19. COCCOLITH AND SILICOFLAGELLATE STRATIGRAPHY, DEEP SEA DRILLING PROJECT LEG 18, EASTERN NORTH PACIFIC[1]

David Bukry, U. S. Geological Survey, La Jolla, California

INTRODUCTION

Leg 18 of the Deep Sea Drilling Project, May-July 1971, from Honolulu to Kodiak, recovered 273 cores at eleven drilling sites in the eastern North Pacific (Figure 1). Light-microscope techniques were used to examine 206 samples from these cores for coccoliths and silicoflagellates.

Only at Site 173 off northern California are both coccoliths and silicoflagellates common and diverse through a thick stratigraphic section. At more northerly sites, these groups are only sporadically represented by low-diversity assemblages.

SITE 172
(lat 31°32.23'N, long 133°22.36'W, depth 4768 m)

Site 172 is in an area of rugged bottom topography between the Murray and Molokai fracture zones in the eastern Pacific. Magnetic-anomaly lineations for this area, shown by Atwater and Menard (1970), suggest that the site is between Anomaly 13 (38 m.y.) and Anomaly 21 (53 m.y.), probably near Anomaly 15 (40 m.y.) by interpolation. The deepest sediment core (17 to 24 m), recovered above extrusive basalt, contains an early Oligocene *Helicopontosphaera reticulata* Zone coccolith ooze having as estimated age of 36 to 38 m.y. (Burkry, 1973). The occurrence of *Bramletteius serraculoides, Cyclococcolithina formosa,* and *Isthmolithus recurvus* indicate an early assemblage of the *H. reticulata* zone. Solution-resistant species predominate, yet even the large specimens of such taxa have been extensively attacked by etching. For example, in many specimens of *Dictyococcites,* central-area crystallites have been removed by dissolution, producing ragged, irregular central openings in species typified by a closed central-area structure. The calcium-carbonate content of Sample 172-3-2(70-71) is low, and the rare discoaster specimens are centerless as a result of strong dissolution. Coccoliths are most abundant in the bottom two samples. Most of the sediment layers of Core 3 have been disrupted by the coring process, resulting in mixing of coccolith assemblages (S. W. Wise, pers. commun., 1972). The occurrence of coccolith species in samples from Site 172 is shown in Figure 2.

SITE 173
(lat 39°57.71'N, long 125°27.12'W, depth 2927 m)

Site 173 is on the lower continental slope about 80 km southwest of Cape Mendocino. The site was continuously cored from 0 to 336 meters (Cores 1 to 38) to provide a biostratigraphic reference for this region of the eastern North Pacific. The fossil-rich sediment ranges in age from late Oligocene or early Miocene to Pleistocene. Although diatoms predominate, coccoliths and silicoflagellates are abundant in various intervals. For some intervals at Site 173, the low-latitude zones for coccoliths and silicoflagellates can be used but other intervals require new regional zonation. Middle Miocene to Pleistocene zones at Site 173 are compared with those of Sites 157 and 158 in the Panama Basin in Figure 3.

A reduction in the number of species of living coccolith-producing algae between equatorial and subarctic-antarctic regions of the Pacific Ocean (Hasle, 1960; S. Honjo, pers. commun., 1971) has been corroborated for fossil coccolith assemblages from both the Atlantic and Pacific by the results of recent work of the Deep Sea Drilling Project.

Cenozoic coccolith assemblages from Leg 12 in the North Atlantic and from Leg 19 in the North Pacific and Bering Sea are dominated by only a few placolith species. Site 173 provides an intermediate setting at a middle latitude, where the assemblages, though reduced from those of the tropics, contain enough low-latitude taxa to allow recognition of part of the low-latitude coccolith zonation. As most assemblages are moderately to strongly etched (preservation stages -2 or -3), the lack of some species in the assemblages is not necessarily the result of paleoecologic exclusion. The occurrence of coccolith species in samples examined and the indicated zonation are shown in Figure 4. Low-latitude zones are recognized at Site 173 by cosmopolitian members of their assemblages. For example, the *Sphenolithus heteromorphus* Zone can be recognized here by the earliest occurrence of *Discoaster exilis* and *Reticulofenestra pseudoumbilica* or by the latest occurrence of *Cyclicargolithus floridanus* and *Discoaster deflandrei*. At low latitudes other indicators of this zone are the presence of *Sphenolithus heteromorphus, Coronocyclus* spp., and the earliest occurrences of *Cyclococcolithina macintyrei s. l., Sphenolithus abies, Discoaster signus*, and *Triquetrorhabdulus rugosus*. The most radical departure of the species composition of Site 173 assemblages occurs in the late middle Miocene and late Miocene assemblages. Instead of the diversified Sorolian Stage succession of five- and six-rayed discoasters that permits detailed zonation at low latitude, *Discoaster intercalaris* and *D. variabilis* are dominant. Only the occurrence of a newly defined species, *D. mendomobensis* Wise, near the top of the interval between the *Sphenolithus heteromorphus* Zone and *Ceratolithus tricorniculatus* Zone, permits a stratigraphic subdivision. The name of the lower subdivision, *Discoaster variabilis* Zone, was suggested by E. D. Milow (McManus and others, 1970).

The *Discoaster variabilis* Zone is defined herein as the interval between the last occurrence of *Cyclicargolithus*

[1] Publication authorized by the Director, U. S. Geological Survey.

