27. SILICOFLAGELLATE AND COCCOLITH STRATIGRAPHY, NORWEGIAN-GREENLAND SEA, DEEP SEA DRILLING PROJECT LEG 38

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INTRODUCTION

Leg 38 of the Deep Sea Drilling Project, recovered 354 cores at 16 drilling sites, Sites 336-350 and 352. Light-microscope techniques (Bukry, 1975) were used to study the silicoflagellates and coccoliths of 140 samples from these cores. The present study is largely devoted to the diverse silicoflagellate assemblages of Eocene to Miocene age.

ZONATION

A paucity of low-latitude biostratigraphic marker coccoliths in the fossil assemblages of Leg 38, together with the low diversity of the assemblages, limits the usefulness of coccoliths for zonation.

Silicoflagellate biostratigraphic determinations for Leg 38 incorporate the work of Ling (1972), Ciesielski (1975), and Perch-Nielsen (1975, 1976). Zonal names are from Bukry (1975) and Perch-Nielsen (1976). The possibility of establishing a bipolar synthesized zonation is indicated by initial studies of Leg 38 cores, but exacting taxonomic comparisons of actual specimens between the assemblages of DSDP Legs 38, 36, 35, 29, and 28 need to be made. This would help to determine what parts of several finely divided, high-latitude, local zonal sequences (Martini 1972, 1974; Perch-Nielsen, 1975, 1976; Ciesielski, 1975) can be applied on a transoceanic basis and, perhaps, what new units may be defined as refinement of species concepts continues.

Changes in the relative abundances of taxa and minor changes in their form from one region to another may appear to suggest numerous different zonations. Evolutionary lineages in some major genera (*Corbisema* and *Naviculopsis*), however, provide a fairly consistent taxonomic and stratigraphic basis with which to assess the more variable (polyphyletic or strongly ecologically controlled) taxa of genera such as *Dictyocha*, *Distephanus*, and *Mesocena*.

Populations of *Naviculopsis foliacea* s. str. and *N. navicula* s. str. have generally well known and limited ranges and are key biostratigraphic markers (Ling, 1972; Martini, 1972, 1974). But, species such as *Distephanus crux crux* s. ampl. and *Mesocena diodon* or *M. elliptica* s. ampl. have recurrent local acmes through the upper Paleogene and Neogene. For example, the coexistence of *Corbisema triacantha*, *Naviculopsis navicula*, and *N. quadrata* in Sample GSCG-466CC, from the Southern California Borderland, determines an early Miocene age (Sanfilippo et al., 1973), but the same sample contains significant numbers of *M. diodon* and *M. elliptica*, which are used as guide fossils for younger stratigraphic horizons. Some regional differences in the assemblages of the *Naviculopsis quadrata* Zone of Leg 38 and other areas are summarized in Table 1.

SITE SUMMARIES

Site 336 (lat 63°21.06′N, long 7°47.27′W, depth 811 m)

Except for two, sparse, Quaternary coccolith assemblages in Cores 1 and 5, no coccoliths or silicoflagellates were observed in deeper cores (Cores 27 to 36) at Site 336. The assemblages of Cores 1 (4 m) and 5 (39 m) are characterized by Quaternary *Gephyrocapsa caribbeanica* and many reworked Cretaceous taxa, such as *Eiffellithus turriseiffeli* and *Micula decussata.*

Site 337 (lat 64°52.30′N, long 5°20.51′W, depth 2631 m)

Four of seven samples from Site 337 in the Norway Basin contain coccoliths or silicoflagellates. Core 1 (8 m) has an abundant Quaternary assemblage of *Cyclococcolithina leptopora*, *Emiliania* sp. cf. *E. annula*, *E. ovata*, *G. caribbeanica*, and *Helicopontosphaera kamptneri*; Cretaceous (*Watznaueria barnesae*) and Eocene or Oligocene (*Reticulofenestra umbilica*) reworked taxa are present. Silicoflagellate assemblages from Cores 9 and 10 (Table 2) are characterized stratigraphically by *Corbisema flexuosa*, *C. katharinae*, and *Dictyocha aspera martinii* which coexist in the late Eocene of the Southern Ocean (Perch-Nielsen, 1975; Bukry, 1975). A late Eocene or Oligocene age is suggested because of the low diversity of the assemblage and the absence of other Eocene guide species.

Site 338 (lat 67°47.11′N, long 5°23.26′E, depth 1297 m)

Quaternary coccolith assemblages, including *Coccolithus pliopelagicus* and *Gephyrocapsa caribbeanica*, together with reworked Cretaceous and Paleogene taxa, are present in samples from Cores 1 to 5 (0 to 48 m). Coccoliths are absent from Cores 6 to 19 (48 to 190 m). An upper Oligocene assemblage in Sample 338-20-3, 30-31 cm (192 m) contains *Chiasmolithus altus*, *Coccolithus pelagicus*, *Cyclicargolithus abisectus*, *C. floridanus*, *Dictyococcites bisectus*, *Discoaster deflandrei*, *Discolithina* spp., *Helicopontosphaera euphratis*, and *Reticulofenestra* sp. (small). Similar low-diversity assemblages of late Oligocene age, based on the coexistence of *C. abisectus* and *D. bisectus*, are present in Cores 22 to 24 (209 to 238 m). The cool-water aspect of the assemblages is seen in the predominance of placoliths and the rarity or absence of discoasters and sphenoliths.

