14. COCCOLITH STRATIGRAPHY LEG 9, DEEP SEA DRILLING PROJECT[1]

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

INTRODUCTION

Leg 9 of the Deep Sea Drilling Project, December 1969 to January 1970, from Tahiti to Panama, recovered 199 cores at nine drilling sites (Figure 1). Light-microscope techniques were used to study the coccoliths of 209 samples from these cores. The zonal assignment of the cores examined, given in Table 1, uses the coccolith zones described in the Leg 7 report (Bukry, 1971). Following a summary of various aspects of the coccolith stratigraphy is an index to the species considered. Coccolith species identified in specific samples are listed for each hole by time-stratigraphic series and biostratigraphic zone (Table 2).

SUMMARY OF COCCOLITH STRATIGRAPHY

Site 76

Twelve coccolith samples were examined from three cores of mixed-age turbidity-current deposits recovered at Site 76 north of Archipel des Tuomotu. The samples are brown deep-sea clay and carbonate ooze with reworking. No diagnostic coccoliths of the Pleistocene or Pliocene occur in these samples. Core 1 of Hole 76 is predominantly brown clay containing rare reworked coccolith specimens of taxa ranging in age from late Eocene to Miocene or Pliocene. Coccoliths are common but poorly preserved in samples from Cores 1A and 2A. All the coccolith assemblages appear to represent the late Oligocene or early Miocene with substantial admixture of Eocene specimens. The lower samples from this site, Core 2A, Sections 5 and 6, show the effects of intensive carbonate solution, as resistant species such as *Coccolithus eopelagicus, Cyclococcolithina neogammation. Discoaster deflandrei, Sphenolithus moriformis* and *Triquetrorhabdulus carinatus* predominate. Even these taxa, by the presence of centerless specimens, show evidence of attack. A near lack of typically shallow-water forms among the reworked Eocene taxa could be attributed to initial deposition in a deep-ocean location or to the effects of solution during reworking of an initial shallow-water deposit. The rare occurrence of shallow-water *Zygrhablithus* and *Braarudosphaera* favors the latter supposition.

Site 77

At Site 77 a thick section of biogenic sediment ranging in age from late Eocene to late Pleistocene was extensively cored. There are no major gaps in the section; and the occurrence together throughout the section of diatoms, silicoflagellates, radiolarians and foraminifera, in addition to coccoliths, makes it a valuable reference for work on multiple zonation by these groups.

In the upper Miocene sediment, *Reticulofenestra pseudoumbilica*, an abundant and prominent species in coccolith assemblages of middle Miocene through early Pliocene age, is absent from Cores 13B to 16B, which are assigned to the lower *Ceratolithus tricorniculatus* Zone and *Discoaster quinqueramus* Zone or *Discoaster neohamatus* Zone. This absence of *R. pseudoumbilica* is noted in the same stratigraphic interval at other tropical Pacific DSDP sites (55, 56, 62, 71 and 83). Some specimens of *R. pseudoumbilica* from lower cores, such as, 17B and 19B, have central areas that have been overly calcified and resemble *Coccolithus bisectus* of the Eocene and Oligocene. In Core 28B some specimens of a similar but smaller and more elongate species, *Reticulofenestra gartneri*, have a calcified central area, and these too resemble *C. bisectus*.

The Oligocene of Cores 37B to 51B extends from a subbottom depth of 343 meters to 471 meters and has a well diversified and abundant assemblage. *Helicopontosphaera reticulata*, a guide to the lower Oligocene, is normally not preserved in deep-ocean assemblages but is present here in Core 51B. In sharp contrast, small upper Eocene assemblages in Cores 52B and 53B appear to have been so decimated by solution that only the more resistant taxa, such as, *Coccolithus bisectus, Coccolithus eopelagicus, Cyclococcolithina formosa, Discoaster barbadiensis, Discoaster saipanensis*, and *Reticulofenestra umbilica* are common.

Site 78

The extensive lower Miocene and Oligocene section cored at Site 78 (Cores 5 to 32) is comparable to that at Site 77B in stratigraphic thickness and diversity of assemblages. *Coccolithus fenestratus* is unusually abundant in Core 19, which is assigned to the *Sphenolithus ciperoensis* Zone of late Oligocene age.

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

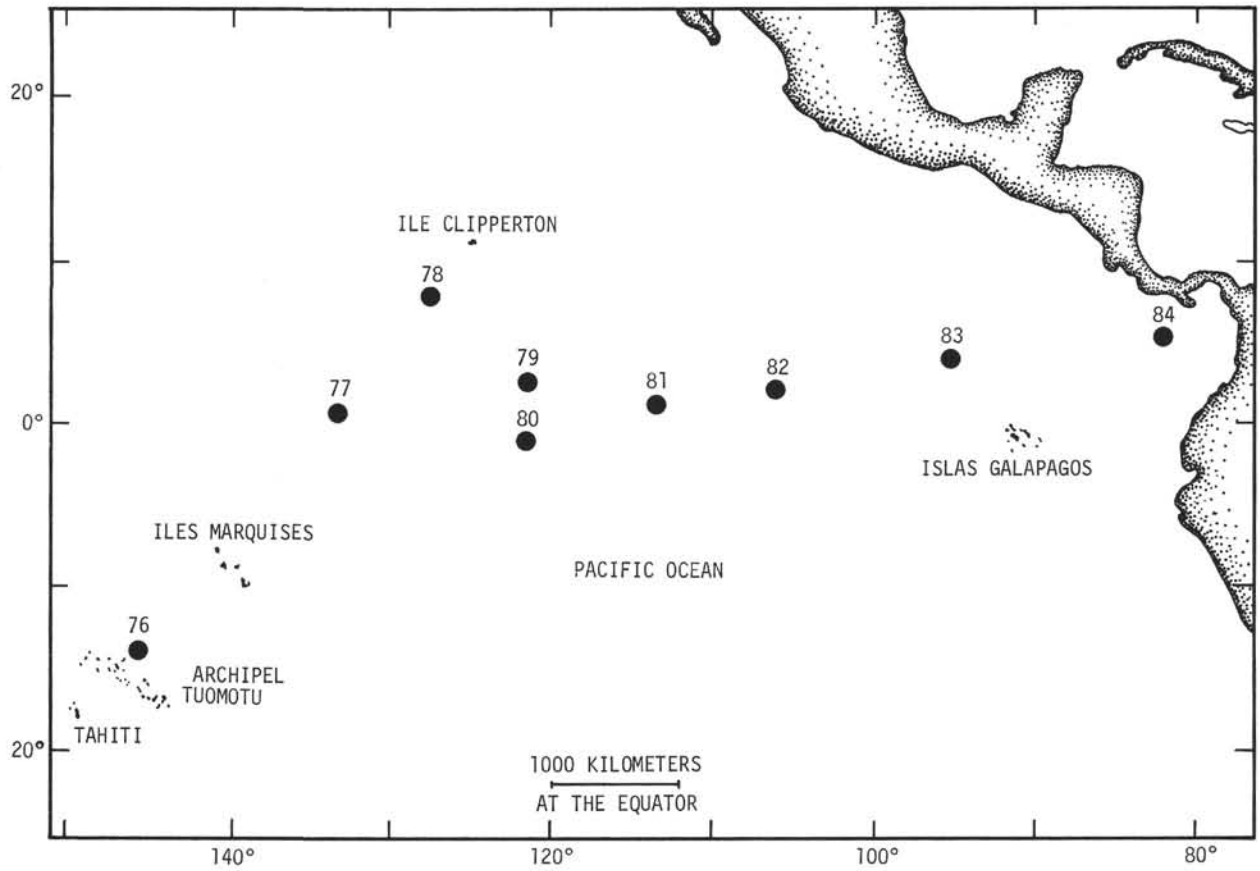

Figure 1. *Sites cored during Leg 9, Deep Sea Drilling Project.*

Sites 79 to 84

Cores from Sites 79 to 84 are largely late Miocene to late Pleistocene in age. Continuous sections through this interval are available at Site 83, Cores 1A to 16A, and at Site 84, Cores 1 to 28.

A bizarre double form of *Ceratolithus tricorniculatus* (figured in Bukry and Bramlette, 1968), which is a guide to lower Pliocene assemblages when present, occurs in Core 3A of Hole 82A and Core 9A of Hole 83A. The lower part of the upper Miocene or lower Pliocene *Ceratolithus rugosus* Zone contains a transitional form of ceratolith having a pointed arch and moderate birefringence in cross-polarized light (Core 2 of Hole 79). These characters and the stratigraphic restriction of the ceratolith to this zone indicate that it is a transitional form between *Ceratolithus tricorniculatus* and *Ceratolithus rugosus*. A similar form was noted in cores recovered during Deep Sea Drilling Project Leg 8, which also investigated the tropical Pacific.

