

17. COCCOLITH AGE DETERMINATIONS LEG 4, DEEP SEA DRILLING PROJECT

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Leg 4 of the Deep Sea Drilling Project, February-March 1969, recovered 120 cores. A total of 173 samples from these cores were examined by light-microscope techniques for coccolith assemblages. Age-diagnostic species in selected samples from each drilling site, listed by biostratigraphic zone, follow a brief summary of the coccolith stratigraphy at each drilling site. The coccolith zones used in this report are those described by Bukry and Bramlette (1970) in the report on Leg 3. During study of Leg 4 material, M. N. Bramlette, of Scripps Institution of Oceanography, provided valuable information on the stratigraphic assignment of several of these cores.

Sample numbers given under the biostratigraphic zones for each site represent, in the following sequence: (cruise-leg number)-(drill-hole designation, consisting of site number, plus a letter if more than one hole)-(core designation)-(core-section number). This series is followed by the interval below the top of each core section in centimeters. For example, 4-27A-1A-1, 75-76 cm, indicates that the sample came from Leg 4, Hole 27A (at Site 27), the first barrel of core recovered, the top section of that core, and from 75 to 76 centimeters below the top of the section. Most core runs were 9.1 meters long, but commonly the core liners were not full. In this report, 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.

Species considered in this report are listed below in Table 1.

TABLE 1
Coccolith Species Considered in This Report

Bramletteius serraculoides Gartner

Campylosphaera dela (Bramlette and Sullivan)

Catinaster calyculus Martini and Bramlette

Ceratolithus cristatus Kamptner

Ceratolithus rugosus Bukry and Bramlette

Ceratolithus tricorniculatus Gartner

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

TABLE 1 – *Continued*

Chiphragmalithus austriacus (Stradner)

Original designation:

Trochoaster austriacus Stradner, 1959. *Proc. Fifth World Petrol. Congr.* 1, 1088 (Figure 11).

Chiphragmalithus mexicanus (Stradner)

Original designation:

Trochoaster mexicanus Stradner, 1959. *Erdoel-Zeitschrift.* 75, 480 (Figure 55).

Chiphragmalithus sp.

Chiasmolithus gigas (Bramlette and Sullivan)

Original designation:

Coccolithus gigas Bramlette and Sullivan, 1961. *Micropaleontology.* 7 (2), 140 (Plate 1, Figures 6a-6d).

Chiasmolithus grandis (Bramlette and Riedel)

Original designation:

Coccolithus grandis Bramlette and Riedel, 1954. *J. Paleontol.* 28 (4), 391 (Plate 38, Figures 1a-1b).

Chiasmolithus staurion (Bramlette and Sullivan)

Original designation:

Coccolithus staurion Bramlette and Sullivan, 1961. *Micropaleontology.* 7 (2), 141 (Plate 2, Figures 5a-5b, 6a-6c).

Chiasmolithus sp.

Coccolithus bisectus (Hay, Mohler, and Wade) of Bramlette and Wilcoxon

Coccolithus sp. aff. *C. bisectus* (Hay, Mohler, and Wade) of Bramlette and Wilcoxon

Coccolithus doronicoides Black and Barnes

Coccolithus eopelagicus (Bramlette and Riedel)

Cyclococcolithus leptoporus (Murray and Blackman)
varieties A, B, and C of McIntyre, Bé, and Preikstas

Cyclococcolithus lusitanicus (Black)

Cyclococcolithus neogammation Bramlette and Wilcoxon

Cyclolithella annula (Cohen)