The next deepest coccolith-bearing sample available, 338-33-6, 90-91 cm (322 m), contains a provincial lower Eocene *Tribrachiatus orthostylus* Zone assemblage that has been encountered previously in the London Clay in England and from North Atlantic cores (see Site 343

TABLE 1
Comparison of Lower Miocene *Naviculopsis quadrata* Zone Silicoflagellate Assemblages

	Sample	Depth (m)	*Corbisema triacantha*	*Dictyocha fibula*	*Distephanus boliviensis major*	*D. crux crux*	*D. crux hannai* and *D. schauinslandii*	*D. pseudofibula* and *D. varians*	*D. speculum binoculus*	*D. speculum hemisphaericus*	*D. speculum pentagonus*	*D. speculum quintus*	*D. speculum speculum*	*D. speculum triommata*	*Mesocena apiculata*	*M. diodon*	*M. elliptica*	*M. triodon*	*Naviculopsis lata*	*N. navicula*	*N. quadrata*	*"Rocella gemma"*	Total Specimens
Pacific Region	GSCG-466CC	0.1	5			22				<1	<1		1	3	1	19	4	12	1	1	32		300
	278-26-6, 75 cm	337			1	15	9	1		2	8		29		25				1		3	6	100
Leg 38	338-14-3, 40-41 cm	136	4	<1	<1	46	5	1	3	14		<1	3	3	5				1	4	10		300

Note: Taxa are recorded in percent. Sample GSCG-466CC from the Southern California Borderland (lat 120°28′W, long 33°14′N) also contains coccoliths of the *Sphenolithus belemnos* Zone.

TABLE 2
Silicoflagellates in Upper Eocene or Oligocene Samples from Site 337 Recorded in Percent

Sample (Interval in cm)	Depth (m)	*Cannopilus* sp.	*Corbisema apiculata*	*C. flexuosa*	*C. katharinae*	*C.* cf. *C. triacantha*	*Dictyocha aspera martinii*	*D. deflandrei*	*D.* sp. (asperoid)	*Distephanus crux darwinii*	*D. raupii* s. ampl.	*Naviculopsis* sp.	Total Specimens
337-9-6, 80-81	83	1		61	24	1	8		1		3	1	100
337-10-3, 60-61	89			44	8	1	6		7		34		100
337-10-6, 62-64	93	3	1	22	5	1	9	1	17	1	43		200

summary). Species present include: *Coccolithus pelagicus* s. ampl., *Cyclococcolithina* sp. aff. *C. luminis*, *Discolithina* sp. cf. *D. pectinatus*, *Imperiaster obscurus*, *I.* sp. aff. *I. obscurus* (quadrate), *Transversopontis pulcher*, *Zygolithus dubius*, and *Z. protenus*.

Silicoflagellates of late Oligocene to middle Miocene age are common in Cores 8 to 23 (76 to 228 m). Species of *Distephanus* numerically dominate most of the samples (Table 3). Several taxa from upper Oligocene Cores 20 to 23, *Distephanus crux darwinii* and *D. raupii*, are considered to be conspecific with coeval forms described from the upper Oligocene of DSDP Leg 36 in the South Atlantic Ocean. Many of the specimens, however, appear to be variants and are tabulated as compared species of *D. crux crux* and *D. crux darwinii*. Additional study is needed to distinguish significant cosmopolitan evolutionary populations from local variant populations.

Pseudorocella corona, a problematic silicoflagellate, is present within the lower Miocene range of *Naviculopsis quadrata* at Site 338; this is similar to its occurrence at the top of the *N. quadrata* Zone at Site 278 in the Antarctic (Bukry, 1975). The lower Miocene at Site 338 is identified by the overlapping ranges of *N. lata, N. navicula,* and *N. quadrata*; *Corbisema triacantha* is virtually absent in younger samples. Sample 338-17-3, 40-41 cm (164 m) from the lower Miocene is unusual in the presence of giant specimens of *Dictyocha pentagona*, *Distephanus pseudofibula*, and *D. varians*. The multiply-barred apical structures of these taxa suggest an affinity between them. This affinity is further emphasized here by their matching size and proportions.

The middle Miocene, characterized by the overlapping ranges of *Distephanus* sp. cf. *D. longispinus*, *D. speculum hemisphaericus*, and *Mesocena apiculata* s. ampl., has an unusual abundance of *Cannopilus ernestinae* at the top of the section. *C. ernestinae* may be a bipolar marker species for the middle Miocene, because it is also present in the Antarctic in sediments of this age (see Site 348 summary).

TABLE 3
Silicoflagellates from the Upper Oligocene to Middle Miocene at Site 338 Recorded in Percent

Age	Middle Miocene				Early Miocene						Late Oligocene		
Depth (m)	79	86	97	116	126	136	146	164	174	183	192	212	228
Species \ Sample (Interval in cm)	338-8-3, 100-101	338-9-1, 100-102	338-10-2, 130-132	338-12-3, 60-61	338-13-3, 40-41	338-14-3, 40-41	338-15-3, 40-41	338-17-3, 40-41	338-18-2, 101-103	338-19-3, 50-51	338-20-3, 30-31	338-22-3, 29-30	338-23-6, 94-95
Cannopilus ernestinae	18	2											
C. cf. *C. picassoi*		1											
C. cf. *C. schulzii*		2	<1										
Corbisema archangelskiana											<1		1
C. flexuosa and cf.							1	1	1	12			
C. triacantha and cf.	1				3	4	7		2	50			
Dictyocha aff. *D. aspera clinata*					1			<1					
D. cf. *D. deflandrei*											1	1	
D. fibula						<1							
D. pentagona (large)					<1		<1	14					
D. pulchella	1												
D. sp. (fibuloid)					1			1					
Distephanus boliviensis boliviensis	3	1	17					1					
D. boliviensis major			4			<1		1			<1		
D. crux crux s. ampl.	18	21	33	55	52	46	42	11	6	21	5		
D. aff. *D. crux crux* (1)												4	
D. aff. *D. crux crux* (2)									12		2	17	
D. crux darwinii									2			46	62
D. aff. *D. crux darwinii*											86	29	22
D. cf. *D. longispinus*		4	3	2									
D. pseudofibula (large)								3					
D. raupii											2	1	6
D. schauinslandii schauinslandii	2		1	<1	5	5	7		29				
D. schauinslandii stradneri	16	25	5				3						
D. speculum binoculus	1	1		9	1	3	4	6	3				
D. speculum elongatus	1	1						1					
D. speculum giganteus			30										
D. speculum hemisphaericus	1		2	12	15	14	13	6	8	11	2		
D. speculum minuta		6											
D. speculum pentagonus			<1							1		1	1
D. speculum pseudocrux	1			<1				1		1			
D. speculum quintus						<1		<1					
D. speculum speculum	5	25		3	2	3	4	6	4			1	
D. speculum triommata			2	14	4	3	3	13	4				
D. cf. *D. staurodon*									13				
D. varians (large)					1	1	1	22					
Mesocena apiculata s. ampl.		1	4	3	4	5	8		1	5	2	1	8
M. diodon	34	10											
M. triangula	1												
Naviculopsis cf. *N. biapiculata*										1	<1		
N. lata					<1		1	2					
N. lata (prolongate)					<1	1	1						
N. navicula					1	4	3						
N. quadrata					9	10	1		16				
Pseudorocella corona	1						1	8					
Total specimens	200	100	300	300	300	300	300	300	300	200	300	170	100

