11. PALEOGENE AND NEOGENE DIATOMS FROM THE FALKLAND PLATEAU AND MALVINAS OUTER BASIN: LEG 36, DEEP SEA DRILLING PROJECT

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ABSTRACT

The distribution of Neogene and Paleogene diatoms from six sites located in the Argentine Basin, the Malvinas Outer Basin, and on the Falkland Plateau is presented. Biostratigraphic zonations based on diatoms are proposed for part of the late Paleocene from Site 327 and for the late Eocene and Oligocene from Site 328. Five new diatom taxa are described.

INTRODUCTION

Leg 36 started at Ushuaia, Argentina, on 4 April 1974 and ended at Rio de Janeiro, Brazil, on 22 May 1974. The original cruise plan called for an investigation of the evolution of the Scotia Sea and the development of the Circumpolar Current system. However, bad weather and other problems forced a reorganization of the cruise plan. Emphasis was shifted to problems of the evolution of the Falkland Plateau and the southernmost Atlantic.

Six sites were occupied (Figure 1). Of these, four were successful (Sites 327, 328, 329, and 330); the other two (Sites 326 and 331) resulted in the recovery of only one and two near surface cores, respectively. Three of the successful sites (327, 329, and 330) are located on the Maurice Ewing Bank on the eastern end of the Falkland Plateau. The fourth site (328) is located in the Malvinas Outer Basin east of the Falkland Plateau.

Diatoms ranging in age from late Paleocene to Recent were encountered at the Leg 36 sites. Extensive Neogene sections were penetrated at Sites 328 and 329. An upper Eocene to upper Oligocene sequence was penetrated at Site 328. The late Paleocene was encountered at Site 327.

Table 1 summarizes coring operations on Leg 36.

METHODS

Samples were routinely examined from all core catchers as they were brought on deck during drilling operations. Samples from the top and bottom of core sections were examined as time permitted. Examination of these samples, during drilling operations, established the extent of diatomaceous sediment at each site.

After completion of drilling operations cores were routinely sampled for future shore-based investigation. For this purpose, samples of 10 cc were taken from near the top and bottom of each core section as well as at approximately 30 to 50 cm intervals in between from all cores containing diatomaceous sediment. Samples were also taken at selected intervals, such as at lithologic boundaries, within the cores.

Samples were prepared for shore-based investigation according to the method described by McCollum (1975). It was necessary to sieve (45 μm) certain samples in order to concentrate the diatoms. Unless noted otherwise, abundances derived from such samples are given as rare.

Slides made from each preparation were mounted in Hyrax. Microscopic examination of prepared slides was carried out with the Zeiss Standard RA research microscope equipped with 100×, 40×, and 16× objectives and Nomarski differential interference contrast (DIC). All photomicrographs were taken on Panatomic-X film using a Nikon AFM 35-mm camera. Scanning electron micrographs were taken with a 35-mm Nikon camera attached to the ISI Super Mini Scan electron microscope in the Geology Department of Florida State University.

Selected specimens and type species were located on the microscope slides by means of a Leitz diamond stylus object marker adapted for use on the Zeiss microscope.

All of the samples taken onboard ship were examined on shore with the exception of those from Site 329, which totaled 103. Of these, every fifth sample was examined, intervening samples being examined where necessary.

Estimates of the relative frequency of taxa were made using the method suggested by Andrews (1972).

A sample was defined as containing a trace amount of diatoms if one or two valves or fragments of valves were observed during 10 traverses of the slide at 400×. A sample was defined as being barren of diatoms if no valves or fragments of valves were observed during 10 traverses at 400×.

Estimates of gross diatom abundance are given as rare, frequent, common, and abundant. Preservation is indicated as poor, moderate, or good (P, M, G), depending on the extent of valve destruction.

Each strewn slide was systematically scanned at 160× and 400× until approximately 40% to 50% of the 18 mm × 18 mm cover slip was traversed. Specific identifications were made at 400× or 1000× as necessary.

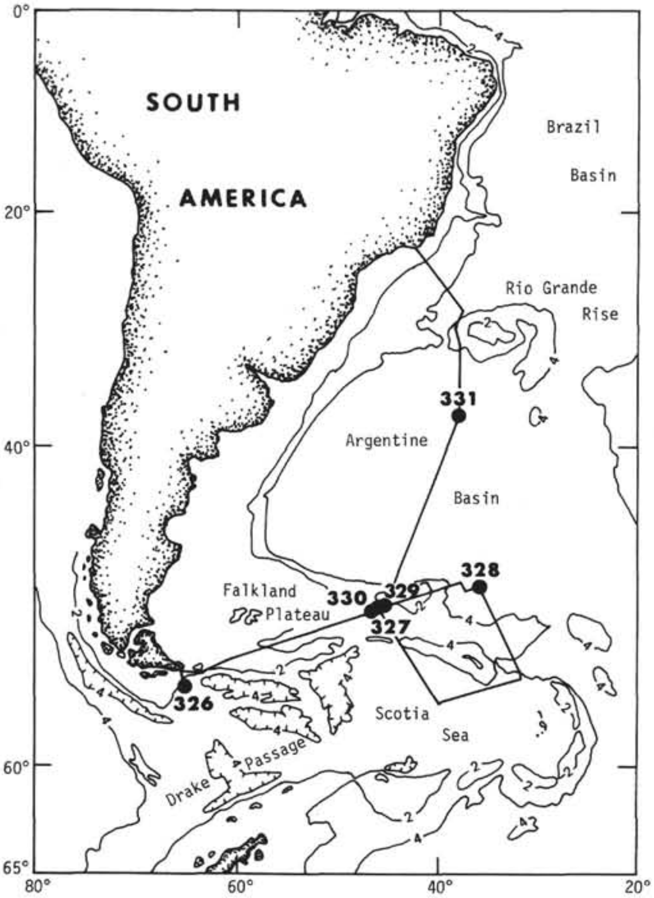


Figure 1. *Location of Leg 36 drill sites.*

Scans at 160× were necessary in order to detect species which sometimes occur consistently but in rare amounts and which may be important stratigraphically.

DIATOMS AT EACH SITE

Site 326

Two samples (1-1, 116-117 cm; 1-1, 124-125 cm) examined from this core were barren of diatoms. A slide prepared from material in the core catcher contained four specimens of *Nitzschia kerguelensis*. The range of this species is Pliocene to Recent.

Hole 327

Diatoms are common to abundant and are moderately well preserved in Hole 327.

The core catcher of Core 1 contains a predominately Plio/Pleistocene assemblage of diatoms with a few older (late Miocene) forms also present. Among the species observed are *Coscinodiscus lentiginosus*, *Nitzschia kerguelensis*, *Actinocyclus ingens*, *Cosmiodiscus insignis*, *Hemidiscus karstenii*, *Coscinodiscus vulnificus*, *Denticula antarctica*, and *Denticula hustedtii*.

Only one core was recovered from this hole.

Hole 327A (Tables 2, 3)

Diatoms are rare and poorly preserved in Sample 1-1, 129-130 cm, and are common to abundant and poor to moderately well preserved in Samples 1-2, 10-11 cm through 1-4, 126-127 cm.

Core 1 contains an admixture of Pliocene and Quaternary diatoms, possibly due to deformation of the core. The admixture of Pliocene and Quaternary forms makes zonal assignments difficult. The last occurrence of *Actinocyclus ingens* in Sample 1-3, 9-11 cm suggests the position there of the base of the *Coscinodiscus lentiginosus* Partial Range Zone of McCollum (1975). The top of this zone is defined as "recent sediment being formed in the Southern Ocean containing *Coscinodiscus lentiginosus*." Therefore, if the base of the *Coscinodiscus lentiginosus* Zone is located between Samples 1-2, 28-30 cm and 1-3, 9-11 cm, all samples above and including 1-2, 28-30 cm are Quaternary. Zonation of the interval 1-3, 9-11 cm through 1-4, 126-127 cm was not possible; that interval is assigned a Pliocene/Quaternary age.

The interval including Samples 2-1, 103-105 cm through 3-2, 120-121 cm is barren of diatoms.

Diatoms are common to abundant and are moderately well preserved in the interval including Samples 5-1, 45-48 cm through 8-1, 46-48 cm. This interval has been dated as late Paleocene by calcareous nannofossils, Radiolaria, and silicoflagellates. Three diatom zones have been defined from this section. The *Hemiaulus inaequilaterus* Zone is present in Core 5. The *Sceptroneis* sp. A Zone is present in Samples 6-1, 102-103 cm through 6-2, 146-148 cm. The *Odontotropis*

TABLE 1
Coring Summary, Leg 36

Hole	Dates (1974)	Latitude	Longitude	Water Depth (m)	Penetration (m)	No. of Cores	Cored (m)	Recovered (m)	Recovery (%)
326	5-6 April	56°35.00'S	65°18.20'W	3812	9.5	1	9.5	0.5	05
327	13-14 April	50°52.28'S	46°47.02'W	2401	5.5	1	5.5	5.5	100
327A	14-17 April	50°52.38'S	46°47.02'W	2401	469.5	27	256.5	128.1	50
328	24-27 April	49°48.67'S	36°39.53'W	5013	397.0	12	112.0	62.1	55
328A	27-28 April	49°48.67'S	36°39.53'W	5013	17.0	2	17.0	7.4	44
328B	28-30 April	49°48.67'S	36°39.53'W	5013	471.0	8	67.0	63.0	94
329	4-6 April	50°39.31'S	46°05.73'W	1519	464.5	33	312.5	215.1	69
330	6-8 May	50°55.19'S	46°53.00'W	2626	575.5	17	161.5	85.5	53
330A	8 May	50°55.19'S	46°53.00'W	2626	53.0	5	47.5	4.0	08
331	13-16 May	37°53.00'S	38°06.92'W	5067	18.0	2	18.0	8.5	47
Total					2480.5	108	1007.0	579.7	57.6

TABLE 2
Distribution of Selected Diatom Species in Hole 327A

Sample (Interval in cm)	*Coscinodiscus lentiginosus*	*Actinocyclus ingens*	*Rhizosolenia barboi*	*Nitzschia kerguelensis*	*Coscinodiscus kolbei*	*Cosmiodiscus insignis*	*Nitzschia interfrigidaria*	*Nitzschia praeinterfrigidaria*	*Denticula hustedtii*	*Denticula antarctica*	Diatom Zones (McCollum, 1975)	Age
1-1, 129-130	X			X		X				X	*C. lentiginosus*	
1-2, 10-11	X			X	X	X	X			X	*C. lentiginosus*	
1-2, 28-30	X			X								
1-3, 9-11	X	X	X			X	X	X		X	*C. elliptopora/ A. ingens*	
1-3, 96-97	X	X	X			X			X	X		
1-3, 146-147		X		X			X	X	X	X		
1-4, 126-127	X	X				X	X		X	X	? ? ? ?	Quaternary ?
2-1, 103-105	–	–	–	–	–	–	–	–	–	–		
2-2, 97-98	–	–	–	–	–	–	–	–	–	–		
1-3, 93-96	–	–	–	–	–	–	–	–	–	–		
2-4, 46-48	–	–	–	–	–	–	–	–	–	–		
2-5, 51-53	–	–	–	–	–	–	–	–	–	–	Barren of Diatoms	
2-5, 119-121	–	–	–	–	–	–	–	–	–	–		
3-1, 91-93	–	–	–	–	–	–	–	–	–	–		
3-2, 45-47	–	–	–	–	–	–	–	–	–	–		
3-2, 120-121	–	–	–	–	–	–	–	–	–	–		

Note: The X's indicate presence of the species in the sample.

TABLE 3
Distribution of Species in the Late Paleocene in Hole 327A

Sample (Interval in cm)	Abundance	Preservation	*Sceptroneis* sp. A	*Sceptroneis caduceus*	*Stephanopyxis turris*	*Hemiaulus altus*	*Hemiaulus incurvus*	*Hemiaulus polymorphus*	*Trinacria simulacrum*	*Stephanopyxis simonseni*	*Hemiaulus* sp. D	*Hemiaulus inaequilaterus*	*Triceratium* cf. *tessellatum*	*Stephanopyxis* sp. A	*Pterotheca* sp. A	*Triceratium gracillium*	*Sceptroneis* sp. B	*Triceratium aries*	*Hemiaulus* cf. *subacutus*	*Hemiaulus disimilis*	*Pyrgupyxis prolongata*	*Sceptroneis grunowii*	*Trinacria pileolus*	*Triceratium crenulatum*	*Hemiaulus elegans*	*Synedra jouseana* v. B	*Odontotropis klavsenii*	*Trinacria excavata*	Age
5-1, 45-58	A	M	C	F	C	R	C	C	F	C	C	R	R	F	R	R	R	R											
5-1, 105-107	C	M	C		C	R	C	C	F	R	F	R	F	F		R	R	R	R										
5-2, 126-128	C	P	C		C		F	F	R	R	F	R	R	R	R	R	R	R	R	R	R	R							
5-3, 113-115	C	M	C		C	F	C	C	R	F	R			F		R	R	R	F			R							
5-4, 138-139	C	P	C		C		R	R	R		F			R		F	F	R				F	F	R					
5-5, 119-121	A	P	C	R	C	F	C	C	C	R	C	R	C	R	R	C	R	C	F		R							R	
5-6, 119-121	A	M	C		C	C	C	F	F		R	R		F	R	R		C	F		R				R				Late Paleocene
6-1, 102-103	C	P	F	R	R		R		R		R		R					R										R	
6-2, 146-148	C	P	C		R	R	F	F	R					R	R	R	R	C	R							C			
6-3, 109-111	C	P	F		R	R	F	F	R	R	R						F	C	F		F					C	R		
6-4, 130-131	A	M	F		F	R	C	C	R		C					R	R	A	F		R					C	R		
6-5, 146-147	F	P	R	R		R	R	R	R		F							C	R							F	R		
6-6, 116-118	A	M	F		C	R	R	C	F	F	F						R	C	C		R				R	C	R		
7-2, 45-47	A	M	F		F	R	R	F	F	R	C		R				R	A	R				F			C	R		
7-2, 147-148	A	M	R		F		R	R	F	C						R		A								C	C		
8-1, 46-48	C	M			C		R	F	R		R			R		R		C	R							C			
8-3, 12-14	R	P					R	F	R					R	R			F								C			

klavsenii Zone is present in Samples 6-3, 109-111 cm through 7-2, 147-148 cm.

Hole 328 (Tables 4, 5, and 6; Figure 2)

Diatoms are common to abundant through the Neogene interval in Hole 328. Preservation of frustules is poor to moderate. Diatoms in the Paleogene interval in Core 4 are generally abundant and well preserved.

The following Neogene diatom zones of McCollum (1975) are represented in Hole 328: *Coscinodiscus lentiginosus* Partial Range Zone (1-1, 1-3 cm to 1-3, 5-7 cm); *Coscinodiscus elliptopora/Actinocyclus ingens* Concurrent Range Zone (1-3, 81-83 cm to 1-5, 138-140 cm); *Cosmiodiscus insignis* Partial Range Zone (2-1, 148-150 cm to 2-2, 5-7 cm); *Nitzschia interfrigidaria* Partial Range Zone (2-2, 80-82 cm to 2-3, 5-7 cm); *Denticula hustedtii* Partial Range Zone (2-3, 78-80 cm to 2-5, 5-7 cm); *Denticula hustedtii/Denticula lauta* Partial Range Zone (2-5, 81-83 cm to 3-1, 5-7 cm); *Denticula lauta/Denticula antarctica* Partial Range Zone (3-1, 81-83 cm to 3-2, 140-142 cm). The interval from Sample 3-3, 5-7 cm to 3-4, 81-83 cm was not zoned, but is included in the middle Miocene.

The *Coscinodiscus lentiginosus* and *Coscinodiscus elliptopora/Actinocyclus ingens* zones are Quaternary in age. The *Cosmiodiscus insignis* and *Nitzschia interfrigidaria* zones are middle to early Pliocene in age. The *Denticula hustedtii* Zone is late Miocene. The *Denticula hustedtii/Denticula lauta* Zone straddles the middle-late Miocene boundary. The *Denticula lauta/Denticula antarctica* Zone and the interval below it to Sample 3-4, 81-83 cm are middle Miocene.

The absence of the *Rhizosolenia barboi/Nitzschia kerguelensis* Partial Range Zone and the *Coscinodiscus kolbei/Rhizosolenia barboi* Range Zone between the *Coscinodiscus elliptopora/Actinocyclus ingens* Concurrent Range Zone and the *Cosmiodiscus insignis* Partial Range Zone suggests the existence of a hiatus at this level (i.e., between Samples 1-5, 138-140 cm and 2-1, 148-150 cm). Alternatively, the absence of these two zones may be explained fully or in part by a drilling gap of about 1 meter between Cores 1 and 2.

The *Nitzschia praeinterfrigidaria* Partial Range Zone is missing from between the *Nitzschia interfrigidaria* Partial Range Zone and the *Denticula hustedtii* Partial Range Zone within Core 2 (i.e., between Samples 2-3, 5-7 cm and 2-3, 78-80 cm). This interval corresponds to the occurrence of deformed, centimeter scale laminae of sandstone at 3.7 meters in Core 2.

Samples in the interval 3-5, 10-12 cm to 3-6, 48-50 cm are barren of diatoms. Sample 3-6, 81-83 cm contains a trace of diatoms.

Core 4 is late Eocene in age. The *Pyrgupyxis eocena/Pterotheca aculeifera* Zone is represented in the interval 4-1, 147-149 cm through 4-3, 5-7 cm.

Hole 328A (Table 4; Figure 2)

Diatoms are abundant and are moderately well to well preserved in the samples examined from this hole.

The *Coscinodiscus lentiginosus* Partial Range Zone of McCollum (1975) is represented in Samples 1-1, 35-37 cm through 1-4, 70-72 cm. Samples 1-4, 146-148 cm through 2-1, 145-147 cm are assigned to the *Coscinodiscus elliptopora/Actinocyclus ingens* Concurrent Range Zone.

These zones are Pleistocene to Recent in age and have been correlated to the paleomagnetic time scale by McCollum. The Brunhes-Matuyama boundary is nearly coincident with the boundary of the *Coscinodiscus lentiginosus* Zone with the *Coscinodiscus elliptopora/Actinocyclus ingens* Zone.

Hole 328B (Table 6 [foldout in back pocket]; Figure 2)

Diatoms are of Neogene age from the top of Core 1 through Sample 2-4, 70-72 cm. In this interval diatoms are common to abundant from the top of Core 1 through Core 2, Section 2. Preservation in this interval is moderate. Diatoms are rare and poorly preserved in the interval Core 2, Section 3 through Core 2, Section 4.

Samples 1-1, 89-91 cm through 1-2, 5-7 cm are placed within the *Nitzschia interfrigidaria* Zone based on the highest occurrence of *Nitzschia praeinterfrigidaria* in Sample 1-2, 70-72 cm. This indicates a Pliocene age for this interval. The remainder of the Neogene section is disturbed to the extent that it was not possible to assign zones. However, correlation with Hole 328 suggests a late Miocene age for Samples 1-2, 70-72 cm through 1-6, 70-72 cm, and a middle Miocene age for Samples 1-6, 140-142 cm through 2-4, 70-72 cm.

Samples 2-5, 5-7 cm and 2-5, 70-72 cm are barren of diatoms. Sample 2-6, 5-7 cm contains a trace of diatom fragments. Sample 2-6, 123-125 cm is barren of diatoms.

Diatoms are common to abundant and poorly to moderately well preserved in Cores 3 through 5. This interval is Paleogene and includes late Eocene through late Oligocene age sediments.

The late Eocene *Pyrgupyxis eocena/Pterotheca aculeifera* Zone is represented in Samples 5-1, 147-149 cm through 5-3, 84-86 cm. The late Eocene-late Oligocene *Hemiaulus incisus* Zone is represented in Samples 4-4, 5-7 cm through 5-1, 9-11 cm. The late Oligocene *Melosira architecturalis* and *Pyrgupyxis prolongata* zones are represented in Samples 4-1, 45-47 cm through 4-3, 145-147 cm and 3-2, 70-72 cm through 3-6, 126-128 cm, respectively.

Site 329 (Table 7)

Diatoms are abundant at Site 329 in Cores 1 through 28, are present in trace amounts in Cores 29 and 30, and are absent from the remaining cores. Diatoms are generally poor to moderately well preserved in the 30 cores in which they are present. *Thalassiothrix* spp. are the dominant forms through the first 28 cores, often constituting over 50% of the flora.

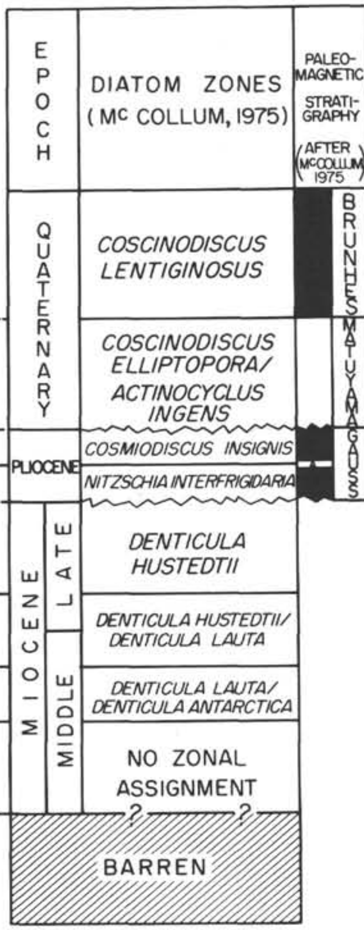
Core 1, Section 1 is dated as Pleistocene to Recent on the occurrence of *Coscinodiscus lentiginosus* and *Nitzschia kerguelensis*.

Samples 1-2, 30-32 cm through 1-6, 30-32 cm contain a mixed Miocene through Recent diatom assemblage. Diatoms occurring within this interval include: *Coscinodiscus lentiginosus*, *Coscinodiscus vulnificus*, *Nitzschia kerguelensis*, *Nitzschia interfrigidaria*,

TABLE 4
Zonation and Correlation of the Neogene at Holes 328 and 328A

SITE 328

Core	Section	Sample Interval in cm.	Coscinodiscus lentiginosus	Actinocyclus ingens	Coscinodiscus elliptopora	Rhizosolenia barboi	Nitzschia kerguelensis	Coscinodiscus kolbei	Cosmiodiscus insignis	Nitzschia interfrigidaria	Nitzschia praeinterfrigidaria	Denticula hustedtii	Denticula lauta	Denticula antarctica	Coscinodiscus lewisianus	Denticula nicobarica	Pyrgupyxis prolongata
1	1	1-3	X				X										
	1	48-50	X				X										
	1	130-132	X				X										
	1	140-142	X				X										
	2	5-7	X				X										
	2	81-83	X				X										
	3	5-7	X	X	X		X										
	3	81-83	X	X	X		X										
	4	5-7	X	X	X		X										
	4	79-81	X	X	X		X										
	5	5-7	X	X	X		X										
	5	81-83	X	X	X		X										
	5	138-140	X	X	X		X										
2	1	148-150		X				X	X								
	2	5-7		X				X	X								
	2	80-82		X		X				X							
	3	5-7		X		X				X	X						
	3	78-80		X		X			X	X		X					
	3	146-148				X											
	4	5-7				X			X			X					
	4	81-83				X			X			X					
	5	5-7				X			X			X					
	5	81-83				X						X	X				
	6	5-7				X			X	X		X	X				
	6	81-83				X			X	X		X	X				
3	1	5-7				X						X	X				
	1	81-83		X									X	X			X
	2	87-89		X						X			X	X			X
	2	140-142		X									X	X			
	3	5-7		X									X			X	
	3	28-30		X									X				
	3	140-142		X													
	4	5-7		X													
	4	81-83		X													
	5	10-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	81-83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	5-7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	40-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	48-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	81-83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



SITE 328A

Coscinodiscus lentiginosus	Actinocyclus ingens	Coscinodiscus elliptopora	Nitzschia kerguelensis	Core	Section	Sample Interval in cm.
X			X	1	1	35-37
X			X		2	5-7
X			X		2	70-72
X			X		2	140-142
X			X		3	72-74
X			X		3	147-149
X			X		4	70-72
X	X	X	X		4	146-148
X	X	X	X	2	1	31-32
X	X	X	X		1	145-147

Note: Diatom zonation from McCollum (1975); correlation to paleomagnetic time scale is after McCollum (1975). The X's indicate presence of the species in the sample.

Nitzschia praeinterfrigidaria, *Cosmiodiscus insignis*, *Denticula hustedtii*, *Denticula antarctica*, *Denticula dimorpha*, and *Thalassiosira burckliana*.

Samples 2-1, 113-115 cm through 28, CC contain Miocene diatoms. Elements of the following zones of McCollum (1975) were noted in that interval: *Denticula antarctica* Partial Range Zone, *Denticula antarctica/Coscinodiscus lewisianus* Zone, *Denticula lauta/Denticula antarctica* Partial Range Zone, *Denticula hustedtii/Denticula lauta* Partial Range Zone, and the *Denticula hustedtii* Partial Range Zone. Due to extensive reworking in this interval, it was not possible to segregate these zones. The middle-late Miocene boundary is tentatively placed between Cores 20 and 21.

Cores 29 and 30 are late to middle Oligocene in age. *Pyrgupyxis prolongata*, *Hemiaulus polymorphus*, and *Stephanopyxis* spp. occur in this interval.

Hole 330

No diatoms were observed in the recovered core material from Hole 330.

Hole 330A (Table 8)

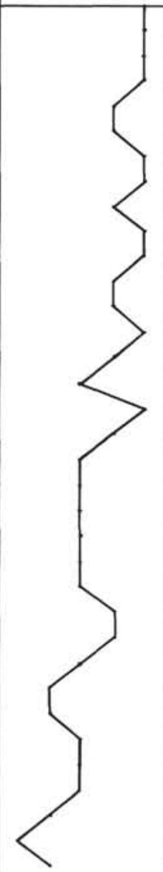
Samples 1-1, 25-27 cm and 1-1, 77-78 cm contain a mixed assemblage of diatoms ranging in age from Eocene through Recent. Included in this assemblage are: *Thalassiothrix* spp., *Thalassionema nitzschioides*, *Nitzschia kerguelensis*, *Coscinodiscus lentiginosus*, *Actinocyclus ingens*, *Coscinodiscus elliptopora*, *Denticula lauta*, *Denticula antarctica*, *Charcotia actinochilus*, *Hemidiscus karstenii*, *Coscinodiscus endoi*, *Pyrgupyxis prolongata*, *Hemiaulus polymorphus*, *Stephanopyxis superba*, and *Coscinodiscus vigilans*.

Samples 1-1, 126-128 cm through 1-2, 140-142 cm contain Eocene diatoms with no admixture of Neogene forms. Among the species observed in this interval are: *Pyrgupyxis prolongata*, *Hemiaulus polymorphus*, *Pterotheca carinifera*, *Pterotheca aculeifera*, *Stephanopyxis superba*, *Triceratium unguiculatum*, *Brightwellia pulchra*, *Goniothecium odontella*, and *Melosira architecturalis*.

The admixture of Eocene diatoms with Quaternary diatoms in the upper 80 cm of Section 1 may be due to slurring of sediment in the core upon recovery. If this is the case, then the possibility of a hiatus at about the 80-cm level in the core exists. Such a hiatus would correspond to a change in lithology at about the 80-cm level from diatom-rich silty clay to clay diatom ooze.

Diatoms are common to abundant and moderately well to well preserved through the core.

TABLE 5
Distribution of Diatom Species in the Neogene Section of Hole 328

Sample (Interval in cm)	Relative Abundance T R F C A	Preservation	*Coscinodiscus lentiginosus*	*Nitzschia kerguelensis*	*Charcotia actinochilus*	*Thalassiothrix* spp.	*Nitzschia angulata*	*Rhizosolenia styliformis*	*Eucampia balaustium* v. *minor*	*Thalassiosira gravida*	*Nitzschia cylindrus*	*Actinocyclus divisus*	*Coscinodiscus tabularis*	*Eucampia balaustium*	*Asteromphalus hookeri*	*Coscinodiscus furcatus*	*Navicula* sp.	*Ethmodiscus* "fragments"	*Nitzschia curta*	*Dicladia* spp.	*Actinoptychus splendens*	*Hemidiscus karstenii*	*Coscinodiscus nodulifer*	*Pseudoeunotia doliolus*	*Coscinodiscus endoi*	*Thalassiosira gracilis*	*Thalassiosira antarctica*	*Thalassiosira convexa*	*Asteromphalus parvulus*	*Nitzschia ritscherii*	*Coscinodiscus elliptopora*	*Actinocyclus ingens*	*Coscinodiscus vetustissimus*
1-1, 1-3		M	F	A	F	A	C	C	C	C	R	R	R	F	R															R			
1-1, 48-50		M	C	A	F	A	F	F	C	F	F	R	R	C	R				F											R			
1-1, 130-132		M	F	C	F	A	F	F	C	F	R	F		C	F	R			R											R			
1-1, 140-142		M	F	C	F	A	F	R	C	R	R			C			R	R	F											R			
1-2, 5-7		M	C	C	F	A	F	F	F	F	R		R	F		R			R	F	R	R								R			
1-2, 81-83		M	C	C	R	A	F	R	F	R	R		R	F	R				F	R		R	R	R	R	R				R			
1-3, 5-7		M	C	C	F	A	R	R	F	F	R	R		F	R	R			R				R			R	R			R			
1-3, 81-83		M	C	C	F	C	R	R	R		R	F	R	C	F				R								R	F	F	R		F	
1-4, 5-7		M	F	C	R	C	R		F			R		F	R			F	R										R	R	R	F	F
1-4, 79-81		M	F	C	R	C	R	R	F			R		F	R			F	R						R			R		R	R	R	R
1-5, 5-7		M	R	C	R	C		R	F			R	R	C				R	R											R	F	R	
1-5, 81-83		M	C	C	F	C			R			R	F	R	R			R	R						R						F	R	
1-5, 138-140		M	F	C	R	C	R	R					R	R				R	R		R				R					R	F	F	
2-1, 148-150		M	R	C		C	R	F		R			R	R					R			R			R							R	
2-2, 5-7		P-M	R			A	F					R		R	R				R			R					R						
2-2, 80-82		G-M				C	C						R						R														
2-3, 5-7		P-M				C	C	R				R							R														
2-3, 78-80		P				C	C					R		R					R	R													
2-3, 146-148		P				C		R						R					R														
2-4, 5-7		P				C		R				R		R					R			R			R								
2-4, 81-83		P				R		R						R					R						R		F						
2-5, 5-7		P				C		R											R														
2-5, 81-83		P				A		F																									
2-6, 5-7		P				C		R					R																				
2-6, 81-83		P				R		R																									
3-1, 5-7		P				A		R					R																			R	
3-1, 81-83		P				A		R					R																			A	
3-2, 87-89		P				A		C																								F	
3-2, 140-142		P				A		R																								A	
3-3, 5-7		P				A		R																								F	
3-3, 28-30		P				A																										C	
3-3, 140-142		VP				R																										A	
3-4, 5-7		VP																														C	
3-4, 81-83		P																														C	

Site 331 (Table 9)

Samples from the core catchers of Cores 1 and 2 were examined for this site. Diatoms are abundant and moderately well to well preserved in the samples examined.

A Quaternary age is suggested for these samples by the presence of *Nitzschia kerguelensis*, *Eucampia balaustium*, *Charcotia actinochilus*, *Coscinodiscus lentiginosus*, *Actinocyclus ingens*, and *Coscinodiscus elliptopora*.

All of the above-listed species are endemic to the Antarctic except *Actinocyclus ingens*. This suggests transportation of the diatom frustules to the site by current action, probably the Antarctic Bottom Water.

SOUTHERN OCEAN DIATOM BIOSTRATIGRAPHY

Neogene

Initial work in the field of Southern Ocean diatom biostratigraphy by Jousé et al. (1962), Donahue (1970), and Abbott (1972) dealt mainly with late Neogene stratigraphy of diatomaceous sediments recovered by piston cores in the Indian and Pacific sectors of the Southern Ocean. Recently McCollum (1975) proposed a diatom zonation based on drill core samples from Leg 28 of the Deep Sea Drilling Project in combination with USNS *Eltanin* (USARP) piston cores which were dated by paleomagnetics. This zonation encompasses the early Miocene through Recent, is correlated to the

TABLE 5 – *Continued*

Actinocyclus oculatus	*Thalassionema nitzschioides*	*Thalassiosira oestrupii*	*Rouxia californica*	*Coscinodiscus excentricus*	*Hemiaulus polymorphus*	*Coscinodiscus margaritaceous*	*Thalassiosira nordenskioldii*	*Cocconeis* sp.	*Cosmiodiscus insignis*	*Cosmiodiscus intersectus*	*Coscinodiscus kolbei*	*Nitzschia interfrigidaria*	*Coscinodiscus vulnificus*	*Actinocyclus ochotensis*	*Rouxia antarctica*	*Nitzschia clementia*	*Actinoptychus undulatus* s.l.	*Stephanopyxis turris*	*Aulacodiscus brownii*	*Coscinodiscus marginatus*	*Denticula antarctica*	*Rouxia heteropolara*	*Rouxia naviculoides*	*Hemidiscus cuneiformis*	*Bogorovia veniamini*	*Nitzschia praeinterfrigidaria*	*Raphoneis surirella*	*Rhizosolenia barboi*	*Xanthiopyxis oblongus*	*Nitzschia fossilis*	*Denticula hustedtii*	*Actinocyclus ellipticus*	*Rouxia yabei*	*Denticula lauta*	*Bruniopsis mirabilis*	*Nitzschia denticuloides*	*Denticula dimorpha*	*Denticula nicobarica*	*Pyrgupyxis prolongata*	*Synedra jouseana*	Age
R				R	F																																				
	R	R	F		F																																				
R	R		R	R	F	R	F																																		
	R		F		F		F	R	R																																
	R		R		R			R	F	R	F	R	C	F	F	R	R	F	R	R																					
	F	R							F		R	R	F	R				F		R																					Pliocene
	F			R								F						F		R	R	R	C	R																	
	C		F											R				R		F	R	R	R		R	C	R														
	C	R	F					R	R							C		R		R		C	R					R	R	R											
R	C		R																	F								R			R										
	C								R							R	R	R		R										R	R										
R	C		R						R							R				C			F	R			R	R			F	R									
	C		R														F			R			F	R				R			R		R	F							
	C								F											A			F					R			R		R	F							
	A								F											F			F			R				R	F	R		R	R						
	C	R				R											R			R			F	R		C								R							
R																				A			R								C			R							
	A	R	R																	R												R		R							
	R																			R											R			R		F	C				
																				R											R			A	R	R	A	F			
	R																			R														A		F	A	C			
	R																			R														R		F					
	F	R																																					R	R	

paleomagnetic time scale (Brunhes through Gilbert), and relies, in part, on diatom species indigenous to the Southern Ocean. Because of the coeval diffusion of planktonic diatoms by the clockwise movement of the Circumantarctic Current, this zonation is applicable in the Atlantic sector of the Southern Ocean and should be found applicable in other sectors of this ocean as well. McCollum's zonation (Figure 3) was used to date the Neogene diatomaceous sediments recovered on Leg 36.

A difficulty with McCollum's zonation involves the taxonomic position of two key stratigraphic indicators —*Nitzschia interfrigidaria* and *Nitzschia praeinterfrigidaria*. These two species are quite variable in morphology, therefore only those individuals which resembled McCollum's illustrations were assigned to one species or the other. Future taxonomic studies will hopefully clarify this problem (see Schrader, 1976).

Schrader (1976) has recently proposed a Neogene diatom zonation based on samples from DSDP Site 278 (Leg 29) in the Southern Emerald Basin (56°33.42'S, 160°04.29'E) between New Zealand and Antarctica. Schrader was able to use, unaltered, the zonation of McCollum (1975) for that portion of the section from Recent to the Miocene/Pliocene boundary. That portion of the section had previously been studied in Southern Ocean piston cores and is correlated to the paleomagnetic time scale. Schrader found the ranges of some key species in the Miocene at Site 278 to differ from those recorded by McCollum for the same species farther south at DSDP Leg 28 sites. Thus a new zonation, based mainly on species of *Denticula*, has been proposed which further resolves Miocene stratigraphy in the Southern Ocean. Of particular interest here is the refinement of the lower Miocene section by the establishment of six zones in the interval previously de-

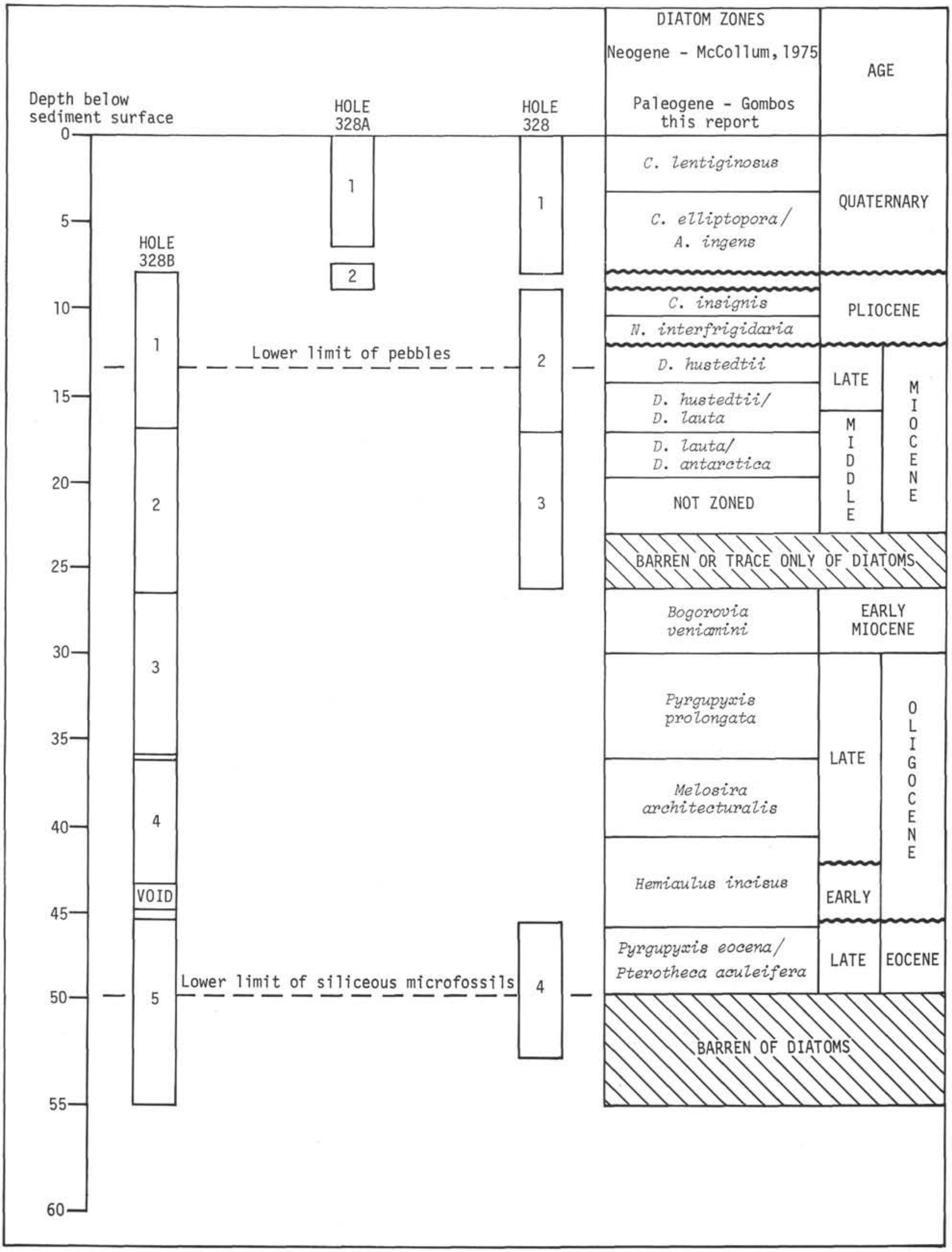


Figure 2. *Diatom biostratigraphy at Site 328. The Neogene at this site was zoned on the basis of the section recovered from Hole 328 by means of McCollum's (1975) Southern Ocean diatom zonation. The Neogene section from Hole 3288 was too badly disturbed for reliable zoning. Early Miocene and Paleogene diatom zones (this report) are based on Cores 3, 4, and 5, Hole 3288 and Core 4, Hole 328. No diatoms were observed below ~50 meters.*

fined by the *Denticula antarctica*, *D. nicobarica*, and *Coscinodiscus* sp. zones of McCollum. The *Coscinodiscus* sp. Zone was not defined by McCollum. It was established to represent "that portion of sediment below the *Denticula nicobarica* Zone to the Miocene/Oligocene boundary and is characterized by *Coscinodiscus* sp. 1." The Miocene/Oligocene boundary was not encountered in Leg 28 material. Schrader has been able to define this boundary as occurring at Site 278 at the top of the *Pyrgupyxis* (*Pyxilla*) species Zone (base of *Bogorovia veniamini* Zone).