Discoaster barbadiensis Tan

Discoaster bollii Martini and Bramlette

Discoaster sp. aff. *D. bollii* Martini and Bramlette

Discoaster brouweri Tan

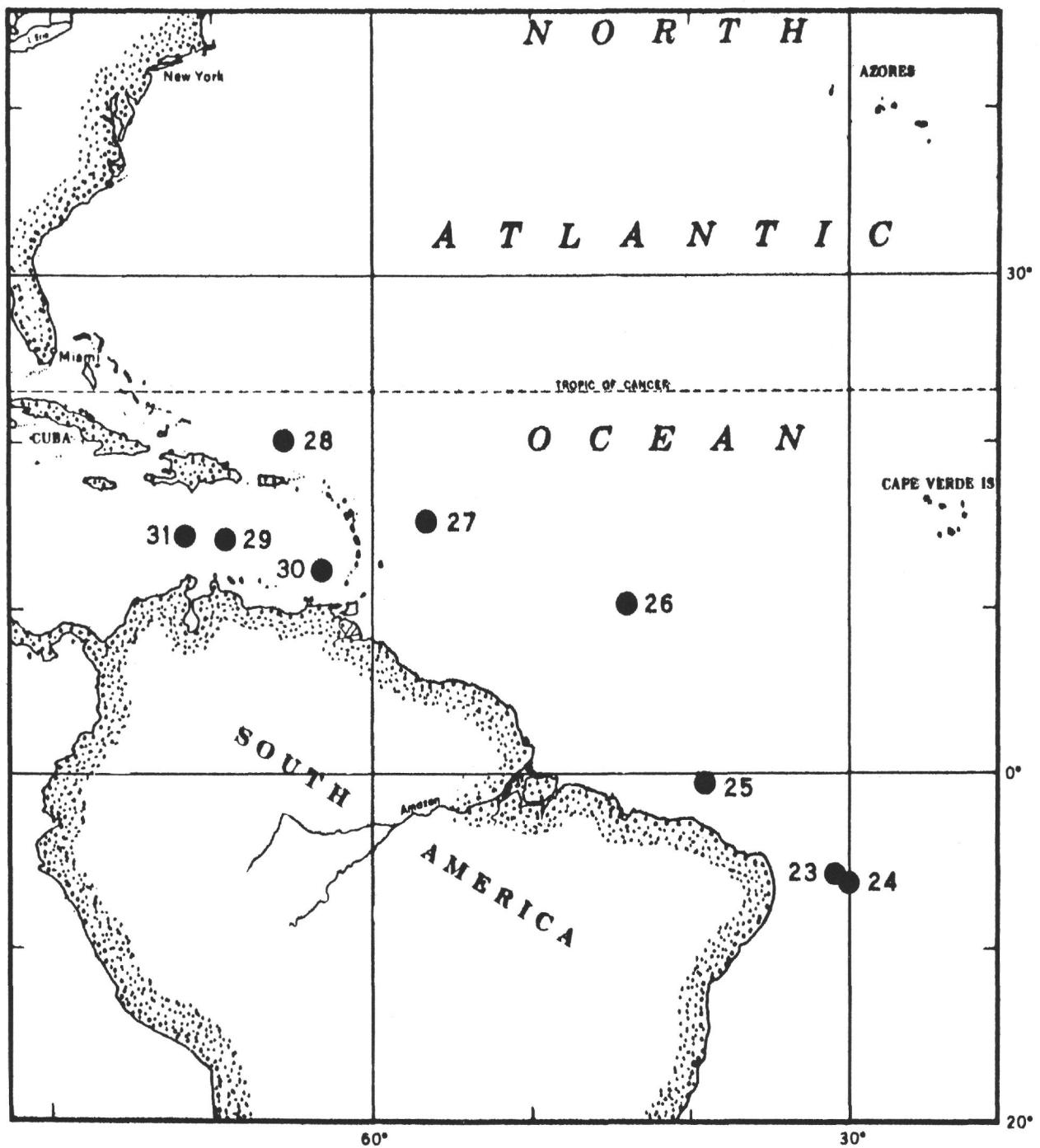


Figure 1. Sites drilled on Leg 4, Deep Sea Drilling Project.