Lower in the section, *Ceratolithus tricorniculatus* is the only ceratolith present. The distinction of the *Ceratolithus tricorniculatus* Zone assemblage from that of the underlying *Discoaster quinqueramus* Zone depends on the criteria of the zonation applied. If the earliest occurrence of *C. tricorniculatus* is chosen as the exclusive criterion in distinguishing the zones, several problems arise. Application of a zonal system that used the earliest presence of a single specimen of *C. tricorniculatus* as the defining criterion of the *C. tricorniculatus* Zone would be plagued by the relationship indicated in Hole 84, where assemblages containing rare *C. tricorniculatus* (one or two specimens after protracted search; Core 27) are interspersed with assemblages that apparently lack *C. tricorniculatus* (Cores 26 and 28). As both the samples with and samples lacking this species are dominated by *D. quinqueramus* and *D. surculus*, a resultant biostratigraphy of little utility would show either an alternation of the *C. tricorniculatus* Zone and the *D. quinqueramus* Zone through the interval, or one broad *C. tricorniculatus* Zone.

Samples from the upper upper Miocene interval of the acme of *C. tricorniculatus* lack *Discoaster quinqueramus* and *Ceratolithus rugosus* and are readily assigned to the *C. tricorniculatus* Zone, not only by the common occurrence of *C. tricorniculatus* but also by the overlap in the ranges of nearly spheric *Scyphosphaera* sp. cf. *S. apsteinii* and rod-like *Triquetrorhabdulus rugosus* [9-83A-11A-4, 60-61 cm]. Below this

TABLE 1

Zonal and Geologic Age Assignments of Cores From Leg 9 as Indicated by the Examined Samples

AGE	ZONE \ DSDP HOLE	76A	77A	77B	78	79	79A	80	80A	81	82	82A	83	83A	84
PLEISTOCENE	*Gephyrocapsa oceanica*		1			1					1		2	1-2	1-5
PLEISTOCENE	*Coccolithus doronicoides*			1-2			1	1		1		1-2	2-3	3	6-9
PLIOCENE	*Discoaster brouweri*			3-4			1				2	2		3-6	10-16
PLIOCENE	*Reticulofenestra pseudoumbilica*			5-6					2					7-8	17-20
PLIOCENE	*Ceratolithus rugosus*			7-8		2						3		9-10	21
PLIOCENE	*Ceratolithus tricorniculatus*			9-13		2	2				3-4			11	22-23
MIOCENE	*Discoaster quinqueramus*			14-17		3	?3	2			6		5	12-15	24-28
MIOCENE	*Discoaster neohamatus*												6-7	16	
MIOCENE	*Discoaster hamatus*			18											
MIOCENE	*Catinaster coalitus*														
MIOCENE	*Discoaster exilis*			19-23	1	4			3						
MIOCENE	*Sphenolithus heteromorphus*			24-27	2-4	5-6		3		3					
MIOCENE	*Helicopontosphaera ampliaperta*														
MIOCENE	*Sphenolithus belemnos*			28	5	7			5						
MIOCENE	*Triquetrorhabdulus carinatus*	1-2		29-36	6-16			4-5							
OLIGOCENE	*Sphenolithus*			37-42	17-22										
OLIGOCENE	*Sphenolithus distentus*			43-47	23-28										
OLIGOCENE	*Sphenolithus predistentus*			48-50	30-32										
OLIGOCENE	*Helicopontosphaera reticulata*			51											
EOCENE	*Discoaster barbadiensis*			52-53											
EOCENE	*Reticulofenestra umbilica*														

assemblage is one in which *Discoaster quinqueramus* and *D. surculus* are especially common. This earlier assemblage identifies the *D. quinqueramus* Zone. If these distinctions are used in identifying the zones, then the occurrence of rare specimens of *C. tricorniculatus* in assemblages dominated by *D. quinqueramus* and *D. surculus* is not considered diagnostic [Hole 84, Core 27]. Examination of coccolith sequences from all DSDP coring sites reported to date (84 sites) indicates that the widespread acmes of *Discoaster quinqueramus* and *Ceratolithus tricorniculatus* are sequential and readily recognizable in warm-water areas.

The upper Miocene *Discoaster neohamatus* Zone in Hole 83, Cores 6 and 7, contains few specimens of *Discoaster neohamatus* and is characterized by an assemblage preceding the common occurrence of *D. quinqueramus* and *D. surculus*. The presence together of *Discoaster brouweri s.l.* with slight or no bending of the rays, *Discoaster variabilis* with unequal bifurcations, and a simple five-rayed discoaster that probably developed from *Discoaster hamatus* seems to best characterize the *D. neohamatus* Zone in cores from the eastern tropical Pacific.

Of the 199 cores totaling 1538 meters of recovery, only one of the cores examined is barren of coccoliths. The diversity and abundance of planktonic microfossils in these cores will make them valuable reference material for studies involving the interrelations of paleoecology and stratigraphy. For example, in Hole 84 does the abundance of still living *Coccolithus pelagicus* in the late Miocene (Cores 24 and 25) and late Pliocene (Cores 9 and 10), in contrast with its rarity in the Pliocene and Quaternary, signify periods of strong cooling (McIntyre and Be, 1967) in this area of the tropics? Is the presence of *Discolithina multipora* in the late Cenozoic of this region, in contrast to its general absence in sediment recovered on previous DSDP Pacific legs, a result of local ecologic factors favoring increased productivity of this species, or a result of less active solution of coccoliths owing to deposition at their present relatively shallow oceanic depth of 3000 to 4500 meters?

ACKNOWLEDGMENTS

Special thanks are extended to Walter Schneider and Nadia Harmash, both with the Deep Sea Drilling Project, and to Velma Hill, U. S. Geological Survey, for their help during the preparation of the report. Valuable discussions with M. N. Bramlette, Scripps Institution of Oceanography, G. W. Moore, U. S. Geological Survey, and S. F. Percival, Princeton University, are also gratefully acknowledged.

Index of coccolith trivial names considered

abies, Sphenolithus
abisectus, Coccolithus
annula, Emiliania
apsteinii, Scyphosphaera
asymmetricus, Discoaster
aulakos, Discoaster
barbadiensis, Discoaster
belemnos, Sphenolithus
bigelowi, Braarudosphaera
bijugatus, Zygrhablithus
bisectus, Coccolithus
brouweri, Discoaster
caribbeanica, Gephyrocapsa
carinatus, Triquetrorhabdulus
challengeri, Discoaster
ciperoensis, Sphenolithus
clavigera, Rhabdosphaera
compacta, Helicopontosphaera
deflandrei, Discoaster
dela, Campylosphaera
dilatus, Discoaster
distentus, Sphenolithus
doronicoides, Coccolithus
druggii, Discoaster
eopelagicus, Coccolithus
exilis, Discoaster
fenestratus, Coccolithus
formosa, Cyclococcolithina
gartneri, Reticulofenestra
grandis, Chiasmolithus
hamatus, Discoaster
heteromorphus, Sphenolithus
histrica, Syracosphaera
intermedia, Helicopontosphaera
japonica, Discolithina
kamptneri, Helicopontosphaera
kugleri, Discoaster
leptopora, Cyclococcolithina
lidzi, Discoaster
lodoensis, Discoaster
macintyrei, Cyclococcolithina
mirabilis, Umbilicosphaera
moriformis, Sphenolithus
multipora, Discolithina
neoabies, Sphenolithus

Index of coccolith trivial names considered – Cont'd.

neogammation, Cyclococcolithina
neohamatus, Discoaster
oamaruensis, Chiasmolithus
obliqua, Helicopontosphaera
oceanica, Gephyrocapsa
parallela, Helicopontosphaera
pelagicus, Coccolithus
pentaradiatus, Discoaster
perplexus, Discoaster
predistentus, Sphenolithus
pseudoumbilica, Reticulofenestra
pulcherrima, Scyphosphaera
quinqueramus, Discoaster
recurvus, Isthmolithus
reticulata, Helicopontosphaera
rotula, Cyclococcolithina
rugosus, Ceratolithus
rugosus, Triquetrorhabdulus
saipanensis, Discoaster
saxea, Thoracosphaera
sellii, Helicopontosphaera
serraculoides, Bramletteius
serratus, Orthorhabdus
stylifera, Rhabdosphaera
surculus, Discoaster
tani nodifer, Discoaster
tani tani, Discoaster
tribrachiatus, Marthasterites
tricorniculatus, Ceratolithus
umbilica, Reticulofenestra
vadosa, Pontosphaera
variabilis, Discoaster

TABLE 2

Coccolith Species Considered in this Report

Braarudosphaera bigelowi (Gran and Braarud)
Bramletteius serraculoides Gartner
Campylosphaera dela (Bramlette and Sullivan)
Ceratolithus cristatus Kamptner
Ceratolithus rugosus Bukry and Bramlette