Paleogene

Many Paleogene diatom species have been described over the past 100 or so years from such classic localities as those at Mors, Denmark; Barbados, West Indies; California, United States, and Oamaru, New Zealand. Early workers in search of new and rare diatom species from these and other localities compiled valuable reference works in which many Paleogene diatoms are described and illustrated (e.g., Greville 1861-1866; Grunow 1884; Grove and Sturt 1886-1887; Kitton 1870-1871; Schmidt's Atlas 1874-1959). Because of works such as these, we know the general characteristics of the diatom floras of Paleogene (especially early Eocene, late Eocene, and Oligocene) age. Unfortunately, most of the samples used by these workers were not documented in the modern sense, i.e., the exact location of the section from which the sample was collected, and the exact relationship of one sample to another vertically within the section was not precisely determined. As the emphasis at the time was on taxonomy and not biostratigraphy, this is understandable. Therefore, it has not been until fairly recent times that biostratigraphical studies of Paleogene diatoms have been undertaken. Following is a brief summary of some of these studies.

Kanaya (1957) carried out an investigation of the diatoms of the late Eocene Kellogg and Sidney shales near Mt. Diablo, California. Fifteen characteristic species were determined from the assemblages. These 15 species were found to comprise about 75% of the population of the assemblages. The compiled geologic ranges of these species and their previously reported occurrences at Mors, Barbados, Oamaru, and other localities in California are shown on a chart. The frequency of occurrence of seven species is compared statistically for each assemblage. Thirty-nine species are treated taxonomically. Kanaya proposed no zonation for the late Eocene.

Benda (1972) presented a preliminary report on his ongoing study of the lower Eocene diatom-bearing strata of the Moler Fm. in Denmark. A catalog of 90 species and varieties from the Moler Fm. is presented of which 37 species and varieties are restricted to the lower Eocene. Important marker species for the lower Eocene and species typical of the marine Paleogene are indicated. Gross comparisons of the Moler flora with those of other localities are made. Potential taxonomic problems are pointed out.

Jousé (1974) has proposed four diatom zones for the Oligocene in the tropical areas of the Pacific Ocean as a "preliminary approach" to the zonation of this interval. The zones correspond to the early, middle, and two parts of the late Oligocene. A late Eocene age is also indicated. The stratigraphic distribution of the species in this study was determined from a compiled section constructed from piston cores, DSDP drill cores, and outcrop samples from the Oceanic Fm. of Barbados, W.I. Discussions of the diatom assemblages in each zone and descriptions of new species are included.

Hajós (1976) has recently completed a study of late Eocene and Oligocene diatoms from Leg 29 sites southeast of Australia. This study shows the distribution of many species, including 19 new species in cores from that leg. Where possible the sediments were dated by means of associated fossil groups.

In the present study, diatoms of Paleocene, Eocene, and Oligocene age from Leg 36 sites on the Falkland Plateau and the Malvinas Outer Basin are investigated. Charts showing the vertical distribution of diatoms in the cored sections are presented, and several Paleogene diatom zones are proposed.

Proposed Paleogene Diatom Zonations

Paleogene sections rich in diatoms were recovered at Sites 327 and 328 on the Falkland Plateau and in the Malvinas Outer Basin, respectively.

A late Paleocene section was cored at Site 327. This section contains diatoms, radiolarians, and calcareous nannofossils. The presence of calcareous nannofossils in this section (Cores 5-8) allows for accurate placement of this interval in the late Paleocene. Wise and Wind (this volume) have placed these cores within the *Heliolithus universus* and *Fasciculithus involutus* zones. The boundary of the *H. universus* Zone with the *Discoaster multiradiatus* Zone is between Cores 4 and 5. Three diatom zones are proposed for this interval (Figure 4).

At Site 328 sediments containing portions of the late Eocene, early Oligocene, and late Oligocene were cored. No calcareous nannofossils were observed in these cores (Hole 328B, Cores 3-5; Hole 328, Core 4). One late Eocene zone, two late Oligocene zones, and one zone spanning the interval late Eocene-early Oligocene-late Oligocene are proposed (Figure 5). Definition and discussion of the proposed zones follow below.

DEFINITION OF PALEOCENE DIATOM ZONES (FIGURE 4)

Odontotropis klavsenii Range Zone

Definition: This zone is defined as the local range of *Odontotropis klavsenii* in the region of the Falkland Plateau.

Associated diatom species: *Pyrgupyxis prolongata*, *Stephanopyxis* cf. *simonseni*, *Sceptroneis* sp. A, *Synedra jouseana* v. B, *Triceratium aries*, *Hemiaulus incurvus*, *Trinacria simulacrum*, *Hemiaulus* sp. D.

Reference section: DSDP Leg 36, Hole 327A, Samples 7-2, 147-148 cm to 6-3, 109-111 cm.

Sceptroneis sp. A Partial Range Zone

Definition: The base of this zone is defined as the last occurrence of *Odontotropis klavsenii* and is coincident

TABLE 7
Distribution of Species in Hole 329

Sample (Interval in cm)	Abundance	Preservation	*Eucampia balaustium*	*Eucampia balaustium* v. *minor*	*Nitzschia kerguelensis*	*Coscinodiscus lentiginosus*	*Thalassiothrix* spp.	*Nitzschia angulata*	*Actinocyclus divisus*	*Thalassionema nitzschioides*	Genus et species indet. (D)	*Coscinodiscus endoi*	*Rouxia naviculoides*	*Cestodiscus* sp. 1 Schrader	*Thalassiosira antarctica*	*Coscinodiscus vulnificus*	*Coscinodiscus marginatus*	*Rouxia antarctica*	*Thalassiosira gracilis*	*Nitzschia interfrigidaria*	*Cosmiodiscus insignis*	*Denticula hustedtii*	*Nitzschia fossilis*	*Stephanopyxis turris*	*Rouxia californica*	*Rhizosolenia hebetata.* f *hiemalis*	*Thalassiosira burckliana*
1-1, 35-37	A	M	R	F	A	C	C	R	R	F	F	R	R	R													
1-2, 30-32	A	M			R	R	C	F		F	F	F	R	R	R	C	R	R	R	R	R						
1-3, 30-32	A	M		R			A			A	F		F				R				R	C	R	R	R		
1-4, 30-32	A	M					D			C	R		F				R		R		R		R				C
1-5, 22-24	A	M					A			F	R		R									R				C	A
1-6, 30-32	A	M					A		R	R			R					R				R	R		R		A
2-1, 113-115	A	M					A		R	R							R					C			R	C	
2-3, 30-32	A	M	R				A			F							R					C			R	C	
3-3, 30-32	A	M-P					A			C		R					R					C				C	
4-1, 30-32	A	M-P					C					R					C					C				C	
4-5, 30-32	A	P					A			C		R		R								C				C	
5-4, 30-32	A	P					A			C							R					C				C	
6-6, 30-32	A	P					D			C												C				F	
7-6, 30-32	A	P					D			C							R					C				C	
8-4, 30-32	A	P					C			R							R					R	R			C	
9-2, 40-42	A	P					C			F							R					C				C	
9-6, 80-82	A	P					A			R							C					C				C	
10-6, 30-32	A	P					C						R				R					C	R			C	
12-2, 30-32	A	P					A					F	R									C				C	
13-4, 55-57	A	P					C			C		C					C					C				C	
14-6, 30-32	A	P					D			C		F					F					C				C	
15-4, 30-32	A	P					C			C		R					R					C	R			C	
16-5, 30-32	A	P					C			C		F					R					C			R	F	
17-4, 30-32	A	P					D			C		R					R					C		R		R	
18-2, 30-32	A	P					C			C		R										C				F	
19-1, 60-62	A	P					A			C		C					R					F				C	
20-2, 30-32	A	P					A			C		C					R					C	R			F	
20-6, 30-32	A	P					C			C		C					R					C				C	
22-2, 30-32	A	P					A			C		C					F					C				R	
23-1, 113-116	A	P					C			F		F					C					R				R	
24-1, 138-140	A	P					C			R		R					R									R	
24-2, 24-26	A	P					C			F		F					R										
24-3, 22-24	A	P					C			R		R					R										
26-3, 25-27	A	P					C			C		F										F					
27-1, 11-13	A	M					C			C		F					F										
28, CC	C	P																									
29-1, 137-139	R	P															R										
30-1, 30-32	R	P															R										
30-2, 14-16	R	P															R										

with the top of the *Odontotropis klavsenii* Zone. The top of this zone is defined as the first occurrence of *Hemiaulus inaequilaterus* and is coincident with the base of the *Hemiaulus inaequilaterus* Zone.

Associated diatom species: *Pyrgupyxis prolongata*, *Stephanopyxis* cf. *simonseni*, *Sceptroneis* sp. A, *Hemiaulus incurvus*, *Triceratium aries*, *Trinacria simulacrum*, *Synedra jouseana* v. B.

Reference section: DSDP Leg 36, Hole 327A, Samples 6-2, 146-148 cm to 6-1, 102-103 cm.

Hemiaulus inaequilaterus Partial Range Zone

Definition: The base of this zone is defined as the first occurrence of *Hemiaulus inaequilaterus* and is coincident with the top of the *Sceptroneis* sp. A Zone. The top of this zone is not defined.

Associated diatom species: *Hemiaulus incurvus*, *Trinacria simulacrum*, *Stephanopyxis* cf. *simonseni*, *Hemiaulus* sp. D, *Triceratium* cf. *tessellatum*, *Stephanopyxis* sp. A, *Triceratium gracillium*, *Triceratium aries*, *Pyrgupyxis prolongata*.

TABLE 7 – *Continued*

Actinoptychus undulatus s.l.	*Nitzschia curta*	*Thalassiosira oestrupii*	*Nitzschia clementia*	*Denticula antarctica*	*Rhizosolenia styliformis*	*Denticula dimorpha*	*Melosira sulcata*	*Thalassiosira excentrica*	*Hemidiscus karstenii*	*Cosmiodiscus intersectus*	*Nitzschia praeinterfrigidaria*	*Denticula lauta*	*Synedra jouseana*	*Actinocyclus ingens*	*Ethmodiscus* "fragments"	*Thalassiosira nativa*	*Bogorovia veniamini*	*Actinocyclus ochotensis*	*Actinocyclus ellipticus*	*Actinocyclus oculatus*	*Rhizosolenia barboi*	*Actinocyclus cubitis*	*Coscinodiscus vigilans*	*Rouxia diplonoides*	*Bruniopsis mirabilis*	*Nitzschia denticuloides*	*Coscinodiscus nodulifer*	*Denticula nicobarica*	*Coscinodiscus lewisianus*	*Pyrgupyxis prolongata*	*Raphidodiscus marylandicus*	*Hemiaulus polymorphus*	*Xanthiopyxis oblongus*
R	R	R	R	R	R	R	R																										
	R	F					R	R	R	R																							
R	F		R						R		R																						
						F			R		R	R	R	R	F	F																	
				R							R	R			F	F																	
									R			R			F	C																	
		R										F			F	R																	
F				R	F										F	C	R		R														
					R	F						R		R	R	R				R													
					R							R			R	R		R		R													
				R	R				R			R				C					R												
																A					R												
R					R							R				F																	
						F						R	R	R	R	R																	
												F				C																	
					R	R						R		R		C					R	R	R										
												R				F					R												
				R								R		R							R			R									
F				R												R								R									
												R				R																	
												R				R																	
												R		R		R									R								
				R	F	R								C																			
					C	R						R		C																			
					F	R						R		C											R								
					C	F						R		C																			
					F	A						F		R																			
					F	C						C			C											C	R						
					R	C						C		R	C											C		R					
					R	C						C			C											C	C						
					R	C						C		F	R											C							
				C								C		F	F											F	R	F	R				
																															F		
														R	C															F		R	
																														R			R
															R															R			R

Reference section: DSDP Leg 36, Hole 327A, Samples 5-6, 119-121 cm to 5-1, 45-48 cm.

CORRELATION WITH CALCAREOUS NANNOFOSSIL ZONES (FIGURE 4)

Calcareous nannofossils occur with diatoms in Cores 5-8 in Hole 327A. This has allowed for reliable age determination of the diatom zones proposed above. Core 5, Sections 4, 5, 6 and Cores 6, 7, and 8 are in the *Fasciculithus involutus* Zone. Core 5, Sections 1, 2, and 3 are in the *Heliolithus universus* Zone. The *Heliolithus universus/Discoaster multiradiatus* boundary is between Cores 4 and 5. These zones are all late Paleocene in age (see Wise and Wind, this volume).

DEFINITION OF EOCENE AND OLIGOCENE DIATOM ZONES (FIGURE 5)

Pyrgupyxis eocena/Pterotheca aculeifera Concurrent Range Zone

Definition: The base of this zone is defined as the first occurrence of *Pyrgupyxis eocena*. The top of this

TABLE 8
Distribution of Species in Hole 330A

Sample (Interval in cm)	Abundance	Preservation	*Thalassiothrix* spp.	*Pyrgupyxis prolongata*	*Hemiaulus polymorphus*	*Ethmodiscus* "fragments"	*Stephanopyxis superba*	*Stephanopyxis turris*	*Nitzschia kerguelensis*	*Grammatophora* sp. A	*Denticula lauta*	*Raphoneis* sp. A	*Coscinodiscus elliptopora*	*Thalassionema nitzschioides*	*Actinocyclus ingens*	*Bogorovia veniamini*	*Hemidiscus karstenii*	*Denticula antarctica*	*Coscinodiscus endoi*	*Coscinodiscus vigilans*	*Coscinodiscus lentiginosus*	*Charcotia actinochilus*
1-1, 25-27	A	G	A	C	C	C	R	F	F	R	R	F	R	R	F	R	R	F	R	R	R	R
1-1, 77-78	A	G	F	C	A	F	F	R	R	R					R					R	R	
1-1, 126-128	A	G		A	A	A	R	C														
1-2, 11-13	A	G	R	A	C	C	F	C	R			F										
1-2, 66-68	A	G		A	A	A	R	F														
1-2, 140-142	A	G		C	A	C	F	C				F										
1, CC	A	G	F	A	A	C		C	F	F										R	R	
1, CC (>45 µ)	A	G	R	C	F	D	R															

Sample (Interval in cm)	*Actinoptychus undulatus* s.l.	*Stephanopyxis* cf. *grunowii*	*Stephanopyxis* cf. *schenckii*	*Stephanopyxis superba trispinosa*	*Triceratium unguiculatum*	*Goniothecium odontella*	*Melosira architecturalis*	*Stephanopyxis* sp. A	*Raphoneis* cf. *amphiceros* v. *elongata*	*Coscinodiscus marginatus*	Genus et species indet. (C)	*Pterotheca aculeifera*	*Pyrgupyxis* sp. B	*Stephanopyxis superba bispinosa*	*Raphoneis belgica*
1-1, 25-27															
1-1, 77-78	C	F	F	R	F	R	R	R	R	R					
1-1, 126-128	C	C	C		R	R	F	R	F		R	F	R	R	
1-2, 11-13	F	C	F		R		C	F		C		R			R
1-2, 66-68	F	F	F		R			F	F	F					F
1-2, 140-142	C	F	C		R		F	F	R	R	R	R			R
1, CC	C			R	R			C	R	F	R				
1, CC (>45 µ)			R		C			C		A	R		R		

Sample (Interval in cm)	*Hemiaulus* "artifacts"	*Stictodiscus californicus*	*Chaetoceros* sp. A	*Brightwellia pulchra*	*Pterotheca carinifera*	*Actinocyclus curvatulus*	*Stephanopyxis grunowii*	*Coscinodiscus* cf. *venutissimus*	*Hemiaulus incisus*	*Denticula dimorpha*	*Hemiaulus* cf. *altus*	*Pyrgupyxis eocena*	*Asterolampra vulgaris*	*Trinacria simulacrum*	*Rhizosolenia* sp. B	*Asterolampra insignis*
1-1, 25-27																
1-1, 77-78																
1-1, 126-128		R														
1-2, 11-13																
1-2, 66-68	R	R														
1-2, 140-142		R	R	R	R											
1, CC	R	R				R	R	F	R	R	R	R				
1, CC (>45 µ)				R		F							R	R	R	R

zone is defined as the last occurrence of *Pterotheca aculeifera* and is coincident with the base of the *Hemiaulus incisus* Zone.

Associated diatom species: *Stephanopyxis superba* v. *trispinosa*, *Pterotheca carinifera*, *Hemiaulus incisus*, *Trinacria simulacrum*, *Triceratium unguiculatum*, *Pyrgupyxis prolongata*, *Melosira architecturalis*.

Reference section: DSDP Leg 36, Hole 328B, Samples 5-3, 84-86 cm to 5-1, 147-149 cm.

Hemiaulus incisus Partial Range Zone

Definition: The base of this zone is defined as the last occurrence of *Pterotheca aculeifera* and is coincident with the top of the *Pyrgupyxis eocena*/*Pterotheca aculeifera* Zone. The top of this zone is defined as the last occurrence of *Stephanopyxis superba* v. *trispinosa* and is coincident with the base of the *Melosira architecturalis* Zone.

Associated diatom species: *Pyrgupyxis eocena*, *Stephanopyxis superba* v. *trispinosa*, *Pterotheca carinifera*, *Melosira architecturalis*, *Hemiaulus incisus*, *Trinacria simulacrum*, *Triceratium unguiculatum*, *Pyrgupyxis prolongata*.

Reference section: DSDP Leg 36, Hole 328B, Samples 4-5, 145-147 cm to 4-4, 5-7 cm.

Melosira architecturalis Partial Range Zone

Definition: The base of this zone is defined as the last occurrence of *Stephanopyxis superba* v. *trispinosa* and is coincident with the top of the *Hemiaulus incisus* Zone. The top of this zone is defined as the last occurrence of *Melosira architecturalis* and is coincident with the base of the *Pyrgupyxis prolongata* Zone.

Associated diatom species: *Pterotheca carinifera*, *Hemiaulus incisus*, *Trinacria simulacrum*, *Triceratium unguiculatum*, *Pyrgupyxis prolongata*, *Synedra jouseana* v. A, *Coscinodiscus vigilans*.

Reference section: DSDP Leg 36, Hole 328B, Samples 4-3, 145-147 cm to 4-1, 45-47 cm.

Pyrgupyxis prolongata Partial Range Zone

Definition: The base of this zone is defined as the last occurrence of *Melosira architecturalis* and is coincident with the top of the *Melosira architecturalis* Zone. The top of this zone is defined as the last occurrence of *Pyrgupyxis prolongata* and is coincident with the base of the *Bogorovia veniamini* Zone.

Associated diatom species: *Hemiaulus incisus*, *Trinacria simulacrum*, *Triceratium unguiculatum*, *Synedra jouseana* v. A, *Coscinodiscus vigilans*, *Bogorovia veniamini*.

Correlation with other diatom zonation: The top of this zone is correlative with the top of Schrader's (1976) *Pyrgupyxis* (*Pyxilla*) sp. zone.

Reference section: DSDP Leg 36, Hole 328B, Samples 3-6, 126-128 cm to 3-3, 5-7 cm.

Bogorovia veniamini Partial Range Zone

Definition: The base of this zone is defined as the last occurrence of *Pyrgupyxis prolongata* and is coincident with the top of the *Pyrgupyxis prolongata* Zone. The top of this zone is not defined.

TABLE 9
Distribution of Species in Hole 331

Sample	Sample Size Fraction	*Thalassiothrix* spp.	*Nitzschia kerguelensis*	*Eucampia balaustium*	*Eucampia balaustium* v. minor	*Charcotia actinochilus*	*Coscinodiscus lentiginosus*	*Actinocyclus divisus*	*Melosira sulcata*	*Thalassionema nitzschoides*	*Coscinodiscus endoi*	*Stephanopyxis turris*	*Hemiaulus polymorphus*	*Nitzschia curta*	*Pyrgupyxis prolongata*	*Asteromphalus hookeri*	*Actinoptychus splendens*	*Ethmodiscus* "fragments"	*Actinocyclus ingens*	*Coscinodiscus furcatus*	*Coscinodiscus elliptopora*	*Dicladia* spp.
1, CC	<45 μm	22	22	3	2	3	8	3	2	1	1	2	1	1	1							
1, CC	>45 μm	1				6	23	3	1							3	1	2	2	4	1	
2, CC	unsieved	36	16	1	1	12	6		1			1		1		1		3		3	11	1
2, CC	>45 μm	15				5	6	11								2		41	1	3	30	

Note: Numbers indicate the number of specimens observed during 8-10 traverses at 400X.

Associated diatom species: *Synedra jouseana* v. A, *Coscinodiscus vigilans*, *Bogorovia veniamini*.

Correlation with other diatom zonation: The base of this zone is correlative with the base of the *Bogorovia veniamini* Zone of Schrader (1976) and with the Oligocene/Miocene boundary as defined by Schrader (1976).

Reference section: DSDP Leg 36, Hole 328B, Samples 3-2, 70-72 cm to 3-1, 5-7 cm.

Discussion

The zones defined above are considered by the author to be tentative, pending future investigations and comparisons of other diatomaceous sediment cores and outcrop sections of Paleogene age. As the applicability of the zonations have not been tested outside the region of the Falkland Plateau and Malvinas Outer Basin, the zones should be labeled "local" dependent upon future studies.

Age determinations for the Paleogene sections used in this study were made, primarily, by means of associated microfossil groups other than diatoms. The late Paleocene age for Cores 5-8 in Hole 327A is given by calcareous nannofossils. The late Eocene and early and late Oligocene ages for Core 4, Hole 328 and Cores 3-5, Hole 328B are given by silicoflagellates and radiolarians. The late Oligocene/early Miocene boundary in Hole 328B was determined on the basis of diatoms.

Schrader (1976) in a study of the Neogene and late Oligocene diatoms in Hole 278, Leg 29, defined the Oligocene/Miocene boundary as occurring at the top of his *Pyxilla* species Zone. The top of this zone is defined by Schrader as the "extinction of *Pyxilla johnsoniana* and all *Pyxilla* species." The base of this zone is not defined. The top of the *Pyxilla* species Zone defines the base of Schrader's early Miocene *Bogorovia veniamini* Zone. Schrader's zones are tied into the calcareous nannofossil stratigraphy of Hole 278.

In the present study, the top of the *Pyrgupyxis prolongata* Zone (see Taxonomic Notes for discussion of *Pyrgupyxis* versus *Pyxilla*) is defined by the last occurrence of *P. prolongata*. This datum is also coincident with the last occurrence of all *Pyrgupyxis* species. The top of the *P. prolongata* Zone also defines the base of the *Bogorovia veniamini* Zone.

Thus, the top of the *Pyrgupyxis prolongata* Zone appears to be correlative with the top of Schrader's *Pyxilla* species Zone, and the Oligocene/Miocene boundary as defined by Schrader. The *Pyrgupyxis prolongata* Zone and the *Pyxilla* species Zone of Schrader are correlative to the uppermost part of the *Coscinodiscus vigilans-Craspedodiscus coscinodiscus* Zone of Jousé (1974) for the tropical region of the Pacific Ocean.

Schrader also correlates his *Pyxilla* species Zone with McCollum's (1975) *Pyxilla prolongata* Zone. McCollum defined this zone as "the local range of *Pyxilla prolongata*" in Hole 274, Leg 28 (68°59.81'S, 173°25.64'E; ~250 km north-northeast of Cape Adare, Antarctica). This zone was intended as a provisional zone to define the Oligocene in Hole 274. No detailed study of Oligocene diatom ranges was undertaken due to time restrictions (McCollum, personal communication). *Pyrgupyxis* (*Pyxilla*) *prolongata* has since been found to range at least from late Eocene through late Oligocene. Also, the interval defined by the range of *P. prolongata* in Hole 274 is lower Oligocene (Ciesielski, 1975, p. 645). Thus, the "top" of McCollum's *Pyxilla prolongata* Zone (sensu stricto) is not correlative with the top of Schrader's *Pyxilla* species Zone. Nor is McCollum's zone (sensu stricto) correlative with the *Pyrgupyxis prolongata* Zone of this report. However, McCollum's *Pyxilla prolongata* Zone (sensu lato) may correlate with Schrader's *Pyxilla* species Zone (sensu lato) since the base of the later zone is not defined. In light of the above, it is suggested that McCollum's *Pyxilla prolongata* be abrogated to avoid confusion and misinterpretation.

The *Hemiaulus incisus* Zone of this report spans the interval late Eocene-late Oligocene. This zone may be modified in the future.

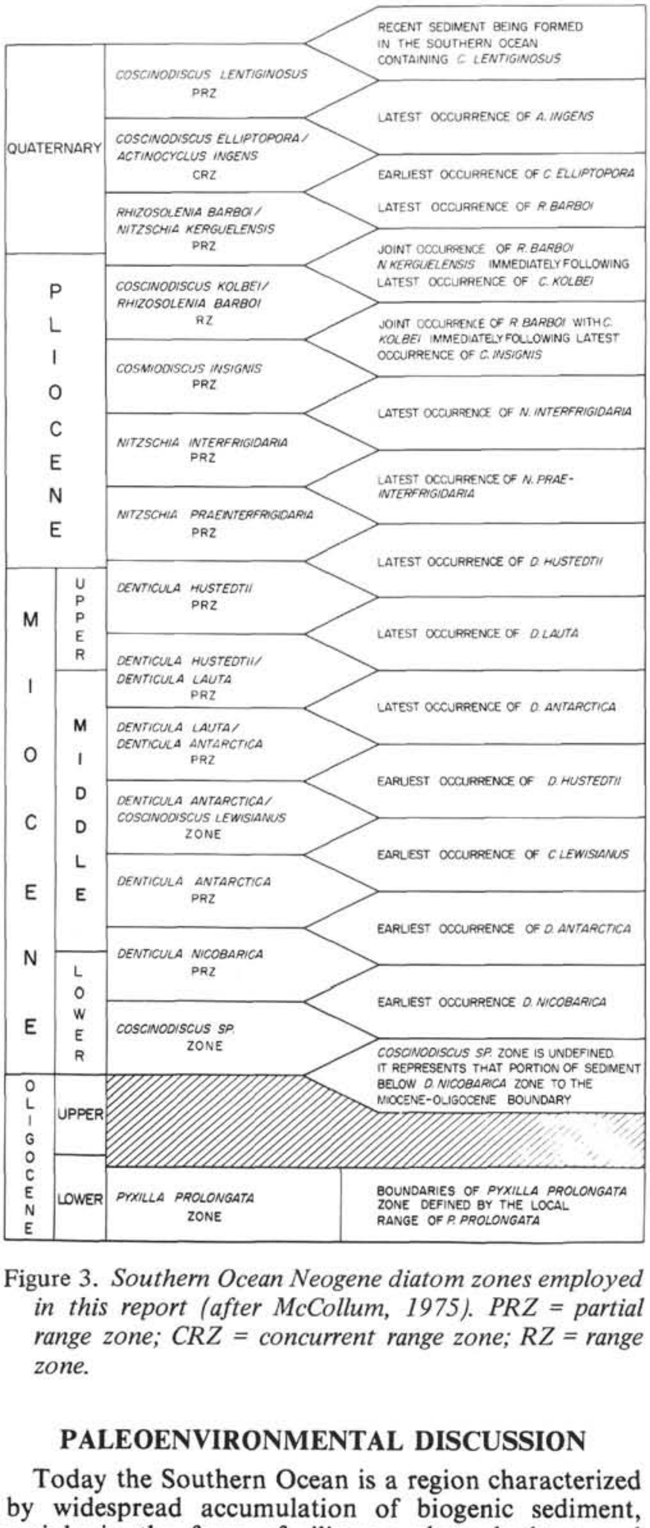


Figure 3. *Southern Ocean Neogene diatom zones employed in this report (after McCollum, 1975). PRZ = partial range zone; CRZ = concurrent range zone; RZ = range zone.*

PALEOENVIRONMENTAL DISCUSSION

Today the Southern Ocean is a region characterized by widespread accumulation of biogenic sediment, mainly in the form of siliceous phytoplankton and zooplankton (i.e., diatoms, silicoflagellates, radiolarians) tests. Accumulation of these sediments is greatest in the region roughly between the Antarctic Divergence and the Antarctic Convergence or Polar Front. The boundaries of the Polar Front zone are not regular and are known to fluctuate in time (Figure 6).

The explanation for the relatively increased rate of primary production in this region is the upwelling of nutrient-rich Circumpolar Deep Water (CPDW) at the Antarctic Divergence. This water, enriched in silica and other nutrients, is transported northwards at the surface over several degrees of latitude before it "dives" beneath the less dense Subantarctic Surface Water at the Antarctic Convergence. There is a change in sediment composition across this boundary from a predominately siliceous component south of the convergence to a predominately carbonate component north of the convergence. A transition zone of carbonate-siliceous ooze is often present separating the siliceous and carbonate facies (Frakes, 1975).

All Leg 36 sites, except Site 331, are located slightly north of the present-day northern boundary of the Polar Front Zone (Figure 6).

The thick (390 m) accumulation of middle and late Miocene nanno-diatom ooze at Site 329, characterized by sediment accumulation rates in excess of 30 m/m.y., may possibly reflect increased phytoplankton productivity in the vicinity of Site 329 at that time. Fairly continuous reworking of older diatoms, radiolarians, and coccoliths up the section further suggests that older sediments were being eroded by bottom currents flowing northward over the saddle on the Falkland Plateau and that these sediments were redeposited in the vicinity of Site 329.

A Neogene section was penetrated in Hole 328 in the Malvinas Outer Basin, east of the Falkland Plateau. This sequence includes middle and late Miocene, Pliocene, and Quaternary age sediments. Two biostratigraphic discontinuities were noted in this section. One between the Pliocene *Cosmiodiscus insignis* Zone and the Quaternary *Coscinodiscus lentiginosus/Actinocyclus ingens* Zone (Figure 2) may be partially or fully explained by a coring gap of about 1 meter between Cores 1 and 2. Another discontinuity occurs between the late Miocene *Denticula hustedtii* Zone and the Pliocene *Nitzschia interfrigidaria* Zone (Figure 2). This hiatus is roughly correlative with the first occurrence of ice-rafted pebbles in Core 2 (Figure 2) and may be the result of current activity associated with glaciation. Weaver (personal communication) also has noted the existence of a late Miocene/early Pliocene hiatus in a number of Southern Ocean piston cores.

At Site 331 in the Argentine Basin two near-surface cores were recovered. These contained a considerable number of Antarctic diatom species. Principally these include: *Coscinodiscus lentiginosus*, *Charcotia actinochilus*, *Coscinodiscus elliptopora*, *Nitzschia kerguelensis*, and *Eucampia balaustium*. The presence of indigenous Antarctic diatoms at Site 331 indicates that the frustules were transported to the site by the Antarctic Bottom Water as suggested by Burckle (1974).

In general the Neogene diatoms of Leg 36 suggest normal pelagic sedimentation. Sporadic occurrences of benthonic diatoms were noted in the cores indicating transport of these forms to the sites by currents.

The Eocene and Oligocene thanatocoenosis encountered at Site 328 in the Malvinas Outer Basin is characterized by an appreciable variety of species. These are generally abundant and well preserved suggesting rather favorable conditions of growth and

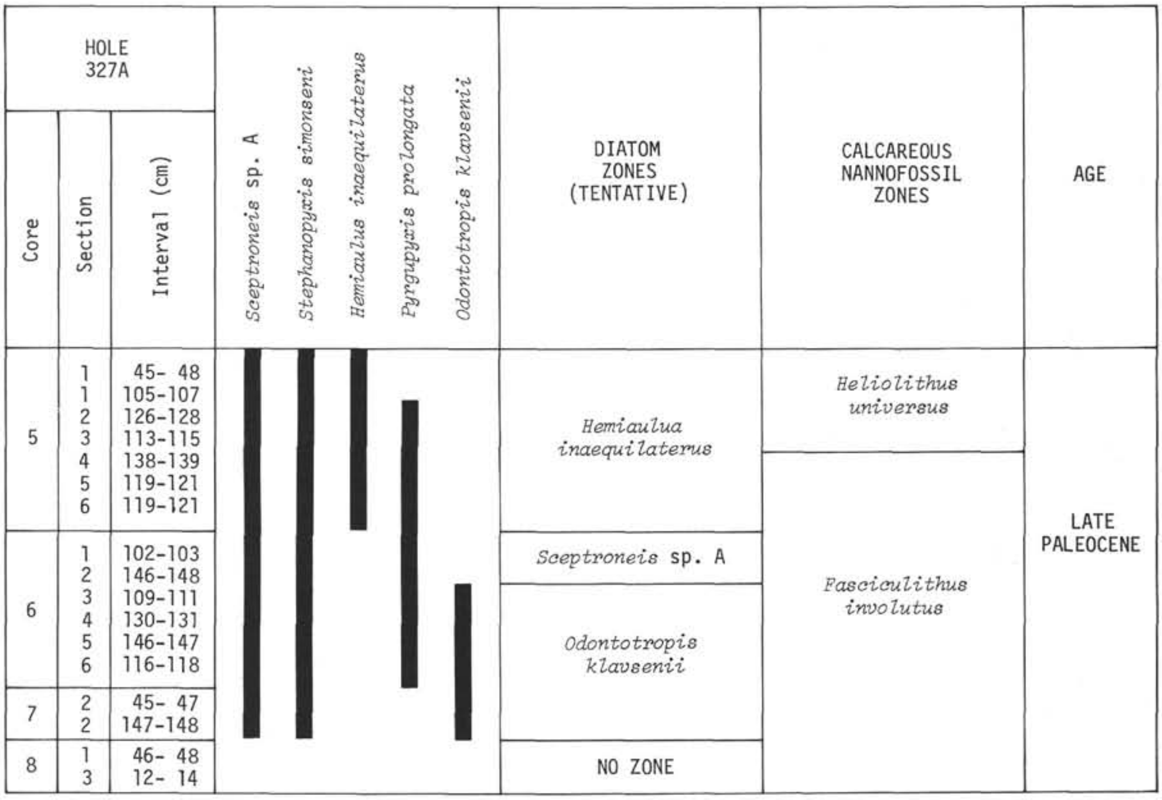


Figure 4. *Paleocene diatom zones defined in this report showing ranges of key and selected species and correlation with calcareous nannofossil zones. Reference section: DSDP Leg 36, Hole 327A, Falkland Plateau.*

preservation. Abundance and quality of preservation declines in Hole 328B, Core 5 where zeolites become dominant (Table 6). In this core, robust forms such as *Hemiaulus*, *Stephanopyxis*, *Trinacria*, *Pyrgupyxis*, and *Pterotheca* show the greatest resistance to diagenetic alteration associated with zeolite formation, and thus the samples appear artificially enriched in species of these genera.

Many of the species occurring in the Eocene and Oligocene are now extinct. This makes determination of paleoenvironmental conditions by analogy with extant species difficult. Examination of the literature reveals that the genera which dominate the Eocene-Oligocene assemblages from Leg 36 are also among the dominant genera in diatomaceous sediments of equivalent age in various parts of the world, for example: South Tasman Basin (Hajos, 1976); New Zealand (Grove and Sturt, 1866-1867); California (Kanaya, 1957); Barbados (Greville, 1861-1866); Tropical Pacific Ocean (Jousé, 1974). Such an equable distribution of characteristically dominant genera, and in many instances species (e.g., *Stephanopyxis superba*, *Trinacria simulacrum*, *Pyrgupyxis prolongata*, *Triceratium unguiculatum*, *Hemiaulus polymorphus*, etc), apparently derives from the fact that the Eocene was an epoch of rather mild worldwide climatic conditions. The temperate regions were during that time greatly expanded poleward. Therefore, it may be assumed that the Eocene diatom assemblage at Site 328 reflects temperate conditions. The Oligocene assemblage at Site 328 does not differ significantly from the Eocene assemblage until latest Oligocene suggesting that conditions similar to those prevailing during the Eocene persisted into the Oligocene.

Paleocene diatoms are insufficiently known to permit precise paleoenvironmental conclusions to be drawn at this time. However, judging from the calcareous nannofossil assemblage, it seems safe to assume that temperate conditions prevailed at Site 327 during the late Paleocene (see Wise and Wind, this volume). Precise paleotemperature estimates of these and other siliceous microfossil assemblages will only be possible by isotopic studies.

