27. COCCOLITH AND SILICOFLAGELLATE STRATIGRAPHY, TASMAN SEA AND SOUTHWESTERN PACIFIC OCEAN, DEEP SEA DRILLING PROJECT LEG 21[1]

David Bukry, United States Geological Survey, La Jolla, California

INTRODUCTION

Leg 21 of the Deep Sea Drilling Project, November 1971 to January 1972, which began at Suva, Fiji, and ended at Darwin, Australia, investigated several submarine structures in the Tasman Sea and southwestern Pacific Ocean, recovering 288 cores at eight drilling sites (Figure 1). Light-microscope techniques were used to study the coccoliths of 235 samples from these cores. The zonation employed in zonal assignments of core samples (summarized in Figure 2) is based on Bukry (1973a). Following a discussion of the silicoflagellates from DSDP Leg 21 are summaries of the coccolith assemblages recovered at each site.

DISCOASTER/CHIASMOLITHUS RATIO INDICATES EOCENE PALEOTEMPERATURE

The coccolith genus *Discoaster* is most abundant at warm-water low-latitude sites. For example, at Site 44 (lat 19 N.) a middle Eocene Sample 44-4-5, 145-150 cm contains 98 percent *Discoaster* and only 2 percent *Chiasmolithus* in a count of 500 specimens of these two genera. In contrast, the coccolith genus *Chiasmolithus* is most abundant at cool-water high-latitude sites. For example, at Site 112 (lat 54 N.) a middle Eocene Sample 112-15-6, 141-142 cm contains only 33 percent *Discoaster* but 67 percent *Chiasmolithus* for a count of 300 specimens of the two genera.

A similar relation exists in coccolith assemblages of Leg 21 sites at the southern end and to the north of the Lord Howe Rise. Two lower Eocene samples from the *Discoaster lodoensis* Zone are used as illustrations. Sample 207A-23A-6, 35-36 cm (lat 37 S.) is the temperate, higher-latitude example; it contains 46 percent *Discoaster* and 54 percent *Chiasmolithus* for a count of 300. The warm-water lower-latitude example, Sample 210-46-3, 76-77 cm (lat 14 S.) contains 76 percent *Discoaster* and 24 percent *Chiasmolithus* for a count of 300.

SILICOFLAGELLATES

Silicoflagellates are sparse in Leg 21 samples, but several occurrences are stratigraphically significant. In the early Paleocene of Site 208, the *Corbisema hastata* Zone (Bukry and Foster, in press) is present. Comparison of the species array recorded from this site on the Lord Howe Rise to assemblages from Sites 214 and 216 (Fig. 3 and 4) shows it to be very similar to that of Site 214 on the Ninetyeast Ridge.

Samples from these three sites with associated coccoliths and silicoflagellates indicate that, whereas the latest occurrence of *Lyramula furcula* approximates the Cretaceous-Tertiary boundary, *L. furcula* ranges into the basal Paleocene. The boundary between the *L. furcula* Zone and the *C. hastata* Zone in the Paleocene is placed at the first occurrence of *C. hastata.*

Middle Eocene silicoflagellates are sparse but occur at DSDP Sites 206C, 207A, and 208. As suggested by Ling (1972) and Mandra (1968), the occurrences of *Naviculopsis foliacea* and *Dictyocha hexacantha* are convenient guides to Eocene assemblages. For example, Sample 21-206C-15-2, 28-29 cm (613 m), which is part of the *Reticulofenestra umbilica* Zone of coccoliths, contains a *Dictyocha hexacantha* Zone assemblage. Species present include *Corbisema triacantha, Dictyocha hexacantha, Naviculopsis constricta,* and *N. foliacea.* Other samples containing *N. foliacea*, 21-208-27-5, 103-104 cm (490 m), are part of the *Nannotetrina quadrata* Zone of coccoliths.

The *Rocella gemma* Zone (Ling, 1972; Bukry and Foster, in press) of late Oligocene age is represented at DSDP 206C Cores 5-7 (440-489 m) by the occurrence of *Naviculopsis regularsis* and *Rocella gemma.* Only a few specimens are present in a given sample; *R. gemma* is most common in Sample 21-206C-6C-3, 35-36 cm (465 m). All Leg 21 samples assigned to the *R. gemma* Zone are also part of the *Sphenolithus ciperoensis* Zone of coccoliths.