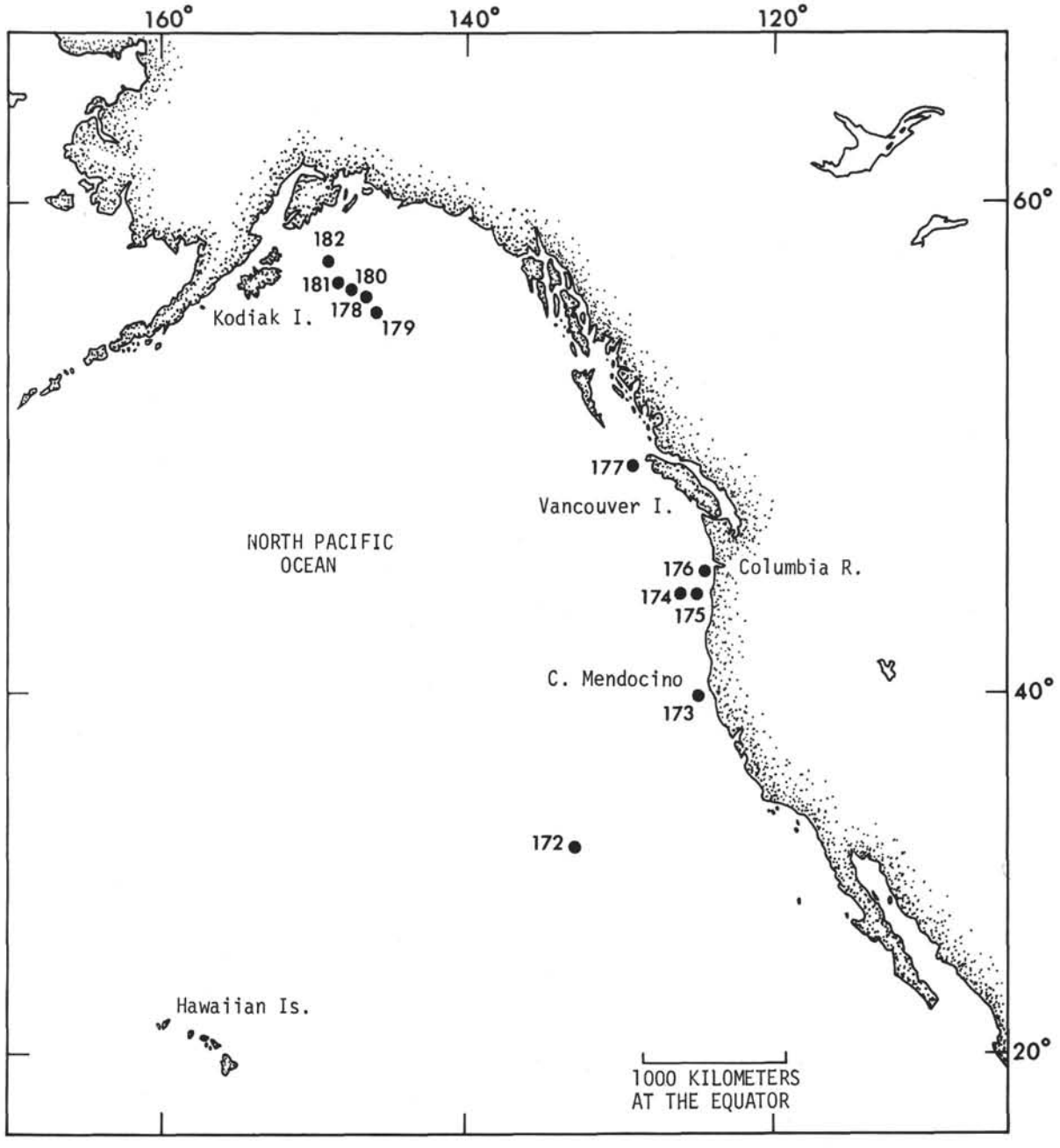

Figure 1. *Location of sites cored during Deep Sea Drilling Project Leg 18.*

floridanus and the first occurrence of *Discoaster mendomobensis* at Site 173; typical assemblages are indicated in Figure 4. This zone is approximately equivalent to the *Discoaster exilis, Catinaster coalitus, Discoaster hamatus*, and *D. neohamatus* Zones of low latitudes. The *Discoaster mendomobensis* Zone is defined herein as the interval between the first occurrence of *Discoaster mendomobensis* and the first occurrence of *Ceratolithus tricorniculatus* at Site 173; typical assemblages are indicated in Figure 4. This zone is approximately equivalent to the *Discoaster quinqueramus* Zone of low latitudes.

The last rare specimens of *Discoaster* are noted in the Pliocene of Cores 12 to 15. *Helicopontosphaera sellii*, most abundant near the Pliocene-Pleistocene boundary of North Atlantic cores (Bukry, 1972), is most common at Site 173 in Core 12, which contains the highest definitive Pliocene coccolith assemblage. The lowest assemblage that contains *Gephyrocapsa caribbeanica*, which indicates a definite Pleistocene age, is in Core 5. The nondiagnostic assemblages of Cores 6 to 11 could be either late Pliocene or early Pleistocene; samples from Cores 7 and 8 are barren of coccoliths.

Age (Zone)	Sample Site 172	Depth (m)	Coccolith Species															
			Bramletteius serraculoides	*Coccolithus eopelagicus*	*C. pelagicus*	*Cyclococcolithina formosa*	*Dictyococcites bisectus*	*D. scrippsae*	*Discoaster deflandrei*	*D. nodifer*	*D. tani*	*Discolithina* sp.	*Isthmolithus recurvus*	*Pontosphaera vadosa*	*Reticulofenestra hillae*	*R. umbilica*	*Sphenolithus predistentus*	*S. pseudoradians*
–	1-1 (70-71)	1																
	1-5 (70-71)	7																
	2-2 (70-71)	10																
	2-5 (78-79)	15																
	2-6 (70-71)	16																
Early	3-1 (47-48	17	X	X		X	X	X	X		X		X	X	X			
Oligocene	3-2 (70-71	19					X	X	X		X							
(Helicoponto-	3-3 (70-71)	21	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
sphaera	3-4 (70-71)	23																
reticulata	3-5 (70-71	24	X	X		X	X		X		X			X	X	X	X	
Zone)	3-6 (10-11)	25	X	X		X	X	X	X	X	X		X	X	X	X	X	

Figure 2. *Occurrence of coccoliths in samples from DSDP Site 172.*

Silicoflagellate assemblages of middle Miocene to Pleistocene age at Site 173 were recorded from some of the smear slides examined for coccoliths. The entire slide area of 22 X 40 mm was scanned unless a count of 300 specimens was achieved. Therefore, counts less than 300 provide an estimate of relative silicoflagellate abundance. In all cases, species abundance is recorded as percentage; the total count of the assemblage is also indicated. Paleotemperatures were calculated using the curve of Mandra (1969). For determination of generic ratios used to calculate paleotemperatures, *Corbisema* is considered with *Dictyocha, Cannopilus* with *Distephanus*. Silicoflagellate data and zonation are shown in Figure 5. Typical specimens are shown in Plates 1-3.