Site 339 (lat 67°12.65'N, long 6°17.05'E, depth 1262 m)

All six samples examined from Site 339 contain coccoliths and silicoflagellates. The upper three samples of Cores 1 to 8 (0 to 75 m) contain common, but low-diversity assemblages of Quaternary coccoliths, such as *Coccolithus pelagicus*, *Crenalithus doronicoides*, *C.* sp. cf. *C. productellus*, and *Gephyrocapsa* sp. cf. *G.*

caribbeanica, admixed with reworked Cretaceous (*Prediscosphaera cretacea* and others) and Eocene (*Zygolithus dubius* and others). Silicoflagellate assemblages from Cores 7 to 12 (Table 4) are assigned to the middle or upper Eocene *Dictyocha hexacantha* Zone on the basis of the association of *Dictyocha hexacantha, D. spinosa*, *Naviculopsis constricta*, and *N. foliacea.*

Site 340 (lat 67°12.47′N, long 6°18.38′E, depth 1217 m)

All 11 samples examined from Site 340 contain coccoliths or silicoflagellates. As at other Leg 38 sites, the Quaternary coccolith assemblage of Core 1 (3 m) is admixed with common Cretaceous (*Arkhangelskiella cymbiformis* and others) and Eocene (*Isthmolithus recurvus* and others) reworked specimens. Eocene silicoflagellates, predominately of the genus *Naviculopsis*, are present in all 10 samples from Cores 2 to 11; four representative assemblages were counted (Table 5). *Dictyocha hexacantha* and *D. spinosa* are cosmopolitan indicators for the middle or upper Eocene *Dictyocha hexacantha* Zone (Bukry, 1975; Perch-Nielsen, 1976); however, the assemblages at Site 340 are provincial in character based on the common occurrence of *Naviculopsis nordica*, *N. punctilia*, and the presence of *Corbisema ovalis* and *Distephanus norvegiensis*, all newly recognized taxa from the Norwegian-Greenland Sea (see section on Taxonomy). Most of the elements of the regional *Naviculopsis vemae* Zone and *N. punctilia* Zone of Perch-Nielsen (1976) are present, except for the marker species *Naviculopsis vemae.*

Site 341 (lat 67°20.10′N, long 6°06.64′E, depth 1439 m)

Although middle Miocene to Quaternary coccoliths are generally common in the 19 samples examined from Cores 1 to 32, diversity is so low that only broad age estimates are possible. Silicoflagellates are rare. Samples from Cores 1 to 5 (0 to 48 m), assigned to the Quaternary, contain *Gephyrocapsa caribbeanica* and an abundance of reworked Cretaceous and Paleogene taxa. Cores 6 to 30 (48 to 418 m) are assigned to the middle Miocene to Pliocene based on the occurrences of cosmopolitan species such as *Cyclococcolithina macintyrei* and *Reticulofenestra pseudoumbilica*. Reworked Cretaceous and Eocene taxa are common above Core 20, but rare below. The presence of *Discoaster* sp. cf. *D. exilis* and *D. variabilis* in Core 32 (431 m) indicates a probable middle Miocene age.

TABLE 4
Silicoflagellates in Middle or Upper Eocene Samples from Site 339 Recorded in Percent

Sample (Interval in cm)	Depth (m)	*Cannopilus* sp.	*Corbisema apiculata*	*C.* cf. *C. flexuosa*	*C. hastata* s. ampl.	*C. triacantha* s. ampl.	*Dictyocha hexacantha*	*D.* aff. *D. perlaevis perlaevis*	*D. spinosa*	*D.* sp. (asperoid)	*Mesocena apiculata*	*Naviculopsis constricta*	*N. foliacea*	Total Specimens
339-7-3, 143-144	59		9		20	41	3	2		12	5	4	4	100
339-10-3, 40-41	87	2	9		39	28	2	2	1	11	2	4		100
339-12-3, 30-31	105		5	2	40	35	5			10	1	2		100

TABLE 5
Silicoflagellates in Middle or Upper Eocene Samples from Site 340 Recorded in Percent

Sample (Interval in cm)	Depth (m)	*Corbisema apiculata*	*C. archangelskiana*	*C. archangelskiana* (quadrate)	*C. flexuosa*	*C. hastata* s. ampl.	*C. ovalis*	*C. triacantha* s. ampl.	*Dictyocha* cf. *D. fibula formicata*	*D. frenguellii* s. str.	*D. hexacantha*	*D. pentagona*	*D. spinosa*	*D.* sp. (asperoid)	*Distephanus crux* s. ampl.	*D. norvegiensis*	*D. speculum pentagonus* s. ampl.	*Mesocena concava*	*M. oamaruensis*	*Naviculopsis constricta*	*N. foliacea*	*N. nordica hyalina*	*N. nordica nordica*	*N. punctilia punctilia*	*N. punctilia taenia*	Total Specimens
340-2-3, 60-61	13		4	4	3	8						6		2		1	3		2		4			63		100
340-3-3, 40-41	22	2		1	1	15	9		1			2	5	5	1				6			9	11	19	17	200
340-7-6, 50-51	65	4	1	1	1	5	10	1					2	10			1		8	1	1	5	20	16	17	200
340-11-6, 40-41	102	4		2	1	1		18	<1	1	2	<1	4	8	3	1	2	<1		6	3	2	8	31	1	300