Younger silicoflagellate occurrences are rare. One of the best assemblages, from a short silicoflagellate-bearing interval at Site 205, contains an early late Miocene suite of the *Distephanus crux* Zone, *Dictyocha aspera* Subzone (the lower part of the zone, identified by the dominance of *Dictyocha aspera* and *D. rhombica* over *D. fibula*). Percentages and species present in Sample 21-205-6-2, 25-26 cm (49 m), for a count of 50 specimens, include 46% *Dictyocha aspera,* 18% *D. fibula,* 10% *D. rhombica,* 6% *Distephanus speculum,* 2% *D. crux,* 2% *D. quinquangellus,* and 6% *Mesocena circula.* Associated coccoliths belong to the *Discoaster neohamatus* Zone, *Discoaster bellus* Subzone, and the cooccurrence of the diatoms *Coscinodiscus plicatus* and *Hemidiscus cuneiformis* in Core 6 indicates the *Coscinodiscus plicatus* Zone of diatoms. This correlation of three phytoplankton zones matches the association reported for the Panama Basin (Bukry and Foster, 1973). Silicoflagellates from DSDP Leg 21 samples are figured (Plate 1).

SITE SUMMARIES

DSDP 203

(lat 22°09.22'S., long. 177°32.77'W., depth 2720 m)

Coring at DSDP 203 was intended to determine the age and composition of sediment in the inter-arc Lau Basin at

