15. CENOZOIC COCCOLITH AND SILICOFLAGELLATE STRATIGRAPHY, OFFSHORE NORTHWEST AFRICA, DEEP SEA DRILLING PROJECT LEG 41

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INTRODUCTION

Leg 41 of the Deep Sea Drilling Project, February to April 1975, which began at Abidjan, Ivory Coast, and ended at Malaga, Spain (Figure 1), recovered 300 cores at five drilling sites, 366-370. Light-microscope techniques were used to study the Cenozoic coccoliths and silicoflagellates of 220 samples from these cores. Coccolith zonation of the samples, summarized in Figure 2, follows Bukry (1975c).

A nearly complete sequence of Cenozoic tropical coccolith assemblages occurs at Site 366. At Site 370, to the north, contrasting temperate coccolith assemblages are indicated by a low *Discoaster/Chiasmolithus* ratio in the Eocene and low *Discoaster/Coccolithus* ratios in the Pliocene.

Silicoflagellate assemblages of Oligocene and early Miocene age, at Sites 369 and 370, contain two new subspecies: *Corbisema bimucronata rotatoria* Bukry and *C. triacantha mediana* Bukry. New taxonomic combinations resulting from a count of 4500 specimens include: *Dictyocha brevispina ausonia* (Deflandre), *D. quadrangula* (Bachmann), *Distephanus speculum haliomma* (Ehrenberg), *D. staurodon* (Ehrenberg), *D. stradneri* (Jerković), and *Mesocena apiculata glabra* (Schulz).

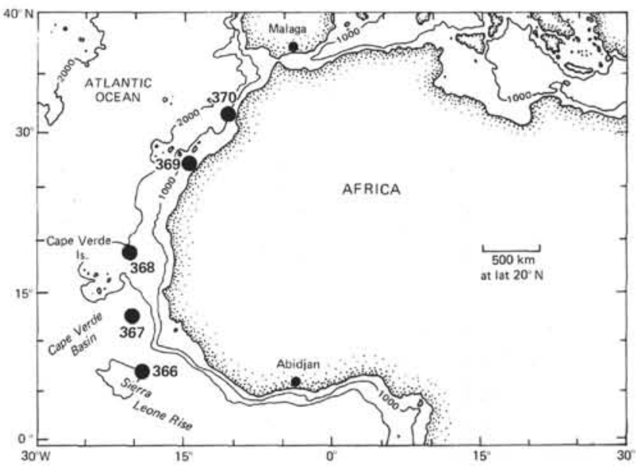

Figure 1. *Sketch map of sites drilled on Deep Sea Drilling Project Leg 41 in the eastern Atlantic Ocean. Depth contours in fathoms.*

SITE SUMMARIES

Site 366
(lat 05°40.68'N, long 19°51.08'W, depth 2860 m)

Site 366, on the Sierra Leone Rise, was continuously cored to obtain a stratigraphic reference section for the tropical eastern Atlantic Ocean. Coccoliths are abundant through the Paleocene and upper Eocene to Holocene; they are rare to common in the lower and middle Eocene limestone of Cores 18 to 41 (490 to 718 m). Upper Miocene to Holocene coccoliths are well preserved, showing slight overgrowth and etching. Paleocene and upper Eocene to middle Miocene coccoliths are moderately overgrown. Only lower and middle Eocene assemblages are thickly overgrown.

Quaternary coccolith assemblages of Cores 1 and 2 (0 to 15 m) and Cores 1A to 3A (0 to 25 m) are composed of tropical species, including *Ceratolithus cristatus, C. telesmus, Emiliania annula, E. ovata, Gephyrocapsa oceanica*, and *G. omega*.

Discoasters are abundant through the Pliocene and their assemblages are typical for tropical conditions. The youngest assemblage observed, that from the *Cyclococcolithina macintyrei* Subzone, has about equal numbers of *Discoaster brouweri* and *D. triradiatus. Discoaster pentaradiatus* dominates the *Discoaster surculus* Subzone. Warm-water conditions for the *Discoaster tamalis* Subzone and *Discoaster asymmetricus* Subzone are further supported by the presence of *Discoaster blackstockae, D. decorus, D. quadramus*, and *Hayaster perplexus*.

The upper Miocene *Discoaster quinqueramus* Zone of Cores 11A and 12A (92 to 111 m) is dominated by discoasters, *Helicosphaera carteri* and *Sphenolithus abies*. Similarly, the middle Miocene *Catinaster calyculus* Subzone of Core 13A (111 to 120 m) is dominated by low-latitude guide species *Discoaster bellus, D. hamatus, D. neohamatus*, and *Catinaster calyculus*. In Core 14A (120 to 130 m) *Catinaster coalitus* and *Discoaster variabilis* dominate the coccolith assemblage of the *Catinaster coalitus* Zone.

Species of *Discoaster, Sphenolithus*, and *Triquetrorhabdulus* are abundant in the lower Miocene, permitting recognition of all designated low-latitude stratigraphic units for coccoliths (Figure 2).

Placoliths dominate Oligocene assemblages; discoasters, mainly *D. deflandrei*, are common to meager. Relatively warm-water conditions are indicated by a common to abundant occurrence of *Sphenolithus* species.

Eocene discoaster specimens have thicker overgrowths (+4 to +5; Bukry, 1973a) than the specimens of any other series. The larger, more distinctive species, such as *Discoaster diastypus, D. lodoensis, D. mirus, D. saipanensis, D. strictus, D.*

Age	Zone	Subzone	366	366A	367	368	369	370
Quaternary	*Emiliania huxleyi*		1-2	1A-3	1-1/?1-5	1-1	1-1	
	Gephyrocapsa oceanica	*Ceratolithus cristatus*			2-5	1-6/2-2		
		Emiliania ovata	2-2/2-6	2A-4/3A-6				
	Crenalithus doronicoides	*Gephyrocapsa caribbeanica*						
		Emiliania annula				3-1/3-3		
Pliocene	*Discoaster brouweri*	*Cyclococcolithina macintyrei*		4A-2/4A-5				
		Discoaster pentaradiatus						
		Discoaster surculus		5A-2/5A-5	3-2	4-1/4-6		
		Discoaster tamalis		6A-2/6A-5	4-3/4-5			1-3/1-5
	Reticulofenestra pseudoumbilica	*Discoaster asymmetricus*		7A-1/7A-3				
		Sphenolithus neoabies		7A-6/8A-3		5-1/5-2		
	Amaurolithus tricorniculatus	*Ceratolithus rugosus*		9A-1		5, CC		
		Ceratolithus acutus		9A-3				
Miocene		*Triquetrorhabdulus rugosus*		10A-1				
	Discoaster quinqueramus	*Amaurolithus primus*		11A-3		6-2/8-5		
		Discoaster berggrenii		12A-3			1-3/2-3	
	Discoaster neohamatus	*Discoaster neorectus*				9-2	3-3/?4-3	
		Discoaster bellus				9-5		
	Discoaster hamatus	*Catinaster calyculus*		13A-3		10-1	5-1	
		Helicosphaera carteri					5-3	
	Catinaster coalitus		3-1	14A-3			1A-3	
	Discoaster exilis	*Discoaster kugleri*	?3-6	15A-1/16A-3				
		Coccolithus miopelagicus					2A-3/3A-5	
	Sphenolithus heteromorphus		4-1	17A-3/18A-3	6, CC	13-3/14-2	4A-2/10A-3	2-2/3-2
	Helicosphaera ampliaperta			20A-2		15-4/16-2	10A-6/11A-3	
	Sphenolithus belemnos			21A-2/?23A-3				?4-2/4-4
	Triquetrorhabdulus carinatus	*Discoaster druggii*		?25A-1		16-4		
		Discoaster deflandrei	4-3/5-1	26A-2/29A-3			11A-6/13A-3	
Oligocene		*Cyclicargolithus abisectus*		30A-3				
	Sphenolithus ciperoensis	*Dictyococcites bisectus*	5-5	31A-3/33A-2			14A-3/19A-4	?5-3/5-5
		Cyclicargolithus floridanus					20A-1	
	Sphenolithus distentus			34A-3/38A-2			20A-4/24A-4	6-1
	Sphenolithus predistentus		6-3/8-3	39A-2			25A-2/27A-5	
	Helicosphaera reticulata	*Reticulofenestra hillae*					?28A-3/30A-2	
		Coccolithus formosus	9-2/10-2				31A-3/32A-4	
		Coccolithus subdistichus						
Eocene	*Discoaster barbadiensis*	*Isthmolithus recurvus*	10-6/16-CC				33A-2	
		Chiasmolithus oamaruensis						
	Reticulofenestra umbilica	*Discoaster saipanensis*	18-1/23-2					?7-2/14-2
		Discoaster bifax					33A-4/35A-4	
	Nannotetrina quadrata	*Coccolithus staurion*	?23-CC/25-CC					15-2
		Chiasmolithus gigas	26-3/27-2					
		Discoaster strictus	27-5/29-4					
	Discoaster sublodoensis	*Rhabdosphaera inflata*	31-3/33-4					
		Discoasteroides kuepperi						16-2/18-2
	Discoaster lodoensis		34-3/38-3		12, CC	28-1		18, CC
	Tribrachiatus orthostylus		?39-3					
	Discoaster diastypus	*Discoaster binodosus*	41-3 40-3					
		Tribrachiatus contortus						
Paleocene	*Discoaster multiradiatus*	*Campylosphaera eodela*	42-3/43-3					
		Chiasmolithus bidens	45-3/46-3					
	Discoaster nobilis							
	Discoaster mohleri		47-3					
	Heliolithus kleinpellii		48-1/48-3					
	Fasciculithus tympaniformis		49-3					
	Cruciplacolithus tenuis		49-6/53-CC					