Site 342 (lat 67°57.04'N, long 4°56.02'E, depth 1303 m)

A Quaternary coccolith assemblage, including *Coccolithus pelagicus*, *Crenalithus doronicoides*, *C. productellus*, *Gephyrocapsa caribbeanica*, *G.* sp. cf. *G. lumina*, *G. oceanica*, *Pontosphaera scutellum*, and reworked Cretaceous specimens, is present in 342-1-6, 78-79 cm (7 m) and is assigned to the *Gephyrocapsa oceanica* Zone.

Silicoflagellates are common and diverse in samples from Cores 5 and 6. A lower Miocene *Naviculopsis quadrata* Zone assemblage in Sample 342-6-3, 60-61 cm (145 m) contains the following percentages of taxa based on a count of 200 specimens: 32% *Distephanus crux*, 30% *D. speculum hemisphaericus* s. ampl., 11% *D. schauinslandii schauinslandii*, 6% *Mesocena apiculata* s. ampl., 5% *Distephanus* sp. cf. *D. longispinus*, 4% *D.* sp. aff. *D. crux darwinii*, 4% *Corbisema triacantha*, 3% *Naviculopsis quadrata*, and 1% or 2% each of *N. lata*, *N. navicula*, *N. ponticula*, *Distephanus speculum pentagonus*, *D. speculum speculum*, *D. varians* (same large form as in Core 17, Site 338), and *Corbisema flexuosa*. The assemblage of Sample 342-5-6, 40-41 cm (140 m) lacks the early Miocene *Naviculopsis* and *Corbisema* and is assigned to the early middle Miocene on the basis of the predominance of *Distephanus speculum hemisphaericus*. Percentages of taxa, based on a count of 300 specimens, are 41% *D. speculum hemisphaericus*, 33% *D. crux crux*, 12% *D. schauinslandii* s. ampl., 11% *D.* sp. aff. *D. crux darwinii*, 2% *M. apiculata* s. ampl., 1% *Distephanus speculum speculum*, and <1% *D.* sp. cf. *D. longispinus*.

Site 343 (lat 68°42.91'N, long 5°45.73'E, depth 3131 m)

A Quaternary *Gephyrocapsa oceanica* Zone coccolith assemblage containing *Gephyrocapsa caribbeanica* and *G. oceanica* is present in Core 2 (5 m). The only other coccolith-bearing sample examined, from Core 8 (215 m), contains a lower Eocene, probable *Tribrachiatus orthostylus* Zone assemblage, based on quadrate *Imperiaster* sp. aff. *I. obscurus*, *Syracosphaera* sp. cf. *S. fimbriata* and *Zygolithus dubius*. Quadrate *I.* sp. aff. *I. obscurus* is associated with the *T. orthostylus* Zone in the North Atlantic (Bukry, 1972). Additional evidence for this zonal assignment comes from Core AS 1-9 at lat 66°21'N., long 00°18'E., which was kindly provided by Tsune Saito (see Saito et al., 1967). Two samples from this core at 295 cm and 310 cm contain the coccoliths *Chiasmolithus grandis*, *Imperiaster obscurus*, *I.* sp. aff. *I. obscurus*, *Syracosphaera fimbriata*, *Transversopontis pulchra*, *Tribrachiatus orthostylus*, *Zygolithus dubius*, and a few reworked Paleocene taxa.

Sample 343-5-3, 75-76 cm (148 m) contains the first reported specimens of the silicoflagellates *Dictyocha rotundata secta* and *Distephanus antiquus* from DSDP cores. Originally described from the upper Eocene or Oligocene of the USSR (Glezer, 1966), these species are present with *Dictyocha spinosa* and *Naviculopsis foliacea*, which indicate a probable middle Eocene lower *Dictyocha hexacantha* Zone assignment at Site 343. The assemblage, based on a count of 300 specimens, includes: 49% *D. rotundata secta*, 18% *D.* sp. (asperoid), 9% *Distephanus* sp. aff. *D. speculum pentagonus* (large, no basal pikes), 7% *Naviculopsis foliacea*, 7% *Dictyocha spinosa*, 5% *Corbisema apiculata*, 2% *Distephanus antiquus*, and <1% or 1% each of *Corbisema* sp. cf. *C. hastata minor*, *C. ovalis*, *Cannopilus* sp. aff. *C. schulzii*, *Dictyocha frenguellii* s. str., *Mesocena oamaruensis*, and *Naviculopsis nordica nordica*.

Site 344 (lat 76°08.98'N, long 7°52.52'E, depth 2156 m)

Coccoliths are rare and nondiagnostic in samples examined from Site 344. No silicoflagellates were observed.

Site 345 (lat 69°50.23'N, long 1°14.26'W, depth 3195 m)

Quaternary coccolith assemblages indicated by *Gephyrocapsa caribbeanica* and containing admixed Cretaceous taxa are present in samples from Cores 1 to 4 (0 to 37 m). Rare silicoflagellates in Core 7, including *Naviculopsis navicula* s. str., *N. quadrata*, *Mesocena apiculata curvata*, and *Distephanus speculum hemisphaericus* suggest lower Miocene, if they are in place. Deeper samples examined from Cores 8 to 25 (94 to 83 m) are barren of these fossils.