SUMMARY

Sites originally planned for the Scotia Sea and Drake Passage had to be abandoned due to terrible weather. A revised drilling schedule was devised which included sites on the Falkland Plateau and in the Malvinas Outer Basin as well as the originally planned Argentine Basin site. Six sites were occupied, four of which were successful. Diatomaceous sediments were encountered at all sites except Site 326 off Cape Horn. A Neogene section including sediments of middle Miocene to Recent age was penetrated at Site 328. At the same site a Paleogene section of late Eocene-late Oligocene age diatomaceous sediments was penetrated. A thick middle-upper Miocene sequence was penetrated at Site

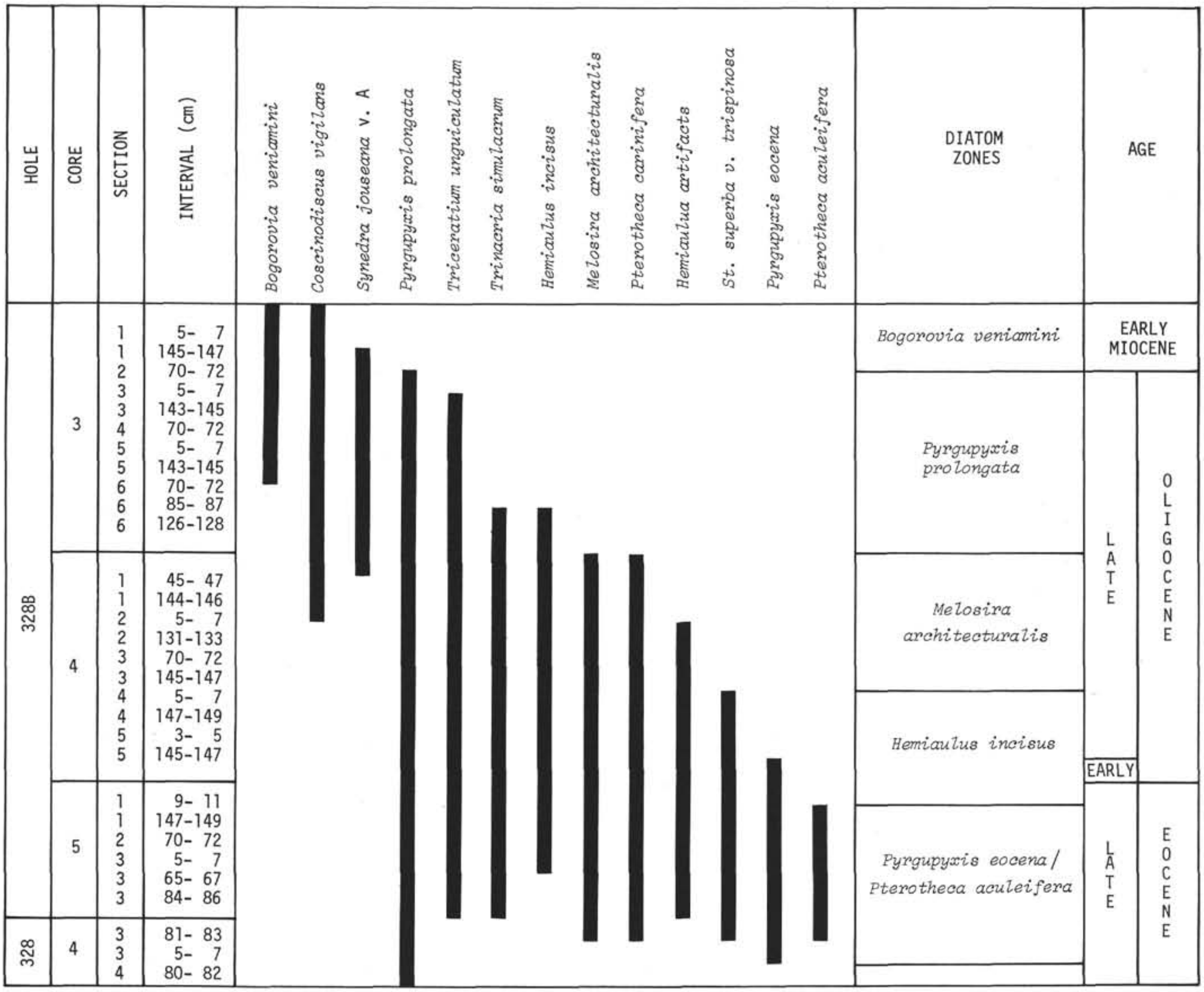


Figure 5. *Eocene and Oligocene diatom zones defined in this report showing ranges of key and selected species. Reference section: DSDP Leg 36, Site 328, Malvinas Outer Basin*

329. This sequence reflects considerable reworking of diatoms and other microfossils probably due to deposition by bottom currents flowing northwards over the Falkland Plateau. An upper Paleocene section, dated by calcareous nannofossils, was penetrated at Site 327. A diatom assemblage rich in Antarctic species was encountered in a near-surface core at Site 331 in the Argentine Basin. Presumably these diatoms were wafted to the site by Antarctic Bottom Water currents.

Three late Paleocene zones, four late Eocene-late Oligocene zones, and one early Miocene zone are proposed on the basis of diatoms.

Diatom assemblages suggest temperate conditions for the late Paleocene and late Eocene-late Oligocene at Sites 327 and 328.

FLORAL REFERENCES AND TAXONOMIC NOTES

In the following section the original reference to the species is given. Additional references which illustrate or describe the species or which are more readily accessible than the original reference are sometimes given. Notes and comments are made where appropriate.

The following list is not complete. Future studies will undoubtedly add to it. For the present study an attempt has been made to include the most characteristic forms. The list of Paleogene diatoms, especially, will most likely be augmented and altered as more workers become involved with diatoms of this period. As a point of future reference, Tables 10 and 11 are included which list the diatoms restricted to the late Paleocene and late Eocene at Sites 327 and 328, respectively.

Type material will be deposited at the United States National Museum, Washington, D.C.

Genus ACTINOCYCLUS Ehrenberg (1837)

Actinocyclus cubitis Hanna and Grant (1926)
(No Illustration)

Description: Hanna and Grant (1926), p. 118, pl. 11, fig. 3.

Actinocyclus divisus (Grunow) Hustedt (1958)
(No Illustration)

Description: Hustedt (1958), p. 129-130, pl. 8, fig. 81.

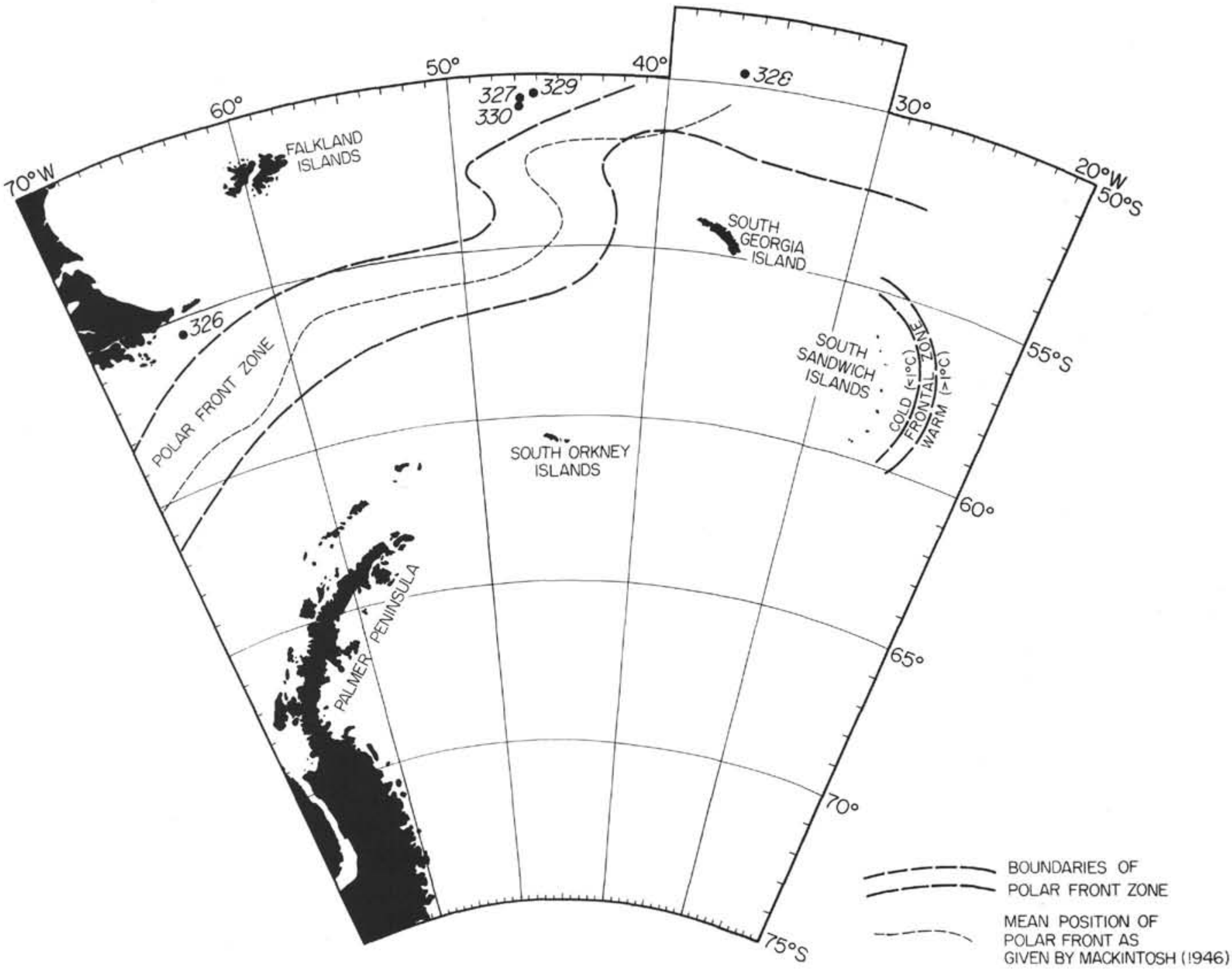


Figure 6. *Position of the Antarctic Polar Front Zone in relation to DSDP Sites 326, 327, 328, 329, and 330. After Gordon (1967).*

TABLE 10
Species Restricted to Late Paleocene at Site 327

Hemiaulus altus
Hemiaulus inaequilaterus
Hemiaulus incurvus
Hemiaulus cf. *subacutus*
Odontotropis klavsenii
Sceptroneis cf. *caduceus*
Sceptroneis grunowii
Sceptroneis sp. A
Sceptroneis sp. B
Stephanopyxis simonseni
Synedra jouseana v. B
Triceratium aries
Triceratium oracillium
Triceratium cf. *tessellatum*
Trinacria simulacrum

Actinocyclus ellipticus Grunow in Van Heurck (1881)
(No Illustration)

Description: Hustedt (1930), p. 533, fig. 303.

Discussion: This species was observed rarely in the middle and late Miocene at Site 328. Schrader (1976) reports it "in trace abundance in

TABLE 11
Species Restricted to Late Eocene at Site 328

Brightwellia pulchra
Hemiaulus disimilis
Hemiaulus sp. A
Hemiaulus sp. C
Pseudorutilaria monile
Pterotheca aculeifera
Pterotheca sp. A
Pyrgupyxis johnsoniana
Stephanopyxis superba v. *bispinosa*
Stephanopyxis sp. A
Triceratium crenulatum

Miocene sediments" from Leg 35 and McCollum (1975) finds it rarely in early and middle Miocene sediments from Leg 28.

Actinocyclus ingens s.l. Rattray (1891)
(No Illustration)

Description: Kanaya (1971), p. 554, pl. 40.6, fig. 1-8. Koizumi (1968), p. 207-208, pl. 32, fig. 5, 6.

Discussion: A wide range in valve morphology has been noted for this species (Kanaya, 1971; Koizumi, 1968, 1973; McCollum, 1975).

This variation which ranges from a small, flat form to a larger undulating form is well illustrated by Kanaya's (1971) series of photographs referenced above. Koizumi (1973) was not able to separate these forms into two different taxa because of the continuous transition of form from one extreme to the other.

McCollum (1975) noted that the "large undulated forms tend to be found in Pliocene material while the smaller, flat forms are found to a greater extent in Miocene sediments." In the present material the opposite appears to be the case, with the larger undulating forms found lower in the section than the smaller flat forms.

Schrader (1976) places the small flat forms in a separate category.

Actinocyclus ochotensis Jousé (1968)
(No Illustration)

Description: Jousé (1968), p. 17, pl. 2, fig. 2-5; Donahue (1970), p. 135, pl. 2, fig. 2-5.

Actinocyclus oculatus Jousé (1968)
(No Illustration)

Description: Jousé (1968), p. 18, pl. 2, fig. 6, 7; Donahue (1970), p. 135, pl. 2, fig. 6, 7.

Genus ACTINOPTYCHUS Ehrenberg (1839)

Actinoptychus splendens (Shadbolt 1854) Ralfs in Pritchard (1861)
(No Illustration)

Description: Ralfs *in* Pritchard (1861), p. 840.
Discussion: Several 12-sector forms were noted in the present material.

Actinoptychus undulatus s.l. (Bailey) Ralfs in Pritchard (1861)
(Plate 26, Figures 1-3)

Discussion: Specimens close to *A. undulatus* have been collectively placed in this species. I follow Schrader (1976) in this matter who says: "it also seems to be impossible at present to define the range and taxonomic position of specific types within this 'group taxon'."

Genus ARACHNOIDISCUS Deane *in* Pritchard (1852)

Arachnoidiscus ehrenbergii Bailey in Ehrenberg (1849)
(Plate 6, Figure 1; Plate 26, Figure 4)

Description: Bailey *in* Ehrenberg (1849), p. 63-64.

Genus ASTEROLAMPRA Ehrenberg (1845)

Asterolampra insignis Schmidt (1886)
(Plate 25, Figures 2, 4)

Description: Schmidt's Atlas, pl. 137, fig. 1-3.

Asterolampra vulgaris Greville (1862)
(Plate 25, Figures 1, 3, 5)

Description: Greville (1862), p. 47, pl. 7, 8, fig. 17-25.

Genus ASTEROMPHALUS Ehrenberg (1844)

Asteromphalus hookeri Ehrenberg (1844)
(No Illustration)

Description: Hustedt (1958), p. 127, pl. 8, fig. 88-90.

Asteromphalus parvulus Karsten (1905)
(No Illustration)

Description: Karsten (1905), p. 90, pl. 8, fig. 14; Hustedt (1958), p. 128, pl. 8, fig. 91.

Genus AULACODISCUS Ehrenberg (1844)

Aulacodiscus brownii Norman (?)
(No Illustration)

Description: Long, Fuge, and Smith (1946), p. 97, pl. 14, fig. 12.

Genus BRIGHTWELLIA Ralfs *in* Pritchard (1861)

Brightwellia pulchra Grunow (1883)
(Plate 27, Figures 3, 4)

Description: Grunow *in* Van Heurck (1880-1885), pl. 128, fig. 9; Hanna and Brigger (1964), p. 8, pl. 2, fig. 2.

Genus BRUNIOPSIS Karsten (1928)

Bruniopsis mirabilis (Brun) Karsten (1928)
(Plate 6, Figure 4)

Description: Kolbe (1954), p. 24, pl. 4, fig. 44.
Discussion: This species was observed rarely in the Neogene sections of Leg 36, and then only as readily recognizable fragments.

Genus CESTODISCUS Greville (1865)

Cestodiscus sp. 1 Schrader (1976)
(No Illustration)

Reference: Schrader (1976), p. 51, pl. 12, fig. 6.

Genus CHAETOCEROS Ehrenberg (1844)

Representatives of this genus were observed with some regularity in the present material. Spores (*Dicladia*), spines, and sometimes complete frustules were encountered. Two forms are illustrated.

Chaetoceros sp. A
(Plate 24, Figures 1-6)

Discussion: Figure 6 appears to be the *Xanthiopyxis panduraeformis* of Pantocsek (1886, p. 43, pl. 29, fig. 297) from Hungary and/or the *Xanthiopyxis panduraeformis* v. *soleiformis* of Forti (1913, p. 18, pl. 2, fig. 2, 4). Figures 4 and 5 show the apparent transition of *C.* sp. A into *X. panduraeformis*. Figures 1 and 2 are scanning electron micrographs and Figure 3 is a light micrograph of *C.* sp. A. This form was noted as *X. panduraeformis* from the late Eocene of Leg 29 by Hajos (1976), p. 25, pl. 11, fig. 6 and by McCollum (1975, no illustration) from the lower Oligocene of Leg 28.

Chaetoceros sp. 8
(Plate 6, Figure 2)

Discussion: Compare with *C. furcellatus* Bailey illustrated in Proschkina-Lavrenko (1974), pl. 58, fig. 3.

Genus CHARCOTIA Peragallo (1921)

Charcotia actinochilus (Ehr.) Hustedt (1958)
(Plate 1, Figure 8)

Description: Hustedt (1958), p. 122-126, pl. 7, fig. 57-80.
Discussion: This diatom is indicative of extreme polar (icefront) conditions. According to Kozlova (1964), the northern limit of this species' distribution in plankton and sediment is the Antarctic Divergence Zone, however, isolated finds north of this zone have been reported. Thus this species is a good indicator of prevailing conditions at the time and place of deposition.

Genus COCCONEIS Ehrenberg (1838)

Cocconeis sp.
(Plate 5, Figures 6, 7)

Discussion: Found sporadically in the Neogene sections.

Genus COSCINODISCUS Ehrenberg (1838)

Coscinodiscus elliptopora Donahue (1970)
(Plate 3, Figures 1-3, 6; Plate 9, Figure 3)

Description: Donahue (1970), p. 201, pl. 4, fig. 3, i-m.
Discussion: This distinctive species shows some variation in the degree of ellipticity of the pores. This is illustrated on Plate 3.

Coscinodiscus endoi Kanaya (1959)
(Plate 2, Figures 6, 7; Plate 5, Figure 3)

Description: Kanaya (1959), p. 76, 77, pl. 3, fig. 8-11; Koizumi (1968), p. 211, pl. 32, fig. 21, 22.

Coscinodiscus furcatus Karsten (1905)
(No Illustration)

Description: Hustedt (1958), p. 113, 114, pl. 3, fig. 18, 19, pl. 5, fig. 39.

Coscinodiscus kolbei Jousé (1962)
(Plate 6, Figure 3)

Description: Donahue (1970), p. 202, pl. 5, fig. A-C.

Coscinodiscus lentiginosus Janisch in Schmidt (1878)
(Plate 3, Figures 4, 5)

Description: Hustedt (1958), p. 116, pl. 4, fig. 22-25.
Discussion: Under low power this diatom often appears purple or brilliant blue in color. This property is useful in rapidly locating this zonal indicator of McCollum.

Coscinodiscus lewisianus Greville (1866)
(No Illustration)

Description: Greville (1866), p. 78, pl. 8, fig. 8-10; Kanaya (1971), p. 555, pl. 40.5, fig. 4-6.

Coscinodiscus margaritaceous Castracane (1886)
(No Illustration)

Description: Castracane (1886), p. 164, pl. 18, fig. 13.

Coscinodiscus marginatus Ehrenberg (1841)
(Plate 5, Figure 5)

Description: Hustedt (1930), p. 416-418, fig. 223.

Coscinodiscus nodulifer Schmidt (1878)
(No Illustration)

Description: Hustedt (1930), p. 426-427, fig. 229.

Coscinodiscus tabularis Grunow (1884)
(No Illustration)

Description: Hustedt (1930), p. 427, fig. 230a; Hustedt (1958), p. 119, fig. 48-56.

Coscinodiscus vetustissimus Pantocsek (1903)
(Plate 27, Figure 2)

Description: Hustedt (1930), p. 412, fig. 220.

Coscinodiscus vigilans Schmidt (1888)
(Plate 40, Figures 5, 6)

Description: Kolbe (1954), p. 36, pl. 1, fig. 13, 14.
Discussion: See Bukry, this volume.

Coscinodiscus vulnificus n. sp. Gombos
(Plate 4, Figures 1-3; Plate 42, Figures 1, 2)

Synonym: *Coscinodiscus* sp. 2 McCollum.
Illustration: McCollum (1975), pl. 8, fig. 1, 2.
Description: Valve circular; diameter 22 to 62 μm, average diameter of 68 specimens 37 μm. Valve surface covered with circular areolae of uniform diameter (0.80 μm) arranged in radial rows, some rows longer than others; 7 areolae in 10 μm. Valve surface pierced by from 2 to 11 (commonly 3) larger areolae of about twice the diameter of the smaller ones.
Holotype: Plate 42, Figures 1, 2; DSDP Sample 328-2-1, 148-150 cm. USNM No. 237337, Cat. No. 36.
Type locality: DSDP Leg 36, Site 328, Malvinas Outer Basin, lat 49°48.67'S, long 36°39.53'W.

Genus COSMIODISCUS Greville (1866)

Schrader (1976) retains this genus even though Van Landingham (1969) has combined it with the genera *Coscinodiscus* e.p. and *Stephanodiscus* e.p. I will follow Schrader in this matter and retain the genus even though it is in need of revision.

Cosmiodiscus insignis Jousé (1961)
(Plate 4, Figures 4, 5)

Description: Jousé (1961), p. 67, pl. 2, fig. 8; Koizumi (1973), p. 832, pl. 4, fig. 7-11.
Discussion: Frequently, the only evidence for this diatom in the sediment is the central hyaline area, the outer parts of the valve often being dissolved or broken away.

Cosmiodiscus intersectus (Brun) Jousé (1961)
(No Illustration)

Description: Jousé (1961), p. 68, pl. 2, fig. 9, 10; Koizumi (1973), p. 832, pl. 4, fig. 12, 13.

Genus CRASPEDODISCUS Ehrenberg (1844)

Craspedodiscus molleri Schmidt (1893)
(Plate 27, Figure 6)

Description: Schmidt's Atlas, pl. 184, fig. 3.

Genus BOGOROVIA Jousé (1974)

Bogorovia veniamini Jousé (1974)
(Plate 1, Figures 6, 7; Plate 12, Figures 1, 2, 4)

Description: Jousé (1974), p. 351, pl. 4, fig. 1-3.

Genus DENTICULA Kutzing (1844)

Denticula antarctica McCollum (1975)
(Plate 12, Figures 9, 10)

Description: McCollum (1975), p. 527, pl. 8, fig. 6-10.
Discussion: Forms illustrated in this paper are not typical; forms such as those illustrated by McCollum (1975, e.g. fig. 6) are more abundant. For further discussion of this species see Schrader (1976).

Denticula dimorpha Schrader (1973)
(Plate 8, Figure 11)

Description: Schrader (1973), p. 704, pl. 1, fig. 37-46.

Denticula hustedtii Simonsen and Kanaya (1961)
(Plate 8, Figures 1-3)

Description: Simonsen and Kanaya (1961), p. 501, pl. 1, fig. 19-25.

Denticula lauta Bailey (1954)
(Plate 8, Figures 6, 7, 12)

Description: Simonsen and Kanaya (1961), p. 500-501, pl. 1, fig. 1-8.

Denticula nicobarica Grunow (1868)
(Plate 8, Figure 8)

Description: Simonsen and Kanaya (1961), p. 503, pl. 1, fig. 11-13.

Genus ETHMODISCUS Castracane (1886)

Ethmodiscus rex (Rattray) Hendey and Wiseman (1953)
(No Illustration)

Description: Hendey and Wiseman (1953), p. 51-57, pl. 1, fig. 1-6; pl. 2, fig. 1-3.
Discussion: Complete valves were not observed in any of the samples examined, though large fragments of the outer parts of the valves were sometimes quite common. Therefore, following the convention of Schrader (1976), all *Ethmodiscus* fragments have been collectively placed in the species *E. rex*.

Genus EUCAMPIA Ehrenberg (1886)

Eucampia balaustium Castracane (1886)
(Plate 1, Figures 1, 2; Plate 11)

Description: Castracane (1886), p. 97, pl. 18, fig. 5.
Discussion: This species is common in late Neogene sediments of the Southern Ocean. It generally occurs in subordinate numbers in

the plankton, but appears enriched, relative to many other forms, in the sediment due to its heavily silicified frustules (Kozlova, 1964; Schrader et al., 1976).

This species is distributed from near the Antarctic Continent to north of the Antarctic Convergence. Kozlova (1964) says that its northern distributional limit is the Antarctic Convergence. Abbott (1972) however, reports this species to be abundant in the Subantarctic zone between Australia and Antarctica. Schrader et al. (1976) in an important study of the plankton diatoms collected in the Southeast Pacific off Chile and in the Bellingshausen Sea have shown that this species is indeed not limited to waters south of the convergence. *E. balaustium* was found to have its greatest abundance in the open ocean between 63° and 56°S latitude in the Southeast Pacific. Gombos (1974a) proposed that the abundance of this species in sediment cores could be useful in tracing movements of the ice front. In light of Schrader et al.'s data cited above this assumption is not valid as *E. balaustium* reaches its maximum abundance independent of ice association.

Genus EUNOTIA Ehrenberg (1837)

Eunotia cf. monodon Ehrenberg (1841)
(Plate 40, Figure 9)

Description: Ehrenberg (1841), pl. 2, fig. 5; pl. 3, fig. 3. Schmidt's Atlas, pl. 381, fig. 3-6.
Discussion: Only one specimen observed.

Genus GONIOTHECIUM Ehrenberg (1844)

Goniothecium odontella Ehrenberg (1844)
(Plate 40, Figure 1)

Description: Jousé (1951), p. 60, pl. 5, fig. 1-7; Hajos (1976), p. 34, pl. 17, fig. 13; pl. 25, fig. 1, 2.

Genus GRAMMATOPHORA Ehrenberg (1839)

Grammatophora sp.
(Plate 14, Figure 9)

Genus HEMIAULUS Ehrenberg (1884)

Diatoms belonging to this genus are among the most characteristic forms encountered in the Paleogene sections drilled on the Falkland Plateau and in the Malvinas Outer Basin (Sites 327 and 328). The abundant and diverse occurrence of members of this genus suggest that they may be useful in biostratigraphic correlation.

Hemiaulus altus Hajos (1975)
(Plate 20, Figures 3, 4)

Description: Hajos (1975), p. 931, pl. 5, fig. 17-19.
Discussion: Hajos reports this species from the Late Cretaceous of Site 275 on the Southeast Campbell Plateau. In the present investigation it was observed to occur in the late Paleocene of Site 327 on the Falkland Plateau.

Hemiaulus ambiguus Janisch
(Plate 17, Figure 4)

Description: Schmidt's Atlas, pl. 142, fig. 18.

Hemiaulus "artifacts"
(Plate 15, Figures 4-6)

Description: Schmidt's Atlas, pl. 142, fig. 12. Hajos (1976), p. 31, pl. 15, fig. 10.
Discussion: This unique form was observed in the late Eocene and early Oligocene of Site 328 on the Falkland Plateau; Hajos observed it in the late Eocene at Site 283 in the Central Tasman Sea; Schmidt mentions that it was observed in material from Mors, Denmark (early Eocene). Many examples of this form were observed in the present material. A wide range of variation was observed, not only in terms of dimension, but also in terms of ornamentation. Forms varying from completely hyaline to forms with partial aerolation to forms which are recognizable as more conventional *Hemiaulus* with strongly developed horns were observed. They may be remnants or artifacts of dissolution. I therefore refrain from calling them by a specific name until a more complete study is made of their structure and affinities.

Hemiaulus claviger Weissfl.
(Plate 15, Figure 7)

Description: Schmidt's Atlas, pl. 143, fig. 6.

Hemiaulus dissimilis Grove and Sturt (1887)
(Plate 19, Figure 4)

Description: Grove and Sturt (1887), p. 143, pl. 13, fig. 43.

Hemiaulus elegans Heiberg
(Plate 19, Figure 6)

Description: Schmidt's Atlas, pl. 143, fig. 52-55 (as *Corinna elegans*).

Hemiaulus inaequilaterus n. sp. Gombos
(Plate 20, Figures 5-7)

Derivation of name: *Inaequilaterus* (Latin) = with unequal sides.
Diagnosis: A *Hemiaulus* with long horns of unequal thicknesses. Horns sometimes straight, sometimes gently curved; thicker horn about twice the diameter of the thinner one and tipped with a hyaline process. Of the many specimens of this species observed, all were found to have the thinner horn broken off, often close to the base, thus the terminal nature of this horn was not discernible directly. However, fragmentary *Hemiaulus* horns, presumably derived from *H. inaequilaterus*, were sometimes observed in the same samples. These show hyaline processes at their tips.
Dimensions of type: Length of thicker horn, 70 μm; length of thinner (broken) horn, 46 μm. Diameter of valve (long axis) 43 μm.
Holotype: Prep. 327A-5-1, 45-48 cm, Slide No. 1; USNM No. 237338, Cat. No. 36. Plate 20, Figure 5.
Type locality: DSDP Leg 36, Hole 327A, lat 50°52.38'S, long 46°47.02'W.
Age: Late Paleocene.

Hemiaulus incisus Hajos (1976)
(Plate 15, Figure 3)

Description: Hajos (1976), p. 31, pl. 23, fig. 4-9.
Discussion: McCollum (1975) observed this species in Leg 28 material and referred to it as *Hemiaulus* sp. 1. It is similar to *H. kittoni* Grunow in Schmidt's Atlas, pl. 142, fig. 2-8.

Hemiaulus incurvus Schibkova (1959)
(Plate 16, Figures 6, 7; Plate 17, Figures 1-3)

Description: Krotov and Schibkova (1959), p. 124, pl. 4, fig. 8.
Discussion: A very distinctive diatom observed in the Paleocene of Site 327. Krotov and Schibkova report it from the lower Eocene of the Irbit area, Middle Urals.

Hemiaulus polycystinorum Ehrenberg (1854)
(Plate 18, Figure 5)

Description: Ehrenberg (1854), p. 36, fig. 43; Hanna (1957), p. 104, pl. 7, fig. 12-15.

Hemiaulus polymorphus Grunow (1884)
(Plate 18, Figures 1-4)

Description: Grunow 1884, p. 66; Grove and Sturt 1887, pt. II, p. 11; Hanna, 1927, p. 20-21, pl. 2, fig. 9, 10.
Discussion: A very common species in the Paleogene material from Leg 36. Grove and Sturt (1887) say that "forms of this, varying considerably in appearance are numerous" in the Oamaru deposits.

Hemiaulus subacutus Grunow
(Plate 17, Figures 5-8)

Description: Illustrated in Proschkina-Lavrenko et al. (1974), pl. 36, fig. 10.
Discussion: Forms resembling the one illustrated in Proschkina-Lavrenko et al. (1974) are tentatively assigned to this species.

Hemiaulus sp. A
(Plate 19, Figures 1, 2)

Hemiaulus sp. B
(Plate 19, Figure 3)

Hemiaulus sp. C
(Plate 19, Figure 5)

Hemiaulus sp. D
(Plate 20, Figures 1, 2)

Discussion: This form closely resembles *Hemiaulus* sp. 5 of Schrader (1976) and is similar to *Hemiaulus altus* Hajos, though the valve is not quite as high as in that species.

Genus HEMIDISCUS Wallich (1860)

Hemidiscus cuneiformis Wallich (1860)
(No Illustration)

Description: Hustedt (1930), p. 904-907, fig. 542.

Hemidiscus karstenii Jousé (1962)
(Plate 4, Figure 8)

Description: Abbott (1972), p. 110-112, pl. 1, fig. D-F; Schrader (1976) p. 71, pl. 14, fig. 2.

Genus MELOSIRA Agardh (1824)

Melosira architecturalis Brun (1892)
(Plate 26, Figures 5-7)

Description: Brun (1892); *in* Schmidt's Atlas (1874-1959), pl. 177, fig. 49, 50.
Synonym: *Cyclotella hannae* Kanaya (1957), p. 82-84, pl. 3, fig. 10a, b, 11-14.

Melosira sulcata (Ehrenberg) Kutzing (1844)
(No Illustration)

Description: Hustedt (1930), p. 276-278, fig. 118-120.

Genus NITZSCHIA Hassal (1854)

Nitzschia angulata Hasle (1972)
(Plate 8, Figure 16)

Synonyms: *Diatoma rhombica* O'Meara (1877), p. 55, pl. 1, fig. 2; *Fragilariopsis rhombica* (O'Meara) Hustedt (1952), p. 296, fig. 6, 7.
Description: Hasle (1965), p. 24-26, pl. 1, fig. 6; pl. 4, fig. 19; pl. 6, fig. 5; pl. 8, fig. 11; pl. 9, fig. 1-6; pl. 10, fig. 2-6.

Nitzschia clementia Gombos n. sp.
(Plate 8, Figures 18, 19)

Derivation of name: From the euphonic Latin word *clementis*.
Diagnosis and description: Valve claviform, heteropolar, with one apex blunt, rounded, opposite apex tapered to an acute, rounded tip. Length (apical axis) 35-75 μm (length of holotype 72 μm); width (transapical axis) 6-8 μm (width of holotype 8 μm) at widest point; width at narrow tip 2 μm. Transapical costae 5-6 in 5 μm. Costae straight in middle portion of valve, curved towards wider apex, straight or slightly curved towards narrow apex. In elongate specimens sides parallel for short distance in wide part of valve, in smaller specimens sides sometimes convex.
Holotype: Prep. 328-2-3, 78-80 cm. Marked with diamond stylus. (Plate 8, Figure 18). USNM No. 237339, Cat. No. 36.
Type locality: DSDP Hole 328; lat 49°48.67′S, long 36°39.53′W (Falkland Plateau).
Age: Late Miocene-Pliocene.

Nitzschia curta (Van Heurck) Hasle (1972)
(No Illustration)

Description: Hustedt (1958), p. 160-161, pl. 11, fig. 140-144, pl. 12, fig. 159.

Nitzschia cylindrica Burckle (1972)
(Plate 7, Figures 4, 5)

Description: Burckle (1972), p. 239-240, pl. 2, fig. 1-6.

Nitzschia cylindrus (Grunow) Hasle (1972)
(No Illustration)

Description: Hasle (1965), p. 34-37, pl. 12, fig. 6-12; pl. 14, fig. 1-10; pl. 17, fig. 2-4.

Nitzschia denticuloides Schrader (1976)
(Plate 13, Figures 9-11)

Description: Schrader (1976), pl. 3, fig. 7, 8, 10, 12, 18-24; pl. 15, fig. 22.
Discussion: Forms similar to Schrader's fig. 8, 10, and 12 (Schrader pl. 3) are the most common in the present material.

Nitzschia cf. efferans Schrader (1976)
(Plate 7, Figure 6)

Description: Schrader (1976), pl. 2, fig. 1, 3, 5-7.

Nitzschia fossilis (Frenguelli) emend. Kanaya in Kanaya and Koizumi (1970)
(Plate 8, Figure 17)

Description: Schrader (1973), p. 707, pl. 4, fig. 9-11, 24, 25.

Nitzschia interfrigidaria McCollum (1975) sensu lato
(Plate 7, Figure 3)

Description: McCollum (1975), p. 535, pl. 9, fig. 7-9.
Discussion: The taxonomic position of this species needs clarification, see Schrader (1976).

Nitzschia kerguelensis (O'Meara) Hasle (1972)
(Plate 8, Figures 13, 14)

Description: Hasle (1968), p. 205-208, fig. 1, 2, 7-9.

Nitzschia pliocena (Brun) Wornardt (1967)
(Plate 8, Figure 15)

Description: Brun (1891), p. 28, pl. 14, fig. 7; Wornardt (1967), p. 88, fig. 212, 213.

Nitzschia praeinterfrigidaria McCollum (1975)
(Plate 7, Figures 1, 2)

Description: McCollum (1975), p. 535, pl. 10, fig. 1.
Discussion: See Schrader (1976).

Nitzschia ritscherii (Hustedt) Hasle (1972)
(No Illustration)

Description: Hasle (1965), p. 20-21, pl. 1, fig. 20; pl. 3, fig. 3; pl. 4, fig. 1-10; pl. 5, fig. 12, 13; pl. 6, fig. 1; pl. 7, fig. 8.

Nitzschia sp. A
(Plate 7, Figures 7, 8)

Nitzschia sp. B
(Plate 7, Figure 9)

Genus ODONTOTROPIS Grunow (1884)

Odontotropis klavensii Debes ex Hustedt
(Plate 39, Figures 1-4)

Illustration: Hustedt (1930), p. 858, fig. 510a; Benda (1972), pl. 4, fig. 26.

Genus PSEUDOEUNOTIA Grunow in Van Heurck (1880)

Pseudoeunotia doliolus (Wallich) Grunow in Van Heurck (1880)
(No Illustration)

Description: Hustedt (1959), p. 258-260.
Discussion: This is an equatorial/tropical species. It was observed to be very rare in Core 1, Hole 328 and may be the result of contamination.

Genus PSEUDORUTILARIA Grove and Sturt (1886)

Pseudorutilaria monile Grove and Sturt (1886)
(Plate 40, Figure 7)

Description: Grove and Sturt (1886), p. 324, pl. 18, fig. 7.
Discussion: Very rare in the present material. A good guide for late Eocene.

Genus PTEROTHECA (Grunow) Forti (1909)

Pterotheca aculeifera Grunow (1880)
(Plate 23, Figures 1, 2)

Description: Van Heurck (1896), p. 430, fig. 151; Kanaya (1957), p. 109, pl. 8, fig. 1, 2.

Pterotheca carinifera Grunow (1880)
(No Illustration)

Description: Grunow *in* Van Heurck (1880-1885), pl. 83, fig. 5, 6; Hanna (1927), p. 119, pl. 20, fig. 9, 10.

Pterotheca danica Grunow (1880)
(Plate 23, Figure 5)

Description: Grunow *in* Van Heurck (1880-1885), pl. 83, fig. 7, 8; Hanna (1927), p. 119, pl. 83, fig. 7, 8.

Pterotheca sp. A
(Plate 23, Figures 3, 4)

Genus PYRGUPYXIS Hendey (1969)

Members of this genus are perhaps the most characteristic diatoms of the Eocene and Oligocene sections drilled by Leg 36. They are virtually absent from Leg 36 Paleocene sediments.

Pyrgupyxis eocena Hendey (1969)
(Plate 22, Figures 6, 7)

Description: Hendey (1969), p. 3, fig. 1-4.

Pyrgupyxis johnsoniana (Greville) Hendey (1969)
(Plate 22, Figure 8)

Description: Greville (1865), p. 2, pl. 1, fig. 6.

Pyrgupyxis johnsoniana (Greville) Hendey v. corniculum (Brun) Hendey
(Plate 21, Figures 8-10)

Description: Brun (1893-1896), p. 243, pl. 19, fig. 12, 13.

Pyrgupyxis prolongata (Brun) Hendey (1969)
(Plate 21, Figures 1-7; Plate 22, Figure 11)

Description: Brun (1890-1893), p. 176, pl. 24, fig. 7.

Pyrgupyxis reticulata (Grove and Sturt) Hendey (1969)
(Plate 22, Figures 4, 5)

Description: Grove and Sturt (1887), p. 145, pl. 13, fig. 50.
Discussion: McCollum (1975) suggests that this species is only a portion of *P. johnsoniana* and should be synonymous with the same.

Pyrgupyxis sp. A
(Plate 22, Figures 1, 2)

Discussion: This diatom is similar in form to *P. johnsoniana* v. *corniculum* but is of a less robust structure.

Pyrgupyxis sp. B
(Plate 21, Figure 11; Plate 22, Figures 9, 10)

Discussion: This diatom differs from *P. prolongata* in that it has a more inflated, less elongate base, and from *P. johnsoniana* v. *corniculum* in that the stem rises abruptly from the basal funnellike structure, whereas in that variety the stem rises in a gradual taper from the edges of the funnel.

Taxonomic Note

The genus *Pyrgupyxis* established by Hendey (1969) includes several species previously included in the genus *Pyxilla* Greville. The following species, previously included in *Pyxilla* are referred to *Pyrgupyxis* in this report: *P. johnsoniana*, *P. johnsoniana* v. *corniculum*, *P. prolongata*, and *P. reticulata*.

Genus RAPHIDODISCUS Smith (1887)

Raphidodiscus marylandicus Christian (1887)
(No Illustration)

Description: Andrews (1974), p. 233-235, pl. 1-5.

Discussion: Andrews (1974, p. 241) states: "*Raphidodiscus marylandicus* has a worldwide distribution in marine rocks of Miocene age. It appears to be restricted to deposits of the uppermost part of the Burdigalian Stage and the lower part of the Helvetian (Langhian) Stage—in other words, latest Early Miocene to early Middle Miocene in age. Because of its restricted stratigraphic range, its widespread distribution, and its distinctive morphology, *R. marylandicus* should be useful as a guide fossil in marine Miocene strata."

Schrader (1976) has extended the range of this species higher into the middle Miocene section at DSDP Site 278. In the present material *R. marylandicus* was observed only in the core catcher of Core 28, Site 329.

Genus RHAPHONEIS Ehrenberg (1844)

Rhaphoneis cf. amphiceros Ehrenberg v. elongata Peragallo (1901)
(Plate 14, Figure 5)

Description: Peragallo (1897-1908), pl. 83, fig. 10; Schrader (1969), p. 24, pl. 8, fig. 3.

Rhaphoneis aff. belgica Grunow
(Plate 14, Figures 1-4, 6).

Description: Van Heurck (1896), p. 330, pl. 10, fig. 396.

Rhaphoneis sp. A
(Plate 14, Figure 8)

Rhaphoneis sp. B
(Plate 14, Figure 7)

Discussion: This species somewhat resembles *R. elliptica* Jousé (1951) from the Paleocene in the Urals.

Genus RHIZOSOLENIA Ehrenberg (1841)

Rhizosolenia barboi Brun (1894)
(No Illustration)

Description: Donahue (1970), p. 136, pl. 1, fig. B-C (as *R. curvirostris* v. *inermes*).

Rhizosolenia hebetata (Bail.) Gran forma hiemalis Gran (1904)
(No Illustration)

Description: Hustedt (1930), p. 590-592, fig. 337.

Rhizosolenia styliformis Brightwell (1858)
(No Illustration)

Description: Hustedt (1930), p. 584-588, fig. 333-335.

Rhizosolenia sp. A
(Plate 23, Figure 6)

Discussion: This diatom occurs sporadically through the Eocene and Oligocene of Site 328.