A great abundance and diversity of silicoflagellates in middle and late Miocene sediment at Site 173 allows the recognition of the tropical *Corbisema triacantha* Zone and *Distephanus longispinus* Zone (Martini, 1971; Bukry and Foster, 1973). The late Miocene silicoflagellate assemblages differ from those recorded in the tropics by the occurrence of abundant *Dictyocha pseudofibula* and few to rare *Distephanus pseudocrux* and *D.* sp. cf. *D. pseudocrux* (Plates 1-2). Instead of assemblages dominated by *Dictyocha aspera* or *D. fibula,* the Site 173 assemblages contain abundant *D. pseudofibula.* The *Dictyocha pseudofibula* Zone is herein defined as the interval from the first to the last common occurrence of *D. pseudofibula*; typical assemblages are shown in Figure 5. At Site 173, the base of this zone coincides with the last occurrences of *D. pseudocrux,* and *Dictyocha pentagona.* Owing to a change in the sedimentary regime at Site 173, there is at the top of the zone a contrasting increase in *Distephanus speculum* and reduction in *Dictyocha pseudofibula* and quadrate species of *Distephanus.* The *Dictyocha pseudofibula* Zone is equivalent to part of the tropical *Distephanus crux* Zone. The late Miocene reversal in the *Dictyocha aspera/ Dictyocha fibula* ratio occurs within these zones.

The *Distephanus speculum* Zone is herein defined as the interval from the last common occurrence of *Dictyocha pseudofibula* to the first occurrence of *Distephanus octangulatus*; typical assemblages are shown in Figure 5. The sedimentologic change at the base of the *D. speculum* Zone at Site 173 is associated with a distinct climatic change reflected in abundance of *Distephanus speculum*. Relative to the whole assemblage, *D. speculum* is twice as abundant in Cores 1 to 15 as in Cores 16 to 30. The *D. speculum* Zone is equivalent to the upper *Distephanus crux, Cannopilus major, Distephanus boliviensis*, and lower *Mesocena elliptica* Zones of the tropics. The *Distephanus octangulatus* Zone is herein defined as the interval from the first occurrence of *Distephanus octangulatus* to living assemblages; typical assemblages at Site 173 are shown in Figure 5. The almost total dominance in this zone of three species, *Distephanus octangulatus, D. polyactis*, and *D. speculum*, contrasts sharply with equivalent tropical assemblages of the *Dictyocha epidon* Zone and upper *Mesocena elliptica* Zone, where *Dictyocha fibula, D. epiodon, Mesocena elliptica* and *Octactis pulchra* dominate. But this assemblage is nearly identical with those of subarctic regions recovered in the Bering Sea by DSDP Leg 19. As a result of strong paleoecologic control on the distribution of silicoflagellates, zonal units are more regional in nature than those of coccoliths.

Paleotemperatures indicated by silicoflagellates were calculated for all samples examined from Site 173 although total counts in some of the upper cores are too small to be considered reliable. The two most significant warm periods are indicated during the Holocene and late Miocene (Figure 5). These high-paleotemperature intervals and several others are corroborated by the "Td" values calculated for

