 1, Figures 7-8
Marthasterites tribrachiatus (Stradner)	Holotype
Micrantholithus bramlettei Deflandre	Bramlette and Sullivan, 1961: Plate 9, Figure 2
Micrantholithus crenulatus Bramlette and Sullivan	Holotype
Micrantholithus stradneri Chang	Bukry and Bramlette, 1969: Plate 2, Figures 16-19
Micrantholithus vesper Deflandre	Bramlette and Sullivan, 1961: Plate 9, Figure 10
Microrhabdulus decoratus Deflandre	Holotype
Micula staurophora (Gardet)	Perch-Nielsen, 1968: Plate 31, Figures 1-4
Nannotetrina cristata (Martini)	Plate 15, Figures 3, 4
Nannotetrina fulgens (Stradner)	Plate 15, Figure 1
Nannotetrina pappi (Stradner)	Plate 15, Figure 2
Neococcolithes dubius Deflandre	Holotype
Neococcolithes junctus Bramlette and Sullivan	Holotype
Neococcolithes protenus Bramlette and Sullivan	Holotype
Parhabdolithus embergeri (Noel)	Holotype
Pontosphaera discopora Schiller	Boudreaux and Hay, 1969: Plate 6, Figures 3-7
Pontosphaera scutellum Kamptner	Boudreaux and Hay, 1969: Plate 5, Figures 10-13
Prediscosphaera cretacea (Arkhangelsky)	Perch-Nielsen, 1968: Plate 13, Figures 1-6
Prediscosphaera spinosa (Bramlette and Martini)	Holotype
Prinsius bisulcus Hay and Mohler	Holotype
Prinsius martinii Perch-Nielsen	Holotype
Pseudoemiliania lacunosa (Kamptner)	Gartner, 1969: Plate 2, Figures 9, 10
Reticulofenestra insignita Roth and Hay	Holotype
Reticulofenestra laevis Roth and Hay	Holotype
Reticulofenestra pseudoumbilica (Gartner)	Gartner, 1969: Plate 2, Figure 4
Reticulofenestra umbilica (Levin)	Holotype
Rhabdolithus inflatus (Bramlette and Sullivan)	Holotype
Rhabdolithus splendens Deflandre	Holotype
Rhabdosphaera clavigera (Murray and Blackman)	Boudreaux and Hay, 1969: Plate 4, Figures 8-10
Rhabdosphaera tenuis Bramlette and Sullivan	Holotype
Rheinhardtites anthophorus (Deflandre)	Perch-Nielsen, 1968: Plate 5, Figures 1-8
Scapholithus fossilis Deflandre	Holotype
Scapholithus rhombiformis Hay and Mohler	Holotype
Scyphosphaera amphora Deflandre	Holotype
Scyphosphaera apsteinii Lohmann	Deflandre, 1942: Figures 10-15
Scyphosphaera pulcherrima Deflandre	Holotype
Semihololithus biskayae Perch-Nielsen	Holotype
Semihololithus kerabyi Perch-Nielsen	Holotype
Sphenolithus abies Deflandre	Holotype

Sphenolithus anarrhopus Bukry and Bramlette	Holotype
Sphenolithus belemnos Bramlette and Wilcoxon	Holotype
Sphenolithus ciperoensis Bramlette and Wilcoxon	Holotype
Sphenolithus distentus (Martini)	Holotype
Sphenolithus furcatolithoides Locker	Holotype
Sphenolithus heteromorphus Deflandre	Holotype
Sphenolithus moriformis (Bronnimann and Stradner)	Bramlette and Wilcoxon, 1967: Plate 2, Figures 7-9
Sphenolithus neoabies Bukry and Bramlette	Holotype
Sphenolithus orphanknolli Perch-Nielsen	Holotype
Sphenolithus predistentus Bramlette and Wilcoxon	Holotype
Sphenolithus primus Perch-Nielsen	Holotype
Sphenolithus pseudoradians Bramlette and Wilcoxon	Holotype
Sphenolithus radians Deflandre	Holotype
Staurolithes matalosus Stover	Holotype
Syracosphaera histrica Kamptner	Boudreaux and Hay, 1969: Plate 8, Figures 12-19
Tetralithus aculeus Stradner	Holotype
Tetralithus murus Martini	Holotype
Tetralithus obscurus Deflandre	Holotype
Thoracosphaera sp.	
Toweius craticulus Hay and Mohler	Perch-Nielsen, 1971: Plate 13, Figures 7-10
Toweius eminens (Bramlette and Sullivan)	Perch-Nielsen, 1971: Plate 13, Figures 4, 6
Toweius occultatus (Locker)	Holotype
Toweius tovae Perch-Nielsen	Holotype
Tranolithus exiguus Stover	Holotype
Transversopontis exilis (Bramlette and Sullivan)	Holotype
Transversopontis pulcher Deflandre	Holotype
Transversopontis pulcheroides (Sullivan)	Perch-Nielsen, 1971: Plate 33, Figures 3, 7
Triquetrorhabdulus carinatus Martini	Holotype
Triquetrorhabdulus inversus Bukry and Bramlette	Holotype
Triquetrorhabdulus rugosus Bramlette and Wilcoxon	Holotype
Umbilicosphaera mirabilis Lohmann	Boudreaux and Hay, 1969: Plate 3, Figures 9-13
Watznaueria barnesae (Black)	Perch-Nielsen, 1968: Plate 22, Figures 1-7
Zygodiscus sigmoides Bramlette and Sullivan	Holotype
Zygolithus erectus Deflandre	Holotype
Zygolithus ponticulus (Deflandre)	Perch-Nielsen, 1968: Plate 29, Figures 1, 2
Zygolithus tractus Stover	Holotype
Zygrhablithus bijugatus (Deflandre)	Holotype

COCCOLITH BIOSTRATIGRAPHY AND DISTRIBUTION IN THE NORTH ATLANTIC

General

The reports of Legs 1 to 4 of DSDP which contain the sites drilled in the North Atlantic are published and available for comparison with the sites drilled on Leg 12. Figure 1 gives the location of the sites drilled on Leg 12 and on the legs mentioned above. Table 1 lists the presence of calcareous nannofossil zones in North Atlantic sites, as well as the intervals represented on Tables 2 to 6 and the age assigned to the zones (according to Berggren, Chapter 2) and used for the calculation of the sedimentation rates. These tables show the distribution of coccoliths in calcareous nannofossil zones of Maestrichtian, Paleocene, Eocene, Oligocene and Pliocene/Pleistocene age recovered on these legs. Also included are coccolith assemblages known from other high latitude localities (France, Denmark, USA, Germany). Generally, from Tables 2 to 6 it appears that the assemblages described from previous legs are poorer than those found on Leg 12. This is probably due to the incomplete listing of species in the reports published, where normally mainly the species relevant for an age assignment are listed. A study of the material itself is therefore needed to give a complete picture of the lateral and vertical distribution of the coccoliths in high latitudes compared to mid and low latitudes.

Maestrichtian

In Table 2, where the distribution of the coccoliths in the Maestrichtian is shown, the localities including as well as the reworked Late Cretaceous assemblages encountered in the Pleistocene of Sites 116 (Rockall) and 118 (Bay of Biscay), and the Paleocene of Site 119 (Bay of Biscay).

TABLE 2
Coccoliths from Maestrichtian Localities

Northern Latitude	Sample \ Maestrichtian Coccoliths	*Ceratolithoides kamptneri*	*Braarudosphaera bigelowi*	*Cylindralithus serratus*	*Cylindralithus gallicus*	*Prediscosphaera cretacea*	*Prediscosphaera spinosa*	*Cribrosphaerella ehrenbergi*	*Cretarhabdus? decorus*	*Cretarhabdus crenulatus*	*Cretarhabdus conicus*	*Tetralithus aculeus*	*Tetralithus nitidus*	*Tetralithus obscurus*	*Tetralithus pyramidus*	*Tetralithus murus*	*Watznaueria barnesae*	*Lithraphidites quadratus*	*Lithraphidites carniolensis*	*Microrhabdulus attenuatus*	*Microrhabdulus* sp.	*Microrhabdulus decoratus*	*Micula staurophora*	*Eiffellithus turriseiffeli*	*Eiffellithus eximius*	*Tranolithus orionatus*	*Zygodiscus pseudanthophorus*	*Rhabdolithina regularis*	*Rhabdolithina splendens*	*Arkhangelskiella parca*	*Arkhangelskiella cymbiformis*	*Vekshinella* sp.	*Kamptnerius* sp.	*Kamptnerius magnificus*	*Lucianorhabdus cayeuxi*	*Crepidolithus* sp.	*Discorhabdus ignotus*	*Reinhardtites mirabilis*	*Reinhardtites anthophorus*	*Glaukolithus diplogrammus*	*Glaukolithus fessus*	*Ahmullerella octoradiata*	*Biscutum constans*	*Markalius reinhardtii*	*Markalius inversus*	*Dodekapodorhabdus noelae*	*Nephrolithus frequens*
32°	DSDP 9A-2-cc	X			X	X					X	X				X	X																														
32°	DSDP 10-10				X	X	X	X	X	X	X	X				X	X	X	X	X		X	X	X			X	X	X		X		X														
	DSDP 10-11			X	÷	X	÷	X	X		X	X			X	÷	X	÷	X	X		X	X	X			X	X	X	X	X	X	X														
50°	DSDP 111A-11-Top		X		X	X	X	X						X		?	X				X	X	X	X							X			X	X				÷		X	X	X	X		÷	
	DSDP 111A-11-1				X	X	X	X								-	X	X			X	X	X	X							X			X	X				÷		X	X	X			÷	
	DSDP 111A-6-cc				X	X	X	X			X		X			-	X		?		X	X	X	X						X	X			X	X				X	X	X	X	X			X	
57°	Kojby Gord, Denmark		X			X	X	X		X	X			X			X	X		X	X		X	X							X			X		X	X	X		X	X	X	X	X	X		X
55°	Mon, Denmark		X			X		X		X				X			X	X		X	X	X	X	X		X				X	X			X	X	X	X		X	X	X	X	X	X	X	X	
57°	DSDP 116A reworked in Pleistocene		X		sp	X	X	X						X			X					X	X	X	X						X	X		X	X				X				X				
45°	DSDP 118 reworked in Pleistocene			?	sp	X		X		X				X			X					X	X	X	X						X	X		X	X						X		X				X
48°	DSDP 119 reworked in Paleocene				sp	X	X	X		X		X		X			X	X				X	X	X	X	X			X		X	X				?					X	X					X

TABLE 3
Coccoliths From Palocene Localities

Localities[a]	Coccoliths / Nannofossil Zones	*M. iversus*	*B. sparsus*	*B. bigelowi*	*B. discula*	*Micrantholithus sp.*	*C. tenuis*	*C. danicus*	*Z. sigmoides*	*E. cava* s.l.	*Tetralithus* sp.	*P. bisulcus*	*H. concinnus*	*Thoracosphaera* sp.	*M. reinhardtii*	*E. robusta*	*E. macellus*	*T. craticulus*	*N. junctus*	*N. protenus*	*T. operculata*	*G. fluckigeri*	*E. distichus*	*F. tympaniformis*	*C. consuetus*	*C. bidens*	*Z. adamas*	*S. primus*	*F. ulii*	*F. billii*	*F. janii*	*F. thomasii*	*M. pinguis*	*M. truncus*	*H. kleinpelli*	*D. gemmeus*
DSDP 119-25 to 27	*D. multiradiatus*	X		X	X			cf	X	X						X	X	X	X	X			X	X	X	X	X	X				X			X	X
DSDP 117A6 to 10		X		X		X		cf		X				X	X			X	X	X	X		X	X		X		sp								X
Pont Labau		X	X	X	X	X	X		X	X			X					X	X	X			X		X	X	X									
Lodo 31				X	X	X			X	X			X			X				X			X		X								X			
Lodo 6+1	*D. nobilis*								X	X			X				X		X		X		X		X	X	X	sp								
DSDP 119-28, 29				X	X			X	X	X			X	X		X	X	X					X	X	X	X		X							X	X
DSDP 119-30	*D. gemmeus*			X	X			X	X	X				X		X	X	X		X			X	X				X							X	X
Pont Labau		X		X	X		X		X	X			X											X	X		X								X	X
DSDP 119-31	*H. kleinpelli*	X		X	X		X		X	X				X		X	X	X			X		X	X		X		X							X	sp
Pont Labau		X	X	X			X			X			X											X	X	X									X	
DSDP 119-33 to 37	*F. tympaniformis*	X		X	X		X	X	X	X		X	X	X		X	X	X	cf	X			X	X		X		X	X	X	X	X	X	X		
Pont Labau		X	X	X	X	X	X	X	X	X			X											X	X	X	X									
DSDP 119-39	*E. macellus*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X				X		X													
Alabama 2A		X	X	X		X	X	X	X	X			X	X		X	X	sp	X	X	X	X														
DSDP 119-40cc?	*C. danicus*	X		X		X	X	X		X	X		X	X	X	X																				
Pont Labau		X	X	X	X	X	X	X	X	X	X	X																								

[a]Paleocene localities: DSDP 119 and 117A, Lodo Formation California (Bramlette & Sullivan, 1961), Alabama (Bramlette & Martini, 1964) and Pont Labau Sw France (Hay & Mohler, 1967).

TABLE 3 – *Continued*

Localities[a]	Coccoliths / Nannofossil Zones	*H. conicus*	*F. involutus*	*T. eminens*	*C. aff. gigas*	*T. tovae*	*S. anarrhopus*	*Z. plectopons*	*S. rhombiformis*	*N. distentus*	*S. kerabyi*	*S. biskayae*	*F. bobii*	*H. riedeli*	*D. helianthus*	*D. lenticularis*	*D. multiradiatus*	*D. plana*	*R. cuspis*	*D. falcatus*	*C. delus*	*D. rimosus*	*C. ellipticus*	*M. bramlettei*	*C. inseadus*	*Rhabdolithus* sp.	*M. crenulatus*	*D. nobilis*	*F. schaubi*	*D. binodosus*	*D. delicatus*	*C. californicus*	*Conococcolithus* sp.	*D. salisburgensis*	*Crepidolithus* sp.	*F. lillianae*	*F. alanii*	*F. richardii*	*F. tonii*
DSDP 119-25 to 27	*D. multiradiatus*		X	X	X	X			X	X	X	X	X		X		X	X											X			X	X			X	X	X	X
DSDP 117A-6 to 10								X								X	X					cf							X					X	X				
Pont Labau				X				X	X							X	X				X							X	X	X	X	X	X						
Lodo 31			X					X								X	X	cf	X	X	X	X	X	X	X	X	X												
Lodo 6+1	*D. nobilis*		X	X	X			cf						X	X																								
DSDP 119-28, 29			X	X	X	X			X	X			X																										
DSDP 119-30	*D. gemmeus*			X	X	X	X		X	X																													
Pont Labau																																							
DSDP 119-31	*H. kleinpelli*	X	X	X	X	X	X																																
Pont Labau																																							
DSDP 119-33 to 37	*F. tympaniformis*																																						
Pont Labau																																							
DSDP 119-39	*F. macellus*																																						
Alabama 2A																																							
DSDP 119-40cc?	*C. danicus*																																						
Pont Labau																																							

[a]Paleocene localities: DSDP 119 and 117A, Lodo Formation California (Bramlette & Sullivan, 1961), Alabama (Bramlette & Martini, 1964) and Pont Labau Sw France (Hay & Mohler, 1967).

TABLE 4
Coccoliths From Eocene Samples

Localities[a]	Nannofossil Zones / Coccoliths	D. saipanensis	D. barbadiensis	D. tani tani	R. umbilica	H. compacta	R. scissura	C. orbis (lusitanicus)	B. serratus	I. recurvus	H. situliformia	S. pseudoradians	S. furcatolithoides	Sphenolithus sp.	C. eopelagicus	E. ovalis	R. reticulata	Rhabdolithus sp.	T. pulcheroides	Z. bijugatus	C. oamaruensis	Chiasmolithus sp.	L. minutus	G. flueckigeri	C. germanicus	C. spinosus	C. expansus	E. obruta	C. grandis	H. seminulum	D. multipora	Braarudosphaera sp.	D. deflandrei	D. tani nodifer	C. gigas	T. pulcher	E. subdisticha	C. delus	N. dubius	N. quadrata	M. basquensis	D. gemmifer	P. stradneri	N. pappi	N. fulgens
DSDP 10-5 to 7	I. recurvus s.l.	X	X	X	X	X	X	X	X	X	X	X																																	
DSDP 111A-6-3			X		X		X			X			X	X	X	X																													
DSDP 112-13		X	X		X		X	X		X				X		X	X	X	X	cf	X																								
DSDP 116-26 to 28		X	X		X	sp	X			X				X	X	X	X	X		cf	X	X	X	X																					
Denmark (Viborg)		X	X		X	X	X	X		X				X		X	X	X	X	X	X			X	X	X	X	X																	
DSDP 27A-6, 7	D. tani nodifer s.l.	X	X		X		X								X	X													X	cf	X	X	X	X											
DSDP 28-1 to 4		X	X		X										X	X				X									X	cf		X	X	X	X	X	X	?	X	X	X	X			
DSDP 111A-6-3, 115		X	X		X			cf						X	X	X	X												X					cf					X						
DSDP 112-14			X		X		sp	cf								X	X					X												cf									X		
DSDP 119-19			X	X	X										X	X																	cf	cf						sp		X		X	X
Denmark (Meldrup)		X	X		X			X					X	X		X	X	X	X	X		X		X		X	X	X	X	X	X		cf	cf		X		X	X				X		
DSDP 6-3 to 5	N. fulgens	X	X		X			sp					X									X	X				X		X	X									X						
DSDP 7-2					X										X	X											X		X																X
DSDP 13-1A ?			X		sp																																								X
DSDP 118-12, 13			X		sp			X						X				X				X					cf		X			X			X					X				X	
DSDP 119-19 to 22		X	X	X	sp			sp						X	X	X						X							X											X		X		X	
Denmark (Ørby)		X	X	cf	sp								X	X				X	X	X										X	X	X							X	X			cf	X	X
DSDP 6-6	D. sublodensis	X	X		sp								X									X					X		X											X					
DSDP 111A-7			X		sp											X		X				X								X								X	X						
DSDP 112-15		X	X		sp			sp					X			X		X	X	X		X																	X				sp		
DSDP 118-14, 66		X	X					sp						X		X						X																							
DSDP 10-8, 9	D. lodoensis		X					X																					cf																
DSDP 111A-8, 9			X		sp											X		X				X								X								X	X						
DSDP 118-14, 130								cf						X		X																													
DSDP 119-23			X													X																													
DSDP	M. tribrachiatus		X					cf								X		X												X								X	X						
DSDP																																													
DSDP			X																													X													
Denmark (Rosnaes)														X		X		X				X																	X		sp				