TABLE 2 – *Continued*

Ceratolithus tricorniculatus Gartner
Chiasmolithus grandis (Bramlette and Riedel)
Chiasmolithus oamaruensis (Deflandre)
Coccolithus abisectus Muller
Coccolithus bisectus (Hay, Mohler, and Wade) of Bramlette and Wilcoxon)
Coccolithus doronicoides Black and Barnes
Coccolithus eopelagicus (Bramlette and Riedel)
Coccolithus fenestratus (Deflandre and Fert)
Coccolithus pelagicus (Wallich)
Cyclococcolithina formosa (Kamptner)
Cyclococcolithina leptopora (Murray and Blackman)
Cyclococcolithina macintyrei (Bukry and Bramlette)
Cyclococcolithina neogammation (Bramlette and Wilcoxon)
Cyclococcolithina rotula (Kamptner)
Discoaster asymmetricus Gartner
Discoaster aulakos Gartner
Discoaster barbadiensis Tan
Discoaster brouweri Tan
Discoaster challengeri Bramlette and Riedel
Discoaster deflandrei Bramlette and Riedel
Discoaster dilatus Hay
Discoaster druggii Bramlette and Wilcoxon
Discoaster exilis Martini and Bramlette
Discoaster hamatus Martini and Bramlette
Discoaster kugleri Martini and Bramlette
Discoaster lidzi Hay
Discoaster lodoensis Bramlette and Riedel
Discoaster neohamatus Bukry and Bramlette
Discoaster pentaradiatus Tan
Discoaster perplexus Bramlette and Riedel
Discoaster quinqueramus Gartner
Discoaster saipanensis Bramlette and Riedel
Discoaster surculus Martini and Bramlette
Discoaster tani nodifer Bramlette and Riedel
Discoaster tani tani Bramlette and Riedel
Discoaster variabilis Martini and Bramlette
Discolithina japonica Takayama
Discolithina multipora (Kamptner)
Emiliania annula (Cohen)
Gephyrocapsa caribbeanica Boudreaux and Hay

TABLE 2 – *Continued*

Gephyrocapsa oceanica Kamptner
Helicopontosphaera compacta (Bramlette and Wilcoxon)
Helicopontosphaera intermedia (Martini)
Helicopontosphaera kamptneri Hay and Mohler
Helicopontosphaera parallela (Bramlette and Wilcoxon)
Helicopontosphaera obliqua (Bramlette and Wilcoxon)
Helicopontosphaera reticulata (Bramlette and Wilcoxon)
Helicopontosphaera sellii Bukry and Bramlette
Isthmolithus recurvus Deflandre
Orthorhabdus serratus Bramlette and Wilcoxon
Marthasterites tribrachiatus (Bramlette and Riedel)
Pontosphaera vadosa Hay, Mohler, and Wade
Reticulofenestra gartneri Roth and Hay
Reticulofenestra pseudoumbilica (Gartner)
Reticulofenestra umbilica (Levin)
Rhabdosphaera clavigera Murray and Blackman
Rhabdosphaera stylifera Lohmann
Scyphosphaera apsteinii Lohmann
Scyphosphaera pulcherrima Deflandre
Sphenolithus abies Deflandre
Sphenolithus belemnos Bramlette and Wilcoxon
Sphenolithus ciperoensis Bramlette and Wilcoxon
Sphenolithus distentus (Martini)
Sphenolithus heteromorphus Deflandre
Sphenolithus moriformis (Bronnimann and Stradner)
Sphenolithus neoabies Bukry and Bramlette
Sphenolithus predistentus Bramlette and Wilcoxon
Syracosphaera histrica Kamptner
Thoracosphaera saxea Stradner
Triquetrorhabdulus carinatus Martini
Triquetrorhabdulus rugosus Bramlette and Wilcoxon
Umbilicosphaera mirabilis Lohmann
Zygrhablithus bijugatus (Deflandre)

Coccolith Stratigraphy of Cores from Leg 9

Sample numbers given under the biostratigraphic zones for each site consist of elements in the following sequence: (cruise-leg number)–(drill-hole designation, consisting of site number plus a letter suffix if more than one hole)–(core designation)–(core-section number), (interval in centimeters below the top of each core section). For example, 9-77B-9B-2, 70-71 cm, indicates that the sample came from Leg 9, Hole 77B (at Site 77), the ninth barrel of core recovered from that hole, the second section from the top of that core, and from 70 to 71 centimeters below the top of the section. Core sections are 1.5 meters long, and most core runs were 9.1 meters long, but occasionally the core liners were not full. In this report, the tops of recoveries are arbitrarily placed at the top of the core runs, and an approximate depth in meters below the sea floor follows each sample number.

HOLES 76 AND 76A
(lat 14° 05.90'S., long 145° 39.64'W., depth 4598 meters)

Coccoliths in Selected Samples, Hole 76

Series Not Determined

9-76-1-2, 68-69 cm; depth 2 m:
Barren.

9-76-1-3, 64-65 cm; depth 4 m:
Barren.

Mixed, Eocene or Oligocene to Miocene or Pliocene

9-76-1-5, 42-43 cm; depth 6 m:
C. formosa, C. leptopora, D. brouweri s.l., Discoaster sp. cf. *D. deflandrei, D. dilatus, Discoaster* sp. cf. *D. pentaradiatus, R. pseudoumbilica, R. umbilica, Sphenolithus* sp.

9-76-1-6, 62-63 cm; depth 8 m:
B. serraculoides, C. eopelagicus, C. neogammation, Discoaster sp. cf. *D. deflandrei.*

Coccoliths in Selected Samples, Hole 76A

Upper Oligocene or Lower Miocene, with Reworked Eocene and Oligocene
(*Sphenolithus ciperoensis* Zone or *Triquetrorhabdulus carinatus* Zone)

9-76A-1A-1, 115-116 cm; depth 10 m:
C. bisectus, C. abisectus, D. deflandrei, S. ciperoensis, S. moriformis, T. carinatus. Reworked taxa: *B. bigelowi, D. barbadiensis, D. tani tani, H. compacta, S. distentus, S. predistentus, Z. bijugatus.*

9-76A-1A-6, 63-64 cm; depth 17 m:
C. bisectus, C. abisectus, C. neogammation, D. deflandrei, S. ciperoensis, S. moriformis, T. carinatus. Reworked taxa: *B. serraculoides, C. dela, C. grandis, D. barbadiensis, D. lodoensis, D. tani tani, S. predistentus, Z. bijugatus.*

9-76A-2A-3, 83-84 cm; depth 22 m:
C. bisectus, C. abisectus, C. neogammation, D. deflandrei, H. parallela, S. ciperoensis, T. carinatus. Reworked taxa: *B. serraculoides, C. dela, C. grandis, D.*

barbadiensis, D. lodoensis, H. compacta, R. umbilica, S. predistentus.

9-76A-2A-5, 42-43 cm; depth 25 m:
C. eopelagicus, C. neogammation, D. deflandrei [abundant], *S. moriformis, T. carinatus.*

9-76A-2A-6, 61-61 cm; depth 26 m:
C. abisectus, C. eopelagicus [some centerless], *C. neogammation, D. deflandrei* [some centerless], *T. carinatus.*

HOLES 77A AND 77B
(lat 00° 28.90'N., long 133° 13.70'W., depth 4291 meters)

Coccoliths in Selected Sample, Hole 77A

Pleistocene
(*Gephyrocapsa oceanica* **Zone**)

9-77A-1A-4, 61-62 cm; depth 5 m:
C. cristatus, C. rugosus, C. doronicoides, C. leptopora, E. annula, G. oceanica, H. kamptneri.

Coccoliths in Selected Samples, Hole 77B

Pleistocene
(*Coccolithus doronicoides* **Zone**)

9-77B-1B-4, 61-62 cm; depth 14 m:
C. cristatus, C. doronicoides, C. leptopora, E. annula, H. kamptneri.

9-77B-2B-4, 68-69 cm; depth 23 m:
C. cristatus, C. doronicoides, C. leptopora, G. caribbeanica, H. kamptneri, T. saxea.

Upper Pliocene
(*Discoaster brouweri* **Zone**, *Cyclococcolithina macintyrei* **Subzone**)

9-77B-3B-1, 80-81 cm; depth 28 m:
C. rugosus, C. doronicoides, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. perplexus, H. kamptneri, H. sellii.

9-77B-3B-3, 80-81 cm; depth 31 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, H. kamptneri.

Upper Pliocene
(*Discoaster brouweri* **Zone**, *Discoaster pentaradiatus* **Subzone**)

9-77B-4B-3, 70-71 cm; depth 40 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri [abundant], *Discoaster* sp. aff. *D. exilis, D. pentaradiatus, D. surculus, D. variabilis.*

9-77B-4B-4, 66-67 cm; depth 42 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus, Discoaster sp. cf. *D. variabilis* [long rays, narrow tips], *H. kamptneri.*

9-77B-4B-6, 70-71 cm; depth 45 m:
C. rugosus, C. pelagicus, C. macintyrei, D. asymmetricus, D. brouweri, D. variabilis.

Lower Pliocene
(*Reticulofenestra pseudoumbilica* **Zone**, *Discoaster asymmetricus* **Subzone**)

9-77B-5B-3, 70-71 cm; depth 49 m:
C. rugosus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies.