Figure 2. *Cenozoic coccolith zonation of core samples from DSDP Leg 41. If more than one sample is assigned to a zonal unit, only the highest and lowest samples are listed, separated by a slash. Cores from second drill holes at the same site are labeled A.*

sublodoensis, Nannotetrina quadrata, and *Tribrachiatus orthostylus*, can generally be differentiated. An absence of temperate- and cool-water guide species of *Chiasmolithus* and *Isthmolithus*, in the upper Eocene (Cores 10 to 16, 414 to 480 m) is typical of warm-water coccolith assemblages. The large, circular placoliths *Coccolithus formosus* and *Reticulofenestra reticulata*, indicating tropical to temperate conditions, are common in the lower upper Eocene of Cores 13 to 16 (442 to 480 m).

Placoliths and sphenoliths dominate the low-diversity assemblages of the middle Eocene. Smaller or more delicate coccoliths have presumably been destroyed by diagenesis of original calcareous ooze to limestone. Robust species such as *Chiasmolithus grandis, C. solitus, Coccolithus pelagicus, Discoaster* *barbadiensis, D. strictus, Nannotetrina quadrata, Reticulofenestra samodurovii, Sphenolithus radians, Triquetrorhabdulus inversus*, and *Zygrhablithus bijugatus* characterize many of the diagenetic assemblages of middle Eocene Cores 23 to 29 (537 to 604 m). The presence of *Chiasmolithus gigas* and *Sphenolithus furcatolithoides* in Samples 366-26-3, 59-60 cm (568 m) and 366-27-2, 91-92 cm (572 m), helps define the middle part of the *Nannotetrina quadrata* Zone. *Discoaster strictus*, having a large overgrown central plug, was illustrated from the lower *N. quadrata* Zone of the tropical East Pacific Rise (Bukry, 1973a); the same form is common at the Sierra Leone Rise in four samples between 366-27-5, 48-49 cm (582 m) and 366-29-2, 72-73 cm (596 m). The overlap in ranges of *Discoaster sublodoensis, Lophodolithus mochlophorus*, and *Triquetrorhabdulus inversus* in Cores 31 and 32 (613 to 632 m) indicates the *Discoaster sublodoensis* Zone. *Discoaster sublodoensis* occurs in Core 33 (633 m) with older *Coccolithus crassus* and *Discoaster lodoensis*. Diversity and preservation of coccoliths is poor in the lower Eocene.

Paleocene coccolith assemblages contain typical low-latitude guide species, but the assemblages are poorly preserved and dominated by durable species, such as *Chiasmolithus californicus, Coccolithus pelagicus* s. ampl., *Cruciplacolithus tenuis, Fasciculithus pileatus, F. tympaniformis, Neochiastozygus chiastus*, and *Zygodiscus sigmoides*. The sequential appearances, through Cores 42 to 53 (718 to 832 m), of the species *F. tympaniformis, Heliolithus kleinpellii, Discoaster mohleri, D. multiradiatus*, and *Campylosphaera eodela* are used for Paleocene zonation. The deepest Cenozoic sample, 366-53, CC, contains a mixture of Late Cretaceous and Paleocene species.

Normal oceanic conditions through the Cenozoic are indicated at Site 366 by the absence of the pentaliths *Braarudosphaera, Micrantholithus*, or *Pemma* (Bukry et al., 1971). Unlike South Atlantic Sites 14, 17, 19, 20, 22, and 362, no *Braarudosphaera* chalks were developed during the late Oligocene (*Sphenolithus distentus* Zone).

Site 367
(lat 12°29.21'N, long 20°02.83'W, depth 4748 m)

Site 367, located in the Cape Verde Basin, was cored to establish the age of acoustic-reflector horizons and to compare the Mesozoic section of the area with that east of North America. Coccoliths occur in several Cenozoic cores between 0 and 379 meters. Below the Pliocene of Core 4 (64 to 73 m), coccoliths are absent from most samples.

Gephyrocapsa oceanica and tiny placoliths (?*Emiliania huxleyi*) dominate the Quaternary assemblage of Core 1 (0 to 8 m). *Emiliania annula* and *E. ovata* are missing from Sample 367-2-5, 80-81 cm (15 m), which is assigned to the upper Quaternary *Ceratolithus cristatus* Subzone.

Moderately etched, warm-water Pliocene assemblages are common to abundant in Cores 3 and 4 (54 to 73 m). The *Discoaster tamalis* Subzone of Sample 367-4-5, 100-101 cm (71 m) contains *Ceratolithus* sp. cf. *C. cristatus, Coccolithus pelagicus, Crenalithus doronicoides, Cyclococcolithina macintyrei, Discoaster asymmetricus, D. brouweri, D. pentaradiatus* (predominant), *D. surculus, D. tamalis, Emiliania* sp. cf. *E. annula*, and *Helicosphaera carteri*.

The only definitive coccolith assemblages from Cores 5 to 13 are in Samples 6, CC and 12, CC. Samples from Cores 8, 13, 14, and 15 are barren. A lower middle Miocene *Sphenolithus heteromorphus* Zone assemblage in Sample 6, CC (246 m) contains *Coccolithus pelagicus, Cyclicargolithus floridanus, Discoaster braarudii, D. exilis, D.* sp. cf. *D. variabilis, Discolithina multipora, Helicosphaera carteri, Sphenolithus heteromorphus* (common), and reworked *Transversopontis pulcher* and *Triquetrorhabdulus carinatus*.

A moderately etched early Eocene assemblage in Sample 12, CC (369 m) contains reworked Cretaceous species (*Watznaueria barnesae*) and Paleocene species (*Heliolithus kleinpellii* and *Zygodiscus sigmoides*). The indigenous assemblage includes: *Camplyosphaera dela, Chiasmolithus consuetus, Coccolithus crassus, C. pelagicus, Discoaster binodosus, D. lodoensis, D. nonaradiatus, Discolithina* spp., *Helicosphaera seminulum, Sphenolithus radians, Transversopontis pulcheroides*, and *Tribrachiatus orthostylus*.

Site 368
(lat 17°30.43'N, long 21°21.23'W, depth 3367 m)

Site 368, on the Cape Verde Rise, was cored to determine the history of this prominent sea-floor structure that divides the Canary Basin from the Cape Verde Basin off northwest Africa. Cenozoic coccoliths occur in Cores 1 to 16 (0 to 266 m) and 28 (395 to 404 m). Coccoliths are abundant and slightly etched in Cores 1 to 16, and rare and strongly etched in Core 28.

Gephyrocapsa is abundant in upper Quaternary Cores 1 to 2 (0 to 19 m). The lower Quaternary *Emiliania annula* Subzone of Core 3 (47 to 57 m) is characterized by *Ceratolithus cristatus, Coccolithus pelagicus, Crenalithus doronicoides, Cyclococcolithina macintyrei*, and *Emiliania annula*, and by the absence of *Discoaster* and *Gephyrocapsa*.

The middle and late Miocene assemblages of Core 9 and 10 (190 to 209 m) are dominated by discoasters. The *Discoaster neohamatus* Zone of Core 9 has a well-preserved and diverse warm-water assemblage including: *Discoaster bellus, D. bollii, D. braarudii, D. loeblichii, D. neohamatus, D. pansus, D. pentaradiatus, D. prepentaradiatus*, and *D. variabilis*. The *Discoaster hamatus* Zone in Sample 368-10-1, 80-81 cm (200 m) is characterized by abundant and moderately etched discoasters such as *Catinaster calyculus, Discoaster bellus, D. braarudii, D. hamatus*, and *D. variabilis*.

The rare specimens of early Eocene coccoliths in Sample 368-28-1, 61-62 cm (395 m) are apparently the residuum of an originally more complete assemblage which was dissolved and reprecipitated as numerous large calcareous rhombs. An assignment to the *Discoaster lodoensis* Zone is indicated by the presence of *Coccolithus crassus, Discoaster cruciformis, D. distinctus, D. lodoensis, Discoasteroides kuepperi*, and *Tribrachiatus orthostylus*.