TABLE 4 – *Continued*

Localities[a]	Nannofossil Zones / Coccoliths	*R. vitrea*	*B. staurion*	*H. lophota*	*Z. aureus*	*E. fenestrata*	*E. femurcentrum*	*N. deflandrei*	*S. moriformis*	*P. scissura*	*H. salebrosa*	*D. punctulata*	*D. elegans*	*D. distichus*	*C. gammation*	*Conococcolithus* sp.	*D. wemmelensis*	*D. sublodoensis*	*D. lenticularis*	*C. californicus*	*D. binodosus*	*L. nascens*	*T. pulcher*	*D. exilis*	*D. bicaveata*	*D. punctosa*	*D. pectinata*	*D. diastypus*	*R. coenura*	*B. arenosa*	*R. inflata*	*C. solitus*	*D. lodoensis*	*C. eograndis*	*N. protenus*	*D. plana*	*D. kuepperi*	*S. radians*	*L. mochloporus*	*L. reniformis*	*M. tribrachiatus*	*C. armatus*	*I. obscurus*	*M. mirabilis*
DSDP 10-5 to 7	*I. recurvus* s.l.																																											
DSDP 111A-6-3																																												
DSDP 112-13																																												
DSDP 116-26 to 28																																												
Denmark (Viborg)																																												
DSDP 27A-6, 7	*D. tani nodifer* s.l.																																											
DSDP 28-1 to 4																																												
DSDP 11A-6-3, 115																																												
DSDP 112-14																																												
DSDP 119-19																																												
Denmark (Meldrup)		X	X	X	X	X	X	X	X	X	X	X	X	cf																														
DSDP 63 to 5	*N. fulgens*																																											
DSDP 7-2				X									X																															
DSDP 13-1A ?																		cf														X												
DSDP 118-12, 13									X						X	X	X																											
DSDP 119-19 to 22																X		X	X	cf	X																							
Denmark (Ørby)			X	X		X							X	cf		X	X		X			X	X	X	X	X	X	X	X	X														
DSDP 6-6	*D. sublodensis*														X			X				sp									X													
DSDP 111A-7						X											X	X			X	X	X	cf									X	X	X	X	X	X						
DSDP 112-15			sp	X															X			X	X				X				X		cf	X	X			X	X					
DSDP 118-14, 66																	X	X															X				X							
DSDP 10-8, 9	*D. lodoensis*		X												X																		X				X	X						
DSDP 111A-8, 9						X				X											X	X	X	X								X	X	X	X		X	X						
DSDP 118-14, 130																																	X	X			cf							
DSDP 119-23																	cf				cf												X				cf							
DSDP 111A-9, 10	*M. tribrachiatus*																					cf		X									X	X	X		X	X	X	X	X			
DSDP 117A-1 to 3																					X			X									X				X				X	X		
DSDP 119-23																					X												X								X			
Denmark (Rosnaes)												X									X	X											X	X	X		X				X	X	X	X

[a]Eocene samples from DSDP Legs 1, 2, 4 and 12 in the North Atlantic and from Denmark (Perch-Nielsen, 1971)

TABLE 5
Coccoliths from Oligocene Samples

Localities[a]	Nannofossil Zones \ Coccoliths	*E. ovalis* ("*C.pelagicus*")	*E. pauciperforata*	*E. subdisticha*	*R. alabamensis*	*C. bisectus*	*R. falcata*	*R. foveolata*	*R. hesslandii*	*R. oamaruensis*	*R. umbilica*	*C. floridanus*	*C. formosus*	*C. kingi*	*B. amplus*	*D. multipora*	*T. zigzag*	*Z. bijugatus*	*I. recurvus*	*L. minutus*	*R. coenura*	*B. creber*	*B. incompertus*	*B. scabrosus*	*H. seminulum*	*T. obliquipons*	*B. bigelowi*	*S. moriformis*	*E. fenestrata*	*I. iris*	*R. tenuis*	*B. spinulus*	*C. elongata*	*C. hayi*	*R. scissura*	*I. fusa*	*H. euphratis*	*S. predistentus*	*P. alta*	*H. compacta*	*M. vesper*	*D. tani nodifer*	*C. germanicus*	*C. lunulus*	*R. vitrea*
DSDP 10-2(?)	*D. druggi* *T. carinatus*																											X																	
DSDP 27A-3,4		X				X						X				X												X																	
DSDP116-15 to 18		X				X										sp.												X							cf.										
DSDP 119-8 to 11		X				cf.																						X																	
DSDP 10-3	*S. ciperoensis*	X									X																	X							X			X							
DSDP 27A-5		X				X						X				X									cf.			X												X					
DSDP 116-19 to 22 (?)		X								sp.																																			
DSDP 117-2(?)		X				X					sp.																																		
DSDP 119-12 to 14		X				X																						X																	
DSDP 112-5 to 7	*S. distentus*	X				X					sp.					X												X			sp.														
DSDP 119-14 & 15		X				X					sp.																X	X										cf.							
DSDP 112-8 to 11	*S. predistentus*	X				X										X												X										X							
DSDP 117-3(?) + 117A-1		X				X																						X										X							
DSDP 119-16 & 17		X				X																						X			sp.							X							
N. Germany		X							X			X				X	X	X									X	X			X							X							
DSDP 119-17 & 18	*H. reticulata*	X				X																									sp.							X							
Chattian N. Germany		X				X		X	X		X	X				X		X			X					X		X							X			X						X	X
Rupelian N. Germany		X				X		X	X		X	X				X	X	X			X							X		X					X	X		X	X						
Rupelian N. Germany		X	X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X					X		X	X	X		X	X	X		X		X		X			X		X
DSDP 10-4 & 5	*E. obruta*, *E. subdisticha*										X								X									X							X										
DSDP 112-12				X		X					X						sp.		X		cf.							X	cf.		sp.														
DSDP 116-23 to 25		X		X	sp.	X					X							cf.	X								X				sp.							X							
DSDP 119-18		X		X		X					X		X						X												sp.							X							
Lattorfian N. Germany		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lattorfian N. Germany		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																	

[a]Oligocene samples from DSDP Legs 2, 4 and 12 in the North Atlantic and the Type region (N. Germany) of the Oligocene (from Roth, 1970)

TABLE 5 – *Continued*

Localities[a]	Nannofossil Zones / Coccoliths	*H. intermedia*	*C. serratus*	*D. deflandrei*	*D. tani ornatus*	*R. reticulata*	*E. obruta*	*C, neogammation*	*Discoaster* sp.	*Discolithina* cf. *D. segmenta*	*Sphenolithus* sp.	*C. altus* (+*Chiasmolithus* sp.)	*H. parallela*	*C. oamaruensis*	*B. serraculoides*	*C. eopelagicus*	*S. pseudoradians*	*D. tani tani*	*C. tarquinius*	*C. margaritae*	*R. danica*	*B. rosa*	*D. rufus*	*L. perdurum*	*R. pectinata*	*C. bollii*	*R. insignita*	*R. laevis*	*C. parvulus*	*C. primalis*	*H. macroporus*	*S. distentus*	*D. adamanteus*	*H. recta*	*D. saundersi*	*T. carinatus*	*D. druggi*	*S. ciperoensis*	*D. anisotrema*	*S. radians*	*S. belemnos*	*C. leptoporus*	*D. aulakos*	*C. nitescens*	*H. ampliaperta*	*C. pseudocarteri*
DSDP 10-2(?)	*D. druggi* *T. carinatus*							X	X																												X									
DSDP 27A-3,4				X									X																			X			X	X	cf.							X		X
DSDP 116-15 to 18				cf.				cf.	X		X	X	X																				X			sp.									X	
DSDP 119-8 to 11				X				X								X																				X	X				X	X	X	sp.		
DSDP 10-3	*S. ciperoensis*							X	X																													X		X						
DSDP 27A-5				X									X			X																			X	X		X	X							
DSDP 116-19 to 22 (?)								X		X	X	X	X			X																				X	cf.									
DSDP 117-2(?)								X	X	X	X	X				X																														
DSDP 119-12 to 14				X				X			X	sp.				X												cf.								X										
DSDP 112-5 to 7	*S. distentus*							X	X			X																				X			cf.											
DSDP 119-14 & 15				X								sp.				X												cf.																		
DSDP 112-8 to 11	*S. predistentus*							X	X			X																cf.				X														
DSDP 117-3(?) + 117A-1							X	X		X						X																X		X												
DSDP 119-16 & 17				cf.				X								X												cf.					X													
N. Germany																			X		X					X	X	X			X	X														
DSDP 119-17 & 18	*H. reticulata*							X								X												cf.																		
Chattian N. Germany																					X				X			X	X	X																
Rupelian N. Germany																				X	X			X	X	X	X																			
Rupelian N. Germany			X																X	X	X	X	X	X																						
DSDP 10-4 & 5	*E. obruta, E. subdisticha*							X							X	X	X	X																												
DSDP 112-12														cf.																																
DSDP 116-23 to 25							X	X	X	X	X	sp.	sp.	X																																
DSDP 119-18				cf.	X	X	X	X																																						
Lattorfian N. Germany		X	X																																											
Lattorfian N. Germany																																														

[a]Oligocene samples from DSDP Legs 2, 4 and 12 in the North Atlantic and the Type region (N. Germany) of the Oligocene (from Roth, 1970)

TABLE 6
Late Pliocene to Early Pleistocene samples from DSDP Legs 1, 2, 3 and 12 in the North Atlantic

DSDP Localities[a]	Nannofossil Zones / Coccoliths	*C. leptoporus*	*C. macintyrei*	*C. pelagicus*	*D. brouweri*	*D. pentaradiatus*	*P. lacunosa*	*H. kamptneri*	*D. variabilis*	*P. discopora*	*H. sellii*	*S. neoabies*	*S. abies*	*Syracosphaera* sp.	*Rhabdosphaera* sp.	*Scyphosphaera* sp.	*R. pseudoumbilica*	*D. surculus*	*Thoracosphaera* sp.	*C. rugosus*	*C. tricorniculatus*	*S. fossilis*	*Gephyrocapsa* sp.	*U. mirabilis*	*C.* cf. *neohelis*	*R. clavigera*	*G. aperta*	*C. cristatus*
7-1	*P. lacunosa*	X																					X					X
9-6				X	(X)		X																X	X				X
12-1, 2C		X						X															X	X		X		
111-2, 111A-1 to 4		X	X	X			X	X		X	X			X		X			X			X	X		X	X	X	
112A-1		X	X	X			X	X		X	X			X	X				X			X	X			X	X	sp.
113-2 to 4		X	X	X			X	X		X	X		cf.	X					X				X		X	X	X	
114-1, 2		X		X			X	X		X	X			X									X		X			
116A-6, 7		X	X	X			X	X		X	X			X	X	X							X		X	X	cf	
118-2, 119-2		X	X	X			X	X		X	X			X	X				X			X	X				X	
7-1	*D. brouweri*				X																							
11-1					X		X													X			X	X				
12-2C					X		X																					
111A-4		X	X	X	X		X	X		X				X	X				X	X		X	X			cf.		
112-2,112A-1		X	X	X	X		X	X		X				X	X	X			X			X			X	X		
113-4		X	X	X	X			X			X																	
116A-7, 8		X	X	X	X			X		X	X			X	X	X						X						
7-1	*D. pentaradiatus*				X	X																						
12-2C		X		X	X	X	X																					
13-1, 2		X			X	X	X	X												X								
113-4		X	X	X	X	X	X	X		X	X			X	X					X		X				cf.		
112A-1 to 4		X	X	X	X	X	X	X		X				X	X				X	sp.		X			X	X		
10-1	*D. surculus*				X	X	cf.											X		X								
12-3C, 4C, 4D, 5D		X		X	X	X	cf.	X	X									X		X			X	X				
111A-5, 6		X	X	X	X	X	X	X		X	X			X	X	X		X	X	sp.		X						
112A-4		X	X	X	X	X	cf.	X										X		sp.								
116-1		X	X	X	X		X	X		X	X	X		X	X	X		X	X									
118-3, 119-3		X	X	X	X	X	X	X		X	X			X	X			X	X									
10-1	*R. pseudoumbilica*				X	X							X				X	X			X							
12-4C		X		X	X	X			X								X	X		sp.								
13-2		X			X	X											X			X								
111A-6		X	X	X	X	X	cf.	X	X	X	X		X	X	X	(X)	X	X	X		X							
112A-5		X	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X	sp.	X							
116A-8 to 10		X	X	X	X	X	cf.	X	X	X	X	X	X	X	X	X	X											

[a]Late Pliocene to Early Pleistocene samples from DSDP Legs 1, 2, 3, and 12 in the North Atlantic.

Cretaceous/Tertiary Boundary

In the North Atlantic, at the Cretaceous/Tertiary boundary, samples of Danian age have not yet been found, while Late Maestrichtian is known from Sites 9, 10 and 111. At Site 111 on Orphan Knoll, Lower Eocene overlies Upper Maestrichtian with only a few meters left for Paleocene deposits. Discoasters found in the water of Core 111A-12 suggest, however, that the *Discoaster multiradiatus* Zone of the Late Paleocene is present at the site in an interval not sampled although cored continuously. On Rockall, Site 117, the *D. multiradiatus* Zone is also present, and overlies basalt. In the Bay of Biscay drilling was stopped in ?Late Danian due to a shortage of time at the end of the cruise.

Paleocene

Late Paleocene was recovered only on Sites 117, 118 and 119, while Early Paleocene was cored on Site 119 only. Table 3 shows the distribution of Paleocene coccoliths at these sites compared with sections from California (Lodo), Pont Labau (France) and Alabama. Of special interest is the Paleocene of Site 119 in the Bay of Biscay as it contains very well-preserved coccoliths. The assemblages in the different zones are very similar to those described by Hay and Mohler (1967) from Pont Labau, with those from Lodo described by Bramlette and Sullivan (1961), and those from Alabama described by Bramlette and Martini (1964). *Heliolithus riedeli*, reported from Lodo, was not found in the Bay of Biscay, however *Heliolithus cantabriae* occurs at about the same time. A very rich and varied assemblage of species of *Fasciculithus* was found and described in Perch-Nielsen, 1971a.

Eocene

Eocene sediments were recovered in the North Atlantic on Leg 1, 2, 3 and 12. The distribution of Eocene coccoliths reported by these legs is listed on Table 4, together with Eocene assemblages from Denmark (described in Perch-Nielsen, in print). Generally, the samples from Denmark are richer in species than those recovered by DSDP. The genera *Pontosphaera* (Discolithina) and *Chiasmolithus*, especially, show more variety nearshore than in the oceanic samples. While *Bramletteius serratus* and *Hayella situliformis* were not found in high latitude assemblages (both oceanic and nearshore, DSDP and Denmark), *Corannulus germanicus* and *Clatrolithus spinosus* are found in Denmark, but are absent in the DSDP samples listed. To date, *Micrantholithus mirabilis* has only been found in Northern Germany and Denmark, where it occurs in the *Marthasterites tribrachiatus* Zone. *Imperiaster obscurus* also seems to be a nearshore species and was not found in the DSDP cores listed.

Oligocene

The Oligocene coccoliths reported from Legs 2, 4 and 12 are listed on Table 5 together with the assemblages described by Roth (1970) from the type localities of the Oligocene stages in Northern Germany. As in the Eocene, these nearshore sediments contain a richer assemblage of coccoliths than the samples recovered from the ocean. However, some species reported by Roth to occur in the Oligocene might be reworked from the Eocene. Generally, sphenoliths are rare in Oligocene nearshore deposits; while they are very rare to common in the high latitude cores recovered on Leg 12, they are never abundant. Often the Oligocene assemblages showed bad preservation, especially when abundant diatoms were present, as on Site 112 in the Labrador sea.

Miocene

No distribution chart has been prepared for the Miocene interval. Only Legs 2 and 12 recovered sediments of this age in the North Atlantic. The Miocene assemblages recovered on Leg 12 generally include fewer discoasters, sphenoliths and ceratoliths than in lower latitudes, a fact which rendered the zonal assignment difficult. *Catinaster coalitus* was not found on Leg 12, perhaps either because the interval was not cored, or because the species may be absent in high latitudes. *Catinaster calyculus* is very rare on Site 111 in the Labrador sea.

Pliocene/Pleistocene

In Table 6 the coccolith distribution in the Late Pliocene and Early Pleistocene is shown. There are far less species present here than in the Miocene of high latitudes and the Pliocene and Pleistocene of lower latitudes, a fact related to the effect of descending temperatures during this time.

Influence of the glaciation

In the sediments recovered on Leg 12, the preglacial/glacial boundary was cored at Sites 111, 112 and 116, and estimates for its depth have been made for Sites 113 and 114. At this boundary, *Sphenolithus abies* and *Reticulofenestra pseudoumbilica* disappear, possibly somewhat earlier than in lower latitudes. The onset of glaciation in the North Atlantic as covered by Leg 12 can be dated to about 3 million years. Generally, the sedimentation rate increases in the glacial sequence. It is smaller, however, in the glacial Pliocene of Site 116 than in the non-glacial Pliocene, and it increases again in the glacial Pleistocene. The calcium-carbonate content decreases with the increase in sedimentation, but from the little evidence available it seems that it decreases less than should be expected if the sedimentation per time unit of calcium-carbonate remained the same. McIntyre *et al.* (in press) show that glacial periods are characterized by a carbonate minimum in high latitudes. The indication for partly higher carbonate sedimentation during the glacial period (including glacials and interglacials) found on Leg 12 (see also chapter 11, Table 1) can be explained either by higher detrital input of carbonate and/or higher productivity, or that, as a whole, the contribution of carbonate in interglacial times overcompensates for the lower production in glacial periods. Closer sampling and more calcium-carbonate determinations, made exclusively on coccoliths, are needed to decide which possibility is most probable.

PRESERVATION

No special studies have been made on the preservation of coccoliths collected on this leg. Calcification as well as solution were found to occur, but well-preserved coccoliths are common, too.

SYSTEMATIC REMARKS ON THE TERTIARY COCCOLITHS

Besides the stratigraphical aspect of the coccoliths collected on Leg 12, the SEM-studies carried out on the Stereoscan EM of the Institute of Historical Geology and Paleontology of the University of Copenhagen permit some systematic remarks. As the "Initial Report" is to give general information about the leg rather than special studies on systematics, these have mainly been published elsewhere. The families Fasciculithaceae and the Paleocene members of the genera *Toweius* and *Sphenolithus* were treated in Perch-Nielsen (1971a). The Paleocene members of the Zygodiscaceae and the Heliolithaceae were dealt with in Perch-Nielsen (1971c), while a study of the Paleocene Pontosphaeraceae is in preparation (Perch-Nielsen, in preparation). Some further SEM-pictures from Leg 12 material were given to illustrate a review of Tertiary coccoliths in Perch-Nielsen (1971b). The plates in this report contain mainly Eocene to Pleistocene forms, generally arranged in systematic and not in stratigraphic order. This order was chosen because I feel that it is here that the SEM gives us the possibility of comparing details in the fine structure of similar forms of the same or different ages.

Table 7 shows the SEM illustrations previously published, those in preparation, and ones included in this report of coccoliths and related calcareous nannoplankton collected on Leg 12. No illustrations are given of forms in the families Rhabdosphaeraceae, Ceratolithaceae, Goniolithaceae and Lithostromationaceae, while Plate 22 (this report) contains reworked Upper Cretaceous coccoliths of different families. No SEM-studies were made on the Late Cretaceous coccoliths from Site 111.

Braarudosphaeraceae

Braarudosphaera bigelowi and other members of the *Braarudosphaeraceae* were found in the Paleogene of Sites 116 and 117 (Rockall) and the turbidites in the Bay of Biscay (118, 119). They are very rare or lacking in the Neogene sediments cored. This is in accordance with the observations made on living *Braarudosphaera bigelowi* to be a nearshore species. Only few species and specimens of *Micrantholithus* and *Pemma* were found in some of the samples containing *Braarudosphaera* as well.

Calciosoleniaceae

Two species of the genus *Scapholithus* were found. *Scapholithus fossilis* is usually rare in the Pliocene and Pleistocene of Sites 111, 112, 114 (Pliocene only), 116, 118 and 119; and *S. rhombiformis* was found in the Paleocene of Site 119. *Scapholithus* seems to be lacking from the Eocene to the Miocene in mid- as well as in high latitudes, and *S. fossilis* is lacking or very rare in high latitudes.

