32. COCCOLITH AND SILICOFLAGELLATE STRATIGRAPHY, SOUTH ATLANTIC OCEAN, DEEP SEA DRILLING PROJECT LEG 39

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INTRODUCTION

Leg 39 of the Deep Sea Drilling Project, September to December 1974, which began at Amsterdam, Netherlands, and ended at Cape Town, South Africa (Figure 1), recovered 165 cores at seven drilling sites, Sites 353-359. Light-microscope techniques were used to study the coccoliths and silicoflagellates of 220 samples from these sites.

As a result of studies of the silicoflagellates from Site 356, an Eocene *Dictyocha spinosa* Subzone is newly defined, and the definitions of the *Dictyocha hexacantha* Zone and *Naviculopsis foliacea* Zone are emended. Two new silicoflagellates are described—*Mesocena venusta* n. sp. and *Macrora najae* n. sp. Several revisions of silicoflagellate taxonomy are proposed: *Mesocena occidentalis* Hanna ex Bukry, a validation; *Mesocena tsumurai* nom. nov., a substitute name; lectotype designations for *Mesocena oamaruensis quadrangula* Schulz and *Naviculopsis biapiculata* (Lemmermann); and *Macrora barbadensis* (Deflandre), a new combination.

Site 353
(lat 10°55.00′N, long 44°02.25′W, depth 5165 m)

Site 353, near the north wall of the Vema Fracture Zone, was drilled primarily to sample igneous basement rock. Only three sediment cores were recovered from the interval 0 to 271 meters. The deepest sample available, 353-3-2, 138-139 cm (262 m), contains a warm-water late Quaternary coccolith assemblage including *Ceratolithus cristatus, Gephyrocapsa oceanica, G. omega,* and *Helicopontosphaera wallichii.*

Site 354
(lat 05°53.95′N, long 44°11.78′W, depth 4052 m)

Site 354, on the western margin of the Ceará Rise, was drilled to determine a biostratigraphic reference section for the western equatorial Atlantic Ocean. Coccolith assemblages ranging in age from Maestrichtian to late Quaternary (Figure 2) occur in the 18 cores that were cut discontinuously between 0 and 881 meters. The Oligocene zones appear to be all present in Cores 8 to 12 (344 to 615 m); zonal sequences for other series are incompletely represented.

Sample 354-4-2, 130-131 cm (143 m) contains an early Pliocene assemblage with a diverse group of ceratoliths including *Amaurolithus bizzarus, A. delicatus, A. tricorniculatus, Ceratolithus acutus,* and *C. armatus.* As in most warm-water assemblages, *Scyphosphaera globulata* is prominent. It is distinguished from similar *S. globulosa* by smaller aperture and by the lack of a distinctly concave base.

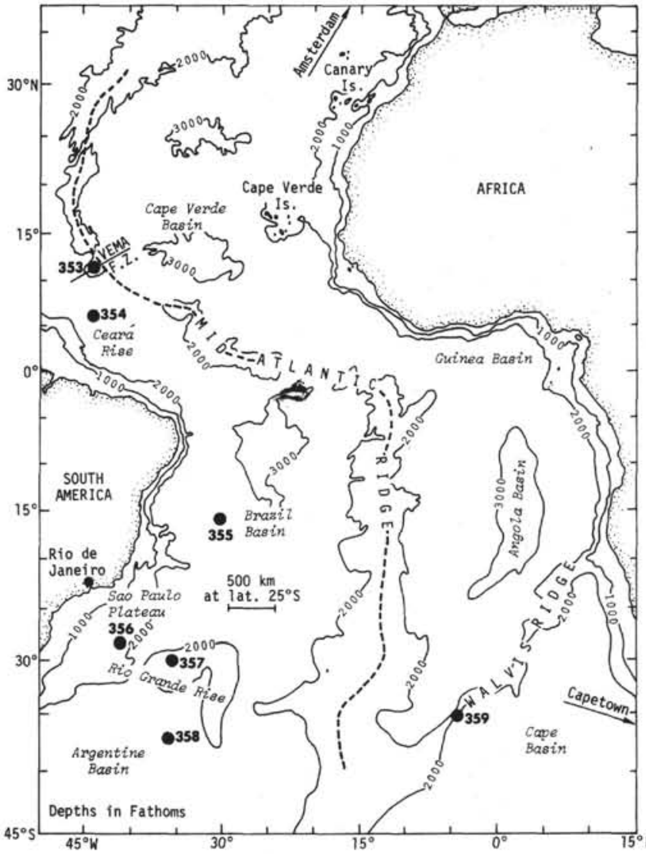

Figure 1. *Sketch map of sites drilled on Deep Sea Drilling Project Leg 39.*

The upper Miocene *Amaurolithus primus* Subzone is recognized in Samples 356-5-2, 130-131 cm (190 m) and 356-6-2, 110-111 cm (236 m) by the overlapping ranges of *Amaurolithus amplificus, A. delicatus, A. primus,* and *Discoaster quinqueramus.* The warm-water aspect of the coccolith assemblages is indicated by the abundant occurrence of *Discoaster* and *Sphenolithus.* The same abundance relation in the *Sphenolithus heteromorphus* Zone of Core 7 is augmented by the presence of *Hayaster perplexus,* a characteristic tropical species.

Warm-water stratigraphic-marker species of *Sphenolithus* and *Helicopontosphaera* designated by Bramlette and Wilcoxon (1967) are present through the Oligocene section of Cores 8 to 12 (344 to 615 m).

Late Eocene assemblages of Core 13 (691 to 699 m) contain abundant *Coccolithus formosus, Cyclococcolithina? kingii,* and common *Reticulofenestra reticulata* and discoasters. Cool-water marker species of *Chiasmolithus* and *Isthmolithus recurvus* are absent.

Age	Zone	Subzone	353	354	355	356	357	358	359	359A
Quaternary	*Emiliania huxleyi*		3-2	1-2						
	Gephyrocapsa oceanica	*Ceratolithus cristatus*					1-2			
		Emiliania ovata					1-5			
	Crenalithus doronicoides	*Gephyrocapsa caribbeanica*								
		Emiliania annula								
Pliocene	*Discoaster brouweri*	*Cyclococcolithina macintyrei*				2-3/2-5				
		Discoaster pentaradiatus								
		Discoaster surculus								
		Discoaster tamalis		3-2		2-2	2-2/2-4			
	Reticulofenestra pseudoumbilica	*Discoaster asymmetricus*					2-6			
		Sphenolithus neoabies								
	Amaurolithus tricorniculatus	*Ceratolithus rugosus*								
		Ceratolithus acutus		4-2/4-5						
Miocene		*Triquetrorhabdulus rugosus*					3-2			
	Discoaster quinqueramus	*Amaurolithus primus*		5-2/6-2			3-4		1-1 & 1-4	
		Discoaster berggrenii								
	Discoaster neohamatus	*Discoaster neorectus*					4-2			
		Discoaster bellus								1-1/1-4
	Discoaster hamatus	*Catinaster calyculus*								2-2
		Helicosphaera carteri								
	Catinaster coalitus								2-5	
	Discoaster exilis	*Discoaster kugleri*					5-2/5-5			
		Coccolithus miopelagicus								
	Sphenolithus heteromorphus			7-2/7-4	2-4		6-1/6-4			
	Helicosphaera ampliaperta									
	Sphenolithus belemnos					3-1 & 1A-2	7-3			
	Triquetrorhabdulus carinatus	*Discoaster druggii*		8-1		3-3/4-5				
		Discoaster deflandrei				5-1/5-3	8-3			
Oligocene		*Cyclicargolithus abisectus*		?8-3/9-2		5-6	9-3/13-3			
	Sphenolithus ciperoensis	*Dictyococcites bisectus*		9-5/10-5		1A-5/2A-6	15-2/18-2			
		Cyclicargolithus floridanus		?11-2						
	Sphenolithus distentus			11-5/11-6						
	Sphenolithus predistentus			?12-1			19-2			
	Helicosphaera reticulata	*Reticulofenestra hillae*		12-3/12-6						
		Coccolithus formosus								
		Coccolithus subdistichus								
Eocene	*Discoaster barbadiensis*	*Isthmolithus recurvus*		13-2/13-5			20-2/20-3		2-6 & 4-1	
		Chiasmolithus oamaruensis							3-2/3-4	
	Reticulofenestra umbilica	*Discoaster saipanensis*					21-1 | 22-2/			
		Discoaster bifax				6-2/6-6	24-2/24-5 | 23-5			
	Nannotetrina quadrata	*Coccolithus staurion*				7-2/7-5	25-3			
		Chiasmolithus gigas		14-2		8-2/9-2	26-2			
		Discoaster strictus		14-5		10-2	26-5/28-2			
	Discoaster sublodoensis	*Rhabdosphaera inflata*				10-3/10-4	28-5			
		Discoasteroides kuepperi								
	Discoaster lodoensis					11-1/14-1		11-4/12-3		
	Tribrachiatus orthostylus					15-2/16-2		12-3/12-4		
	Discoaster diastypus	*Discoaster binodosus*						12-4/12-6		
		Tribrachiatus contortus								
Paleocene	*Discoaster multiradiatus*	*Campylosphaera eodela*		15-2						
		Chiasmolithus bidens		16-3/16-5						
	Discoaster nobilis									
	Discoaster mohleri									
	Heliolithus kleinpellii			16-6		17-1/17-5				
	Fasciculithus tympaniformis					18-2/18-5	29-1	13-1		
	Cruciplacolithus tenuis					19-2/29-2	30-1/30-5	13-4/14-3		