Site 369
(lat 26°35.55'N, long 14°59.92'W, depth 1760 m)

Site 369, on the continental slope off Cape Bojador, was cored to determine the history of the development of the continental slope off northwest Africa. Cenozoic coccoliths are common to abundant and moderately etched in Cores 1 to 5 (0 to 42 m) and Cores 1A to 35A (42 to 375 m).

Quaternary coccoliths *Gephyrocapsa oceanica* and *G. omega* occur only in a thin, 50-cm layer of grayish-orange sediment at the top of Core 1. A greenish-gray upper Miocene sediment containing common discoasters lies immediately below in Core 1. *Discolithina multipora* is common in Sample 369-1-3, 70-71 cm (3 m), and there is a persistent occurrence of this and other species of *Discolithina* in Miocene Cores 1 to 5 and 1A to 13A. *Scyphosphaera* is less common, suggesting differential dissolution of these two related form genera, skeletons of which can be produced by the same organism (Gaarder, 1970).

Middle Miocene discoasters are especially well preserved and diverse. Discoaster assemblages through the *Sphenolithus heteromorphus* Zone and *Discoaster exilis* Zone are sequentially dominated by *Discoaster deflandrei, D. signus, D. variabilis*, and *D. exilis*. Other species present include *D. aulakos, D. braarudii, D. challengeri, D.* sp. cf. *D. icarus, D. moorei*, and *D. subsurculus*. The *Discoaster hamatus* Zone in the upper middle Miocene includes such species as *Catinaster calyculus, Discoaster bellus, D. bollii, D. calcaris, D. hamatus, D. pansus, D. perclarus*, and *D. variabilis*.

Late Oligocene assemblages of the *Sphenolithus distentus* Zone and *Sphenolithus ciperoensis* Zone are similar and suggest warm-temperate conditions. A composite assemblage includes: *Chiasmolithus altus, Cyclicargolithus abisectus, C. floridanus, Dictyococcites bisectus, Discoaster deflandrei, Helicosphaera euphratis, H. intermedia, H. recta, Reticulofenestra gartneri, Sphenolithus ciperoensis* or *S. distentus, S. moriformis*, and *Zygrhablithus bijugatus*.

The early Oligocene assemblages contain meager *Chiasmolithus altus, C. oamaruensis*, and *Isthmolithus recurvus*, which may be reworked from the upper Eocene, as it is represented by an abbreviated, presumably eroded, section within the upper part of Core 33A (346 to 348 m). The section is described as bioturbated and possibly a slump deposit; it contains common *I. recurvus* and rare *Discoaster saipanensis*.

The middle Eocene *Discoaster bifax* Subzone, ranging from lower Core 33A through Core 35A (350 to 375 m), has common to abundant discoasters; *D. bifax*, however, is identified only in Sample 369A-35A-4, 67-68 cm (369 m). Other samples are assigned to the subzone on the basis of the overlapping ranges of *Chiasmolithus solitus* and *Reticulofenestra umbilica*, and the first appearance of *Sphenolithus obtusus* in Sample 369A-33A-4, 67-68 cm (350 m).

Oligocene and early Miocene silicoflagellates occur in varying abundance as a minor constituent of Cores 10A to 32A at Site 369. The Oligocene assemblages have a distinctive low-latitude aspect, because the warm-water genus *Corbisema* constitutes 20% to 80% of the populations, whereas this genus constitutes less than 14% at the high-latitude sites of DSDP Legs 29 and 36. And several common, high-latitude stratigraphic guide species, such as *Dictyocha deflandrei, D. fischeri*, and *Naviculopsis trispinosa*, are missing.

Early Miocene silicoflagellate assemblages at Site 369 are more cosmopolitan. The occurrence of *Distephanus crux* s. ampl., *D. crux hannai, D. speculum hemisphaericus, Naviculopsis lata*, and *Macrora stella* shows strong affinities to silicoflagellate populations described from Europe (Martini, 1972; Sanfilippo et al., 1973), and from DSDP sites in the Atlantic, Pacific, and Southern oceans (Bukry, 1975b, in press [c]; Perch-Nielsen, 1975).

The youngest silicoflagellate sample studied has common *Corbisema triacantha triacantha, Dictyocha pulchella*, and *Distephanus crux* s. ampl., and is above the range of *Naviculopsis*. This assemblage is part of the middle Miocene *Corbisema triacantha* Zone.

Site 370
(lat 32°50.25′N, long 10°46.56′W, depth 4216 m)

Site 370, located in a deep basin west of Morocco, was cored to obtain a Mesozoic sedimentary section in a near-continent setting. Cenozoic coccoliths occur in samples from Cores 1 to 18 (0 to 645 m). The Neogene was only spot cored and the Paleogene was skip cored (cores cut only every other 10 m, the intervening 10 m being washed away), resulting in a discontinuous stratigraphic record. Small numbers of reworked Mesozoic species occur in many samples.

Upper Pliocene *Discoaster tamalis* Subzone coccoliths occur in Samples 370-1-3, 70-71 cm (3 m) and 370-1-5, 80-81 cm (6 m). The assemblage shows much cooler conditions at Site 370 than do coeval assemblages at tropical Sites 366 and 367. For example, *Coccolithus pelagicus* is abundant, *Ceratolithus rugosus* is missing, and *Discoaster surculus* dominates *D. pentaradiatus* among the sparse discoasters. The reverse is true at the tropical sites (Figure 3). The general distribution pattern showing *Coccolithus pelagicus* and *Discoaster surculus* most common in cooler waters of the late Pliocene in the Pacific (Bukry, 1975c; 1976a) seems to be repeated in Atlantic sites of Leg 41.

Cores 2 (103 to 113 m) and 3 (208 to 217 m) sampled the upper and lower parts of a thick middle Miocene *Sphenolithus heteromorphus* Zone. The assemblages are interpreted as a temperate-water facies, on the basis of sparse sphenoliths, common discoasters, and abundant placoliths. Coeval tropical assemblages at Hole 366A are dominated by sphenoliths and discoasters. Species present in the moderately to strongly etched assemblage, at Site 370, Core 2 are: *Coccolithus miopelagicus, C. pelagicus, Cyclicargolithus floridanus, Cyclococcolithina macintyrei* (early, elliptic variety), *Discoaster aulakos, D. braarudii, D. challengeri, D. deflandrei, D. exilis, D. signus, D. subsurculus, D. variabilis, Discolithina multipora, Helicosphaera carteri, Sphenolithus abies, S. heteromorphus*, and reworked *Micula decussata*.

Sample 370-3-2, 75-76 cm (210 m) contains *Coccolithus miopelagicus* (more strongly etched than above), *Cyclicargolithus floridanus* (abundant), *Cyclococcolithina macintyrei* (elliptic variety), *Discoaster deflandrei, D. exilis, D. variabilis, Helicosphaera carteri, Sphenolithus abies, S. heteromorphus*, and reworked *Zygodiscus deflandrei*.

				Discoasters												
Sample (Interval in cm)	Depth (m)	Water Depth (m)	Latitude	*Discoaster/ Coccolithus* Ratio	*Discoaster asymmetricus*	*D. blackstockae*	*D. brouweri*	*D. decorus*	*D. intercalaris*	*D. pentaradiatus*	*D. quadramus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*D. variabilis* s. ampl.	*Hayaster perplexus*
370-1-3, 70-71	3	4216	33°N	20/80	10		28		7	5		36	13		1	
370-1-5, 80-81	6			17/83	6		22			15		44	9	1	4	
367-4-3, 50-51	67	4748	12°N	94/6	7	<1	15			60		7	9	<1		
367-4-5, 100-101	71			96/4	12		30	<1		33		10	9	1	5	
366A-6-2, 67-68	46	2860	6°N	97/3	3		14	<1		67	1	9	4		1	<1
366A-6-5, 67-68	50			100/0	5		16			61		9	7	<1		1

Figure 3. *The* Discoaster/Coccolithus *ratio and relative abundance of* Discoaster *species are used to help distinguish the Pliocene* Discoaster tamalis *Subzone of tropical Sites 366 and 367 from temperate Site 370. The percentages of discoasters and the ratio with* Coccolithus *are based on independent counts of 300 specimens.*

The warm-water indicator genus *Sphenolithus* is rare in deeper cores.

A thick Eocene interval in Cores 7 to 18 (445 to 645 m) is characterized by moderately to strongly etched and fragmented assemblages containing calcareous rhombs. Placoliths, including chiasmoliths, outnumber discoasters, indicating temperate depositional conditions (Bukry, 1973b). For example, Sample 370-14-2, 87-88 cm (571 m) has a *Discoaster/Chiasmolithus* ratio of 31/69. The assemblage includes *Chiasmolithus grandis* (rare), *C. solitus, Coccolithus formosus* (rare), *C. pelagicus, Cyclicargolithus pseudogammation, Discoaster barbadiensis, D. distinctus, D. martinii, Helicosphaera seminulum, Nannotetrina quadrata* (rare), *Reticulofenestra samodurovii, R. umbilica* (rare), *Zygolithus dubius*, and reworked *Watznaueria barnesae* and *Zygolithus deflandrei.*

Both five- and six-rayed forms of *Discoaster sublodoensis* occur in Cores 16 and 17 (607 to 625 m).