Ceratolithaceae

Ceratolithus cristatus, C. tricorniculatus and *C. rugosus* were found occasionally in Miocene to Pleistocene sediments. In addition to these forms, not yet described ceratoliths were found, some of which stand between the described ones. They were always very rare to rare, and the zonation based on them at the Miocene-Pliocene boundary was therefore difficult.

Calyptrosphaeraceae

With the exception of abundant *Zygrhablithus* cf. *bijugatus* on Rockall (Sites 116 and 117) and *Semihololithus kerabyi* and *S. biskayae* in the Paleocene of the Bay of Biscay, representatives of the family of the *Calyptrosphaeraceae* (holococcoliths) are very rare or mostly lacking. No new information was gained as to whether this is due to their preservability or their absence in deep oceans.

In the Paleogene of Sites 116 and 117, *Zygrhablithus* cf. *Z. bijugatus* can attain up to 30 per cent of the coccoliths present, which is in accordance to other occurrences of holococcoliths in nearshore or shallow water deposits (Rockall Basin was shallow and/or nearshore at this time). However, no other holococcoliths were found in these sediments.

Coccolithaceae and Prinsiaceae

In most samples, the Coccolithaceae and Prinsiaceae constitute the bulk of coccoliths present. Discoasters were concentrated only in sediments where calcium carbonate has been partly dissolved and solution has affected all other coccoliths.

Coccolithus pelagicus was found in different varieties and states of preservation (Plates 1 and 2). Forms with a small elliptical central opening, a bar, a small cross or no central opening were found, as well as forms with an elevated wall. Small forms with a wider central opening spanned by a cross were assigned to *Cruciplacolithus* cf. *C. neohelis*, as they differ from the recent *C. neohelis* in the construction of the junction of the wall and the distal shield (Plate 2, Figures 1, 3, 5).

In the genus *Chiasmolithus*, most of the described species were found, however, typical *C. oamaruensis* is lacking (Plates 3 and 4). *Chiasmolithus* occurs mainly in the Paleocene and Eocene with only *C. altus* in the Oligocene. In some samples of Sites 116 and 117, *C. altus* is abundant, together with *Zygrhablithus* cf. *Z. bijugatus*, in the Upper Oligocene.

Cruciplacolithus is less common generally than *Chiasmolithus. Cruciplacolithus tenuis* was found with the bars of the central cross enlarged (Plate 4, Figure 4) in the Paleocene of Core 119-37, while the central cross is very small and almost closes the central opening in the older forms of Core 119-39.

In the Paleogene, the genus *Ericsonia* is mainly represented by *E. cava* and *E. ovalis* and similar forms. An Eocene form with a central opening covered by small plates was designed as *E.* cf. *E. cribellum* (Bramlette and Sullivan, 1961, Plate 7, Figures 5 and 6, *Coccolithites cribellum*) and illustrated in Plate 4, Figure 6. *E. cribellum* has not yet been described in electronmicroscopy. Another, small form of *Ericsonia* differing from the known forms, was found in the Paleocene of Site 119. Here, the wall on the distal side consists of overlapping plates rather than plates lying side

TABLE 7
Illustrations of Coccoliths Collected on Leg 12 of the DSDP

		Perch-Nielsen			
Family	Plate:Figures (This report)	Plate:Figures 1971a	Plate:Figures 1971b	Plate:Figures 1971c	Plate:Figures In Preparation
Braarudosphaeracea	8:5				
Calciosoleniaceae	8:3, 4		1:2		
Calyptrolithaceae		9:5-7			
		10:1-6			
		11:7-11			
Coccolithaceae &	1:1-6	13:1-10	1:4, 7-9		
Prinsiaceae	2:1-7				
	3:1-6				
	4:1-6				
	5:1-6				
	6:1-6				
	7:1-6				
	8:2-6				
	9:6				
Discoasteraceae	9:1-4		2:1, 4, 5	1:6, 7	
	10:1-7				
	11:1-6				
	12:1-6				
	13:1-6				
	14:1, 2, 4-6				
Fasciculithaceae		1:1-10	2:2, 3, 6-8		
		2:1-6			
		3:1-6			
		4:1-11			
		5:1-10			
		6:1-6			
		7:1-6			
		8:1-4			
Heliolithaceae			1:10, 11	1:1-4	
				2:1-7, 8?	
Pontosphaeraceae inkl.	18:1-2				In prepara-
Helicopontosphaera	19:1-7				tion
	20:1-7				
	21:1, 2?				
Sphenolithaceae	16:1-12	11:1-6			
	17:1-6	12:1-12		3:1-3	
Syracosphaeraceae	21:6, 7		1:5		
Triquetrorhabdulaceae	9:5				
	15:5				
Thoracosphaeraceae	8:1				
Zygodiscaceae				3:4, 5	
				4:1-8	
				5:1-8	
				6:1-8	
Incertae sedis	9:7		1:3, 6	1:5	
	14:3				
	15:1-4, 6, 7				
	21:3-5				
Reworked Cretaceous	14:3?				
coccoliths	22:1-6				

by side as in the contemporary *E. cava* (Plate 8, Figure 6). *Cyclolithus robustus* Bramlette and Sullivan might belong to *Ericsonia* too (Plate 5, Figure 5).

Cyclococcolithus leptoporus and *C. macintyrei* (Plate 5, Figures 1, 2, 3), occur together up to the lower Pleistocene. *Markalius inversus* (Plate 5, Figures 4, 6) has a wider central opening in the Eocene than in the Paleocene.

Coccolithus aff. *C. bisectus* (Hay and Mohler, 1967) and *Coccolithus bisectus* (Hay and Mohler, 1967) and similar, but smaller forms (Plate 6) constitute the bulk of coccoliths in the Oligocene. More electronmicroscopy on these forms and their variation is necessary to attain a better understanding of their interrelations. *C. bisectus* as well as many other species have been left in the genus they were from in the reference cited in the checklist, which includes mainly light-microscope pictures.

The genus *Toweius* is specially well-developed in the Paleocene and lower Eocene (Plate 7). *Biscutum? dimorphosum* Perch-Nielsen (Plate 8, Figure 2) is common in some samples in the Paleocene of Site 119. This form might be related to *Toweius* or *Prinsius.*

Reticulofenestra umbilica appears already in the *Discoaster lodoensis* Zone on Site 111 (Plate 9, Figure 6) and other high latitude assemblages. The relation between the size of the central area and the overall size of the coccolith varies considerably and so does the size of the coccolith. The other species of *Reticulofenestra* have not yet been investigated by SEM from the Leg 12 material.

Gephyrocapsa oceanica and *G. aperta* are rare, while other species of *Gephyrocapsa* are common to abundant where present in the Pleistocene. *Emiliania huxleyi* was found in Sites 111 and 116.

Discoasteraceae

Generally, discoasters are more rare in the high latitude assemblages studied here than in mid and low latitudes. However, enough discoasters were usually found to permit an assignment to the zones defined by discoasters. In the glacial Pliocene, *Discoaster brouweri* often is very rare or only present in relicts. *D. pentaradiatus* is usually rare too, as well as *D. challengeri* and *D. surculus. Discoaster quinqueramus* in the core sheets of this report includes also the recently described *D. berggreni* Bukry (Plates 9 and 10). These two species and *D. hamatus* show a considerable variation in the size of the distal knob and the proximal knob; this makes it difficult sometimes to draw the boundary between the species, especially when the arms are not well preserved. *Discoaster bollii* occurs only very seldomly (Plate 9, Figure 4). *Discoaster variabilis* shows considerable variation in the size and form of the branches and nodes (Plate 12, Figures 1-4, 6). *D. adamanteus* occurs with or without caves around the center, probably according to the state of preservation (plate 12, Figure 5). *D. deflandrei* is usually badly calcified and hard to identify, as are other discoasters in the Oligocene. Discoasters are well represented in the Eocene and Upper Paleocene and are the only calcareous nannofossils left in red clays. Most of the current discoasters of high latitude Eocene assemblages were found, only a few are illustrated on Plate 13. The Paleocene discoasters need more investigation, especially their relation to the Heliolithaceae and Fasciculithaceae. *Discoaster multiradiatus*-like forms show a proximal knob only little smaller than the central area. Other forms are similar to *Heliolithus*, but no definite links can yet be demonstrated between the Fasciculithaceae, the Heliolithaceae and the Discoasteraceae. The Paleocene of Site 119, however, should provide some more information about these problems. Unfortunately for biostratigraphy, it consists of turbidites, so that the stratigraphic control is weak.

Fasciculithaceae

Twelve species of *Fasciculithus* were distinguished in the Paleocene of Site 119; nine of which were new (Perch-Nielsen 1971a). Some of the new forms have since been found in the Paleocene of Iran (B. Haq, personal communication, 1971). Due to the fact that this Paleocene sequence consists of turbidites and that the state of preservation of the coccoliths is partly excellent and partly very poor, nothing definite can yet be said about the stratigraphic value of these forms.

Goniolithaceae

The only species in this family, *Goniolithus flueckigeri*, was found sporadically in Paleogene samples.

Heliolithaceae

Three species of *Heliolithus* were distinguished in the Paleocene of Site 119, two of which were new, while typical *H. riedeli* was not found (Perch-Nielsen 1971c). The fine structure of the proximal coloumn of *H. cantabriae* is quite different from its construction in other species of *Heliolithus*, while it is very flat in *H. kleinpelli.*

Lithostromationaceae

Only very few specimens of *Lithostromation* sp. were found.

Pontosphaeraceae* including *Helicopontosphaera

Different species of *Pontosphaera* are often common in the Pliocene and Pleistocene, also in the glacial facies (Plate 19). In the Miocene and Upper Oligocene, *Pontosphaera segmenta* Bukry and Percival, a form with a central area covered by two rows of plates, was found (Plate 21, Figure 1). Sometimes, the central area has lost the walls. The rest of the Oligocene and most of the Eocene contained no *Pontosphaera (Discolithina).* In the Lower Eocene and the Upper Paleocene, however, *Pontosphaera* occurs together with *Lophodolithus. Crepidolithus* and early *Pontosphaera* and *Transversopontis* as well as *Zygodiscus* and early *Helicopontosphaera* will be treated in Perch-Nielsen (in preparation).

Helicopontosphaera occurs regularly from the Eocene to the Pleistocene (Plate 18). It is not so common in the Eocene collected on Leg 12 as in the Eocene of Denmark. On the other hand, *H. sellii* together with *Coccolithus pelagicus* constitute the the dominating part of the assemblage near the Pliocene-Pleistocene boundary at Sites 112, 114 and 116.

Different species of *Scyphosphaera* (Plate 20) were found in the Pleistocene of Site 116, the Pliocene of Sites 111, 112, 114, 116, and the Miocene of Sites 116 and 119. It is only on Site 116 that *Scyphosphaera* occurs common to abundant in some samples; the other occurrences are rare specimens found after long searching.

Rhabdosphaeraceae

Rhabdosphaera clavigera and *Aspidorhabdus stylifer* occur occasionally in the Pleistocene, while an undescribed *Rhabdosphaera* is common around and below the glacial-preglacial boundary in the Pliocene of most sites. Miocene and Oligocene and most of the Eocene as well as the Paleocene are almost barren of rhabdoliths on the sites drilled. *R. inflata*, however, occurs in the middle Eocene of Sites 112 and 119.

Sphenolithaceae

As with the discoasters, sphenoliths are generally rare in the high latitude assemblages. Long searching was often necessary to find the sphenoliths necessary for the zonation in the Oligocene. Most sphenoliths described so far were found (Plates 16 and 17), and two new species were described (Perch-Nielsen, 1971a and c). Some undescribed forms, of which only one SEM picture is available, are also shown on Plate 16.

Syracosphaeraceae

Different species of *Syracosphaera* are rare to common in the Pliocene and Pleistocene of most sites.

Ellipsolithus, tentatively assigned to the *Syracosphaeraceae*, is common in the Paleocene of Site 119 (Plate 21, Figures 6 and 7). *E. distichus* shows great variety in the number of openings in the central area.

Triquetrorhabdulaceae

Triquetrorhabdulus rugosus was found in the Miocene of Sites 111, 112, 118 and 119 (Plate 9, Figure 5). *Triquetrorhabdulus carinatus* and similar forms are abundant in the Oligocene-Miocene of Sites 116 and 117 (Plate 15, Figure 5). *T. inversus* occurs in the middle Eocene of Sites 118 and 119.

Thoracosphaeraceae

Different species of *Thoracosphaera* occur occasionally throughout the Tertiary. *T. operculata* is illustrated in Plate 8, Figure 1.

Zygodiscaceae

The Paleocene *Zygodiscaceae* of Site 119 are treated in Perch-Nielsen (1971c), where a new genus is introduced for the forms with two walls (*Neochiastozygus*). The fine structure of these forms is very similar to the one of early *Pontosphaera* forms. *Chiphragmalithus* and *Neococcolithes* are present in the Eocene, but are less common than in the Eocene of Denmark, another high latitude assemblage. *Isthmolithus recurvus* is present in the Upper Eocene and Lower Oligocene, often badly calcified. No *Zygodiscaceae* were found above the last occurrence of *I. recurvus*, except some *Neococcolithes dubius* that were considered to be reworked.

Incertae sedis

Besides some well known coccoliths not yet placed in a family, a few yet undescribed forms were found, and some of them are illustrated on Plate 21, Figures 1, 4 and 5.

No coccoliths belonging to the genera *Bramletteius, Hayella, Ilselithina, Guttilithion, Corannulus* or *Pyrocyclus* were found. Different species of *Nannotetrina* occur in the Middle Eocene (Plate 15, Figures 1 through 4). *Coronocyclus prionion* (Plate 9, Figure 7) is occasionally common in the Miocene, *Coronocyclus nitescens* in the Oligocene (Plate 21, Figure 3). *Conococcolithus* sp. was found in the Paleocene of Site 119.

Cretaceous coccoliths

No SEM investigations were made on the Cretaceous coccoliths from Site 111. The assemblage of the Maestrichtian is comparable to the assemblages found in the Maestrichtian of Northern Europe. The Cenomanian coccoliths were poorly preserved.

Cretaceous coccoliths, mainly of Late Cretaceous age, were also found reworked into the (glacial) Pleistocene of Site 116 and in the turbidites at Site 118 and 119. On Plate 22, some Cretaceous forms reworked into the Paleocene are illustrated. In the Bay of Biscay, the index species of the Late Maestrichtian, *Nephrolithus frequens* was found reworked,; *Tetralithus murus* was only found in the top water above the core with Maestrichtian in Hole 111A-11, where *N. frequens* is missing. The common occurrence of the "nearshore-species" *Kamptnerius magnificus* at this site is in accordance with the story of Orphan Knoll to be part of the North American continent and still close to it in the Late Cretaceous.

CONCLUSIONS

Compared to the previous DSDP legs drilling in the North Atlantic, more continous coring was done on Leg 12. This yielded some quite complete sections in several parts of the Tertiary. They enabled the recognition of changes in sedimentation rates and their relation to the lithology. They also provided excellent material to study evolutionary trends of coccoliths.

Generally it could be observed that the coccolith zonations based on assemblages from lower latitudes are easier to apply in the Paleocene and Early Eocene than in the Late Eocene, Oligocene, Miocene and Pliocene of high latitudes. Zonations are there based mainly on discoasters and sphenoliths, which are less abundant in higher latitudes than in lower latitudes from the Late Eocene to the Pliocene, with the exception of the Late Miocene, where discoasters again occur in higher numbers. The long-ranging coccoliths of the *Coccolithaceae* and *Prinsiaceae* seem to be the same in low and high latitudes. For the glacial period in the Late Pliocene and the Pleistocene, the forms used for zonation in low latitudes could also be used in high latitudes. However, we do not know yet, what we are dating with "first occurrences" and the "extinction" of species in high latitudes: the real appearance or extinction, the appearance or extinction in the area studied depending on the influence of colder water, or the appearance or disappearance due to onset or offset of currents. This, of course, is true for most zones; but, it appears still more uncertain during the age of glaciation, where, on the other hand, the resolution of the zonation is already better than in most other times. Further studies will hopefully be successful in establishing the paleodistribution of the stratigraphically important species, based on the work already done by McIntyre and Bé (1967) and McIntyre *et al.* (in print).

REFERENCES

Bader, R. G. *et al.*, 1970. *Initial Reports of the Deep Sea Drilling Project, Volume IV.* Washington (U.S. Government Printing Office), 754+ pp.

Bramlette, M. N. and Martini, E., 1964. The great change in calcareous nannoplankton fossils between the Maestrichtian and Danian. *Micropaleontology.* **10**, 291.

Bramlette, M. N. and Sullivan, F. R., 1961. Coccolithophorids and related nannoplankton of the early Tertiary in California. *Micropaleontology.* **7**, 129.

Ewing, M. *et al.*, 1969. *Initial Reports of the Deep Sea Drilling Project, Volume I.* Washington (U. S. Government Printing Office), 672+ pp.

Gartner, S., Jr., 1969. Correlation of Neogene planktonic foraminifera and calcareous nannofossil zones. *Trans. Gulf Coast Assoc. Geol. Soc.* **19** 585.

Hay, W. W. and Mohler, H. P., 1967. Calcareous nannoplankton from early Tertiary rocks of Pont Labau, France, and Paleocene-Early Eocene correlations. *J. Paleontol.* **41**, 1505.

Martini, E., 1970. Standard Paleogene calcareous nannoplankton zonation. *Nature.* **226** (5245), 560.

Martini, E. and Worsley, T., 1970. Standard Neogene calcareous nannoplankton zonation. *Nature.* **225**, 289.

Maxwell, A. E. *et al.*, 1970. *Initial Reports of the Deep Sea Drilling Project, Volume III.* Washington (U.S. Government Printing Office), 806+ pp.

McIntyre, A., Ruddiman, W. F. and Jantzen, R., (1971) Southward penetrations of the North Atlantic polar front: faunal and floral evidence of large-scale surface water mass movements over the last 225,000 years. (In press).

Perch-Nielsen, K., 1968. Der Feinbau und die Klassifikation der Coccolithen aus dem Maastrichtien von Dänemark. *Biol. Skr.* **16**, 1.

Perch-Nielsen, K., 1971a. Einige neue Coccolithen aus dem Paleozän der Bucht von Biskaya. *Meddel. Dansk Geol. Foren.* **20**, 347.

________, 1971b. Durchsicht tertiärer Coccolithen. *Proc. Second Planktonic Conference, Rome,* **939.**

________, 1971 c. Neue Coccolithen aus dem Paleozän von Dänemark, der Bucht von Biskaya und dem Eozä der Labrador See. *Meddel. Dansk Geol. Foren.* 21, **51.**

________, In preparation. Pontosphaera und verwandte Coccolithen im Paleozän und Eozän.

________, 1971. Elektronenmikroskopische Untersuchunge an Coccolithen und verwnadten Formen aus dem Eozän von Dänemark. *Biol. Skr,* **18.3.**

Peterson, M. N. A. *et al.*, 1970. *Initial Reports of the Deep Sea Drilling Project, Volume II.*Washington (U.S. Government Printing Office), 492+ pp.

Roth, P. H., 1970. Oligocene calcareous nannoplankton biostratigraphy. *Eclog. Geol. Helv.* **63** (3), 799.

Further references in Leoblick A. R. and Tappan, H. Annotated Index and Bibliography of the Calcareous Nannoplankton. 1966, I: *Phycologia* **5**, 81. 1968, II: *J. Paleontol.* **42** (2), 584. 1969, III: *J. Paleontol.* **43** (2), 568. 1970, IV: *J. Paleontol.* **44**, 558.