Rhizosolenia sp. B
(Plate 23, Figure 7)

Discussion: This diatom is similar to *R. curvirostris* Jousé, and to *R. interposita* Hajos (1976). Hajos found only apical extensions of *R. interposita* in Oligocene material from Leg 29.

Genus ROUXIA Brun and Heribaud (1893)

Rouxia antarctica Heiden and Kolbe (1928)
(Plate 7, Figure 12)

Description: Heiden and Kolbe (1928), p. 632, pl. 4, fig. 90

Rouxia californica Peragallo in Tempere and Peragallo (1910)
(Plate 7, Figure 13)

Description: Hanna (1930), p. 186-188, pl. 14, fig. 6, 7.

Rouxia diploneides Schrader (1973)
(No Illustration)

Description: Schrader (1973), p. 710, pl. 3, fig. 27-32.

Rouxia heteropolara Gombos (1974b)
(Plate 7, Figures 14, 15)

Description: Gombos (1974b), p. 275, fig. 1.

Rouxia naviculoides Schrader (1973)
(Plate 7, Figures 10, 11)

Description: Schrader (1973), p. 710, pl. 3, fig. 27-32.

Rouxia peragalli Brun and Heribaud (1893)
(No Illustration)

Description: Hanna (1930), p. 180-184, pl. 14, fig. 1, 5.

Rouxia yabei Hanna (1930)
(No Illustration)

Description: Hanna (1930), p. 185, pl. 15, fig. 2-4.

Genus SCEPTRONEIS Ehrenberg (1844)

Sceptroneis caduceus Ehrenberg (1844)
(Plate 13, Figures 1, 2)

Description: Van Heurck (1896), p. 332, pl. 10, fig. 399.

Sceptroneis sp. A
(Plate 13, Figure 6)

Sceptroneis sp. B
(Plate 13, Figures 7, 8)

Sceptroneis sp. C
(Plate 13, Figures 3, 4)

Discussion: This form is similar to *S. grunowii* as illustrated by Jousé (1951), pl. 4, fig. 8.

Genus STEPHANOPYXIS Ehrenberg (1844)

Members of this genus (along with those of *Pyrgupyxis* and *Hemiaulus*) are perhaps the most characteristic forms in the diatomaceous Paleogene sediments from the Falkland Plateau and the Malvinas Outer Basin. This is also true of the deposits at Oamaru, New Zealand. Grove and Sturt (1886-1887, pt. III, p. 70-71) list a number of *Stephanopyxis* species, and then in a note state "the above list by no means exhausts the numerous forms belonging to *Stephanopyxis* in this deposit." Hajos (1976) in her report on the late Eocene and early Oligocene diatoms from Leg 29, lists 16 species for this genus, 6 of them new. Schrader (1976) places all members of this genus in the "group species" *Stephanopyxis turris*.

Schrader (1976) feels that species in this genus can be satisfactorily separated on the basis of marginal areas and spine arrangement and, further, that this genus must be reviewed before the various species can be applied to stratigraphic problems.

The author concurs with Schrader's views in this matter. The many forms of *Stephanopyxis* were found to be confusing and in need of review. However, several species were found to be well enough defined and illustrated to at least permit an attempt at systematic treatment in this report.

Stephanopyxis eocaenica Hajos (1975)
(Plate 31, Figures 3, 4)

Description: Hajos (1976), p. 15, pl. 4, fig. 3, 4.

Stephanopyxis grunowii Grove and Sturt (1888)
(Plate 28, Figures 3-5; Plate 31, Figures 1, 2, 7;
Plate 32, Figures 1-3)

Description: Schmidt's Atlas, pl. 130, fig. 1-6; Hanna (1927), p. 33, pl. 4, fig. 12.

Discussion: According to Hanna (1927, p. 34) this species "is probably the most common diatom in the Moreno (California) Cretaceous deposit. It did not reach the huge size that it did during the Monterey Miocene in California but otherwise it does not appear to differ to any noteworthy extent. The development of spines is very erratic, the specimen figured (by Hanna) being without, but in others they are as large and variable in number and size as Schmidt has shown" (I count 12 spines on Schmidt's fig 4).

Stephanopyxis hyalomarginata Hajos (1976)
Plate 30, Figure 7; Plate 31, Figure 4)

Description: Hajos (1976), p. 16, pl. 19, fig. 11, 12.

Discussion: Figure 7 on Plate 30 shows 4 spines, whereas Hajos says the number varies from 11 to 18; the variations in this species must be studied further.

Stephanopyxis cf. schenckii Kanaya (1959)
(Plate 28, Figure 6)

Description: Kanaya (1959), p. 67, pl. 2, fig. 2-4.

Stephanopyxis cf. simonseni Hajos (1974)
(Plate 27, Figure 5)

Description: Hajos (1974), p. 926, pl. 2, figs. 7, 8.

Discussion: The diatom illustrated most closely resembles *St. simonseni* Hajos from the Cretaceous of Leg 29 and is common to rare in the Paleocene of Hole 327A.

Stephanopyxis superba (Greville) Grunow (1884)
(Plate 29, Figures 1-4)

Description: Grunow (1884), p. 91; Greville (1865), v. 9, p. 68, pl. 8, fig. 3-5, as *Creswellia superba*; Schmidt's Atals, pl. 123, fig. 3-8; Hajos (1975), p. 926, pl. 2, fig. 11, 12.

Discussion: A statement of Greville's original description seems appropriate here; "Valves hemispherical, depressed, with a broadly expanded hyaline margin; areolation large; connecting processes robust, spine like, situated nearer to the margin than the apex." In his discussion of this species, Greville says that the average specimen has 6 to 8 spines, but examples with 4 or 5 and up to 19 are known. Greville (1865, v. 13, p. 44, pl. 5, fig. 3) describes *Coscinodiscus splendidus* thusly: "Disc large, convex; cellules large, hexagonal, all equal except those of the outer row, which are generally more or less oblong; the margin is quite smooth." In his discussion Greville says, "*Coscinodiscus splendidus* is exceedingly similar in general appearance to *Cresswellia* (i.e., *Stephanopyxis*) *superba*; so similar, indeed, that if the spines of the latter happen to be out of focus, the one might be readily taken for the other. But a closer examination shows that, apart from the spines, the irregularity of the outer row of cellules is characteristic of the *Coscinodiscus* as also the much narrower margin."

Stephanopyxis superba (Greville) Grunow v. bispinosa n.v. Gombos
(Plate 30, Figures 1, 2, 8)

Description: Like the species, but with only 2 long spines which in girdle view have the appearance of the horned helmet associated with the Vikings. Length of spines (holotype) 24 μm, diameter 27 μm.

Holotype: Plate 30, Figure 8. Sample 328B-4-2, 131-133 cm. USNM. No. 23734, Cat. No. 36.

Type locality: DSDP Leg 36, Hole 328B, lat 49°48.67'S, long 36°39.53'W. Malvinas Outer Basin.

Stephanopyxis superba (Greville) Grunow v. trispinosa n.v. Gombos
(Plate 30, Figures 3-6, 9)

Description: Like the species, but with 3 spines. Diameter of valve 18-50 μm. Diameter of holotype 30 μm, width of hyaline margin 4 μm. Common in Paleogene of Hole 328.

Holotype: Plate 30, Figures 3 and 4. Sample 328-4-1, 147-149 cm. USNM No. 237341, Cat. No. 36.

Type locality: DSDP Leg 36, Site 328, lat 49°48.67'S, long 36°39.53'W. Malvinas Outer Basin.

Stephanopyxis turris (Grev. and Arn.) Ralfs in Pritchard (1861)
(Plate 2, Figure 5)

Description: Hustedt (1930), p. 304-307, fig. 140-144.

Discussion: All *Stephanopyxis*' from the Neogene intervals were grouped into this species as it proved difficult to consistently separate the various species of this genus described from the Miocene and time was not available to devote to this problem.

Stephanopyxis sp. A
(Plate 28, Figures 1-2)

Discussion: This form occurs consistently through the Eocene and Oligocene sections of Hole 328B.

Stephanopyxis ? sp.
(Plate 27, Figure 1)

Discussion: This rather distinct form occurs sporadically in the Eocene and Oligocene of 328B. Its occurrence is not noted on the range charts.

Genus STICTODISCUS Greville (1861)

Stictodiscus californicus v. nitida Grove and Sturt (1887)
(Plate 25, Figures 6, 7)

Description: Grove and Sturt (1886-1887), v. 3, p. 66, pl. 5, fig. 7. Synonym: *Stictodiscus nitidus* Grove and Sturt (1888), *in* Schmidt's Atlas pl. 131, fig. 7, 8; pl. 202, fig. 4, 5; pl. 451, fig. 5-7.

Genus SYNEDRA Ehrenberg (1830)

Synedra jouseana Sheshukova-Poretskaya (1962)
(Plate 12, Figure 7)

Description: Schrader (1973), p. 710, pl. 23, fig. 21-23, 25, 38.

Synedra jouseana v. A
(Plate 12, Figure 6)

Decription: This variety differs from the species in that there is no swelling in the middle of the valve, the sides are nearly parallel.

Synedra jouseana v. B
(Plate 12, Figure 5)

Genus THALASSIONEMA Grunow (1881)

Thalassionema nitzschoides Grunow in Van Heurck (1881)
(No Illustration)

Description: Hustedt (1959), p. 244-246, fig. 725.

Genus THALASSIOSIRA Cleve (1873)

Thalassiosira antarctica Comber (1896)
(No Illustration)

Description: Hustedt (1958), p. 108, pl. 3, fig. 1-3.

Thalassiosira antiqua (Grunow) Cleve
(No Illustration)

Description: Cleve-Euler (1941), p. 173, fig. 4, 5; Koizumi (1968), p. 218, pl. 35, fig. 11.

Thalassiosira cf. burckliana Schrader (1974)
(Plate 5, Figure 4)

Description: Schrader (1974), p. 916, pl. 1, fig. 21, 23, 24-26.
Discussion: This forms resembles *Th. burckliana* of Schrader except for the larger diameter; specimens measured from the present material range from 26 to 64 μm in diameter.

Thalassiosira convexa Muchina (1965)
(No Illustration)

Description: Donahue (1970), p. 136-137, pl. 3, fig. a-f; Schrader (1973), p. 712, pl. 11, fig. 37-38.

Thalassiosira excentrica (Ehrenberg) Cleve (1903)
(No Illustration)

Description: Sheshukova-Poretskaya (1967), p. 141-142, pl. 14, fig. 4.

Thalassiosira gracilis (Karsten) Hustedt (1958)
(No Illustration)

Description: Hustedt (1958), p. 109, pl. 3, fig. 4-7.

Thalassiosira gravida Cleve (1896)
(No Illustration)

Description: Hustedt (1930), p. 325-326, fig. 161.

Thalassiosira nativa Sheshukova-Poretzkaya (1964)
(No Illustration)

Description: Sheshukova-Poretzkaya (1967), p. 145, pl. 14, fig. 7.

Thalassiosira nordenskioldii Cleve (1873)
(Plate 4, Figures 6, 7)

Description: Hustedt (1930), p. 321-322, fig. 157.

Thalassiosira oestrupii (Ostenfeld) Proskina-Lavrenko (1956)
(Plate 5, Figures 1, 2)

Description: Hustedt (1930), p. 318, fig. 155; Koizumi (1973), p. 834, pl. 7, fig. 27.

Genus THALASSIOTHRIX Cleve and Grunow (1880)

No attempt has been made to treat this group systematically. On the range charts, members of this genus are indicated as *Thalassiothrix* spp.

Genus TRICERATIUM Ehrenberg (1841)

This genus is in need of review. The following list is not complete.

Triceratium (Trig.?) cf. abyssorum Grunow
(Plate 37, Figure 5)

Description: Schmidt's Atlas pl. 471, fig. 9-12.

Triceratium crenulatum Grove and Sturt (1886-1887)
(Plate 38, Figure 2)

Description: Grove and Sturt (1886-1887), pt. II, p. 7, pl. 2, fig. 3; Schmidt's Atlas, pl. 128, fig. 20, 21.
Discussion: Grove and Sturt say this species is "frequent" in the Oamaru deposit. It is rare in the present material.

Triceratium gracillium Hustedt (1959)
(Plate 38, Figure 5)

Description: In Schmidt's Atlas, pl. 467, fig. 18, 19.

Triceratium pulvinar Schmidt (1888)
(Plate 33, Figure 2)

Description: Schmidt (1888) Atlas, pl. 126, fig. 8.
Discussion: See under *Triceratium unguiculatum.*

Triceratium cf. tessellatum Greville (1861)
(Plate 37, Figures 1, 2)

Description: Greville (1861), p. 71, pl. 8, fig. 14.

Triceratium unguiculatum Greville (1864)
(Plate 33, Figures 1, 3; Plate 34, Figures 1-6)

Description: Greville (1864), pt. XII, p. 85, pl. 11, fig. 9.
Discussion: Greville's description of this species is as follows: "Large; valve with 4 angles, very concave sides, and rather large hexagonal cellules; angles somewhat obtuse, furnished with a minute claw-like process." Greville's comments on this Barbados (late Eocene) species are appropriate here: "...one of the most distinct and constant species in the whole genus...The hexagonal cellules are uniform in size, and form a delicate reticulation. The most remarkable feature, however, in the valve is the slender claw-like process which seems to occupy the place of pseudo-nodule, and to arise from a small callous base just within the angles." A number of specimens fitting Greville's description have been examined under plain light and the scanning electron microscope. On Plate 34, Figures 3, 4, and 6 the "claw-like process" is seen to arise from an elongate bifurcating "callous base" within the angles as Greville stated. This process, when fully developed, often extends out over the margin of the valve and is readily visible in valve view under the microscope, as shown in Greville's illustration. Sometimes, however, this process is broken off and therefore not readily discernible under the microscope.

Forms similar to this species and identified as *Tri. pulvinar* (Schmidt's Atlas, pl. 126, fig. 8; McCollum, 1975, p. 536, pl. 14, fig. 10; Hajos, 1976, p. 29, pl. 12, fig. 8, 9, pl. 13, fig. 3, 4, pl. 14, fig. 1-8, pl. 21, fig. 11, 12) appear to fit the description of *Tri. unguiculatum* given by Greville. I have not been able to locate the original description of *Tri. pulvinar*, however, the principal difference between the above-mentioned illustrations of *Tri. pulvinar* and that by Greville of *Tri. unguiculatum* seems to be a more pronounced concavity to the sides, and perhaps a coarser aerolation. These characteristics are in keeping with Greville's description (see above). I have included a photograph of a diatom similar to *Tri. pulvinar* (Plate 33, Figure 2) for comparison. For the range charts, these forms are grouped under *Tri. unguiculatum*.

Genus TRINACRIA Heiberg (1863)

Trinacria aries Witt (1886)
(Plate 38, Figures 3, 4, 6)

Description: Schmidt's Atlas, pl. 150, fig. 14, 15; pl. 96, fig. 14-17. Hanna (1927), p. 36, pl. 5, fig. 1, 2.

Trinacria excavata Heiberg (1863)
(Plate 37, Figure 6)

Description: Hustedt (1930), p. 887, 888, fig. 532.

Trinacria pileolus (Ehrenberg Grunow (1884)
(Plate 37, Figures 3, 4)

Description: Hustedt (1930), p. 885, 886, fig. 529.

Trinacria simulacrum Grove and Sturt (1887)
(Plate 35, Figures 1, 2, 4; Plate 36, Figures 1-4)

Description: Grove and Sturt (1886-1887), ser. 2, vol. 3, p. 144, pl. 13, fig. 46; Schmidt's Atlas, pl. 127, fig. 14.
Discussion: Figures 2 and 4 on Plate 35 are most similar to the illustration in Grove and Sturt while Figure 1 is similar to that in Schmidt's Atlas. According to Schrader (written communication), the figures on Plate 36 are the lower valves of this species.

Genus XANTHIOPYXIS Ehrenberg (1844)

Xanthiopyxis oblonga Ehrenberg (1844)
(No Illustration)

Description: Hanna (1927), p. 124.

INCERTAE SEDIS

Genus and species indeterminate (A)
(Plate 40, Figures 4, 8)

Discussion: This diatom was observed only rarely in Hole 328B from intervals which were otherwise barren of diatoms.

Genus and species indeterminate (B)
(Plate 40, Figures 2, 3)

Genus and species indeterminate (C)
(Plate 12, Figure 8)

Genus and species indeterminate (D)
(Plate 2, Figures 3, 4; Plate 10, Figures 1-3)

Discussion: This object is quite common in the Miocene of 329. It is remarkably uniform in size, about 30 μm from point to point. One example was found of two of the objects joined together forming an open circle. It may be that these are girdle bands of a centric diatom.

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PLATE 1

Figures 1-6	*Eucampia balaustium* Castracane. 1. Sample 328-1-5, 138-140 cm (1600×). 2. Sample 328-1-4, 5-7 cm (1200×). 3. Sample 328-1-1, 1-3 cm (1700×). 4. Sample 328-1-2, 81-82 cm (1650×). 5. Sample 328-1-1, 1-3 cm (1650×).
Figures 6, 7	*Bogorovia veniamini* Jousé. 6. Sample 328B-3-2, 70-72 cm (1550×). 7. Sample 328B-3-4, 70-72 cm (1600×).
Figure 8	*Charcotia actinochilus* (Ehr.) Hustedt. Sample 328-1-1, 1-3 cm (1250×).

PLATE 1

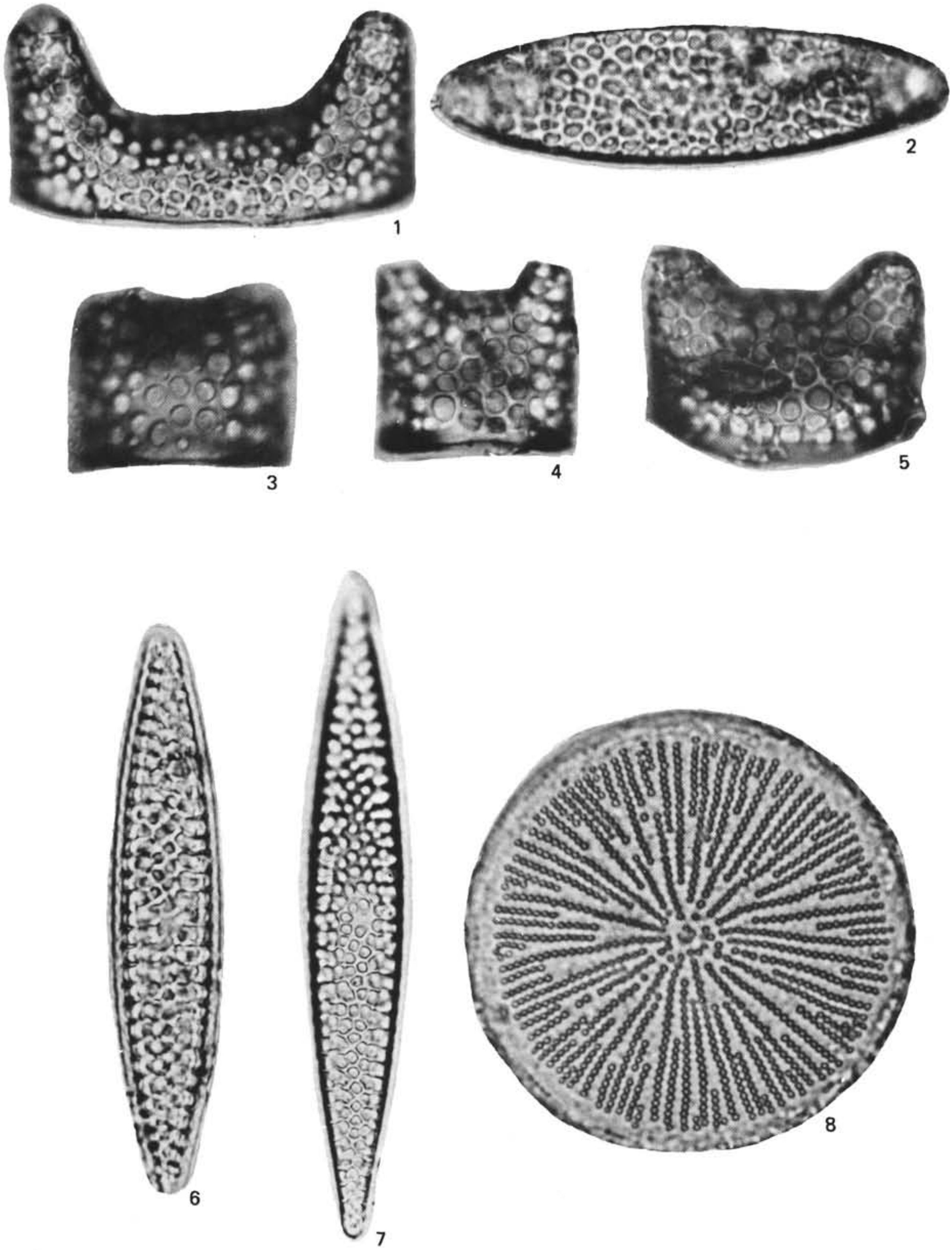


PLATE 2

Figures 1, 2	*Actinocyclus ingens* (?) Rattray. 1. Sample 328-1-5, 138-140 cm (1650×). 2. Sample 328-1-5, 81-83 cm (1620×).
Figures 3, 4	Genus et species indet. (D). 3. Sample 328-3-1, 5-7 cm (1600×). 4. Sample 328-2-2, 80-82 cm (1600×).
Figure 5	*Stephanopyxis turris* (Grev. et Arn.) Ralfs. Sample 328-2-3, 78-80 cm (1650×).
Figures 6, 7	*Coscinodiscus endoi* Kanaya. 6. Sample 328-1-4, 79-81 cm (1650×). 7. Sample 329-12-2, 30-32 cm (1550×).

PLATE 2

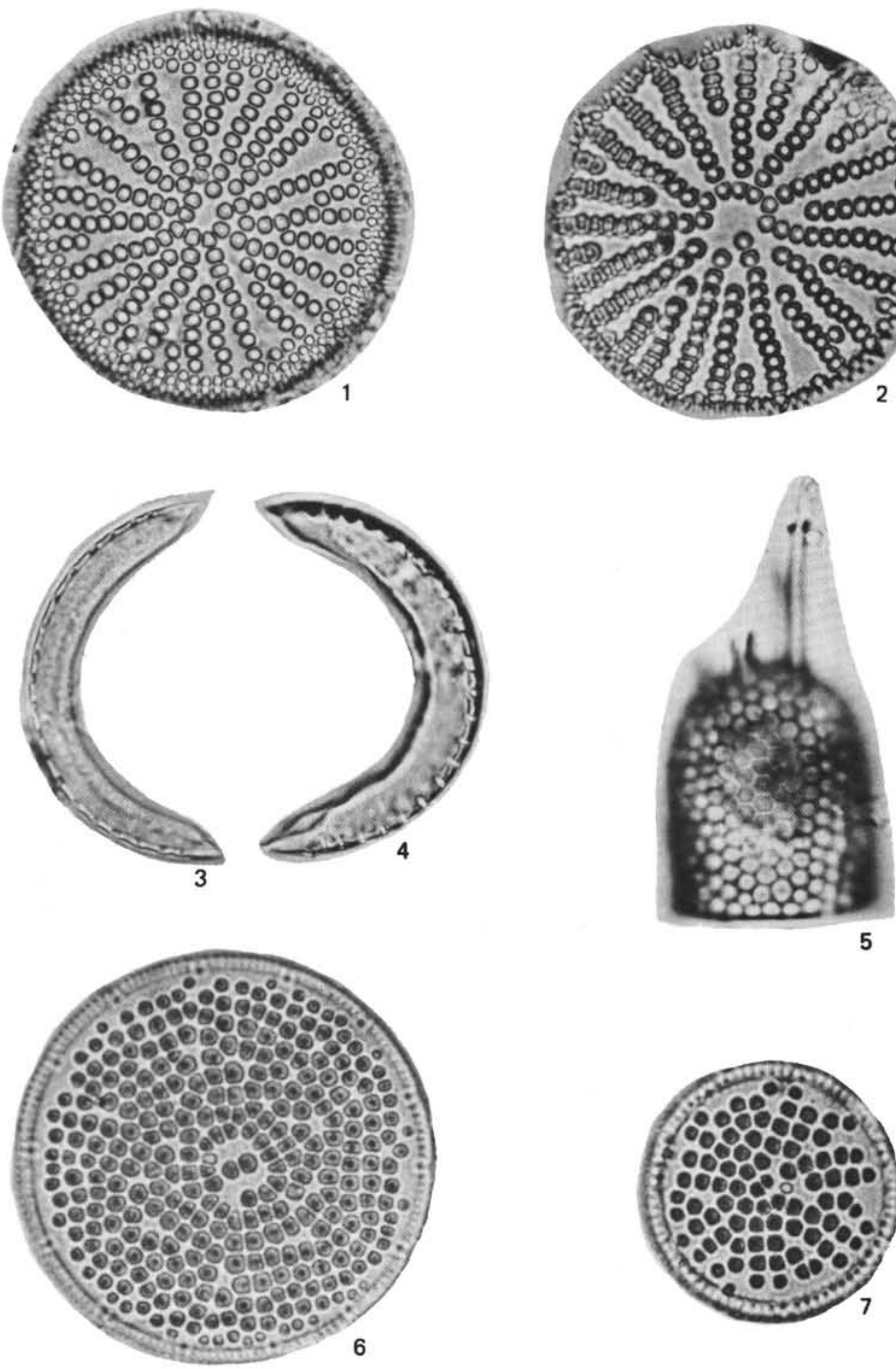


PLATE 3

Figures 1-3, 6	*Coscinodiscus elliptopora* Donahue. 1. Sample 328-1-5, 5-7 cm (1625×). 2. Sample 328-1-5, 5-7 cm (1625×). 3. Sample 328-1-5, 138-140 cm (1575×). 6. Sample 328-1-5, 138-140 cm (900×).
Figures 4, 5	*Coscinodiscus lentiginosus* Janisch. Elongate marginal pore is indicated. 4. Sample 328-1-1, 48-50 cm (5300×). 5. Same specimen (1320×).

PLATE 3

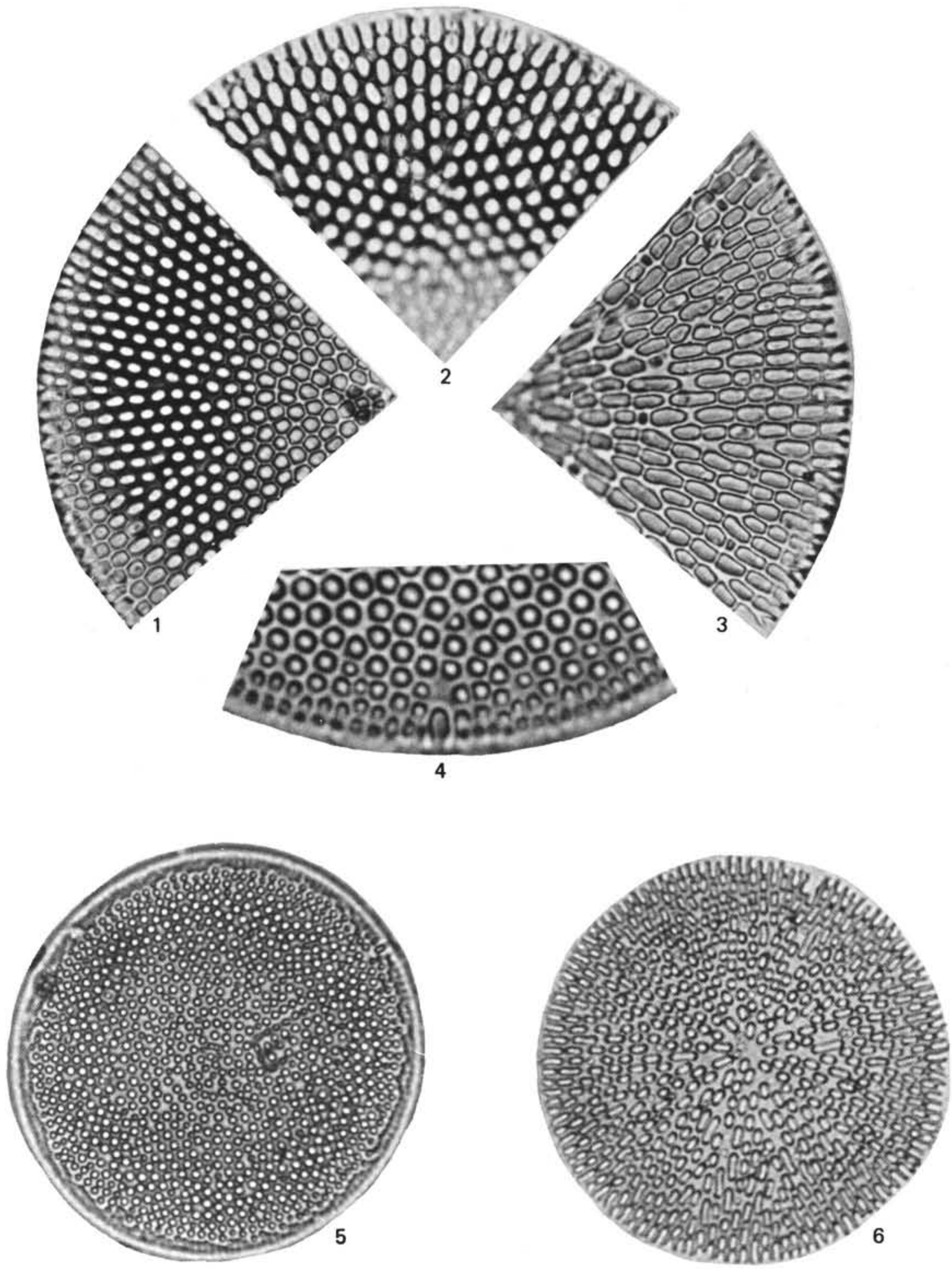


PLATE 4

Figures 1-3	*Coscinodiscus vulnificus* n. sp. Gombos. 1. Sample 328-2-1, 148-150 cm (1650×). 2. Sample 328-2-1, 148-150 cm (1600×). 3. Sample 328-2-1, 148-150 cm (1550×).
Figures 4, 5	*Cosmiodiscus insignis* Jousé. 4. Sample 328-2-1, 148-150 cm (1250×). 5. Sample 328-2-1, 148-150 cm (1650×). Central hyaline area with outer margin dissolved or broken away.
Figures 6, 7	*Thalassiosira nordenskioldii* Cleve. 6. Sample 328-1-5, 81-83 cm (1600×). 7. Sample 328-1-5, 138-140 cm (1850×).
Figure 8	*Hemidiscus karstenii* Jousé. Sample 328-1-2, 5-7 cm (1600×).

PLATE 4

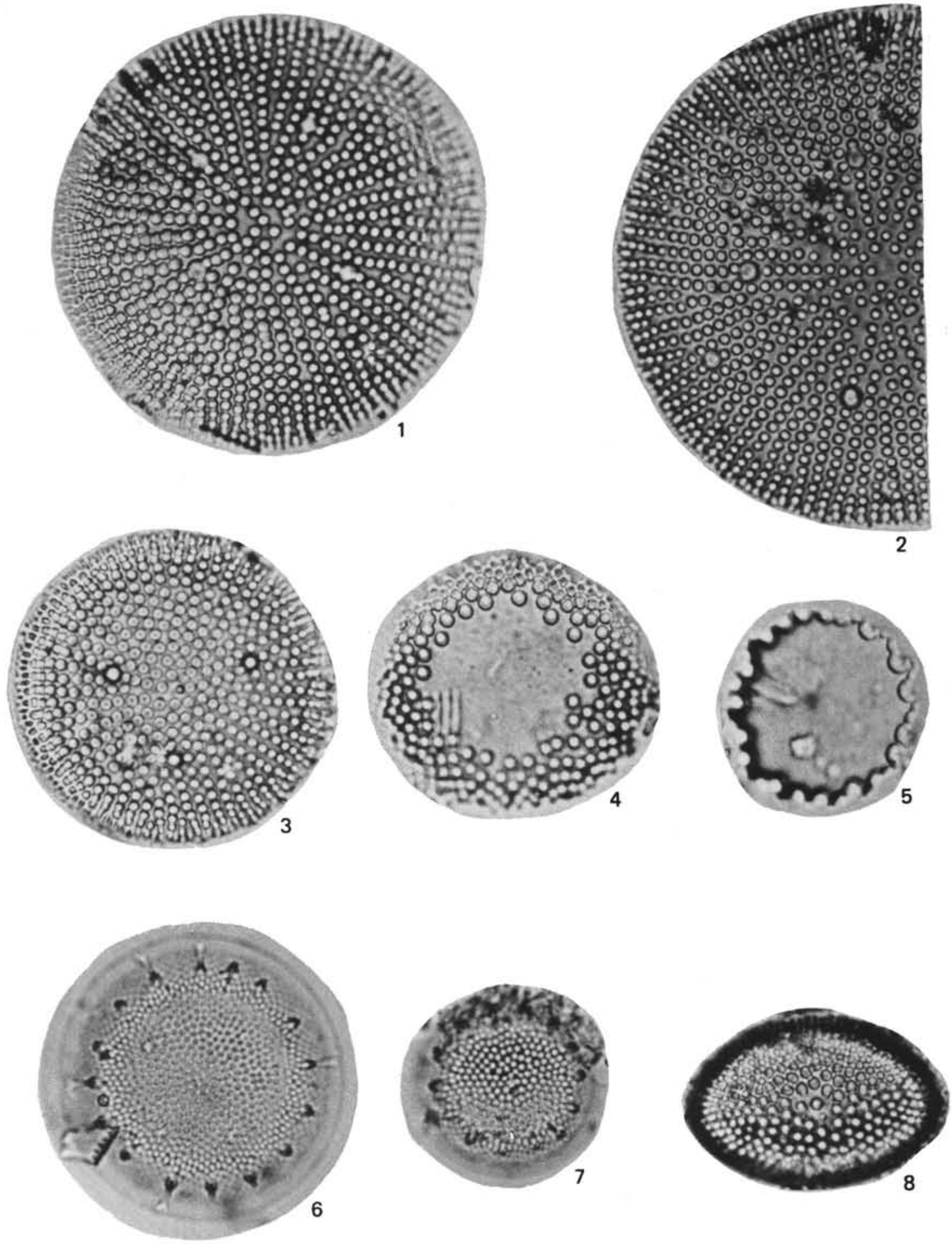


PLATE 5

Figures 1, 2	*Thalassiosira* cf. *oestrupii* (Osten.) Proschkina-Lavrenko. 1. Sample 328-2-3, 78-80 cm (1600×). 2. Sample 328-2-5, 81-83 cm (1600×).
Figure 3	*Coscinodiscus endoi* Kanaya. Sample 328-1-2, 81-83 cm (1600×).
Figure 4	*Thalassiosira* cf. *burckliana* Schrader. Sample 328-2-6, 81-83 cm (1650×).
Figure 5	*Coscinodiscus marginatus* Ehr. Sample 328-2-1, 148-150 cm (850×).
Figures 6, 7	*Cocconeis* sp. 6. Sample 328-2-1, 148-150 cm (1600×). 7. Sample 328-2-3, 78-80 cm (1550×).
Figure 8	*Cestodiscus* ? sp. Sample 328-2-3, 78-80 cm (1615×).

PLATE 5

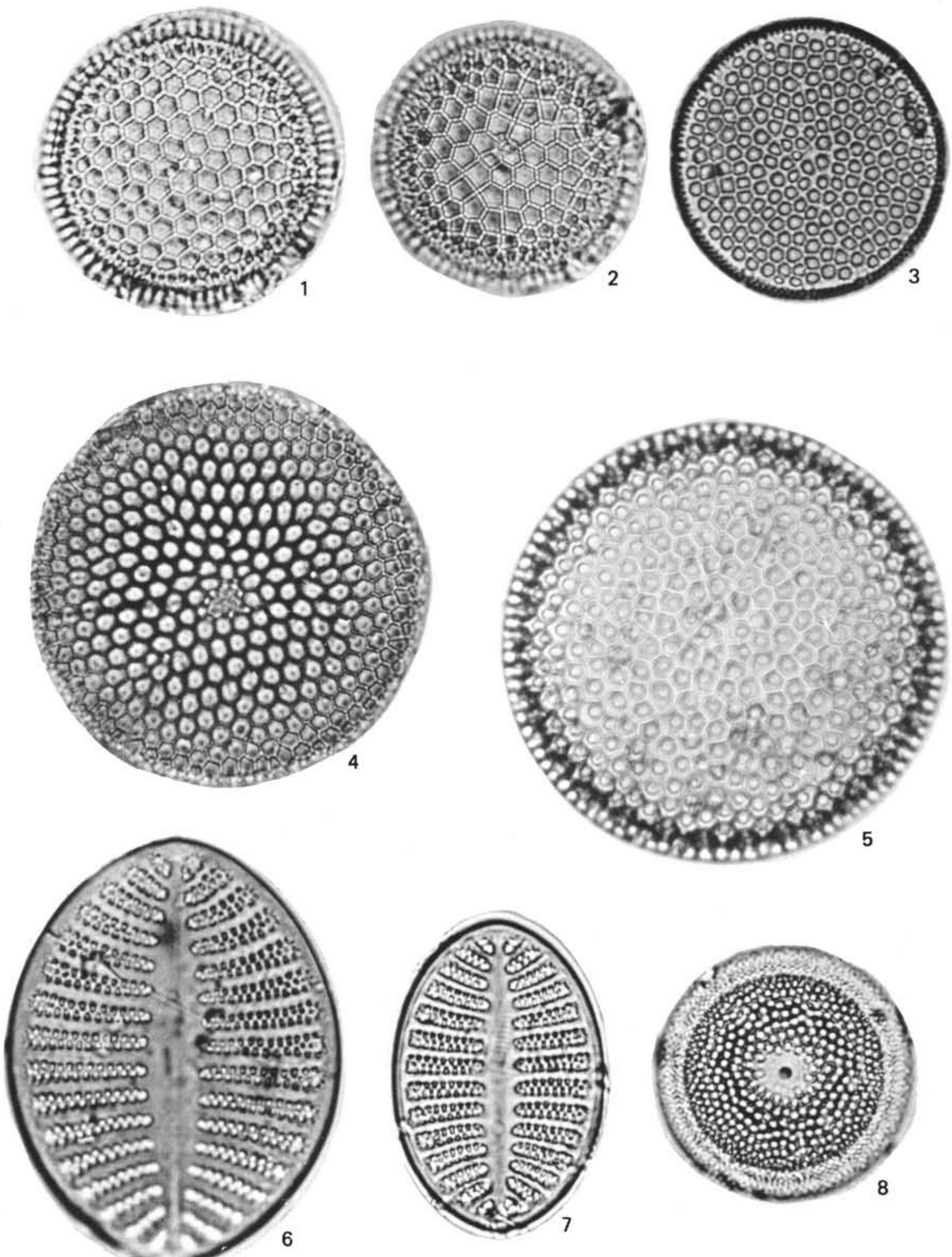
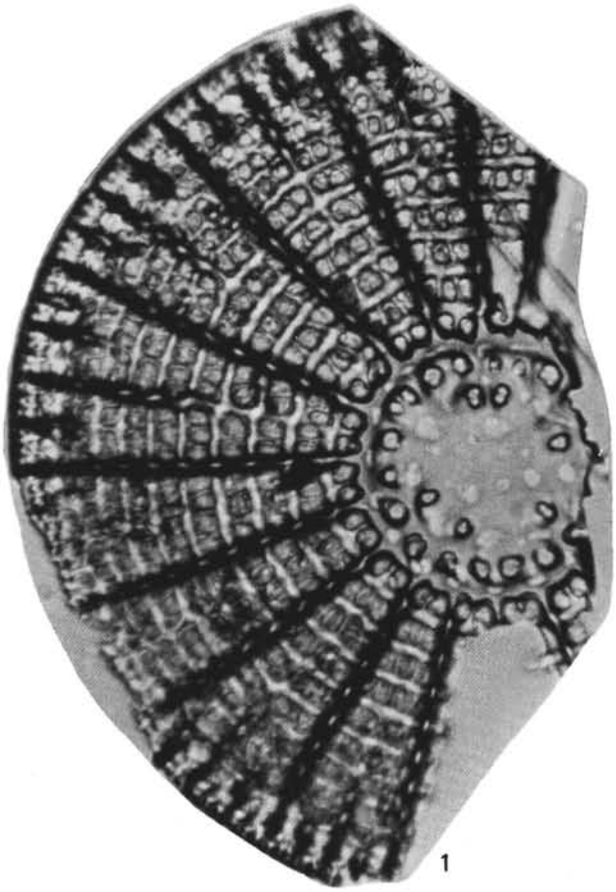


PLATE 6

Figure 1	*Arachnoidiscus* cf. *ehrenbergii* Bailey. Sample 328-1-5, 138-140 cm (800×).
Figure 2	*Chaetoceros* sp. B. Sample 328-2-1, 148-150 cm (1000×).
Figure 3	*Coscinodiscus kolbei* Jousé. Sample 328-2-2, 5-7 cm (1550×).
Figure 4	*Bruniopsis mirabilis* (Brun) Karsten. Sample 328-2-6, 5-7 cm (650×).