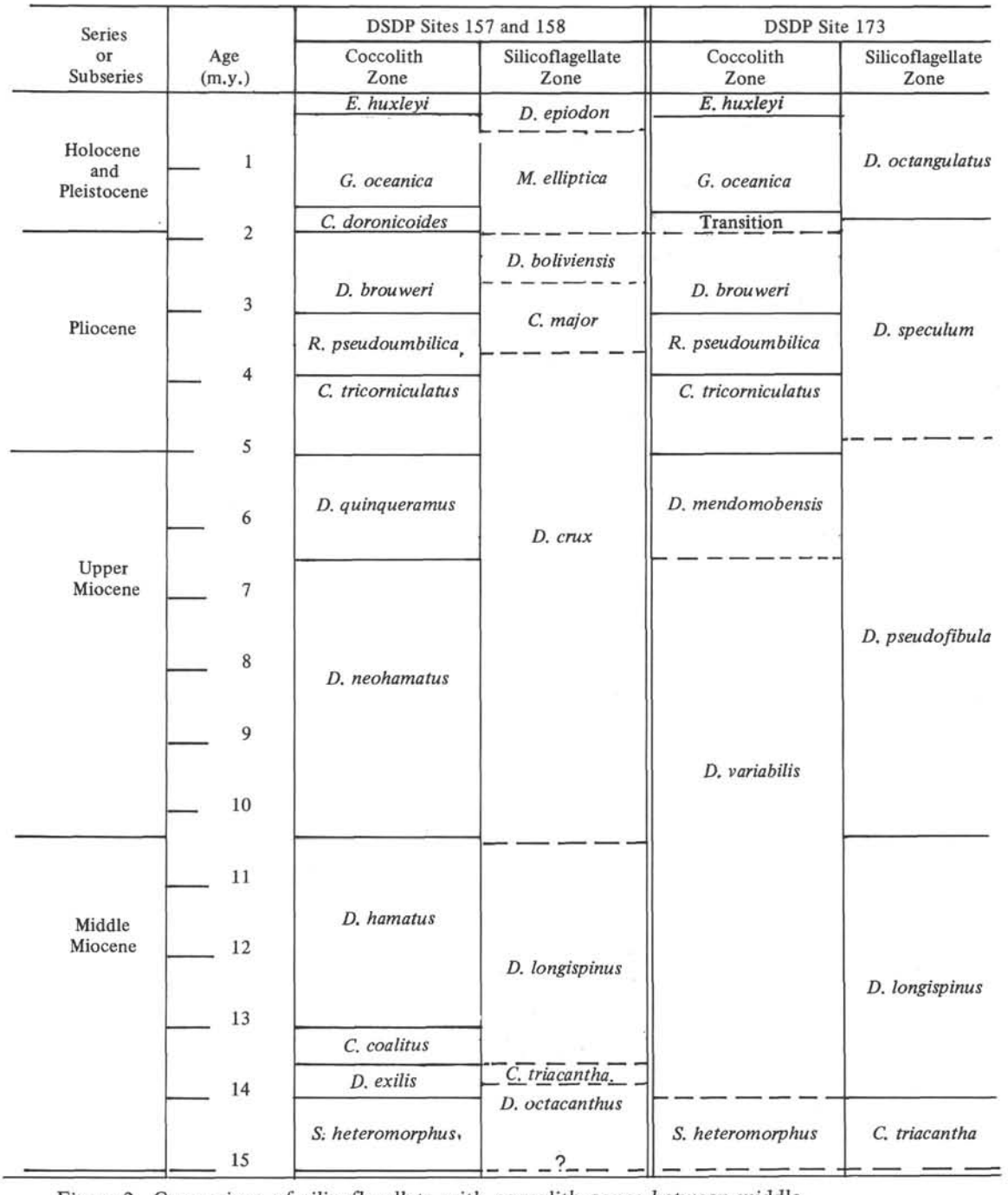

Figure 3. *Comparison of silicoflagellate with coccolith zones between middle- and low-latitude localities in the eastern Pacific Ocean. Independent evidence will be required to further evaluate suggestions of diachronous zonal relations.*

diatom assemblages (Schrader, this volume). Td values are calculated on the ratio of cold to warm diatom species in an assemblage and are expressed from 0 for cold to 100 for warm. Silicoflagellates and diatoms respond to changes in similar manner and degree. The generally low temperatures for this region during the late Cenozoic are unexpectedly high in the late Miocene. In the same interval (Cores 16 to 19), diatom Td values approach 100 where silicoflagellates indicate temperatures from 17 to >25°C. The only indication of elevated temperature shown by coccoliths for this interval is an increase in the abundance of discoasters.

SITE 174
(lat 44°53.38′N, long 126°21.40′W, depth 2799 m)

Site 174 is on the outer part of the Astoria submarine fan, which lies about 140 km west of the mouth of the Columbia River. A total of forty-three cores were cut from 0 to 879 meters to determine the sedimentologic history of this area. Diagnostic coccolith assemblages in samples from these cores are Pleistocene in age. The first *Gephyrocapsa caribbeanica* is recorded in 174A-38-1(129-130) (636 m), the first *G. oceanica* in 174A-33-2(35-36) (343 m). Specimens of *Gephyrocapsa* are smaller than tropical relatives,

Age	Zone or Subzone	Sample Site 173	Depth (m)	Coccolith Species: *Sphenolithus dissimilis*	*Dictyococcites bisectus*	*D.* sp. cf. *D. abisectus*	*Triquetrorhabdulus carinatus*	*Cyclicargolithus bukryi*	*Sphenolithus moriformis*	*Discoaster deflandrei*	*Cyclicargolithus floridanus*	*Coccolithus pelagicus*	*C. miopelagicus*	*C. eopelagicus*	*Sphenolithus* sp. cf. *S. abies*	*Helicopontosphaera euphratis*	*Discolithina* spp.	*Helicopontosphaera granulata*	*Discoaster exilis*	*D. variabilis*	*D. intercalaris*	*Reticulofenestra pseudoumbilica*	*Helicopontosphaera kamptneri*	*Discoaster* sp. aff. *D. deflandrei*	*Sphenolithus neoabies*	*Discoaster braarudii*	*Minylitha convallis*	*Discoaster brouweri*	*Cyclococcolithina macintyrei*	*C. leptopora*	*Discoaster mendomobensis*	*Ceratolithus primus*	*C. tricorniculatus*	*Discoaster pentaradiatus*	*Ceratolithus* sp. cf. *C. amplificus*	*Helicopontosphaera sellii*	*Discoaster triradiatus*	*Emiliania annula*	*Gephyrocapsa doronicoides*	*Coccolithus pliopelagicus*	*Emiliania ovata*	*Gephyrocapsa caribbeanica*	*Rhabdosphaera stylifera*	*Gephyrocapsa oceanica*	*?Emiliania huxleyi*
Pleistocene	*?Emiliania huxleyi*	1-1 (70-71)	1									X																X													
		1-4 (70-71)	5									X																X								X			X	X
	Gephyrocapsa oceanica	2-1 (70-71)	6									X																X								X				
		2-5 (70-71)	12									X																X						X	X	X	X			
		3-2 (70-71)	17									X																X						X	X	X	X			
		3-5 (70-71)	22									X																X						X		X	X			
	Gephyrocapsa caribbeanica	4-1 (70-71)	25									X																X								X	X			
		4-3 (70-71)	28									X					X											X						X		X	X	X		
		4-5 (70-71)	31									X																X						X	X	X	X			
		5-1 (92-93)	34									X											X					X						X						
		5-3 (70-71)	38									X																X						X	X		X	X		
Pleistocene or Pliocene	*Emiliania annula* or *Discoaster brouweri*	6-1 (121-122)	44									X																							X		X			
		6-3 (70-71)	46									X																		X					X	X				
		7-4 (70-71)	58																																					
		8-6 (70-71)	70																																					
		9-6 (20-21)	81									X																		X					X	X				
		10-6 (20-21)	90									X																		X										
		11-4 (20-21)	97									X																		X										
Late Pliocene	*Discoaster brouweri*	12-6 (20-21)	108									X					X						X					X	X	X					X	X	X	X			
		13-6 (17-18)	118									X																X	X	X						X					
Early Pliocene	*R. pseudoumbilica*	14-3 (20-21)	123																	X		X								X				X						
	Ceratolithus tricorniculatus	15-2 (25-26)	130									X								X		X									X	X		X						
		15-3 (20-21)	131									X								X		X			X					X										
		15-4 (20-21)	133																	X		X									X	X								
Late Miocene	*Discoaster mendomobensis*	16-1 (53-54)	139									X								X	X	X	X		X		X	X												
		16-2 (20-21)	140									X								X	X	X					X	X		X	X									
		16-3 (20-21)	141																	X	X	X									X									
		17-1 (104-105)	148									X								X	X	X				X	X													
		17-3 (20-21)	150									X									X	X				X		X		X	X									
	Discoaster variabilis	18-1 (140-141)	158									X								X		X				X	X	X	X	X										
		18-5 (20-21)	163									X								X		X			X	X														
		19-4 (20-21)	170									X								X	X	X			X	X	X													
		20-3 (20-21)	179									X								X	X	X																		
		21-3 (20-21)	188																	X	X	X																		
		22-1 (102-103)	195									X			X						X	X	X		X																
Middle Miocene	*Sphenolithus heteromorphus*	23-3 (20-21)	207									X									X	X																		
		24-5 (20-21)	220									X	X									X		X																	
		25-5 (20-21)	230									X	X	X								X		X																	
		26-4 (20-21)	237									X	X									X		X																	
		27-4 (20-21)	247								X	X	X							X		X																		
		28-3 (20-21)	255									X	X	X							X	X	X	X																	
		29-2 (20-21)	263								X	X								X	X																				
	–	30-1 (4-5)	272																																						
Early Miocene or Late Oligocene		31-1 (135-136)	281						X	X	X	X	X		X			X																						
	Triquetrorhabdulus carinatus	34-2 (20-21)	306				X	X	X	X	X	X	X			X	X																							
		34-2 (68-69)	307			X	X	X	X	X		X	X																											
		34-3 (20-21)	308		X	X	X	X	X	X		X																												
		35-1 (112-113)	311		X	X	X	X	X	X		X	X	X	X																									
		35-3 (10-11)	314		X		X	X	X	X	X	X	X																											
		35-3 (20-21)	314	X	X	X	X	X	X	X	X	X																												