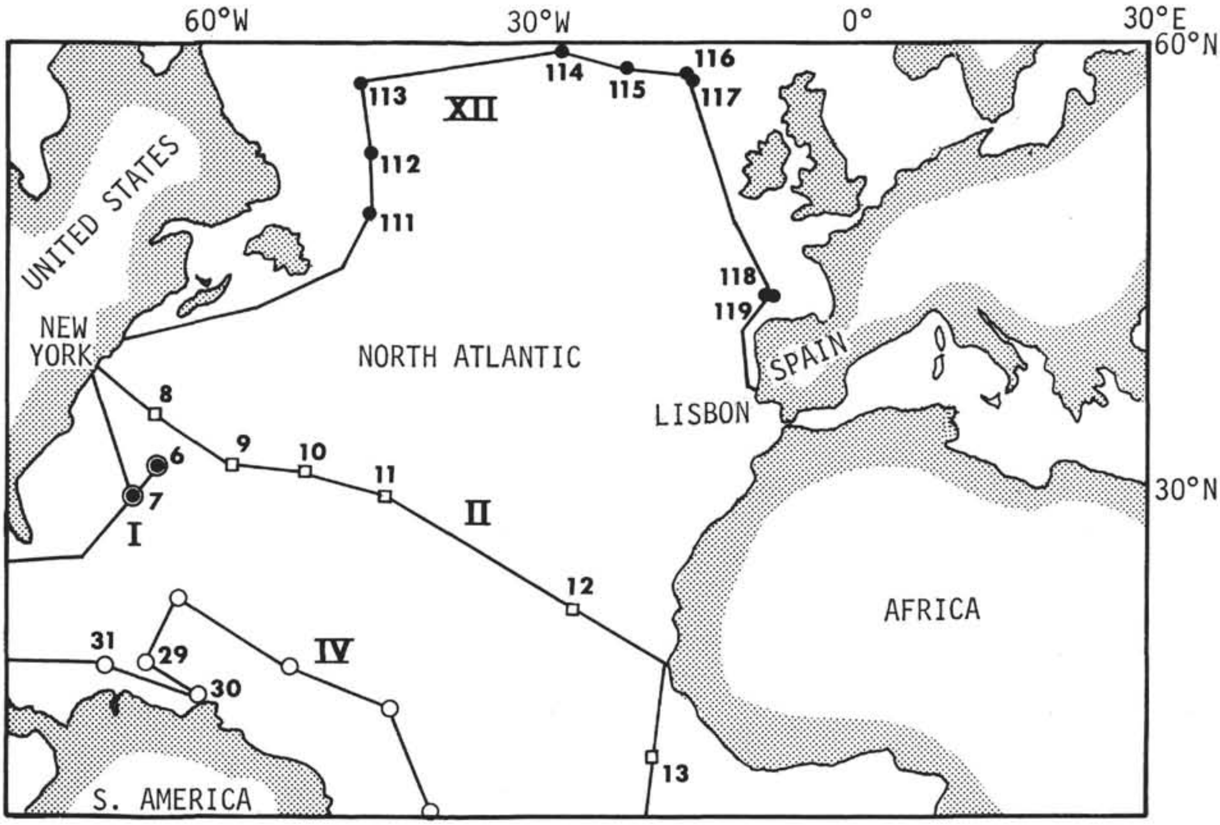

Figure 1. *Sites drilled in the North Atlantic on Deep Sea Drilling Project Legs 1, 2, 3, 4, and 12.*

PLATE 1

Figures 1-6	*Coccolithus pelagicus* (Wallich). Coccospheres of different varieties. Figures 1, 4, 6: Pliocene 116A-7-2. Figures 2, 5: Miocene 116-11-2. Figure 3: Pliocene 112A-5. Figure 1: 7000X. Figure 2: 6200X. Figure 3: 4800X. Figure 4: 7000X. Figure 5: 5700X. Figure 6: 7700X

PLATE 1

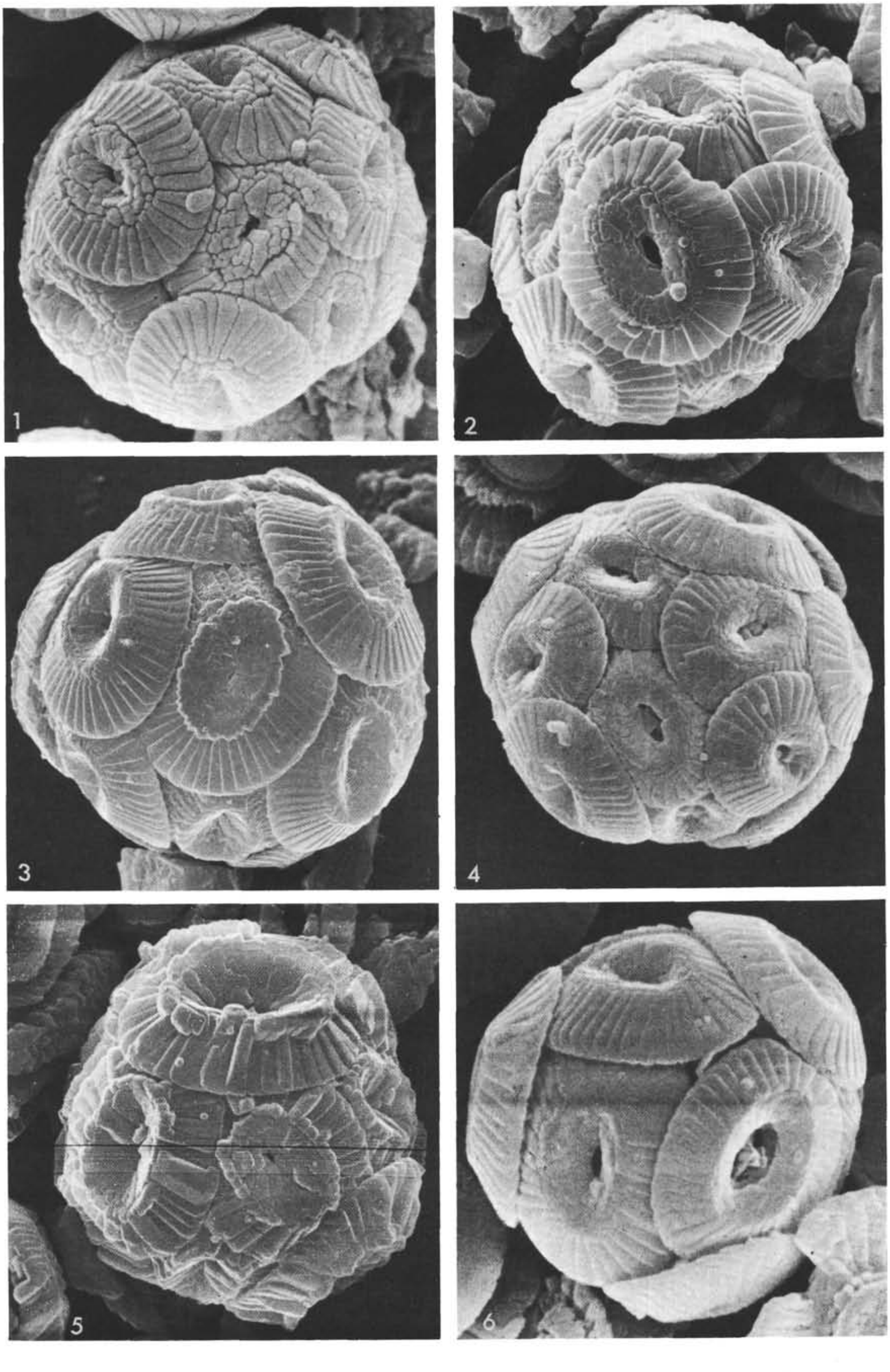

PLATE 2

Figures 1, 3, 5	*Cruciplacolithus* cf. *neohelis* (McIntyre and Bé). Figure 1: Pliocene 116A-7-2. Figures 3, 5: Pleistocene 113-3-3. Figure 1: distal view, 11400X. Figure 3: proximal view, 11600X. Figure 5: distal view, 17400X.
Figures 2, 4, 6, 7	*Coccolithus pelagicus* (Wallich). Figure 4: Pleistocene 111-1-CC, distal view, 8800X. Figures 2, 6, 7: Pliocene 116A-7-2, proximal and distal views, 8400X, 7700X, 8400X. Different varieties of the species? Calcification?

PLATE 2

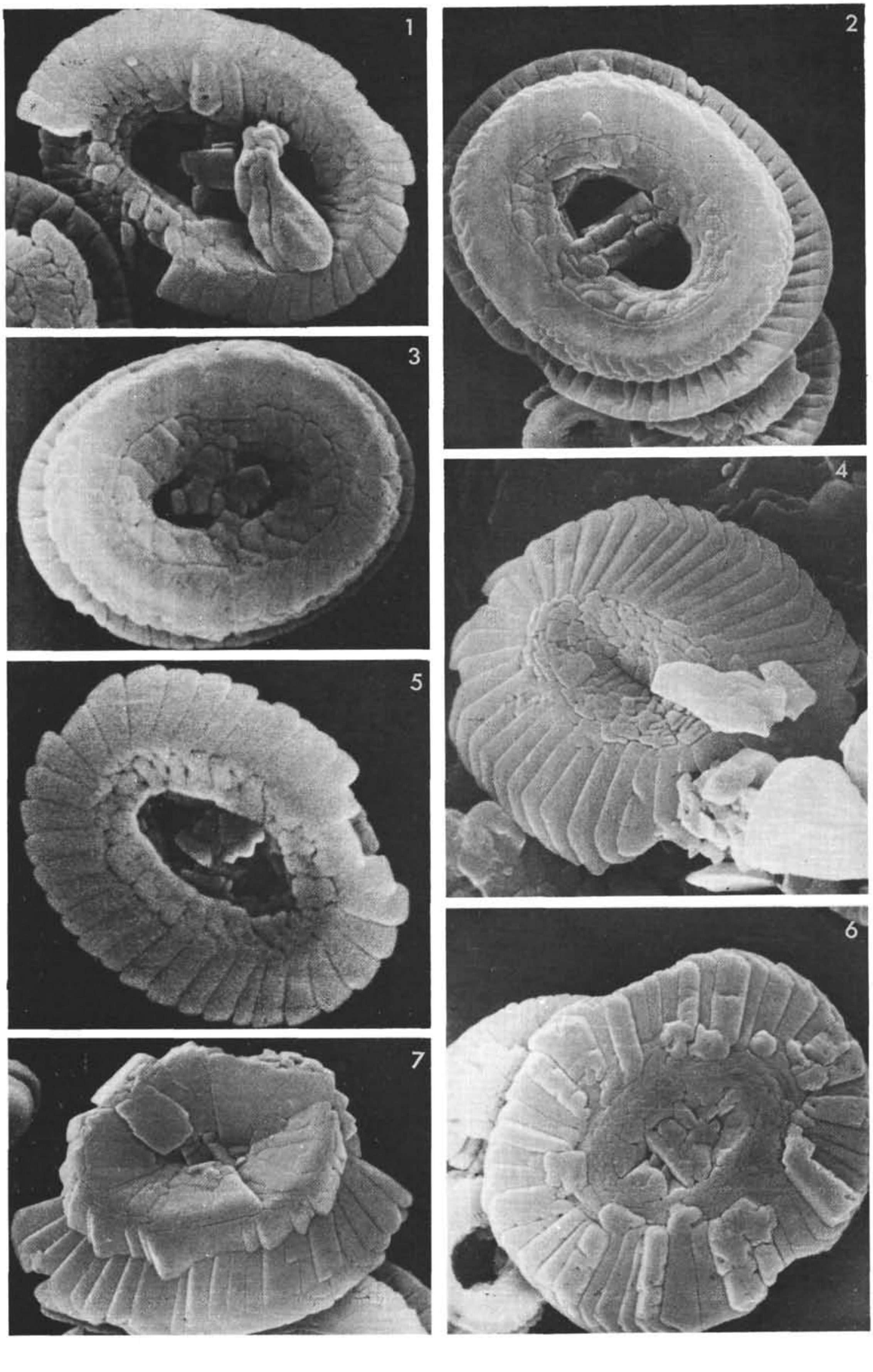

PLATE 3

Figures 1-3	*Chiasmolithus eograndis* Perch-Nielsen. Figures 1, 2: Eocene 117A-3-2, proximal and distal view of calcified specimens, 6500X and 6000X. Figure 3: Eocene 112-6-top, proximal view, 6000X.
Figure 4	*Chiasmolithus grandis* (Bramlette and Riedel), proximal view, Eocene 111A-8-1, 5000X.
Figure 5	*Chiasmolithus altus* Bukry and Percival, distal view, Oligocene 119-17-2, 6200X.
Figure 6	*Chiasmolithus gigas* Bramlette and Sullivan, distal view, Eocene 118-14-2, 6000X.

PLATE 3

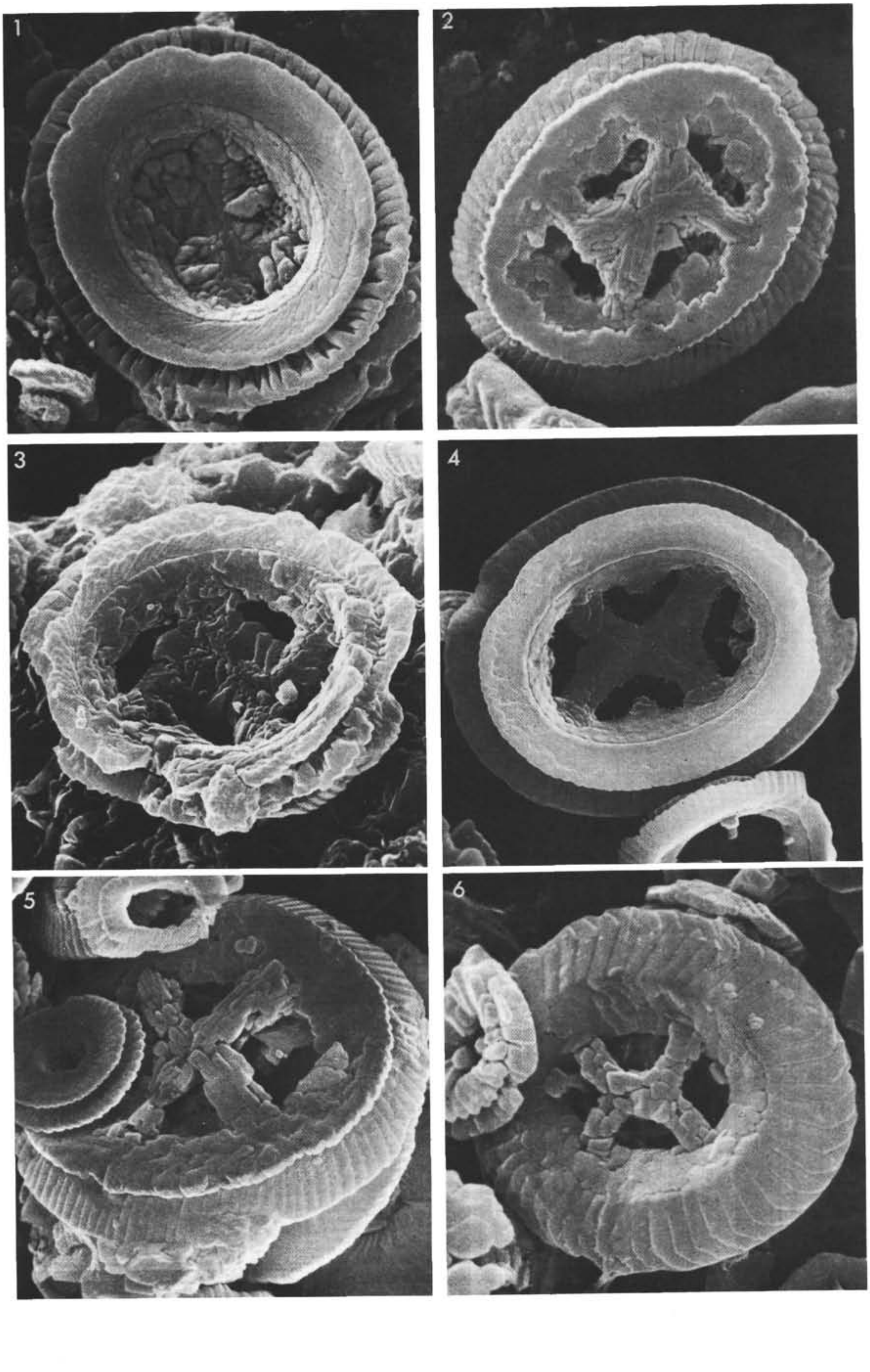

PLATE 4

Figure 1	*Chiasmolithus bidens* (Bramlette and Sullivan), distal view, Paleocene 119-28, 7300X.
Figure 2	*Cruciplacolithus delus* (Bramlette and Sullivan), distal view, Paleocene 119-26, 13200X.
Figure 4	*Cruciplacolithus tenuis* (Stradner), distal view, Paleocene 119-37.
Figures 3, 5	*Chiasmolithus danicus* (Brotzen), distal views, Paleocene 119-38 and 119-37, 9000X, 9800X.
Figure 6	*Ericsonia* cf. *E. cribellum* (Bramlette and Sullivan), distal view, Eocene 118-14-2, 9800X.

