25. PHYTOPLANKTON STRATIGRAPHY, CENTRAL PACIFIC OCEAN, DEEP SEA DRILLING PROJECT LEG 17[1]

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INTRODUCTION

Deep Sea Drilling Project Leg 17, April-May 1971, through the central Pacific Ocean southwest of Hawaii, recovered 247 cores at eight drilling sites (Figure 1). Light-microscope techniques were used to examine the coccoliths, diatoms, and silicoflagellates in 224 samples from these cores. At most sites, coccoliths proved to be the most useful indicators of stratigraphic position, but at Site DSDP 166 a special study was made of the diatoms and silicoflagellates. Stratigraphic assignment of cores from the principal holes is summarized in Figure 2.

SITE DSDP 164
(lat 13°12.1'N., long 161°31.0'W., depth 5485 m)

This site was drilled to help determine the crustal age of the Clarion-Molokai block west of magnetic anomaly 32. The section is essentially barren of calcium carbonate. A single sample from this site, DSDP 164-25-1, 5-7 cm (depth 252 m), contains extensively etched placoliths at preservation stage -4.5 (Table 1). The rare specimens that are nearly complete resemble *Watznaueria barnesae*, a dominant Jurassic and Cretaceous species. See the report of shipboard scientists for determinations of other samples from this site.

TABLE 1
Scale of Coccolith Preservation Stages[a]

−5	Barren
−4	Most species missing
−3	Extensive etching and fragmentation
−2	Moderate etching
−1	Species diversity unchanged by etching
0	Pristine
+1	Species diversity unchanged by overgrowth
+2	Moderate overgrowth
+3	Heavy overgrowth
+4	Most specimens obscured
+5	Limestone

[a]Bukry (1973)

SITE DSDP 165–HOLES DSDP 165 and DSDP 165A
(lat 08°10.7'N., long 164°51.6'W., depth 5053 m)

This site was selected to determine the crustal age of the Clipperton-Clarion block in the region of the Line Islands and to determine the ages, at this site, of three widespread subbottom sonic reflectors. Two cores from 0 to 14 meters were cut at Hole 165. Hole 165A was spot cored from 5 to 490 meters, with 27 cores cut. The highest sample available, 165-1-1, 106-107 cm (depth 1 m), contains assemblages of the lower Miocene *Triquetrorhabdulus carinatus* Zone, *Discoaster deflandrei* Subzone; the deepest sample, 165A-21-3, 113-114 cm (depth 368 to 396 m), contains the Campanian *Eiffellithus augustus* Zone. Lithologically, the cored section is characterized by numerous turbidite layers.

The upper Oligocene and lower Miocene assemblages of Core 1 in Hole DSDP 165 are dominated by overgrown specimens of *Discoaster deflandrei* and *Triquetrorhabdulus carinatus* (preservation stage +3). The most common placoliths, *Coccolithus miopelagicus, C. pelagicus,* and *Cyclicargolithus floridanus*, however, exhibit evidence of etching (-2) as the central-area margins of *C. miopelagicus* are digitate, and the central openings of *C. floridanus* are enlarged. As a result of an apparent coring malfunction, Core 2 (5 to 14 m) contains a chaotic mixture of coccolith species of different ages, for example, *Gephyrocapsa oceanica* (Pleistocene), *Ceratolithus rugosus* (Pliocene), *Discoaster hamatus* (Miocene), *Sphenolithus furcatolithoides* (Eocene), *Discoaster multiradiatus* (Paleocene), and *Broinsonia parca* (Late Cretaceous).

This site was successfully recored at Hole DSDP 165A. A typical oceanic Oligocene coccolith sequence is present in Cores 1A to 7A (5 to 145 m). The basal Oligocene *Coccolithus subdistichus* Subzone is indicated in the lower part of Core 7A. For example, Sample 165A-7-5, 105-106

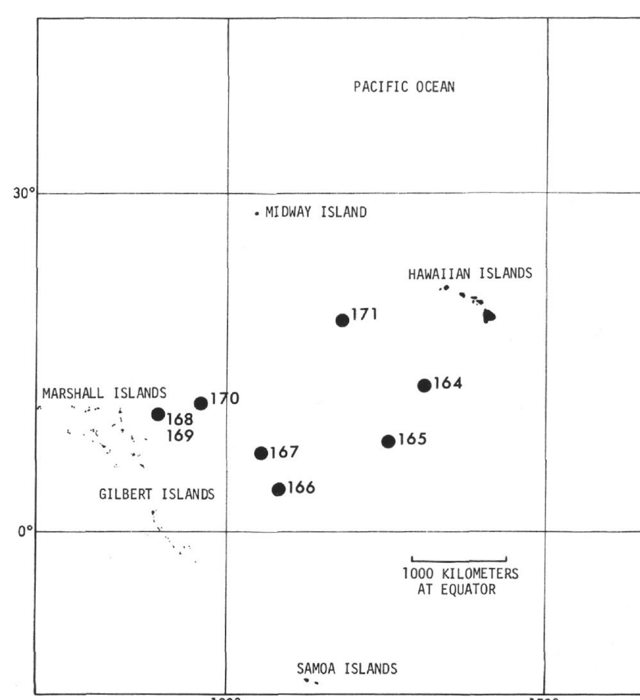

Figure 1. *Locations of sites drilled during Leg 17.*

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

Age	Zone, Subzone, or Stage	DSDP Hole				
		165A	166	167	170	171
Pleisto-cene	Gephyrocapsa oceanica			1-2		
	Gephyrocapsa caribbeanica			2		
	Emiliania annula					1
Pliocene	Cyclococcolithina macintyrei			3		
	Discoaster pentaradiatus			3		
	Discoaster tamalis					1
	Discoaster asymmetricus					
	Sphenolithus neoabies					
	Ceratolithus rugosus					
	Ceratolithus amplificus					
Miocene	Triquetrorhabdulus rugosus					
	Ceratolithus primus					1
	Discoaster berggrenii					
	Discoaster neorectus					
	Discoaster bellus		4	4		
	Discoaster hamatus		4			
	Catinaster coalitus					
	Discoaster kugleri		5	5		
	Coccolithus miopelagicus					
	Sphenolithus heteromorphus			6-7		
	Helicopontosphaera ampliaperta					2
	Sphenolithus belemnos					
	Discoaster druggii		7-8			3
	Discoaster deflandrei			8-10		
Oligocene	Dictyococcites abisectus	1-2		10-11		
	Sphenolithus ciperoensis	2-3		12-13		4-5
	Sphenolithus distentus		10	13-15		
	Sphenolithus predistentus	5		17-21		6
	Reticulofenestra hillae			21-22		
	Cyclococcolithina formosa	6-7		23-24		
	Coccolithus subdistichus	7	12			
Eocene	Discoaster barbadiensis	7		28		8
	Discoaster saipanensis	8-9		30-33		9
	Discoaster bifax	10-11				
	Coccolithus staurion	12				
	Chiasmolithus gigas	12				
	Discoaster strictus	13				
	Discoaster sublodoensis					
	Discoasteroides kuepperi					
	Discoaster lodoensis					
	Tribrachiatus orthostylus					
	Discoaster diastypus					
Paleocene	Campylosphaera eodela					
	Chiasmolithus bidens					
	Discoaster nobilis					

Figure 2. *Coccolith stratigraphy of cores from principal holes drilled during Leg 17. Numbers are core designations and typically represent 9 meters of sediment cored, although actual recovery is sometimes less.*