Figure 2. *Cenozoic coccolith zonation of core samples from Deep Sea Drilling Project Leg 39 sites. The numbers assigned to zonal intervals are core and section numbers of samples examined. Where a zone or subzone is represented in more than one sample, the highest and lowest are given. Poorly diagnostic samples may bracket several zonal intervals.*

Relatively shallow deposition is suggested by the presence of the solution-prone species *Helicopontosphaera reticulata* and *Pedinocyclus larvalis*.

The middle Eocene of Core 14 (701 to 739 m), like the upper Eocene, is characterized by diverse but poorly preserved assemblages. Among the few *Chiasmolithus* present, *C. gigas* in 354-14-2, 128-129 cm (703 m) is a stratigraphic guide to the middle middle Eocene *C. gigas* Subzone of low latitudes.

The overlap of *Campylosphaera eodela*, *Discoaster multiradiatus*, and *Toweius eminens* in Sample 354-15-2, 61-62 cm (815 m) indicates the uppermost Paleocene *Campylosphaera eodela* Subzone. The diverse assemblages from Core 16, Sections 3 to 5, lack *C. eodela* and are assigned to the next older *Chiasmolithus bidens* Subzone of the *Discoaster multiradiatus* Zone. An overlap of *Discoasteroides megastypus*, *Heliolithus kleinpellii*, and *H. riedelii* without associated discoasters in Sample 354-16-6, 130-131 cm (841 m) indicates the upper Paleocene *H. kleinpellii* Zone. Therefore, the intervening *Discoaster mohleri* Zone and *D. nobilis* Zone of the upper Paleocene are missing or very compressed.

Maestrichtian assemblages in Cores 17 and 18 (853 to 881 m) are diverse but many specimens are fragmented as in the Paleogene. No short-ranged marker species were observed (Figure 3).

Site 355
(lat 15°42.59'S, long 30°36.03'W, depth 4896 m)

Site 355, in the Brazil Basin was intended to date the basement to help calibrate the paleomagnetic reversal time scale for the late Cretaceous.

The only definitive coccolith assemblage in four samples examined from Cores 1 to 3 (53 to 117 m) is in Sample 355-2-4, 130-31 cm (117 m) and belongs to the *Sphenolithus heteromorphus* Zone. The warm-water assemblage includes: *Coccolithus pelagicus*, *Cyclicargolithus floridanus*, *Cyclococcolithina macintyrei*, *Discoaster deflandrei*, *D. exilis*, *D. moorei*, *D. signus*, *D. variabilis*, *Hayaster perplexus*, *Helicopontosphaera kamptneri*, and *Sphenolithus heteromorphus*.

The deepest samples available from Cores 17 to 20 (405 to 443 m) are dissolution concentrates of coccolith fragments along with resistant species such as *Broinsonia parca*, *Cylindralithus gallicus*, *Micula decussata*, and *Watznaueria barnesae*. The two lowest samples lack the guide fossils *Tetralithus trifidus* and *Eiffellithus eximius* and are assigned to the middle to upper Campanian *Broinsonia parca* Zone.

Site 356
(lat 28°17.22'S, long 41°05.28'W, depth 3203 m)

Site 356, near the southeastern margin of the São Paulo Plateau, was designed to determine the duration and nature of South Atlantic evaporite deposits and the nature of basement rocks underlying the evaporites. Coccoliths of Late Cretaceous to Quaternary age are abundant through the 44 cores cut between 0 and 741 meters subbottom. As a result of hiatuses, zonal sequences are only present for the lower Miocene, Eocene, Paleocene, and Upper Cretaceous.

Eocene assemblages are especially diverse and contain several moderately solution-prone taxa such as *Scyphosphaera*, but lack pentalith taxa typical of shallow-water deposits. For example, Sample 356-6-5,

		Site				
Age	Zone	354	355	356	357	358
Maestrichtian	*Micula mura*	17-1/18-5		29-3	31-1/31-3	16-2
	Lithraphidites quadratus			30-3/31-3	?32-2	
	Tetralithus trifidus		17-2/18-2	33-3/33-6	34-2/36-2	
Campanian	*Broinsonia parca*		?19-2/20-2	34-3/34-6		
	Eiffellithus eximius				40-2/43-2	
Santonian	*Gartnerago obliquum*					
Coniacian	*Marthasterites furcatus*			35-3/40-3	44-2/49-2	
	Micula decussata/ Tetralithus pyramidus				51-2	
Cenomanian to Coniacian				41-2/44-3		

Figure 3. *Mesozoic coccolith zonation of core samples from Deep Sea Drilling Project Leg 39.*

130-131 cm (121 m), of the middle Eocene *Discoaster bifax* Subzone includes: *Campylosphaera dela*, *Chiasmolithus grandis*, *C. solitus*, *Coccolithus formosus*, *Discoaster barbadiensis*, *D. bifax*, *D. distinctus*, *D. nodifer*, *Helicopontosphaera compacta*, *Lophodolithus acutus*, *Nannotetrina quadrata*, *Reticulofenestra* sp. cf. *R. hillae*, *R. samodurovii*, *Rhabdosphaera tenuis*, *Scyphosphaera expansa*, *Sphenolithus radians*, *S. furcatolithoides*, *Syracosphaera formosa*, and *Zygolithus dubius*.

Silicoflagellates occur sparsely through the middle Eocene in Cores 6 to 9 (114 to 200 m). Stratigraphic marker species *Dictyocha spinosa* and *Naviculopsis foliacea* occur in all four cores, whereas *Dictyocha hexacantha* s. str. occurs only in the upper two (Table 1). This distribution indicates that the *Dictyocha hexacantha* Zone of late middle and late Eocene age (Bukry and Foster, 1974) is only as old as the late *Nannotetrina quadrata* Zone of coccoliths at Site 356 (Figure 2), according to the first occurrence of *D. hexacantha* sensu stricto. The older occurrence of *D. spinosa*, recorded as early as the *Chiasmolithus gigas* Subzone (coccolith) at Sites 208 and 356, suggests an additional cosmopolitan biostratigraphic unit, the *Dictyocha spinosa* Subzone within the *Naviculopsis foliacea* Zone below and *D. hexacantha* Zone above (see Silicoflagellate Zonation).

Siliceous phytoplankton are missing in Core 10 (219 to 228 m), where the lower middle Eocene *Rhabdosphaera inflata* Subzone of coccoliths is easily determined by the presence of diverse assemblages, including, in 356-10-3, 130-131 cm (222 m): *Campylosphaera dela*, *Chiasmolithus grandis*, *C. solitus*, *Coccolithus formosus*, *Cyclicargolithus pseudogammation*, *Discoaster barbadiensis*, *D.* sp. cf. *D. gemmifer*, *D. mirus*, *D. sublodoensis*, *Ellipsolithus lajollaensis*, *Helicopontosphaera lophota*, *H. seminulum*, *Lophodolithus nascens*, *L. rotundus*, *Reticulofenestra dictyoda*, *R. samodurovii*, *Rhabdosphaera inflata*, *Syracosphaera fimbriata*, *Zygolithus dubius*, *Zygrhablithus bijugatus*.