Lower Pliocene
(*Reticulofenestra pseudoumbilica* **Zone**, *Sphenolithus neoabies* **Subzone**)

9-77B-5B-6, 80-81 cm; depth 54 m:
C. rugosus, C. leptopora, C. macintyrei, D. brouweri, D. variabilis, H. sellii, R. umbilica, S. abies, S. neoabies.

9-77B-6B-3, 89-90 cm; depth 59 m:
C. rugosus, C. leptopora, C. macintyrei, D. brouweri, D. surculus, D. variabilis, H. kamptneri, H. sellii, R. pseudoumbilica, S. abies, S. neoabies.

Upper Miocene or Lower Pliocene
(*Ceratolithus rugosus* **Zone**)

9-77B-7B-4, 63-64 cm; depth 69 m:
C. rugosus, C. tricorniculatus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. exilis, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. neoabies.

9-77B-8B-3, 80-81 cm; depth 77 m:
Ceratolithus sp. cf. *C. rugosus* [pointed arch, birefringent], *C. tricorniculatus, C. pelagicus. C. leptopora, C. macintyrei, D. brouweri, D. surculus, R. pseudoumbilica.*

Upper Miocene
(*Ceratolithus tricorniculatus* **Zone**)

9-77B-9B-2, 70-71 cm; depth 84 m:
C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, Discoaster sp. aff. *D. exilis* [webbed rays], *D. surculus, D. variabilis, R. pseudoumbilica.*

9-77B-10B-4, 70-71 cm; depth 97 m:
C. tricorniculatus, C. pelagicus, C. leptopora, D. brouweri, D. exilis, D. quinqueramus, D. surculus, R. pseudoumbilica, T. rugosus.

9-77B-13B-4, 2-3 cm; depth 123 m:
C. tricorniculatus, C. pelagicus, C. leptopora, C. macin-

tyrei, D. brouweri, D. challengeri, D. exilis, D. surculus, D. variabilis, T. rugosus.

9-77B-13B-6, 70-71 cm; depth 127 m:
C. tricorniculatus, C. pelagicus [abundant], *C. leptopora, C. macintyrei, D. brouweri, D. challengeri* [rare], *D. surculus, T. rugosus.*

Upper Miocene
(*Discoaster quinqueramus* **Zone or** *Discoaster neohamatus* **Zone)**

9-77B-14B-2, 70-71 cm; depth 130 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, Discoaster sp. cf. *D. quinqueramus, Discoaster* sp. cf. *D. surculus, D. variabilis, H. kamptneri, T. rugosus.*

9-77B-15B-4, 71-72 cm; depth 142 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. challengeri, Discoaster sp. cf. *D. exilis, D. variabilis, H. kamptneri, S. abies, S. neoabies, T. rugosus.*

9-77B-16B-4, 63-64 cm; depth 151 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. challengeri, Discoaster sp. cf. *D. exilis, D. pentaradiatus, D. variabilis* [unequal bifurcations], *Discoaster* sp. [five tapering rays], *S. abies, S. neoabies, T. rugosus.*

9-77B-17B-4, 68-69 cm; depth 161 m:
C. pelagicus, C. macintyrei, D. brouweri, D. challengeri, D. pentaradiatus, R. pseudoumbilica [some specimens resemble lower Tertiary *C. bisectus*], *T. rugosus.*

9-77B-17B-6, 73-74 cm; depth 164 m:
C. leptopora, D. brouweri s.l., D. challengeri, D. exilis, R. pseudoumbilica [abundant], *T. rugosus.*

Upper Miocene
(*Discoaster hamatus* **Zone)**

9-77B-18B-2, 85-86 cm; depth 167 m:
C. leptopora, C. macintyrei, D. challengeri, Discoaster sp. cf. *D. exilis, D. hamatus* [rare], *Discoaster* sp. [five tapering rays, abundant], *R. pseudoumbilica* [abundant], *T. rugosus.*

9-77B-18B-6, 73-74 cm; depth 173 m:
C. pelagicus, C. leptopora, C. macintyrei, D. challengeri, Discoaster sp. cf. *D. exilis, D. hamatus, Discoaster* sp. [five tapering rays], *H. kamptneri s.l., R. pseudoumbilica, T. rugosus.*

Middle Miocene
(*Discoaster exilis* **Zone)**

9-77B-19B-4, 63-64 cm; depth 176 m:
C. eopelagicus, C. pelagicus, C. macintyrei, Discoaster sp. cf. *D. exilis, Discoaster* sp. cf. *D. variabilis, R. pseudoumbilica* [some specimens mimic *C. bisectus*], *T. rugosus.*

Middle Miocene
(*Discoaster exilis* **Zone,** *Discoaster kugleri* **Subzone)**

9-77B-20B-4, 63-64 cm; depth 165 m:
C. eopelagicus, C. pelagicus, C. leptopora s.l., D. exilis, D. kugleri, H. kamptneri, H. sellii, R. pseudoumbilica, S. neoabies, T. rugosus.

Middle Miocene
(*Discoaster exilis* **Zone,** *Coccolithus eopelagicus* **Subzone)**

9-77B-23B-4, 63-64 cm; depth 212 m:
C. eopelagicus, C. pelagicus, Coronocyclus sp., *Discoaster* sp. cf. *D. dilatus, D. exilis, Discoaster* sp. cf. *D. exilis, R. pseudoumbilica.*

Middle Miocene
(*Sphenolithus heteromorphus* **Zone)**

9-77B-24B-4, 78-79 cm; depth 222 m:
C. eopelagicus, C. neogammation, D. brouweri s.l., D. deflandrei, D. exilis, Discoaster sp. cf. *D. exilis, H. kamptneri s.l., R. pseudoumbilica, S. heteromorphus.*

9-77B-26B-4, 71-72 cm; depth 240 m:
C. eopelagicus, Coronocyclus sp. [large], *C. neogammation, D. aulakos, D. deflandrei, Discoaster* sp. cf. *D. exilis, S. heteromorphus.*

9-77B-27B-4, 67-68 cm; depth 249 m:
C. eopelagicus, C. pelagicus, C. neogammation, D. deflandrei, Discoaster sp. cf. *D. exilis, S. heteromorphus* [abundant].

Lower Miocene
(*Sphenolithus belemnos* **Zone)**

9-77B-28B-4, 63-64 cm; 258 m:
C. eopelagicus, C. pelagicus, Coronocyclus sp., *C. neogammation, Discoaster* sp. cf. *D. aulakos, D. deflandrei, Discoaster* sp. cf. *D. druggii, Reticulofenestra* sp. cf. *R. gartneri, S. belemnos* [rare], *S. moriformis, T. carinatus* [short].

Lower Miocene
(*Triquetrorhabdulus carinatus* **Zone,** *Discoaster druggii* **Subzone)**

9-77B-29B-4, 62-63 cm; depth 267 m:
C. eopelagicus, C. pelagicus, C. neogammation, D. deflandrei, D. druggii, O. serratus, R. gartneri [some specimens resemble *C. bisectus*], *S. moriformis, T. carinatus* [short].

9-77B-33B-4, 64-65 cm; depth 304 m;
C. eopelagicus, C. pelagicus, C. neogammation, D. deflandrei, Discoaster sp. cf. *D. druggii, R. gartneri* [some specimens resemble *C. bisectus*], *T. carinatus* [abundant].

Lower Miocene
(*Triquetrorhabdulus carinatus* **Zone**, *Coccolithus abisectus* **Subzone**)

9-77B-34B-4, 66-67 cm; depth 313 m:
C. abisectus, C. eopelagicus, C. pelagicus, C. neogammation, D. deflandrei, S. belemnos, S. moriformis, T. carinatus [abundant].

9-77B-36B-2, 63-64 cm; depth 328 m:
C. pelagicus, C. neogammation, D. deflandrei, Reticulofenestra sp. cf. *R. gartneri, S. moriformis, T. carinatus.*

Upper Oligocene
(*Sphenolithus ciperoensis* **Zone**)

9-77B-37B-4, 65-66 cm; depth 343 m:
C. abisectus, C. bisectus, C. eopelagicus, C. pelagicus, C. neogammation, D. deflandrei, R. gartneri, S. ciperoensis, S. moriformis, T. carinatus.

9-77B-39B-4, 64-65 cm; depth 359 m:
C. abisectus, C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, R. gartneri, S. ciperoensis, S. distentus [rare], *S. moriformis, T. carinatus.*

9-77B-42B-2, 75-76 cm; depth 383 m:
Chiasmolithus sp. [rims], *C. abisectus, C. eopelagicus, C. neogammation, D. deflandrei, R. gartneri, S. ciperoensis, S. distentus, S. moriformis* [small forms abundant].

Middle Oligocene
(*Sphenolithus distentus* **Zone**)

9-77B-43B-5, 50-51 cm; depth 397 m:
C. abisectus [rare], *C. eopelagicus, Coccolithus* sp. cf. *C. fenestratus, C. neogammation, D. deflandrei, R. gartneri, S. distentus, S. moriformis* [small forms abundant].