PLATE 6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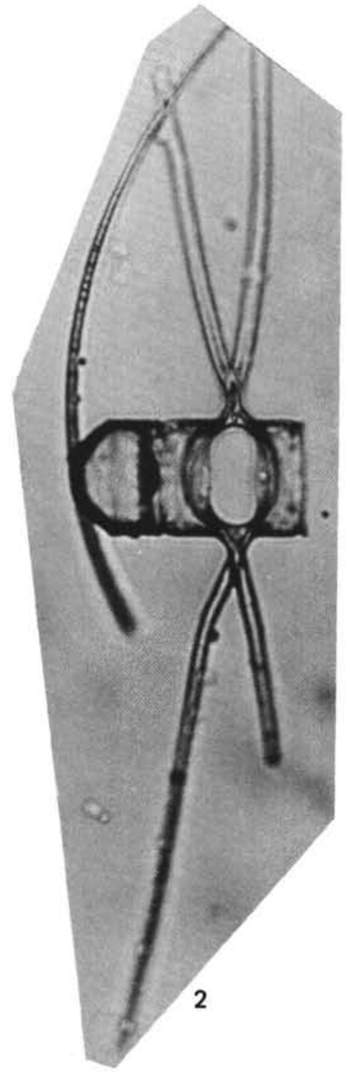
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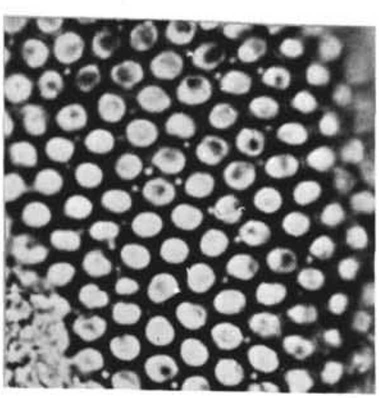
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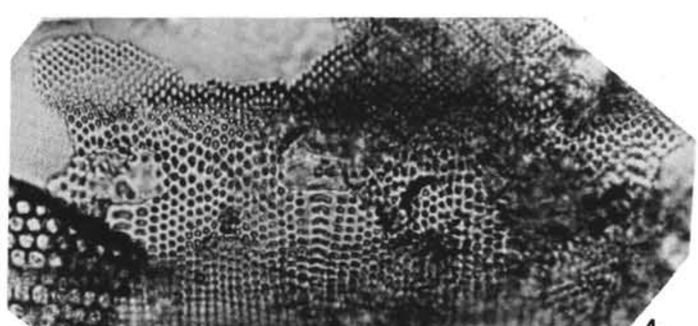
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PLATE 7

Figures 1, 2	*Nitzschia praeinterfrigidaria* McCollum. 1. Sample 328-2-3, 5-7 cm (1450×). 2. Sample 328-2-2, 80-82 cm (1525×).
Figure 3	*Nitzschia interfrigidaria* McCollum. Sample 328-2-6, 81-83 cm (1550×).
Figures 4, 5	*Nitzschia cylindrica* Burckle. 4. Sample 328-2-4, 81-83 cm (1550×). 5. Sample 328-2-4, 81-83 cm (1650×).
Figure 6	*Nitzschia* cf. *efferans* Schrader. Sample 328-2-1, 148-150 cm (1550×).
Figures 7, 8	*Nitzschia* sp. A 7. Sample 328-1-2, 81-83 cm (1600×). 8. Sample 328-1-2, 81-83 cm (1600×).
Figure 9	*Nitzschia* sp. B. Sample 328-1-5, 81-83 cm (1650×).
Figures 10, 11	*Rouxia naviculoides* Schrader. 10. Sample 328-2-4, 81-83 cm (1550×). 11. Sample 328-2-2, 80-82 cm (1650×).
Figure 12	*Rouxia antarctica* Heiden and Kolbe. Sample 328-2-1, 148-150 cm (1600×).
Figure 13	*Rouxia californica* Peragallo. Sample 328-1-4, 79-81 cm (1600×).
Figures 14, 15	*Rouxia heteropolara* Gombos. 14. Sample 328-2-3, 78-80 cm (1650×). 15. Sample 328-2-3, 5-7 cm (1700×).

PLATE 7

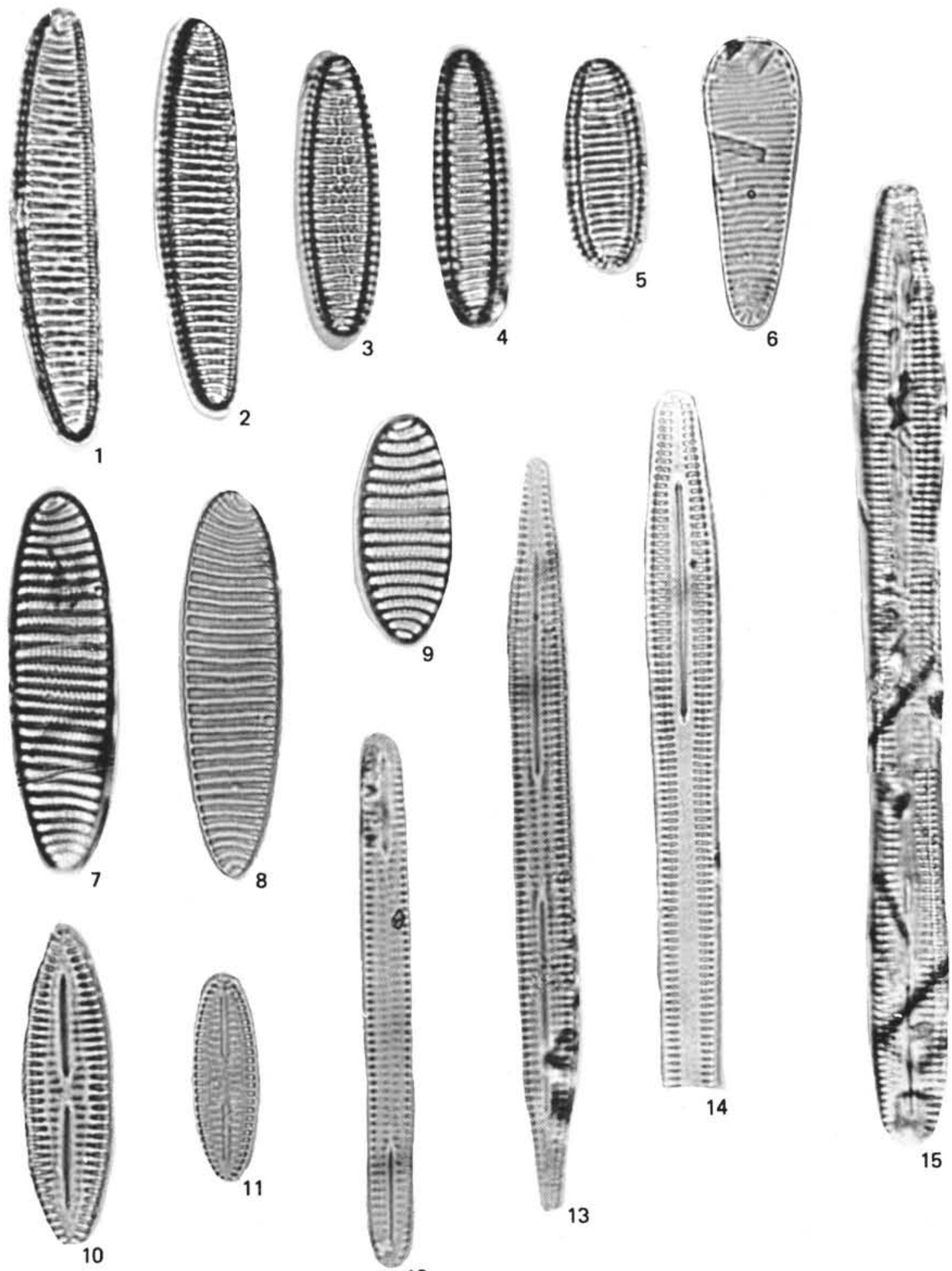


PLATE 8

Figures 1-4	*Denticula hustedtii* Simonsen and Kanaya. 1. Sample 329-15-4, 30-32 cm (1600×). 2. Sample 329-4-1, 30-32 cm (1600×). 3. Sample 328-3-1, 5-7 cm (1700×). 4. Sample 329-15-4, 30-32 cm (1675×).
Figure 5	*Denticula hustedtii* (?) Simonsen and Kanaya. Sample 329-23-1, 113-116 cm (1550×).
Figures 6, 7	*Denticula lauta* Bailey. 6. Sample 329-12-2, 30-32 cm (2200×). 7. Sample 328-3-3, 5-7 cm (2000×).
Figure 8	*Denticula nicobarica* Grunow. Sample 328-3-2, 140-142 cm (1950×).
Figures 9, 10	*Denticula* cf. *dimorpha* Schrader. Sample 329-23-1, 113-116 cm (1750×).
Figure 11	*Denticula dimorpha* Schrader. Sample 329-23-1, 113-116 cm (1700×).
Figure 12	*Denticula lauta* Bailey. Sample 329-23-1, 113-116 cm (1600×).
Figures 13, 14	*Nitzschia kerguelensis* (O'Meara) Hasle. 13. Sample 328-1-2, 5-7 cm (1600×). 14. Sample 328-1-1, 130-132 cm (1500×).
Figure 15	*Nitzschia pliocena* (Brun) Wornardt. Sample 328-2-3, 78-80 cm (1550×).
Figure 16	*Nitzschia separanda* (Hustedt) Hasle. Sample 328-1-2, 5-7 cm (1650×).
Figure 17	*Nitzschia fossilis* (Frenguelli) Kanaya. Sample 328-2-4, 5-7 cm (1600×).
Figures 18-20	*Nitzschia clementei* n. sp. 18. Sample 328-2-3, 78-80 cm (1600×) Holotype. 19. Sample 328-2-3, 78-80 cm (1600×). 20. Sample 329-1-4, 30-32 cm (1600×).
Figure 21	*Nitzschia* cf. *efferans* Schrader. Sample 328-2-4, 81-83 cm (1600×).

PLATE 8

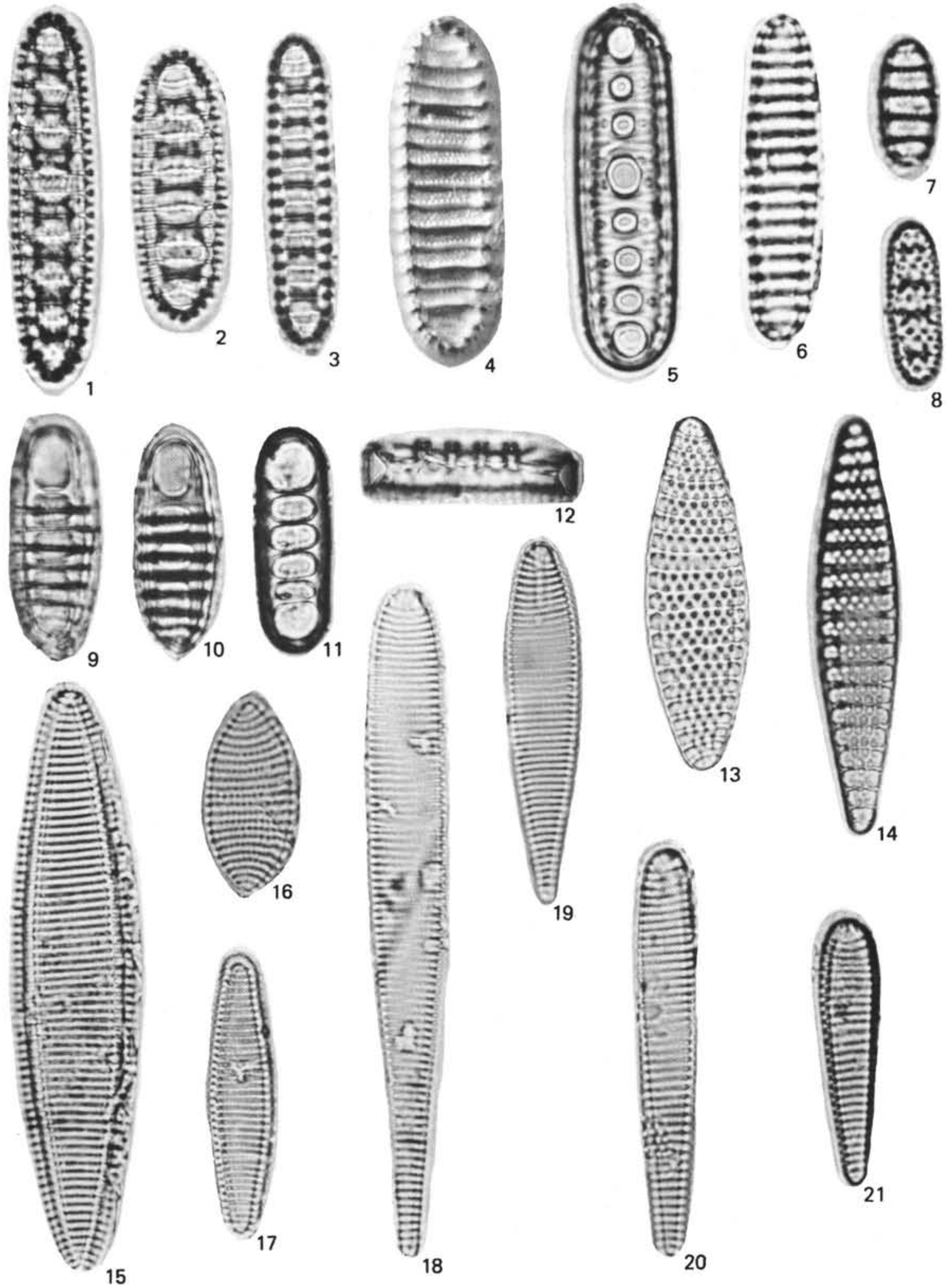
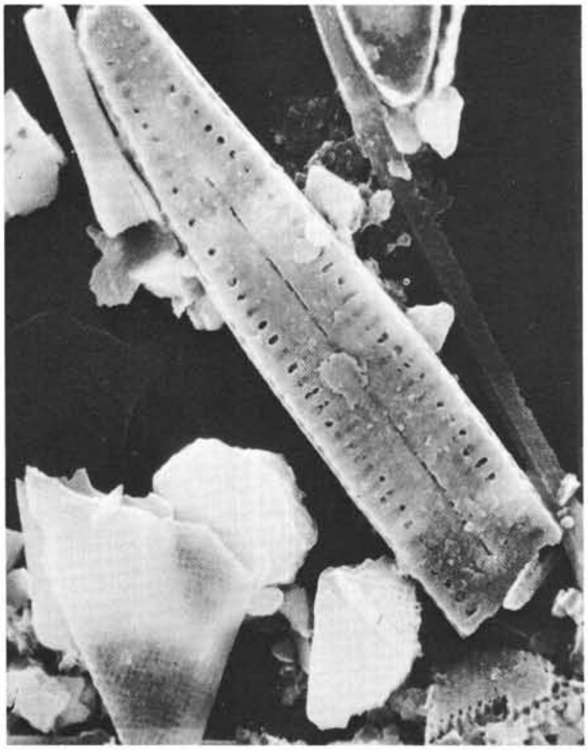


PLATE 9

Figure 1	*Rouxia heteropolara* Gombos. Sample 328-2-3, 78-80 cm (2800×).
Figure 2	*Nitzschia kerguelensis* (O'Meara) Hasle. Sample 328-1-2, 5-7 cm (2000×).
Figure 3	*Coscinodiscus elliptopora* Donahue. Sample 328-1-5, 5-7 cm (1600×).

PLATE 9



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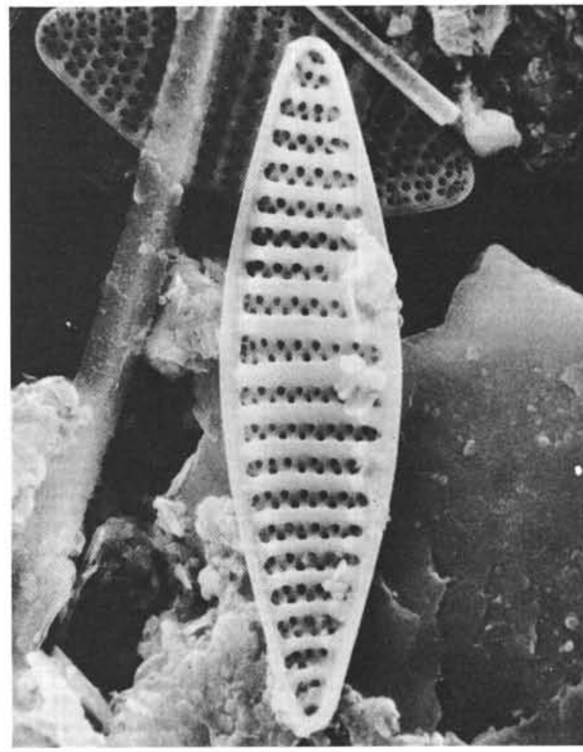

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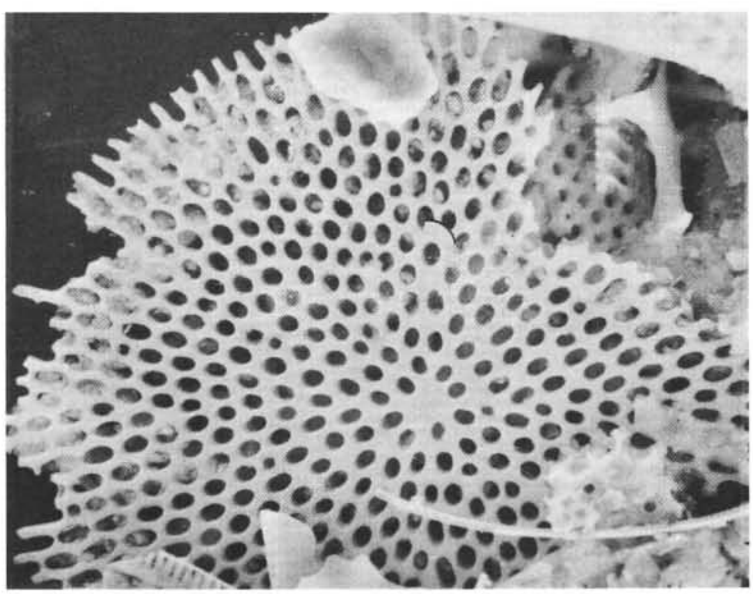
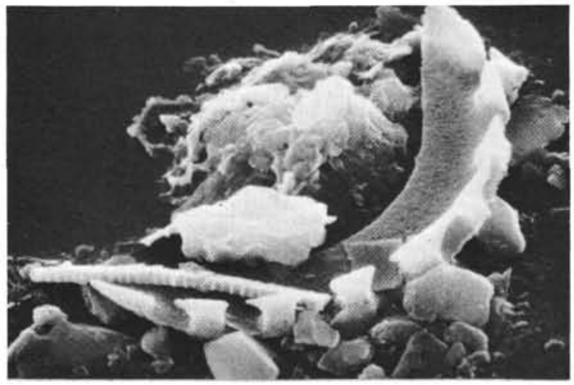


3

PLATE 10

Figures 1-3	Genus et species indet. (D). Sample 328-2-3, 78-80 cm. 1. (4000×) +35°. 2. (4000×) +35°. 3. (3000×) 0°.

PLATE 10



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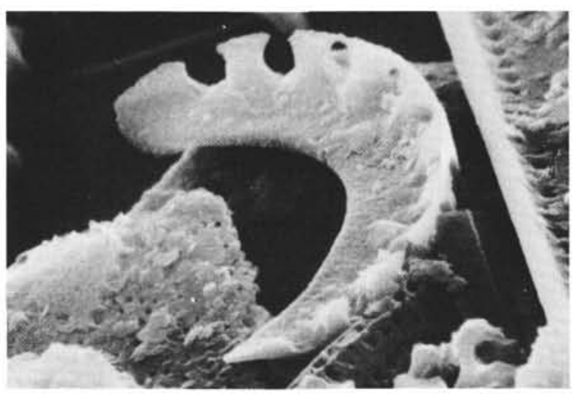

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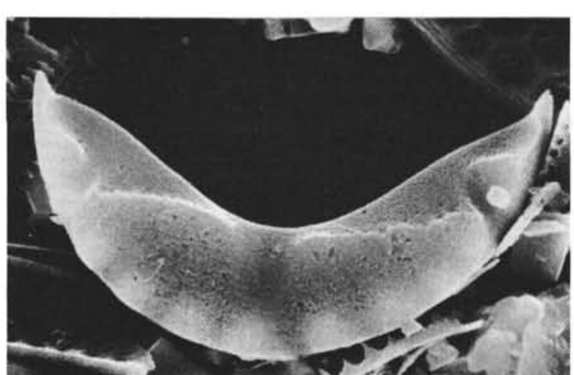
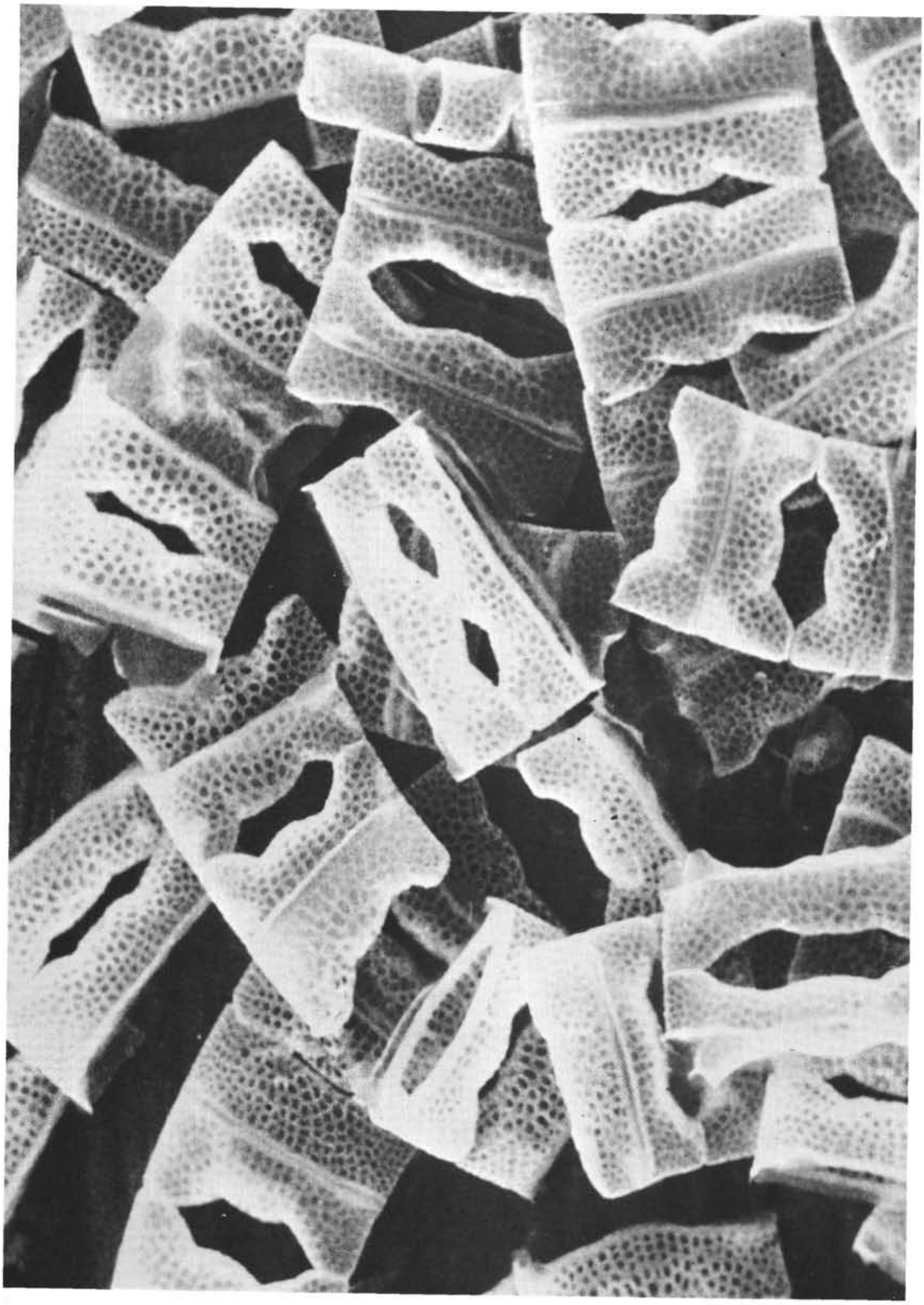


3

PLATE 11

Figure 1	*Eucampia balaustium* Ehr. Plankton Sample AMG-36-21; lat 49°51.8′S, long 37°33.7′W (2500×).

PLATE 11



1

PLATE 12

Figures 1, 4	*Bogorovia veniamini* Jousé. 1. Sample 328B-3-4, 70-72 cm (650×). 4. Sample 328B-3-1, 5-7 cm (650×).
Figure 2	*Bogorovia veniamini* Jousé. Sample 328B-3-1, 5-7 cm (625×).
Figure 3	*Bogorovia veniamini* Jousé. Sample 328B-3-4, 70-72 cm (800×). Girdle view.
Figures 5, 7	*Synedra jouseana* Sheshukova-Poretskaya 5. Sample 328B-3-4, 70-72 cm (850×). 7. Sample 328B-3-1, 5-7 cm (600×).
Figure 6	*Synedra jouseana* v. A. Sample 328B-3-4, 70-72 cm (850×).
Figure 8	Genus et species indet. (C). Sample 328-4-1, 147-149 cm (2400×).
Figures 9, 10	*Denticula* cf. *antarctica* McCollum. Sample 329-2-3, 30-32 cm (1600×).

PLATE 12

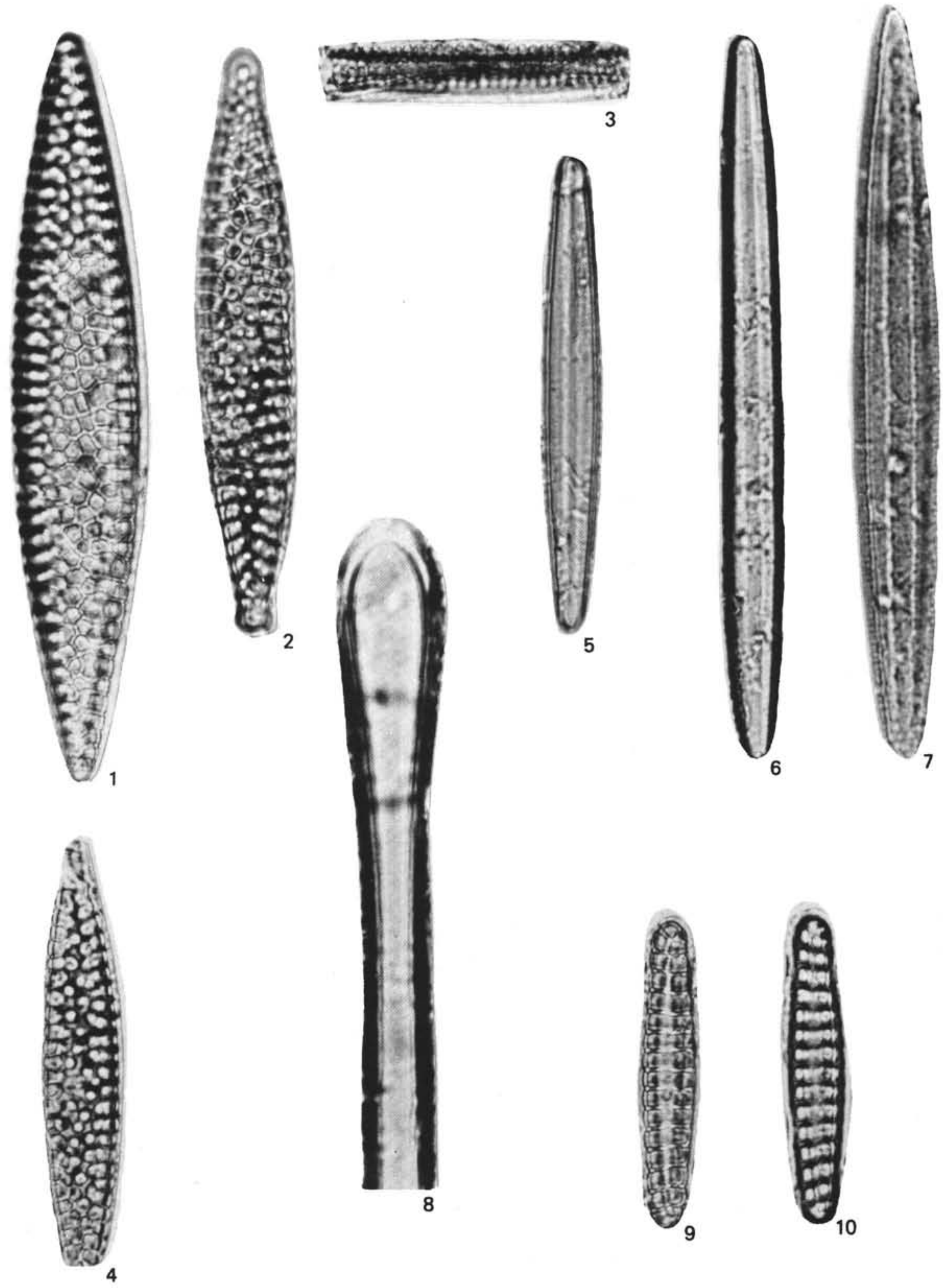


PLATE 13

Figures 1, 2	*Sceptroneis caduceus* Ehr. Sample 327A-5-1, 45-48 cm (1600×).
Figures 3, 4	*Sceptroneis grunowii* Anissimova. Sample 327A-5-1, 45-48 cm (1500×).
Figure 5	*Sceptroneis* sp. Sample 327A-5-1, 45-48 cm (1600×).
Figure 6	*Sceptroneis* sp. A. Sample 327A-5-1, 45-48 cm (1500×).
Figures 7, 8	*Sceptroneis* sp. B. 7. Sample 327A-5-1, 45-48 cm (1750×). 8. Sample 327A-5-1, 45-48 cm (2100×).
Figures 9-11	*Nitzschia denticuloides* Schrader. 9. Sample 328-3-3, 5-7 cm (1900×). 10. Sample 328-3-3, 5-7 cm (1900×). 11. Sample 328-3-3, 28-30 cm (1900×).

PLATE 13

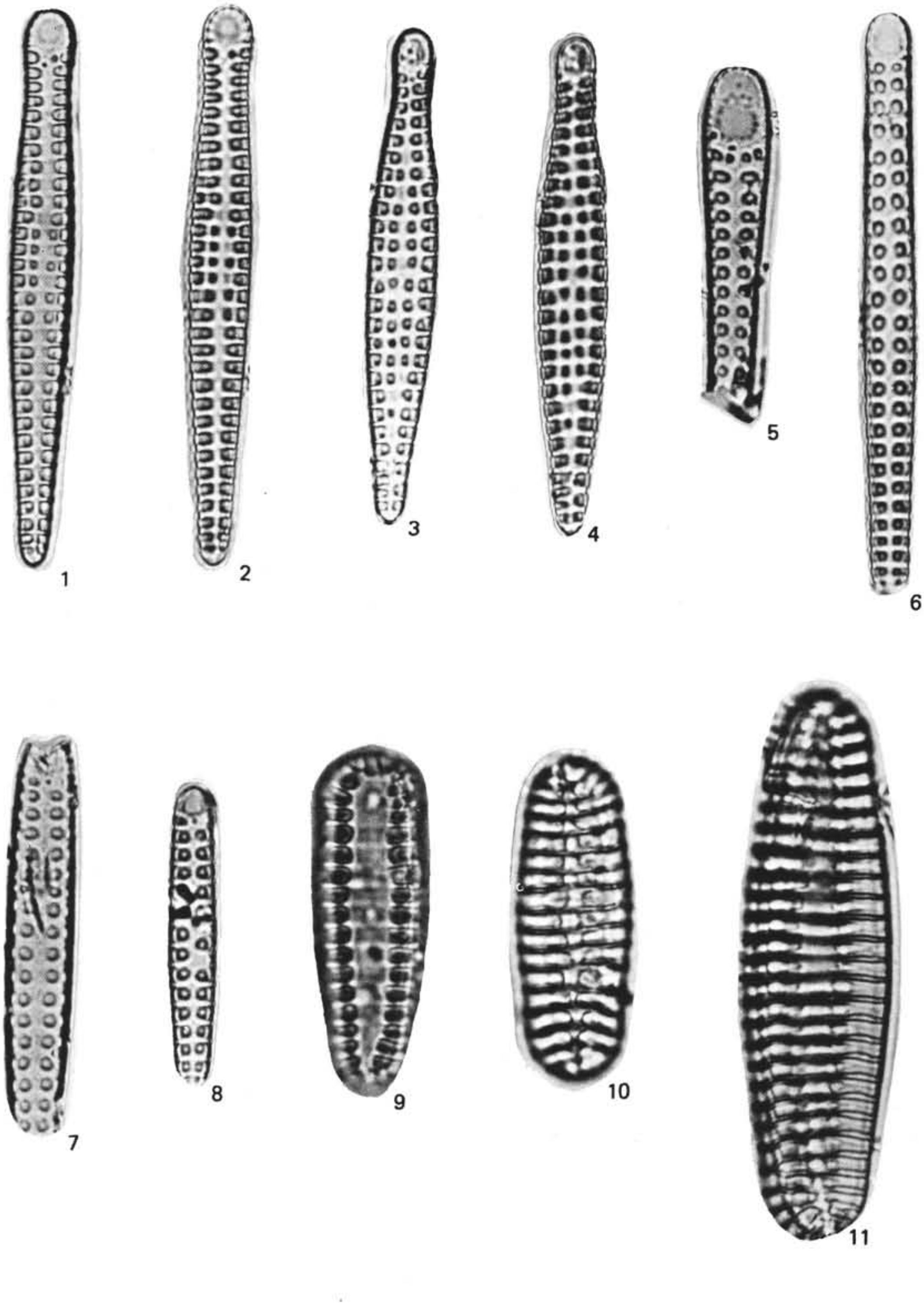


PLATE 14

Figures 1-4, 6	*Rhaphoneis* aff. *belgica* Grunow. 1. Sample 328-4-1, 147-149 cm (1850×). 2. Sample 328-4-1, 147-149 cm (2000×). 3. Sample 328-4-1, 147-149 cm (1850×). 4. Sample 328-4-1, 147-149 cm (1800×). 6. Sample 328-4-1, 147-149 cm (1850×).
Figure 5	*Rhaphoneis* cf. *amphiceros* Ehr. v. *elongata* Perg. Sample 328-4-1, 147-149 cm (1800×).
Figure 7	*Rhaphoneis* sp. B. Sample 328-4-1, 147-149 cm (1900×).
Figure 8	*Rhaphoneis* sp. A. Sample 328-4-1, 147-149 cm (1800×).
Figure 9	*Grammatophora* sp. Sample 328-4-1, 147-149 cm (1800×).

PLATE 14

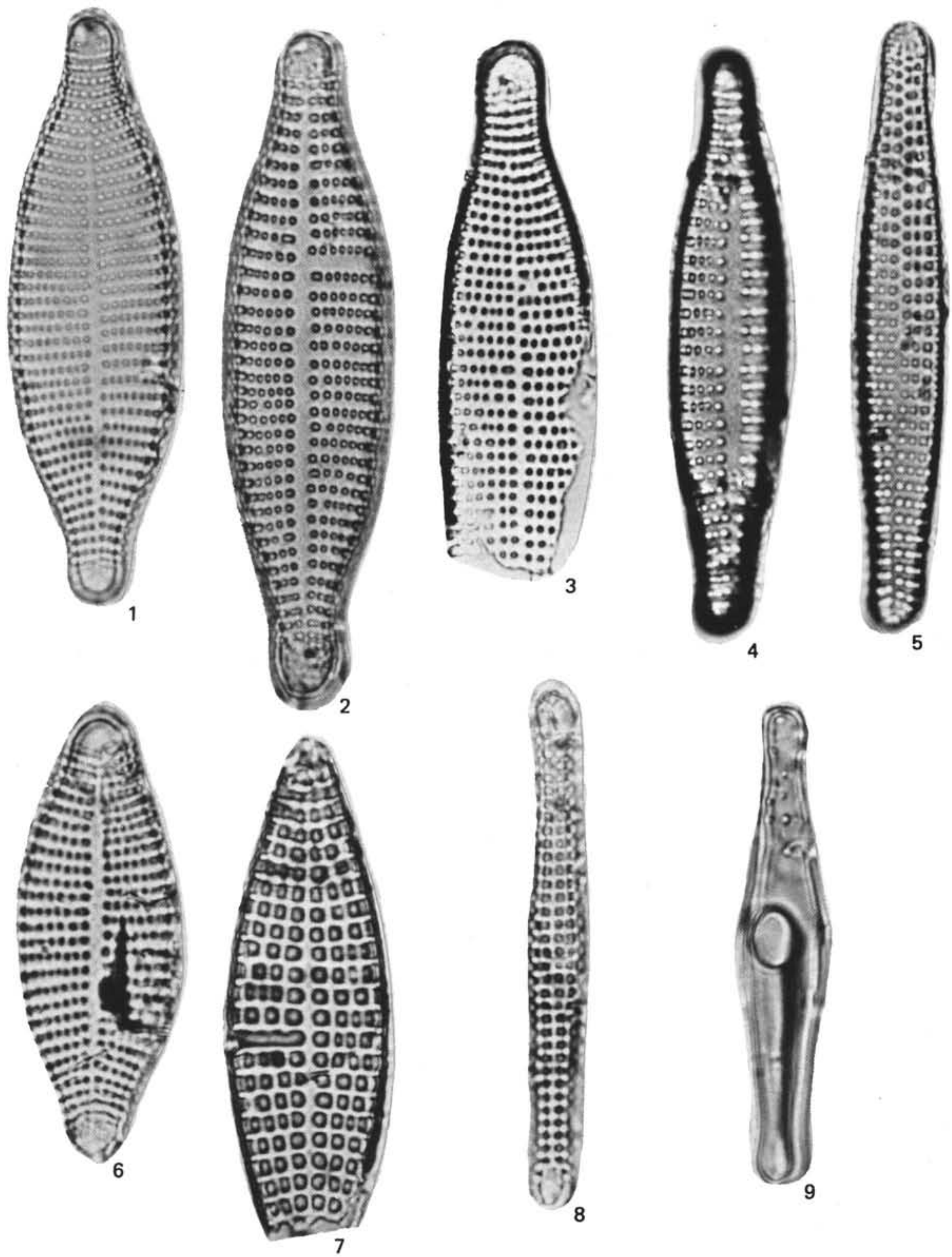


PLATE 15

Figures 1, 2	*Hemiaulus polymorphus* Grunow. 1. Sample 328-4-1, 147-149 cm (1850×). 2. Sample 328-4-1, 147-149 cm (1800×).
Figure 3	*Hemiaulus incisus* Hajos. Sample 328-4-1, 147-149 cm (1700×).
Figures 4-6	*Hemiaulus* "artifacts". 4. Sample 328-4-1, 147-149 cm (750×). 5. Sample 328-4-1, 147-149 cm (700×). 6. Sample 328-4-1, 147-149 cm (750×).
Figure 7	*Hemiaulus clavinger* Weissfl. Sample 328-4-1, 147-149 cm (750×).