Paleocene coccolith assemblages are diverse and contain many species of *Fasciculithus*. The Danian *Cruciplacolithus tenuis* Zone contains *Fasciculithus* sp. cf. *F. involutus*, *F. janii*, and *F. pileatus*, below the range of *F. tympaniformis*, in the *Cyclococcolithina*? *robusta* Subzone of Gartner (1971), for example in Samples 356-19-2, 130-131 cm (316 m) and 356-21-3, 130-131 cm (336 m). A mixed-assemblage interval in upper Core 29 and lower Core 28 has a high proportion of Cretaceous taxa in the early Danian assemblage, which is identified by *Cruciplacolithus tenuis* or *Coccolithus pelagicus* s. ampl. in samples as deep as Sample 356-29-2, 129-131 cm (411 m). The Maestrichtian guide fossil *Lithraphidites quadratus*, which is generally missing in Pacific and Indian ocean cores, occurs at Site 356 in Cores 29 to 31. A persistent occurrence of *Marthasterites furcatus* in Cores 35 to 40, especially common in Core 40, is a guide to the Coniacian and Santonian stages of the Late Cretaceous.

Older assemblages of Cores 41 to 44 are less diagnostic. In Sample 356-42-3, 140-141 cm (717 m), *Tetralithus* sp. cf. *T. pyramidus* suggests a Turonian or younger age. *Nannoconus* sp. cf. *N. globulus* and *N.* sp. cf. *N. kamptneri* are present. On the basis of a general similarity in assemblage, including *Braarudosphaera bigelowii*, *Eiffellithus turriseiffeli*, and *Nannoconus* sp. cf. *N. globulus*, 356-44-3, 147-148 cm (735 m), is probably post-Albian; however, it could be as old as late Albian, by the earliest occurrence of *E. turriseiffeli* (Thierstein, 1971).

TABLE 1
Middle Eocene Silicoflagellates at DSDP 356 Recorded as Percents. Samples Above 134 Meters are Assigned to the *Dictyocha hexacantha* Zone, From 137 to 190 Meters to the *Dictyocha spinosa* Subzone, and From 192 Meters, Tentatively, to an Unnamed Lower Subzone of the *Naviculopsis foliacea* Zone

Site 356 Sample (Interval in cm)	Depth (m)	Total Specimens	*Corbisema apiculata*	*C. bimucronata*	*C. disymmetrica communis*	*C. hastata globulata*	*C. hastata hastata*	*C. hastata minor*	*C. inermis inermis*	*C.* cf. *inermis* (spined)	*C.* cf. *katharinae*	*C. lamellifera*	*C. triacantha* s. ampl.	*C.* cf. *triacantha* (large)	*C.* spp.	*Dictyocha hexacantha* s. str.	*D. pentagona*	*D. spinosa*	*D.* sp. (asperoid)	*D.* sp. (variants)	*Distephanus* aff. *crux*	*D.* aff. *speculum pentagonus*	*Macrora barbadensis*	*M. najae*	*Mesocena apiculata*	*M. oamaruensis*	*M. occidentalis*	*M. venusta*	*Naviculopsis biapiculata* s. ampl.	*N. constricta*	*N. danica*	*N. foliacea*
6-2, 130-131	117	200	3	2			1	2	2	1		10	9	6			1	5	13	4			9	1		2	1		1	6		26
6-4, 130-131	120	61	2	5			2					12	11			3		3	8				23	3		2	2			8		16
6-6, 130-131	123	300	<1	2		<1	<1	<1	1			23	3	1	<1			4	5	<1			37	4		1	1			4		13
7-1, 130-131	134	200	3			2		1	2	1			36		1	2			15	1	1						2	1		20		15
7-3, 130-131	137	200	5	2		2		5	1				30		2			2	19	1	1	1	1				3	2	1	11		17
7-5, 130-131	140	200	3	1		5	2	3	1				29		3			4	19	2	1	1	1				1	1	2	13	1	18
8-1, 130-131	162	60	8			3	1	2					23					3	13	3	2	3							10	3		25
8-2, 130-131	164	40	10			3	3	5		3			28						20		3								8	3		18
9-1, 130-131	190	200	4	1		2	1	1	2	1	1		11		1			1	9	1							1		2	6		59
9-2, 130-131	192	100	2	1	1	10		3	5				13		1				5	2	1				1		1		8	13		34

Site 357
(lat 30°00.25'S, long 35°33.59'W, depth 2109 m)

Site 357, on the northern flank of the Rio Grande Rise, was drilled to complete the stratigraphic record to basement, originally attempted during Leg 3 at Sites 21 and 22.

Generally diverse coccolith assemblages range in age from Turonian or Coniacian to late Quaternary. Discoasters have moderate to heavy overgrowths in most of the Tertiary assemblages.

Rare reworked specimens of *Discoaster brouweri* and *D. variabilis* belie the true age of Sample 357-1-5, 130-131 cm (7 m). An overlap of *Emiliania ovata* and *Gephyrocapsa oceanica* indicates the upper Quaternary *Emiliania ovata* Subzone.

Like Site 356, the middle Eocene assemblages are diverse and contain shallow oceanic taxa such as *Scyphosphaera*. Even shallower Eocene marine conditions are indicated at Site 357, however, by the presence of *Braarudosphaera*, *Micrantholithus*, and *Pemma*. The cool-water marker species, *Chiasmolithus oamaruensis* and *Isthmolithus recurvus*, are rare in upper Eocene Core 20 (256 to 265 m), where the great abundance of *Discoaster* suggests mainly warm-water conditions.

The lowest sample from Core 28, Sample 357-28-5,110-111 cm (443 m), contains *Discoaster sublodoensis*, *Reticulofenestra dictyoda*, and *Rhabdosphaera inflata*, a diagnostic association for the *Rhabdosphaera inflata* Subzone at the base of the middle Eocene. Owing to a coring gap, the next deeper Sample 357-29-1, 129-130 cm (466 m), contains the much older *Fasciculithus tympaniformis* Zone of the Paleocene. *Fasciculithus magnus* is common in Sample 357-30-1, 130-131 cm (475 m), which is below the range of *F. tympaniformis* in the *Cruciplacolithus tenuis* Zone. Cretaceous assemblages in Cores 31 to 51 (493 to 797 m) resemble those at Site 356, but no *Lithraphidites quadratus* were found at this site.

Site 358
(lat 37°39.31'S, long 35°57.82'W, depth 5000 m)

Site 358, in the Argentine Basin, was intended to date the basement to help calibrate the paleomagnetic reversal time scale for the Late Cretaceous.

The siliceous mudstones in Cores 1 to 11 (48 to 713 m) contain sparse silicoflagellates at some levels, but coccoliths are missing. The last coccoliths preserved at Site 358 are of early Eocene age, in the lower part of Core 11. Silicoflagellates in samples from the mudstone section are too sparse to make valid stratigraphic counts. The occurrence of specimens or fragments of *Dictyocha* sp. cf. *D. pulchella*, *Distephanus crux*, *D. speculum*, *Mesocena circulus*, and *M. diodon* indicates a tentative upper Miocene assignment for Sample 358-2-2, 130-131 cm (126 m). A lower Miocene assignment is suggested by rare specimens of *Distephanus crux* and *Naviculopsis* sp. cf. *N. quadrata* in Sample 358-4-2, 140-141 cm (278 m). Similarly, the rare *D. crux*, *Mesocena apiculata*, *N. biapiculata*, and the diatom *Stictodiscus gelidus* (syn. *Rocella gemma*) in Sample 358-5-1, 145-146 cm (352 m), suggest a late Oligocene or early Miocene age. The only silicoflagellates found in Sample 358-6-3, 140-141 cm (421 m) are fragments of *Naviculopsis* sp.; however, the abundant occurrence of *Stictodiscus gelidus* represents part of the latest Oligocene or earliest Miocene acme of that species as indicated by the stratigraphic results of DSDP Legs 28, 29, and 36, and by Ling (1972).

The overlapping ranges of *Coccolithus crassus*, *C. magnicrassus*, and *Discoaster lodoensis*, without *D. sublodoensis*, in Samples 357-11-4, 11-12 cm (708 m) to 357-12-3, 55-56 cm (754 m) determine the lower Eocene *Discoaster lodoensis* Zone (Bukry, 1973a). *Coccolithus magnicrassus* is abundant in the *Tribrachiatus orthostylus* Zone of Samples 358-12-3, 104-105 cm (754 m) and 358-12-4, 47-48 cm (756 m). The *Discoaster binodosus* Subzone of the *Discoaster diastypus* Zone is indicated in Samples 358-12-4, 89-90 cm (758 m) to 358-12-6, 82-83 cm (758 m), the the occurrences of *Discoaster binodosus*, *D. diastypus*, *Discoasteroides kuepperi*, and *Tribrachiatus orthostylus*, in the absence of *Discoaster lodoensis*.