9-77B-47B-4, 63-64 cm; depth 432 m:
Chiasmolithus sp. aff. *C. oamaruensis, C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, H. compacta, R. gartneri, S. distentus, S. moriformis, S. predistentus.*

Middle Oligocene
(*Sphenolithus predistentus* **Zone**)

9-77B-48B-5, 63-64 cm; depth 442 m:
C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, D. tani tani, H. compacta [common], *R. gartneri, S. moriformis, S. predistentus.*

9-77B-49B-5, 64-65 cm; depth 452 m:
C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, D. tani nodifer, D. tani tani, R. gartneri, S. moriformis, S. predistentus.

9-77B-50B-2, 115-116 cm; depth 457 m:
C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, D. tani tani, H. compacta, R. gartneri, S. moriformis, S. predistentus.

Lower Oligocene
(*Helicopontosphaera reticulata* **Zone**)

9-77B-51B-5, 73-74 cm; depth 469 m:
B. serraculoides, C. bisectus, C. eopelagicus, Coccolithus sp. cf. *C. fenestratus, Cyclococcolithina formosa, C. neogammation, D. deflandrei, H. compacta, H. reticulata, P. vadosa, R. gartneri, R. umbilica, Reticulofenestra* sp. cf. *R umbilica, S. moriformis.*

9-77B-51B-6, 78-79 cm; depth 471 m:
B. serraculoides, C. bisectus, C. formosa, C. neogammation, D. deflandrei, D. tani tani, H. reticulata, P. vadosa, R. gartneri, R. umbilica, Reticulofenestra sp. cf. *R. umbilica, S. moriformis.*

Upper Eocene
(*Discoaster barbadiensis* **Zone**)

9-77B-52B-1, 49 cm; depth 472 m:
C. bisectus, C. eopelagicus, C. formosa, D. saipanensis, D. tani tani, I. recurvus, P. vadosa, R. umbilica.

9-77B-52B-2, 59-60 cm; depth 473 m:
C. bisectus, C. eopelagicus, C. formosa, D. barbadiensis, D. saipanensis, R. umbilica.

9-77B-53B-1, 60-61 cm; depth 477 m:
C. bisectus, C. eopelagicus, C. formosa, D. barbadiensis, D. saipanensis, R. umbilica. Reworked taxon: *M. tribrachiatus.*

HOLE 78
(lat 07° 57.00′N., long 127° 21.35′W., depth 4378 meters)

Coccoliths in Selected Samples, Hole 78

Middle Miocene
(*Discoaster exilis* **Zone**)

9-78-1-4, 63-64 cm; depth 5 m:
C. eopelagicus, C. pelagicus, Coronocyclus sp., *C. macintyrei, C. neogammation, D. brouweri s.l., Discoaster* sp. cf. *D. exilis, D. perplexus, H. kamptneri s.l., Reticulofenestra* sp. cf. *R. pseudoumbilica.*

Middle Miocene
(*Sphenolithus heteromorphus* **Zone**)

9-78-2-4, 20-21 cm; depth 14 m:
C. eopelagicus, C. pelagicus, C. neogammation, D. brouweri s.l., D. deflandrei, D. exilis, Discoaster sp. cf. *D. exilis, H. kamptneri s.l., S. heteromorphus.*

9-78-3-4, 65-66 cm; depth 23 m:
Same as above.

9-78-4-4, 65-66 cm; depth 33 m:
Same as above.

Lower Miocene
(*Sphenolithus belemnos* Zone)

9-78-5-4, 63-64 cm; depth 42 m:
C. eopelagicus, Coronocyclus sp. *C. neogammation, D. aulakos, D. deflandrei, Discoaster* sp. cf. *D. druggii* [rare], *Orthorhabdus* sp. [conical], *R. gartneri, S. belemnos, S. moriformis, T. carinatus* [short, rare].

Lower Miocene
(*Triquetrorhabdulus carinatus* Zone, *Discoaster druggii* Subzone)

9-78-6-4, 63-64 cm; depth 51 m:
C. abisectus, C. eopelagicus, Coronocyclus sp., *C. neogammation, D. deflandrei, D. druggii, O. serratus, S. moriformis, T. carinatus.*

Lower Miocene
(*Triquetrorhabdulus carinatus* Zone, *Coccolithus abisectus* Subzone)

9-78-7-4, 63-64 cm; depth 60 m:
C. abisectus, C. eopelagicus, C. neogammation, D. deflandrei, Discolithina sp., *S. moriformis, T. carinatus.*

9-78-9-6, 38-39 cm; depth 81 m:
C. abisectus, C. eopelagicus, C. neogammation, D. deflandrei, Discolithina sp., *H. intermedia, H. parallela, Sphenolithus* sp. aff. *S. belemnos, S. moriformis, T. carinatus.*

9-78-16-4, 63-64 cm; depth 142 m:
C. abisectus, C. eopelagicus, C. neogammation, Discoaster sp. cf. *D. aulakos, D. deflandrei, D. lidzi, Sphenolithus* sp. aff. *S. belemnos, S. moriformis, T. carinatus.*

Upper Oligocene
(*Sphenolithus ciperoensis* Zone)

9-78-17-4, 62-63 cm; depth 151 m:
C. abisectus, C. eopelagicus, C. fenestratus, C. neogammation, D. deflandrei, H. intermedia, R. gartneri, Sphenolithus sp. aff. *S. belemnos, S. ciperoensis, S. moriformis, T. carinatus* [abundant].

9-78-18-6, 63-64 cm; depth 164 m:
C. abisectus, C. bisectus, C. eopelagicus, C. fenestratus, C. neogammation, D. deflandrei, H. intermedia, R. gartneri, S. ciperoensis, S. moriformis, T. carinatus.

9-78-19-4, 62-63 cm; depth 170 m:
C. abisectus, C. eopelagicus, C. fenestratus [unusually abundant], *C. neogammation, D. deflandrei, Discolithina* sp., *H. intermedia, S. moriformis, T. carinatus.*

9-78-20-4, 63-64 cm; depth 179 m:
C. abisectus, C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, Discolithina sp., *H. intermedia, H. parallela, R. gartneri, S. moriformis, T. carinatus.*

9-78-21-4, 63-64 cm; depth 188 m:
Chiasmolithus sp. aff. *C. oamaruensis, C. abisectus, C. bisectus, C. eopelagicus, C. fenestratus, C. neogammation, D. deflandrei, R. gartneri, S. ciperoensis, S. moriformis, T. carinatus.*

9-78-22-6, 70-71 cm; depth 200 m:
C. abisectus, C. eopelagicus, Coronocyclus sp., *C. neogammation, D. deflandrei, R. gartneri, S. ciperoensis, S. moriformis* [small], *T. carinatus* [short].

Middle Oligocene
(*Sphenolithus distentus* Zone)

9-78-23-4, 64-65 cm; depth 206 m:
C. abisectus, C. eopelagicus, C. neogammation, D. deflandrei, Discolithina sp., *R. gartneri, S. distentus, S. moriformis T. carinatus.*

9-78-27-4, 65-66 cm; depth 243 m:
C. abisectus, C. eopelagicus, C. neogammation, D. deflandrei, D. tani nodifer, H. intermedia, Helicopontosphaera sp. cf. *H. obliqua, H. parallela, R. gartneri* [abundant], *S. distentus, S. moriformis.*

9-78-28-4, 83-84 cm; depth 252 m:
C. abisectus, C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, D. tani nodifer, Helicopontosphaera sp. cf. *H. intermedia, R. gartneri, S. distentus, S. moriformis, S. predistentus.*

Middle Oligocene
(*Sphenolithus predistentus* Zone)

9-78-30-6, 56-57 cm; depth 273 m:
C. sp. aff. *C. oamaruensis, C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, D. tani nodifer, D. tani tani, H. compacta* [small, common], *R. gartneri, S. moriformis* [small, abundant], *S. predistentus.*

9-78-32-6, 65-66 cm; depth 292 m:
C. bisectus, C. eopelagicus, C. neogammation, D. deflandrei, D. tani tani, H. compacta, S. distentus, S. predistentus, S. moriformis.

HOLES 79 AND 79A
(lat 02° 33.02′N., long 121° 34.00′W., depth 4574 meters)

Coccoliths in Selected Samples, Hole 79

Pleistocene
(*Gephyrocapsa oceanica* Zone)

9-79-1-4, 60-61 cm; depth 5 m:
C. cristatus, C. leptopora, E. annula, G. oceanica, H. kamptneri.