Age	Zone, Subzone, or Stage	DSDP Hole 165A	166	167	170	171
Paleocene	Discoaster mohleri					
	Heliolithus kleinpellii					
	Fasciculithus tympaniformis			39		
	Cruciplacolithus tenuis					
Late Cretaceous	Micula mura	17		42		
	Lithraphidites quadratus			42-43		9-16
	Tetralithus trifidus	18-20		44-50		17-19
	Broinsonia parca			52		
	Eiffellithus augustus	21		53-57, 58?	6-7	
	Santonian			58-59		22-26
	Coniacian				8	
	Turonian					
	Cenomanian					
Early Cretaceous	Albian			59-76	15	
	Aptian					
	Barremian		27			
	Hauterivian					
	Valanginian					
	Berriasian			92-94		
Late Jurassic	Tithonian					

Figure 2. (*Continued*).

cm (143 m) contains common *Coccolithus obrutus, Cyclococcolithina formosa, Dictyococcites bisectus,* and rare *Coccolithus* sp. cf. *C. subdistichus* and *Helicopontosphaera reticulata.* The rare specimens of *Discoaster barbadiensis* and *D. saipanensis* in this sample are considered part of the suite of reworked specimens that are present. The other reworked specimens include *Chiasmolithus grandis* and *Triquetrorhabdulus inversus*, from the middle Eocene, and *Cretarhabdus crenulatus* and *Cribrosphaera ehrenbergii*, from the Cretaceous. Assignment of the lowest section of Core 7A to the upper Eocene is suggested by the rarity of discoasters, a situation that has been previously observed in the uppermost Eocene of the Gulf Coastal Plain (M. N. Bramlette, pers. commun., 1968). Rare specimens of *D. barbadiensis* are present in 165A-7-6, 58-59 cm (144 m), but the reworking noted above is not evident. Middle Eocene assemblages are present in Cores 8A to 13A (145 to 237 m). The uppermost assemblages of 165A-8-1 to 165A-8-4 (145 to 150 m) are a low-diversity solution concentration of the *Reticulofenestra umbilica* Zone, *Discoaster saipanensis* Subzone, typified by *Bramletteius serraculoides, Chiasmolithus grandis, Discoaster saipanensis,* and *Reticulofenestra umbilica.* Assemblages are more diversified in samples from 165A-8-6 to 165A-9-6 (153 to 163 m), where a few *Helicopontosphaera* sp. cf. *H. compacta, Sphenolithus pseudoradians*, and *Cyclococcolithina protoannula* occur. The assemblages of 165A-10-2 to 165A-11-2 (203 to 213 m) contain few species, but the occurrence of *Chiasmolithus solitus* and *Triquetrorhabdulus inversus*, coupled with the rarity of *R. umbilica*, suggests the lower part of the *R. umbilica* Zone. The occurrence of *Discoaster bifax* in 165A-11-4 to 165A-11-6 (215 to 218 m), combined with rare *Nannotetrina* sp. cf. *N. alata*, indicates the basal *R. umbilica* Zone, *Discoaster bifax* Subzone. Minor reworking is indicated in 165A-11-4 by the rare occurrence of *Tribrachiatus orthostylus* (early Eocene) and of *Discoaster multiradiatus* (late Paleocene).

The middle Eocene *Nannotetrina quadrata* Zone is present in 165-A-12-2 to 165A-13-1 (221 to 229 m) and appears to have the same tripartite division as at DSDP 162, which lies almost due east on the flank of the East Pacific Rise. The middle interval is identified by the restricted range of *Chiasmolithus gigas.* The upper interval, *Coccolithus staurion* Subzone, in 165A-12-2 to 165A-12-4 (221 to 224 m) contains *Coccolithus* sp. cf. *C. staurion, Discoaster martinii, D. strictus, Nannotetrina quadrata, N. spinosa,* and *Triquetrorhabdulus inversus.* The lower interval, *Discoaster strictus* Subzone, is indicated in strongly etched assemblages of 165A-13-1 to 165A-13-2 (228 to 229 m) by common *Discoaster mirus* by an early variety of *T. inversus.*

The next deeper samples available contain Late Cretaceous coccoliths. Diversity is restricted by strong etching (-3). The few resistant species in 165A-17-1, 112-113 cm (284 m), *Cretarhabdus crenulatus, Cylindralithus gallicus, Micula decussata, M. mura,* and *Watznaueria barnesae*, suggest a late Maestrichtian, *Micula mura* Zone, assignment. Samples 165A-18-1, 87-88 cm to 165A-20-3, 134-135 cm (290 to 368 m) are assigned to the late Campanian to early Maestrichtian *Tetralithus trifidus* Zone.

These samples contain *Tetralithus trifidus, Cylindralithus gallicus,* and small *Arkhangelskiella cymbiformis. Broinsonia parca* occurs only in the deepest sample, 165A-21-3, 113-114 cm (368 to 396 m). A restricted assemblage including *B. parca* and *Eiffellithus augustus* indicates that the oldest sample is Campanian (*Eiffellithus augustus* Zone).

SITE DSDP 166
(lat 03°45.7'N., long 175°04.8'W., depth 4962 m)

Diatoms are present throughout the available Cenozoic samples of Core 2 (1 m) to Core 16 (198 m), whereas coccoliths and silicoflagellates are absent from many samples through this interval (Figure 3 and 4). Core 2 is upper Miocene or Pliocene, and Core 16 is Eocene. The only samples from deeper cores are from Core 27 (289 to 298 m), which contains Lower Cretaceous (Hauterivian or Barremian) coccoliths.

The uppermost samples from Cores 2 and 3 (1 to 20 m) are barren of coccoliths and contain common silicoflagellates. *Dictyocha fibula* is the most abundant species, suggesting the upper part of *Distephanus crux* Zone, which is late Miocene or Pliocene. A count of 301 silicoflagellates in Sample 166-2-3, 14-15 cm (4 m), showed an assemblage having 76 percent *D. fibula,* 19 percent *D. aspera,* 4 percent *Distephanus speculum,* and less than 1 percent each for *Cannopilus schulzii, Distephanus crux,* and *D. quinquangellus*. Such a great relative abundance of the genus *Dictyocha* indicates tropical conditions. Tropical deposition also is indicated by diatoms such as *Actinocyclus elongatus, Coscinodiscus nodulifer, Hemidiscus cuneiformis,* and *Triceratium cinnamomeum*. The common occurrence of elongate species of the genera *Thallasionema* and *Thalassiothrix* in this interval and in deeper intervals through Core 10 (130 m) suggests deposition in an area of upwelling.

All three phytoplankton groups are present in Cores 4 to 8 (20 to 93 m). Coccoliths are represented in Sample 166-4-1, 61-62 cm (21 m) only by a solution residue of discoasters, many of which are centerless (preservation state -4). *Discoaster variabilis* is dominant; the occurrence of rare *D. bellus, D. calcaris,* and *D. loeblichii* indicates the *Discoaster neohamatus* Zone of early late Miocene age. Among the rare silicoflagellates, *Dictyocha aspera* is more common than *D. fibula*, which signifies the lower *Distephanus crux* Zone. The latest occurrence of the *Coscinodiscus paleaceus* group and the *C. plicatus* group of diatoms in this sample indicates the top of the *Coscinodiscus plicatus* Zone. The occurrence of the top of this zone within the *Discoaster neohamatus* Zone and the *Distephanus crux* Zone duplicates the stratigraphic relation observed in the eastern equatorial Pacific at DSDP 158 (Bukry and Foster, 1973). Rare specimens of *Discoaster bellus, D. calcaris,* and *D. hamatus,* occurring with abundant *D. variabilis* in 166-4-4, 35-36 cm (25 m), indicate the late middle Miocene *Discoaster hamatus* Zone. Coccolith assemblages down to 166-5-4, 89-90 cm (35 m) are nondiagnostic, although the cooccurrence of *Coccolithus miopelagicus* and *Discoaster variabilis* suggests middle Miocene. Silicoflagellates are common in 166-5-3, 71-72 cm (32 m), with *Dictyocha aspera* dominant (96%) and *D. medusa* rare (2%).