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

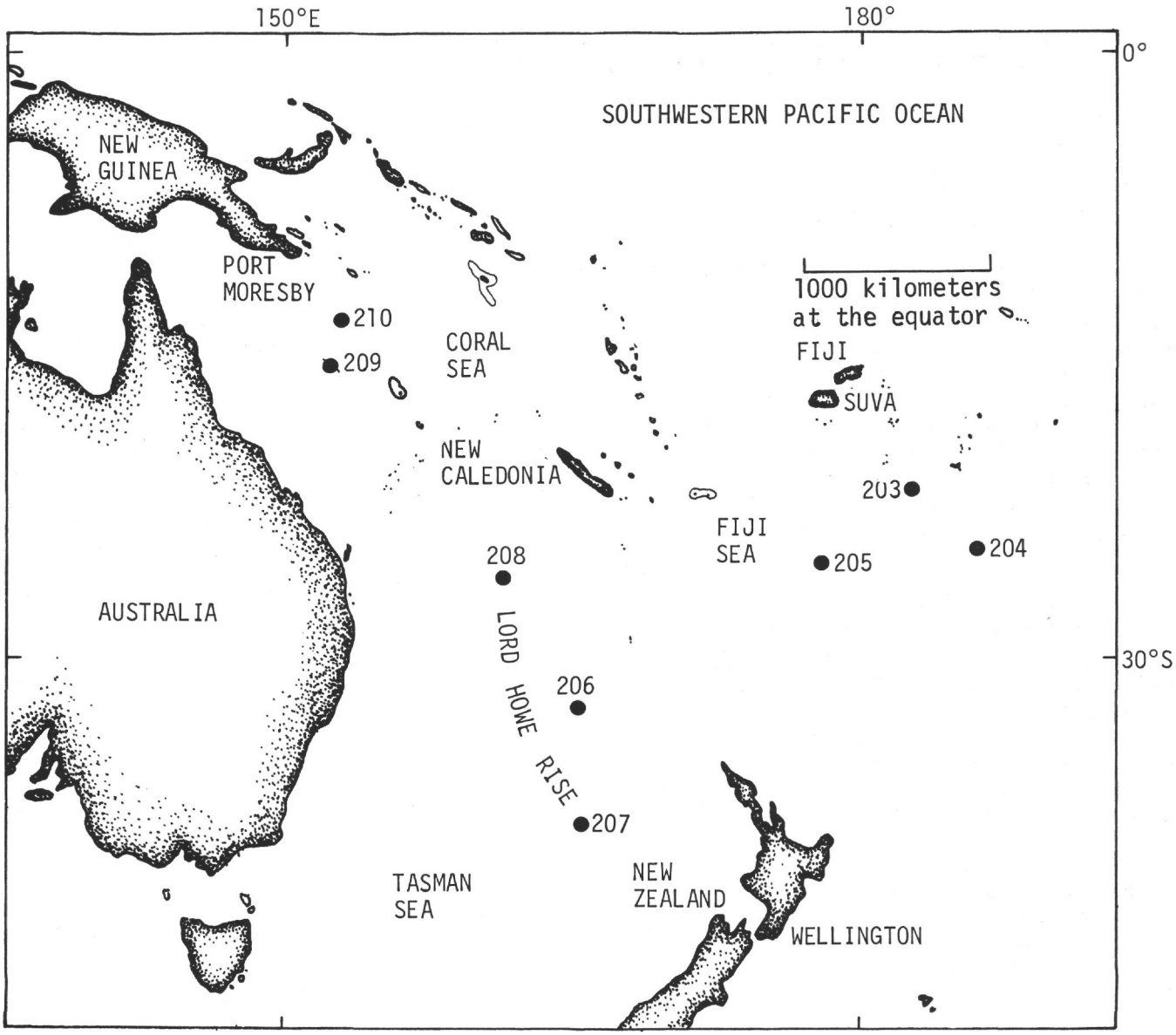

Figure 1. *Location of sites cored during DSDP Leg 21.*

the eastern margin of the Tasman tectonic plate. Samples from the five cores taken in this volcanic-ash-rich sediment range in age from Holocene to middle Pliocene.

Warm-water coccolith assemblages in the cores from DSDP 203 are comparable to those from the Caribbean Sea, as illustrated by the following examples.

21-203-1-1, 65-66 cm (0 m):

Ceratolithus cristatus [large], *Cyclococcolithina leptopora, Discolithina* sp., *?Emiliania huxleyi, Gephyrocapsa caribbeanica, G. oceanica, G. omega, Helicopontosphaera kamptneri* [common], *H. sellii, Rhabdosphaera clavigera* [abundant], *Scapholithus fossilis, Syracosphaera histrica, Thoracosphaera saxea, T.* sp., *Umbilicosphaera sibogae.*

21-203-3-6, 35-36 cm (116 m):

Ceratolithus cristatus, Cyclococcolithina leptopora, C. macintyrei [rare], *Emiliania annula, E. ovata, Helicopontosphaera kamptneri, Pontosphaera discopora, Rhabdosphaera stylifera, Scyphosphaera apsteinii, S. recurvata, Syracosphaera* sp., *Thoracosphaera saxes.*

21-203-5-1, 106-107 cm (401 m):

Ceratolithus rugosus, Cyclococcolithina leptopora, C. macintyrei, Discoaster asymmetricus, D. blackstockae, D. brouweri, D. challengeri, D. decorus, D. pansus, D. pentaradiatus, D. surculus, D. tamalis, D. triradiatus, D. variabilis, Emiliania sp. cf. *E. annula, Gephyrocapsa doronicoides, Hayaster perplexus, Helicopontosphaera kamptneri, H. sellii, Scyphosphaera* sp. cf. *S. globulata, S. pulcherrima, Sphenolithus abies* [rare], *Syracosphaera* sp.