PLATE 15

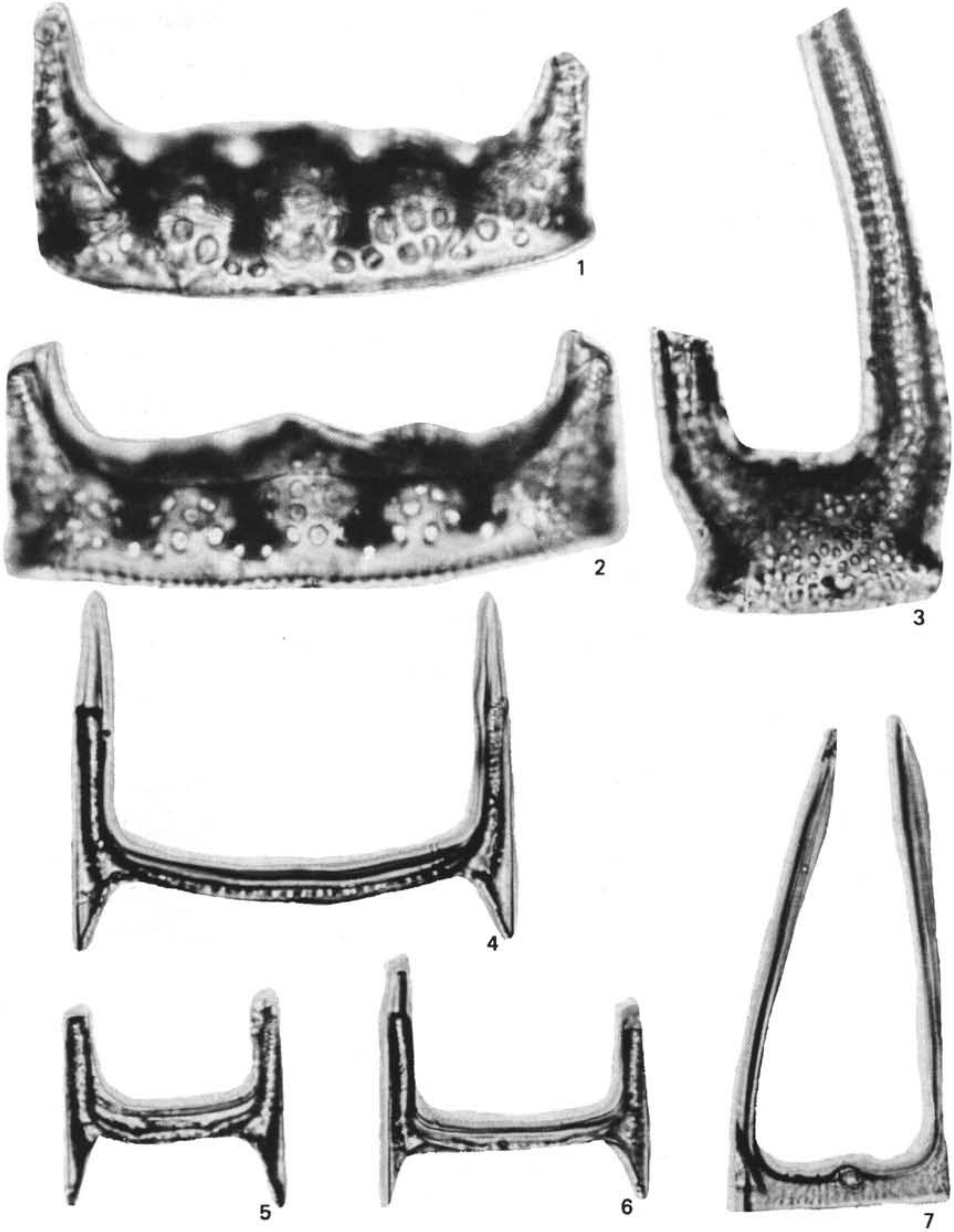


PLATE 16

Figures 1-7 *Hemiaulus incurvus* Schibkova.

1. Sample 327A-6-1, 14-16 cm (1550×).
2. Sample 327A-5-1, 45-48 cm (800×).
3. Sample 327A-5-1, 45-48 cm (800×).
4. Sample 327A-5-1, 45-48 cm (850×).
5. Sample 327A-5-3, 113-115 cm (900×).
6. Sample 327A-7-2, 45-47 cm (900×).
7. Sample 327A-5-1, 45-48 cm (850×).

PLATE 16

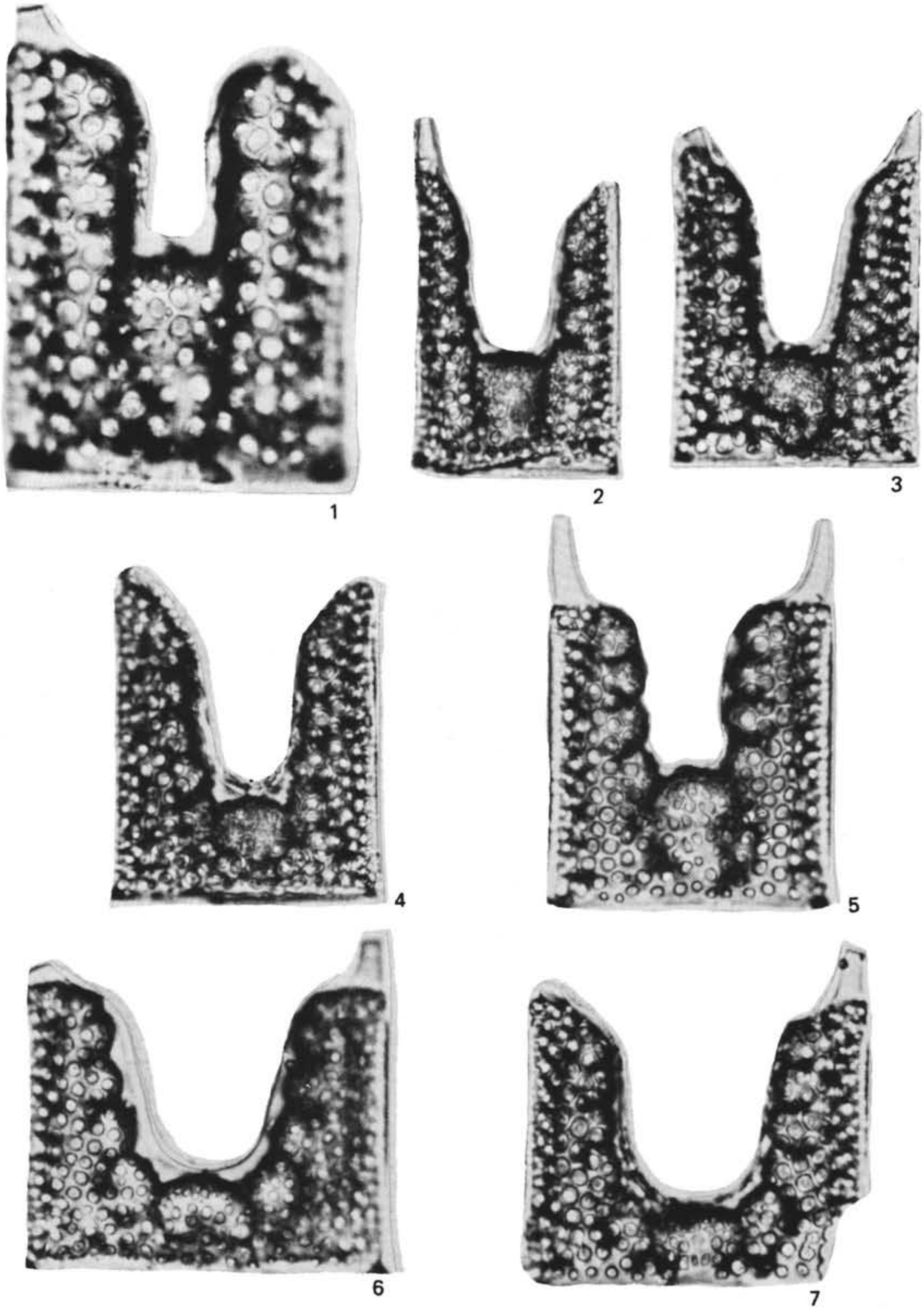


PLATE 17

Figures 1-3	*Hemiaulus incurvus* Schibkova. 1. Sample 327A-5-3, 113-115 cm (800×). 2. Sample 327A-7-2, 45-47 cm (875×). 3. Sample 327A-5-3, 113-115 cm (950×).
Figure 4	*Hemiaulus* cf. *ambiguus* Janisch. Sample 327A-5-1, 45-48 cm (1400×).
Figures 5-8	*Hemiaulus subacutus* Grunow. 5. Sample 327A-5-5, 119-121 cm (950×). 6. Sample 327A-5-5, 119-121 cm (950×). 7. Sample 327A-5-1, 45-48 cm (1450×). 8. Sample 327A-5-1, 45-48 cm (1600×).

PLATE 17

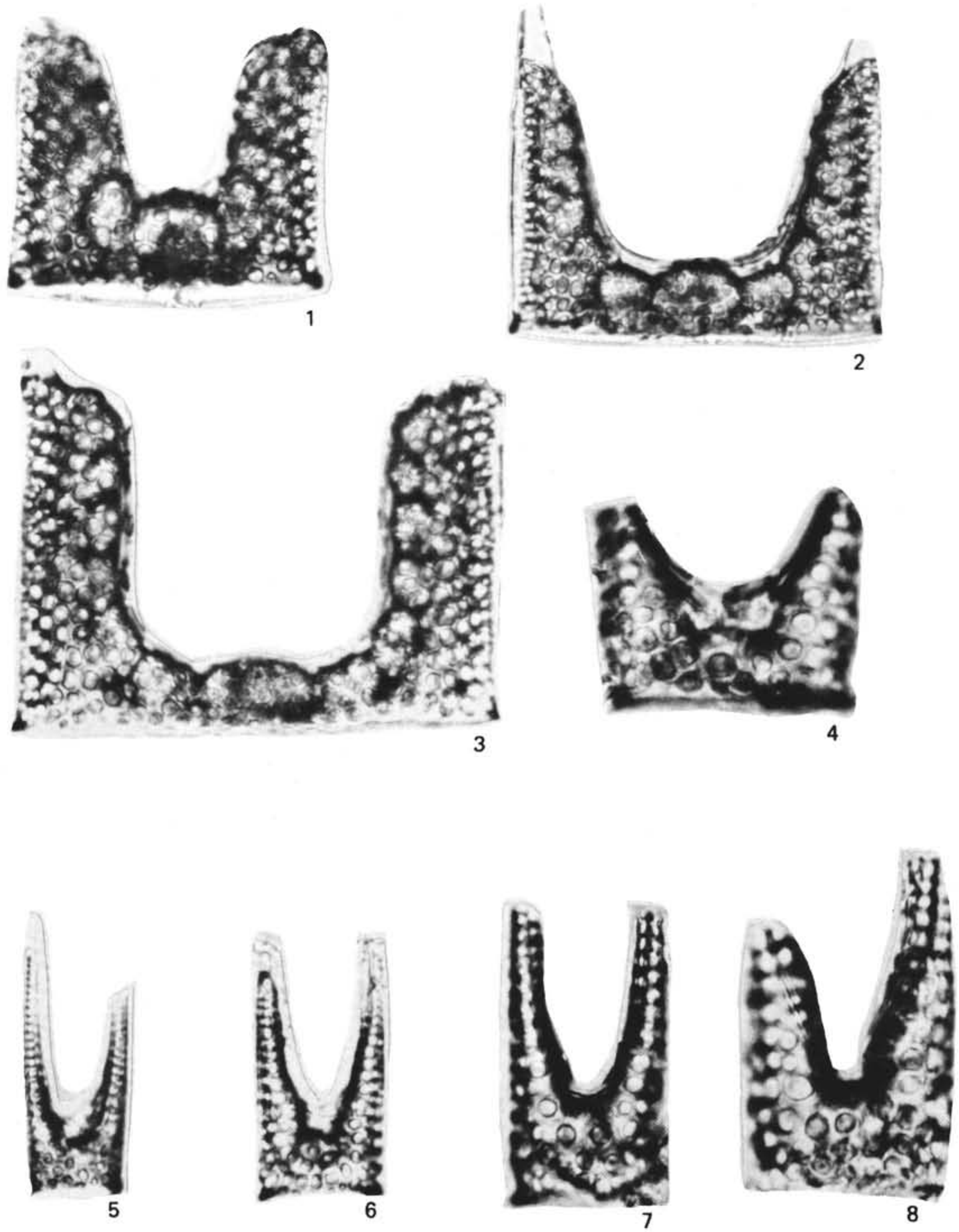


PLATE 18

Figures 1-4	*Hemiaulus polymorphus* Grunow. 1. Sample 328-4-1, 147-149 cm (1800×). 2. Sample 328-4-1, 147-149 cm (1750×). 3. Sample 327A-5-1, 45-48 cm (1550×). 4. Sample 327A-5-1, 45-48 cm (1550×).
Figure 5	*Hemiaulus polycystinorum* Ehm. Sample 328-4-1, 147-149 cm (1750×).

PLATE 18

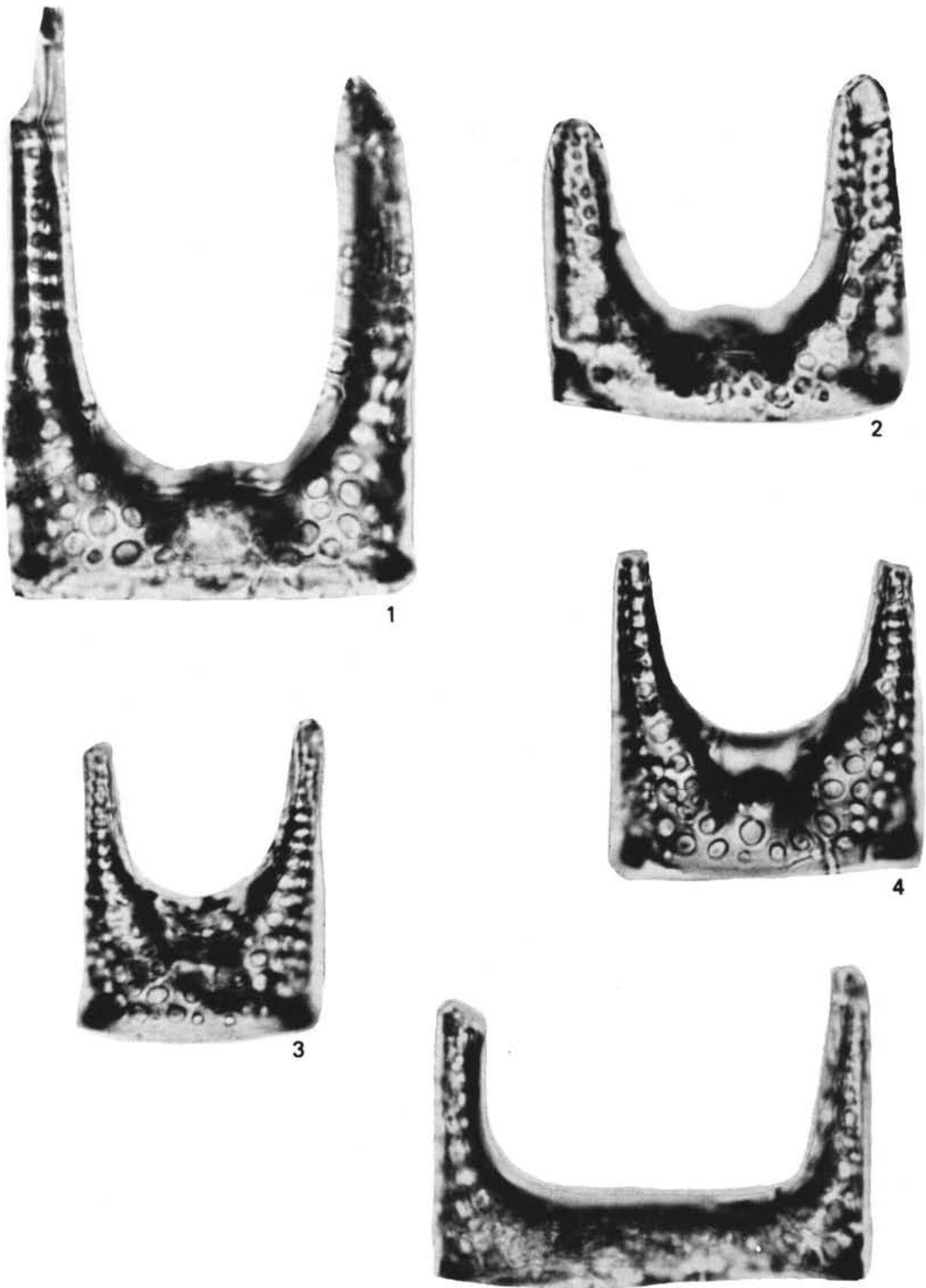


PLATE 19

Figures 1, 2	*Hemiaulus* sp. A. 1. Sample 328-4-3, 5-7 cm (900×). 2. Sample 328-4-3, 81-83 cm (900×).
Figure 3	*Hemiaulus* sp. B. Sample 328B-4-2, 5-7 cm (1750×).
Figure 4	*Hemiaulus disimilis* Grove and Sturt. Sample 328-4-3, 5-7 cm (1550×).
Figure 5	*Hemiaulus* ? sp. C. Sample 328-4-3, 5-7 cm (1650×).
Figures 6, 7	*Hemiaulus elegans* Heiberg. 6. Sample 327A-5-1, 45-48 cm (1600×). 7. Sample 328-4-1, 147-149 cm (1750×).

PLATE 19

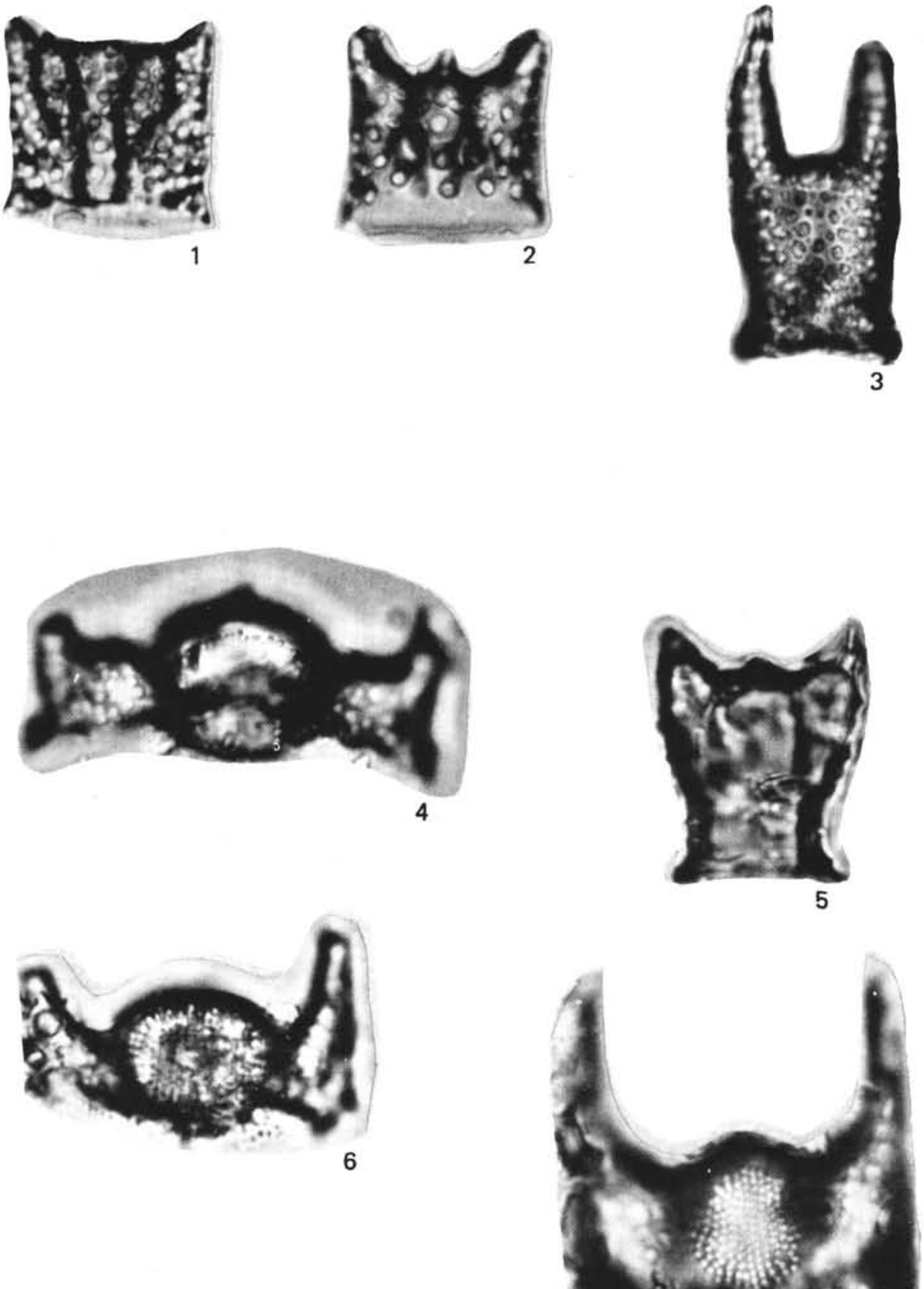


PLATE 20

Figures 1, 2	*Hemiaulus* sp. D.	
	1. Sample 328-4-1, 147-149 cm (1900×).	
	2. Sample 327A-5-1, 45-48 cm (1800×).	
Figures 3, 4	*Hemiaulus altus* Hajos.	
	3. Sample 327A-5-6, 119-121 cm (2200×).	
	4. Sample 327A-5-1, 45-48 cm (1550×).	
Figures 5-7	*Hemiaulus inaequilaterus* n. sp.	
	5. Sample 327A-5-1, 45-48 cm (900×), Holotype.	
	6. Sample 327A-5-5, 119-121 cm (900×).	
	7. Sample 327A-5-5, 119-121 cm (900×).	

PLATE 20

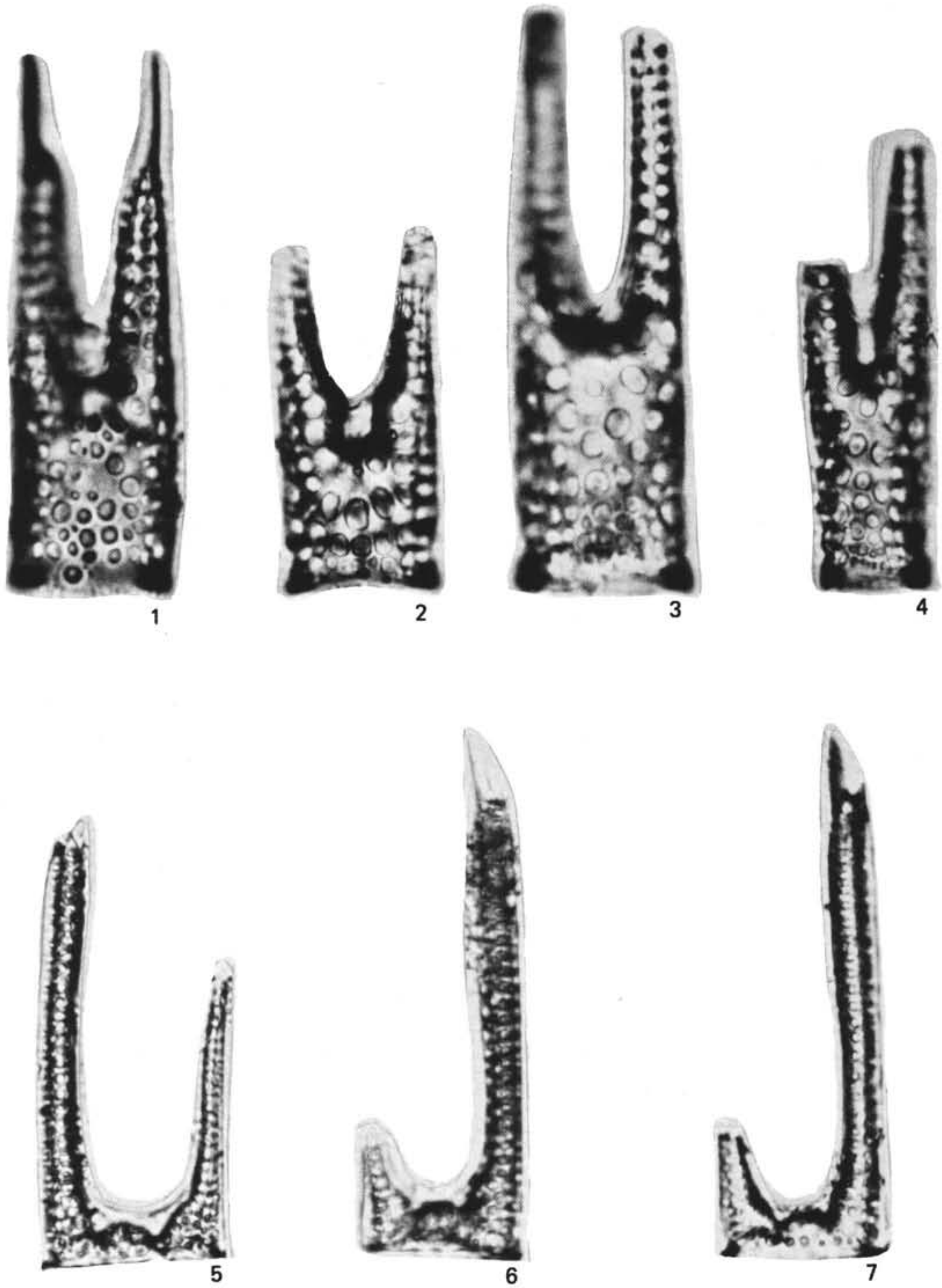


PLATE 21

Figures 1-7	*Pyrgupyxis prolongata* (Brun) Hendey. 1. Sample 328-4-1, 147-149 cm (700×). 2. Sample 328-4-1, 147-149 cm (700×). 3. Sample 328-4-1, 147-149 cm (700×). 4. Sample 328-4-1, 147-149 cm (700×). 5. Sample 328-4-1, 147-149 cm (1700×). 6. Sample 328-4-1, 147-149 cm (700×). 7. Sample 328-4-1, 147-149 cm (700×).
Figures 8-10	*Pyrgupyxis johnsoniana* Greville v. *corniculum* Brun. 8. Sample 328-4-1, 147-149 cm (700×). 9. Sample 328-4-2, 5-7 cm (850×). 10. Sample 328-4-1, 147-149 cm (750×).
Figure 11	*Pyrgupyxis* sp. B. Sample 328-4-1, 147-149 cm (750×).

PLATE 21

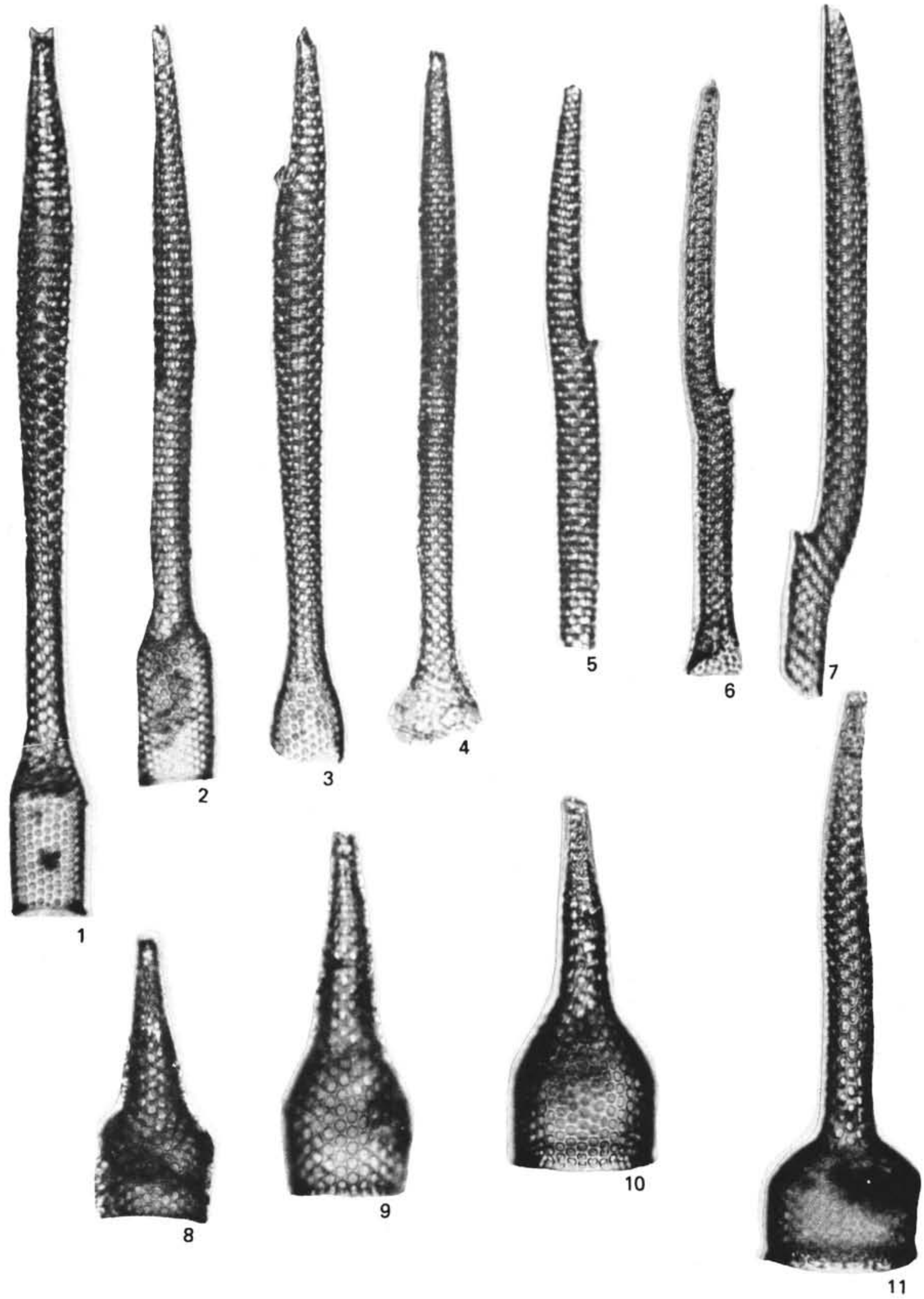


PLATE 22

Figures 1, 2	*Pyrgupyxis* sp. A. 1. Sample 328-4-2, 140-142 cm (750×). 2. Sample 328-4-2, 140-142 cm (800×).
Figure 3	*Pyrgupyxis* cf. *johnsoniana* (Greville) Hendey. Sample 328B-3-2, 70-72 cm (850×).
Figures 4, 5	*Pyrgupyxis johnsoniana* (Greville) Hendey. 4. Sample 328B-3-6, 70-72 cm (750×). 5. Sample 328-4-1, 147-149 cm (1800×).
Figures 6, 7	*Pyrgupyxis eocena* Hendey. 6. Sample 328-4-3, 5-7 cm (900×). 7. Sample 328-4-1, 147-149 cm (750×).
Figure 8	*Pyrgupyxis johnsoniana* (Greville) Hendey. Sample 328-4-2, 5-7 cm (800×).
Figures 9, 10	*Pyrgupyxis* sp. B. 9. Sample 328-4-1, 147-149 cm (300×). 10. Sample 328-4-1, 147-149 cm (300×).
Figure 11	*Pyrgupyxis prolongata* Brun. Sample 328-4-1, 147-149 cm (300×).

PLATE 22

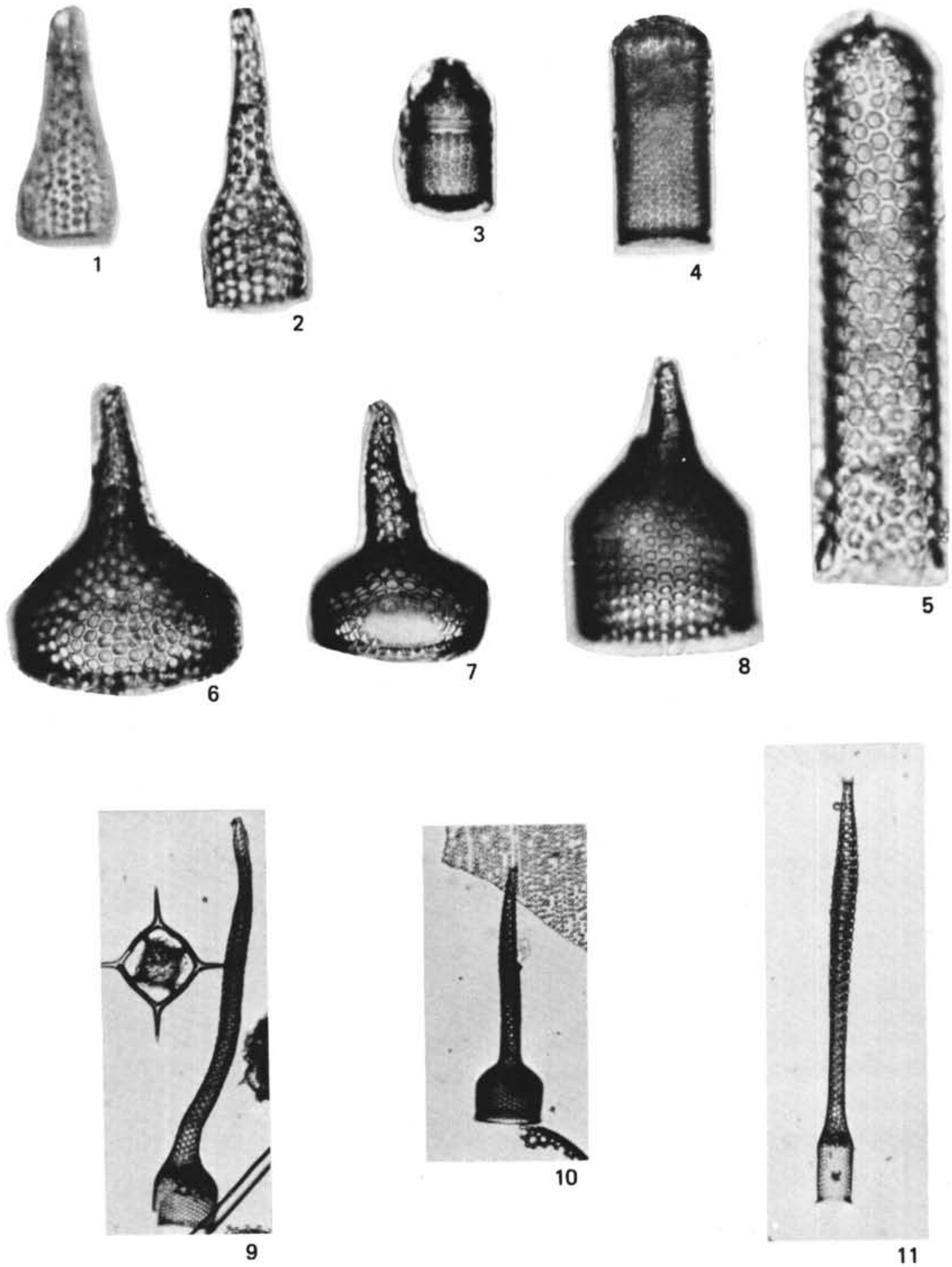


PLATE 23

Figures 1, 2	*Pterotheca aculeifera* Grunow. 1. Sample 328-4-1, 147-149 cm (1875×). 2. Sample 328-4-1, 147-149 cm (1850×).
Figures 3, 4	*Pterotheca* sp. A. 3. Sample 327A-6-1, 14-16 cm (1550×). 4. Sample 328-4-3, 5-7 cm (2100×).
Figure 5	*Pterotheca danica* Grunow. Sample 328-4-1, 147-149 cm (700×).
Figure 6	*Rhizosolenia* sp. A. Sample 328-4-1, 147-149 cm (1750×).
Figure 7	*Rhizosolenia* sp. B. Sample 328-4-1, 147-149 cm (300×).

PLATE 23

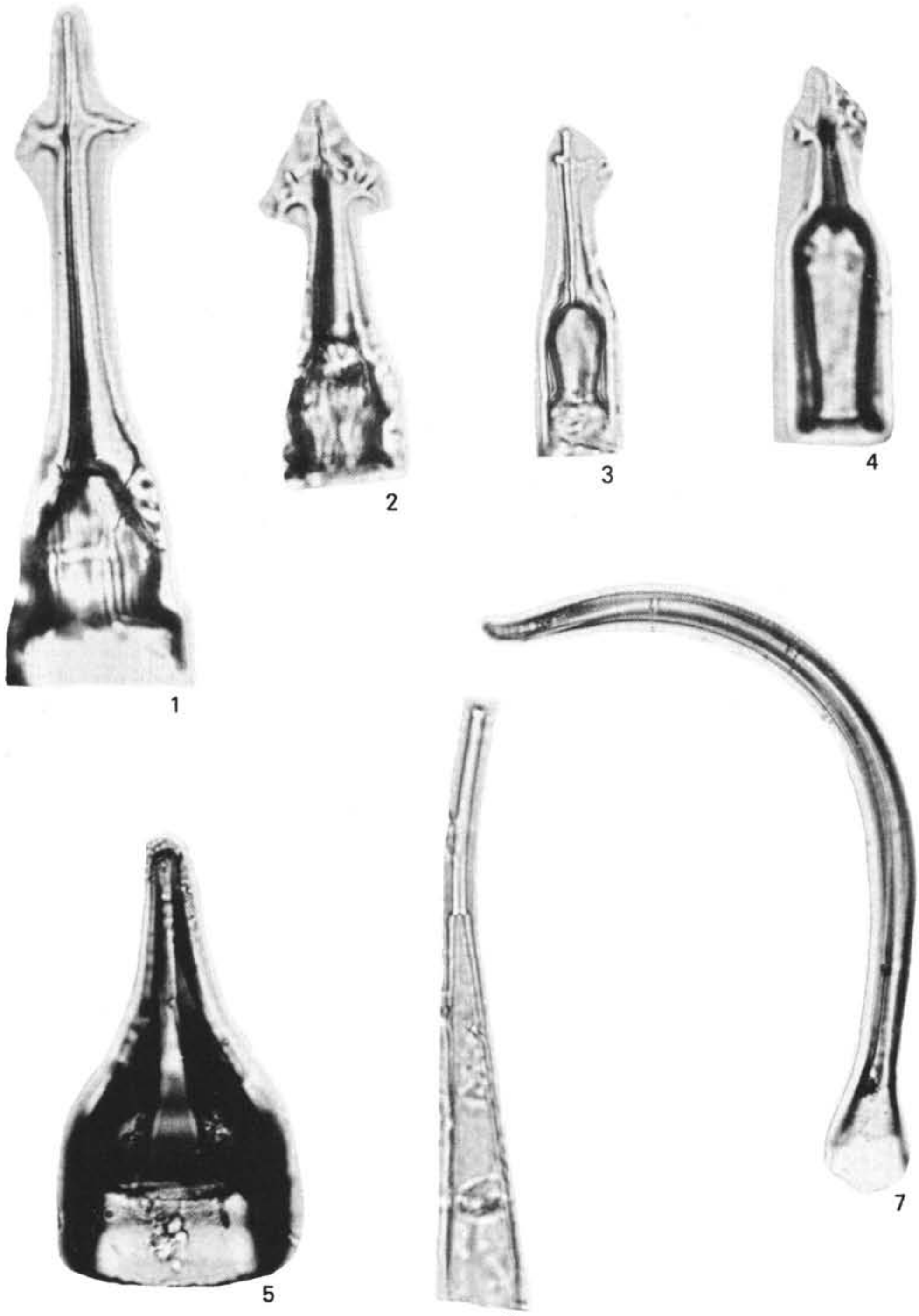


PLATE 24

Figures 1-6 *Chaetoceros* sp. A.
1, 2. Sample 328-4-1, 147-149 cm (1400×); (5500×).
3. Sample 328-4-1, 147-149 cm (700×).
4. Sample 330A-1-CC (900×).
5. Sample 328-4-1, 147-149 cm (1800×).
6. Sample 328-4-1, 147-149 cm (1900×).