The deepest Cenozoic sample available is assigned to the lower Eocene *Discoaster lodoensis* Zone. Species present in Sample 370-18, CC include: *Campylosphaera dela, Chiasmolithus expansus, C. solitus, Coccolithus crassus, C. pelagicus* s. ampl., *Cyclicargolithus pseudogammation, Cyclococcolithina gammation, Discoaster barbadiensis, D. distinctus, D. lodoensis* (large), *D.* sp. cf. *D. saipanensis, Discoasteroides kuepperi, Helicosphaera lophota, H. seminulum, Sphenolithus radians, Transversopontis pulcher*, and *Zygolithus dubius.*

Sparse early Miocene silicoflagellates occur in Cores 3 and 4 (208 to 227 m). Species composition of the assemblages is similar to that at nearby Site 369, permitting identification of the *Corbisema triacantha* Zone and *Naviculopsis lata* Zone (Figure 4).

SILICOFLAGELLATE ZONATION OF THE OLIGOCENE AND LOWER MIOCENE

Oligocene silicoflagellate assemblages of Site 369 lack many of the diagnostic marker species that have been used for high-latitude correlations. Although the cosmopolitan species of *Naviculopsis, N. biapiculata*, and *N. constricta*, are present, no specimens of *N. trispinosa* occur. The absence of *Dictyocha fischeri* and the rarity of *D. deflandrei* further complicate correlation with high-latitude Oligocene assemblages of DSDP Legs 28, 29, and 36. Emended versions of two previously described Oligocene zones are used for the Site 369 assemblages, but a division more specific to low-latitude assemblages will be possible when comparative material from other low-latitude areas is studied.

Early Miocene assemblages of Sites 369 and 370 are more similar to those reported for high latitudes. The zones employed for Leg 41 are described below from oldest to youngest.

Corbisema apiculata Zone (Perch-Nielsen, 1975; emended)

Late Eocene and early Oligocene assemblages from DSDP Sites 277, 280, 281, and 283, south of Australia, were assigned to a *Corbisema hastata-Corbisema apiculata* Zone or *Corbisema apiculata-Corbisema hastata* Zone by Perch-Nielsen (1975). This zone was identified as the interval between the last occurrences of *Dictyocha hexacantha* and *Corbisema hastata*, wherein *C. apiculata* or *C. hastata* are present in low numbers. Certain species of this assemblage occur in the lower Oligocene at Site 369 and are used to indicate the newly emended *Corbisema apiculata* Zone. This zone is characterized at Site 369 by the common occurrence of *Corbisema apiculata* (both regular and isosceles forms) and by the limitation of hastata-form species of *Corbisema* to this interval. *Dictyocha hexacantha* is rare, possibly reworked (Figure 5).

Naviculopsis biapiculata Zone (Bukry, 1974)

This upper Oligocene interval was defined between the first common appearance of *Naviculopsis biapiculata* and the last common occurrence of *N. biapiculata*. *Mesocena apiculata apiculata* and *Naviculopsis biapiculata* are common within the

Age	Miocene											
Depth (m)	210	217	218	220	221	131	141	142	144	145	155	163
Sample (Interval in cm) / Species	370-3-2, 75-76	370-3, CC	370-4-2, 77-78	370-4-3, 60-61	370-4-4, 77-78	369A-10-3, 71-72	369A-11-3, 67-68	369A-11-4, 71-72	369A-11-5, 71-72	369A-11-6, 71-72	369A-12-6, 71-72	369A-13-5, 71-72
Cannopilus depressus			1				1					
C. ernestinae						<1						
C. heptacanthus		<1		1							<1	
C. schulzii							1					
Corbisema flexuosa			1	1	1							
C. hastata minor		<1										
C. triacantha triacantha	9	6	3		2	9	18			<1		2
Dictyocha cf. *aspera aspera*	2			2	2						<1	
D. brevispina ausonia	12					1	15					
D. brevispina brevispina	6	4	9	10	3	4	<1	6	14	12	2	
D. fibula fibula	14					1	2					
D. pulchella	7	<1	1			55	30	<1	1			
D. pulchella (deflandroid)	6					1	5					
D. pulchella (medusoid)							<1					
D. cf. *pumila*									1			
D. cf. *stapedia stapedia*									<1			
Distephanus crux s. ampl.	39	53	37	35	47	15	18	69	52	32	27	57
D. crux darwinii							1	1		1	1	1
D. crux hannai	1	3	2	2	10					12	2	
D. cf. *longispinus*	1	<1		3		5	1	<1			2	13
D. norvegiensis							<1					
D. raupii s. ampl.								<1				
D. speculum binoculus			3	4	1						<1	
D. speculum haliomma	1	1	2	4	4		1	2	2	2	1	<1
D. speculum hemisphaericus			1					1	<1	<1		<1
D. speculum minutus		<1				5						
D. speculum pentagonus			1				<1	<1				2
D. speculum pseudocrux					1							
D. speculum speculum	4	5	25	11	22	1	2	13	11	24	30	1
D. speculum triommata		<1		3	1	<1	1		<1	<1		
D. staurodon		1	1	7	1	2	2	2	1	3	10	8
D. stradneri									1			4
Mesocena apiculata apiculata			3	5	3		<1	1	7	3	3	3
M. apiculata curvata		<1						<1	<1			
M. elliptica	2	7										
Naviculopsis biapiculata			2	5							4	3
N. cf. *biapiculata* (elongate)		2			1							
N. constricta											<1	
N. lata		7	8	7	1			4	8	6	16	2
N. navicula		2										
N. ponticula		2					<1					
N. cf. *ponticula* (narrow)		2										
N. quadrata		1	1									1
N. cf. *quadrata*		1		1				<1				
Macrora stella			2							3	<1	1
Total specimens	200	300	115	101	100	300	300	300	300	300	300	300

Figure 4. *Silicoflagellates from the middle and lower Miocene* Corbisema triacantha *Zone (370-3-2, and 369A-10-3, and 369A-11-3) and the lower Miocene* Naviculopsis lata *Zone (370-3, CC to 370-4-4, and 369A-11-4 to 369A-13-5), recorded as percents.*

Age	Late Oligocene						Early Oligocene			
Depth (m)	204	205	207	248	262	291	315	323	330	341
Species / Sample (Interval in cm)	369A-18-1, 67-68	369A-18-2, 67-68	369A-18-3, 67-68	369A-22-5, 67-68	369A-24-2, 67-68	369A-27-2, 109-110	369A-29-6, 97-98	369A-30-4, 77-78	369A-31-3, 77-78	369A-32-4, 87-88
Corbisema apiculata				1	1		18	3	16	4
C. cf. *apiculata* (isosceles)							14	17	12	
C. archangelskiana								2		
C. bimucronata bimucronata						9	5		2	2
C. cf. *bimucronata bimucronata*						2	1			4
C. bimucronata rotatoria						3				4
C. hastata globulata				1					4	14
C. hastata hastata										2
C. inermis							1			
C. triacantha mediana				7	1	42	35	33	12	
C. triacantha triacantha	24	66	63	21			6	2	18	8
Dictyocha aspera martinii s. ampl.								7	2	
D. aff. *brevispina brevispina*						9				
D. deflandrei					1					8
D. hexacantha							<1			1
D. pentagona					1					
D. sp. (asperoid)			<1		6	21	8	15		8
D. sp. (fibuloid)					2	3	2	9	2	
D. sp. (medusoid)					<1			2		
Distephanus aff. *crux* (large)			<1	2	4		1		2	2
D. crux darwinii			<1							
D. raupii s. ampl.	5		1							
D. speculum haliomma	1	1	1							
D. speculum hemisphaericus			<1							
D. speculum pentagonus		1								
D. speculum speculum	1	5	4							
D. speculum triommata	2		2							
Mesocena apiculata apiculata	54	21	17	54	32	1	1	2		
M. cf. *apiculata apiculata* (rounded)		1	2							
M. apiculata curvata					1					
M. apiculata glabra	2	1	2		1					
Naviculopsis biapiculata	11	2		6	2		4	7	12	4
N. cf. *biapiculata* (elongate)			1	2	2	5				6
N. cf. *biapiculata* (canted bar)							<1			
N. constricta			1	6	32	4	1	3	14	26
N. cf. *constricta* (semibarred)				15			1		4	
N. foliacea						1				7
N. lata			5							
N. cf. *quadrata*		2	2							
Macrora stella							1			
Total specimens	100	100	300	110	300	100	300	60	50	130

Figure 5. *Silicoflagellates from the upper Oligocene* Naviculopsis biapiculata *Zone (369A-18-1 to 369A-27-2) and the upper and lower Oligocene* Corbisema apiculata *Zone (369A-29-6 to 369A-32-4), recorded as percents.*

interval; *Naviculopsis constricta* disappears; and the diatom *Stictodiscus gelidus* appears. The assemblage for the zone at high-latitude Sites 267, 278, and 328 typically lacks *Corbisema apiculata* and *C. hastata* s. ampl., but has the earliest occurrences of *Distephanus speculum hemisphaericus*. These same cosmopolitan stratigraphic relations occur at Site 369, even though the general species array, with abundant *Corbisema triacantha*, reflects much warmer conditions.