Site 346 (lat 69°53.35'N, long 8°41.14'W, depth 732 m)

The shallowest sample examined, 346-4-2, 130-131 cm (27 m), contains rare small *Gephyrocapsa* sp. and reworked Cretaceous coccoliths; a Quaternary age is assigned. Miocene silicoflagellates are rare in Cores 5 and 11, otherwise samples from this site proved barren.

The lower or middle Miocene *Corbisema triacantha* Zone is suggested for Sample 346-5-3, 146-147 cm (40 m), by the predominance of *Corbisema triacantha* and *Distephanus speculum hemisphaericus* over the associated specimens which include *Distephanus crux crux*, *D.* sp. cf. *D. longispinus*, and *Mesocena apiculata curvata*.

The upper Oligocene or lower Miocene acme of *Distephanus crux darwinii* and *D. raupii*, which is present in southern high latitudes (Bukry, in press), is indicated in Sample 346-11-3, 90-91 cm (95 m), by 80% domination of these two species over associated taxa including 12% *Distephanus crux crux*, and 2% each of *D. speculum hemisphaericus*, *Cannopilus schulzii*, *C.* sp., and *Mesocena apiculata curvata*, based on a count of 50 specimens.

Site 347 (lat 69°52.31'N, long 8°41.80'W, depth 745 m)

The single sample examined, 347-1-2, 145-146 cm (2 m), contains a *Coccolithus* ooze. A Quaternary age is assigned based on the occurrence of *Coccolithus neohelis*, *C. pelagicus*, and *C. pliopelagicus*.

Site 348 (lat 68°30.18'N, long 12°27.72'W, depth 1763 m)

Half of the 16 samples provided from Site 348 are barren. Quaternary coccolith assemblages from Cores 1 and 2 (0 to 19 m) contain *Crenalithus productellus*, *Gephyrocapsa* sp. cf. *G. aperta*, *G. caribbeanica*, and reworked Cretaceous specimens, such as *Prediscosphaera cretacea*.

The best silicoflagellate samples from Core 12 and 15 indicate upper Miocene or lower Pliocene and middle Miocene, respectively. Sample 348-12-3, 140-141 cm (165 m) is dominated by pentagonal *Distephanus boliviensis boliviensis*, but also contains a few *D.*

schauinslandii s. ampl., *Mesocena circulus* and *M. diodon*, which, together, suggest lower Pliocene, based on assemblages from the Antarctic area (Ciesielski, 1975). A broader age range is chosen because the translatitudinal correlations of Subarctic to Antarctic fossil ranges is still not well known for silicoflagellates.

Sample 348-15-3, 130-131 cm (213 m) is dominated by long-spined forms of *Distephanus schauinslandii* s. ampl. Percentages of species based on a count of 300 specimens are: 57% *Distephanus schauinslandii* (major spines elongate), 15% *Cannopilus ernestinae* s. str., 10% *Mesocena apiculata curvata* (all isosceles; 8% concave, 2% straight or convex basal side), 7% *Distephanus crux crux* (large; 1% are asperoid, fibuloid, and medusoid variants), 4% *D. schauinslandii* (equant spines), 2% *D. longispinus*, 2% *Cannopilus* sp., 1% *Distephanus speculum speculum*, <1% *D. speculum binoculus*, <1% *Mesocena diodon*. This assemblage resembles those of Cores 8 and 9 at Site 338; and although relative silicoflagellate abundances differ, lithologies are very similar. The association of *C. ernestinae* with *M. apiculata* s. ampl. in middle Miocene siliceous ooze from the Antarctic area (Bukry, in press) suggests the tentative middle Miocene assignment at Site 348.

Site 329 (lat 69°12.41'N, long 8°05.80'W, depth 915 m)

Of five samples examined from this site, only two contained any coccoliths. Core 1 (0 to 6 m) has a sparse Quaternary assemblage admixed with reworked Cretaceous. Core 6 (120 to 130 m) contains sparse *Reticulofenestra umbilica* which has a middle Eocene to lower Oligocene range, if in place.

Site 350 (lat 67°03.34'N, long 8°17.68'W, depth 1275 m)

Four samples from Cores 1 to 8 (0 to 208 m) are barren.

Site 352 (lat 63°38.97'N, long 12°28.26'W, depth 990 m)

No samples.

SILICOFLAGELLATE TAXONOMY

Owing to space limitations for Volume 38, only new or rarely cited taxa and new combinations are treated in this initial report. See other Deep Sea Drilling Project volumes for more complete taxonomies.

Genus CORBISEMA Hanna, 1928

Corbisema katharinae n. sp.
(Plate 1, Figures 1-6)

?*Corbisema* cf. *C. lamellifera hastata* (Glezer) Perch-Nielsen, 1975, p. 685, pl. 3, fig. 18.

Description: *Corbisema katharinae* has a lobed, irregular isosceles basal ring. The radial spines are short and straight, but the basal pikes are long and curved. The apical struts broaden toward the center forming a triangular plate-like area. The irregular outline of the basal ring, together with the more regular form of the apical structure, produces three dissimilarly shaped portals.

Remarks: *Corbisema katharinae* is distinguished from the *C. hastata* group by irregular outline and broadened apical structure, and from *C. lamellifera*, *C. recta*, and *C. schulzii* by the tubular instead of flattened form of its basal ring. The specimens from Leg 38 differ from *C.* cf. *C. lamellifera hastata* of Leg 29 by the tubular form of the basal pikes.

Occurrence: *Corbisema katharinae* is common in upper Eocene or Oligocene Cores 9 and 10 at Site 337.

Size: Basal-ring height 25-50 μm.

Holotype: USNM 236055 (Plate 1, Figure 4).
Isotypes: USNM 236056 to 236059.
Type locality: Norwegian-Greenland Sea, Sample 337-10-6, 62-64 cm (93 m).

Corbisema ovalis Perch-Nielsen

Corbisema ovalis Perch-Nielsen, 1976, p. 33, figs 12, 13, and 23.