The most definitive coccolith assemblage of the upper five cores is the *Discoaster exilis* Zone, *Discoaster kugleri* Subzone of 166-5-4, 89-90 cm (33 m) and 166-5-5, 35-36 cm (34 m). Resistant assemblages containing well-formed *Discoaster kugleri,* with *Coccolithus miopelagicus, C. pelagicus, Discoaster aulakos, D. braarudii, D. exilis, D. variabilis,* and *Reticulofenestra pseudoumbilica* indicate a -3 preservation. Less resistant taxa such as *Discolithina, Helicopontosphaera, Rhabdosphaera, Scyphosphaera,* and *Sphenolithus* are absent. Diatoms are well diversified in these samples and belong to the tropical *Coscinodiscus plicatus* Zone.

The next deeper samples, beginning at 166-7-2, 30-31 cm (67 m), are in the lower Miocene *Triquetrorhabdulus carinatus* Zone, *Discoaster druggii* Subzone; this discoaster-rich interval begins below at 166-8-2, 40-41 cm (86 m). Assemblages are restricted by dissolution to resistant species. *Discoaster deflandrei* is predominant and is represented by specimens showing a high degree of variability in overgrowth and etching. Many have overgrown rays but dissolved centers (Plate 1). Other less numerous taxa include *Coccolithus pelagicus* [rims], *Discoaster calculosus, D. druggii, Sphenolithus moriformis* [large], *Triquetrorhabdulus carinatus,* and *T. milowii.* Among the rare silicoflagellates, *Naviculopsis biapiculata,* a species restricted to early Miocene and older strata, occurs in Core 7. Diatoms, like coccoliths, change distinctly between Cores 5 and 7. Several typical middle Miocene taxa, such as *Asteromphalus moronensis* and *Denticula hustedtii*, are missing. *Cestodiscus* spp. last occur in Core 7 (65 to 74 m). *Raphidodiscus marylandicus,* considered a Miocene guide fossil (Lohman, 1948), occurs in 166-7-2, 30-31 cm (67 m).

The long-ranging coccolith *D. deflandrei* is the only one identified in 166-8-4, 71-72 cm (89 m). On the basis of the continuity of the diatom assemblage to that of Core 7, this sample probably still represents the lower Miocene *T. carinatus* Zone.

Deeper samples, from 166-8-6, 18-19 cm (92 m) to 166-9-4, 72-73 cm (108 m), are barren of coccoliths. Diatom assemblages in this interval are composed of mixtures of species with Miocene affinities (*Coscinodiscus paleaceus*) or Eocene affinities (*Cyclotella hannae*). The small, coarsely aerolate species *Coscinodiscus vigilans* [syn. ?*Rocella gemma*] last occurs in Core 9.

Oligocene coccolith assemblages of solution-resistant species are present in Core 10 (121 to 130 m). Although most samples at this site lack fine calcareous debris derived from disaggregated placoliths, Sample 166-10-5, 94-95 cm (127 m), contains an abundance of such material. Species present in the core are long-ranging cosmopolitan forms such a *Coccolithus eopelagicus, Cyclicargolithus floridanus, Dictyococcites scrippsae, Discoaster deflandrei, D. nodifer, D. tani, Sphenolithus moriformis,* and *S. predistentus.*

Diatom assemblages of Eocene affinity, characterized by *Hemiaulus* spp., *Cyclotella hannae, Coscinodiscus marginatus,* and *Asterolampra* sp. having punctate marginal areas with digitate outlines, occur in the deepest group of Cenozoic samples from Core 12 to 16 (159 to 198 m). The

		COCCOLITHS																											SILICOFLAGELLATES								
Age	DSDP 166 Sample (Depth)	Cyclococcolithina formosa	Dictyococcites bisectus	Reticulofenestra hillae	Sphenolithus predistentus	Dictyococcites scrippsae	Discoaster tani	Coccolithus eopelagicus	Discoaster nodifer	Cyclicargolithus floridanus	Discoaster deflandrei	Coccolithus pelagicus	Triquetrorhabdulus milowii	T. carinatus	Discoaster druggii	D. kugleri	Coccolithus miopelagicus	Reticulofenestra pseudoumbilica	Cyclococcolithina leptopora	Discoaster braarudii	D. variabilis	D. challengeri	D. hamatus	D. bellus	D. pseudovariabilis	D. calcaris	D. brouweri	D. loeblichii	Dictyocha hexacantha	Corbisema triacantha	Distephanus speculum	D. crux	Dictyocha fibula	Naviculopsis biapiculata	Dictyocha aspera	D. medusa	Mesocena circula
Pliocene or Miocene	2-3, 14-15 (4 m)																														X	X	X		X		X
	2-6, 71-72 (9 m)																														X	X	X				
	3-3, 50-51 (14 m)																																X		X		
Miocene	4-1, 61-62 (21 m)																			X	X	X		X		X	X	X			X	X	X		X		
	4-2, 100-101 (23 m)											X							X		X				X	X									X		
	4-4, 35-36 (25 m)											X									X		X	X											X		
	4-6, 30-31 (28 m)											X								X	X														X		
	5-2, 102-103 (32 m)											X					X	X	X	X	X	X											X		X	X	
	5-4, 89-90 (34 m)											X				X	X	X	X	X	X												X		X		
	7-2, 30-31 (67 m)										X	X																						X			
	7-4, 32-33 (70 m)										X				X																		X	X			
	7-6, 12-13 (73 m)										X	X		X	X																						
	8-2, 40-41 (86 m)									X	X	X	X	X	X																		X	X			
Miocene or Oligocene	8-4, 71-72 (89 m)										X																					X					
	8-6, 18-19 (92 m)																																				
	9-2, 59-60 (105 m)																																				
	9-4, 72-73 (108 m)																																				
	9-6, 73-74 (111 m)										X	X																				X					
Oligocene	10-2, 29-30 (121 m)							X	X	X	X	X																									
	10-5, 94-95 (127 m)					X	X		X		X	X																									
Oligocene or Eocene	12-2, 43-44 (161 m)																													X							
	12-6, 61-62 (163 m)	X	X	X	X	X	X	X	X	X	X	X																		X							
	13-1, 42-43 (169 m)																																				
	13-5, 125-126 (176 m)																													X							
	14-2, 48-49 (180 m)																													X							
	16-2, 38-39 (191 m)																												X								

Figure 3. *Occurrence and indicated age of selected Cenozoic coccoliths and silicoflagellate species at Hole DSDP 166.*

rare presence of a heavy rodlike species of *Thalassiothrix*?, which is associated with definitive Eocene coccolith assemblages at DSDP 162 and DSDP 165A, also indicates the Eocene (Plate 5, figs. 21-22). Silicoflagellates are rare. *Corbisema triacantha* is long-ranging, but *Dictyocha hexacantha* in 166-16-2, 38-39 cm (191 m) is typically restricted to the Eocene. *Ebria* sp. cf. *E. antiqua,* noted in 166-12-6, 61-62 cm (167 m), is reported to range from Paleocene to Miocene. Coccoliths are rare and etched in 166-12-6, 61-62 cm; other samples are barren. Although several resistant species that range from late Eocene to early Oligocene are present, diagnostic Eocene discoasters, such as, *Discoaster barbadiensis* and *D. saipanensis*, are missing. Therefore, only the latest Eocene or early Oligocene is indicated by coccoliths.