PLATE 4

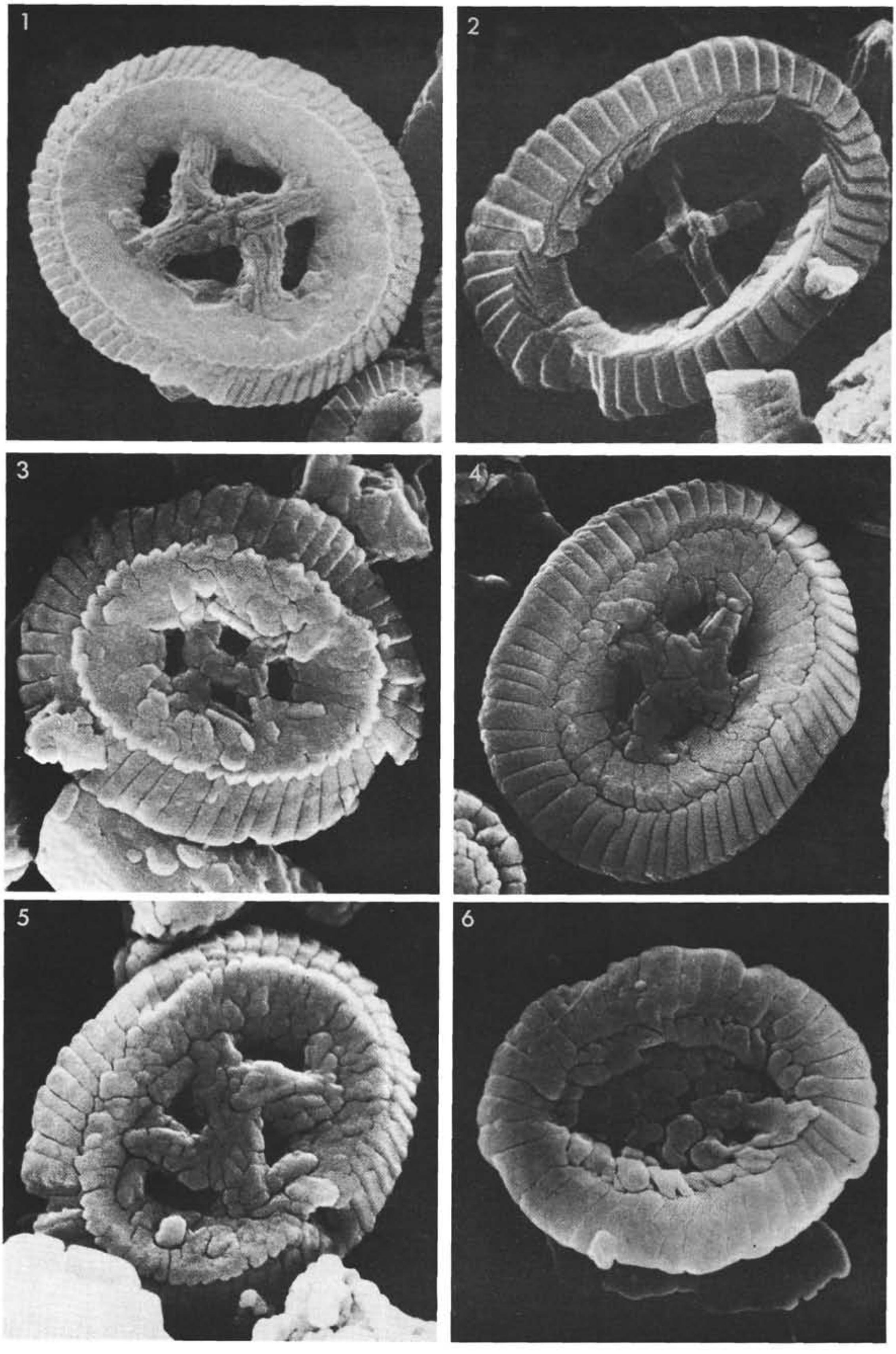

PLATE 5

Figure 1	*Cyclococcolithus macintyrei* Bramlette and Bukry, 7400X. Pliocene 112A-5. Distal view.
Figure 2	*Cyclococcolithus leptoporus* (Murray and Blackman) , 7600X. Miocene 111A-6-3, 77. Distal view.
Figure 3	*Cyclococcolithus leptoporus* (Murray and Blackman), 5400X. Pleistocene 116A-1-1. Coccosphere.
Figure 4	*Markalius inversus* (Deflandre), 6300X. Eocene 117A-3-2, Coccosphere.
Figure 5	?*Cyclolithus robustus* Bramlette and Sullivan, 10800X. Paleocene 119-39-5. Distal view.
Figure 6	*Markalius inversus* (Deflandre), 9000X. Eocene 117-A-3-2, proximal view.

PLATE 5

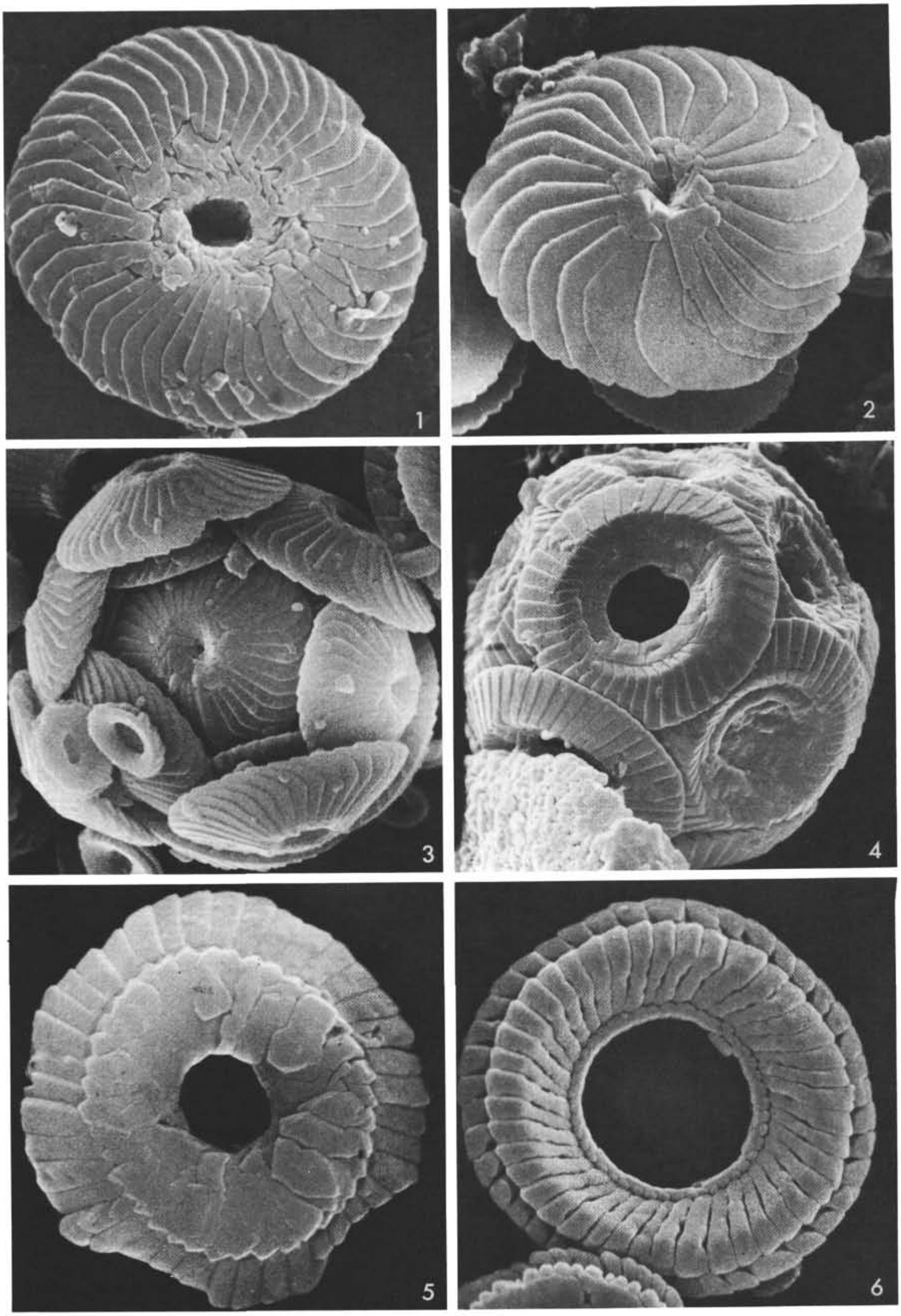

PLATE 6

Figures 1, 2	*Coccolithus* aff. *C. bisectus* (Hay *et al.*), 6600 & 6500X. Oligocene 119-14-5, proximal and distal view.
Figures 3, 5	*Coccolithus* sp. 8750 & 8300X. Oligocene 119-14-5 and 119-17-2, coccospheres.
Figures 4, 6	*Coccolithus bisectus* (Hay *et al.*), 5150 & 7000X. Oligocene 119-14-5 and 119-17-2, distal and proximal view.

PLATE 6

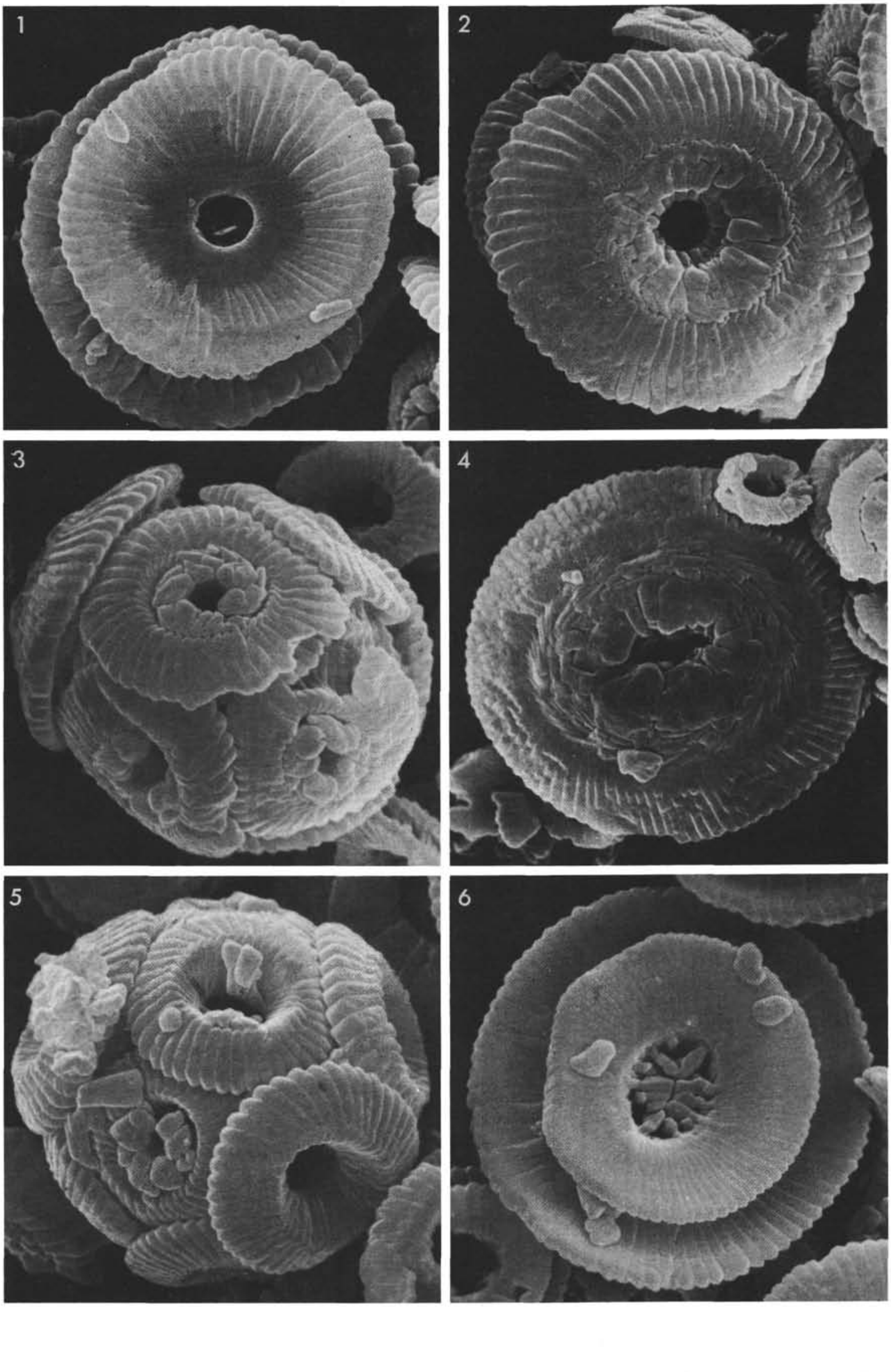

PLATE 7

Figures 1, 2	*Toweius* sp., 9700 & 10500X. Eocene 118-14-2, proximal and distal view.
Figure 3	*Toweius tovae* Perch-Nielsen, 16500X. Paleocene 119-28-2, proximal view.
Figure 4	*Toweius eminens* (Bramlette and Sullivan), 10100X. Paleocene 119-25-2, proximal view.
Figure 5	*Cribrocentrum reticulatum* (Gartner), 12100X. Eocene 117A-3-2, proximal view.
Figure 6	*Toweius callosus* Perch-Nielsen, 8800X. Eocene 112-16-top distal view.

PLATE 7

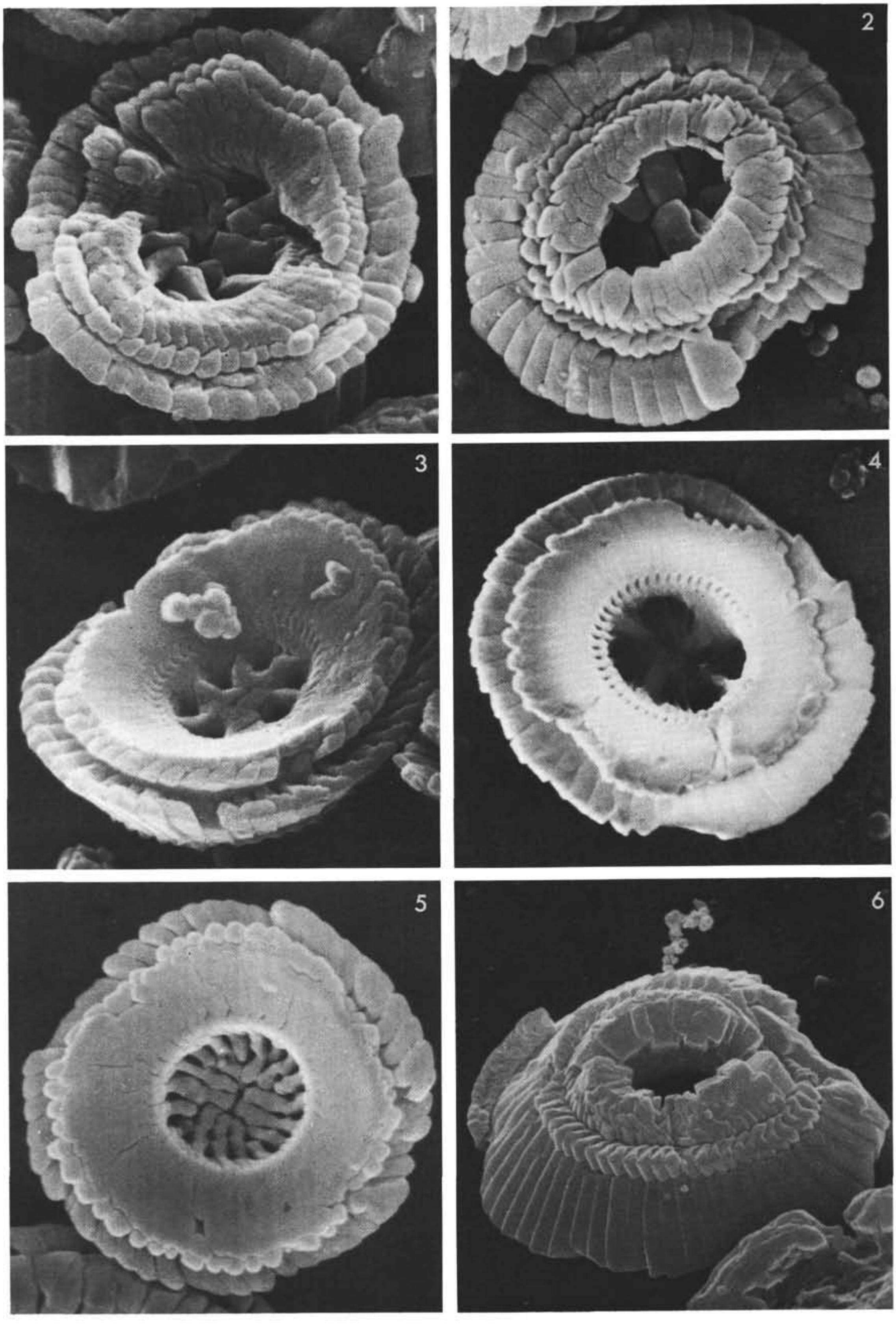

PLATE 8

Figure 1	*Thoracosphaera operculata* Bramlette and Martini, 4650X. Paleocene 119-30-6.
Figure 2	*Biscutum dimorphosus* Perch-Nielsen, 12600X. Paleocene 119-39-5, coccosphere.
Figures 3, 4	*Scapholithus rhombformis* Hay and Mohler, 18500 & 21400X. Paleocene 119-29-1 and 119-26-1, proximal and distal view.
Figure 5	*Micrantholithus pinguis* Bramlette and Sullivan, 9400X. Paleocene 119-30-6.
Figure 6	*Ericsonia* sp., 17800X. Paleocene 119-26-1, distal view.

PLATE 8

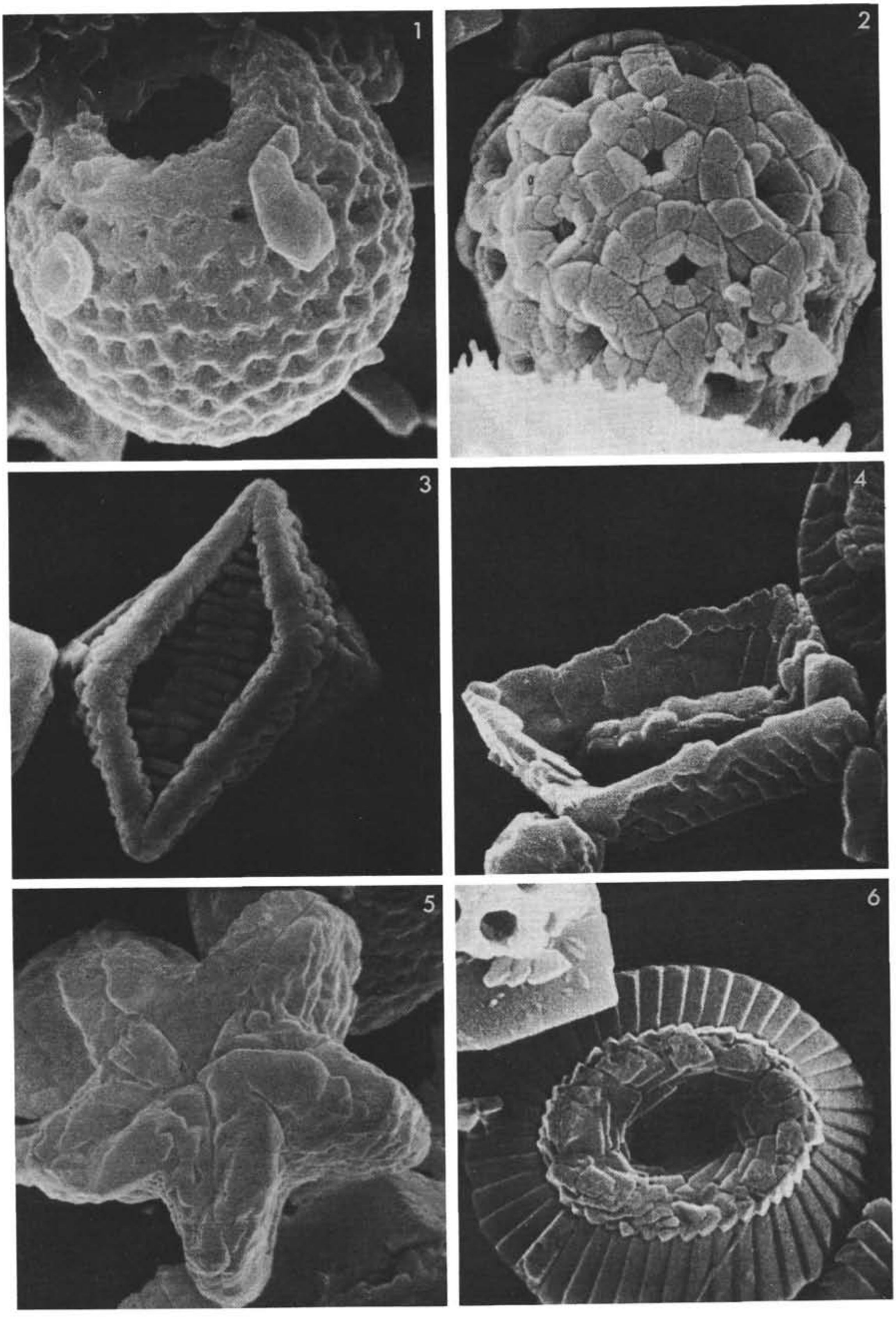

PLATE 9

Figures 1, 2	*Discoaster quinqueramus* Gartner, Miocene 111A-6-3. Figure 1: 10400X. Figure 2: 5800X.
Figure 3	*Discoaster hamatus* Martini and Bramlette, Miocene 111A-6-3. 7400X.
Figure 4	*Discoaster bollii* Martini and Bramlette, Miocene 111A-6-3. 9600X.
Figure 5	*Triquetrorhabdulus rugosus* Bramlette and Wilcoxon, Miocene 111A-6-3. 6100X.
Figure 6	*Reticulofenestra umbilica* (Levin), Eocene 111A-8-1. 5700X.
Figure 7	*Coronocyclus prionion* (Deflandre and Fert), Miocene 111A-6-3. 13500X.