Series or Subseries	Zone	Subzone	DSDP Site 203	205	206	207	208	209	210
Holocene	*Emiliania huxleyi*		1-1			?1-1			
Pleistocene	*Gephyrocapsa oceanica*		2-1		1-1	2-1	1-1	1-1	1-1/10-4
	Coccolithus doronicoides	*Gephyrocapsa caribbeanica*			3-1/9-1	3-1/3-6			11-2
		Emiliania annula	3-1/3-6		10-1	4-1		2-5	
Upper Pliocene	*Discoaster brouweri*	*Cyclococcolithina macintyrei*	4-1/4-2		11-1		3-1/3-3		
		Discoaster pentaradiatus			12-6	4-5	3-5	3-3/3-5	12-3/14-2
		Discoaster tamalis	5-1		14-6/16-6	5-6	4-5/5-5	4-3/5-1	
Lower Pliocene	*Reticulofenestra pseudoumbilica*	*Discoaster asymmetricus*				1A-1	6-5		15-1/19-2
		Sphenolithus neoabies						5-5	
	Ceratolithus tricorniculatus	*Ceratolithus rugosus*		3-2	18-2		7-5/9-5	18-6	22-3/?23-3
		Ceratolithus acutus				1A-6/5A-6	10-5	19-5	
		Triquetrorhabdulus rugosus			?20-6/21-6		11-5	6-1/6-5	
Upper Miocene	*Discoaster quinqueramus*	*Ceratolithus primus*					12-6/14-5		24-3/29-4
		Discoaster berggrenii					?15-5		
	Discoaster neohamatus	*Discoaster neorectus*							
		Discoaster bellus		5-1/8-2	22-6/23-2	6A-6/7A-6	16-5/17-1		
	Discoaster hamatus			?8-4	24-1/25-1		18-1/18-5		
Middle Miocene	*Catinaster coalitus*			10-2/11-2		8A-6			
	Discoaster exilis	*Discoaster kugleri*		?12-1	?26-3/?27-2		19-1/20-3		
		Coccolithus miopelagicus		15-2/17-2	28-4/32-3				
	Sphenolithus heteromorphus			20-2/23-2	33-1	9A-4 & 10A-1	21-5		
	Helicopontosphaera ampliaperta								
Lower Miocene	*Sphenolithus belemnos*						22-5		
	Triquetrorhabdulus carinatus	*Discoaster druggii*			34-2		23-5/24-4		
		Discoaster deflandrei		24-2/24-4					
		Cyclicargolithus abisectus			35-2/44-2				
	Sphenolithus ciperoensis			25-2/27-2	45-3, 6C-3/12C-3		25-5/27-2		
	Sphenolithus distentus			28-1/29-2	13C-3/14C-6				
Oligocene	*Sphenolithus predistentus*								
	Helicopontosphaera reticulata	*Reticulofenestra hillae*							?34-3
		Cyclococcolithina formosa							
		Coccolithus subdistichus							
Upper Eocene	*Discoaster barbadiensis*							18-1; 23-1/24-1	
	Reticulofenestra umbilica	*Discoaster saipanensis*				9A-6		25-1/28-2	
		Discoaster bifax			15C-2/17C-5	11A-6/13A-6	27-3	?28-3; 34-2	
Middle Eocene	*Nannotetrina quadrata*	*Coccolithus staurion*				14A-2/15A-4			
		Chiasmolithus gigas				16-3	27-5/28-5	31-1	
		Discoaster strictus				17-2/18-6			
	Discoaster sublodoensis	*Rhabdosphaera inflata*				19A-2/20A-6			37-3
		Discoasteroides kuepperi							39-2/42-1
Lower Eocene	*Discoaster lodoensis*					21A-2/24A-5			44-2/50-3
	Tribrachiatus orthostylus				19C-3	25A-4/26A-4			
	Discoaster diastypus								
	Discoaster multiradiatus	*Campylosphaera eodela*							
		Chiasmolithus bidens					29-1		
	Discoaster nobilis								
Paleocene	*Discoaster mohleri*					27A-2			
	Heliolithus kleinpellii								
	Fasciculithus tympaniformis								
	Cruciplacolithus tenuis				20C-1/21C-2		?29-5/?31-3		
	Nephrolithus frequens					28A-1	33-1/33-4		
Upper Cretaceous	*Lithraphidites quadratus*						?34-3		
	Tetralithus trifidus								
	Broinsonia parca								
	Eiffellithus augustus								

Figure 2. *Coccolith zonation of sediment from the Tasman Sea and southwestern Pacific Ocean, DSDP Leg 21. The numbers assigned to zonal intervals are core and section numbers of samples examined. A core is typically 9 meters long; a section is a sixth part of a core, 1.5 meters, both numbered from the top. Where a zone or subzone is represented in samples from two or more core sections, the highest and lowest sections are listed.*