The oldest samples available are from a coccolith-ooze sediment in Core 27 (289 to 298 m). The late Hauterivian or Barremian assemblages are only slightly etched. The presence of *Cretarhabdus angustiforatus* (Black) n. comb. [basionym: *Retecapsa angustiforata* Black 1971, p. 409, pl. 33, fig. 4.], *Cyclagelosphaera circumradiata, Rucinolithus*? *radiatus, Watznaueria bayackii,* and *W. britannica*, together with absence of *Cruciellipsis* and *Eiffellithus*, indicates late Neocomian (Thierstein, 1971). No nannoconids are present.

Age	DSDP 166 Sample (Depth)	DIATOMS																																									
		Hemiaulus spp.	Craspedodiscus coscinodiscus	Coscinodiscus marginatus	Coscinodiscus sp. cf. C. marginatus	Craspedodiscus oblongus	Cyclotella hannae	Melosira sulcata	Asterolampra sp. 1	Thalassiothrix? sp.	Coscinodiscus vigilans	Coscinodiscus sp. 1	Actinocyclus ingens	Asterolampra sp. 2	Coscinodiscus sp. 2	Coscinodiscus curvatulus	Thalassionema spp.	Thalassiothrix spp.	Stephanopyxis appendiculata	Aulacodiscus spp.	Nitzschia? sp.	Actinocyclus lanceolatus	Coscinodiscus paleaceus	Actinocyclus ellipticus	Coscinodiscus praepaleaceus	Coscinodiscus lewisianus	Coscinodiscus sp. aff. C. paleaceus	Cestodiscus spp.	Raphidodiscus marylandicus	Coscinodiscus lineatus	Triceratium cinnamomeum	Nitzschia reinholdii	Coscinodiscus plicatus s. l.	Actinocyclus moronensis	Denticula hustedtii	Asteromphalus moronensis	Hemidiscus cuneiformis s. l.	Nitzschia jouseae	Rhizosolenia bergonii	Actinocyclus elongatus	Coscinodiscus excentricus	Coscinodiscus nodulifer	Thalassiosira decipiens
Pliocene or Miocene	2-3, 14-15 cm (4 m)			X													X	X						X						X	X						X	X		X	X	X	X
	2-6, 71-72 cm (9 m)			X													X	X						X						X	X						X	X	X	X	X	X	X
	3-3, 50-51 cm (14 m)																X	X								X				X	X			X	X		X	X	X	X	X	X	X
Miocene	4-1, 61-62 cm (21 m)			X												X	X	X						X	X	X				X	X		X		X		X	X	X	X	X	X	
	4-2, 100-101 cm (23 m)			X												X	X	X					X	X	X	X				X	X	X	X	X	X	X	X	X					
	4-4, 35-36 cm (25 m)			X												X	X	X					X	X	X					X	X		X	X	X		X	X					
	4-6, 30-31 cm (28 m)			X												X	X					X	X	X	X					X	X	X	X	X	X	X	X						
	5-2, 102-103 cm (32 m)															X	X	X					X	X	X					X	X		X	X	X								
	5-4, 89-90 cm (34 m)															X	X	X					X	X	X					X	X	X	X	X	X								
	7-2, 30-31 cm (67 m)																	X	X		X					X			X	X	X												
Miocene or Oligocene	7-4, 32-33 cm (70 m)													X				X	X		X	X	X		X	X		X															
	7-6, 12-13 cm (73 m)			X														X	X		X	X			X			X															
	8-2, 40-41 cm (86 m)			X											X	X		X	X		X	X	X		X		X																
	8-4, 71-72 cm (89 m)			X												X	X	X	X		X	X	X		X	X	X	X															
	8-6, 18-19 cm (92 m)		X	X			X											X	X		X					X																	
	9-2, 59-60 cm (105 m)			X							X				X		X	X	X	X	X	X	X			X																	
	9-4, 72-73 cm (108 m)			X			X				X				X			X	X	X	X	X	X	X	X																		
	9-6, 73-74 cm (111 m)			X							X	X			X			X	X	X	X	X	X	X																			
	10-2, 29-30 cm (121 m)			X			X				X	X	X	X	X	X	X	X	X																								
	10-5, 94-95 cm (127 m)			X			X					X	X	X	X	X	X	X																									
Eocene	12-2, 43-44 cm (161 m)	X		X			X		X	X	X		X	X																													
	12-6, 61-62 cm (163 m)	X					X		X	X	X	X																															
	13-1, 42-43 cm (169 m)	X		X			X	X	X	X	X																																
	13-5, 125-126 cm (176 m)	X		X			X																																				
	14-2, 48-49 cm (180 m)	X		X	X	X																																					
	16-2, 38-39 cm (191 m)	X	X	X																																							

Figure 4. *Occurrence and indicated age of selected Cenozoic diatom species at Hole DSDP 166.*

SITE DSDP 167
(lat 7°04.1′N., long 176°49.5′W., depth 3176 m)

A 1172-meter thick sediment section was intermittently cored in the upper 444 meters (Cores 1 to 15) and continuously cored in the lower 718 meters (Cores 16 to 94). The deepest samples above basalt contain assemblages characteristic of latest Jurassic or earliest Cretaceous age. As a result of intermittent coring in the upper section, most Oligocene to Pleistocene series and subseries boundary assemblages were not recovered. The Pliocene-Pleistocene boundary is indicated between Core 2 and Core 3 (9 to 28 m), and the Miocene-Pliocene boundary between Core 3 and Core 4 (66 to 75 m). Abundant sphenoliths and diverse discoaster populations in the late Miocene *Discoaster neohamatus* Zone of Core 4, containing *Discoaster pseudovariabilis* and *D. neohamatus*, indicate tropical deposition during the late Miocene. A +2 preservation stage is reminiscent of Leg 7, also from the western tropical Pacific. Overgrowths on discoasters are more developed (+3) in the late Oligocene to middle Miocene assemblages. Early to late Oligocene coccolith assemblages of Cores 15 to 24 (435 to 537 m) have common discoasters and abundant sphenoliths characterizing deposition at low latitude. Rare *Helicopontosphaera reticulata* occurs in the lowest Oligocene sample available, 167-24-1, 90-91 cm (529 m). Below Core 24, sediment recovered was usually so small that samples generally were not available.

The uppermost Cretaceous sample available, 167-42-1, 43-44 cm (685 m), contains *Micula mura* Zone assemblages having both early and late varieties of *Micula mura*; 167-42-2, 90-91 cm (687 m) contains the early variety; 167-42-5, 90-91 cm (692 m) lacks *M. mura* and is probably part of the *Lithraphidites quadratus* Zone although no specimens of the name-giving species occur. A sample from Core 43 (696 to 703 m) is similar in character but also contains a diversity of slumped Cenozoic taxa such as *Gephyrocapsa oceanica, Discoaster berggrenii,* and *Chiasmolithus grandis*. Samples from Cores 44 to 57 (703 to 827 m) contain fairly diverse assemblages that permit recognition of the three characteristic Campanian to early Maestrichtian oceanic coccolith zones. *Cretarhabdus schizobrachiatus*, a species previously unrecorded from deep-ocean assemblages, is present in samples from Core 45 (717 m) and Core 50 (760 m). Solution of specimens in 167-57-1, 136-137 cm (824 m) is much greater than above. An abundance of rim fragments and poor taxonomic diversity indicate a -3.5 preservation stage. The presence of *Broinsonia parca* suggests the Campanian. Diversity is poorer in 167-58-1, 120-121 cm (828 m) where only *B. parca, Micula decussata,* and *Watznaueria barnesae* are identified among an abundance of rim fragments. Although more taxa are recognizable in 167-58-2, 69-70 cm (829 m) and 167-58-4, 67-68 cm (832 m), the strongly etched assemblages are dominated by fragmented specimens. The occurrence of *Marthasterites* sp. cf. *M. furcatus* and *Lithastrinus grillii* indicates a probable Santonian age. *M.* sp. cf. *M. furcatus* is also present in 167-59-1, 129-130 cm (833 m).