Upper Miocene or Lower Pliocene
(*Ceratolithus rugosus* Zone)

9-79-2-1, 20-21 cm; depth 61 m:

Ceratolithus sp. cf. *C. rugosus* [slightly refringent, pointed arch], *C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri* [abundant], *Discoaster* sp. cf. *D. exilis, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies.*

9-79-2-4, 65-66 cm; depth 65 m:
Ceratolithus sp. cf. *C. rugosus, C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus, D. surculus, R. pseudoumbilica, S. abies.*

Upper Miocene
(*Ceratolithus tricorniculatus* **Zone**)

9-79-2-6, 110-111 cm; depth 69 m:
C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. pentaradiatus, D. surculus, D. variabilis, D. multipora s.l., R. pseudoumbilica, S. abies.

Upper Miocene
(*Discoaster quinqueramus* **Zone**)

9-79-3-4, 14-15 cm; depth 131 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri s.l. Discoaster sp. cf. *D. exilis, Discoaster* sp. cf. *D. quinqueramus, D. variabilis* [abundant, many forms], *H. kamptneri, R. pseudoumbilica* [rare], *S. abies, S. neoabies* [abundant], *T. rugosus.*

Middle Miocene
(*Discoaster exilis* **Zone**, *Discoaster kugleri* **Subzone**)

9-79-4-4, 2-3 cm; depth 198 m:
C. eopelagicus, C. pelagicus, C. leptopora, D. brouweri s.l., D. exilis, Discoaster sp. cf. *D. exilis, D. kugleri, R. pseudoumbilica* [abundant], *S. abies.*

Middle Miocene
(*Sphenolithus heteromorphus* **Zone**)

9-79-5-4, 67-68 cm; depth 265 m:
C. eopelagicus, C. pelagicus, C. leptopora, C. neogammation, D. deflandrei, D. sp. cf. *D. exilis, H. kamptneri, R. pseudoumbilica, S. heteromorphus.*

9-79-6-4, 30-31 cm; depth 332 m:
C. eopelagicus, C. pelagicus, Coronocyclus sp. [large, common], *C. leptopora, C. neogammation, D. deflandrei, H. kamptneri, R. pseudoumbilica* [small], *S. abies, S. heteromorphus* [small, common].

Lower Miocene
(*Sphenolithus belemnos* **Zone**)

9-79-7-4, 70-71 cm; depth 341 m:
C. eopelagicus, Coronocyclus sp. [large], *C. neogammation, D. deflandrei, D. lidzi, Reticulofenestra* sp. cf. *R. gartneri, S. belemnos, S. moriformis, T. carinatus* [short, few].

Coccoliths in Selected Samples, Hole 79A

Pleistocene
(*Coccolithus doronicoides* **Zone**)

7-79A-1A-4, 66-67 cm; depth 5 m:
C. cristatus, C. doronicoides, C. pelagicus [rare], *C. leptopora, C. macintyrei, D. japonica, H. kamptneri, H. sellii, Syracosphaera* sp.

Upper Pliocene
(*Discoaster brouweri* **Zone**, *Cyclococcolithina macintyrei* **Subzone**)

9-79A-1A-5, 86-87 cm; depth 7 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri [three- and six-rayed].

Upper Miocene
(*Ceratolithus tricorniculatus* **Zone**)

9-79A-2A-1, 100-101 cm; depth 70 m:
C. tricorniculatus [rare], *C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies.*

9-79A-2A-6, 100-101 cm; depth 78 m:
C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, Discoaster sp. aff. *D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, T. rugosus.*

Upper Miocene

9-79A-3A-4, 63-64 cm; depth 150 m:
C. macintyrei [rare], *D. brouweri, Discoaster* sp. cf. *D. exilis, D. variabilis* [abundant], *R. pseudoumbilica* [abundant].

HOLES 80 AND 80A
(lat 00° 57.72′S., long 121° 33.22′W., depth 4411 meters)

Coccoliths in Selected Samples, Hole 80

Pleistocene
(*Coccolithus doronicoides* **Zone**)

9-80-1-4, 73-74 cm; depth 5 m:
C. doronicoides, C. leptopora, E. annula, G. caribbeanica.

Upper Miocene
(*Discoaster quinqueramus* **Zone**)

9-80-2-4, 62-63 cm; depth 66 m:
C. tricorniculatus [rare], *C. pelagicus, C. leptopora, C. macintyrei, D. quinqueramus, D. surculus, D. variabilis, R. pseudoumbilica, T. rugosus.*

Middle Miocene
(*Sphenolithus heteromorphus* **Zone**)

9-80-3-4, 77-78 cm; depth 133 m:
C. eopelagicus, C. pelagicus, C. neogammation, D. deflandrei, Discoaster sp. cf. *D. exilis, H. kamptneri, S. heteromorphus, S. moriformis.*

Lower Miocene
(*Triquetrorhabdulus carinatus* **Zone**)

9-80-4-4, 63-64 cm; depth 172 m:
C. eopelagicus, C. pelagicus, C. neogammation, D. deflandrei, H. kamptneri s.l., H. parallela, R. gartneri, Sphenolithus sp. aff. *S. belemnos, S. moriformis, T. carinatus.*

Lower Miocene
(*Triquetrorhabdulus carinatus* **Zone**, *Coccolithus abisectus* **Subzone**)

9-80-5-2, 63-64 cm; depth 194 m:
C. abisectus, C. pelagicus, C. neogammation, D. deflandrei, H. intermedia, Sphenolithus sp. aff. *S. belemnos, S. moriformis, T. carinatus* [abundant].

Coccoliths in Selected Samples, Hole 80A

Lower Pliocene
(*Reticulofenestra pseudoumbilica* **Zone**)

9-80A-2A-1, 40-44 cm; depth 43 m:
C. rugosus, C. leptopora, C. macintyrei, D. brouweri, D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies.

9-80A-2A-4, 79-80 cm; depth 48 m:
C. rugosus, C. leptopora, C. macintyrei, D. brouweri, Discoaster sp. cf. *D. exilis, D. pentaradiatus, D. surculus, D. variabilis, D. japonica, R. pseudoumbilica, S. abies, S. neoabies.*

Middle Miocene
(*Discoaster exilis* **Zone**, *Discoaster kugleri* **Subzone**)

9-80A-3A-4, 64-65 cm; depth 92 m:
C. eopelagicus, C. leptopora, D. brouweri s.l., D. exilis, D. kugleri, R. pseudoumbilica, T. rugosus.

Lower Miocene
(*Sphenolithus belemnos* **Zone**)

9-80A-5A-4, 100-101 cm; depth 161 m:
C. eopelagicus, C. pelagicus, Coronocyclus sp. [small], *C. neogammation, D. deflandrei, H. kamptneri s.l., H. parallela, R. gartneri, S. belemnos.*

HOLE 81
(lat 01° 26.49′N., long 113° 48.54′W., depth 3865 meters)

Coccoliths in Selected Samples, Hole 81

Pleistocene
(*Coccolithus doronicoides* **Zone**)

9-81-1-4, 68-69 cm; depth 5 m:
C. cristatus, C. doronicoides, C. leptopora, E. annula, H. kamptneri.

Middle Miocene
(*Sphenolithus heteromorphus* **Zone**)

9-81-3-4, 61-62 cm; depth 382 m:
C. eopelagicus, C. pelagicus, C. macintyrei [rare], *C. neogammation, C. rotula, D. brouweri s.l., D. deflandrei, D. exilis, Discoaster* sp. cf. *D. exilis, Discolithina* sp. cf. *D. japonica, H. kamptneri, R. pseudoumbilica* [rare], *S. abies, S. heteromorphus.*

9-81-3-6, 120-121 cm; depth 385 m:
C. eopelagicus, C. pelagicus, C. macintyrei [rare], *C. neogammation, D. aulakos, D. deflandrei, D. exilis, H. kamptneri s.l., Reticulofenestra* sp. cf. *R. pseudoumbilica* [small], *S. heteromorphus.*

HOLES 82 AND 82A
(lat 02° 35.48′N., long 106° 56.52′W., depth 3707 meters)

Coccoliths in Selected Samples, Hole 82

Pleistocene
(*Gephyrocapsa oceanica* **Zone**)

9-82-1-1, 50-51 cm; depth 1 m:
C. cristatus, C. leptopora, G. oceanica, H. kamptneri, H. sellii, R. stylifera, Syracosphaera sp.

9-82-1-4, 75-76 cm; depth 5 m:
C. cristatus, C. doronicoides, C. leptopora, G. oceanica, H. kamptneri.

Upper Pliocene
(*Discoaster brouweri* **Zone**, *Cyclococcolithina macintyrei* **Subzone**)

9-82-2-4, 63-64 cm; depth 74 m:
C. cristatus, C. rugosus, C. doronicoides, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, Discoaster sp. aff. *D. brouweri* [large], *Discoaster* sp. cf. *D. exilis, D. japonica, H. kamptneri.*

Upper Miocene
(*Ceratolithus tricorniculatus* **Zone**)

9-82-3-4, 63-64 cm; depth 140 m:
C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. quinqueramus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. neoabies, T. rugosus.