Several nonfossiliferous samples of ferruginous mudstone in Cores 15 and 16 intervene between early Paleocene coccoliths in Cores 13 and 14 (779 to 798 m) and a Maestrichtian assemblage in Sample 358-16-2, 128-129 cm (819 m), which is a dissolution concentrate dominated by *Micula decussata*.

Site 359
lat 34°59.10'S, long 04°29.83'W, depth 1658 m)

Site 359, on a seamount of the Walvis Ridge, was an unscheduled site of serendipity near the end of Leg 39. Six sediment cores were cut before *Glomar Challenger* had to diesel for port at Cape Town.

Samples from middle or late Miocene assemblages are poorly diagnostic, and the discoasters are thickly overgrown. An overlap of *Discoaster* sp. cf. *D. neohamatus* and *D.* sp. cf. *D. pentaradiatus* in Core 1A and the occurrence of *Catinaster calyculus* in Core 2A provide some restricted guides to correlation (Figure 2).

Shallow-water late Eocene assemblages of Cores 2 to 4 (37 to 95 m) contain a wealth of coccolith guide fossils similar to Caribbean and European localities, including *Braarudosphaera rosa*, *Chiasmolithus oamaruensis*, *Corannulus germanicus*, *Discolithina latoculata*, *Isthmolithus recurvus*, *Micrantholithus ornatus*, *Orthozygus aureus*, and *Peritrachelina joidesa*. The presence of *Scyphosphaera* and the common occurrence of pentaliths indicate shallower deposition than at the western South Atlantic Sites 354 and 357 for the upper Eocene.

SILICOFLAGELLATE ZONATION

The Eocene silicoflagellates at Site 356 of Leg 39 suggest several modifications in zonation and taxonomy for the Paleogene. The boundary criteria for the *Dictyocha hexacantha* Zone and *Naviculopsis foliacea* Zone are altered and a new *Dictyocha spinosa* Subzone is proposed.

Corbisema hastata Zone

Following the discovery of assemblages of the *Corbisema hastata* Zone and *Naviculopsis constricta* Zone associated with upper Paleocene coccoliths at Site 327 of Leg 36, the top of the zone was lowered below the original tentative position at the Paleocene-Eocene boundary (Figure 4).

Naviculopsis constricta Zone

Glezer (1966) and Martini (1974) suggested the occurrence of specimens similar to *Naviculopsis foliacea* in the lower Eocene. This species is believed to be an important stratigraphic marker because of: (l) its consistent abundance in the middle Eocene at Site 356, (2) distinctive morphology, (3) cosmopolitan distribution, and (4) evolutionary development after the establishment of populations of *N. constricta* in the late Paleocene. Therefore, the top of the *N. constricta* Zone is tentatively lowered below the lower to middle Eocene boundary to the first occurrence of *N. foliacea.*

Naviculopsis foliacea Zone

The *Naviculopsis foliacea* Zone was originally indicated by Martini (1974) as the interval between the first *Dictyocha bimucronata* and the last *Dictyocha spinosa*. The top of the zone probably needs modification because of the Oligocene range of *Dictyocha spinosa* suggested by Perch-Nielsen (1975). The first occurrence of *Dictyocha hexacantha* is selected as the new marker for the top of the zone; this will limit the range of the zone to the Eocene in most regions. The first occurrence of the name-giving species *Naviculopsis foliacea* is designated as the base of the zone because it is large distinctive, and widespread.

The difference in range between *Dictyocha hexacantha* and *D. spinosa*, mentioned in Bukry (1975), occurs at Site 356 and indicates that the upper part of the *Naviculopsis foliacea* Zone, below the *Dictyocha hexacantha* Zone, can be designated the new *Dictyocha spinosa* Subzone, on the basis of the earlier first occurrence of *D. spinosa.*

Dictyocha hexacantha Zone

Originally, the base of this zone was determined by the first occurrence of *Dictyocha hexacantha* s. ampl. which included *Dictyocha spinosa*; however, the definition is herein restricted to the first occurrence of *D. hexacantha* s. str. Because of the later appearance of *D. hexacantha* s. str., the duration of the zone is shortened.

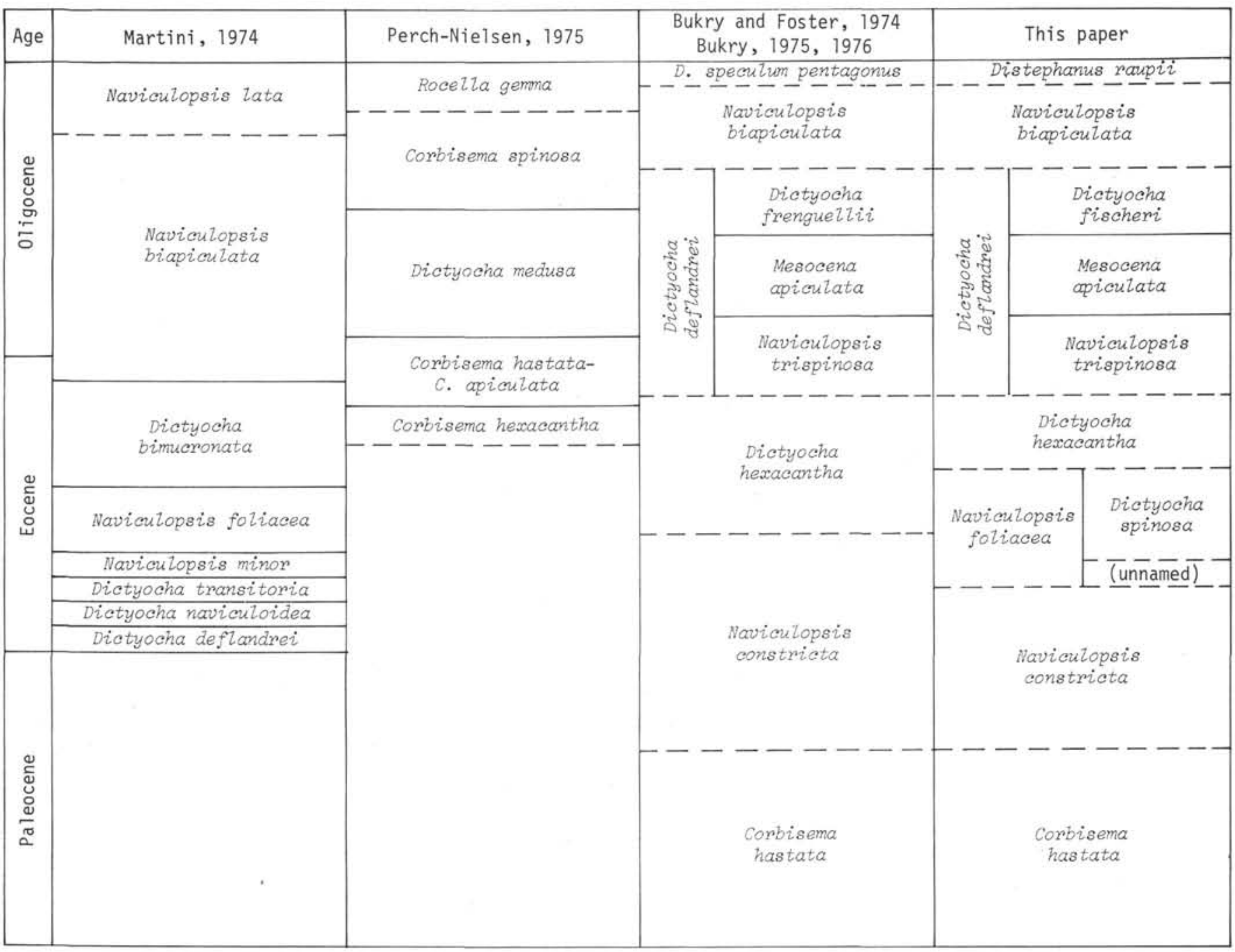

Figure 4. *Comparison of some proposed zonal sequences of Paleogene silicoflagellates.*

Other Paleogene Zones

The remaining zones of the Paleogene are unchanged, except for taxomonic changes, from their descriptions for Leg 29 (Bukry, 1975).

SILICOFLAGELLATE TAXONOMY

Genus CORBISEMA Hanna, 1928

Corbisema apiculata (Lemmermann)

Dictyocha triacantha apiculata Lemmermann, 1901, Deutsche Bot. Ges. Ber., v. 19, p. 259, pl. 10, fig. 19, 20.
Corbisema apiculata (Lemmermann), Perch-Nielsen, 1975, Deep Sea Drilling Proj. Initial Repts., v. 29, p. 685, pl. 2, fig. 5, 16, 19; pl. 3, fig. 19, 20, 14; pl. 15, fig. 1, 2.