PLATE 24

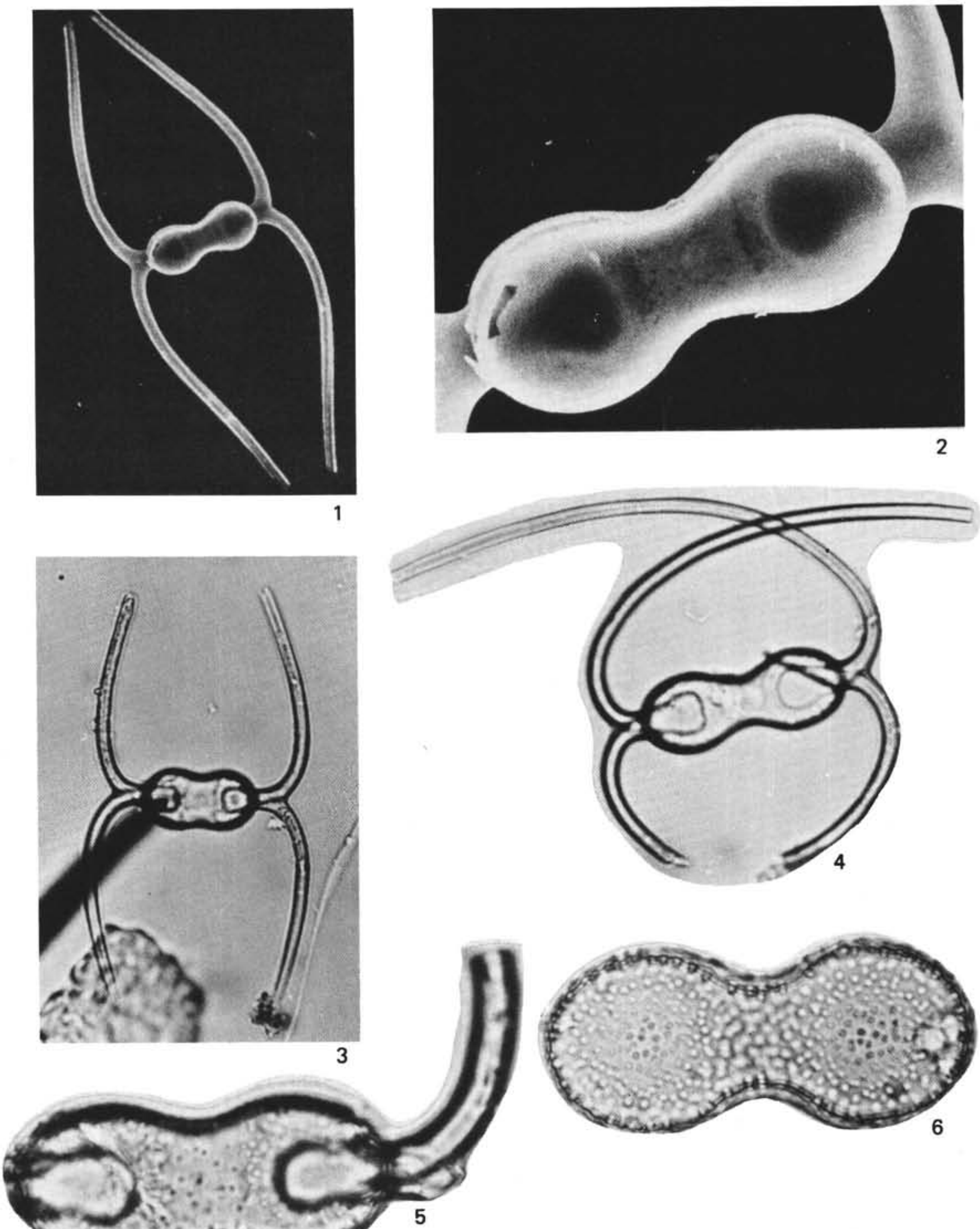


PLATE 25

Figures 1, 3, 5	*Asterolampra vulgaris* Greville. 1. Sample 330A-1-CC (850×). 3. Sample 330A-1-CC (850×). 5. Sample 330A-1-CC (850×).
Figures 2, 4	*Asterolampra insignis* Schmidt. 2. Sample 330A-1-CC (875×). 4. Sample 328-4-1, 147-149 cm (775×).
Figures 6, 7	*Stictodiscus californicus* v. *nitida* Gr. and St. 6. Sample 328-4-1, 147-149 cm (750×). 7. Sample 328-4-1, 147-149 cm (1800×).

PLATE 25

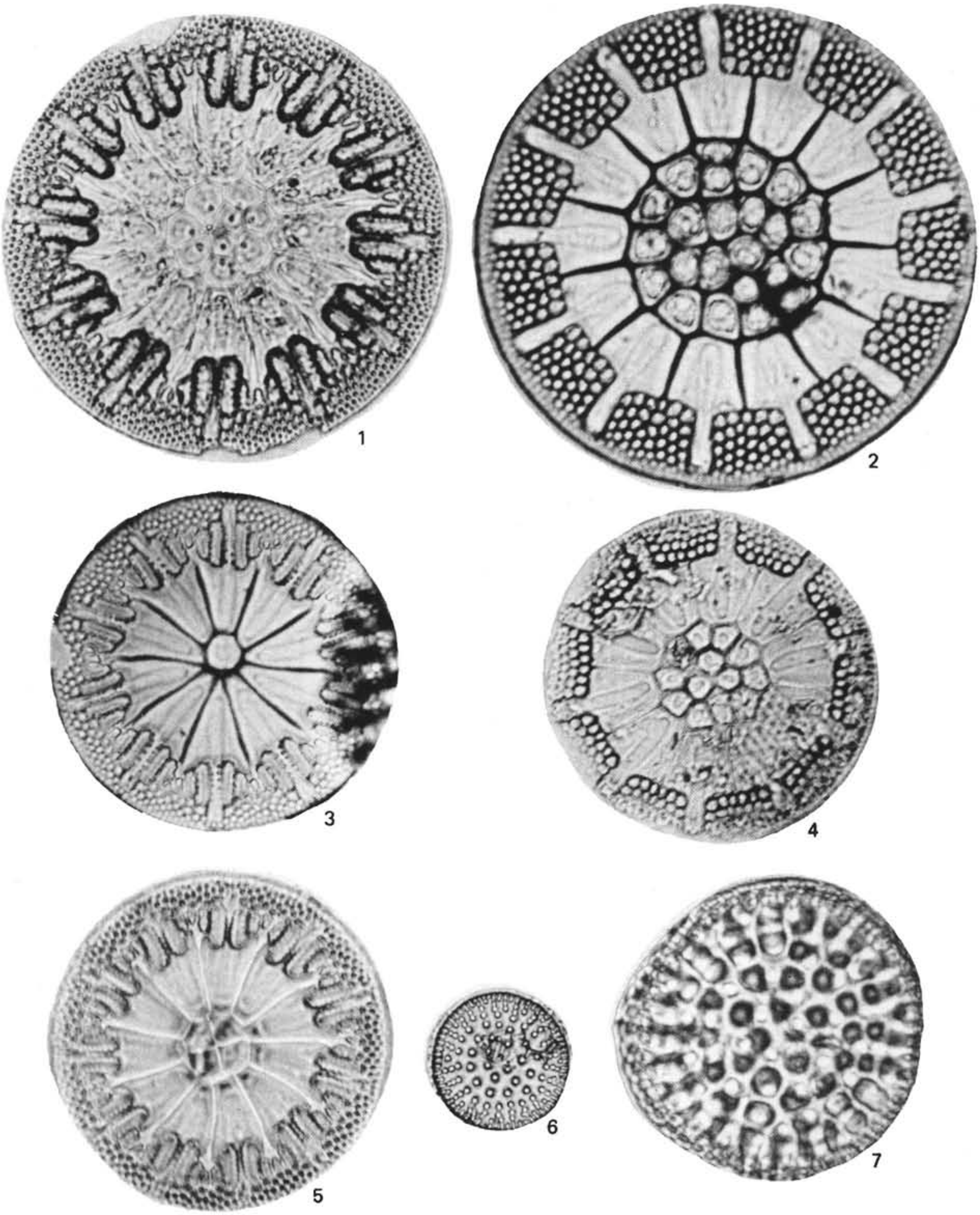


PLATE 26

Figures 1-3	*Actinoptychus undulatus* s.l. (Bailey) Ralfs. 1. Sample 328-4-1, 147-149 cm (750×). 2. Sample 328-4-1, 147-149 cm (750×). 3. Sample 328-3-2, 140-142 cm (1850×).
Figure 4	*Arachnoidiscus* cf. *ehrenbergii* Deane. Sample 328-4-1, 147-149 cm (750×).
Figures 5-7	*Melosira architecturalis* Brun. 5. Sample 328-4-1, 147-149 cm (1800×). 6. Sample 328-4-1, 147-149 cm (1800×). 7. Sample 328-4-3, 5-7 cm (1550×).

PLATE 26

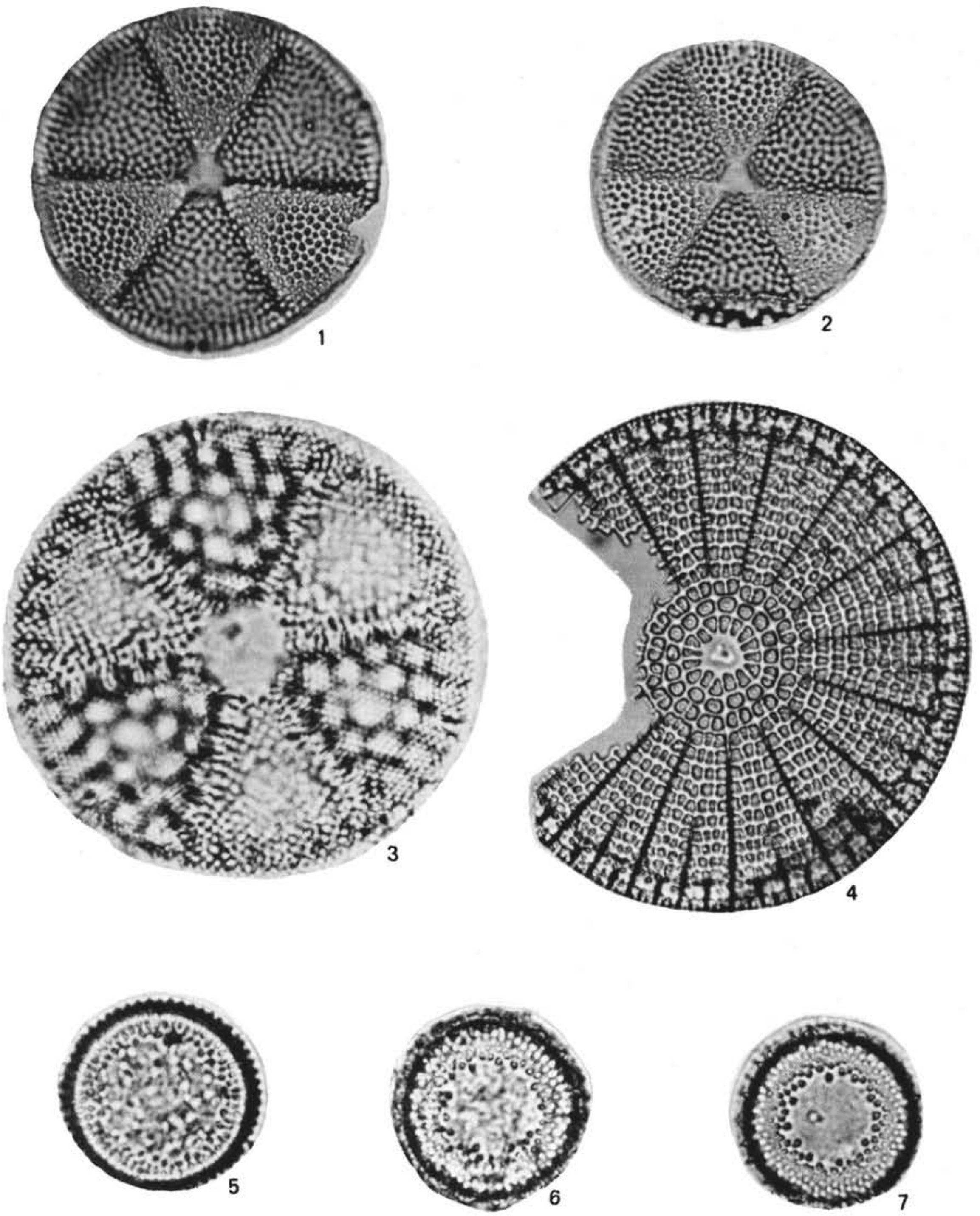


PLATE 27

Figure 1	*Stephanopyxis* ? sp. Sample 328-4-1, 147-149 cm (1900×).
Figure 2	*Coscinodiscus* cf. *vetutissimus* Pantocsek. Sample 328-4-1, 147-149 cm (750×).
Figures 3, 4	*Brightwellia pulchra* Grunow. 3. Sample 328-4-1, 147-149 cm (750×). 4. Sample 328-4-1, 147-149 cm (700×).
Figure 5	*Stephanopyxis* cf. *simonseni* Hajos. Sample 327A-5-1, 45-48 cm (700×).
Figure 6	*Craspedodiscus molleri* Schmidt. Sample 328-4-1, 147-149 cm (700×).

PLATE 27

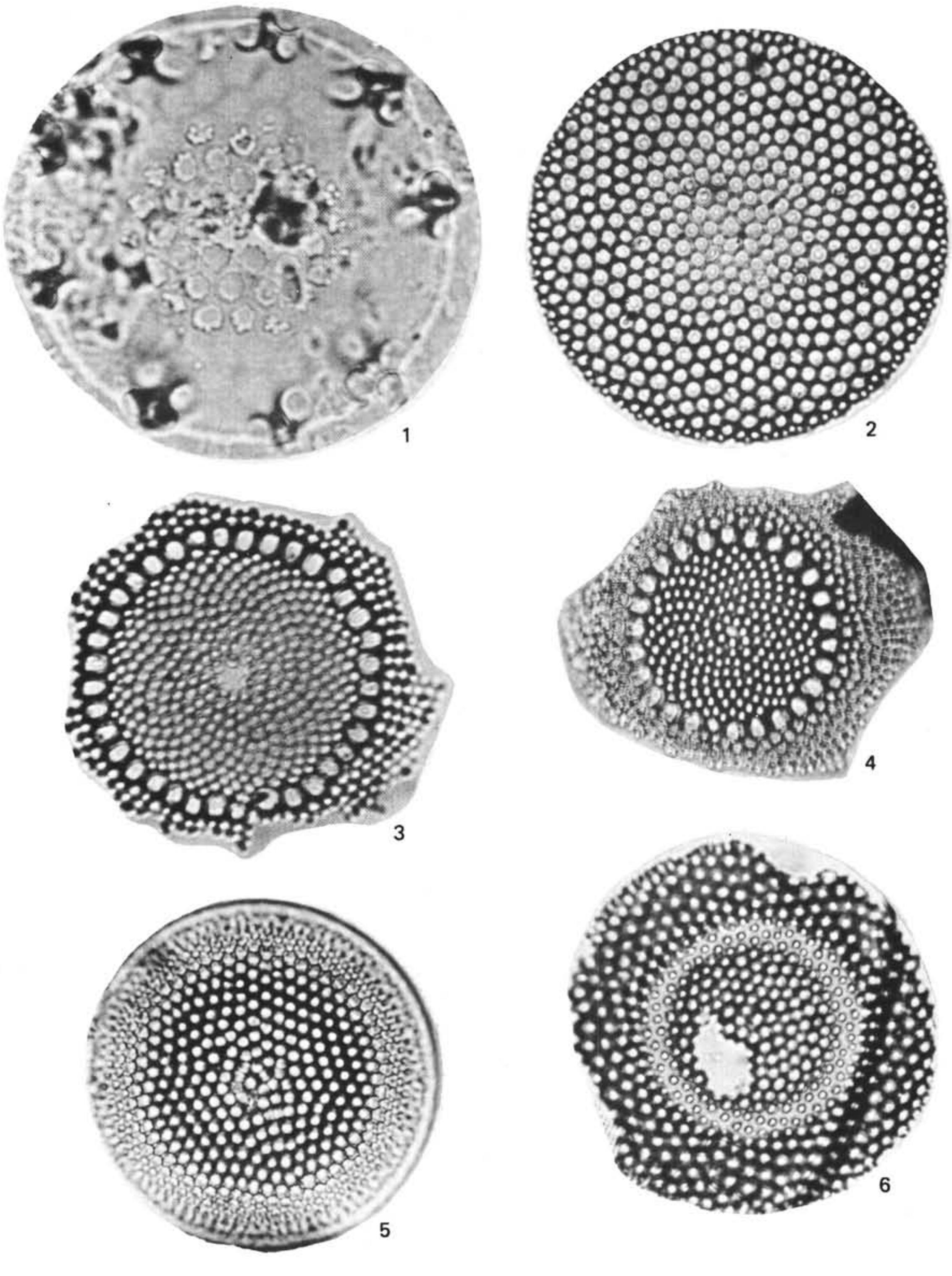


PLATE 28

Figures 1, 2	*Stephanopyxis* sp. A. Sample 328-4-1, 147-149 cm (750×).
Figures 3-5	*Stephanopyxis grunowii* Grove and Sturt. 3, 4. Sample 328-4-1, 147-149 cm (500×). 5. Sample 328-4-1, 147-149 cm (700×).
Figure 6	*Stephanopyxis* cf. *schenckii* Kanaya. Sample 328-4-1, 147-149 cm (1800×).

PLATE 28

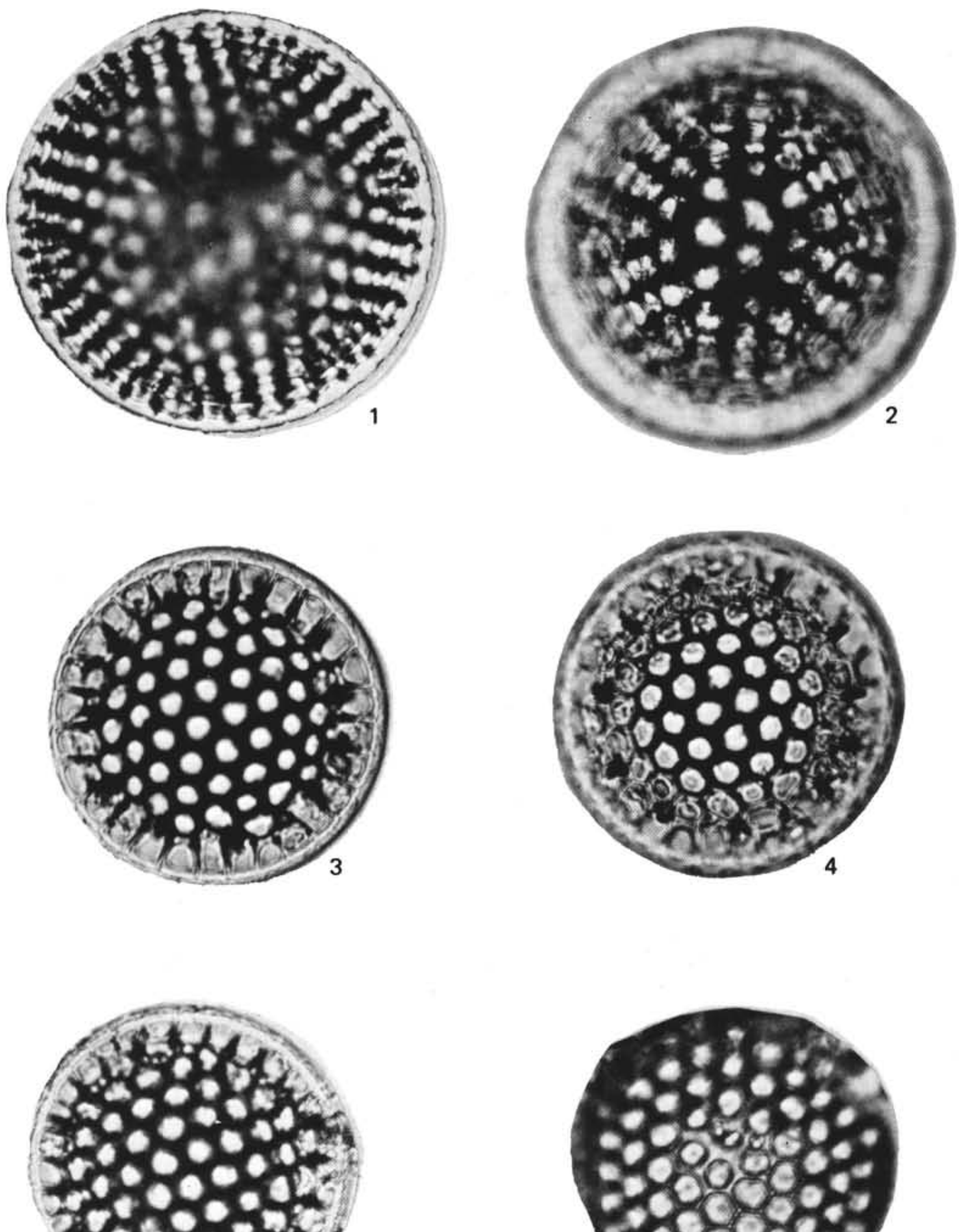


PLATE 29

Figures 1-4	*Stephanopyxis superba* (Greville) Grunow. 1, 2. Sample 328-4-1, 147-149 cm (1900×). 3, 4. Sample 328-4-1, 147-149 cm (1850×).
Figure 5	*Stephanopyxis* cf. *grunowii* Grove and Sturt. Sample 328-4-1, 147-149 cm (1800×).

PLATE 29

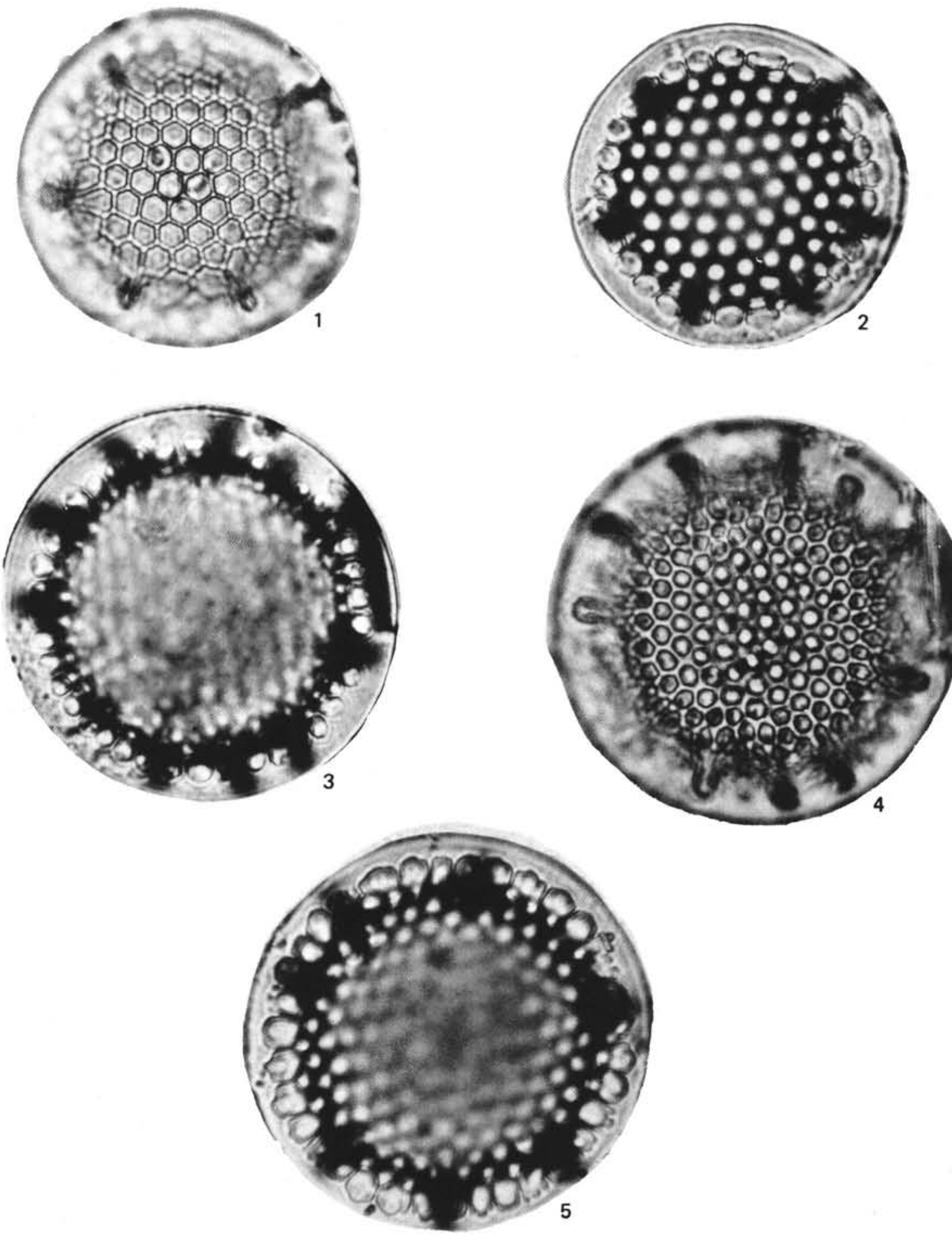


PLATE 30

Figures 1, 2	*Stephanopyxis superba* (Greville) Grunow v. *bispinosa* n. v. Sample 328-4-3, 81-83 cm (1600×).
Figures 3-6	*Stephanopyxis superba* (Greville) Grunow v. *trispinosa* n. v. 3, 4. Sample 328-4-1, 147-149 cm (1950×), Holotype. 5, 6. Sample 328-4-1, 147-149 cm (3000×).
Figure 7	*Stephanopyxis* cf. *hyalomarginata* Hajos. Sample 328-4-2, 140-142 cm (875×).
Figure 8	*Stephanopyxis superba* (Greville) Grunow v. *bispinosa* n. v. Sample 328B-4-2, 131-133 cm (1550×), Holotype.
Figure 9	*Stephanopyxis superba* (Greville) Grunow v. *trispinosa* n. v. Sample 328-4-1, 147-149 cm (1800×).

PLATE 30

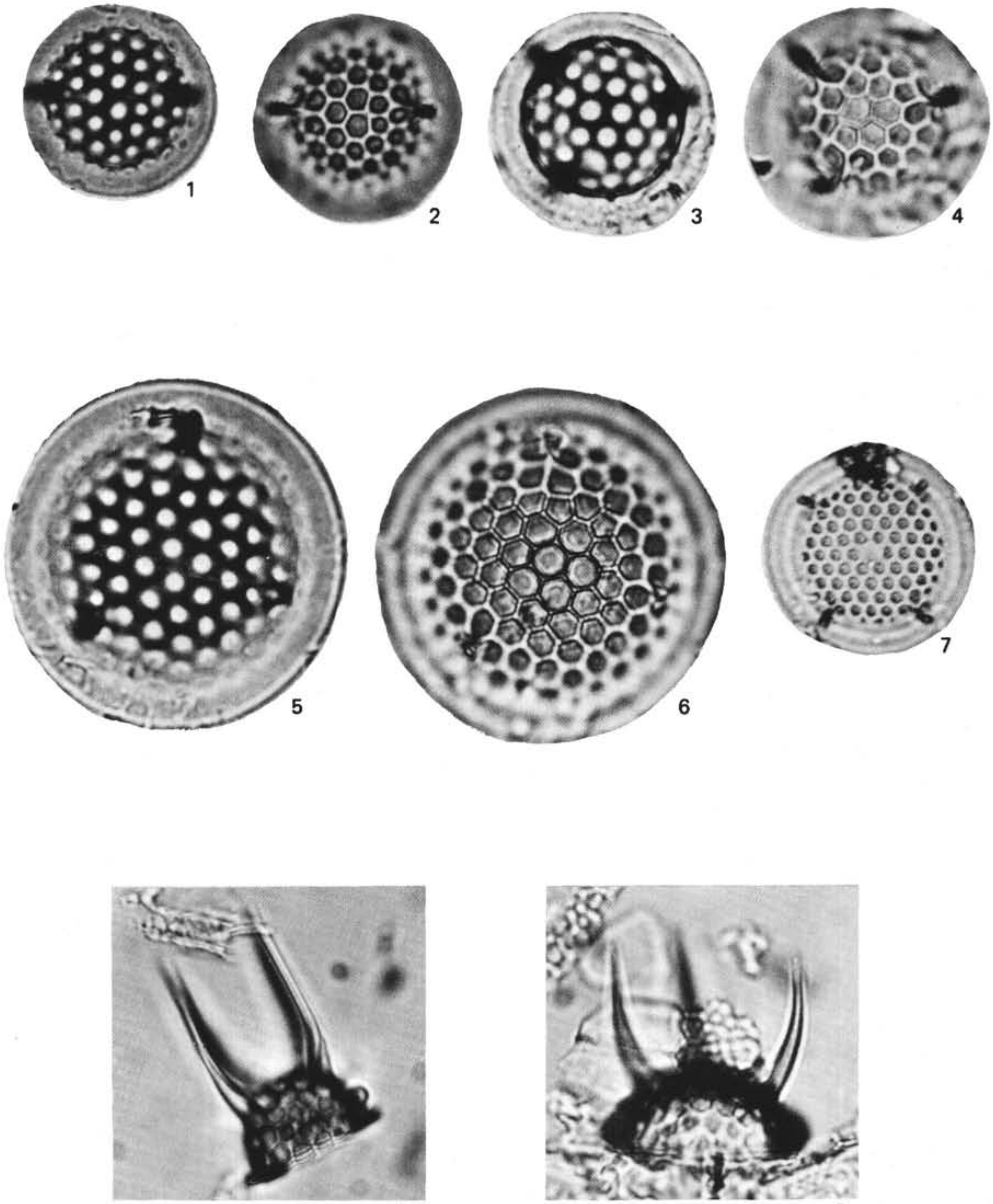


PLATE 31

Figures 1, 2	*Stephanopyxis grunowii* Grove and Sturt. Sample 328-4-1, 147-149 cm (1950×).
Figures 3, 4	*Stephanopyxis eocenica* Hajos. 3. Sample 328-4-1, 147-149 cm (750×). 4. Sample 328-4-1, 147-149 cm (800×).
Figure 5	*Stephanopyxis* cf. *eocenica* Hajos. Sample 328B-4-2, 131-133 cm (875×).
Figure 6	*Stephanopyxis hyalomarginata* Hajos. Sample 328B-4-1, 144-146 cm (800×).
Figure 7	*Stephanopyxis grunowii* Grove and Sturt. Sample 328B-4-2, 131-133 cm (850×).

PLATE 31

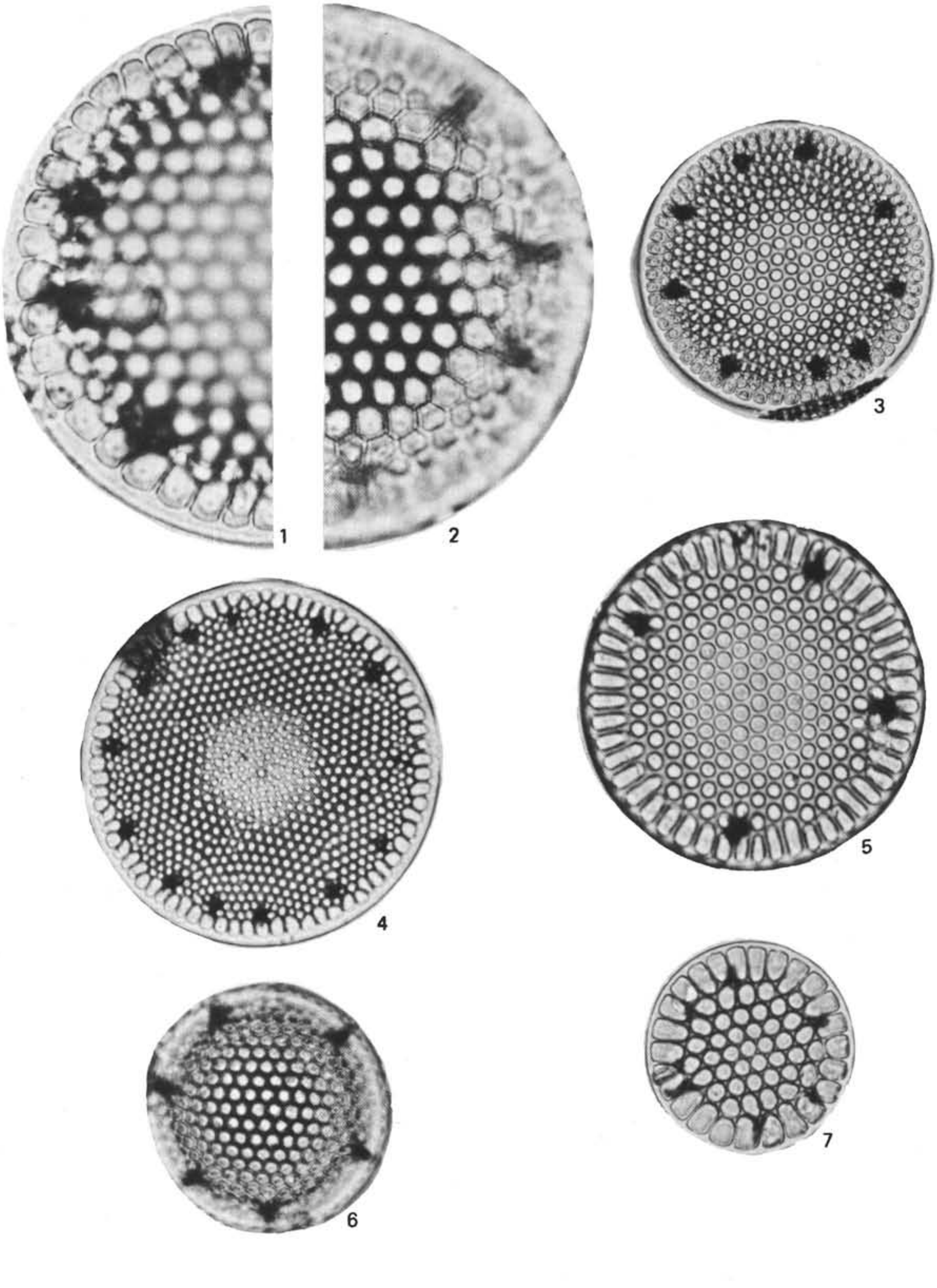
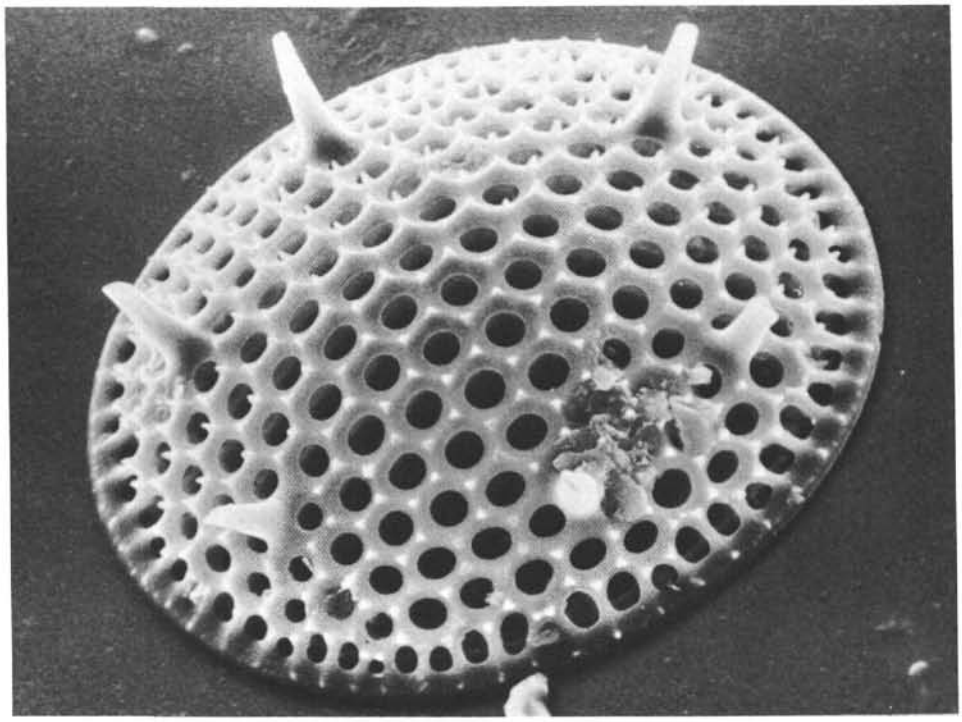


PLATE 32

Figures 1-3	*Stephanopyxis grunowii* Grove and Sturt. 1. Sample 328-4-1, 147-149 cm (2850×). +35°. 2, 3. Sample 328-4-1, 147-149 cm (800×).