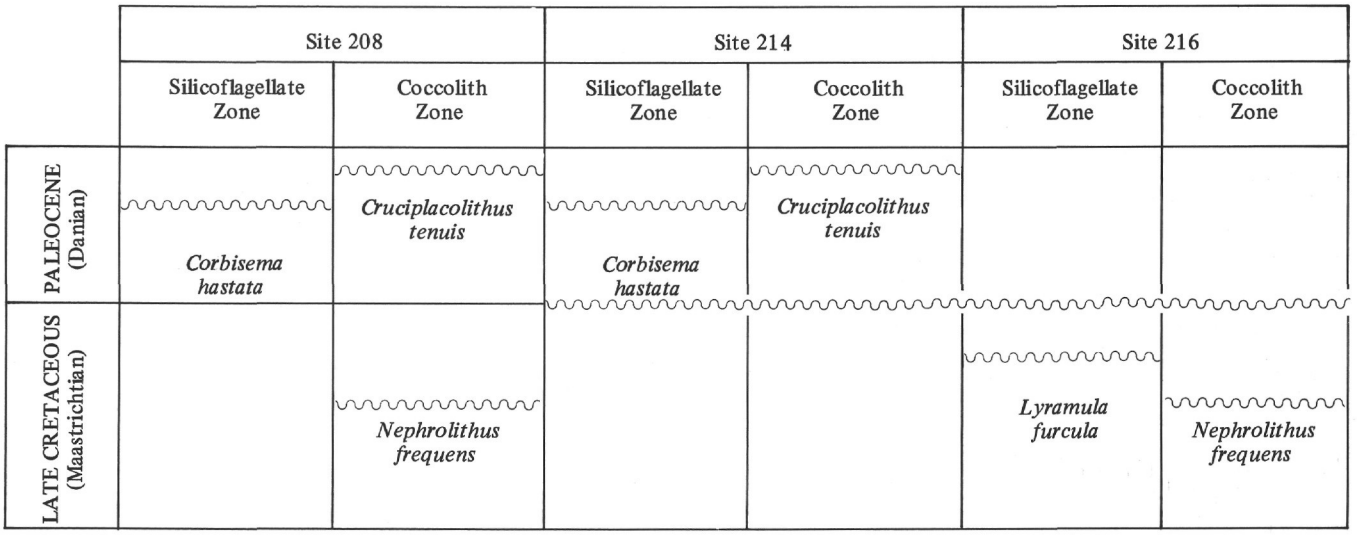

Figure 3. *Correlation of Late Cretaceous and Paleocene silicoflagellate zones. Wavy lines suggest approximate relations determined by differential preservation which could vary at different sites.*

Silicoflagellate Species	Paleocene		Late Cretaceous
	Site 214 38-3, Top (354 m)	Site 208 31-3, 110-111 cm (561 m)	Site 216 30-1, 70 cm (397 m)
Corbisema archangelskiana		X	
C. geometrica	X	X	X
C. hastata	X	X	
C. schulzi	X		
C. triacantha	X	X	
Lyramula furcula		X	X
Vallacerta tumidula			X

Figure 4. *Occurrence of silicoflagellates in three key samples of earliest Paleocene and latest Late Cretaceous age.*

DSDP 204
(lat 24°57.27′S., long. 174°06.69′W., depth 5354 m)

Site 204 was cored to determine the maximum age of the Pacific in the area directly east of the Tonga Trench. An age greater than 75 × 10^6 years had been inferred from magnetic anomalies. The coring terminated in volcanogenic sandstone of probable Cretaceous age at 147 meters. Rare highly etched (–4) coccoliths occur in only 2 of the 10 cores cut. The best sample, 21-204A-1A-3, 135-136 cm (90 m), contains *Arkhangelskiella cymbiformis, Cribrosphaera ehrenbergii, Micula decussata,* ?*Nephrolithus* sp., *Prediscosphaera cretacea, Watznaueria* sp. cf. *W. barnesae* [small], and a placolith resembling both *Coccolithus* and *Biscutum* that suggests a potential lineage of those two genera. A Late Cretaceous, probable Maastrichtian, age is indicated by this assemblage.

DSDP 205
(lat 25°30.99′S., long. 177°53.95′E., depth 4320 m)

Coring at this site in the South Fiji Basin was nearly continuous; Cores 1-32 represent 355 meters penetration. The section was intended, in part, to provide a middle-latitude biostratigraphic reference, but it is characterized by a less than 50 percent recovery rate and variable coccolith preservation in the mixed volcanogenic-pelagic sediment.

The youngest sample available, 21-205-3-2, 108-109 cm (19 m), contains *Ceratolithus primus, C. rugosus, C. tricorniculatus,* and *Triquetrorhabdulus rugosus* indicating the basal Pliocene. Discoasters are especially abundant and diverse; Sample 21-205-6-6, 35-36 cm (55 m), which contains *Coccolithus pelagicus, Cyclococcolithina leptopora, C. macintyrei, Discoaster bellus, D. bollii, D. brouweri, D. challengeri, D. neohamatus, D. pentaradiatus, D. prepentaradiatus, D. variabilis, Minylitha convallis, Reticulofenestra pseucoumbilica,* and *Triquetrorhabdulus rugosus*, is part of the *Discoaster neohamatus* Zone. Samples from Cores 25 and 27 contain *Dictyococcites bisectus* and *Sphenolithus ciperoensis* indicating the *Sphenolithus ciperoensis* Zone; diagenesis has restricted the assemblage. In Cores 28 and 29 near the bottom of the sedimentary section, *Chiasmolithus altus* and common *Sphenolithus distentus* occur. A few *S. distentus* specimens in Core 28 resemble *S. ciperoensis; S. predistentus* occurs in Core 29. Therefore, both cores contain assemblages assigned to the *Sphenolithus distentus* Zone.