TABLE 1 – *Continued*

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| *Discoaster* sp. aff. *D. brouweri* Tan |
| *Discoaster calcaris* Gartner |
| *Discoaster challengerii* Bramlette and Riedel |
| *Discoaster* sp. aff. *D. colleti* (Parejas) |
| *Discoaster deflandrei* Bramlette and Riedel |
| *Discoaster distinctus* Martini |
| *Discoaster exilis* Martini and Bramlette |
| *Discoaster hamatus* Martini and Bramlette |
| *Discoaster* sp. aff. *D. hamatus* Martini and Bramlette |
| *Discoaster lodoensis* Bramlette and Riedel |
| *Discoaster pentaradiatus* Tan |
| *Discoaster perclarus* Hay |
| *Discoaster perplexus* Bramlette and Riedel |
| *Discoaster saipanensis* Bramlette and Riedel |
| *Discoaster sublodoensis* Bramlette and Sullivan |
| *Discoaster subsurculus* Gartner |
| *Discoaster surculus* Martini and Bramlette |
| *Discoaster tani nodifer* Bramlette and Riedel |
| *Discoaster variabilis* Martini and Bramlette |
| *Discoasteroides kuepperi* (Stradner) |
| *Gephyrocapsa oceanica* Kamptner |
| *Helicopontosphaera ampliaperta* (Bramlette and Wilcoxon) |
| Original designation: |
| *Helicosphaera ampliaperta* Bramlette and Wilcoxon, 1967. *Tulane Stud. Geol.* 5 (3), 105 (Plate 6, Figures 1-4). |
| *Helicopontosphaera intermedia* (Martini) |
| *Helicopontosphaera kamptneri* Hay and Mohler |
| *Helicopontosphaera parallela* (Bramlette and Wilcoxon) |
| Original designation: |
| *Helicosphaera parallela* Bramlette and Wilcoxon, 1967. *Tulane Stud. Geol.* 5 (3), 106 (Plate 5, Figures 9-10). |
| *Helicopontosphaera* sp. aff. *H. seminulum* (Bramlette and Sullivan) |
| Original designation: |
| *Helicosphaera seminulum seminulum* Bramlette and Sullivan, 1961. *Micropaleontology*. 7 (2), 144, Plate 4, Figures 1a-1c, 2. |
| *Helicopontosphaera truncata* (Bramlette and Wilcoxon) |
| Original designation: |
| *Helicosphaera truncata* Bramlette and Wilcoxon, 1967. *Tulane Studies Geol.* 5 (3), 106 (Plate 6, Figures 13-14). |

TABLE 1 – *Continued*

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| *Oolithotus antillarum* (Cohen) |
| *Reticulofenestra dictyoda* (Deflandre) |
| *Reticulofenestra pseudoumbilica* (Gartner) |
| *Reticulofenestra umbilica* (Levin) |
| *Rhabdosphaera clavigera* Murray and Blackman |
| *Rhabdosphaera stylifera* Lohmann |
| *Scapholithus fossilis* Deflandre |
| *Scapholithus* sp. aff. *S. fossilis* Deflandre |
| *Sphenolithus abies* Deflandre |
| *Sphenolithus* sp. aff. *S. belemnios* Bramlette and Wilcoxon |
| *Sphenolithus ciperoensis* Bramlette and Wilcoxon |
| *Sphenolithus furcatolithoides* Locker |
| *Sphenolithus heteromorphus* Deflandre |
| *Sphenolithus moriformis* (Brönnimann and Stradner) |
| *Sphenolithus predistentus* Bramlette and Wilcoxon |
| *Sphenolithus radians* Deflandre |
| *Triquetrorhabdulus carinatus* Martini |
| *Triquetrorhabdulus rugosus* Bramlette and Wilcoxon |
| *Triquetrorhabdulus* sp. aff. *T. rugosus* Bramlette and Wilcoxon |
| *Triquetrorhabdulus* sp. |
| *Umbilicosphaera mirabilis* Lohmann |
| *Zygolithus dubius* Deflandre |

HOLE 23

(lat 6° 08.75'S., long 31° 02.60'W., depth 5079 meters)

Summary of Coccolith Age Determinations

The lower Pleistocene sample at 5 meters contains rare specimens of discoasters and *Gephyrocapsa oceanica*. In Cores 5 and 6 the lower part of the Miocene to Oligocene *Triquetrorhabdulus carinatus* Zone is represented by generally poor assemblages. This is the oldest sediment sampled. Most samples from this hole do not contain coccoliths.

Age-diagnostic Coccoliths in Selected Samples, Hole 23**Lower Pleistocene
(Coccolithus doronicoides Zone)**

4-23-14, 94 cm, depth 5 m:

Ceratolithus cristatus, *Coccolithus doronicoides*, *Cyclococcolithus leptoporus* vars. A and B, *Cyclolithella annula*, *Rhabdosphaera clavigera*.