Because *Naviculopsis biapiculata* persists through the whole Oligocene at Site 369, showing no significant acme in the upper Oligocene, the base of the zone is approximated as the disappearance of *Corbisema apiculata* and hastata-form species of *Corbisema*. The first appearance of the *Distephanus speculum haliomma-Distephanus speculum hemisphaericus* plexus within the zone at both high and low latitudes indicates a potential upper and lower division of the *Naviculopsis biapiculata* Zone.

Stictodiscus gelidus (?synonym *Rocella gemma*) is missing in the assemblages studied at Site 369. Its acme is probably brief at low latitude and was not sampled. *Stictodiscus gelidus* occurs in the South Atlantic at Site 328 and in the North Atlantic at Site 385 and is solution resistant. All other known occurrences are in the Pacific region. Its stratigraphic utility is only as an horizon marker in the sense of Martini (1971).

Naviculopsis lata Zone (Martini, 1972; emended)

This zone was originally defined in Europe as the interval between the first *Naviculopsis lata* and the first *N. navicula* (included *N. ponticula*), wherein *Corbisema flexuosa, Distephanus crux, Mesocena apiculata*, and *Naviculopsis lata* were common. The last occurrence of *N. lata* is used to mark the top of the zone for Sites 369 and 370, because *N. navicula* is rare and occurs only at Site 370. The base of the zone, occurring only at Site 369, is more problematic. The top of upper Oligocene Core 18 has common *N. biapiculata* without *N. lata*, but *N. lata* is present in the middle of the core, suggesting difficulty in assigning samples to the lowest part of the zone. Assignment of the upper part of Core 18 to the *N. lata* Zone would be unsupportable without knowledge of the presence of *N. lata* in the middle of the core. Because of possible mixing of sediment in the core by bioturbation and drilling it is provisionally assigned to the uppermost *Naviculopsis biapiculata* Zone.

Corbisema triacantha Zone (Martini, 1971, 1972; emended)

This zone was defined in Europe and the equatorial Pacific Ocean as the interval between the extinctions of *Naviculopsis rectangularis* (syn. *N. quadrata*) and *Corbisema triacantha*. The upper part of the zone was not recovered at Sites 369 or 370, but the middle Miocene extinction of *Corbisema* has proved to be a useful stratigraphic guide at other DSDP sites. The base of the zone is picked at the disappearances of *N. lata* and *N. quadrata*, essentially coincident at Sites 369 and 370. *Naviculopsis navicula* occurs in only a single sample at Site 370 and may prove to be a supplementary horizon-marking fossil rather than a consistent zonal marker fossil.

The *C. triacantha* Zone assemblages of Sites 369 and 370 are similar in the common occurrences of *Dictyocha brevispina ausonia* and *D. pulchella* (normal and deflandroid) which give a local character to the assemblages. *Mesocena elliptica* occurs in both the *N. lata* Zone and *C. triacantha* Zone at Site 370.

SILICOFLAGELLATE TAXONOMY

Two new subspecies and six new combinations are described. Illustration references for taxa cited, but not discussed in the systematic paleontology, appear at the end of this section.

SYSTEMATIC PALEONTOLOGY

Genus CORBISEMA Hanna, 1928

Corbisema bimucronata bimucronata Deflandre
(Plate 1, Figure 5)

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

Remarks: *Corbisema bimucronata bimucronata* is a moderate-sized taxon that is characterized by a basal ring having blunt, two-spined corners. The blunt segment is perpendicular to the bisectrix of the adjoining five-sided portal. The spines are equant and equidistant from the center of the ring. The Oligocene specimens from Site 369 are nearly devoid of spines.

Compared specimens at Site 369 have one basal-ring corner that is simply pointed rather than blunted.

Corbisema bimucronata rotatoria n. subsp.
(Plate 1, Figures 6, 7)

Description: *Corbisema bimucronata rotatoria* has simple, symmetric, apical struts. The basal ring has blunted corners bearing a short spine at the extremity of the blunting segment. The portals are equal and five-sided. The blunting segment is not perpendicular to the bisectrix of the adjoining portal. The degree and sense of inclination are the same for all portals, producing a slight clockwise rotation of the spined corners in basal view.

Remarks: *Corbisema bimucronata rotatoria* is closely related to *C. bimucronata bimucronata* by the blunt corners of the basal ring. It is distinguished by a systematic inclined orientation of the blunting segment.

Occurrence: *Corbisema bimucronata rotatoria* occurs in the Oligocene at Site 369 in the Atlantic Ocean off northwest Africa. Whether it is a local development of *C. bimucronata bimucronata* or a cosmopolitan form is not clear because low-latitude Oligocene silicoflagellates are not well known.

Size: 30 to 50 μm, maximum external diameter (Holotype, 45 μm).

Holotype: USNM 240698 (Plate 1, Figure 6).

Isotype: USNM 240699.

Type locality: Eastern North Atlantic Ocean, Sample 369A-27-2, 109-110 cm (201 m).

Corbisema triacantha mediana n. subsp.
(Plate 1, Figures 8-12)

Dictyocha triacantha var. *flexuosa* (Stradner) Glezer, 1966 (in part), p. 244, fig. 6, 8.

Dictyocha triacantha var. *triacantha* f. *minor* Schulz, Glezer, 1966 (in part), p. 244, fig. 7.

Corbisema minor (Schulz) Perch-Nielsen, 1975 (in part), p. 686, fig. 12.

Corbisema triacantha (Ehrenberg), Perch-Nielsen, 1975 (in part), p. 686, fig. 11.

Description: *Corbisema triacantha mediana* has a regular equilateral or slightly isosceles basal ring with moderate to long spines. The apical strut junctions with the basal ring are distinctly asymmetric, occurring approximately at a third or two-thirds of the distance along each side. The apical structure is simple, but is rarely expanded into a plate.

Remarks: *Corbisema triacantha mediana* is distinguished from *C. triacantha triacantha* by the distinctly asymmetric locations of the junctions of the struts to the basal ring, from *Corbisema flexuosa* by its regular outline. *Corbisema flexuosa* has prolongate portals and distinctly flexed lateral sides (see Stradner, 1961, text-fig. 1c; pl. 1, fig. 1-8; Perch-Nielsen, 1975, pl. 3, fig. 10; and Bukry, 1975b, pl. 1, fig. 4, 5).

Occurrence: *Corbisema triacantha mediana* is common in the lower Oligocene at Site 369 in the Atlantic Ocean off northwest Africa. Because its skeletal structure is intermediate between *C. flexuosa* and *C. triacantha triacantha*, it was probably tabulated with those species in previous studies.

Size: 18 to 30 μm, basal-ring diameter (Holotype, 23 μm).

Holotype: USNM 240700 (Plate 1, Figure 12).

Isotypes: USNM 240701 to 240704.

Type locality: Eastern North Atlantic Ocean, Sample 369A-29-6, 97-98 cm (315 m).

Genus DICTYOCHA Ehrenberg, 1837

Dictyocha brevispina ausonia (Deflandre) n. comb.
(Plate 1, Figures 17-19)

Dictyocha ausonia Deflandre, 1950, p. 195, fig. 194-196, 199-202.

Remarks: Relatively small, rounded specimens of the *Dictyocha brevispina* group that possess extremely small minor-axis portals occur in the *Corbisema triacantha* Zone at Sites 369 and 370. Because there is essentially no lateral protrusion at the minor axis, these specimens have a smoother elliptical outline than do the larger specimens of *D. brevispina brevispina* s. stricto. The populations at Sites 369 and 370 represent the same local phenotype based on the presence of only two moderate-sized basal pikes, located opposite each other, approximately halfway along two of the interspine segments. Although the general size, forms, and stratigraphic occurrences of *Dictyocha brevispina ausonia, Mesocena elliptica minoriformis*, and *Naviculopsis lata* are similar (Deflandre, 1950; Bachmann and Papp, 1968), a direct relation between these has yet to be demonstrated photographically. Ling (1972, pl. 25, fig. 9, 10) illustrates a similar form from the lower Miocene of Trinidad.

Dictyocha fibula fibula Ehrenberg
(Plate 2, Figures 1, 2)

Dictyocha fibula Ehrenberg, 1839, fide Loeblich et al., 1968, p. 90, pl. 9, fig. 7-12.