Figure 4. *Age and zonation of coccoliths in samples from DSDP Site 173.*

Age	Zone	Sample Site 173	Depth (m)	Silicoflagellate Species																																			Total Specimens	Paleotemperature (°C)
				Cannopilus sp. cf. *C. major*	*C. hemisphaericus*	*Corbisema triacantha*	*Dictyocha medusa*	*Mesocena diodon*	*Distephanus longispinus s. l.*	*Dictyocha aspera*	*Distephanus crux*	*Dictyocha fibula*	*Distephanus speculum*	*Cannopilus* sp. cf. *C. quintus*	*Distephanus* sp. cf. *D. pseudocrux*	*D. quinquangellus*	*Mesocena elliptica*	*M. triodon*	*Cannopilus binoculus*	*C.* sp. aff. *C. quintus*	*Mesocena triangula*	*M. circula*	*Cannopilus ernstinae*	*C. sphaericus*	*Distephanus longispinus s. s.*	*Cannopilus* sp. cf. *C. schulzii*	*Distephanus pseudocrux*	*Dictyocha pseudofibula*	*D. pentagona*	*Distephanus boliviensis*	*D. polyactis*	*D. octangulatus*	*Dictyocha* sp. aff. *D. aspera*	*Corbisema* sp.	*Dictyocha* sp. cf. *D. japonica*		
Pleistocene	*Distephanus octangulatus*	1-1 (70-71)	1									42	58									3															117	18
		1-4 (70-71)	5									5	83																						3	36	5
		2-1 (70-71)	6										95																	5					18	4
		2-5 (70-71)	12								1	4	9																79	4		1		68	5
		3-2 (70-71)	17									11	11																67	11				9	6
		3-5 (70-71)	22										75																	25				8	3
		4-1 (70-71)	25										50																25		25			4	12
		4-5 (70-71)	31										50																	50				6	3
Pleistocene or Pliocene	*Distephanus speculum*	5-1 (92-93)	34									5	85				5												5					20	5
		5-3 (70-71)	38									14	72														14							7	13
		6-3 (70-71)	46									5	11																74	11				19	4
		7-4 (70-71)	58									7	7														7			79				14	5
		8-6 (70-71)	70							33		33	33																						3	25
		9-6 (20-21)	81							2		21	78																						58	11
		10-6 (20-21)	90									20	80																						5	10
		11-4 (20-21)	97							9	2	20	64			2											2								44	14
		12-6 (20-21)	108									16	74			5											5								19	11
Pliocene		13-6 (17-18)	118										80														20								10	10
		14-3 (20-21)	123							2	1		25			25	5								1		3	6	30	1					93	6
		15-2 (25-26)	130						<1	3		10	65			7										1	1	2	9						173	8
Late Miocene	*Dictyocha pseudofibula*	16-1 (53-54)	139							<1	10	4	15									<1				<1	64	5	<1						300	25
		16-3 (20-21)	141							10	19	20	21									2					26	2							300	24
		17-1 (104-105)	148					<1		15			16									1				1	66	<1							300	25
		18-1 (140-141)	158					<1	3	2			47		10	<1					<1	<1			<1		<1	36	<1							300	17
		19-4 (20-21)	170					4	3	9		1	10		3							<1					4	66	<1							300	25
Middle Miocene	*Distephanus longispinus*	20-3 (20-21)	179				<1	1	2	4		<1	66			<1			<1					23		<1	1								300	5
		21-3 (20-21)	188			<1	<1		10			<1	5						<1				10	71	2										206	6
		22-1 (102-103)	195		1	1	2	<1	3	11		<1	45				1		<1			<1	<1	1	32										300	8
	Corbisema triacantha	23-3 (20-21)	207			6			3	3	20	3	60			3						3													35	6
		24-5 (20-21)	220	2					33	<1	46	<1	15		<1	1																			156	4
		25-5 (20-21)	230						4	6	38	2	43			2		1	4																84	5
		26-4 (20-21)	237			2			26	1	48	2	6		1		10				1	2													84	5
		27-4 (20-22)	247			12			13	2	57	<1	12	<1		2	<1			<1															300	9
		28-3 (20-21)	255	<1				<1	35		22		40		<1	2	<1																		300	3
		29-2 (20-21)	263	<1		<1	<1		34	2	53	<1	5	1	<1	<1	3	<1																	300	4
		30-1 (4-5)	272	<1	<1	6	<1	<1	45	<1	26	15	5																						220	11

Figure 5. *Age, zonal assignment, and percent of silicoflagellate species in smear slides of samples from DSDP Site 173. A total count of silicoflagellates and a paleotemperature based on silicoflagellate ratios is also included for each sample.*

and the central-area bars are aligned about 45° to the major axis. Most samples are barren or contain only a few nondiagnostic coccoliths. Coccoliths are abundant in only two of the twenty-six samples examined; 174A-33-2(35-36), and 174A-1-1(82-93) (28 m). Sample 174A-1-1 has a diverse probable Holocene assemblage of the *Emiliania huxleyi* Zone. Species present include: *Braarudosphaera bigelowii, Coccolithus pelagicus, C. pliopelagicus, Cyclococcolithina leptopora, ?Emiliania huxleyi, Gephyrocapsa* sp. cf. *G. ericsonii, G. oceanica, Helicopontosphaera* sp. cf. *H. kamptneri* [reworked?], *Rhabdosphaera procera*, and *Syracosphaera* sp. The only silicoflagellates observed in the sample are rare *Dictyocha fibula* (three specimens) and *Distephanus speculum* (one specimen).