Remarks: This moderately large species, having three broad regular lobes, is easily distinguished by the radial spines which are directed downward out of the plane of the basal ring.

Genus DICTYOCHA Ehrenberg, 1837

Dictyocha rotundata secta Glezer
(Plate 1, Figures 7-10)

Dictyocha rotundata var. *secta* Glezer, 1962, p. 152, fig. 5a-k.

Remarks: This unusual taxon was well illustrated by Glezer, but may easily be overlooked because of its shape and small size. Because it is small, short-spined, and is as high as wide, it is commonly seen in side views. *Dictyocha rotundata secta* is abundant in an Eocene sample from Site 343.

Genus DISTEPHANUS Stöhr, 1880

Distephanus antiquus Glezer
(Plate 1, Figures 11, 12)

Distepanus antiquus Glezer, 1964, p. 57, pl. 2, fig. 6-9.

Distephanus sp. aff. D. crux crux (Ehrenberg)

Distephanus crux (Ehrenberg), Locker, 1974 (in part), p. 637, pl. 3, fig. 8.

Remarks: Specimens that resemble *Distephanus crux* var. *parva* of Bachmann (1971), but that lack basal pikes, are listed as *D.* aff. *crux crux* (1). Specimens tabulated from Site 338 that have a moderately large apical ring, regular lobed outline, moderate spines, but that lack basal pikes are listed as *Distephanus* aff. *crux crux* (2).

Distephanus crux darwinii Bukry
(Plate 1, Figures 13, 14)

Distephanus crux darwinii Bukry, in press a, p. 895, pl. 7, fig. 4-13.

Remarks: Specimens of *Distephanus crux darwinii* at Site 338 are similar to those from the South Atlantic. Specimens that have slightly larger apical and basal rings, however, are common and are tabulated as *Distephanus* sp. aff. *D. crux darwinii*; like *D. crux darwinii* they lack basal pikes.

Distephanus norvegiensis Perch-Nielsen
(Plate 1, Figure 15)

Distephanus norvegiensis Perch-Nielsen, in press b, p. 34, figs. 15, 16, and 20.

Distephanus pseudofibula (Schulz) n. comb.

Dictyocha speculum f. *pseudofibula* Schulz, 1928, p. 262, fig. 51a, b.

Distephanus raupii Bukry
(Plate 1, Figures 16-18)

Distephanus raupii Bukry, in press a, p. 895, pl. 7, fig. 14, 15.

Remarks: Oligocene and Miocene *Distephanus raupii* from Leg 38 have similar size ranges and proportions to those from the South Atlantic and Subantarctic. Larger, longer spined specimens from the Eocene at Site 337 are tabulated as *Distephanus raupii* s. ampl.

Distephanus speculum giganteus n. subsp.
(Plate 1, Figure 19; Plate 2, Figures 1, 2)

Description: *Distephanus speculum giganteus* has a large hexagonal basal ring with straight or slightly convex sides. Basal pikes are small, knob-like, and offset from the strut junctions; one pair of spines is distinctly longer than the other two. The apical ring is large and rounded, its diameter is only slightly less than the basal ring.

Remarks: *Distephanus speculum giganteus* is distinguished from *D. speculum minuta* by being two to three times larger (90 to 100 μm maximum length compared to 35-56 μm) and by having a more elongate basal ring. Because of its large apical ring, *D. speculum*

giganteus may bear the same phenotypic relation to *D. boliviensis boliviensis* that *D. speculum minuta* bears to *D. speculum speculum*. However, its elongate form prompts its initial classification in the *D. speculum* group.

Occurrence: *Distephanus speculum giganteus* is associated with other large taxa such as the *D. boliviensis* and *D. schauinslandii* groups in Sample 338-10-2, 130-132 cm (97 m) which is assigned to the middle Miocene. It is missing from other samples examined from Leg 38.

Size: Length 90-100 μm, inner diameter 30-40 μm.

Holotype: USNM 236060 (Plate 2, Figure 1).

Isotypes: USNM 236061 and 236062.

Type locality: Norwegian-Greenland Sea, Sample 338-10-2, 130-132 cm (97 m).

Distephanus varians (Gran and Braarud) n. comb.

Distephanus speculum f. *varians* Gran and Braarud, 1935, p. 390, fig. 68A, B.

Remarks: *Distephanus varians* could be considered a junior synonym of *D. pseudofibula* (Ling, 1972; Bukry, in press a); however, observed differences in their relative percentages from sample to sample and area to area suggest a potential value in continuing the distinction.

Genus MESOCENA Ehrenberg, 1843

Mesocena apiculata curvata n. subsp.
(Plate 2, Figures 15, 16)

Septamesocena apiculata (Schulz), Perch-Nielsen, 1975 (in part), p. 689, pl. 10, fig. 6.

Mesocena apiculata (Schulz), Bukry, 1975 (in part), p. 856, pl. 5, fig. 7.

Description: *Mesocena apiculata curvata* has a triangular basal ring, isosceles in form, and having, usually, one side that is concave. Spines are moderate to short and septate.

Remarks: *Mesocena apiculata curvata* is distinguished from *M. apiculata apiculata* (Schulz, 1928) by having isosceles form and usually one concave side. It is distinguished from *M. oamaruensis* by spines and a more isosceles form. A triconcave variation, *Mesocena* sp. cf. *M. apiculata curvata*, was noted only in 338-22-6, 84-85 cm (217 m) (see Plate 2, Figure 17).

Occurrence: *Mesocena apiculata curvata* is most common in the lower and middle Miocene where it may dominate *M. apiculata apiculata*. It appears to have evolved from the equilateral *M. apiculata apiculata* of the upper Eocene and Oligocene.

Size: Basal-ring height 50-70 μm.

Holotype: USNM 236063 (Plate 2, Figure 15).

Isotypes: USNM 236064 and 236065.

Type locality: Norwegian-Greenland Sea, Sample 346-5-3, 146-147 cm (40 m).