Corbisema bimucronata Deflandre
(Plate 1, Figure 1)

Corbisema bimucronata Deflandre, 1950, Microscopie, v. 2, p. 191, fig. 174-177.

Corbisema disymmetrica communis Bukry

Corbisema disymmetrica communis Bukry, 1976, Deep Sea Drilling Proj. Initial Repts., v. 35, p. 891, pl. 1, fig. 5-9.

Corbisema hastata globulata Bukry
(Plate 1, Figure 2)

Corbisema hastata globulata Bukry, 1976, Deep Sea Drilling Proj. Initial Repts., v. 35, p. 892, pl. 4, fig. 1-8.

Corbisema hastata hastata (Lemmermann)

Dictyocha triacantha hastata Lemmermann, 1901, Deutsche Bot. Ges., Ber., v. 19, p. 259, pl. 10, fig. 16,17.

Corbisema hastata minor (Schulz)

Dictyocha triacantha apiculata minor Schulz, 1928 (in part), Bot. Archiv, v. 21, p. 249, fig. 29b.

Corbisema inermis inermis (Lemmermann)
(Plate 1, Figure 3)

Dictyocha triacantha inermis Lemmermann, 1901, Deutsche Bot. Ges., Ber., v. 19, p. 259, pl. 10, fig. 21.

Remarks: Compared specimens of *Corbisema inermis inermis* have small spines. Typical specimens of this species lack spines (Bukry, 1976).

Corbisema sp. cf. C. katharinae Bukry

Corbisema katharinae Bukry, in press, Deep Sea Drilling Proj. Initial Repts., v. 38, p. 848, pl. 1, fig. 1-6.

Remarks: The single specimen from Site 356 is smaller and has a less developed plate than typical specimens from Leg 38.

Corbisema lamellifera (Glezer)
(Plate 1, Figrues 4, 5)

Dictyocha lamellifera Glezer, 1962, Paleont. Zhur. 1962, no. 1, p. 150, fig. 3b, v.
Dictyocha lamellifera constricta Glezer, 1964, Akad. Nauk SSSR, Novosti sistematiki nizshikh rasteniy, otdel. ottisk, p. 50, pl. 1, fig. 3.
Dictyocha lamellifera lamellifera Glezer, 1964, p. 48, pl. 1, fig. 2.

Remarks: Spine lengths of specimens from Site 356 are intermediate between the end members of Glezer's (1964) type suite. The Atlantic specimens have wider apical struts.

Corbisema triacantha (Ehrenberg) s. ampl.

Dictyocha triacantha Ehrenberg, 1844, K. Preuss. Akad. Wiss. Berlin, Ber., Jahrg. 1844, p. 80.

Remarks: The small form *Corbisema triacantha minor* (see Ling, 1972) was not separated from moderate sized forms of this equilateral species (see Bukry and Foster, 1974). Some especially large, pinched specimens in Core 6 at Site 356 are tabulated as compared species.

Corbisema spp.

Remarks: Broken, tilted, or unnamed variants or species are grouped together under this heading.

Genus DICTYOCHA Ehrenberg, 1837

Dictyocha hexacantha Schulz

Dictyocha hexacantha Schulz, 1928, Bot. Archiv, v. 21, no. 2, p. 255, fig. 43.
Corbisema hexacantha (Schulz), Perch Nielsen, 1975, Deep Sea Drilling Proj. Initial Repts., v. 29, p. 685, pl. 3, fig. 13, 14.

Dictyocha pentagona (Schulz)

Dictyocha fibula var. *pentagona* Schulz, 1928, Bot. Archiv, v. 21, no. 2, p. 255, fig. 41a, b.

Remarks: Two large specimens of this long-ranged form taxon (Bukry, 1976) were found at Site 356.

Dictyocha sp. cf. D. pulchella Bukry

Dictyocha pulchella Bukry, 1975, Deep Sea Drilling Proj. Initial Repts., v. 32, p. 687, pl. 4, fig. 1-3.

Remarks: This moderate-sized member of the asperoid group is distinguished from *Dictyocha lingii* by its thicker bar, unrounded basal ring, and unnoded surface. It is distinguished from *Dictyocha varia* by its distinctly longer bar, less equant portals, and less rounded basal ring. Discriminating parameters for various forms within the asperoid group are not yet well established.

Dictyocha spinosa (Deflandre)
(Plate 1, Figures 6-8)

Corbisema spinosa Deflandre, 1950, Microscopie, v. 2, p. 193, fig. 178-182.
Dictyocha spinosa (Deflandre) Glezer, 1966, Akad. Nauk SSSR, V.A. Komarova Bot. Inst., v. 7, p. 238, pl. 10, figs. 6-8.
Dictyocha hexacantha s. ampl., Bukry and Foster, 1974, U.S. Geol. Surv. J. Research, v. 2, p. 304, fig. lj.

Remarks: Only three of the six spines are in the plane of the basal ring.

Dictyocha sp. (asperoid)
(Plate 1, Figure 10)

Remarks: Most of the specimens of *Dictyocha* at Site 356 are asperoid, having apical bars aligned nearly perpendicular to the long axis of the base. These are generally small, have distinct basal pikes, and typically, canted apical bars. Variants having similar basal-ring style, but medusoid, fibuloid, or deflandroid apical arrays are less abundant and are tabulated together as *Dictyocha* sp. (variants).

Genus DISTEPHANUS Stöhr, 1880

Distephanus crux (Ehrenberg) s. ampl.
(Plate 1, Figure 9)

Dictyocha crux Ehrenberg, 1840, K. Preuss. Akad. Wiss. Berlin, Abh., Jahrg. 1839, p.207.

Remarks: Eocene specimens at Site 356 have moderate to large apical rings but lack basal pikes.

Distephanus speculum pentagonus Lemmermann

Distephanus speculum var. *pentagonus* Lemmermann, 1901, Deutsche Bot. Ges., Ber., v. 19, p. 264, pl. 11, fig. 19.

Remarks: Eocene specimens at Site 356 lack basal pikes.

Distephanus speculum speculum (Ehrenberg)

Dictyocha speculum Ehrenberg, 1839, K. Preuss. Akad. Wiss. Berlin, Abh., Jahrg. 1838, p. 129.

Genus MESOCENA Ehrenberg, 1843

Mesocena apiculata (Schulz)

Mesocena oamaruensis apiculata Schulz, 1928, Bot. Archiv, v. 21, no. 2, p. 240, fig. 11.

Mesocena circulus (Ehrenberg)

Dictyocha (Mesocena) circulus Ehrenberg, 1840, K. Preuss. Akad. Wiss. Berlin, Ber., p. 208.
Mesocena circulus (Ehrenberg) Ehrenberg, 1854, Mikrogeologie, p. 19, fig. 44.

Mesocena diodon Ehrenberg

Mesocena diodon Ehrenberg, 1844, K. Preuss. Akad. Wiss. Berlin, Ber., Jahrg. 1844, p. 71, 84.
Mesocena diodon (Ehrenberg) Ehrenberg, 1854, Mikrogeologie, pl. 33 (XV), fig. 18.

Mesocena elliptica (Ehrenberg)

Dictyocha (Mesocena) elliptica Ehrenberg, 1844, K. Preuss. Akad. Wiss. Berlin, Ber., Jahrg. 1844, p. 71, 84.
Mesocena elliptica (Ehrenberg) Ehrenberg, 1854, Mikrogeologie, pl. 20 (I), fig. 44a, b.
Mesocena quadrangula Ehrenberg ex Haeckel, 1887, *Challenger* Rept., v. 18, p. 1556.

Mesocena oamaruensis Schulz

Mesocena oamaruensis Schulz, 1928, Bot. Archiv, v. 21, p. 240, fig. 10a, b.

Mesocena occidentalis Hanna ex Bukry

Mesocena oamaruensis var. *quadrangula* Schulz, 1928 (in part), Bot. Archiv, v. 21, p. 240, fig. 12.
Mesocena occidentalis Hanna, 1931, Mining California, p. 200, pl. E, fig. 1.
Mesocena occidentalis Hanna, Perch-Nielsen, 1975, Deep Sea Drilling Proj. Initial Repts., v. 29, p. 688, pl. 10, fig. 15, 16.
Mesocena oamaruensis quadrangula Schulz, Bukry, 1975, ibid., p. 857, pl. 6, fig. 4.