Samples available from deeper cores generally contain limited assemblages of long-ranging, resistant coccolith species. Diagnostic assemblages are present in 167-92-1, 76-77 cm (1148 m) and 167-94-2, 47-48 cm (1167 m). The Core 92 sample contains *Cruciellipsis cuvillieri, Cyclagelosphaera margerelii, Diazomatolithus lehmanii, Rucinolithus wisei, Watznaueria britannica,* and *Nannoconus steinmannii.* This association is probably Berriasian, on the basis of recent stratigraphic studies by Moshkovitz (1972) and Thierstein (1971) but no definitive criteria exist to distinguish Tithonian from Berriasian coccolith assemblages. The deepest sample, from Core 94, has a slightly different assemblage that lacks *N. steinmannii.* The large placolith *Watznaueria manivitae* n. comb. [new name substituted for *Coccolithus deflandrei* Manivit 1966, p. 268, text-figs. 1 a-c because *Watznaueria deflandrei* (Noël) Reinhardt (ex *Actinosphaera*) has already been transferred to *Watznaueria*], which is common in Upper Jurassic samples from the western Atlantic and Sicily, is also common in Core 94. Coupled with the presence of *Parhabdolithus embergeri* and the absence of *Stephanolithion bigotii*, this suggests a Tithonian age, but a definite assignment can be made only to Tithonian or Berriasian at this time.

SITE DSDP 168
(lat 10°42.2′N., long 173°35.9′E., depth 5430 m)

A single sample from this site, 168-4-2, 82-83 cm (33 m), is barren of phytoplankton.

SITE DSDP 169
(lat 10°40.2′N., long 173°33.0′E., depth 5415 m)

A single sample from this site, 169-7-1, 46-47 cm (192 m), is barren of phytoplankton.

SITE DSDP 170
(lat 11°48.0′N., long 177°37.0′E., depth 5792 m)

Samples containing coccoliths were available for four of the sixteen cores recovered at DSDP 170. The shallowest assemblages in 170-6-4, 142-143 cm (107 m) and 170-7-2, 101-102 cm (112 m) are slightly etched (-1 to -2), well diversified, and from the Late Cretaceous *Eiffellithus augustus* Zone. An unzoned Turonian or Coniacian assemblage of moderately etched (-2) specimens in 170-8-1, 23-24 cm (120 m) contains *Micula decussata* and *Eiffellithus eximius* and is composed mainly of long-ranging, solution-resistant species. Core 15 (184 to 192 m) specimens are slightly etched, and, based on the presence of *Parhabdolithus angustus* and the absence of *Cruciellipsis, Eiffellithus,* and *Prediscosphaera,* the assemblage is referable to the Aptian to Albian *Parhabdolithus angustus* Zone of Thierstein (1971).

SITE DSDP 171
(lat 19°07.9′N., long 169°27.6′W., depth 2295)

Site DSDP 171 is located on Horizon Guyot west of the Hawaiian Islands. Previous drilling on this guyot at Hole DSDP 44 was terminated by Eocene chert, but at DSDP 171, drilling penetrated the chert and a Cretaceous basalt flow below. Sediment was recovered in 33 cores that were cut discontinuously through the 474-meter section.

Core 1 (0 to 9 m) contains a condensed upper Miocene to Pleistocene section as indicated by the following samples: 171-1-2, 89-90 cm (2 m), early Pleistocene

Emiliania annula Subzone; 171-1-4, 90-91 cm (5 m), late Pliocene *Discoaster tamalis* Subzone; 171-1-6, 91-92 cm (8 m), late Miocene *Ceratolithus primus* Subzone. Early Miocene assemblages in Core 2 (22 to 31 m) and Core 3 (41 to 50 m) have abundant irregularly overgrown *Discoaster deflandrei* and a few *D. perplexus.* Although *Helicopontosphaera* is rare, the abundance of *Cyclicargolithus floridanus, D. deflandrei,* and *Sphenolithus heteromorphus* indicates assignment of Core 2 to the *Helicopontosphaera ampliaperta* Zone. Rare specimens of *Triquetrorhabdulus milowii* also support this assignment. *Triquetrorhabdulus carinatus* Zone assemblages of Core 3 have rare *Discoaster druggii, Orthorhabdus serratus,* and *T. milowii* and common *C. floridanus, Sphenolithus dissimilis,* and *Triquetrorhabdulus carinatus*. The characteristic late Oligocene and early Miocene increase in five- and seven-rayed variants of *D. deflandrei* is represented here in Cores 3 to 6 (41 to 106 m), an interval also including early Oligocene assemblages. Placolith specimens are large in the Oligocene section. The most abundant occurrence of *Sphenolithus ciperoensis* yet observed in DSDP cores is noted in 171-5-4, 90-91 cm (83 m). *Sphenolithus predistentus* is especially abundant in 171-6-2, 90-91 cm (99 m).

Late Eocene assemblages in Core 8 (124 to 133 m) contain abundant *Bramletteius serraculoides* and show variation in the abundances of several other notable species. *Discoaster nodifer* is common in Section 3, whereas *D. tani* is abundant in Sections 4 to 6. The dominant placoliths in Section 4 are *Cyclococcolithina formosa* and *Reticulofenestra umbilica*, whereas *Cyclicargolithus floridanus* predominates in Section 5. Similar abrupt changes in dominance occur in Eocene assemblages from nearby DSDP 44. A few middle Eocene taxa such as *Campylosphaera dela, Nannotetrina* sp., and *Triquetrorhabdulus* occur in 171-8-6, 90-91 cm (132 m) and represent reworking. Core 9 contains Maestrichtian assemblages at the bottom and mixed assemblages of Maestrichtian, Paleocene, and middle Eocene in the upper part. The middle Eocene elements include *C. dela, Chiasmolithus grandis, Helicopontosphaera heezenii, Sphenolithus furcatolithoides, S. spiniger,* and *Triquetrorhabdulus inversus*. Paleocene *Fasciculithus* spp. and Late Cretaceous taxa, *Arkhangelskiella cymbiformis, Cribrosphaera ehrenbergii, Cylindralithus gallicus,* and *Watznaueria barnesae* are the most obvious older species. The lowest sample in Core 9, 171-9-5, 120-121 cm (150 m), and those from Core 10 (152 to 161 m) contain mainly Late Cretaceous specimens with minor (slumped?) Eocene elements such as *Cyclococcolithina formosa, Dictyococcites bisectus,* and *Reticulofenestra umbilica.*

The Late Cretaceous coccolith-bearing sediment of Cores 11 to 26 (161 to 329 m) ranges from Coniacian or Santonian to early Maestrichtian. Several taxa that are susceptible to solution in deep water—preserved in shelf sediment but largely absent in open-ocean sediment—include: *Kamptnerius magnificus, Cylindralithus coronatus, Chiastozygus* spp., *Lucianorhabdus cayeuxi, Marthasterites furcatus, Cretarhabdus lorei, Gartnerago inclinatum, Corollithion signum, C. exiguum, Lithastrinus grillii,* and *Scapholithus* sp. These forms are present mainly in Cores 17 to 26 (236 to 329 m) and suggest a Late Cretaceous interval of shallow deposition at the site of Horizon Guyot. The occurrence of *Kamptnerius* sp., *Chiastozygus disgregatus,* and *Micula decussata* in Core 25 (310 to 320 m) and *Amphizygus brooksii brooksii* and *M. furcatus* in Core 26 (320 to 329 m) indicate the Coniacian or Santonian for the deepest coccolith assemblages studied (Bukry, 1969; Manivit, 1971).