PLATE 9

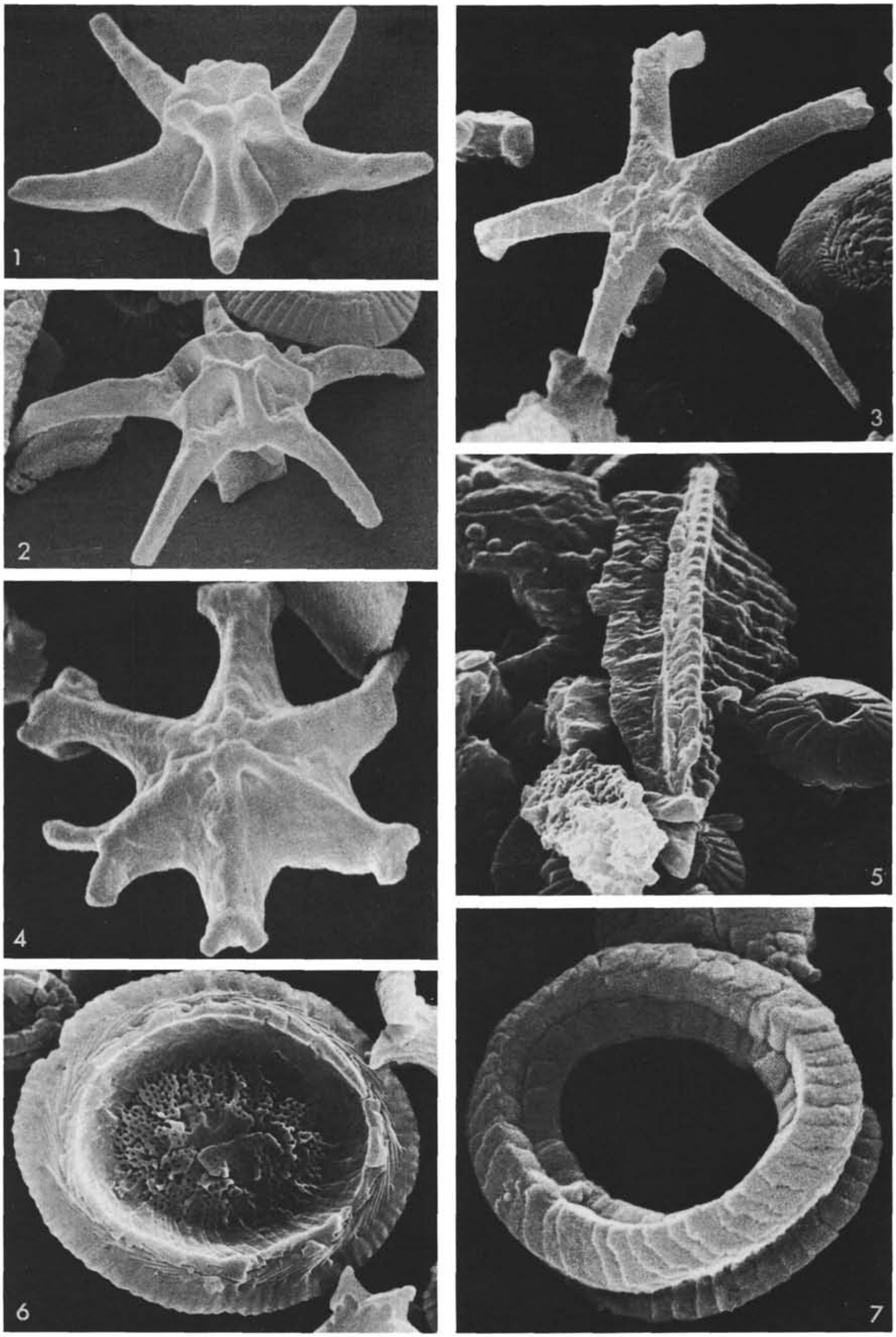

PLATE 10

Figures 1, 3	*Discoaster berggrenii* Bukry to *Discoaster quinqueramus* Gartner, 12400X & 8000X. Miocene 111A-6-3, 77. Proximal and distal view.
Figures 2, 4	*Discoaster quinqueramus* Gartner, 8300X & 10900X. Miocene 111A-6-3, 83. Proximal views.
Figures 5-7	*Discoaster berggrenii* Bukry, 15300X, 8000X and 8000X. Miocene 111A-6-3, 77 and 65 (Figure 7). Distal, proximal and distal view.

PLATE 10

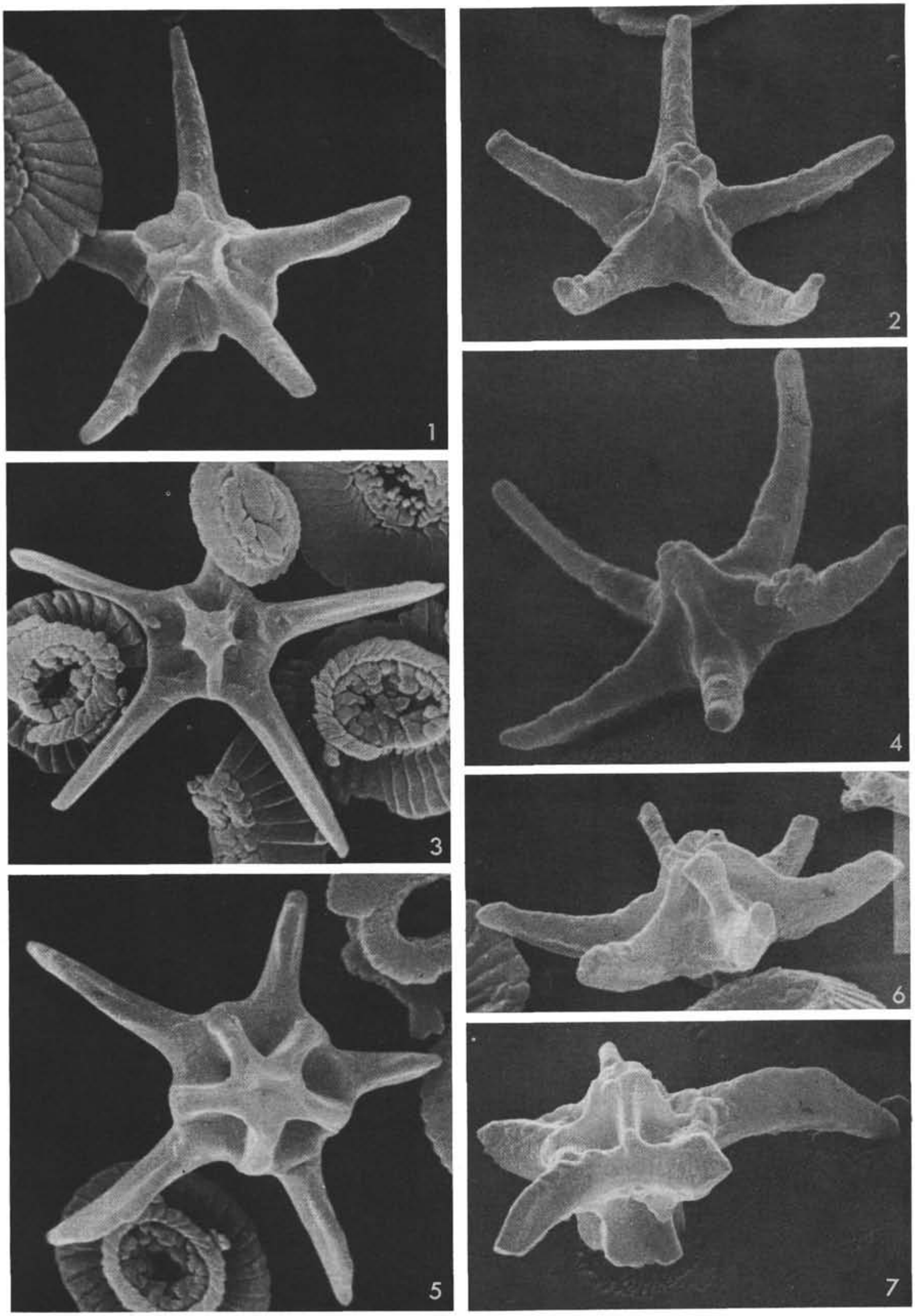

PLATE 11

Figure 1	*Discoaster surculus* Martini and Bramlette, 6100X. Miocene 111A-6-3, 77, proximal view.
Figures 2, 4, 6	*Discoaster hamatus* Martini and Bramlette, 5800X, 5600X and 8800X. Miocene 111A-6-3, 77 and 65 (Figure 4). Distal views.
Figure 3	*Discoaster challengeri* Bramlette and Riedel, 6300X. Miocene 111A-6-3, 77, proximal view.
Figure 5	*Discoaster brouweri* Tan Sin Hok, 7000X. Miocene 111A-6-3, 77, proximal view.

PLATE 11

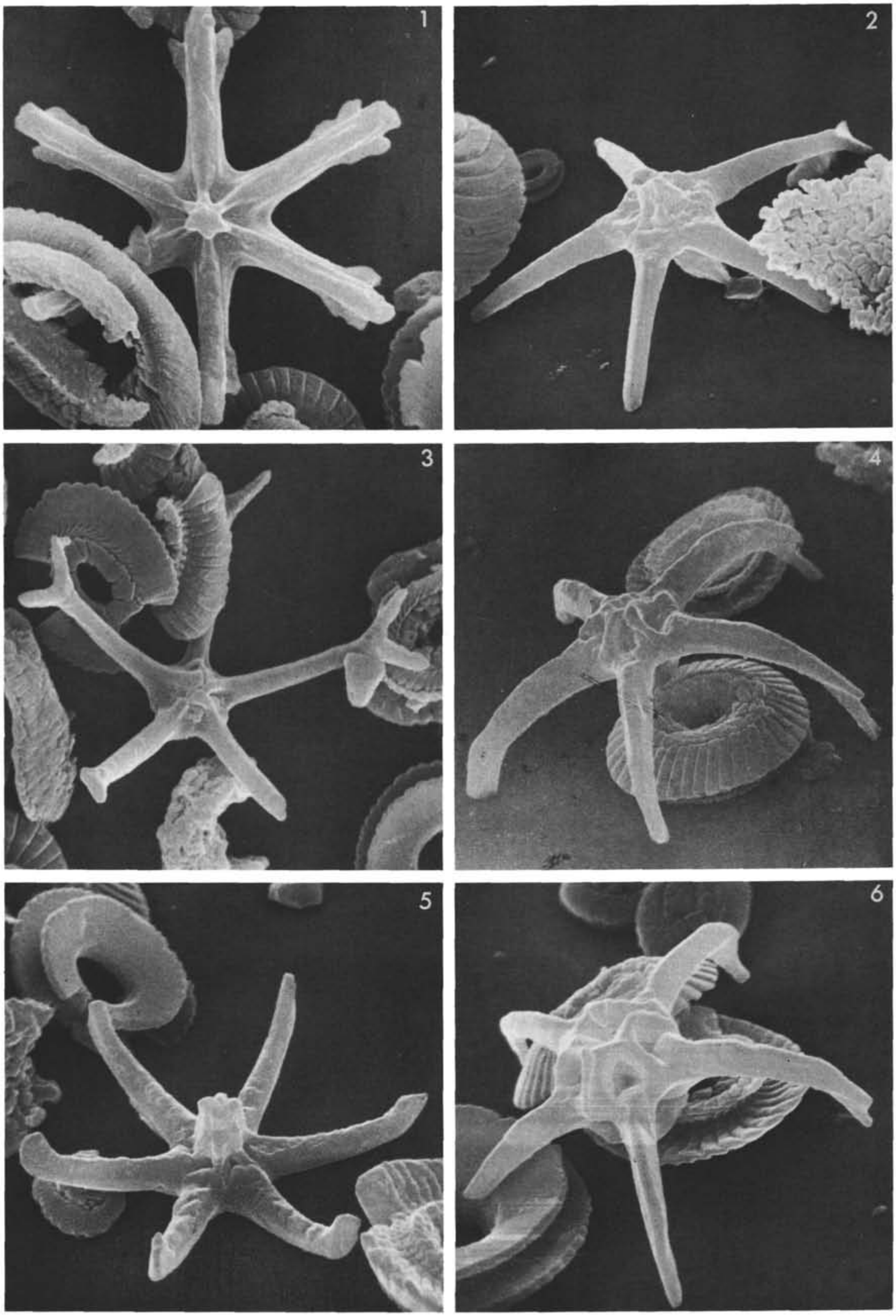

PLATE 12

Figures 1-4, 6	*Discoaster variabilis* Martini and Bramlette, Miocene 119-4-1. Figure 1: 5100X, Figure 2: 4500X. Figure 3: 5300X. Figure 4: 4300X. Figure 6: 7400X.
Figure 5	*Discoaster adamanteus* Bramlette and Wilcoxon, Miocene 119-4-1, 7900X.

PLATE 12

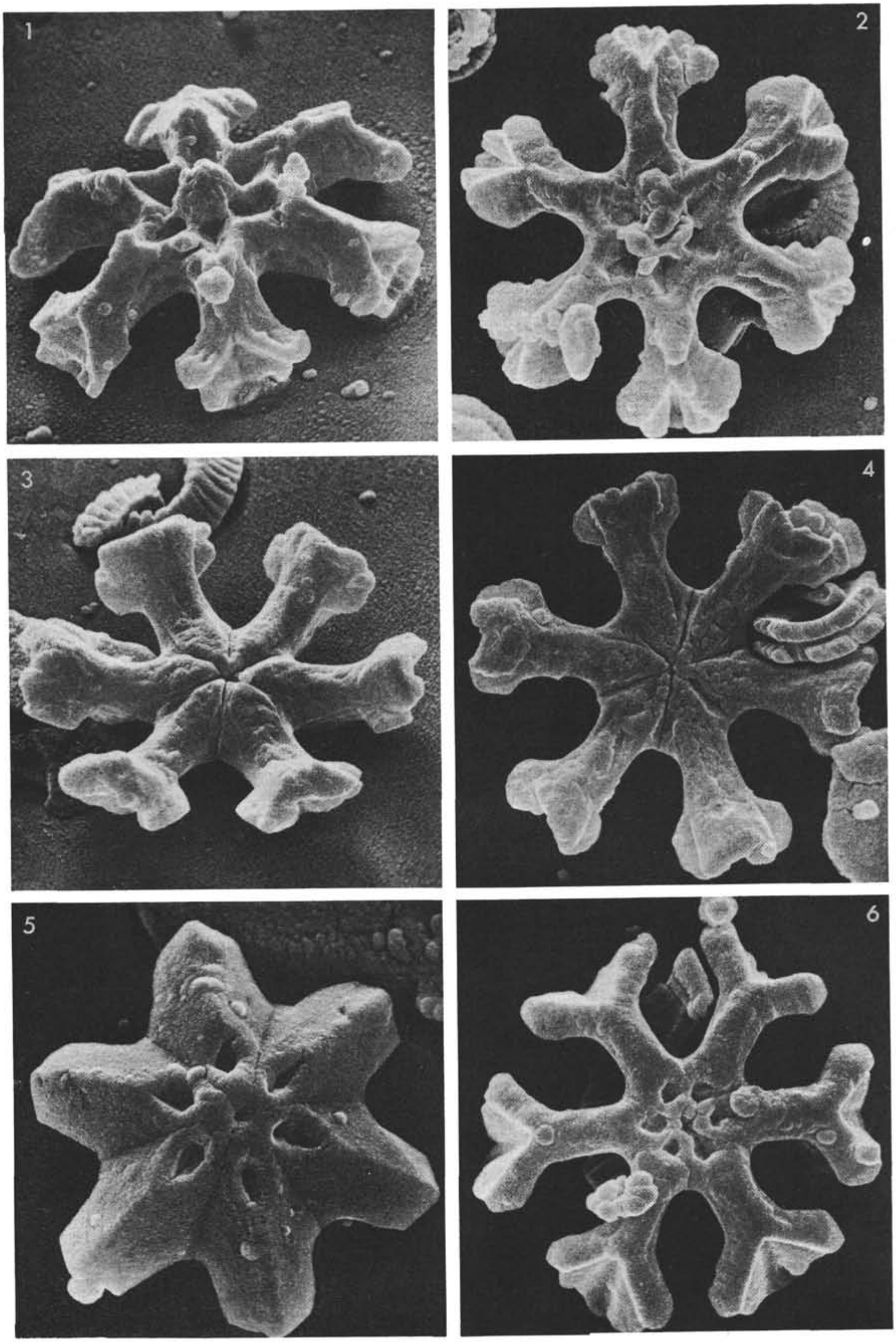

PLATE 13

Figures 1, 2	*Discoaster binodosus* Martini, 4800X & 4700X. Eocene 111A-8-1, proximal views.
Figure 3	*Discoaster cruciformis* Bramlette and Sullivan, 8100X. Eocene 111A-8-1.
Figure 4	*Discoaster* sp. 1, 11000X. Eocene 111A-8-1.
Figures 5, 6	*Discoaster keupperi* Stradner, 10200X & 9500X. Eocene 111A-8-1, side view and proximal view.