Remarks: More critical distinction of species and subspecies of fibuloid silicoflagellates in recent years has restricted application of the name *Dictyocha fibula fibula*. For example, such diverse forms as *D. perlaevis perlaevis* and *D. stapedia stapedia* are now recorded as separate entities and further divided into subspecies. *Dictyocha fibula fibula* has been reduced, from a composite taxon, to the relatively rounded, short-spined forms of Ehrenberg (1854). These forms are probably related to the Miocene *D. pulchella-D. varia* sequence with which they share the same general size and proportions and with which they coexist in the *Corbisema triacantha* Zone at both Sites 369 and 370.

Dictyocha quadrangula (Bachmann) n. comb.

Distephanus staurodon (Ehrenberg) fa. *quadrangula* Bachmann, 1971, p. 64, pl. 5, fig. 10, 11; pl. 6, fig. 1-7.

Distephanus staurodon (Ehrenberg) fa. *pentagona* Bachmann, 1971, p. 64, pl. 5, fig. 9; pl. 6, fig. 8, 9.

Remarks: The specimen illustrated as pl. 6, fig. 4 of Bachmann (1971) is designated the lectotype of *Dictyocha quadrangula*. It is characterized by elevated struts and a spire. This Miocene species has not been recorded from DSDP cores and may be restricted to near-shore deposits.

Genus DISTEPHANUS Stöhr, 1880

Distephanus crux (Ehrenberg)
(Plate 2, Figures 7-9)

Dictyocha crux Ehrenberg, 1840, p. 207; Figured by Ehrenberg 1854, pl. 18; fig. 56; pl. 20(I), fig. 46; pl. 33(XV), fig. 9, pl. 33(XVI), fig. 9; pl. 33(XVII), fig. 5.

Remarks: A high degree of intraspecific variation is recognized within this species. For Leg 41 only the most distinct end members have been separated; transitional forms have been tabulated with *Distephanus crux* s. ampl. Oligocene assemblages contain only a large, unpiked cruxoid form, tabulated as *D.* sp. aff. *D. crux*.

As a general rule specimens are assigned to *D. crux* if they are quadrate and have a moderate to large apical ring opening that is equal to 1/4 or more of the area of an adjacent portal (see lectotype in Locker, 1974). Neogene forms have small to moderate basal pikes. Quadrate specimens of *Distephanus* having small apical openings (equivalent to less than 1/4 of an adjacent portal) are classified as *D. crux darwinii, D. crux hannai, D. staurodon*, or *D. stradneri*.

Distephanus longispinus (Schulz)

Distephanus crux f. *longispina* Schulz, 1928, p. 256, fig. 44.

Remarks: *Distephanus longispinus* is a quadrate species that is distinguished by a combination of proportions. The major-axis spines are more than twice as long as those of the minor axis. The greatest diameter of the basal ring is shorter than either major-axis spine. It is distinguished from *D. schauinslandii* s. str. (see Lemmermann, 1901; Ling, 1973) by its relatively shorter basal ring. It is distinguished from *D. crux* by its highly disproportionate minor and major spines.

Distephanus schauinslandii Lemmermann

Distephanus schauinslandii Lemmermann, 1901, p. 262, pl. 11, fig. 4, 5.

Distephanus crux var. *longispina* Schulz, Bachmann, 1971 (in part), p. 65, pl. 4, fig. 8.

Distephanus schauinslandii Lemmermann, Ling, 1973, p. 753, pl. 2, fig. 7-9.

Remarks: The type specimens of *Distephanus schauinslandii* are illustrated by drawings showing an unusual elliptic basal ring, asymmetric struts, and highly disproportionate spines. Ling's (1973) illustrations have longer spines and a smaller apical opening than the type specimen but are within a range of intraspecific variation for the species. Bachmann's (1971) illustration has proportions closer to the proportions of the type specimens, but all of these specimens deviate from the perfectly elliptical basal ring of the types. This difference may be considered an artifact of the original drawings, but it then suggests the need to critically distinguish *D. schauinslandii* from *D. longispinus* on the basis of spine and basal ring proportions.

Distephanus schauinslandii is missing from Leg 41, but *D. stradneri*, formerly considered its subspecies, is present.

Distephanus speculum haliomma (Ehrenberg) n. comb.
(Plate 2, Figure 10)

Dictyocha haliomma Ehrenberg, 1844, p. 64, 80; Figured by Ehrenberg, 1854, pl. 21, fig. 46.

Dictyocha haliomma Ehrenberg, Locker, 1974, p. 641, pl. 4, fig. 8.

Remarks: Miocene specimens that differ from *Distephanus speculum hemisphaericus* by irregularly arranged and sized apical openings are classified as *D. speculum haliomma* for this report. Although Locker (1974) recommended consolidating this taxon with *D. speculum hemisphaericus*, it has a longer range and is more abundant at Sites 369 and 370.

Distephanus speculum hemisphaericus (Ehrenberg)
(Plate 2, Figures 11-13)

Cannopilus hemisphaericus (Ehrenberg), Lemmermann, 1901, p. 268, pl. 11, fig. 21.

Cannopilus calyptra Lemmermann, Schulz, 1928 (in part), p. 265, fig. 62d.

Cannopilus calyptra var. *heptacanthus* (Ehrenberg), Schulz, 1928 (in part), p. 267, fig. 63b?, 63c.

non *Cannopilus heptacanthus* (Ehrenberg) Locker, 1974, p. 639, pl. 4, fig. 9.

Cannopilus hemisphaericus (Ehrenberg), Locker, 1974 (in part), p. 639, pl. 4, fig. 1.

Distephanus speculum hemisphaericus (Ehrenberg) Bukry, 1975b, p. 855, pl. 4, fig. 8.

Remarks: *Distephanus speculum hemisphaericus* has regular apical structure of six to eight, equant, round or rounded polygonal apical openings. The regular pattern has one central opening and five to seven openings arranged symmetrically about it. The apical structure is relatively flat and is connected to the basal ring by short struts. The basal ring is typically hexagonal and rarely pentagonal or heptagonal. Spines and pikes are short to moderate.

Distephanus speculum hemisphaericus is less abundant than *D. speculum haliomma* and has a shorter range at Sites 369 and 370.

Distephanus staurodon (Ehrenberg) n. comb.

Dictyocha staurodon Ehrenberg, 1844, p. 80; Figured by Ehrenberg, 1854, pl. 18, fig. 58.

non *Dictyocha staurodon* Ehrenberg, Schulz, 1928, p. 251, fig. 34a-f.

non *Dictyocha staurodon* Ehrenberg, Mandra, 1968, p. 253, fig. 65.

non *Distephanus staurodon* (Ehrenberg) fa. *quadrangula* Bachmann, 1971, pl. 5, fig. 10, 11; pl. 6, fig. 1-7.

Dictyocha staurodon (Ehrenberg), Locker, 1974, p. 637, pl. 3, fig. 10.

Remarks: As illustrated by Locker (1974), *Distephanus staurodon* of Ehrenberg has a small apical opening, asymmetric struts, basal pikes, and rhomboid basal ring. It is an end member of the cruxoid specimens of *Distephanus* on the basis of its small apical ring. The specimens having a spire (see Bachmann, 1971) need to be reclassified. *Distephanus staurodon* of this report in unspired.

Distephanus stradneri (Jerković) n. comb.

Dictyocha schauinslandii stradneri Jerković, 1965, p. 3, pl. 2, fig. 2; *in* Stradner, 1961, fig. 90.
?*Distephanus schauinslandii* var. *stradneri* fa. *fibularis* Bachmann, 1971, p. 67, pl. 1, fig. 1-6.
Distephanus schauinslandii var. *stradneri* fa. *pentagona* Bachmann, 1971, p. 67, pl. 3, fig. 2-6.
Distephanus schauinslandii var. *stradneri* fa. *quadrangula* Bachmann, 1971, p. 66, pl. 2, fig. 1-6; pl. 3, fig. 1.

Remarks: Large cruxoid specimens having an angular, rhomboid to square basal ring and a very small apical opening are tabulated as *Distephanus stradneri.* There is no obvious affinity of this form to *D. schauinslandii.* Bachmann's (1971) analysis of form variation for this species shows that the cruxoid form is predominant and the fibuloid and pentagonal variations are sufficiently rare that they could be treated as intraspecific variation. Only the cruxoid form has been observed in DSDP cores.

Genus MESOCENA Ehrenberg, 1843

Mesocena apiculata glabra (Schulz) n. comb.
(Plate 2, Figures 14, 15)

Mesocena polymorpha var. *triangula* Lemmermann fa. *glabra* Schulz, 1928, p. 237, fig. ?3b, 3c.

Remarks: *Mesocena apiculata glabra* is nearly equilateral, but two sides are concave and one convex, generally unequally. One or more spines may not be symmetrically located. *Mesocena apiculata glabra* is an uncommon but persistent form in the upper Oligocene from Site 369.

Genus NAVICULOPSIS Frenguelli, 1940

Naviculopsis constricta (Schulz)
(Plate 2, Figure 17)

Dictyocha navicula biapiculata constricta Schulz, 1928, p. 246, fig. 21.

Remarks: Typical specimens of *Naviculopsis constricta* have an apical band. Compared specimens from the Oligocene of Site 369 have the band modified into bar near the center of the apical structure.