9-82-4-4, 130-131 cm; depth 197 m:
C. tricorniculatus, C. pelagicus, C. leptopora, D. quinqueramus [rare], *D. variabilis, D. japonica, H. kamptneri, R. pseudoumbilica* [small], *S. abies, S. neoabies.*

Upper Miocene
(?*Discoaster quinqueramus* Zone)

9-82-6-4, 77-78 cm; depth 215 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, Discoaster sp. cf. *D. quinqueramus* [rare], *D. surculus, D. variabilis, H. kamptneri, S. abies, S. neoabies, T. rugosus.*

Coccoliths in Selected Samples, Hole 82A

Pleistocene
(*Coccolithus doronicoides* Zone)

9-82A-1A-4, 64-65 cm; depth 23 m:
C. cristatus, C. doronicoides, C. leptopora, D. japonica, E. annula, H. kamptneri, R. stylifera, T. saxea. Reworked upper Tertiary specimen: *Discoaster* sp. cf. *D. surculus.*

9-82A-1A-6, 100-101 cm; depth 27 m:
C. cristatus, C. doronicoides, C. leptopora, E. annula, G. caribbeanica, H. kamptneri, H. sellii.

9-82A-2A-4, 61-62 cm; depth 42 m:
C. doronicoides, C. pelagicus, C. leptopora, C. macintyrei, Discolithina sp., *H. kamptneri, H. sellii* [abundant].

Upper Pliocene
(*Discoaster brouweri* Zone, *Cyclococcolithina macintyrei* Subzone)

9-82A-2A-6, 133-134 cm; depth 45 m:
C. cristatus C. rugosus, C. doronicoides, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. japonica, E. annula, H. kamptneri, H. sellii, Syracosphaera sp.

Lower Pliocene
(*Ceratolithus rugosus* Zone)

9-82A-3A-1, 120-121 cm; depth 103 m:
C. rugosus, C. tricorniculatus [bizarre form typical of lower Pliocene], *C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. neoabies.*

9-82A-3A-4, 63-64 cm; depth 107 m:
C. rugosus, C. tricorniculatus [bizarre], *C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. surculus, H. kamptneri, R. pseudoumbilica.*

HOLES 83 AND 83A
(lat 04° 02.80′N., long 95° 44.25′W., depth 3646 meters)

Coccoliths in Selected Samples, Hole 83

Pleistocene
(*Gephyrocapsa oceanica* Zone)

9-83-2-1, 79-80 cm; depth 6 m:
C. cristatus, C. doronicoides, C. leptopora, G. oceanica, H. kamptneri, H. sellii.

9-83-2-4, 63-64 cm; depth 10 m:
C. cristatus, C. doronicoides, C. leptopora, G. caribbeanica, G. oceanica [small], *H. kamptneri.*

Pleistocene
(*Coccolithus doronicoides* Zone)

9-83-2-6, 60-61 cm; depth 13 m:
C. cristatus, C. doronicoides, C. leptopora, D. japonica, H. kamptneri.

9-83-3-3, 70-71 cm; depth 18 m:
C. cristatus, C. doronicoides, C. pelagicus, C. leptopora, C. macintyrei, Discolithina sp. cf. *D. japonica, G. caribbeanica, H. kamptneri, H. sellii.*

Upper Miocene
(*Discoaster quinqueramus* Zone)

9-83-5-2, 75-76 cm; depth 138 m:
C. tricorniculatus, C. pelagicus, D. brouweri, Discoaster sp. cf. *D. exilis, D. pentaradiatus, D. quinqueramus, Discoaster* sp. cf. *D. quinqueramus* [short rays, large center], *D. surculus, D. variabilis, R. pseudoumbilica, S. abies, S. neoabies, T. rugosus.*

9-83-5-4, 68-69 cm; depth 141 m:
C. tricorniculatus, C. leptopora, C. macintyrei, D. brouweri s.l., Discoaster sp. cf. *D. exilis, D. quinqueramus, Discoaster* sp. cf. *D. quinqueramus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. neoabies, T. rugosus.*

Upper Miocene
(?*Discoaster neohamatus* Zone)

9-83-6-4, 63-64 cm; depth 207 m:
C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus [rare], *D. brouweri s.l., D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies, T. rugosus.*

9-83-7-2, 100-101 cm; depth 224 m:
C. pelagicus, C. leptopora, D. brouweri s.l., D. variabilis, Discoaster sp. [five tapering rays], *D. multipora, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies, T. rugosus.*

Upper Miocene
(*Discoaster neohamatus* **Zone**)

9-83-7-4, 69-70 cm; depth 227 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri s.l., D. neohamatus, D. variabilis, Discoaster sp. [five tapering rays], *H. kamptneri, R. pseudoumbilica, S. neoabies.*

9-83-7-6, 102-103 cm; depth 230 m:
C. pelagicus, C. macintyrei, D. asymmetricus [rare], *D. brouweri s.l., D. challengeri, D. neohamatus, D. variabilis, D. japonica, D. multipora, H. kamptneri s.l., R. pseudoumbilica, Rhabdosphaera* sp., *S. abies, S. neoabies.*

Coccoliths in Selected Samples, Hole 83A

Pleistocene
(*Gephyrocapsa oceanica* **Zone**)

9-83A-1A-4, 64-65 cm; depth 18 m:
C. cristatus, C. leptopora, G. oceanica, H. kamptneri, Scyphosphaera sp., *T. saxea.* Reworked upper Tertiary taxa: *C. rugosus, C. macintyrei, R. pseudoumbilica.*

9-83A-2A-4, 64-65 cm; depth 27 m:
C. cristatus, C. doronicoides, C. leptopora, G. caribbeanica, G. oceanica, H. kamptneri, T. saxea.

Pleistocene
(*Coccolithus doronicoides* **Zone**)

9-83A-3A-4, 65-66 cm; depth 36 m:
C. cristatus, C. doronicoides, C. pelagicus, C. leptopora, D. japonica, H. kamptneri, H. sellii, S. histrica, T. saxea. ?Reworked taxa: *C. macintyrei, D. brouweri, Discoaster* sp. cf. *D. surculus.*

Upper Pliocene
(*Discoaster brouweri* **Zone**, *Cyclococcolithina macintyrei* **Subzone**)

9-83A-3A-6, 70-71 cm; depth 40 m:
C. rugosus, C. doronicoides, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri [three- and six-rayed], *H. kamptneri, H. sellii.*

9-83A-4A-4, 59-60 cm; depth 46 m:
C. rugosus, C. doronicoides, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, H. kamptneri.

9-83A-5A-4, 63-64 cm; depth 55 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. japonica, H. kamptneri.

Upper Pliocene
(*Discoaster brouweri* **Zone**, *Discoaster pentaradiatus* **Subzone**)

9-83A-6A-6, 139-140 cm; depth 68 m:
C. rugosus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus [rare], *Discoaster* sp. cf. *D. surculus, D. variabilis s.l., H. kamptneri.*

Lower Pliocene
(*Reticulofenestra pseudoumbilica* **Zone**)

9-83A-7A-1, 40-41 cm; depth 68 m:
C. rugosus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis s.l., H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies.

9-83A-8A-2, 101-102 cm; depth 80 m:
C. rugosus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, R. pseudoumbilica, S. abies, S. neoabies.

9-83A-8A-6, 80-81 cm; depth 85 m:
C. rugosus, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies.

Upper Miocene or Lower Pliocene
(*Ceratolithus rugosus* **Zone**)

9-83A-9A-4, 105-106 cm; depth 92 m:
Ceratolithus sp. cf. *C. rugosus, C. tricorniculatus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus* [large], *D. surculus, D. variabilis, D. japonica, H. kamptneri, R. pseudoumbilica, S. neoabies.*

9-83A-10A-6, 80-81 cm; depth 104 m:
Ceratolithus sp. cf. *C. rugosus, C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, D. multipora, H. kamptneri, R. pseudoumbilica* [rare], *S. abies.*

Upper Miocene
(*Ceratolithus tricorniculatus* **Zone**)

9-83A-11A-1, 104-105 cm; depth 106 m :
C. tricorniculatus, C. pelagicus, C. leptopora, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies.

9-83A-11A-4, 60-61 cm; depth 110 m:
C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, Discoaster sp. cf. *D. exilis, D. pentaradiatus, D. surculus, D. variabilis, D. japonica, D. multipora, H. kamptneri, R. pseudoumbilica, Scyphosphaera* sp. cf. *S. apsteinii, S. abies, S. neoabies, T. rugosus.*

Upper Miocene
(*Discoaster quinqueramus* **Zone**)

9-83A-12A-4, 63-64 cm; depth 119 m:
C. tricorniculatus [rare], *C. leptopora, C. macintyrei, D. brouweri, D. quinqueramus* [common], *D. surculus, D. variabilis, D. japonica, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies.*

9-83A-13A-4, 63-64 cm; depth 128 m:
C. tricorniculatus, C. leptopora, D. brouweri, Discoaster sp. cf. *D. exilis, D. quinqueramus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies.*

9-83A-14A-4, 61-62 cm; depth 164 m:
C. tricorniculatus, C. pelagicus, C. macintyrei, D. brouweri, D. quinqueramus, D. surculus, D. variabilis, D. japonica, H. kamptneri, R. pseudoumbilica, S. neoabies.