PLATE 13

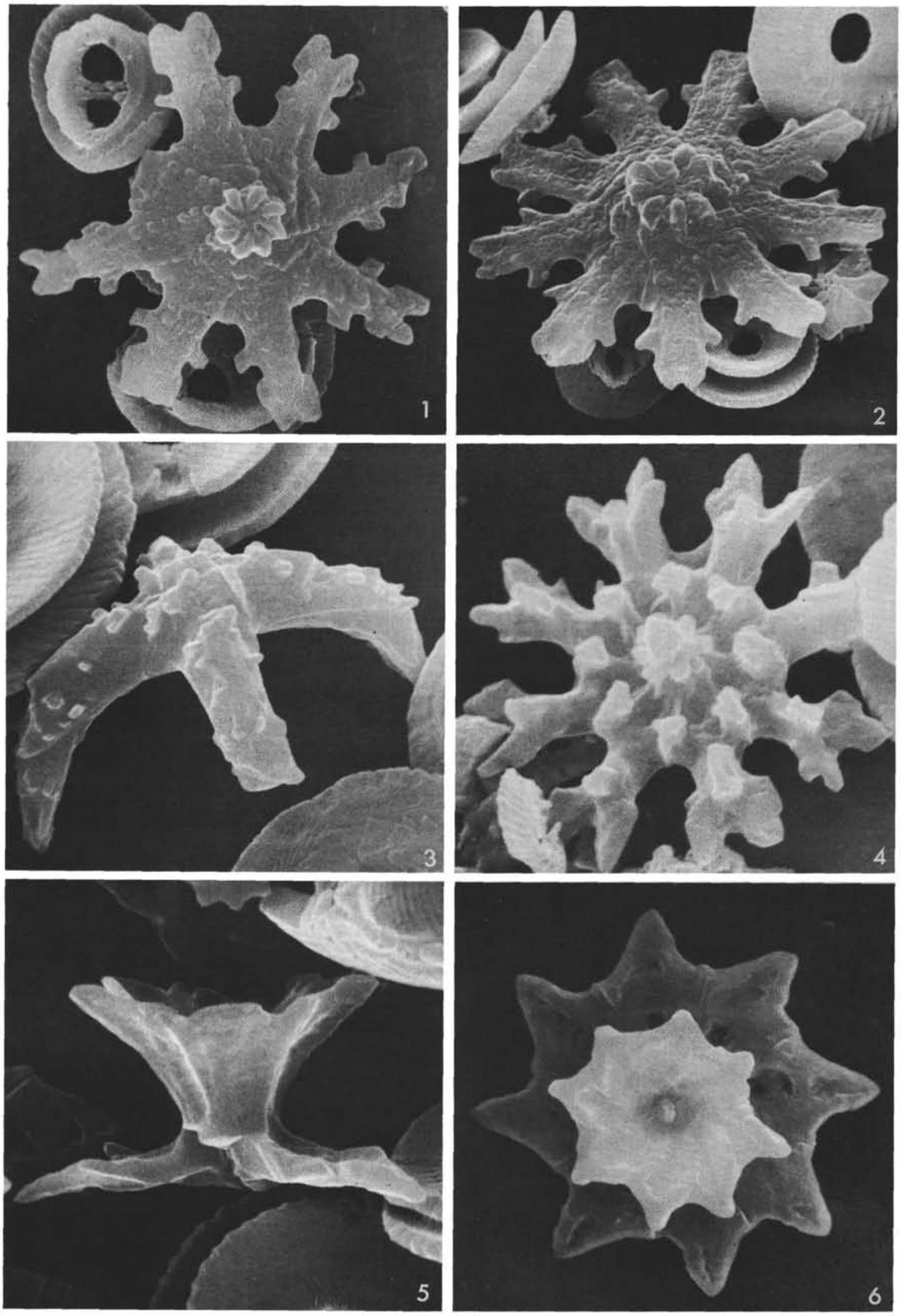

PLATE 14

Figure 1	*Discoaster* sp. 2, 8400X. Eocene 118-14-2, distal view.
Figure 2	*Discoaster* sp. 3, 8550X. Eocene 118-4-2, proximal view.
Figure 3	Gen. et sp. indet., 16400X. Paleocene 119-30-6, side view.
Figure 4	*Discoaster* sp. 4, 9900X. Paleocene 119-30-6, distal view.
Figure 5	*Discoaster* aff. *D. multiradiatus* Bramlette and Riedel, 7350X. Paleocene 119-28-2, distal view.
Figure 6	*Discoaster elegans* Bramlette and Sullivan, 5400X. Paleocene 119-25-2.

PLATE 14

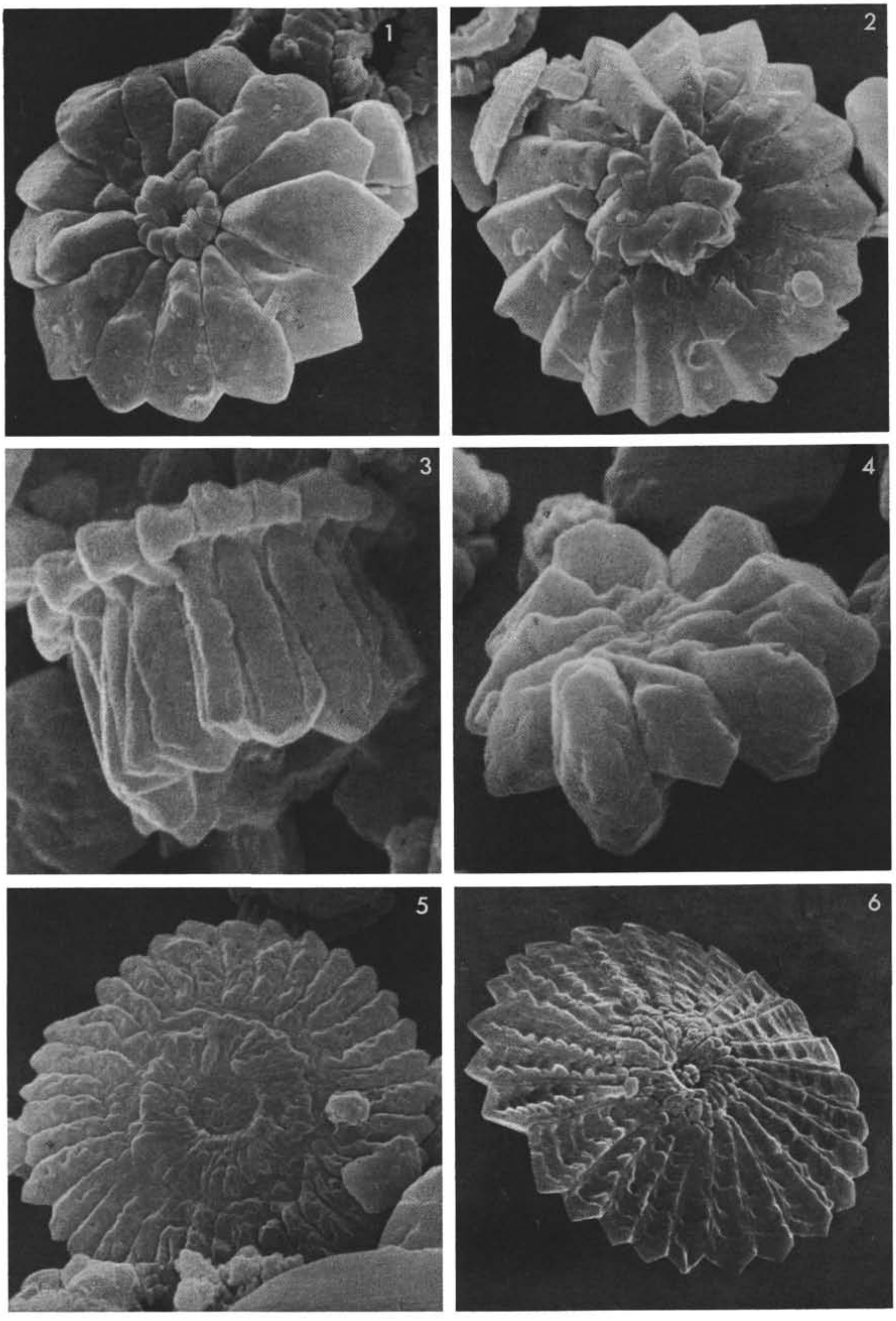

PLATE 15

Figure 1	*Nannotetrina fulgens* (Stradner), Eocene 119-20-2, 3000X.
Figure 2	*Nannotetrina pappi* (Stradner), Eocene 119-19-1, 6100X.
Figures 3, 4	*Nannotetrina cristata* (Martini), Eocene 119-20-2. Figure 3: 7200X. Figure 4: 6300X.
Figure 5	*Triquetrorhabdulus carinatus* Martini, Oligocene-Miocene 119-11-2, 7400X.
Figures 6, 7	*Zygrhablithus* cf. *Z. bijugatus* Deflandre, Oligocene 116-20-3 and 117A-3-2. Figure 6: 5300X. Figure 7: 6400X.

PLATE 15

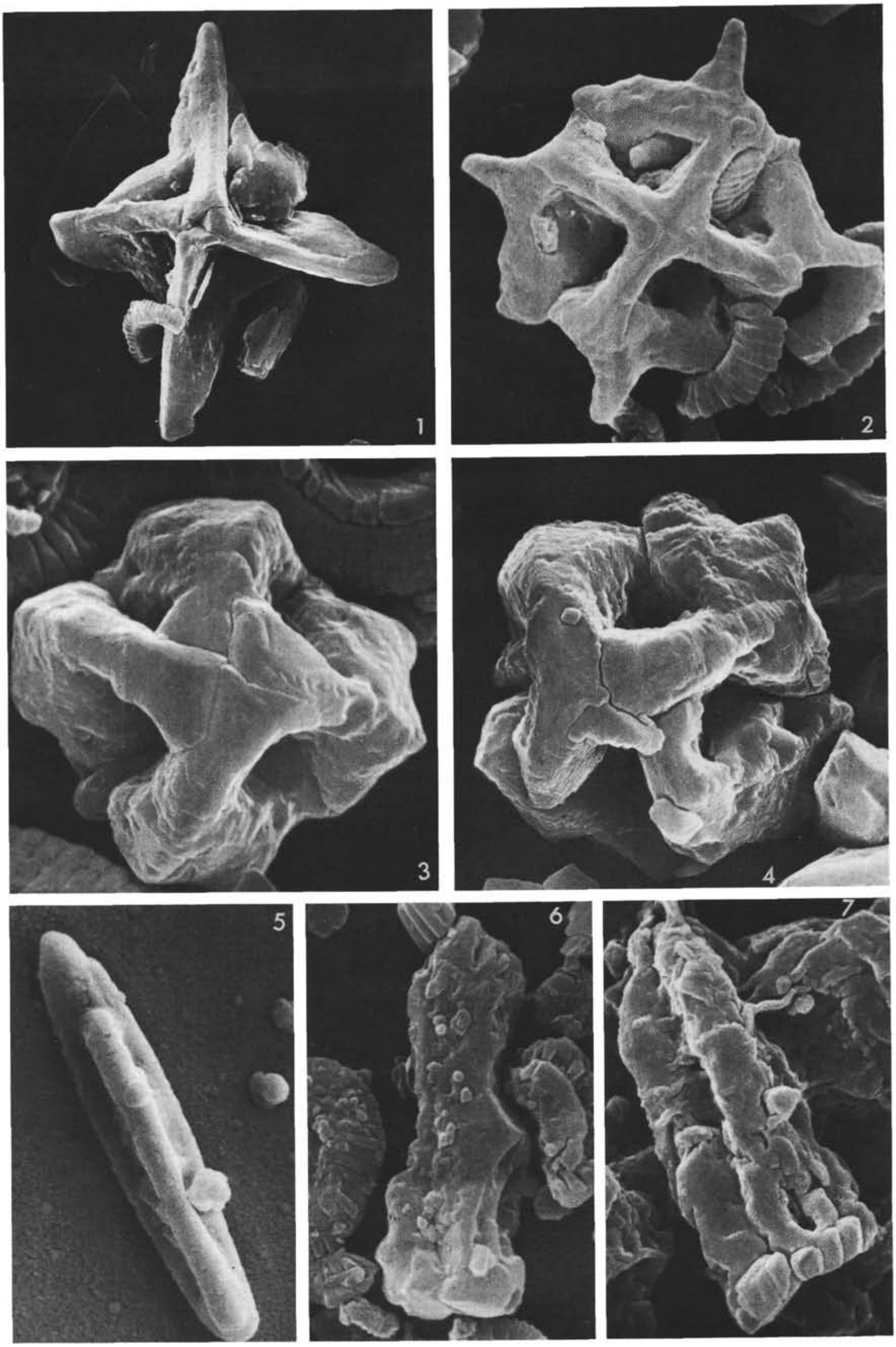

PLATE 16

Figures 1, 4, 5	*Sphenolithus moriformis* (Brönnimann and Stradner), Miocene 116-8-2, 116-11-6 and 116-12-5. Figure 1: 13200X. Figure 4: 13400X. Figure 5: 10900X.
Figure 2	*Sphenolithus* sp. 1, Miocene 116-11-6, 8200X.
Figure 3	*Sphenolithus* sp. 2, Miocene 116-11-6, 6800X.
Figures 6, 7	*Sphenolithus distentus* (Martini), Oligocene 119-14-5, 16000X, and 11900X.
Figure 8	*Sphenolithus* cf. *S. distentus* (Martini), Oligocene 119-16-4, 5800X.
Figure 9	*Sphenolithus predistentus* Bramlette and Wilcoxon, Oligocene 119-18-1, 11800X.
Figure 10	*Sphenolithus primus* Perch-Nielsen, Paleocene 119-37-4, 9000X.
Figures 11, 12	*Sphenolithus* cf. *S. anarrhopus* Bukry and Bramlette, Eocene 118-14-2, 14400X, 9500X.

PLATE 16

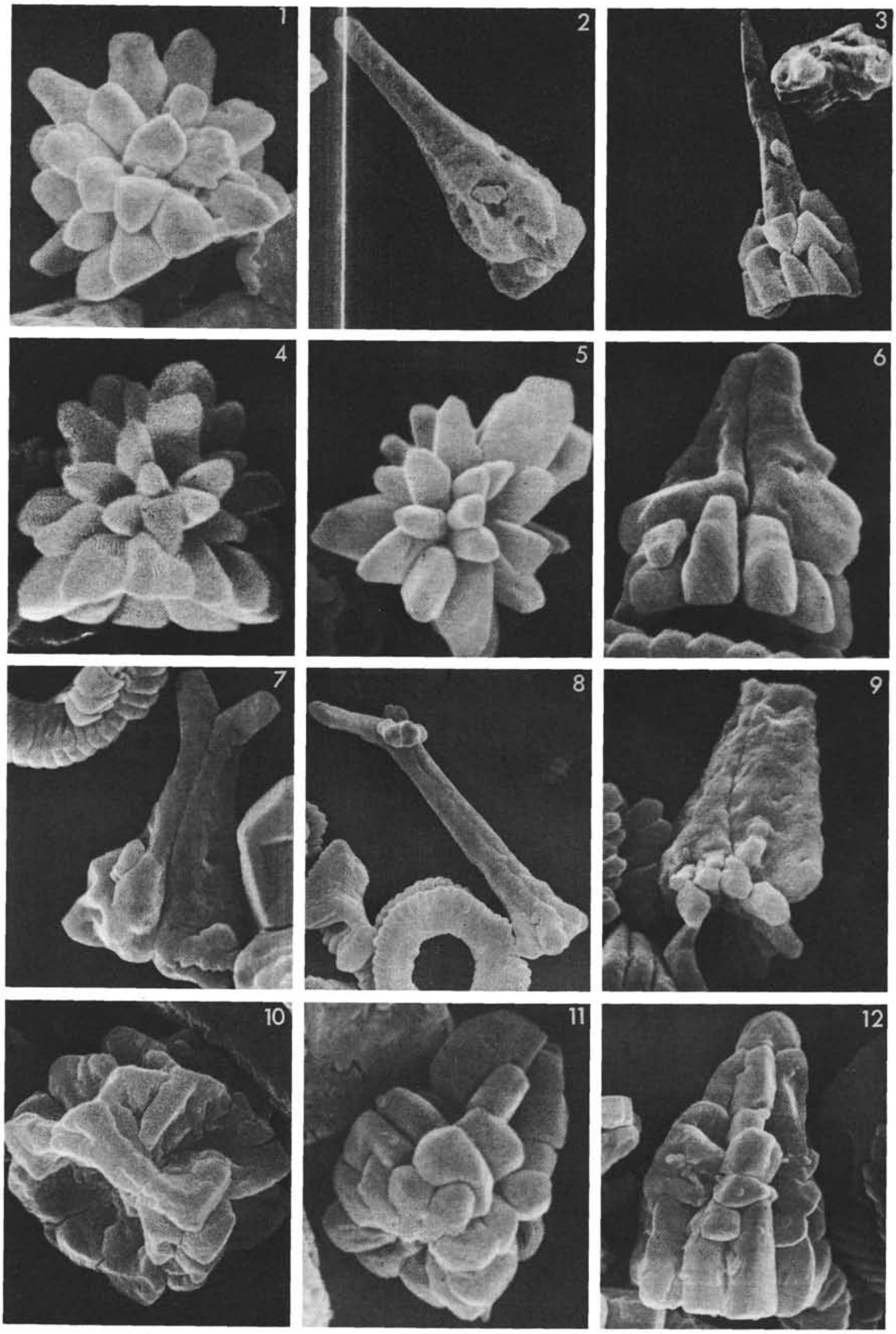

PLATE 17

Figure 1	*Sphenolithus furcatolithoides* Locker, 17500X. Eocene 111A-8-1.
Figure 2	*Sphenolithus orphanknolli* Perch-Nielsen, 14400X. Eocene 111A-8-1.
Figure 3	*Sphenolithus* sp. 21000X. Eocene 111A-8-1.
Figure 4	*Sphenolithus radians* Deflandre, 12300X. Eocene 111A-8-1.
Figure 5	*Sphenolithus* cf. *S. distentus* (Martini), 18800X.
Figure 6	*Sphenolithus abies,* Deflandre, 15400X. Miocene 111A-6-3.

PLATE 17

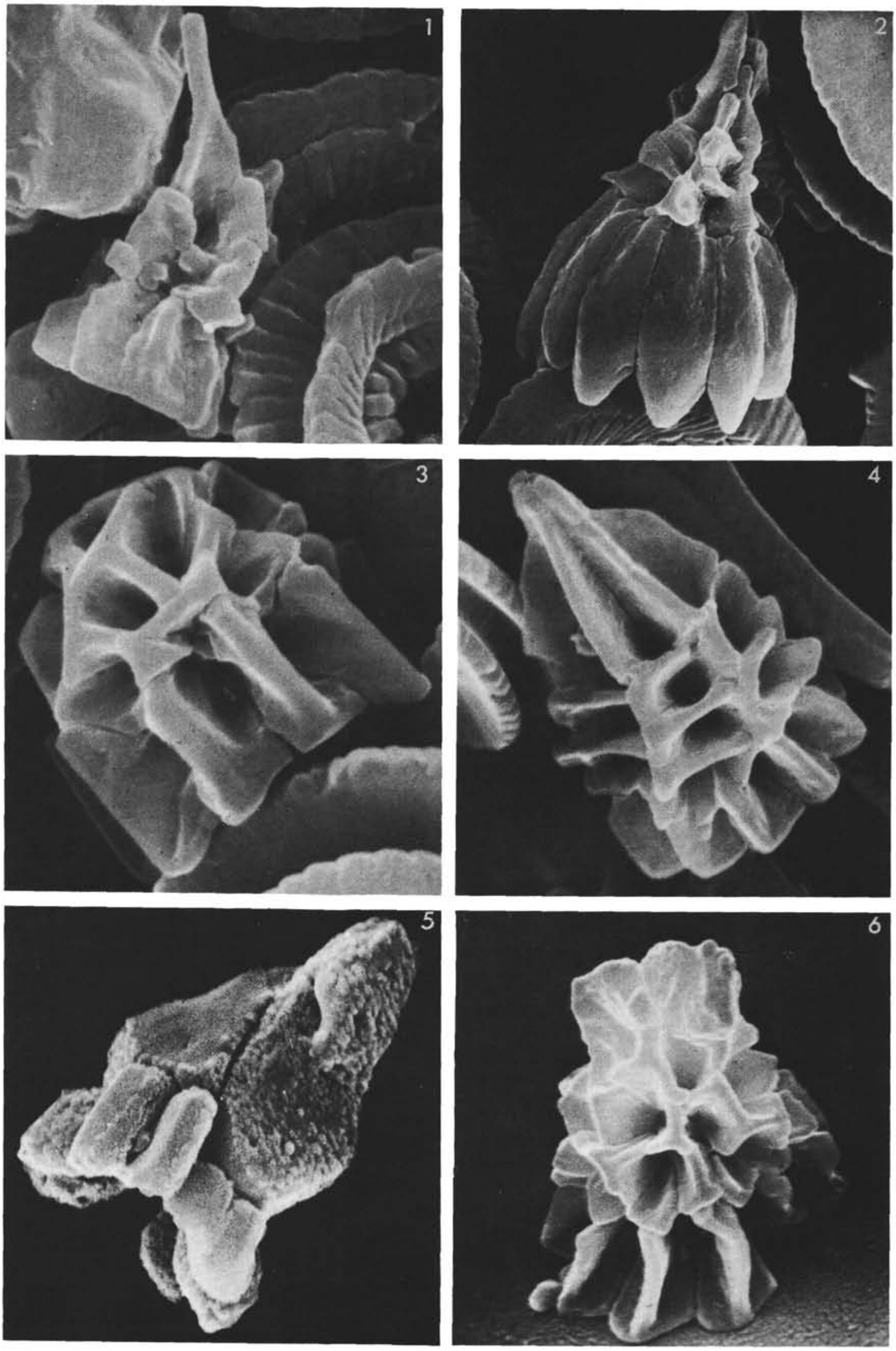

PLATE 18

Figures 1-3, 8, 11	*Helicopontosphaera wallichii* (Lohmann). Figures 1-3, distal views; Figures 8, 11, proximal views. Figure 1: Pleistocene 118-2-1, 5700X. Figure 2: Miocene 111A-6-3, 5600X. Figure 3: Miocene 111A-6-3, 6100X. Figure 8: Pleistocene 116A-1-1, 8100X, Figure 11: Miocene 111A-6-3, 4900X.
Figure 4, 6	*Helicopontosphaera sellii* Bukry and Bramlette. Figure 4: distal view, Pliocene 112-5, 9700X, Figure 6: distal view, Pleistocene 116A-7-2, 8100X (specimen between *H. wallichii* and *H. sellii*).
Figure 5, 9, 12	*Helicopontosphaera kamptneri* Hay and Mohler. Figure 5: distal view, Pleistocene 111-1-CC, 6300X, Figure 9: proximal view, Miocene 116-8-2, 5400X, Figure 12: Miocene 111A-6-3, 7800X.
Figure 7, 10	*Helicopontosphaera seminulum* (Bramlette and Sullivan), distal and proximal view, Eocene 111A-8-1, 6200X and 7000X.