Description: *Mesocena occidentalis* is a quadrangular ring having a moderate to long spine at each corner. The format is typically square, and ring and spines lie in the same plane. Spines are nonseptate, and surfaces of spines and the straight-sided ring appear smooth in light microscopy.

Remarks: Following Perch-Nielsen (1975), the individual illustrated as fig. 13 of Schulz (1928) is herein designated the lectotype for *Mesocena oamaruensis quadrangula* Schulz. The companion fig. 14, showing a long-spined form, was referred to *Mesocena occidentalis* Hanna by Perch-Nielsen. Because there was no diagnosis published with the original illustration for *M. occidentalis*, it has been described herein to validate it and to satisfy ICBN Article 32.

Mesocena occidentalis Hanna ex Bukry is distinguished from *Mesocena venusta* by having spines at the corners, from *M. oamaruensis quadrangula* by lacking any septae, and from *M. elliptica* by being more straight-sided and regular in form, having longer spines, and being generally less noded.

Figure 1 of Plate E (Holotype no. 3278 C.A.S.) in Hanna (1931) is herein designated the type specimen for *Mesocena occidentalis*.

Mesocena tsumurai nom. nov.

Mesocena oamaruensis var. *quadrangula* Schulz, 1928 (in part), Bot. Archiv, v. 21, p. 240, fig. 13.
non *Mesocena quadrangula* Ehrenberg ex Haeckel, 1887, *Challenger* Rept., v. 18, p. 1556.
Septamesocena cf. *S. quadrangula* (Schulz) Perch-Nielsen, 1975, Deep Sea Drilling Proj. Initial Repts., v. 29, p. 690, pl. 10, fig. 17,18.

Remarks: Because of *Mesocena quadrangula* Ehrenberg ex Haeckel, the newly designated lectotype for *Mesocena oamaruensis quadrangula* Schulz cannot be elevated to species rank under that name in genus *Mesocena*. The name *Mesocena tsumurai* is proposed as a new substitute name for Schulz's taxon at the species level. A substitute name would be superfluous if this taxon were classified in *Septamesocena* (see Perch-Nielsen, 1975). However, it is not believed at this time that the presence or absence of septae represents a consistent basis for distinction at the genus level.

Mesocena venusta n. sp.
(Plate 1, Figures 11-13)

Description: *Mesocena venusta* is a rhomboid ring having rounded, spineless corners. The ring is nonseptate, and the surface appears smooth in light microscopy. The ratio of major to minor axis length ranges from 1.3 to 1.8.

Remarks: *Mesocena venusta* is distinguished from *M. elliptica* and *M. occidentalis* by the absence of spines, and from *M. tsumurai* by the lack of spines and septae, and by being more elongate in form.

Occurrence: *Mesocena venusta* is a rare but distinctive form in the middle Eocene of Core 7 at DSDP Site 356 in the South Atlantic.

Size: Maximum diameter 100 μm; holotype 80 μm.

Holotype: USNM 237371 (Plate 1, Figure 11).

Isotypes: USNM 237372 and 237373.

Type locality: South Atlantic Ocean, Sample 356-7-3, 130-131 cm (137 m).

Genus NAVICULOPSIS Frenguelli, 1940

Naviculopsis biapiculata (Lemmermann) s. ampl.
(Plate 2, Figure 2)

?*Dictyocha navicula biapiculata* Lemmermann, 1901, Deutsche Bot. Ges., Ber., v. 19, p. 258, pl. 10, fig. 14,15.
Naviculopsis biapiculata (Lemmermann), Bukry, 1975, Deep Sea Drilling Proj. Initial Repts., v. 29, p. 856, pl. 6, fig. 5-8.

Remarks: Eocene specimens at Site 356 have a less rounded ring and a less arched bar than do the more abundant specimens of the upper Oligocene. Further study should differentiate these (see *N. eobiapiculata* Bukry, in press).

To fix the name to barred forms only in the modern usage of genus *Naviculopsis*, Lemmermann's (1901) pl. 10, fig. 15 specimen, is herein designated the lectotype for *Naviculopsis biapiculata*.

Naviculopsis constricta (Schulz)
(Plate 1, Figure 14)

Dictyocha navicula biapiculata constricta Schulz, 1928, Bot. Archiv, v. 21, p. 246, fig. 21.
Naviculopsis constricta (Schulz), Ling, 1972, Am. Paleontol. Bull., v. 62, p. 183, pl. 30, fig. 5-8.

Naviculopsis danica Perch-Nielsen
(Plate 2, Figure 1)

Naviculopsis danica Perch-Nielsen, 1976, Geol. Soc. Denmark Bull., v. 25, p. 35, fig. 5, 6, 21.
Naviculopsis danica Perch-Nielsen, Bukry, 1976, Deep Sea Drilling Proj. Initial Repts., v. 35, p. 897, pl. 9, fig. 3.

Naviculopsis foliacea Deflandre

Naviculopsis foliacea Deflandre, 1950, Microscopie, v. 2, p. 204, fig. 235-240.
Naviculopsis foliacea Deflandre, Ling, 1972, Bull. Am. Paleontol., v. 62, p. 184, pl. 30, fig. 9-11.

Naviculopsis quadrata (Ehrenberg)

Dictyocha quadrata Ehrenberg, 1844, K. Preuss. Akad. Wiss. Berlin, Ber., p. 258, 267.
Naviculopsis quadrata (Ehrenberg), Bukry, 1975, Deep Sea Drilling Proj. Initial Repts., v. 29, p. 856.

Genus MACRORA Hanna, 1932

(Synonym: Pseudorocella Deflandre, 1938)

Remarks: Although originally described as a diatom, *Macrora* could be considered among genera incertae sedis because of its unusual form. Due to its small size, it has generally been described with silicoflagellates as *Pseudorocella*.

Macrora barbadensis (Deflandre) n. comb.
(Plate 2, Figures 3-8)

Pseudorocella barbadensis Deflandre, 1938 (in part), Soc. Franç. Microsc., Bull., v. 7, p. 91, fide Loeblich et al., 1968, Geol. Soc. Am. Mem. 109, p. 139, pl. 33, fig. 4-13, 15-19 (not 14).
Pseudorocella barbadensis Deflandre, Bukry and Foster, 1974, U.S. Geol. Surv. J. Res., v. 2, p. 307, fig. 2f.

Remarks: These flat, approximately circular and entire-margined fossils are abundant in certain middle Eocene samples from Atlantic DSDP Sites 6, 29, and 356.

Macrora stella (Azpeitia)

Pyxidicula(??) *stella* Azpeitia, 1911, Assoc. Esp. Prog. Cien. Cong. de Zargoza, v. 4, pt. 2, sec. 3, p. 150, 152, 213, pl. 1, fig. 1.
Macrora stella (Azpeitia) Hanna, 1932, California Acad. Sci. Proc., v. 20, p. 196, pl. 12, fig. 7.
Pseudorocella corona Deflandre, 1947, Bull. Soc. Bot. France, v. 93, p. 337, fig. 4.
Pseudorocella corona Deflandre, Stradner, 1961, Erdöl Kohle, v. 14, p. 92, fig. 105, 106.
Pseudorocella corona Deflandre, Bukry, 1975, Deep Sea Drilling Proj. Initial Repts., v. 29, p. 871, pl. 7, figs. 8, 9.

Remarks: These forms have raised centers and indented margins. Though usually circular, some specimens are elliptical and have fewer pores (see Stradner, 1961, fig. 106). The early Miocene specimens from Site 338 in the Norwegian-Greenland Sea have fewer pores than the circular multipored variety from Site 278 in the Southern Ocean. *Macrora stella* was not recognized among the sparse early Miocene silicoflagellates at Site 358.

Macrora najae n. sp.
(Plate 2, Figures 9-12)

Pseudorocella barbadensis Deflandre, 1938 (in part), Soc. Franç. Microsc., Bull., v. 7, p. 91, fide Loeblich et al., 1968, Geol. Soc. Am. Mem. 109, p.139, pl.33, fig.14.

Description: *Macrora najae* is an elongate, planar, irregular framework of rounded polygonal pores. Peripheral pores are larger than the sinuous, single or double line of interior pores by a factor of about two to four. The margin is lobed about the larger, peripheral pores. Total pore counts range from 10 to 20 (mean 13).

Remarks: *Macrora najae* is distinguished from *M. barbadensis* by its lobed periphery, elongate shape, and bimodal pore groups. It is distinguished from *M. stella*, which has an indented margin and bimodal pores, by its elongate and more planar form.