Naviculopsis lata (Deflandre)
(Plate 3, Figure 2)

Dictyocha biapiculata lata Deflandre, 1932, p. 500, fig. 30, 31.
Naviculopsis lata (Deflandre), Bukry, 1975b, p. 856, pl. 7, fig. 4.

Remarks: *Naviculopsis lata* is distinguished from *N. quadrata* (see lectotype illustrated by Locker, 1974) and from *N. biapiculata* (see Lemmermann, 1901, pl. 10, fig. 15) by two main criteria. The spine of *N. biapiculata* is longer than one half the maximum diameter of the basal ring, whereas in *N. lata* it is less than one halt the diameter. Besides being more rectangular (length exceeds width by two to one or more), *N. quadrata* has very short spines equal to one half or less the minor diameter of the basal ring, whereas those of *N. lata* are more than half (Figure 6).

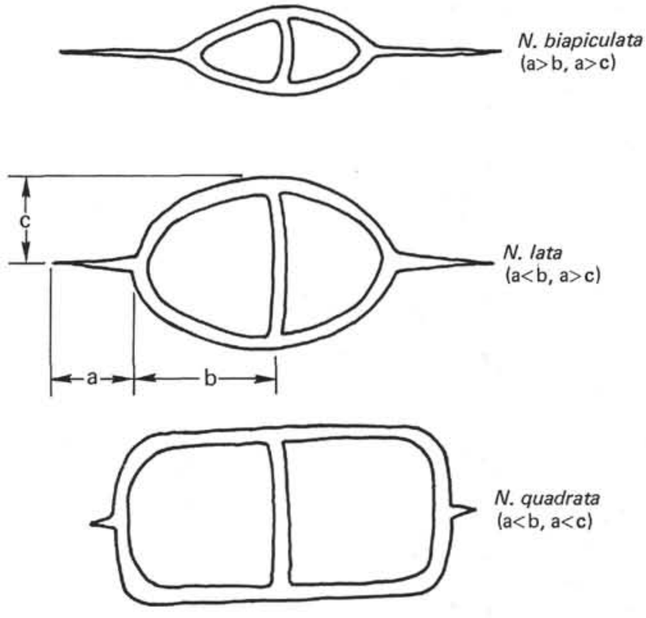

Figure 6. *Sketches of three Miocene species of* Naviculopsis *showing differences in proportions that are useful for taxonomic distinctions.*

ILLUSTRATION REFERENCES FOR OTHER SPECIES TABULATED

Cannopilus depressus (Ehrenberg)—Locker, 1974
C. ernestinae Bachmann—Bukry, in press (a)
C. heptacanthus (Ehrenberg)—Locker, 1974
C. schulzii Deflandre—Bukry and Foster, 1973
Corbisema apiculata (Lemmermann)—Ling, 1972
C. archangelskiana (Schulz)—Perch-Nielsen, 1975
C. flexuosa (Stradner)—Bukry, 1975b
C. hastata globulata Bukry—Bukry, in press (b)
C. hastata hastata (Lemmermann)—Bukry, in press (b)
C. hastata minor (Schulz)—Bukry, 1975a
C. inermis (Lemmermann)—Bukry, in press (b)
C. triacantha triacantha (Ehrenberg)—Locker, 1974
Dictyocha aspera aspera (Lemmermann)—Bukry, 1973b
D. aspera martinii Bukry—Bukry, 1975b
D. brevispina brevispina Lemmermann—Bukry, 1976b
D. deflandrei Frenguelli ex Glezer—Bukry, 1975b
D. hexacantha Schulz—Bukry, 1975b
D. pentagona (Schulz)—Bukry, 1973c
D. pulchella Bukry—Bukry, 1975c
D. pumila Ciesielski—Ciesielski, 1975
D. stapedia stapedia Haeckel—Bukry, 1976b
Distephanus crux darwinii Bukry—Bukry, in press (c)
D. crux hannai Bukry—Bukry, 1975a
D. norvegiensis Perch-Nielsen—Perch-Nielsen, in press
D. raupii Bukry—Bukry, in press (c)
D. speculum binoculus (Ehrenberg)—Locker, 1974
D. speculum hemisphaericus (Ehrenberg)—Locker, 1974
D. speculum minutus (Bachmann)—Ichikawa et al., 1967
D. speculum pentagonus Lemmermann—Ling, 1972
D. speculum pseudocrux Schulz—Ling, 1972
D. speculum speculum (Ehrenberg)—Martini, 1971
D. speculum triommata Ehrenberg)—Locker, 1974
Macrora stella (Azpeitia) [syn. *Pseudorocella corona* Deflandre]
Mesocena apiculata apiculata Schulz—Ciesielski, 1975
M. apiculata curvata Bukry—Bukry, in press (c)
M. elliptica (Ehrenberg)—Bukry and Foster, 1973
Naviculopsis biapiculata (Lemmermann)—Bukry, 1975b
N. foliacea Deflandre—Bukry, 1973b
N. navicula (Ehrenberg)—Locker, 1974
N. ponticula (Ehrenberg)—Locker, 1974
N. quadrata (Ehrenberg)—Ling, 1972

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PLATE 1

Silicoflagellates from DSDP Leg 41; Magnification 800×; scale bar equals 10 μm.

Figures 1, 2	*Cannopilus schulzii* Deflandre. Apical (1) and basal (2) focuses. Sample 369A-11-6, 71-72 cm (145 m).
Figures 3, 4	*Corbisema* sp. cf. *C. apiculata* (Lemmermann). Isosceles forms. Sample 369A-29-6, 97-98 cm (315 m).
Figure 5	*Corbisema bimucronata bimucronata* Deflandre. Sample 369A-29-6, 97-98 cm (315 m).
Figures 6, 7	*Corbisema bimucronata rotatoria* n. subsp. 6. Holotype, USNM 240698, Sample 369A-27-2, 109-110 cm (291 m). 7. USNM 240699, Sample 369A-27-2, 109-110 cm (291 m).
Figures 8-12	*Corbisema triacantha mediana* n. subsp. 8. USNM 240701, Sample 369A-29-6, 97-98 cm (315 m). 9. USNM 240702, Sample 369A-30-4, 77-78 cm (323 m). 10. USNM 240703, Sample 369A-29-6, 97-98 cm (315 m). 11. USNM 240704, Sample 369A-27-2, 109-110 cm (291 m). 12. Holotype, USNM 240700, Sample 369A-29-6, 97-98 cm (315 m).
Figures 13-15	*Corbisema triacantha triacantha* (Ehrenberg). 13, 15. Sample 369A-11-3, 67-68 cm (141 m). 14. Sample 369A-18-3, 67-68 cm (207 m).
Figure 16	*Dictyocha* sp. [asperoid]. Sample 269A-29-6, 97-98 cm (315 m).
Figures 17-19	*Dictyocha brevispina ausonia* (Deflandre). 17, 19. Sample 370-3-2, 75-76 cm (210 m). 18. Sample 369A-11-3, 67-68 cm (141 m).