PLATE 32



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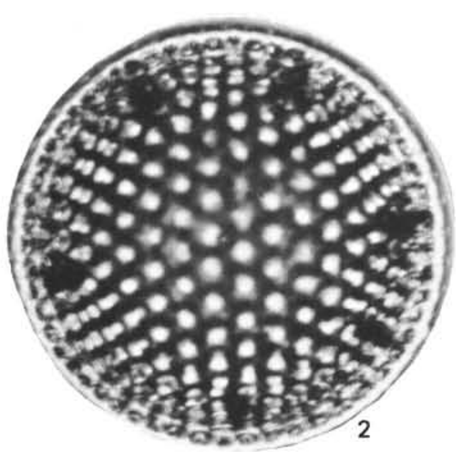

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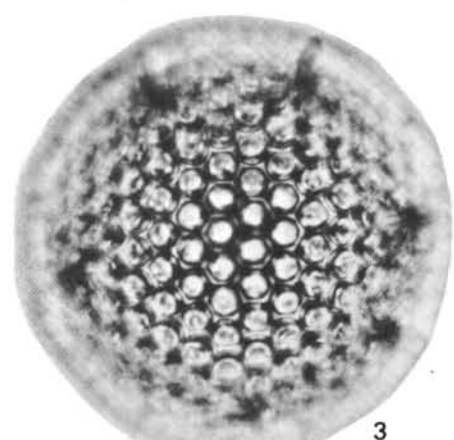


3

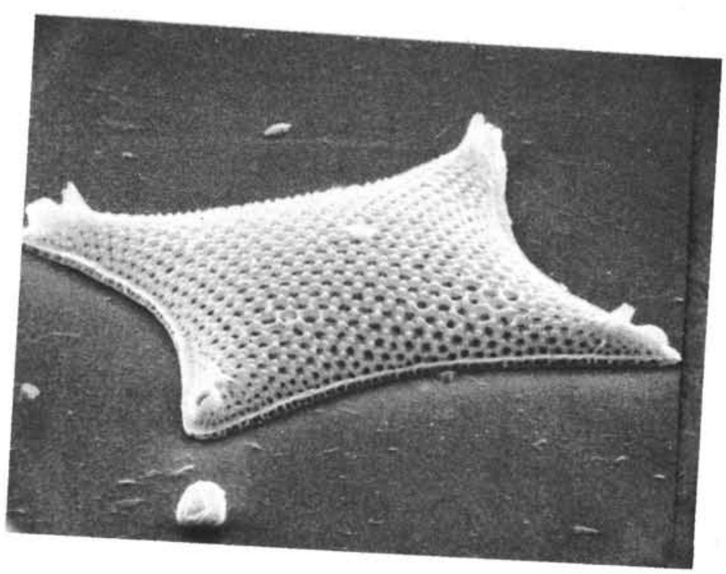
PLATE 33

Figures 1, 3	*Triceratium unguiculatum* Greville. 1. Sample 328-4-1, 147-149 cm (750×). 3. Sample 328-4-1, 147-149 cm (650×).
Figure 2	*Triceratium* cf. *pulvinar* Schmidt. Sample 330A-1-CC (800×).

PLATE 33

1

2

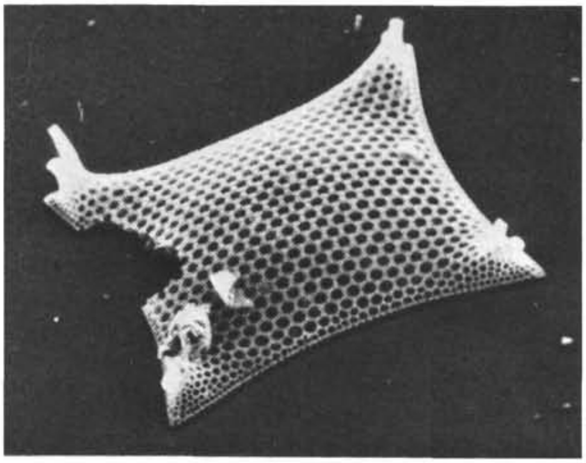


3

PLATE 34

Figures 1-6	*Triceratium unguiculatum* Greville.
	1. Sample 328-4-1, 147-149 cm (600×).
	2. Sample 328-4-1, 147-149 cm (600×).
	3. Sample 330A-1, CC (850×).
	4. Sample 330A-1, CC (4200×).
	5. Sample 330A-1, CC (850×).
	6. Sample 330A-1, CC (850×).

PLATE 34



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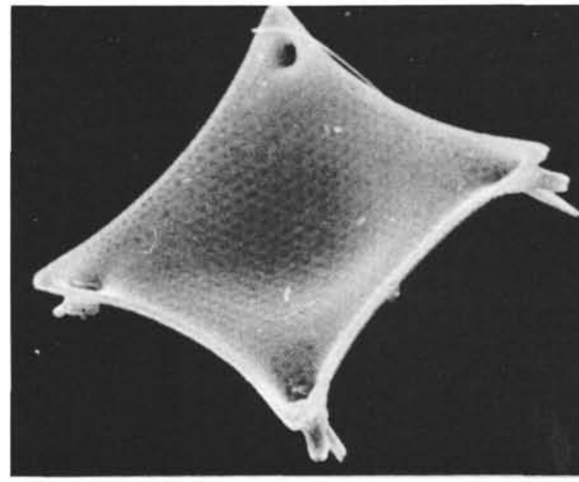

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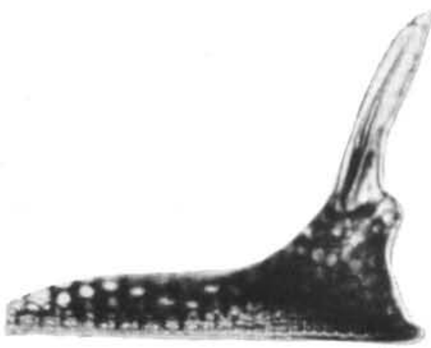

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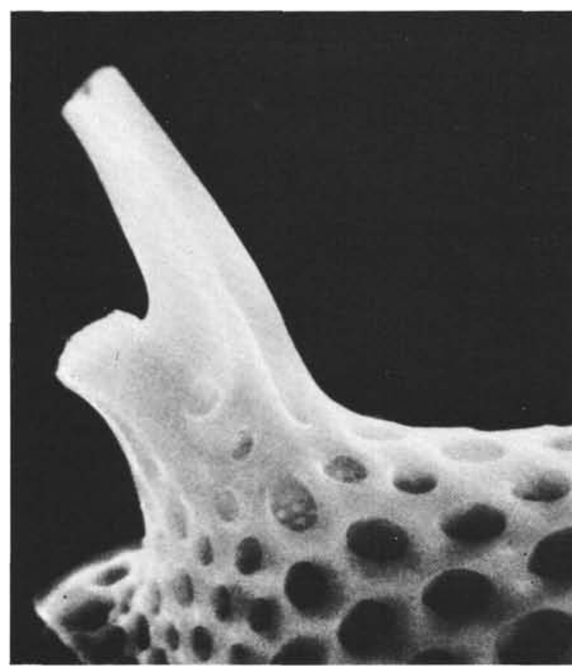

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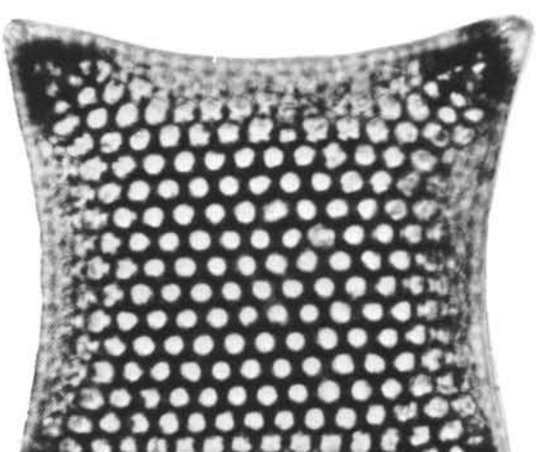

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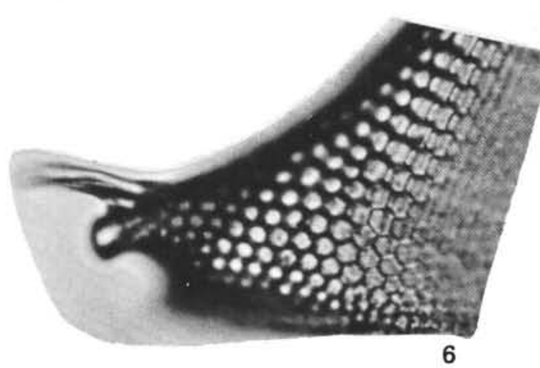


6

PLATE 35

Figures 1, 2, 4	*Trinacria simulacrum* Grove and Sturt. 1. Sample 328-4-1, 147-149 cm (750×). 2. Sample 327A-7-2, 45-47 cm (800×). 4. Sample 327A-7-2, 45-47 cm (800×).
Figure 3	*Trinacria simulacrum* Grove and Sturt. Aberrant form. Sample 327A-5-5, 119-121 cm (800×).

PLATE 35

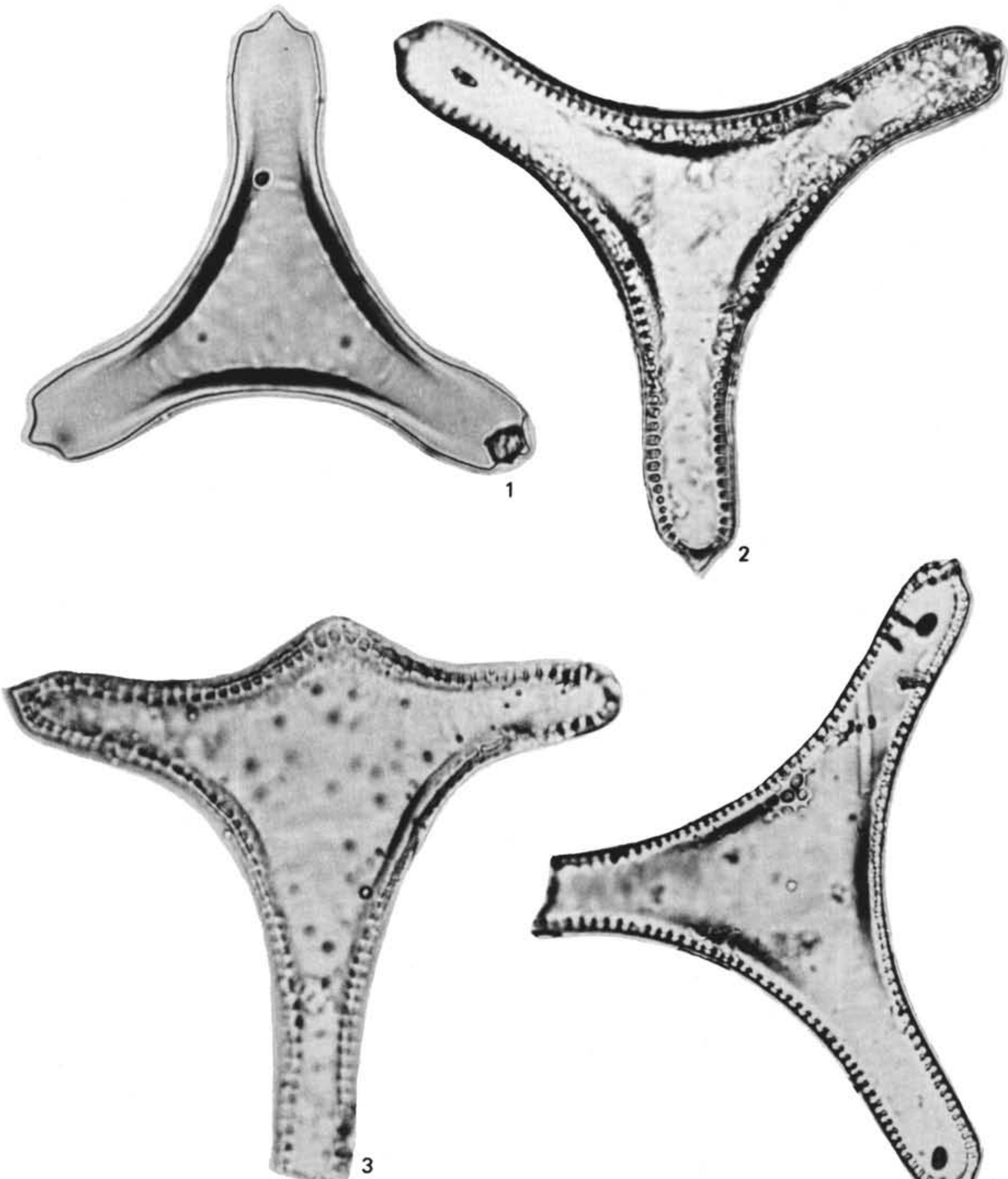


PLATE 36

Figures 1-4	*Trinacria simulacrum* Grove and Sturt. 1, 2. Sample 327A-7-2, 45-47 cm (750×). 3. Sample 327A-5-1, 45-48 cm (850×). 4. Sample 327A-7-2, 45-47 cm (750×).

PLATE 36

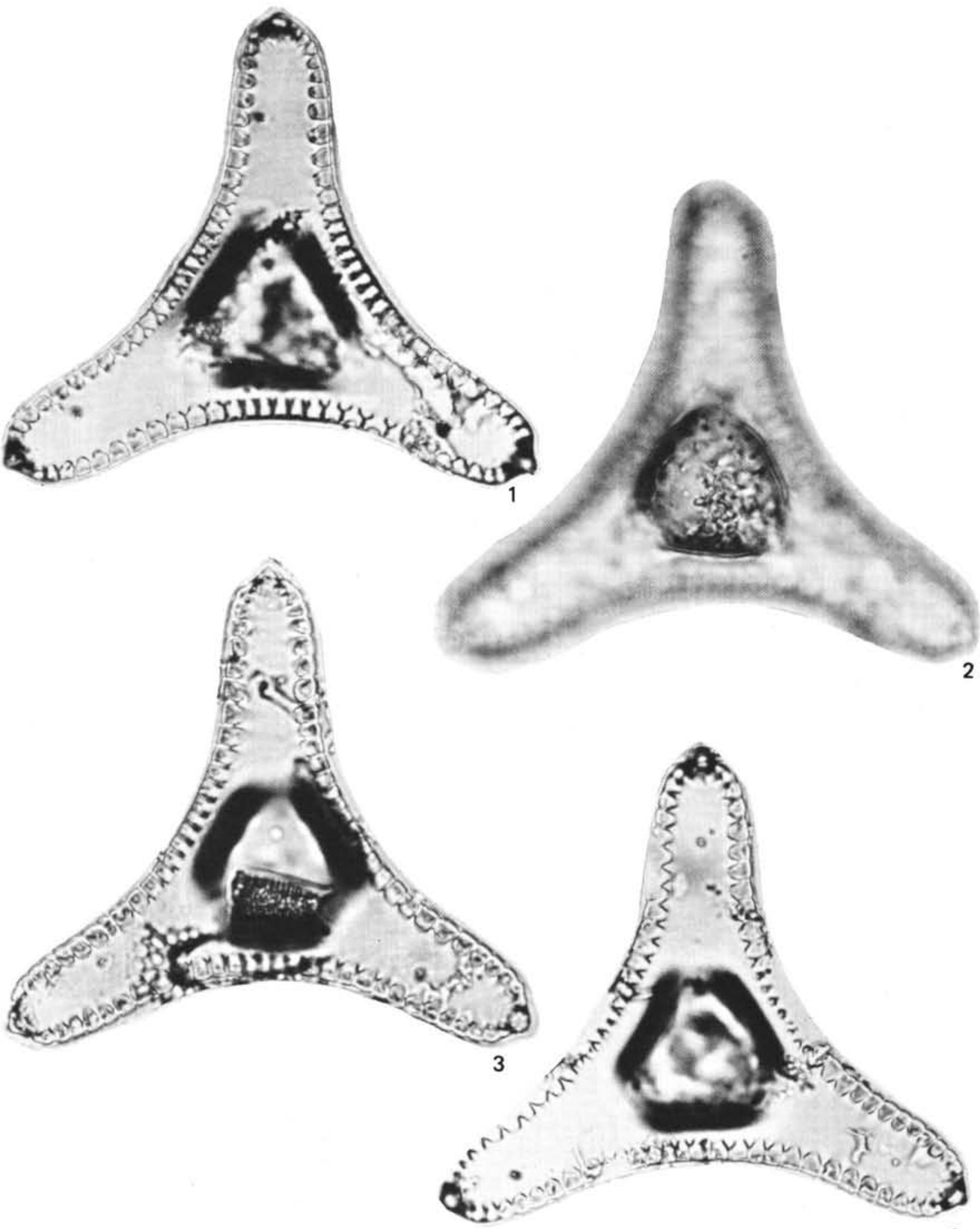


PLATE 37

Figures 1, 2	*Triceratium* cf. *tessellatum* Greville. 1. Sample 327A-5-1, 45-48 cm (1600×). 2. Sample 327A-5-1, 45-48 cm (1250×).
Figures 3, 4	*Trinacria pileolus* (Ehr.) Grunow. Sample 327A-5-1, 45-48 cm (600×).
Figure 5	*Triceratium abyssorum* Grunow. Sample 328-4-1, 147-149 cm (800×).
Figure 6	*Trinacria excavata* Heiberg. Sample 328-4-1, 147-149 cm (650×).

PLATE 37

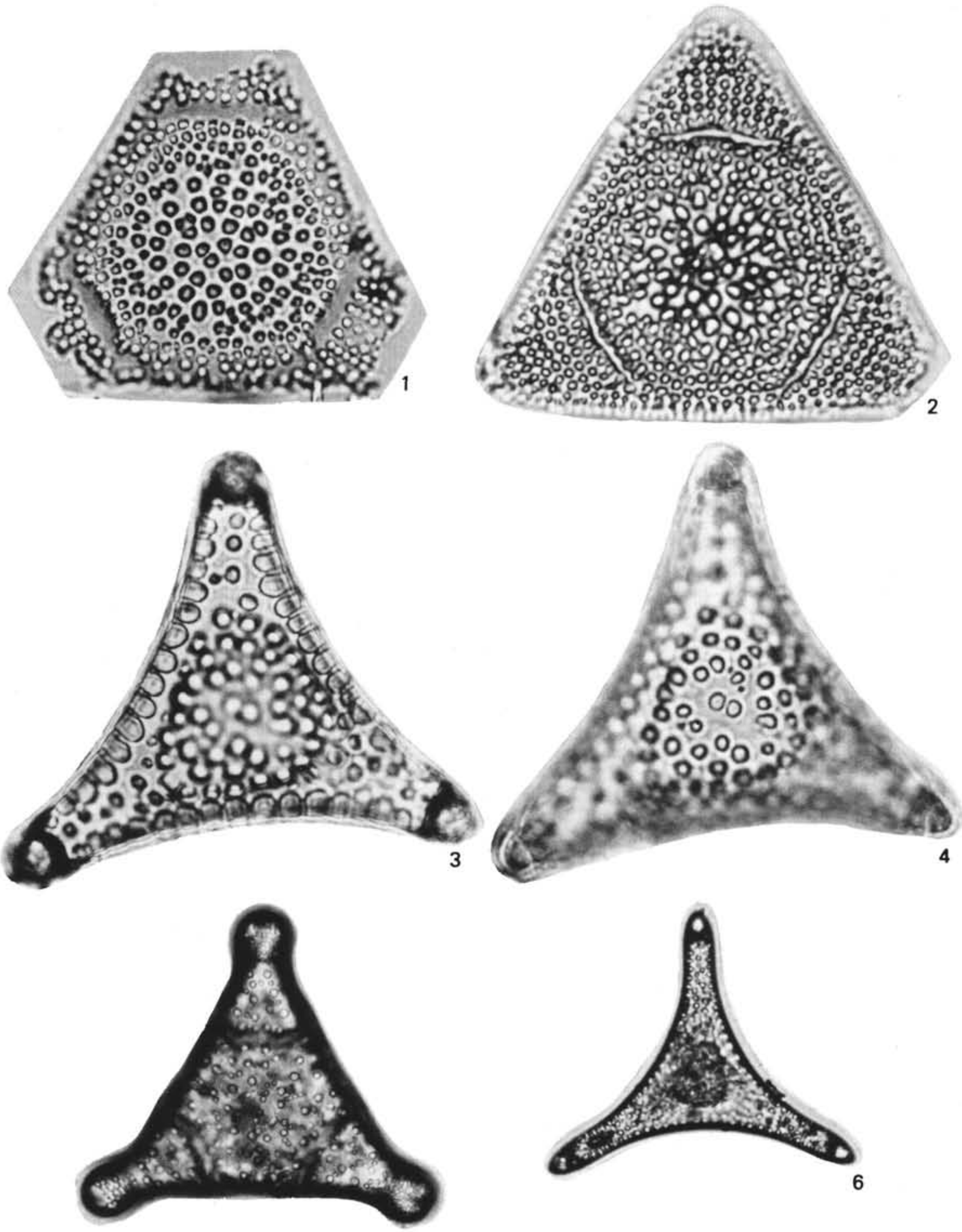


PLATE 38

Figure 1	*Trinacria* cf. *pileolus* (Ehr.) Grunow. Sample 327A-7-2, 45-47 cm (1600×).
Figure 2	*Triceratium crenulatum* Grove and Sturt. Sample 328-4-1, 147-149 cm (700×).
Figures 3, 4, 6	*Trinacria aries* Witt. 3. Sample 327A-7-2, 45-47 cm (1500×). 4. Sample 327A-7-2, 45-47 cm (1500×). 6. Sample 327A-5-4, 138-139 cm (1500×).
Figure 5	*Triceratium gracillium* Hustedt. Sample 327A-5-1, 45-48 cm (1600×).

PLATE 38

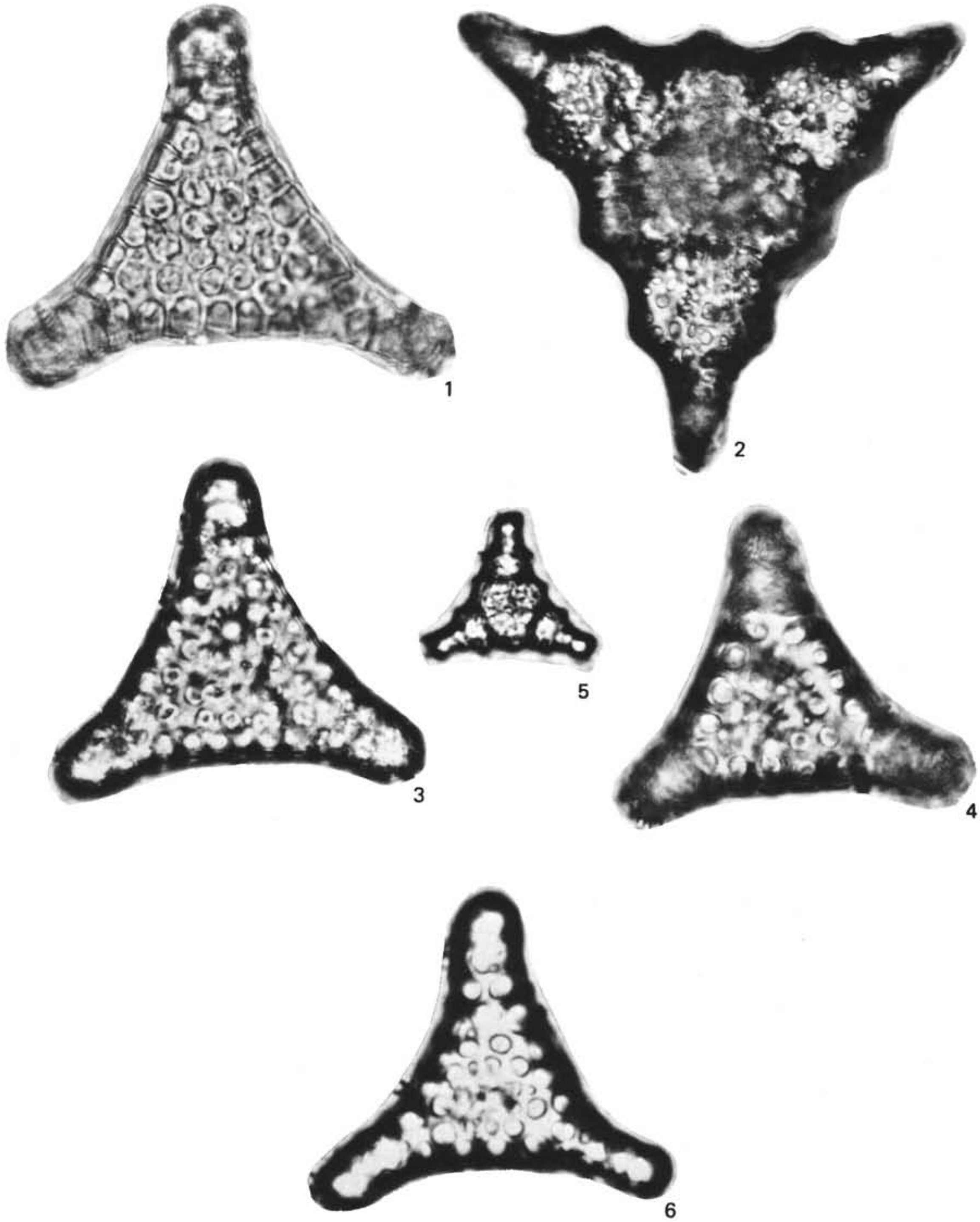
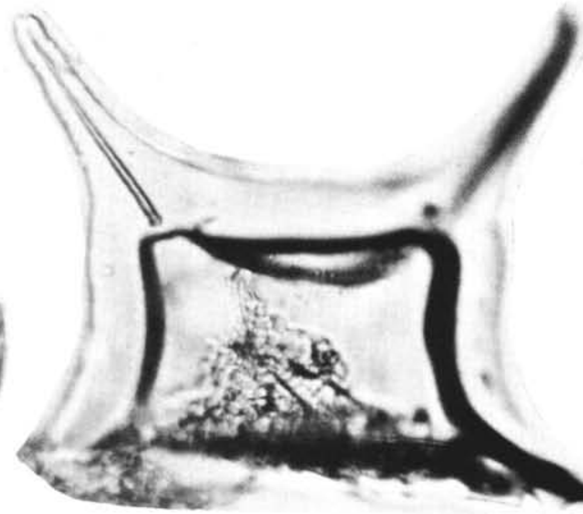


PLATE 39

Figures 1-4 *Odontotropis klavsenii* Debes.

1. Sample 327A-7-2, 45-47 cm (700×).
2. Sample 327A-7-2, 45-47 cm (900×).
3. Sample 327A-7-2, 147-148 cm (700×).
4. Sample 327A-7-2, 45-47 cm (650×).

PLATE 39



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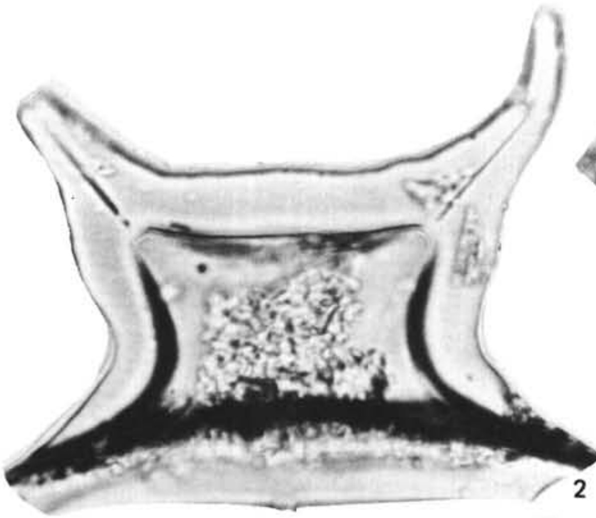

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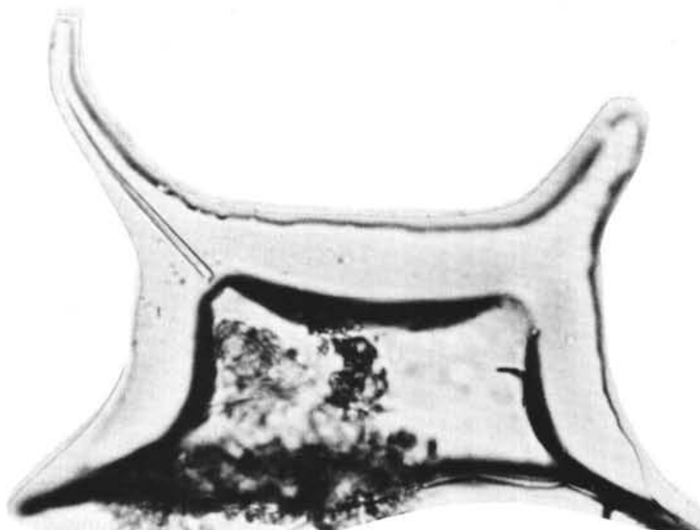


3

4

PLATE 40

Figure 1	*Goniothecium odontella* Ehrenberg. Sample 328-4-1, 147-149 cm (1850×).
Figures 2, 3	Genus et species indet. (B). 2. Sample 328-4-1, 147-149 cm (1925×). 3. Sample 328-4-1, 147-149 cm (1850×).
Figures 4, 8	Genus et species indet. (A). 4. Sample 328-3-6, 81-83 cm (1900×). 8. Sample 327A-5-1, 45-48 cm (1575×).
Figures 5, 6	*Coscinodiscus vigilans* Schmidt. 5. Sample 328B-3-5, 143-145 cm (600×). 6. Sample 328B-3-4, 70-72 cm (900×).
Figure 7	*Pseudorutilaria monile* Grove and Sturt. Sample 328-4-1, 147-149 cm (800×).
Figure 9	*Eunotia* cf. *monodon* Ehrenberg. Sample 328-4-1, 147-149 cm (750×).
Figure 10	*Pterotheca* ?. Sample 328-4-1, 147-149 cm (1950×).

PLATE 40

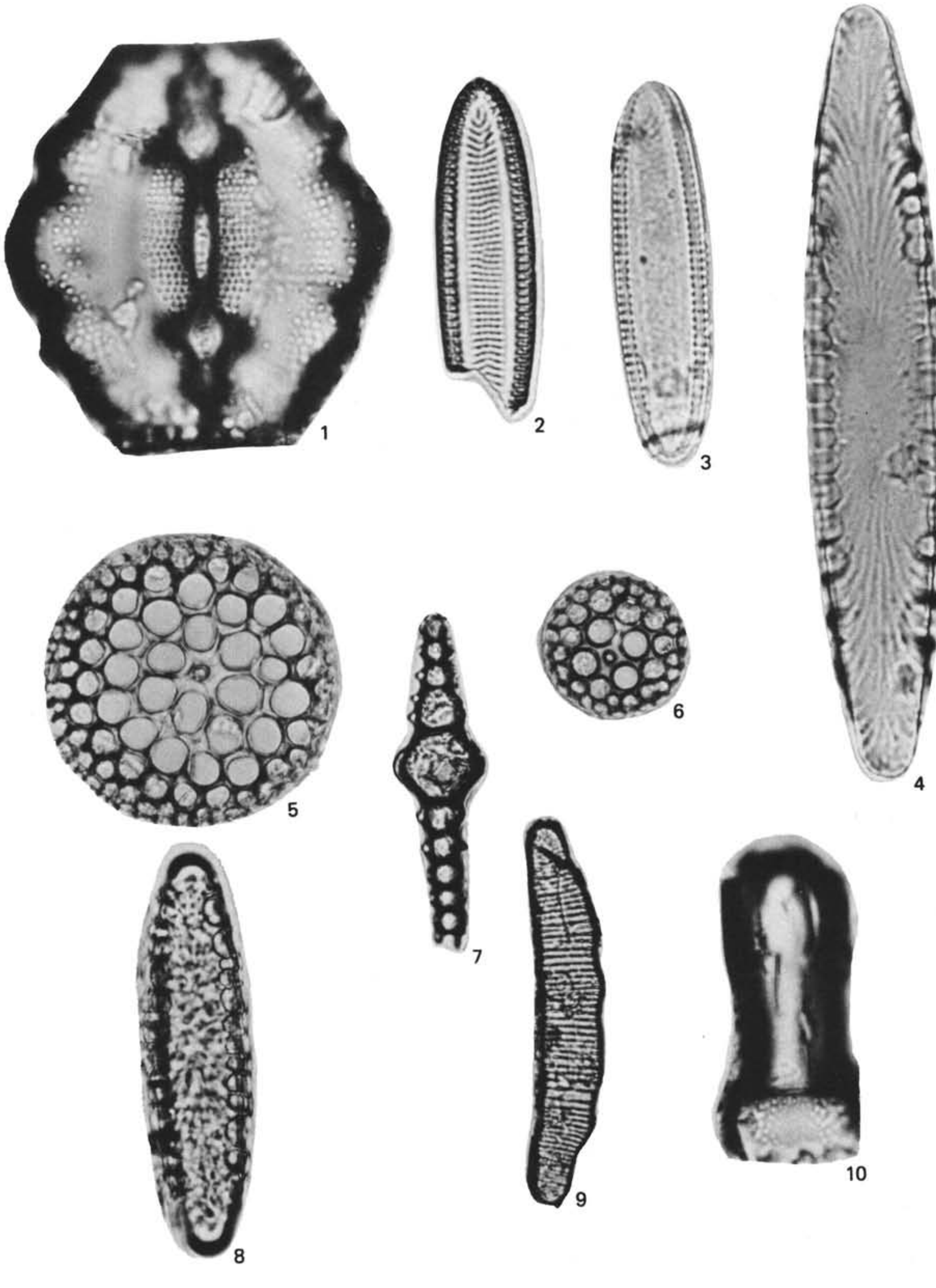
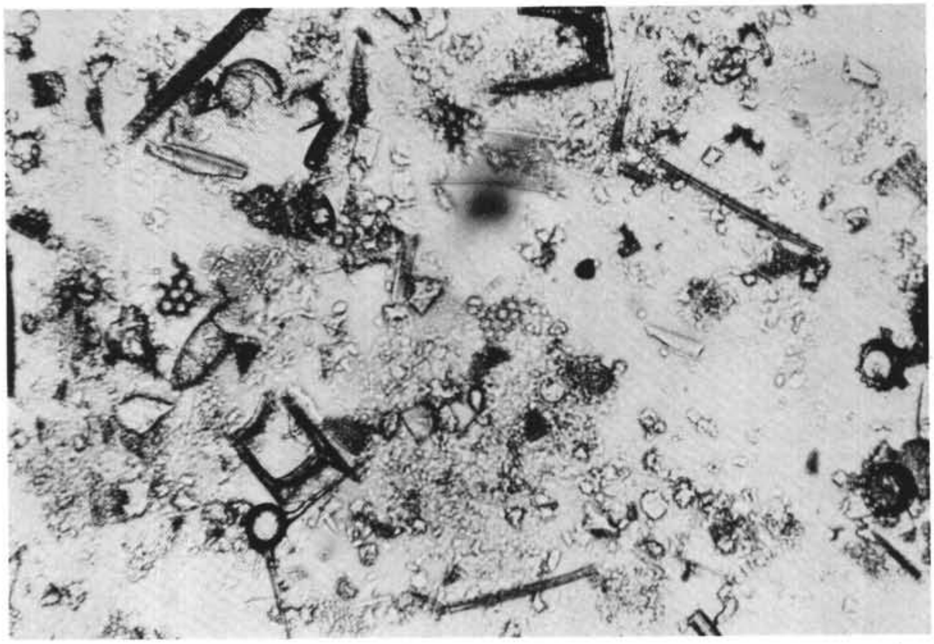


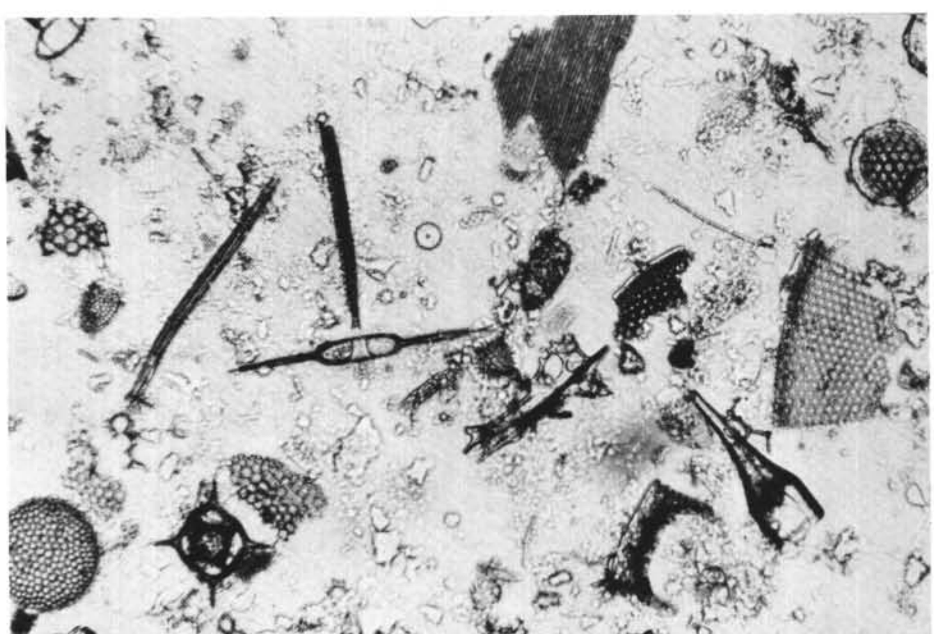
PLATE 41

Figures 1, 2 Typical fields of view of late Eocene siliceous interval at Site 328.
1. Sample 328-4-1, 147-149 cm (300×).
2. Sample 328-4-1, 147-149 cm (300×).

PLATE 41



1

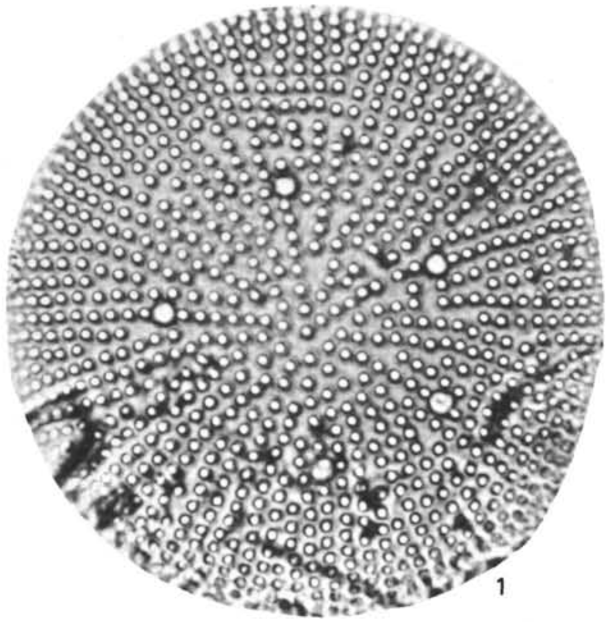


2

PLATE 42

Figures 1, 2 *Coscinodiscus vulnificus* n. sp.
1. Sample 328-2-1, 148-150 cm, Holotype (1650×).
2. Same specimen (4000×).

PLATE 42



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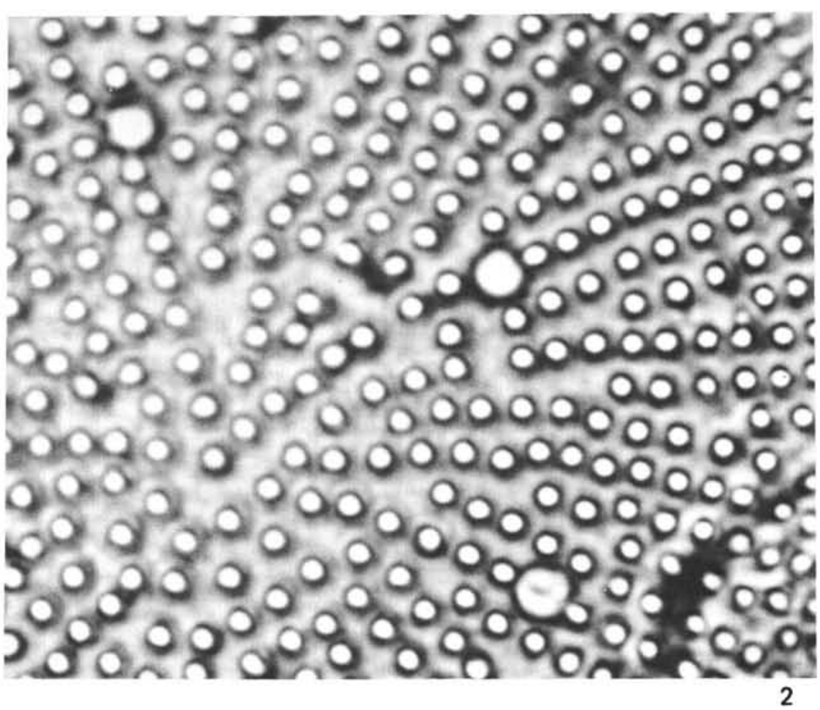

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