DSDP 206
(lat 32°00.75′S., long. 165°27.15′E., depth 3196 m)

Site 206 was cored in the New Caledonia Basin to determine the biostratigraphic history of the area east of the Lord Howe Rise. A total of 67 cores were cut in four holes at this site, recovering 333 meters. Although a maximum penetration of 734 meters was achieved at Hole 206C, basement was not reached. An upper Oligocene to Pleistocene coccolith record is fairly complete, but the assemblages are typically less diverse than the comparable shallow-water (1545 m) section cored at Site 208 on the Lord Howe Rise.

The oldest coccolith assemblages available from Site 206 are basal Paleocene. The assemblages are restricted by strong diagenesis that has converted the sediment to a

coccolith-fragment hash. Intact specimens are generally large (see Adelseck et al., 1973). Sample 21-206C-20C-1, 27-28 cm (706 m), contains *Chiasmolithus danicus, Coccolithus pelagicus* s. ampl., *Cruciplacolithus tenuis,* and *Zygodiscus* sp. cf. *Z. sigmoides.* Sample 21-206C-21C-1, 62-63 cm (725 m), contains a mixture of Late Cretaceous and Paleocene species but lacks *Watznaueria barnesae,* suggesting deposition at a site nearer to the pole. Species present include *Arkhangelskiella cymbiformis, Chiasmolithus danicus, Coccolithus pelagicus* s. ampl., *Kamptnerius magnificus, Lucianorhabdus cayeuxi, Markalius astroporus, Marthasterites inconspicuus, Micula decussata, Prediscosphaera* sp. cf. *P. cretacea,* and *Zygodiscus* sp. cf. *Z. sigmoides.* The deepest sample contains a Paleocene suite with *Chiasmolithus danicus, Coccolithus pelagicus* s. ampl., *Hornibrookina teuriensis, Markalius astroporus, Thoracosphaera operculata,* and *Zygodiscus sigmoides.*

DSDP 207
(lat 36°57.75′S., long. 165°26.06′E., depth 1389 m)

Site 207 was cored on the southern part of the Lord Howe Rise. A total of 50 cores were cut in 513 meters of penetration. A relatively complete temperate-climate coccolith sequence for the lower and middle Eocene and middle Miocene to Pleistocene was obtained. An Eocene to Miocene unconformity is indicated by reworking and intercalation of assemblages in Cores 9A-10A (119-142 m).

A cool-water Pleistocene of Cores 1-4 (0-38 m) is indicated by the common occurrence of large *Coccolithus pelagicus* s. str., by the absence of *Ceratolithus,* and by the high angle of the cross-bar in the *Gephyrocapsa* specimens present (Gartner, 1972; Bukry, 1973b). The Pliocene and late Miocene assemblages are characterized by the dominance of placoliths over discoasters and sphenoliths. Owing to shallow deposition at this site, preservation is good (–1 to –2) and a diverse suite of *Scyphosphaera* is preserved (see Bukry, 1973b, for explanation of preservation notation). The related taxon *Discolithina japonica* is also unusually common. Middle Miocene assemblages are dominated by placoliths; discoasters are thickly overgrown (+3 to +4). Eocene assemblages are more diverse and better preserved with overgrown (+2 to +3) discoasters and etched (–2) placoliths. *Chiasmolithus* species are much more common in these assemblages than they are in lower-latitude correlatives. Some coccolith assemblages, as in 21-207A-20A-2, 35-36 cm (225 m), are practically a *Chiasmolithus* ooze. The relative species ranges and abundances for this genus should provide a key to Paleogene coccolith paleoecology. Early Paleocene species such as *Biantholithus sparsus* and *Thoracosphaera operculata* and late Plaeocene species such as *Discoaster multiradiatus* and *Discoasteroides megastypus* are reworked together in Sample 21-207A-26A-3, 95-96 cm (285 m), which occurs between early Eocene samples of the *Tribrachiatus orthostylus* Zone.