SITE 175
(lat 44°50.2′N, long 125°14.5′W, depth 1999 m)

Site 175 is on the lower continental slope east of Site 174. A total of twenty-five cores (0 to 271 meters) were cut in terrigenous sediments. Pleistocene coccoliths are common to abundant in samples from Cores 1 to 17 (0 to 157 m). A sparse Pleistocene assemblage in 175-18-4(20-21) (162 m) contains rare, small *Gephyrocapsa caribbeanica* and *G. oceanica*. Deeper samples are barren. *Braarudosphaera bigelowii, Coccolithus pelagicus, C. pliopelagicus, Gephyrocapsa caribbeanica, G. oceanica*, and *?G. producta* occur through the section; *Helicopontosphaera kamptneri* occurs in 175-8-2(11-12) (62 m). *Gephyrocapsa* sp. cf. *G. ericsonii* occurs in 175-1-1(120-121) (0 m) with *?Emiliania huxleyi* indicating a probable Holocene *Emiliania huxleyi* Zone assignment. Assemblages from Cores 2 to 18 are either assigned to the *Gephyrocapsa oceanica* Zone or are nondiagnostic.

SITE 176
(lat 45°56.0′N, long 124°37.0′W, depth 193 m)

Site 176 is 1 to 2 km west of Nehalem Bank southwest of the Columbia River. Coring was intended to date a shallow angular unconformity presumably related to an uplift of the Oregon continental shelf. Coccoliths are present in samples from Cores 2 and 5 of the five cores cut (0 to 41 m). Sample 176-2-1(13-14) (6 m) contains abundant *?Emiliania huxleyi* and rare *Braarudosphaera bigelowii* and *Coccolithus pelagicus*; this assemblage is assigned to the *Emiliania huxleyi* Zone. Sample 176-5-5(110-111) (39 m) contains rare reworked coccoliths of mixed ages, including Cretaceous *Watznaueria barnesae*, Eocene *Discoaster barbadiensis*, and Oligocene or Miocene *Cyclicargolithus bukryi* and *Sphenolithus moriformis.*

SITE 177
(lat 50°28.18′N, long 130°12.30′W, depth 2006 m)

Site 177 is on the northeastern end of Paul Revere Ridge, just west of northern Vancouver Island. This site is near the triple junction of the Pacific, American, and Juan de Fuca plates in a tectonically complex area. A total of twenty-five cores (9 to 460 m) were cut at Hole 177A and a single core (0 to 9 m) at Hole 177. The sediment section is basically composed of terrigenous turbidites and mud. The majority of the coccolith samples examined are either barren or contain only rare nondiagnostic assemblages. Coccoliths, of Pleistocene or Holocene age, are common in only three samples from the upper 45 meters. Sample 177-1-1(3-4) (0 m) contains abundant *Coccolithus pliopelagicus* having elongate, narrow central areas. Other species present include *Braarudosphaera bigelowii, ?Emiliania huxleyi*, and *Gephyrocapsa* sp. cf. *G. ericsonii*. Sample 177A-1-1(27-28) (9 m) contains *Braarudosphaera bigelowii* and *Coccolithus pliopelagicus*. Sample 177A-4-5 (4-5) (42 m) contains small *Gephyrocapsa caribbeanica* and *G. oceanica* in addition to *Coccolithus pliopelagicus.*

SITE 178
(lat 56°57.38′N, long 147°07.86′W, depth 4218 m)

Site 178 is on the Alaskan Abyssal Plain about 330 km east of Kodiak Island. A total of fifty-nine cores (0 to 795 m) were cut to obtain a representative stratigraphic reference section for the Alaskan Abyssal Plain. Except for rare specimens of *Coccolithus pliopelagicus* in the top sample, 178-1-1(27-28) (0 m), samples from the upper fifty-three cores are barren of coccoliths. In Core 54 (742 to 749 m), strongly etched, placolith-rich assemblages of probable early Miocene age are present. Species include *Coccolithus eopelagicus, C. miopelagicus, C. pelagicus, Cyclicargolithus bukryi, Discoaster* sp. cf. *D. deflandrei, Reticulofenestra* sp., *?Sphenolithus* sp. cf. *S. heteromorphus*, and *S. moriformis*. Sphenoliths and discoasters are rare. *Coccolithus miopelagicus* specimens having especially small centers and distinctly elliptic *Cyclicargolithus bukryi* are common in samples from Sections 1 and 2 of Core 54. Coeval tropical populations of *Cyclicargolithus* are dominated by circular specimens, suggesting high- to middle-latitude deposition of this assemblage. Deeper samples are barren.

SITE 179
(lat 56°24.54′N, long 145°59.32′W, depth 3781 m)

Site 179 is on the eastern side of Giacomini Guyot in the Gulf of Alaska. Intended to help establish a North Pacific biostratigraphic section free of abyssal-plain turbidites, this site yielded a sparsely fossiliferous Pleistocene section, and coring was terminated at 109 meters in basalt. Coccoliths are present only in samples from Cores 1 and 5 (0 to 4 m and 32 to 42 m), where cold-water *Coccolithus pliopelagus* is common. Sample 179-2-4(10-11) (9 m), contains a sparse assemblage of silicoflagellates. Ten specimens in a coccolith smear slide include 60% *Distephanus speculum*, 20% *D. crux*, 10% *Dictyocha* sp. cf. *D. aspera*, and 10% *Dictyocha subarticos*. On the Mandra curve, this assemblage yields a 10°C paleotemperature.