Occurrence: *Macrora najae* is presently known only from the Eocene of the Atlantic region at Barbados, Site 29, and Site 356.

Size: Maximum length 30 μm.

Holotype: USNM 237374 (Plate 2, Figure 11).

Isotypes: USNM 237375 to 237377.

Type locality: South Atlantic Ocean, Sample 356-6-6, 130-131 cm (123 m).

ACKNOWLEDGMENT

I thank George W. Moore and John A. Barron, U.S. Geological Survey, and Katharina Perch-Nielsen, Geologisches Institut ETH, Zurich, Switzerland, for their helpful comments and suggestions on various aspects of this study.

ADDENDUM

Some silicoflagellate figures on page 547 of DSDP Volume 30 are misnumbered. The illustration shown as 10 should read 11; change 11 to 13, 12 to 14, 13 to 10, and 14 to 12.

REFERENCES

Bramlette, M.N. and Wilcoxon, J.A., 1967. Middle Tertiary calcareous nannoplankton of the Cipero Section, Trinidad, W.I.: Tulane Studies Geol., v. 5, p. 93-131.

Bukry, D., 1973a. Low-latitude coccolith biostratigraphic zonation. *In* Edgar, N.T., Saunders, J.B., et al., Initial Reports of the Deep Sea Drilling Project., Volume 15, Washington (U.S. Government Printing Office), p. 685-703.

———, 1973b. Phytoplankton stratigraphy, central Pacific Ocean, Deep Sea Drilling Project Leg 17. *In* Winterer, E.L., Ewing, J.I., et al., Initial Reports of the Deep Sea Drilling Project, Volume 17: Washington (U.S. Government Printing Office), p.871-889.

———, 1975. Silicoflagellate and coccolith stratigraphy, Deep Sea Drilling Project Leg 29. *In* Kennett, J.P., Houtz, R.E., et al., Initial Reports of the Deep Sea Drilling Project, Volume 29: Washington (U.S. Government Printing Office) p. 845-872.

———, 1976. Cenozoic silicoflagellate and coccolith stratigraphy, South Atlantic Ocean, Deep Sea Drilling Project Leg 36. *In* Hollister, C.D., Craddock, C., Initial Reports of the Deep Sea Drilling Project, Volume 35: Washington (U.S. Government Printing Office), p. 885-918.

———, in press. Cenozoic silicoflagellate and coccolith stratigraphy, northwestern Atlantic Ocean, Deep Sea Drilling Project Leg 43. *In* Tucholke, B., Vogt, P., et al., Initial Reports of the Deep Sea Drilling Project, Volume 43: Washington (U.S. Government Printing Office).

Bukry, D. and Foster, J.H., 1974. Silicoflagellate zonation of Upper Cretaceous to lower Miocene deep-sea sediment: U.S. Geol. Surv. J. Res., v. 2, p. 303-310.

Gartner, S., Jr., 1971. Calcareous nannofossils from the JOIDES Blake Plateau cores and revision of Paleogene nannofossil zonation: Tulane Studies Geol. Paleontol., v. 8, p. 101-121.

Glezer, Z.I., 1964. Novye kremnevye zhgutikovye vodorosli Paleogena SSSR [New silicoflagellates from the Paleogene of the USSR]: Akad. Nauk SSSR, Novosti sistematiki nizshikh rasteniy, otdel. ottisk, p. 46-58.

———, 1966, Silicoflagellatophyceae. *In* Gollerbakh, M.M. (Ed.), Cryptogamic plants of the U.S.S.R.: Akad. Nauk SSSR, V.A. Komarova Bot. Inst. (Translated from Russian by Israel Program for Scientific Translations Ltd., Jerusalem, 1970), v. 7, p. 1-363.

Hanna, G.D., 1931. Diatoms and silicoflagellates of the Kreyenhagen shale: California Div. Mines State Mineral. Rept., v. 27, p. 187-201.

Lemmermann, E., 1901, Silicoflagellatae: Deutsche. Bot. Gesell. Ber., v. 19, p. 247-271.

Ling, H.Y., 1972, Upper Cretaceous and Cenozoic silicoflagellates and ebridians: Am. Paleontol. Bull., v. 62, p. 135-229.

Martini, E., 1974. Silicoflagellate zones in the Eocene and early Oligocene: Senckenberg. Lethaea, v. 54, p. 527-532.

Perch-Nielsen, K., 1975. Late Cretaceous to Pleistocene silicoflagellates from the southern southwest Pacific, DSDP Leg 29. *In* Kennett, J.P., Houtz, R.E., et al., Initial Reports of the Deep Sea Drilling Project, Volume 29: Washington (U.S. Government Printing Office), p. 677-721.

Schulz, P., 1928. Beiträge zur Kenntnis fossiler und rezenter Silicoflagellaten: Bot. Archiv, v. 21, p. 225-292.

Stradner, H., 1961. Über fossile Silicoflagelliden und die Möglichkeit ihrer Verwendung in der Erdölstratigraphie: Erdöl Kohle, v. 14, p. 87-92.

Thierstein, H.R., 1971. Tentative Lower Cretaceous calcareous nannoplankton zonation: Eclog. Geol. Helv., v. 64, p. 459-487.

PLATE 1
Silicoflagellates from DSDP Leg 39
All figures at magnification 800×;
scale bar equals 10 μm.

Figure 1	*Corbisema bimucronata* Deflandre. Sample 356-6-6, 130-131 cm (123 m).
Figure 2	*Corbisema hastata globulata* Bukry. Sample 356-8-2, 130-131 cm (164 m).
Figure 3	*Corbisema inermis inermis* (Lemmermann). Sample 356-7-1, 130-131 cm (134 m).
Figures 4, 5	*Corbisema lamellifera* (Glezer). Sample 356-6-6, 130-131 cm (123 m).
Figure 6-8	*Dictyocha spinosa* (Deflandre). 6. Sample 356-6-6, 130-131 cm (123 m). 7. Sample 356-8-1, 130-131 cm (162 m), apical focus. 8. Sample 356-8-1, 130-131 cm (162), basal focus.
Figure 9	*Distephanus crux* (Ehrenberg) s. ampl. Sample 356-7-1, 130-131 cm (134 m).
Figure 10	*Dictyocha* sp. (asperoid). Sample 356-7-1, 130-131 cm (134 cm).
Figures 11-13	*Mesocena venusta* n. sp. 11. Holotype, USNM 237371, Sample 356-7-3, 130-131 cm (137 m). 12. USNM 237372, Sample 356-7-5, 130-131 cm (140 m), fragment. 13. USNM 237373, Sample 356-7-1, 130-131 cm (134 m), obscured specimen.
Figure 14	*Naviculopsis constricta* (Schulz). Sample 356-6-6, 130-131 cm (123 m).