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PLATE 1

Various Effects and Degrees of Dissolving of Discoasters at Site DSDP 166 (Photomicrographs, 1200 X)

Figures 1-4	Progressive stages of shortening and irregular etching of discoaster rays and ray tips, where the central area remains intact. 1-3. 166-7-4, 32-33 cm. 4. 166-10-5, 94-95 cm.
Figures 5-8	Progressive stages of regular shortening of rays and removal of central area. 5-6, 8. 166-8-4, 71-72 cm. 7. 166-9-6, 73-74 cm.
Figures 9-10	Unusual perforation of ray tips by etching. 166-7-4, 32-33 cm.
Figures 11-12	Variation in ray-tip morphology of individual discoasters as a result of etching. 11. 166-7-6, 12-13 cm. 12. 166-7-4, 32-33 cm.

PLATE 1

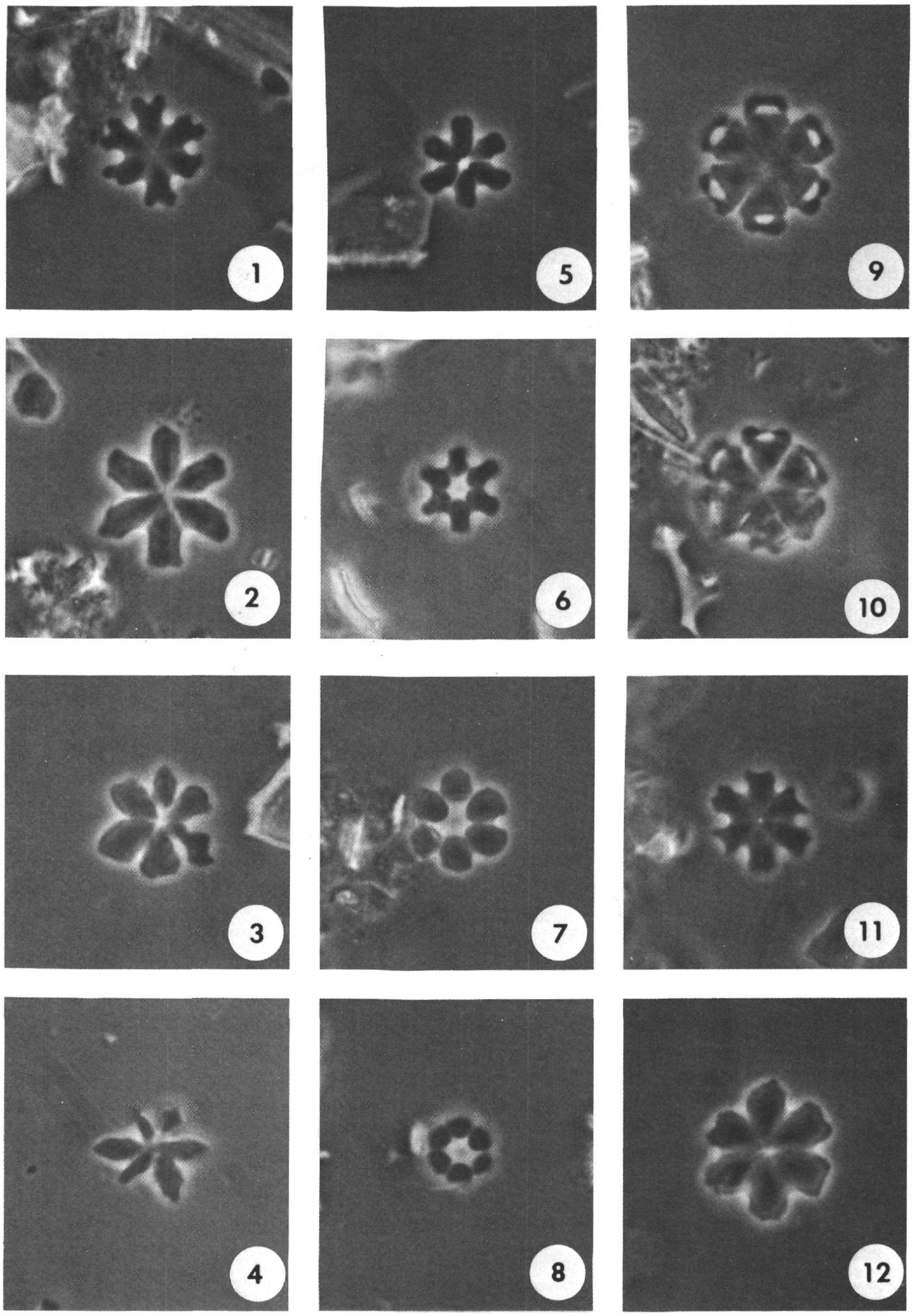

PLATE 2

Preservation and Taxonomy of Some Discoasters
and Placoliths from Site DSDP 166
(Photomicrographs, 1200 X)

Figure 1	Group of discoasters showing typical preservation in open-ocean sediment, from left to right *Discoaster deflandrei* Bramlette and Riedel; *D.* sp., *D. druggii* Bramlette and Wilcoxon; *D. calculosus* Bukry. 166-7-2, 12-13 cm.
Figure 2	*Discoaster calculosus* Bukry. 166-7-6, 12-13 cm.
Figures 3-5	*Discoaster lidzii* Hay showing an overgrowth sequence from left to right and possible synonymy with *D. deflandrei*. 166-7-6, 12-13 cm.
Figure 6	*Discoaster* sp. cf. *D. deflandrei,* seven-rayed variant with moderate etching of central area and ray tips. 166-9-6, 73-74 cm.
Figure 7	*Discoaster* sp. cf. *D. deflandrei*, overgrowth thickening producing two triads of rays. 166-7-6, 12-13 cm.
Figure 8	*Discoaster pseudovariabilis* Martini and Worsley, well preserved with slight etching. 166-4-2, 100-101 cm.
Figure 9	*Cyclococcolithina leptopora* (Murray and Blackman), a distal shield remnant resulting from etching. 166-4-2, 100-101 cm.
Figures 10-11	*Dictyococcites scrippsae* Bukry and Percival, strong solution produces irregular removal of central-area crystallites prior to disaggregation of the rims (polarizers crossed). 10. 166-12-6, 61-62 cm. 11. 166-10-5, 94-95 cm.