SITE 180
(lat 57°21.76′N, long 147°51.37′W, depth 4923 m)

Site 180 is in the eastern Aleutian Trench, east of Kodiak Island. A total of twenty-five cores (0 to 471 m) were cut to investigate the stratigraphy of trench sediment. Twelve samples were examined for coccoliths; all proved to be barren.

SITE 181
(lat 57°26.30′N, long 148°27.88′W, depth 3086 m)

Site 181 is on the lower continental slope of Alaska, east of Kodiak Island. A total of thirty cores (0 to 369 m) were

cut. The section is essentially barren of coccoliths. Rare *Coccolithus pliopelagicus* were observed in only two samples, 181-2-2(10-11)(10 m) and 181-9-4(10-11) (80 m).

SITE 182
(lat 57°52.96'N, long 149°42.99'W, depth 1419 m)

Site 182 is on the upper continental slope east of Kodiak Island. This site was intended to provide a biostratigraphic reference section for calcareous microfossils. A total of six cores (0 to 123 m) were cut. Samples were available to me from Core 1 (0 to 9 m). The sparse Pleistocene or Holocene assemblage contains *Coccolithus pliopelagicus, Gephyrocapsa oceanica*, and ?*G. producta.*

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PLATE 1

Silicoflagellates from DSDP Leg 18

Figure 1 — *Cannopilus binoculus* (Ehrenberg) Sample DSDP 173 20-3(20-21 cm) (179 m), 500 X

Figure 2 — *Corbisema triacantha* (Ehrenberg) Sample DSDP 173-27-4(20-21 cm) (247 m), 700 X.

Figure 3 — *Dictyocha aspera* (Lemmermann) Sample DSDP 173-17-3(20-21 cm) (150 m), 500 X.

Figure 4 — *Dictyocha fibula* Ehrenberg Sample DSDP 173-17-3(20-21 cm) (150 m), 500 X.

Figures 5-6 — *Dictyocha pentagona* (Schulz) Sample DSDP 173-14 3(20-21 cm) (123 m).
5. 700 X.
6. 1000 X.

Figures 7-9 — *Dictyocha pseudofibula* (Schulz)
7. Sample DSDP 173-19-4(20-21 cm) (170 m), 1000 X.
8. Sample DSDP 173-17-3(20-21 cm) (150 m), 700 X.
9. Sample DSDP 173-18-1(140-141 cm) (158 m), 500 X.

Figure 10 — *Distephanus crux* (Ehrenberg) Sample DSDP 173-27-4(20-21 cm) (247 m), 500 X.

Figure 11 — *Distephanus longispinus* (Schulz) *s. s.* Sample DSDP 173-18-1(140-141 cm) (158 m), 1000 X.

PLATE 1

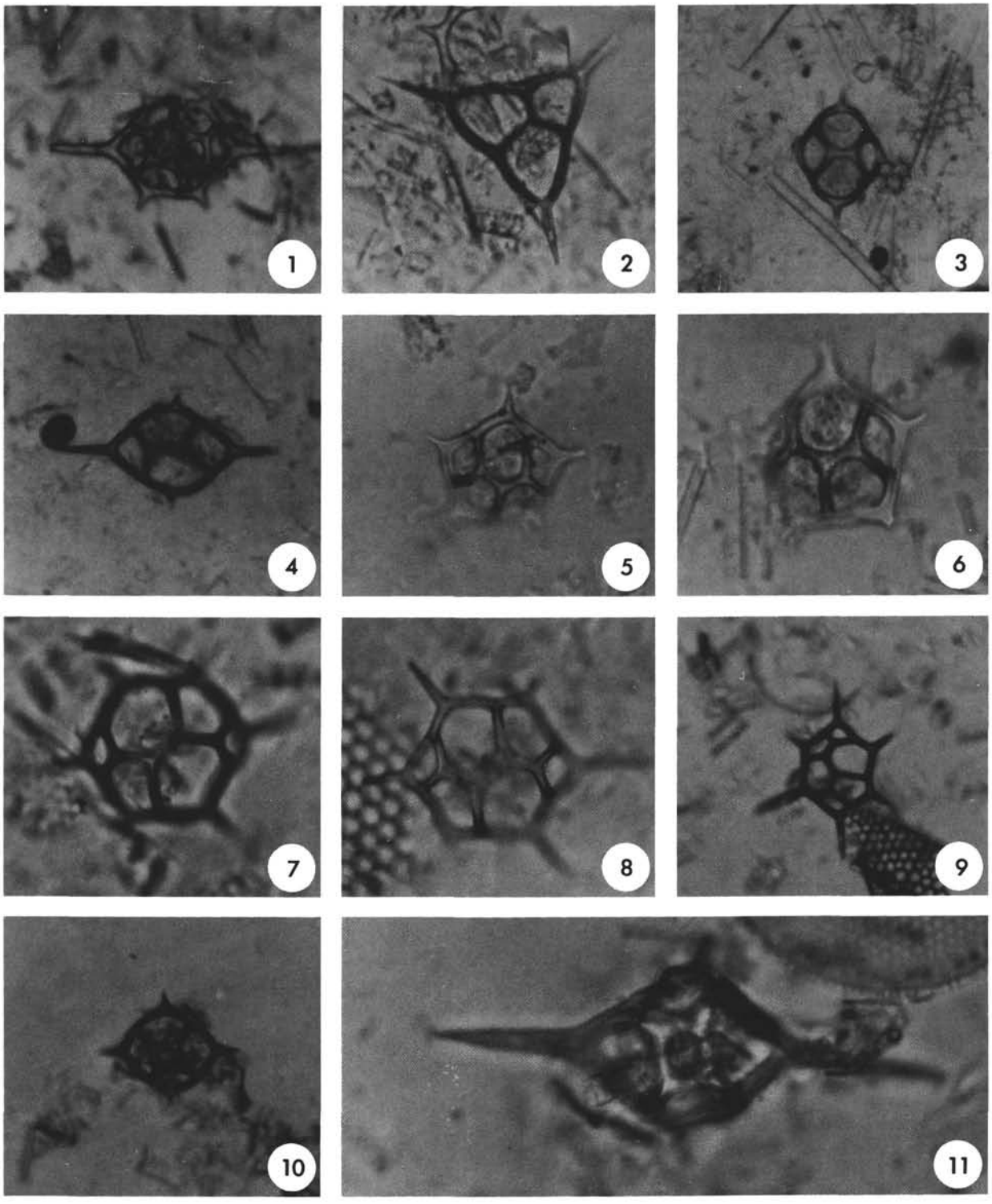

PLATE 2

Silicoflagellates from DSDP Leg 18

Figure 1 — *Distephanus longispinus* (Schulz) *s. s.* Sample DSDP 173-20-3(20-21 cm) (179 m), 700 X.