Genus NAVICULOPSIS Frenguelli, 1940

Naviculopsis foliacea Deflandre
(Plate 2, Figure 11)

Naviculopsis foliacea Deflandre, 1950, p. 204, fig. 235-240.

Remarks: *Naviculopsis foliacea* has distinctly larger portals than *N. nordica nordica*.

Naviculopsis nordica n. sp.
(Plate 2, Figures 12-14)

Description: *Naviculopsis nordica* has a narrow elongate basal ring. The spines are shorter than the basal ring and form a nearly continuous line with the ring outline. The apical plate has two small perforations at the ends of the basal ring. The perforations are circular or elongate and canted such that one long side may be bounded by the ring and the other lie within the plate.

Remarks: *Naviculopsis nordica* is distinguished from *N. nordica hyalina* by the small perforations at the ends of the apical plate. It is distinguished from *N. foliacea* by the distinctly smaller size of its perforations compared to the portals of *N. foliacea*. The length of the perforations of *N. nordica* occupy only 3% to 11% of the length of the basal ring, whereas the length of the portals of *N. foliacea* occupy 26% to 42% (see Deflandre, 1950; Ling, 1972; Dumitrica, 1973; Bukry, 1973; and Perch-Nielsen, 1975).

Occurrence: *Naviculopsis nordica* is rare to common in middle or upper Eocene samples from Cores 3 to 11 at Site 340 and Core 5 at Site 343.

Size: Basal-ring length 70-85 μm.

Holotype: USNM 236069 (Plate 2, Figure 12).

Isotypes: USNM 236070 and 236071.

Type locality: Norwegian-Greenland Sea, Sample 340-11-6, 40-41 cm (102 m).

Naviculopsis nordica hyalina n. subsp.
(Plate 2, Figures 8-10)

Description: *Naviculopsis nordica hyalina* has a narrow elongate basal ring. The spines are shorter than the basal ring and form a continuous line with the ring outline. The apical plate is imperforate filling the entire inner area of the basal ring.

Remarks: *Naviculopsis nordica hyalina* is distinguished from *N. nordica nordica* by having an imperforate plate. It is distinguished from *N. foliacea* by its narrower tapering basal ring and unflexed outline where the spines and basal ring join.

Occurrence: *Naviculopsis nordica hyalina* is known only from the middle or upper Eocene of Cores 3 to 11 at Site 340.

Size: Basal-ring length 70-85 μm.

Holotype: USNM 236066 (Plate 2, Figure 10).

Isotypes: USNM 236067 and 236068.

Type locality: Norwegian-Greenland Sea, Sample 340-7-6, 50-51 cm (65 m).

Naviculopsis punctilia punctilia Perch-Nielsen
(Plate 2, Figure 3)

Naviculopsis punctilia Perch-Nielsen, 1976, p. 36, figs. 1 and 32.

Naviculopsis punctilia taenia n. subsp.
(Plate 2, Figures 4-7)

Description: *Naviculopsis punctilia taenia* has long spines that are approximately equal to the basal ring which is parallel-sided or slightly convex. The elevated apical plate occupies a third, or less, of the basal ring and borders one side of the two large portals. Two additional smaller portals occur at the minor axis of the basal ring where the plate joins the ring. This creates an X-shaped apical plate.

Remarks: Depending on the relative sizes of the lamellar apical structures and the basal ring, different specimens of *Naviculopsis punctilia taenia* can resemble *N. constricta*, *N. foliacea*, or *N. punctilia punctilia*. It is distinguished from all of these by the combined presence of an apical plate and side portals.

Occurrence: *Naviculopsis punctilia taenia* occurs with a diverse suite of *Naviculopsis* species in middle or upper Eocene Cores 3 to 11 at Site 340.

Size: Basal-ring length 50-75 μm.

Holotype: USNM 236072 (Plate 2, Figure 5).

Isotypes: USNM 236073 to 236075.

Type locality: Norwegian-Greenland Sea, Sample 340-3-3, 40-41 cm (22 m).

Naviculopsis vemae Perch-Nielsen

Naviculopsis vemae Perch-Nielsen, 1976, p. 36, figs. 3, 4, and 18.

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PLATE 1

Silicoflagellates from DSDP Leg 38.

Figures 1-6, 11-16, and 19 magnification 800×;
scale bar equals 10 μm
Figures 7-10, 17, and 18 magnification 1100×;
scale bar equals 10 μm.

Figures 1-6 *Corbisema katharinae* n. sp.
All specimens from Sample 337-10-6, 62-64 cm (93 m).
1. USNM 236056.
2. USNM 236057.
3. USNM 236058.
4. Holotype, USNM 236055
5, 6. USNM 236059, apical and basal focuses.

Figures 7-10 *Dictyocha rotundata secta* Glezer.
All specimens from Sample 343-5-3, 75-76 cm (148 m).
7, 8. Same specimen, basal and apical focuses.
9, 10. Same specimen, basal and apical focuses.

Figures 11, 12 *Distephanus antiquus* Glezer.
Sample 343-5-3, 75-76 cm (148 m).
Same specimen, basal and apical focuses.

Figures 13, 14 *Distephanus crux darwinii* Bukry.
13. Sample 338-23-3, 119-120 cm (223 m).
14. Sample 337-10-6, 62-64 cm (93 m).

Figure 15 *Distephanus norvegiensis* Perch-Nielsen.
Binoculoid specimen, Sample 340-2-3, 60-61 cm (13 m).

Figures 16-18 *Distephanus raupii* Bukry.
16. Sample 337-10-6, 62-64 cm (93 m).
17, 18. Sample 338-23-3, 119-120 cm (223 m), basal and apical focuses.

Figure 19 *Distephanus speculum giganteus* n. subsp.
USNM 236061, Sample 338-10-2, 130-132 cm (97 m).