PLATE 2

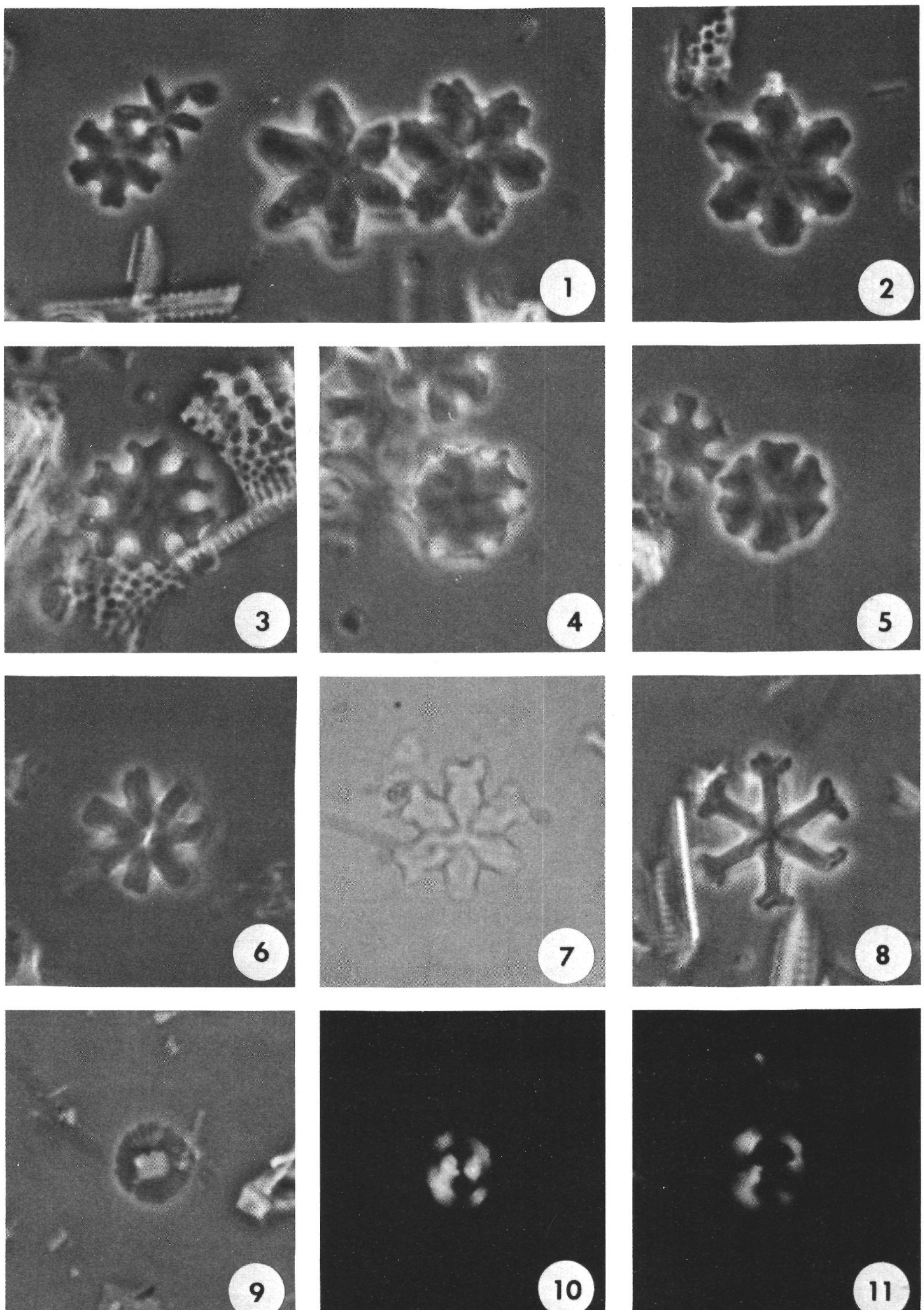

PLATE 3

Diatoms from Site DSDP 166
(Photomicrographs, 600 X, except
Figure 1 which is 1200 X)

Figure 1	*Actinocyclus cubitus* Hanna and Grant. 166-4-4, 35-36 cm (1200 X).
Figure 2	*Actinocyclus* sp. cf. *A. ehrenbergii* Ralfs. 166-7-4, 32-33 cm.
Figure 3	*Actinocyclus ellipticus* Grunow. 166-9-4, 72-73 cm.
Figures 4-5	*Actinocyclus ingens* Rattray. 4. 166-12-2, 43-44 cm. 5. 166-10-2, 29-30 cm.
Figures 6-8	*Actinocyclus lanceolatus* (Castracane). 6. 166-7-4, 32-33 cm. 7. 166-9-4, 72-73 cm. 8. 166-8-2, 40-41 cm.
Figures 9-10	*Asterolampra* sp. 1, fragment. 166-12-2, 43-44 cm.
Figure 11	*Asterolampra* sp. 2. 166-9-6, 73-74 cm.
Figure 12	*Asterolampra* sp. 166-8-4, 71-72 cm.
Figures 13-15	*Aulacodiscus* sp. 13. 166-9-2, 59-60 cm. 14. 166-9-4, 72-73 cm. 15. 166-9-6, 73-74 cm.
Figure 16	*Cestodiscus* sp. 166-7-4, 32-33 cm.

PLATE 3

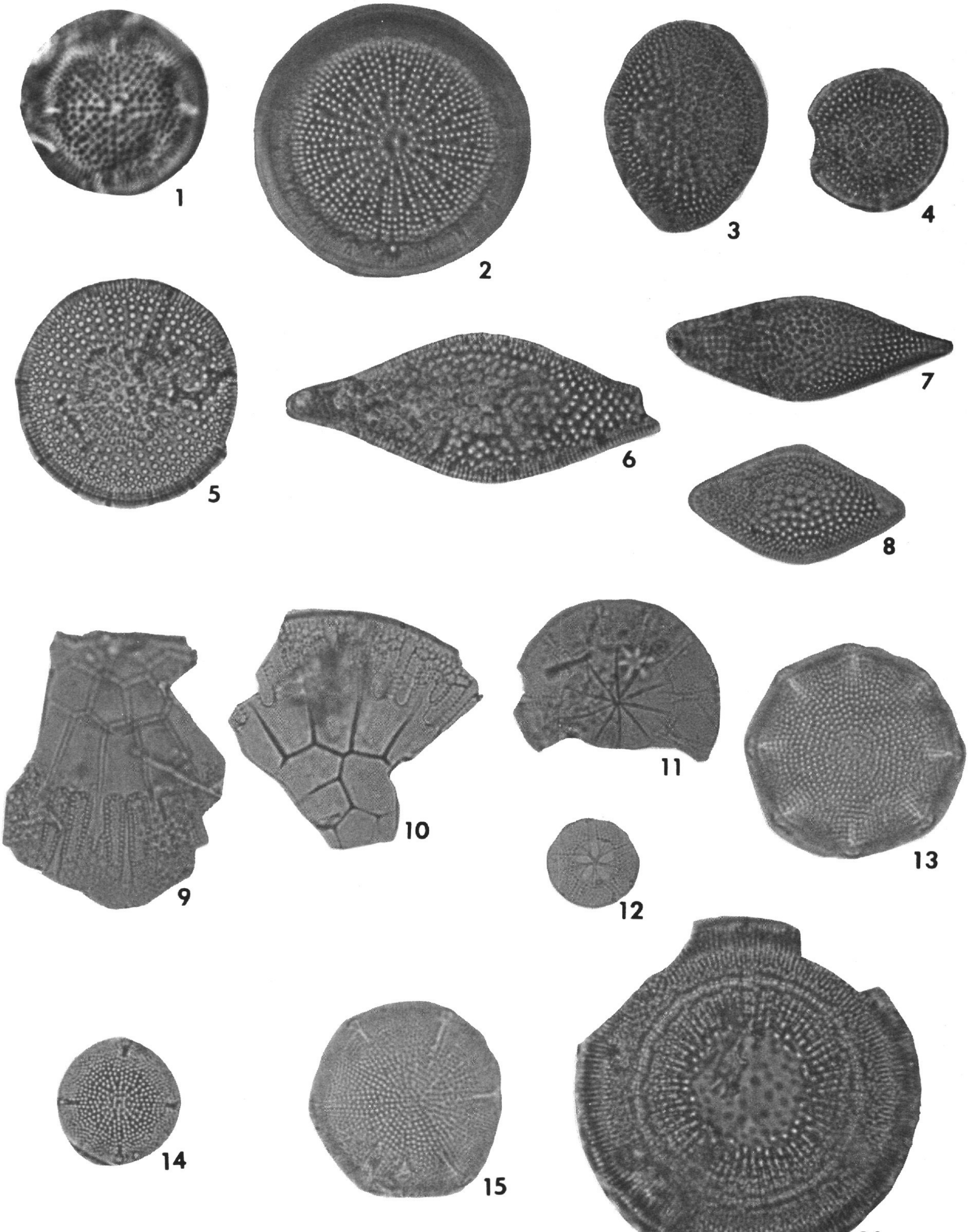

PLATE 4

Diatoms from Site DSDP 166
(Photomicrographs, 600 X, except Figures 2-3 which are 300 X and Figure 15 which is 1200 X)