Sample 21-207A-28-1, 102-103 cm (300 m), contains an assemblage that is composed of species considered to be Late Cretaceous (approximately 95%) and early Paleocene (5%). The small recovery makes future detailed analysis of Section 1 critical. The assemblage is remarkable in the common occurrence of *Kamptnerius magnificus* and the absence of *Watznaueria barnesae.* The reverse is generally true in low-latitude oceanic sections. Only at very high-latitude localities such as those studied by Vekshina (1959) in western Siberia and Edwards (1966) in New Zealand has *Watznaueria barnesae* been found to be absent from Late Cretaceous assemblages. Late Cretaceous samples from as far north as DSDP 192 (lat 53°N) and Denmark (lat 57°N) do contain *W. barnesae.* The occurrence of *Nephrolithus frequens, N. gorkae,* and *Kamptnerius magnificus* at 207A matches their Late Cretaceous occurrences in classic sections of northern Europe (Aberg, 1966; Perch-Nielsen, 1968, 1969; Bukry, 1969; Worsley and Martini, 1970). This, together with the absence of *W. barnesae,* suggests a comparable but cool- and shallow-water depositional environment. Species present at 207A include: *Arkhangelskiella cymbiformis, Chiasmolithus danicus, Coccolithus pelagicus* s. ampl., *Cretarhabdus lorei, Kamptnerius magnificus, Nephrolithus frequens, N. gorkae, Prediscosphaera cretacea, Tetralithus obscurus, Thoracosphaera operculata, Zygodiscus sigmoides,* and *Z. spiralis.* My examination of the Edwards (1966) and Vekshina (1959) high-latitude samples led to the following assemblages:

New Zealand, S68/f1010, N1130: *Arkhangelskiella cymbiformis, ?Cribrosphaera ehrenbergii, Eiffellithus turriseiffeli, Kamptnerius magnificus, Nephrolithus gorkae, Prediscosphaera cretacea, Zygodiscus spiralis,* [no *Watznaueria barnesae*].

Western Siberia, OMSK 1-P, 600.0 m: *Arkhangelskiella cymbiformis, A. specillata, Biscutum testudinarium, Cretarhabdus decorus, Cribrosphaera ehrenbergii, Micula decussata, Prediscosphaera cretacea, P. lata,* [no *Watznaueria barnesae*].

Western Siberia, OMSK 1-P, 773.3 m: *Arkhangelskiella* sp. cf. *A. cymbiformis* [small], *Broinsonia parca, Dodekapodorhabdus noelae, Eiffellithus turriseiffeli, Markalius circumradiatus* [of Perch-Nielsen, 1968], *Microrhabdulus decoratus, Micula decussata, Prediscosphaera cretacea, P. lata, Zygodiscus meudini,* [no *Watznaueria barnesae*].

DSDP 208
(lat 26°06.61′S., long. 161°13.27′E., depth 1545 m)

Site 208, drilled at the northern end of the Lord Howe Rise, provided a lower latitude, paleoecologic-biostratigraphic comparison for Sites 206 and 207. Sediment recovery was excellent for the 34 cores attempted in the 594 meters penetration.

Relatively warm-water, shallow-water late Oligocene to Pleistocene assemblages are present as indicated by abundant discoasters and sphenoliths and diverse assemblages. Both *Sphenolithus ciperoensis* and *Helicopontosphaera recta* are present in Cores 25 and 27. In Core 27, an unconformity juxtaposes upper Oligocene above middle Eocene. The Eocene assemblages have only fair diversity and preservation and are commonly diluted by abundant radiolarian and diatom fragments. Discoasters are rare throughout. A cool-water late Plaeocene sample from Core 29 (539-548 m) contains abundant *Chiasmolithus bidens* and rare *Discoaster multiradiatus.* Mixing is indicated by the discordant association of *Heliolithus kleinpellii, Hornibrookina teuriensis,* and *Toweius eminens.* The basal

Paleocene and Maastrichtian of Samples 29-5 to 34-3 (545-587 m) also contain cool-water assemblages similar to those of Sites 206 and 207 drilled to the south.

DSDP 209
(lat 15°56.19′S., long. 152°11.27′E., depth 1428 m)

Site 209 was cored at the northeastern margin of the Queensland Plateau. A total of 34 cores were cut to a depth of 344 meters. Recovery of sediment from the lower section was poor, but that in the lower Pliocene to Pleistocene tropical coccolith ooze of Cores 1-5 (0-45 m) is nearly complete. Sample 21-209-1-1, 30-31 cm (0 m), contains *Oolithotus antillarum* and common *Hayaster perplexus*. Sample 21-209-2-5, 110-111 cm (16 m), contains abundant *Cyclococcolithina leptopora* and *Emiliania annula* but no discoasters or barred gephyrocapsids; it is assigned to the *Emiliania annula* Subzone. Cool-water *Coccolithus pelagicus* is missing and *Helicopontosphaera sellii* is rare. The late Pliocene sediment from 209-3-3 to 209-5-1 contains a great abundance of discoasters, especially *Discoaster pentaradiatus*. A *D. pentaradiatus* predominance is a clear indicator of warm-water conditions.