9-83A-15A-1, 40-41 cm; depth 180 m:
C. pelagicus, C. leptopora, C. macintyrei, Discoaster sp. cf. *D. asymmetricus* [small], *D. brouweri, Discoaster* sp. aff. *D. brouweri* [broad tapering rays, large], *D. pentaradiatus, D. quinqueramus, Discoaster* sp. cf. *D. quinqueramus* [vestigial rays], *D. surculus, D. variabilis, H. kamptneri, S. abies, S. neoabies, T. rugosus.*

9-83A-15A-6, 130-131 cm; depth 189 m:
C. pelagicus, C. leptopora, D. brouweri, Discoaster sp. cf. *D. quinqueramus, D. surculus, D. variabilis, H. kamptneri, T. rugosus.*

Upper Miocene
(*Discoaster neohamatus* Zone)

9-83A-16A-4, 64-65 cm; depth 215 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri s.l., D. neohamatus, D. pentaradiatus, D. variabilis, [unequal bifurcations], *D. japonica, D. multipora, H. kamptneri, S. abies, S. neoabies, T. rugosus.*

HOLE 84
(lat 05° 44.92'N., long 82° 53.29'W., depth 3097 meters)

Coccoliths in Selected Samples, Hole 84

Pleistocene
(*Gephyrocapsa oceanica* Zone)

9-84-1-1, 100-101 cm; depth 1 m:
C. leptopora, G. oceanica, Gephyrocapsa sp., *H. kamptneri.*

9-84-1-6, 50-51 cm; depth 8 m:
C. cristatus, C. leptopora, G. oceanica.

9-84-2-6, 80-81 cm; depth 17 m:
C. leptopora, G. oceanica, Gephyrocapsa sp., *H. kamptneri, R. clavigera, U. mirabilis.*

9-84-3-6, 91-91 cm; depth 27 m:
C. leptopora, G. oceanica, Gephyrocapsa sp., *H. kamptneri, R. clavigera.*

9-84-4-6, 100-101 cm; depth 36 m:
C. leptopora, D. japonica, G. oceanica, Gephyrocapsa sp., *H. kamptneri.*

9-84-5-6, 100-101 cm; depth 45 m:
C. leptopora, D. japonica, G. caribbeanica, G. oceanica, H. kamptneri.

Pleistocene
(*Coccolithus doronicoides* Zone)

9-84-6-4, 50-51 cm; depth 51 m:
C. doronicoides, C. leptopora, H. kamptneri, S. histrica.

9-84-7-6, 87-88 cm; depth 63 m:
C. doronicoides, C. leptopora, D. japonica, G. caribbeanica, H. kamptneri, S. histrica. Reworked Pliocene specimens: *C. rugosus, D. brouweri.*

9-84-8-6, 80-81 cm; depth 72 m:
C. doronicoides, C. leptopora, D. japonica, G. caribbeanica, H. kamptneri, H. sellii, R. stylifera, Scapholithus sp.

9-84-9-6, bottom; depth 82 m:
C. doronicoides, C. pelagicus [large], *C. leptopora, D. japonica, H. kamptneri, H. sellii* [common]. Reworked(?) upper Tertiary specimens: *C. rugosus, C. macintyrei, D. brouweri, Discoaster* sp. cf. *D. variabilis.*

Upper Pliocene
(*Discoaster brouweri* Zone, *Cyclococcolithina macintyrei* Subzone)

9-84-10-6, 116-117 cm; depth 91 m:
C. rugosus [rare], *C. doronicoides, C. pelagicus. C. leptopora, C. macintyrei, D. brouweri, D. japonica, H. kamptneri, H. sellii.*

9-84-11-6, 70-71 cm; depth 100 m:
C. rugosus, C. pelagicus, C. leptopora, D. brouweri, D. japonica, H. kamptneri, H. sellii, T. saxea.

Upper Pliocene
(*Discoaster brouweri* Zone, *Discoaster pentaradiatus* Subzone)

9-84-12-6, 70-71 cm; depth 109 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, H. kamptneri, H. sellii. Reworked(?) Miocene taxon: *Discoaster* sp. cf. *D. quinqueramus.*

9-84-13-6, 80-81 cm; depth 118 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus, D. japonica, H. kamptneri, H. sellii. Reworked(?) Miocene taxon: *Discoaster* sp. cf. *D. quinqueramus.*

9-84-14-5, 76-77 cm; depth 126 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, Discoaster sp. cf. *D. exilis, D. pentaradiatus, D. surculus, D. japonica, H. kamptneri.*

9-84-16-1, 80-81 cm; depth 138 m:
C. rugosus, C. pelagicus [rare], *C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. perplexus, D. variabilis s.l., H. kamptneri, H. sellii.*

9-84-16-6, 63-64 cm; depth 145 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. pentaradiatus, D. perplexus, D. surculus, D. variabilis s.l., H. kamptneri, H. sellii, R. pseudoumbilica [rare], *S. abies* [rare].

Lower Pliocene
(*Reticulofenestra pseudoumbilica* **Zone**)

9-84-17-2, 100-101 cm; depth 149 m:
C. rugosus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, D. perplexus, D. surculus, D. variabilis, H. kamptneri, H. sellii, R. pseudoumbilica, S. abies. Reworked(?) Miocene taxon: *Discoaster* sp. cf. *D. quinqueramus.*

9-84-18-2, 80-81 cm; depth 158 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. asymmetricus, D. brouweri, Discoaster sp. cf. *D. exilis* [webbed rays], *D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. abies, S. neoabies.*

9-84-19-3, 90-91 cm; depth 169 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. variabilis s.l., D. japonica, H. kamptneri, R. pseudoumbilica [rare], *S. neoabies* [rare].

9-84-19-6, 80-81 cm; depth 173 m:
C. rugosus, C. leptopora, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. neoabies.

9-84-20-2, 30-31 cm; depth 176 m:
C. rugosus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, D. japonica, H. kamptneri, R. pseudoumbilica, Scyphosphaera sp. cf. *S. apsteinii, S. abies, S. neoabies,* Reworked(?) Miocene taxon: *Discoaster* sp. cf. *D. quinqueramus.*

Lower Pliocene or Upper Miocene
(*Ceratolithus rugosus* **Zone**)

9-84-21-5, 70-71 cm; depth 188 m:
C. rugosus, C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. surculus, D. variabilis, H. kamptneri, S. abies, S. neoabies.

Upper Miocene
(*Ceratolithus tricorniculatus* **Zone**)

9-84-22-5, 80-81 cm; depth 198 m:
C. tricorniculatus, C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. perplexus, D. surculus, D. variabilis, H. kamptneri, Scyphosphaera sp. cf. *S. apsteinii, S. abies, S. neoabies.*

Upper Miocene
(*Discoaster quinqueramus* **Zone**)

9-84-24-3, 80-81 cm; depth 210 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. pentaradiatus, D. quinqueramus, D. surculus, H. kamptneri, R. pseudoumbilica, Scyphosphaera sp. cf. *S. apsteinii, S. abies, S. neoabies, T. rugosus.*

9-84-25-2, 83-84 cm; depth 221 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, Discoaster sp. cf. *D. exilis, D. pentaradiatus, D. quinqueramus* [abundant], *D. surculus, H. kamptneri, R. pseudoumbilica, S. neoabies, T. rugosus.*

9-84-27-2, 80-81 cm; depth 240 m:
C. tricorniculatus [rare], *C. pelagicus, C. leptopora, C. macintyrei, D. brouweri, D. quinqueramus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica, S. pulcherrima, S. abies, S. neoabies, T. rugosus.*

9-84-27-6, 84-85 cm; depth 246 m:
C. tricorniculatus [early variety], *C. pelagicus* [abundant], *C. leptopora, C. macintyrei, D. brouweri, D. quinqueramus* [abundant], *D. surculus, H. kamptneri, S. abies, S. neoabies.*

9-84-28-4, 70-71 cm; depth 251 m:
C. pelagicus, C. leptopora, C. macintyrei, D. brouweri [large], *D. quinqueramus, D. surculus, D. variabilis, H. kamptneri, R. pseudoumbilica* [abundant], *S. abies, S. neoabies, T. rugosus.*

REFERENCES

Bukry, D., 1970. Coccolith stratigraphy, Leg 7, Deep Sea Drilling Project. In Riedel *et al.*, 1971, *Initial Reports of the Deep Sea Drilling Project, Volume VII,* in press.

Bukry, D. and Bramlette, M. N., 1968. Stratigraphic significance of two genera of Tertiary calcareous nannofossils. *Tulane Stud. Geol.* **6**, 149.

McIntyre, A. and Bé, A.W.H., 1967. Modern Coccolithophoridae of the Atlantic Ocean–I. Placoliths and Cyrtoliths. *Deep-Sea Res.* **14**, 561.