Figure 1	*Cestodiscus* sp. 166-7-4, 32-33 cm.
Figures 2-3	*Cestodiscus* sp. 166-7-4, 32-33 cm. 2. High focus. 3. Los focus
Figures 4-5	*Coscinodiscus marginatus* Ehrenberg. 4. 166-10-2, 29-30 cm. 5. 166-7-6, 12-13 cm.
Figures 6-7	*Coscinodiscus* sp. cf. *C. marginatus* Ehrenberg. 166-14-2, 48-49 cm.
Figures 8-10	*Coscinodiscus paleaceus* (Grunow). 8-9. 166-8-2, 40-41 cm. 10. 166-9-6, 73-74 cm.
Figures 11-12	*Coscinodiscus* sp. aff. *C. paleaceus* (Grunow). 166-8-2, 40-41 cm.
Figure 13	?*Coscinodiscus* sp. aff. *C. paleaceus* (Grunow). 166-10-2, 29-30 cm.
Figure 14	*Coscinodiscus praepaleaceus* Schrader. 166-7-6, 12-13 cm.
Figures 15-17	*Coscinodiscus* sp. cf. *C. vetutissimus* Pantocsek 15. 166-10-2, 29-30 cm. (1200 X). 16. 166-10-5, 94-95 cm. 17. 166-8-6, 18-19 cm.
Figures 18-21	*Coscinodiscus vigilans* Schmidt. 18-19. 166-10-2, 29-30 cm. 20. 166-9-6, 73-74 cm. 21. 166-9-2, 59-60 cm.
Figure 22	*Coscinodiscus* sp. cf. *C. vigilans.* 166-9-6, 73-74 cm.

PLATE 4

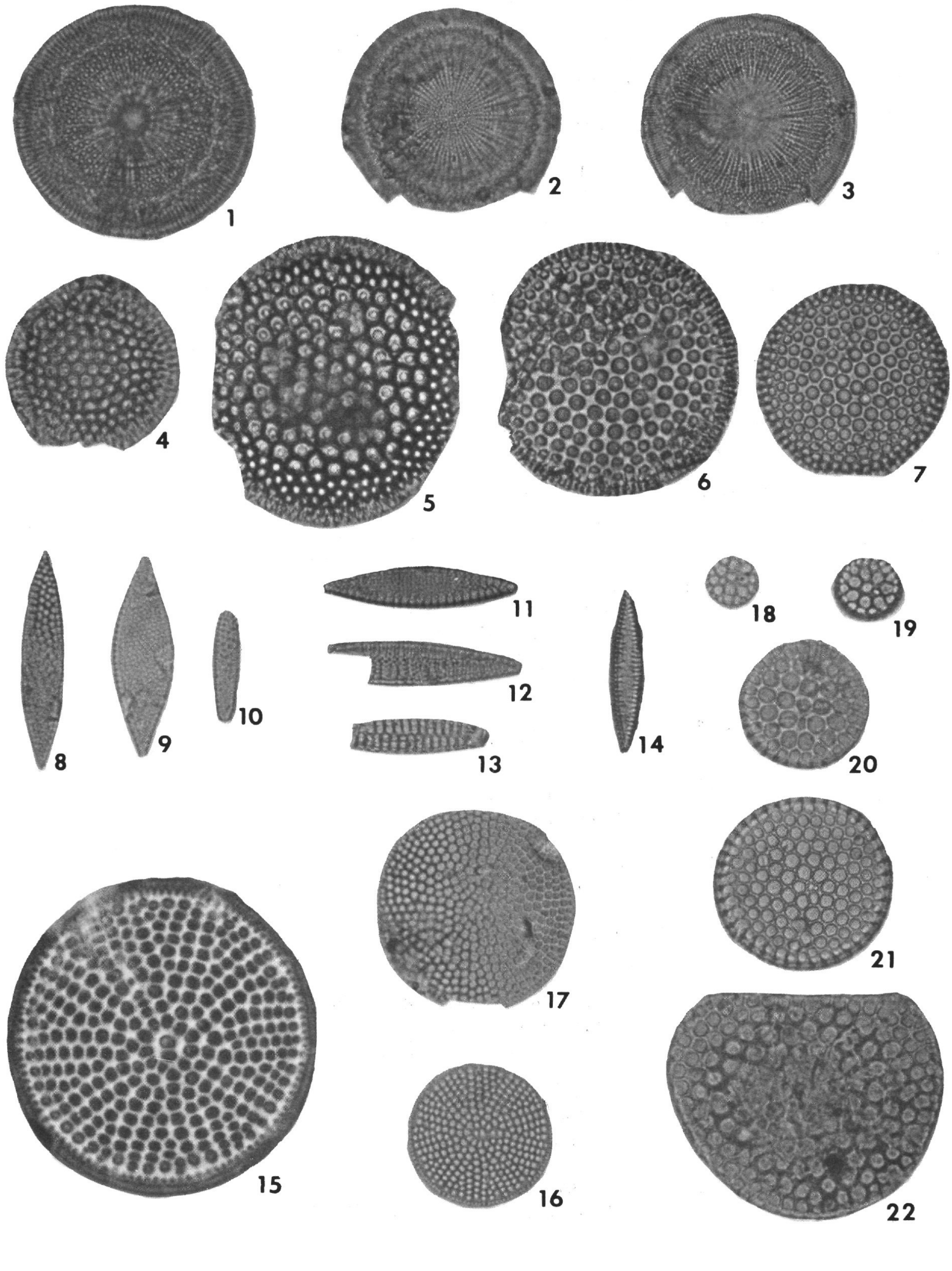

PLATE 5

Diatoms from Sites DSDP 165 and DSDP 166
(Photomicrographs, 600 X, except Figures 5 and 21 which are 300 X and Figures 8 and 18 which are 1200 X)

Figures 1-2	*Coscinodiscus* sp. 1. 1. 166-10-2, 29-30 cm. 2. 166-10-5, 94-95 cm.
Figure 3	*Coscinodiscus* sp. 2. 166-8-2, 40-41 cm
Figure 4	*Coscinodiscus* sp. 166-10-5, 94-95 cm.
Figure 5	*Craspedodiscus coscinodiscus* Ehrenberg. 166-8-6, 18-19 cm (300 X).
Figure 6	*Craspedodiscus oblongus* (Greville). 166-14-2, 48-49 cm.
Figures 7-8	*Cyclotella hannae* Kanaya. 7. 166-9-4, 72-73 cm. 8. 166-10-2, 29-30 cm (1200 X).
Figures 9-13	*Hemiaulus* spp. 9, 12. 166-14-2, 48-49 cm. 10. 166-13-1, 42-43 cm. 11. 166-12-4, 61-62 cm. 13. 166-13-5, 125-126 cm.
Figure 14	*Melosira sulcata* (Ehrenberg). 166-13-1, 42-43 cm.
Figure 15	*Nitzschia jouseae* Burckle. 166A-1A-1, 123-124 cm.
Figure 16	*Nitzschia reinholdii* Kanaya. 166-4-2, 100-101 cm.
Figure 17	*Nitzschia*? sp. 166-8-2, 40-41 cm.
Figure 18	*Raphidodiscus marylandicus* Christian and *Thalassiothrix* sp. fragment. 166-7-2, 30-31 cm (1200 X).
Figure 19-20	*Stephanopyxis appendiculata* Ehrenberg. 19. 166-7-4, 32-33 cm. 20. 166-9-6, 73-74 cm.
Figures 21-22	*Thalassiothrix*? sp. 165-11A-6, 21-22 cm. (Figure 21-300X).

PLATE 5