PLATE 1

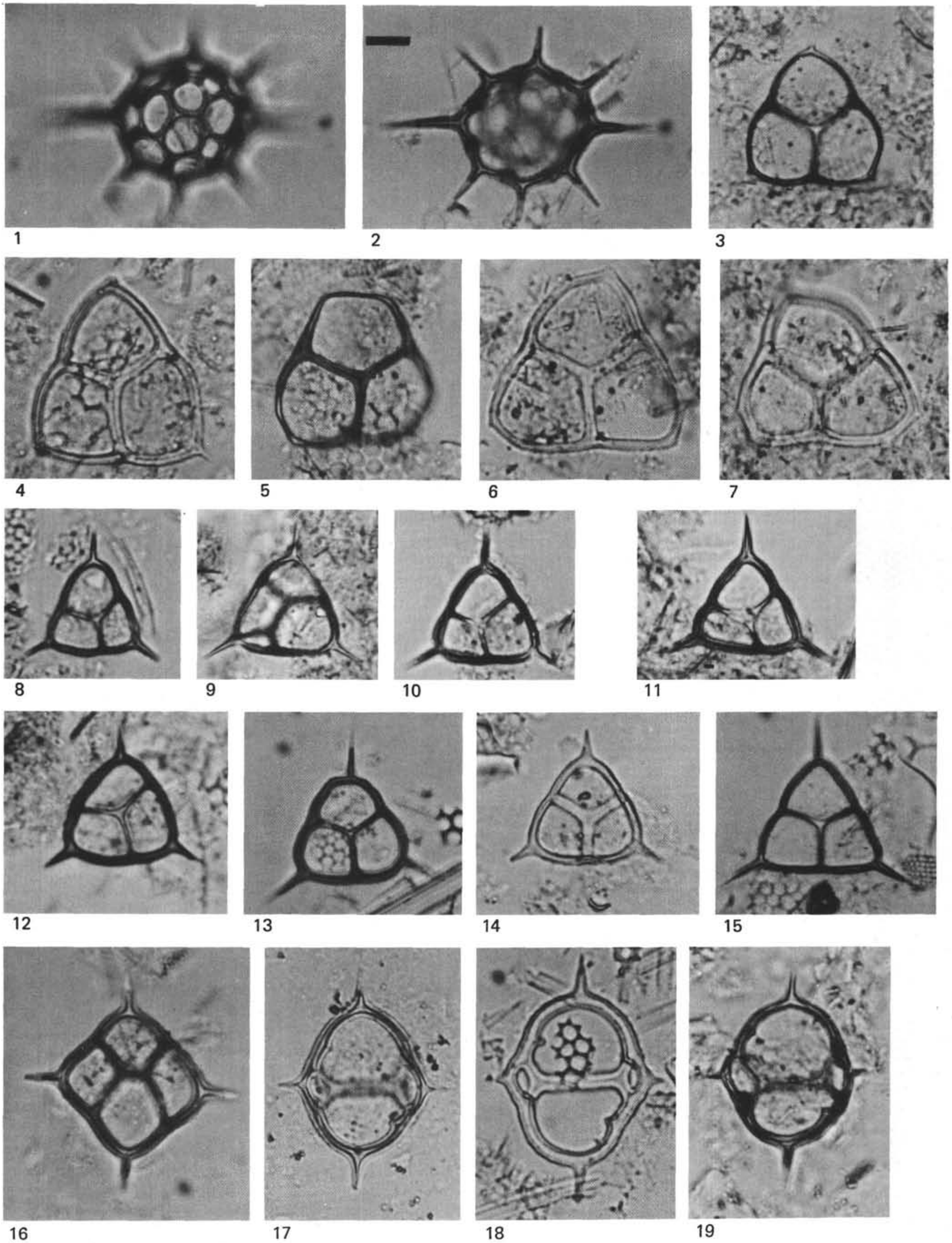

PLATE 2

Silicoflagellates from DSDP Leg 41; Magnification 800×; scale bar equals 10 μm.

Figures 1, 2	*Dictyocha fibula fibula* Ehrenberg. 1. Sample 369A-11-4, 71-72 cm (142 m). 2. Sample 369A-11-3, 67-68 cm (141 m).
Figures 3-6	*Dictyocha pulchella* Bukry. Sample 369A-11-3, 67-68 cm (141 m). 3. Normal. 4, 5. Deflandroid. 6. Medusoid.
Figures 7-9	*Distephanus crux* (Ehrenberg) s. ampl. 7. Sample 369A-11-3, 67-68 cm (141 m). 8, 9. Apical and basal focuses; basal ring similar to *Mesocena elliptica minoriformis* in size and form; Sample 370-3, CC (217 m).
Figure 10	*Distephanus speculum haliomma* (Ehrenberg). Sample 370-3, CC (217 m).
Figures 11-13	*Distephanus speculum hemisphaericus* (Ehrenberg). 11. Sample 369A-18-3, 67-68 cm (207 m). 12, 13. Basal and apical focuses; Sample 369A-11-4, 71-72 cm (142 m).
Figures 14, 15	*Mesocena apiculata glabra* (Schulz). 14. Sample 369A-24-2, 67-68 cm (262 m). 15. Sample 369A-18-3, 67-68 cm (207 m).
Figure 16	*Mesocena elliptica* (Ehrenberg). Sample 370-3, CC (217 m).
Figure 17	*Naviculopsis constricta* (Schulz). Sample 369A-29-6, 97-98 cm (315 m).
Figure 18	*Naviculopsis* sp. cf. *N. constricta* (Schulz). Semibarred variation, Sample 369A-24-2, 67-68 cm (262 m).

PLATE 2

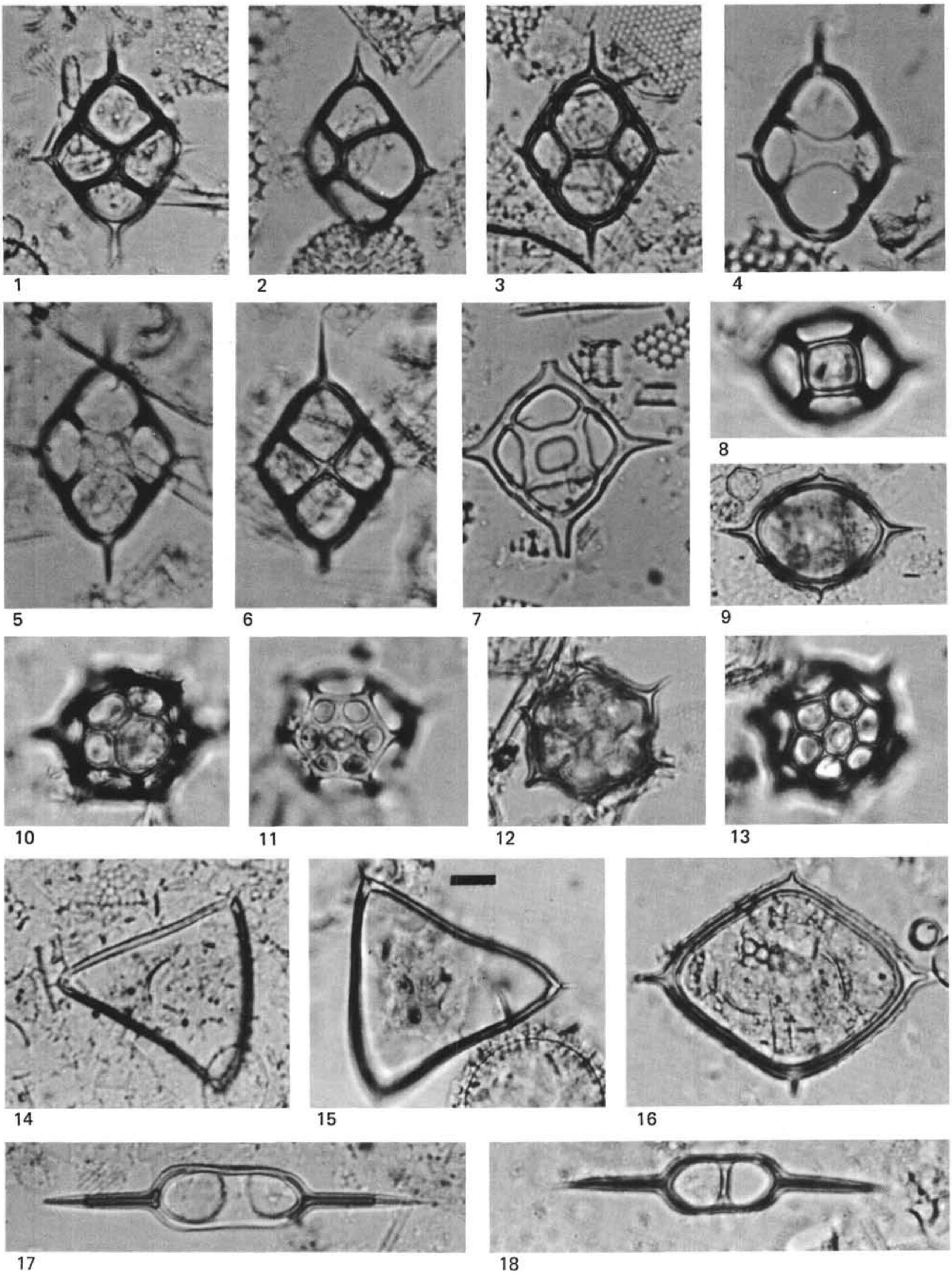

PLATE 3

Silicoflagellates and diatoms (Figures 10, 11) from Leg 41;
Magnification 800×; scale bar equals 10 μm.

Figure 1	*Naviculopsis* sp. cf. *N. constricta* (Schulz). Semibarred variation, Sample 369A-24-2, 67-68 cm (262 m).
Figure 2	*Naviculopsis lata* (Deflandre). Sample 370-3, CC (217 m).
Figure 3	*Naviculopsis navicula* (Ehrenberg). Sample 370-3, CC (217 m).
Figure 4	*Naviculopsis ponticula* (Ehrenberg). Unusual ring flexure, Sample 370-3, CC (217 m).
Figure 5	*Naviculopsis* sp. cf. *N. ponticula* (Ehrenberg). Narrow variation, Sample 370-3, CC (217 m).
Figures 6-8	*Naviculopsis quadrata* (Ehrenberg). 6. Normal, Sample 369A-18-2, 67-68 cm (205 m). 7, 8. Flared-spine variation, Sample 369A-13-5, 71-72 cm (163 m).
Figure 9	*Macrora stella* (Azpeitia). Sample 369A-29-6, 97-98 cm (315 m).
Figure 10	*Actinocyclus* sp. Sample 369A-29-6, 97-98 cm (315 m).
Figure 11	*Brightwellia* sp. Sample 369A-29-6, 97-98 cm (315 m).

PLATE 3