Eocene assemblages are poorly preserved (overgrown +2, +3), often broken, and diluted with terrigenous? sediment and therefore provide a poor biostratigraphic reference.

DSDP 210
(lat 13°45.99′S., long. 152°53.78′E., depth 4643 m)

Site 210 was cored near the middle of the Coral Sea Abyssal Plain. A total of 50 cores were cut to a penetration depth of 711 meters. The thick Pleistocene section in Cores 1-11 (0-112 m) contains warm-water assemblages with *Gephyrocapsa caribbeanica, G. lumina, G. oceanica, G. omega, Emiliania annula, E. ovata,* and *Ceratolithus cristatus*. Extensive reworking of Pliocene material is present at several levels such as 21-210-8-5, 49-50 cm (69 m).

In the Pliocene to late Miocene assemblages of Cores 12 to 29 (72-449 m), discoasters and sphenoliths are common, ceratoliths and *Coccolithus pelagicus* few. Reworked Eocene to Miocene specimens at various, but not all, levels in this section support the shipboard interpretation that turbidite deposition has occurred in the basin.

Thick irregular overgrowth (+3 to +4) of coccoliths characterizes the few samples available from the middle Eocene to upper Miocene section of Cores 27 to 35 (403-551 m).

Cores 37 to 50 (560-711 m) contain moderate to strongly overgrown, but diverse, assemblages of the *Discoaster sublodoensis* Zone and *Discoaster lodoensis* Zone. The diversity, preservation, and relative abundance of coccoliths is similar to that I have observed for the Eocene of the Santa Ynez Mountains in California (unpublished data, 1972). Species occurrence in samples from Cores 37 to 50 are shown in Figure 5.

Coccolith Species	DSDP Hole 210						
	37-3, 71-72	39-2, 82-83	42-1, 69-70	44-2, 85-86	46-3, 76-77	48-3, 73-74	50-3, 84-85
Campylosphaera dela			X	X	X	X	X
Chiasmolithus expansus				X			
C. grandis	X	X	X	X	X	X	X
C. solitus	X	X	X			X	X
Coccolithus crassus			X	X	X	X	X
C. cribellum				X	X	X	
C. magnicrassus			X		X	X	X
Cyclicargolithus pseudogammation	X	X	X	X	X		
Cyclococcolithina gammation		X	X	X	X		X
Discoaster barbadiensis	X	X	X	X		X	X
D. gemmifer				X			
D. cf. *germanicus*		X					
D. lodoensis		X	X	X	X	X	X
D. mirus	X	X	X		X	X	X
D. strictus			X				
D. sublodoensis	X	X	X				
Discoasteroides kuepperi				X	X	X	X
Discolithina plana					X	X	
Helicopontosphaera lophota		X	X	X	X		X
H. seminulum			X				X
Nannotetrina cristata	X						
Reticulofenestra cf. *dictyoda*	X	X					
Sphenolithus radians	X	X	X	X	X	X	X
Tribrachiatus orthostylus			X	X	X		
Triquetrorhabdulus inversus	X						
Zygolithus cf. *protenus*		X	X	X		X	X
Zygrhablithus bijugatus		X	X	X		X	

Figure 5. *Occurrence of selected coccolith species in lower samples from DSDP Site 210.*

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PLATE 1

Silicoflagellates from DSDP Leg 21
Figures 1-3 Magnified 1000X; Scale bar 10 microns
Figures 4-10 Magnified 800X; Scale bar 10 microns

Figure 1 — *Corbisema hastata* (Lemmermann). 208-30-5, 107-108 cm (555 m), lower Paleocene.

Figure 2 — *Dictyocha aspera* (Lemmermann). 205-6-2, 25-26 cm (49 m), upper Miocene.

Figure 3 — *Dictyocha rhombica* (Schulz). 205-6-2, 25-26 cm (49 m), upper Miocene.

Figures 4-5 — *Naviculopsis constricta* (Schulz).
4. 206C-17C-1, 35-36 cm (630 m), middle Eocene.
5. 207A-20A-2, 35-36 cm (225 m), middle Eocene.

Figures 6-7 — *Naviculopsis foliacea* Deflandre. 208-27-5, 103-104 cm (490 m), middle Eocene.

Figure 8 — *Lyramula furcula* Hanna. 208-31-3, 110-111 cm (561 m), Upper Cretaceous.

Figures 9-10 — *Rocella gemma* Hanna. 206C-6C-3, 35-36 cm (465 m), upper Oligocene.

PLATE 1