PLATE 1

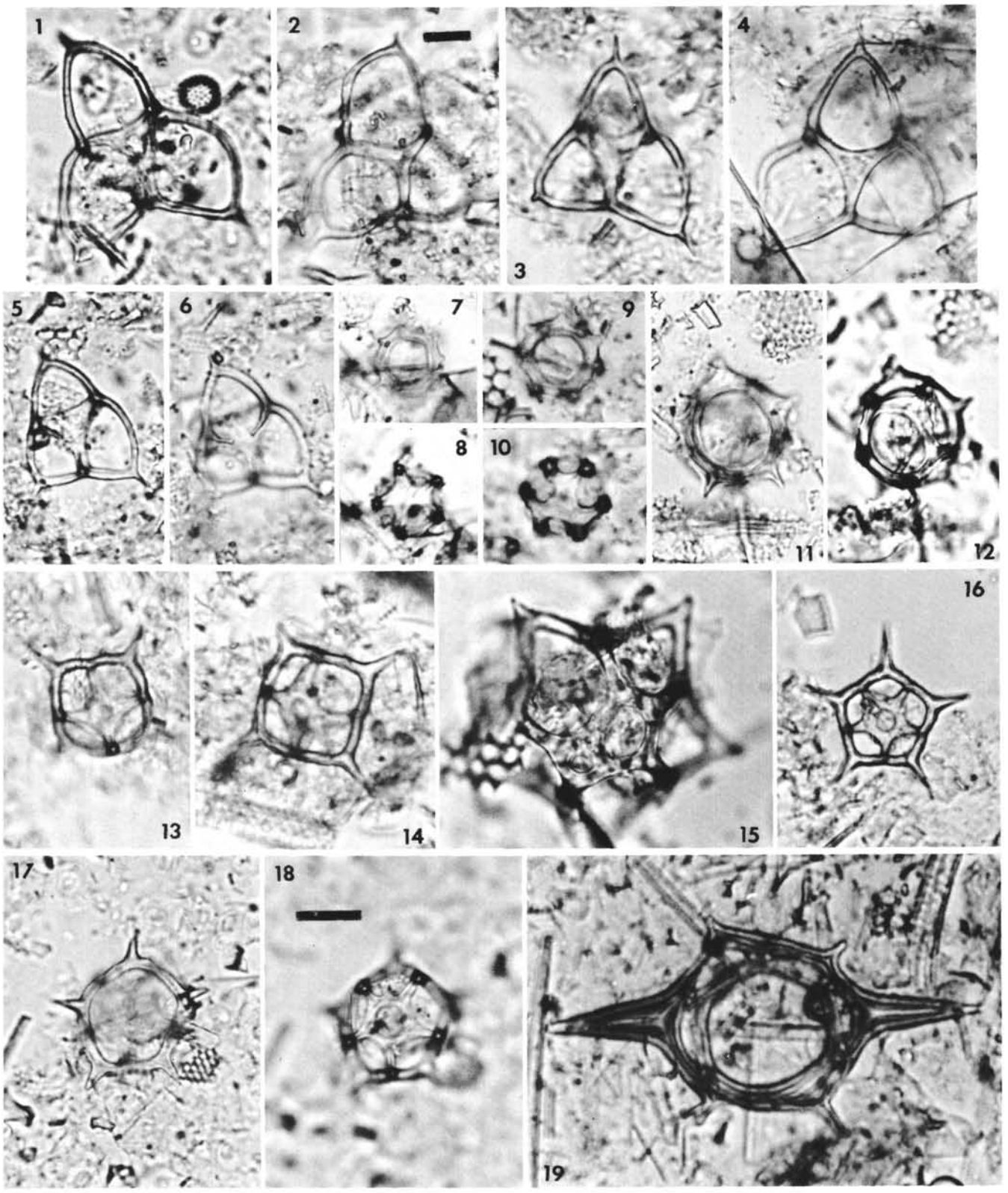

PLATE 2

Silicoflagellates from DSDP Leg 38.
All figures same magnification; scale bar equals 10 μm.

Figures 1, 2 — *Distephanus speculum giganteus* n. subsp.
1. Holotype, USNM 236060, Sample 338-10-2, 130-132 cm (97 m).
2. USNM 236062, Sample 338-10-2, 130-132 cm (97 m).

Figure 3 — *Naviculopsis punctilia punctilia* Perch-Nielsen.
Sample 340-3-3, 40-41 cm (22 m).

Figures 4-7 — *Naviculopsis punctilia taenia* n. subsp.
4. USNM 236073, Sample 340-3-3, 40-41 cm (22 m).
5. Holotype, USNM 236072, Sample 340-3-3, 40-41 cm (22 m).
6. USNM 236074, Sample 340-7-6, 50-51 cm (65 m).
7. USNM 236075, Sample 340-7-6, 50-51 cm (65 m).

Figures 8-10 — *Naviculopsis nordica hyalina* n. subsp.
All specimens from Sample 340-7-6, 50-51 cm (65 m).
8. USNM 236067.
9. USNM 236068.
10. Holotype, USNM 236066.

Figure 11 — *Naviculopsis foliacea* Deflandre.
Sample 343-5-3, 75-76 cm (148 m).

Figures 12-14 — *Naviculopsis nordica* n. sp.
12. Holotype, USNM 236069, Sample 340-11-6, 40-41 cm (102 m).
13. USNM 236070, Sample 340-3-3, 40-41 cm (22 m).
14. USNM 236071, Sample 340-7-6, 50-51 cm (65 m).

Figures 15, 16 — *Mesocena apiculata curvata* n. subsp.
15. Holotype, USNM 236063, Sample 346-5-3, 146-147 cm (40 m).
16. USNM 236064, Sample 338-12-3, 60-61 cm (116 m).

Figure 17 — *Mesocena* sp. cf. *M. apiculata curvata* n. subsp.
USNM 236065, Sample 338-22-6, 84-85 cm (217 m).

PLATE 2