PLATE 1

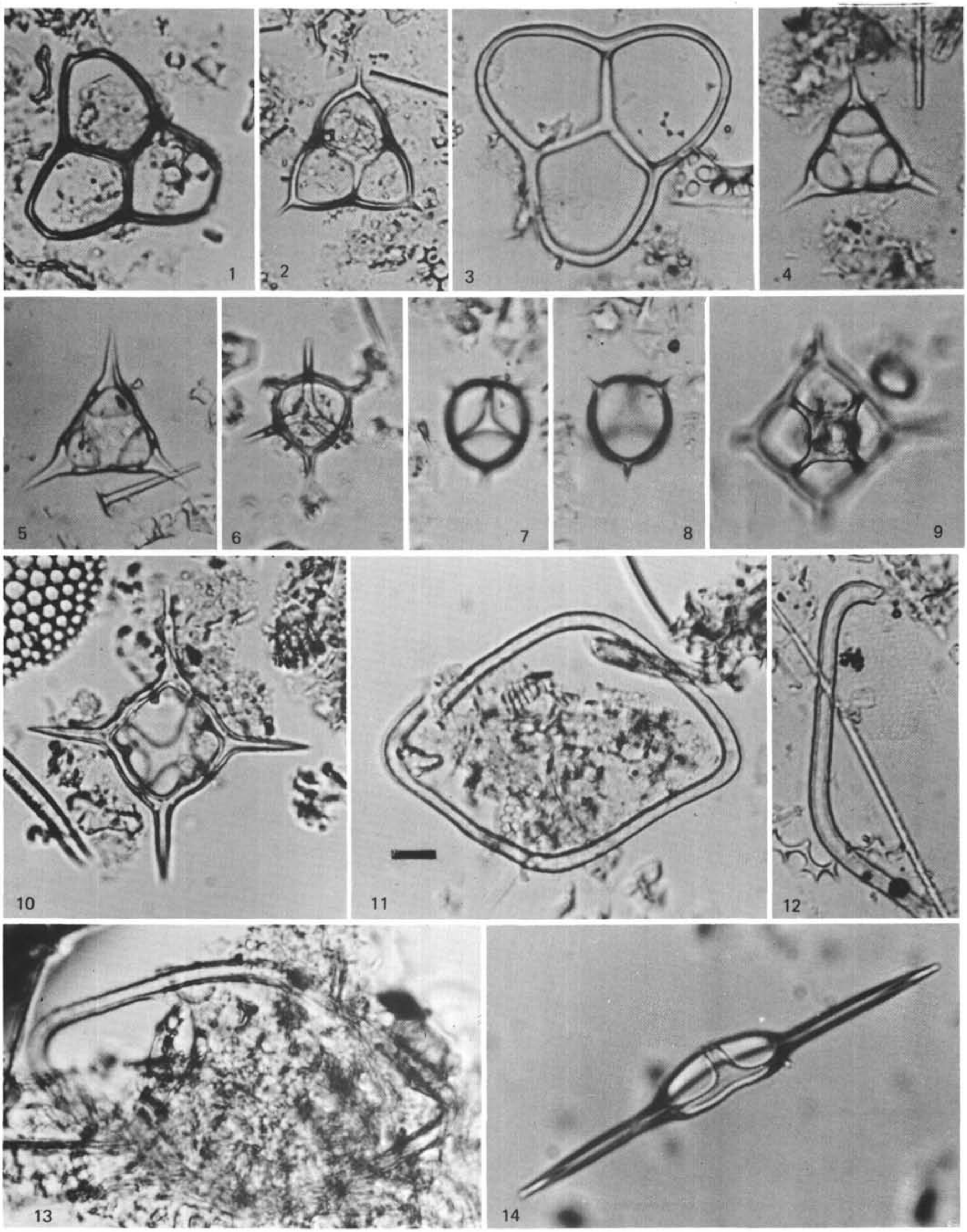

PLATE 2
Silicoflagellates and Diatoms from DSDP Leg 39
Figures 1-14, 17 at magnification 800×; scale bar equals 10 μm.
Figures 15, 16 at magnification 500×; scale bar equals 10 μm.

Figure 1	*Naviculopsis danica* Perch-Nielsen. Sample 356-7-5, 130-131 cm (140 m).
Figure 2	*Naviculopsis biapiculata* (Lemmermann) s. ampl. Sample 356-8-2, 130-131 cm (164 m).
Figures 3-8	*Macrora barbadiensis* (Deflandre). All specimens from Sample 356-6-6, 130-131 cm (123 m).
Figures 9-12	*Macrora najae* n. sp. All specimens from Sample 356-6-6, 130-131 cm (123 m). 9. USNM 237375. 10. USNM 237376. 11. Holotype, USNM 237374. 12. USNM 237377.
Figure 13	*Asterolampra decora* Greville, var. nov. of Castracane (1886). Sample 356-9-1, 130-131 cm (190 m).
Figure 14	*Brightwellia* sp. cf. *B. pulchra* Grunow. Sample 356-9-2, 130-131 cm (192 m).
Figure 15	*Brightwellia* sp. Sample 356-9-1, 130-131 cm (190 m).
Figure 16	*Actinocyclus* sp. cf. *A. bisenarius* Ehrenberg. Sample 356-9-1, 130-131 cm (190 m).
Figure 17	*Craspedodiscus oblongus* (Greville). Sample 356-6-6, 130-131 cm (123 m).

PLATE 2

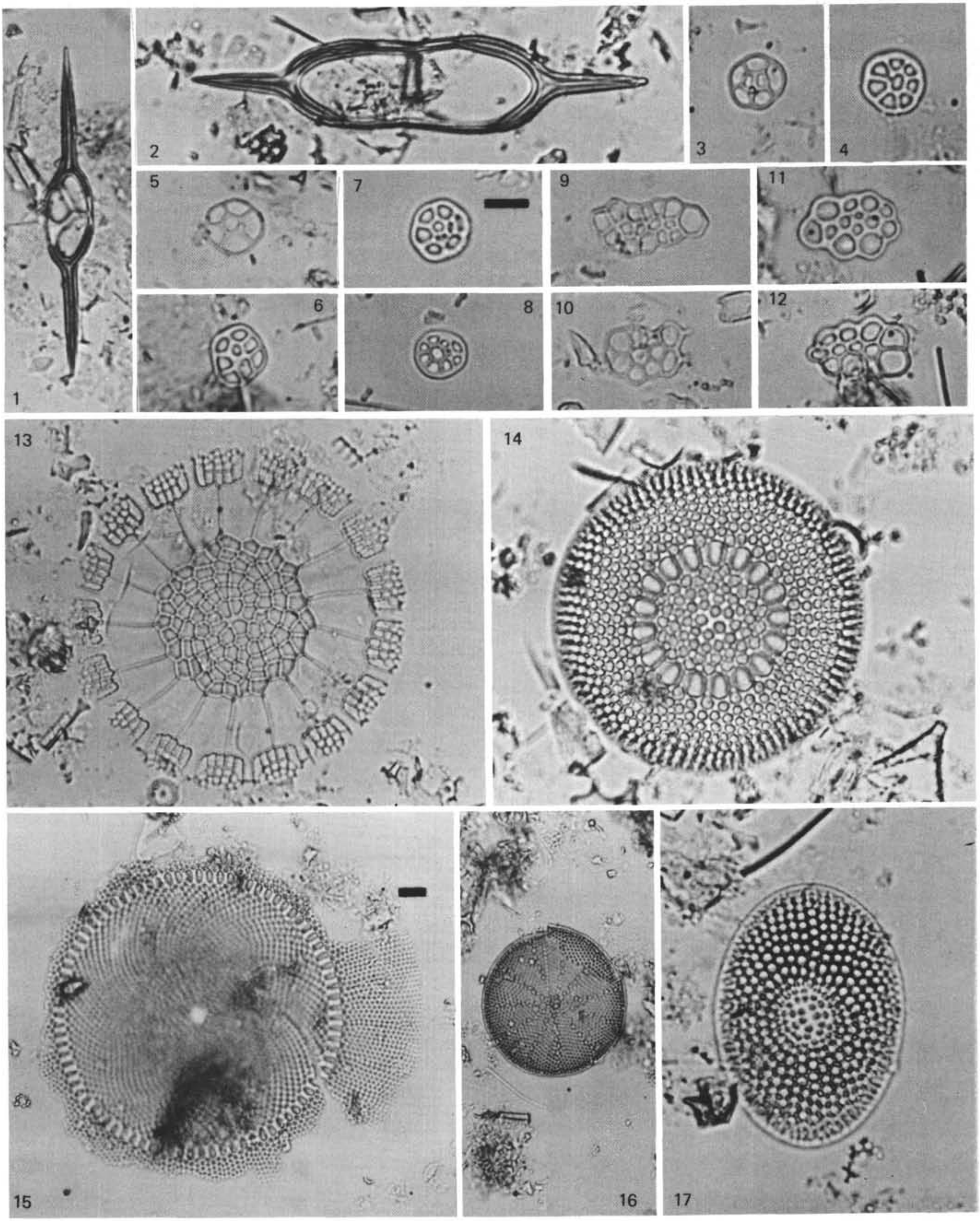

PLATE 3

Diatoms from DSDP Legs 21 and 39

Figure 1 at magnification 500×; scale bar equals 10 μm.

Figure 2 at magnification 1100×; scale bar equals 10 μm.

Figures 3-7 magnification 800×; scale bar equals 10 μm.

Figures 1, 2 — *Hemiaulus* sp.
Sample 356-6-6, 130-131 cm (123 m). Structures shown here suggest that the Eocene *Thalassiothrix*? sp. in DSDP Volume 17 (Bukry, 1973b) may be a fragment of a *Hemiaulus* sp.

Figures 3-5 — *Trinacria*? sp.
Sample 356-9-1, 130-131 cm (190 m).
3, 4. Surface and profile focuses of same specimen.
5. General focus.

Figures 6, 7 — Diatom sp. 1. Compare *Rylandsia biradiata* Greville—Schmidt Atlas, pl. 137/23-25.
6. Sample 356-9-1, 130-131 cm (190 m).
7. Sample 208-27-5, 103-104 cm (490 m).

PLATE 3