Figures 2-3 — *Distephanus pseudocrux* (Schulz) Sample DSDP 173-19-4(20-21 cm) (170 m), 1000 X.

Figures 4-5 — *Distephanus* sp. cf. *D. pseudocrux* (Schulz) Sample DSDP 173 18-1(140-141 cm) (158 m), 1000 X.

Figures 6-7 — *Distephanus quinquangellus* Bukry and Foster Sample DSDP 173-14-3(20-21 cm) (123 m), 700 X.

Figure 8 — *Distephanus* sp. cf. *D. speculum* (Ehrenberg) Sample DSDP 173-18-1(140-141 cm) (158 m), 1000 X.

Figures 9-10 — *Distephanus speculum* (Ehrenberg). Large apical ring. Sample DSDP 173-20-3(20-21 cm) (179 m), 1000 X.

Figure 11 — *Distephanus speculum* (Ehrenberg). Small apical ring. Sample DSDP 173-14-3(2021 cm) (123 m). 500 X.

PLATE 2

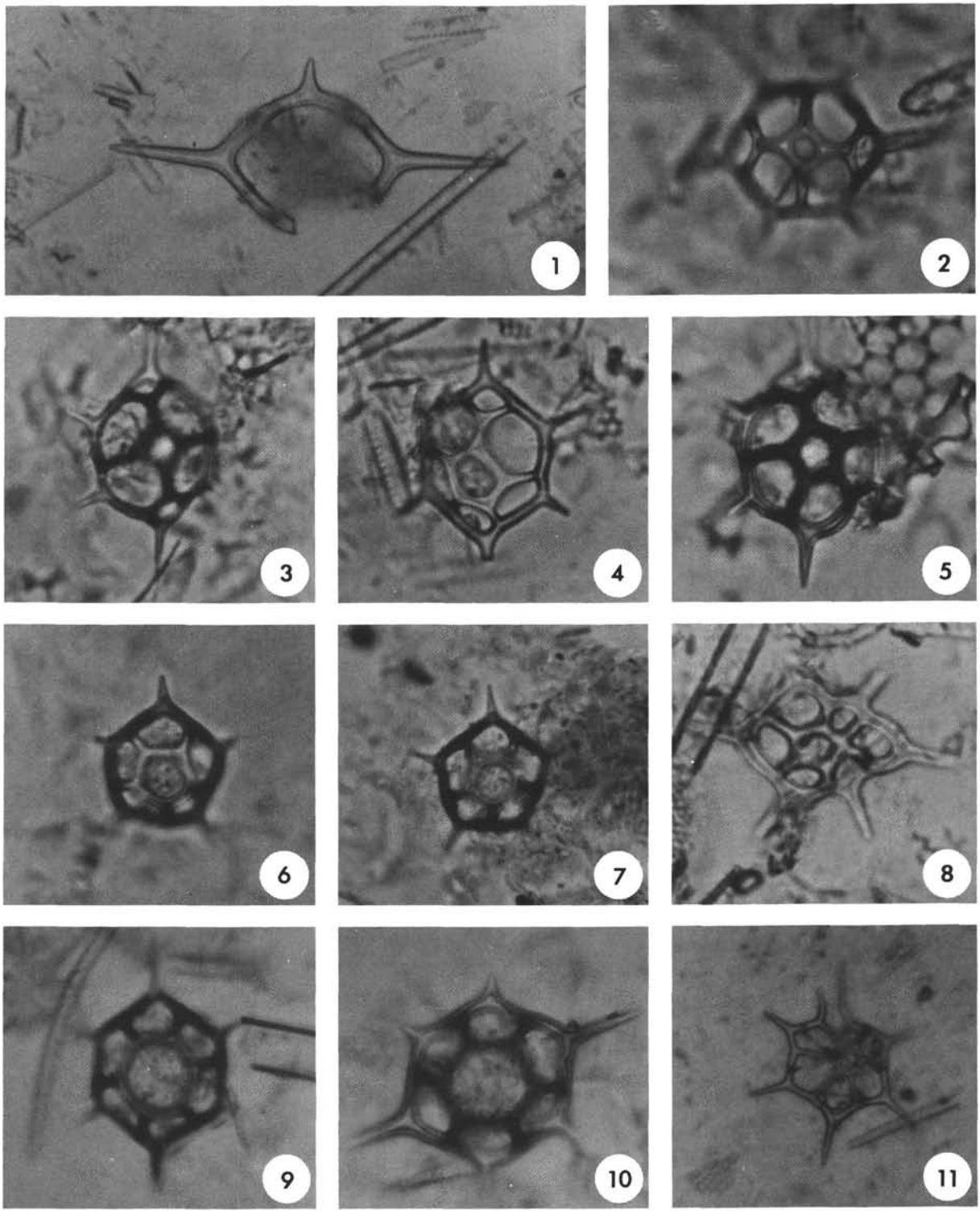

PLATE 3

Silicoflagellates and Diatom from DSDP Leg 18

Figure 1 — *Distephanus speculum* (Ehrenberg) Sample DSDP 173 14-3(20-21 cm) (123 m), 700 X.

Figures 2-3 — *Mesocena circula* (Ehrenberg) Sample DSDP 173-19-4(20-21 cm) (170 m).
2. 500 X.
3. 1000 X.

Figures 4-5 — *Mesocena diodon* Ehrenberg. Sample DSDP 173-19-4(20-21 cm) (170 m).
4. 700 X.
5. 500 X.

Figure 6 — *Coscinodiscus marginatus* Ehrenberg. Side view of diatom valve. Sample DSDP 173-19-4(20-21 cm) (170 m), 700 X.

PLATE 3