PLATE 18

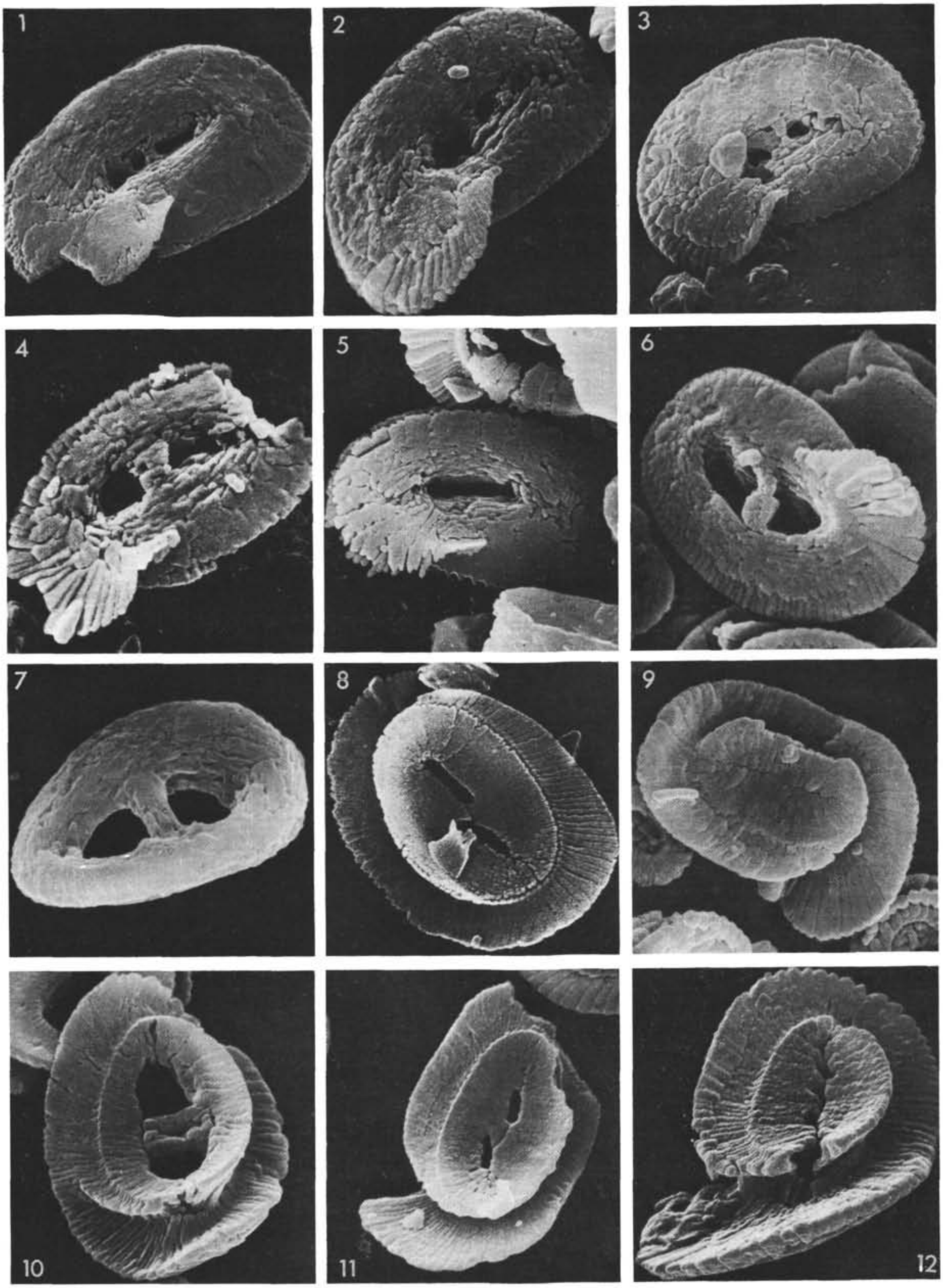

PLATE 19

Figure 1	*Pontosphaera* sp. 1, 8200X. Pleistocene 119-2-5, distal view.
Figure 2	*Lophodolithus nascens* Bramlette and Sullivan, 9300X. Eocene 111A-8-1, proximal view.
Figure 3	*Pontosphaera* sp. 2, 9900X. Pleistocene 116A-7-2, distal view.
Figure 4	*Pontosphaera* sp. 3, 9000X. Pleistocene 118-2-1, proximal view.
Figure 5	*Pontosphaera* sp. 4, 10700X. Eocene 117A-3-2, distal view.
Figure 6	*Pontosphaera* sp. 5, 6250X. Pleistocene 118-2-1, distal view.
Figure 7	*Pontosphaera* sp. 6, 10700X. Pleistocene 119-2-5, proximal view.

PLATE 19

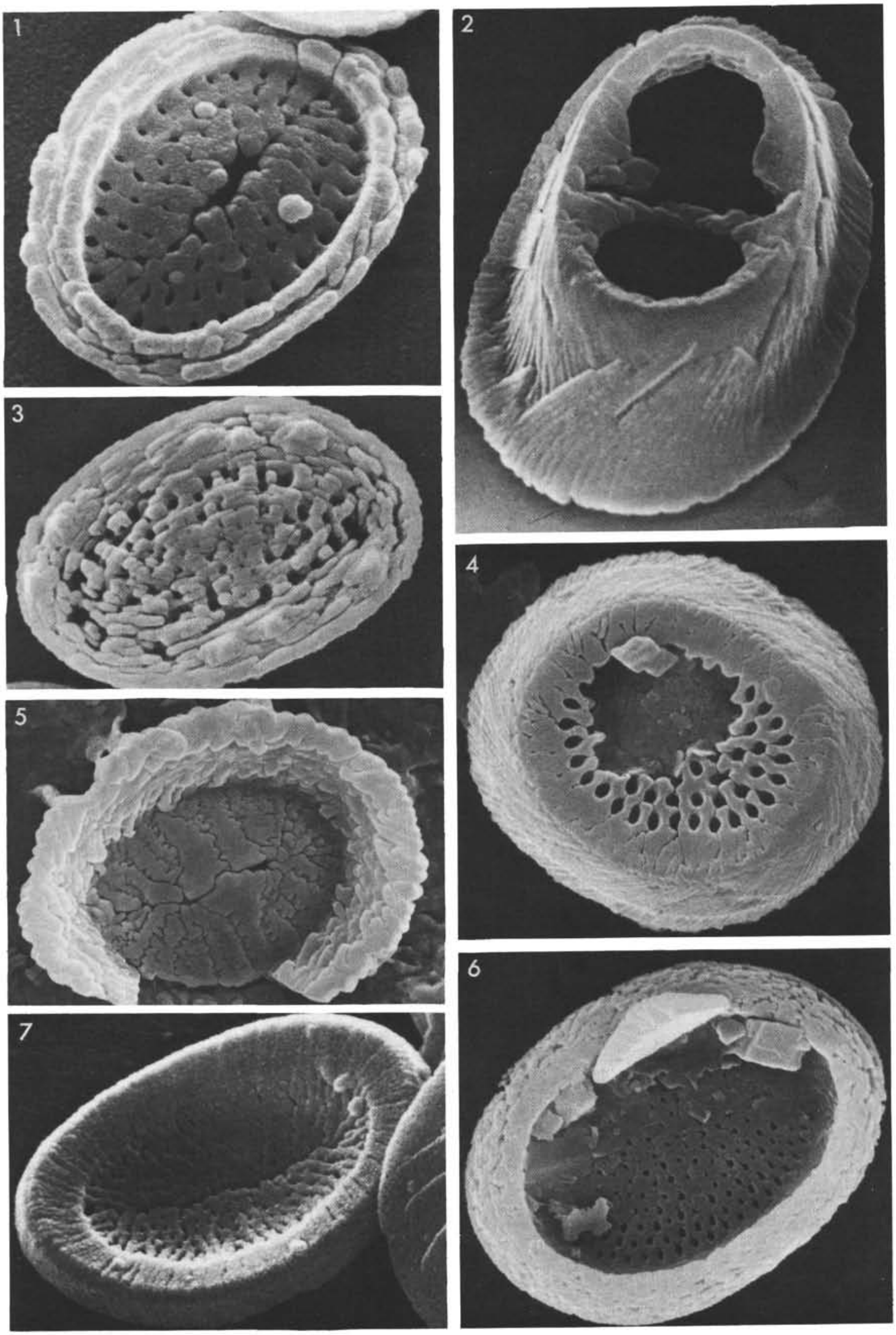

PLATE 20

Figures 1-4	*Scyphosphaera amphora* Deflandre, Pleistocene 116A-1-3. Figure 1: 5900X, Figure 2: 5800X, Figure 3: 5100X, Figure 4: 9200X.
Figure 5	*Scyphosphaera* cf. *S. recurvata* Deflandre, Pleistocene 116A-1-3, 4700X.
Figures 6, 7	*Scyphosphaera apsteinii* Lohmann, Pleistocene 116A-1-3. Figure 6: 8000. Figure 9: 6800X.

PLATE 20

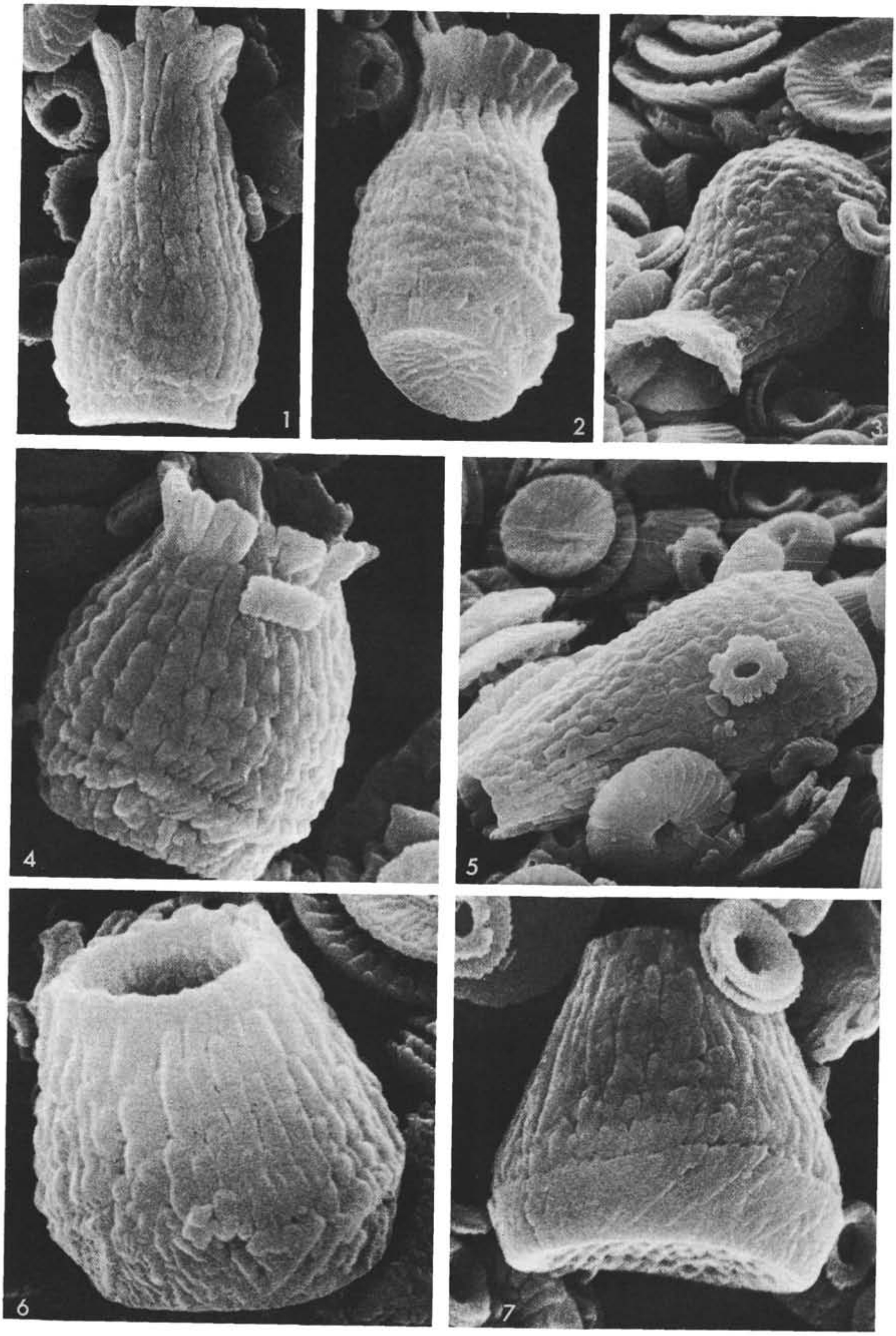

PLATE 21

Figure 1	*Discolithina segmenta* Bukry and Percival, distal view, 10500X, Miocene 116-11-2.
Figure 2	*Cribrosphaerella*? sp., 10400X, Oligocene 119-14-5.
Figure 3	*Coronocyclus nitescens* (Kamptner), 11800X, Oligocene 119-14-5.
Figure 4	Coccolith, gen. indet. sp. indet., 16400X, Paleocene 119-28-2.
Figure 5	Coccolith, gen. idet. sp. indet., 14300X, Paleocene 119-28-2.
Figure 6, 7	*Ellipsolithus macellus* (Bramlette and Sullivan) 5500X, Paleocene 119-26-1; 8300X, Paleocene 119-27-1.

PLATE 21

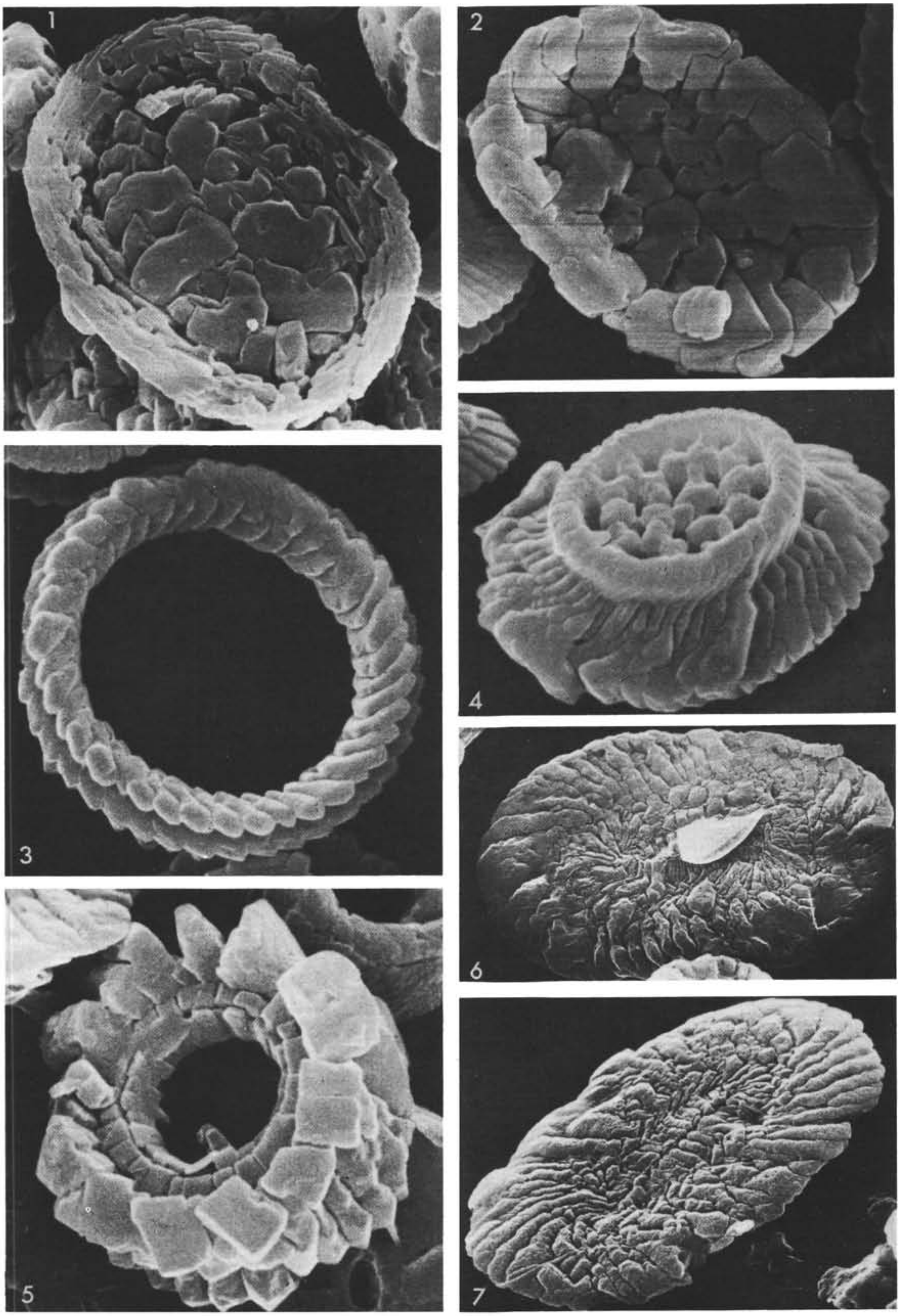

PLATE 22

Figure 1, 3	*Prediscosphaera cretacea* (Arkhangelsky), 13700X, 12600X. Reworked Upper Cretaceous in the Paleocene of 119-37-4 and 119-27-1. Side views.
Figure 2	*Parhabdolithus*? sp., 9350X. Reworked Cretaceous in the Paleocene of 119-28-2, distal side view.
Figure 4, 6	*Eiffellithus* aff. *E. eximius* (Stover), 10300X. Reworked Upper Cretaceous in the Paleocene of 119-31-1, distal and side view of the same specimen.
Figure 5	*Broinsonia parca* (Stradner), 8300. Reworked Upper Cretaceous in the Paleocene of 119-30-6.

PLATE 22