Miocene or Oligocene
(*Triquetrorhabdulus carinatus* Zone)

4-23-5-1, 26 cm, depth 121 m:

Chiasmolithus sp., *Coccolithus eopelagicus*, *Cyclococcolithus neogammation*, *Discoaster deflandrei*, *Helicopontosphaera intermedia*, *Helicopontosphaera kampnieri*, *Helicopontosphaera parallela*, *Helicopontosphaera truncata*, *Sphenolithus* sp. aff. *S. belemnos*, *Triquetrorhabdulus carinatus*.

HOLE 24
(lat $6^{\circ}16.30'S.$, long $30^{\circ}53.53'W.$, depth 5148 meters)

Summary of Coccolith Age Determinations

The shallowest sample from this site contains coccoliths of the *Triquetrorhabdulus carinatus* Zone, Miocene to Oligocene. Deeper samples contain only rare specimens of *Coccolithus bisectus*, *Cyclococcolithus neogammation*, and *Sphenolithus moriformis*, indicating an Oligocene age. Since all of these coccoliths are generally resistant to destruction, this assemblage indicates solution effects and possible reworking.

Age-diagnostic Coccoliths in Selected Samples, Hole 24

Miocene or Oligocene
(*Triquetrorhabdulus carinatus* Zone)

4-24-1-1, 35 cm, depth 198 m:

Coccolithus sp. aff. *C. bisectus*, *Cyclococcolithus neogammation*, *Discoaster deflandrei* [5- and 6-rayed], *Helicopontosphaera intermedia*, *Sphenolithus* sp. aff. *S. belemnos*, *Triquetrorhabdulus carinatus*.

HOLES 25 AND 25A
(lat $0^{\circ}31.00'S.$, long $39^{\circ}14.40'W.$, depth 1916 meters)

Summary of Coccolith Age Determinations

Samples examined from this site contain well-preserved coccolith assemblages representing the upper Pleistocene to lower Miocene. Samples from the upper cores (Cores 1 and 2) are Pleistocene, and those from the lower ones, Cores 3, 4, 5 and 1A, are Miocene. The Miocene section is mainly lower upper Miocene. The redrilling of the site at Hole 25A succeeded in recovering an upper middle to lower upper Miocene sequence.

Age-diagnostic Coccoliths in Selected Samples, Hole 25

Upper Pleistocene
(*Gephyrocapsa oceanica* Zone)

4-25-1-1, 110 cm, depth 1 m:

Cyclococcolithus leptoporus var. B, *Discoaster perplexus*, *Gephyrocapsa oceanica* [few], *Oolithotus antillarum*, *Scapholithus* sp. [common], *Umbilicosphaera mirabilis*.

Lower Pleistocene
(*Coccolithus doronicoides* Zone)

4-25-2-3, 0-2 cm, depth 12 m:

Ceratolithus rugosus, *Coccolithus doronicoides*, *Cyclococcolithus leptoporus* vars. A and B, *Discoaster perplexus*, *Rhabdosphaera clavigera*, *Rhabdosphaera stylifera*, *Scapholithus* sp.

Upper Miocene
(*Ceratolithus tricorniculatus* Zone)

4-25-3-1, 150 cm, depth 20 m:

Ceratolithus tricorniculatus, *Discoaster brouweri*, *Discoaster challenger*, *Discoaster pentaradiatus*, *Discoaster surculus*.

Lower Upper Miocene
(*Triquetrorhabdulus rugosus* Zone)

4-25-4-2, 0-2 cm, depth 29 m:

Discoaster challenger, *Discoaster* sp. aff. *D. hamatus*, *Discoaster perclarus*, *Discoaster perplexus*, *Sphenolithus abies*, *Triquetrorhabdulus rugosus*.

Lower Miocene
(*Sphenolithus heteromorphus* Zone)

4-25-5-CC, depth 46 m:

Cyclococcolithus leptoporus, *Cyclococcolithus neogammation*, *Discoaster brouweri*, *Discoaster challenger*, *Discoaster deflandrei*, *Discoaster exilis*, *Reticulofenestra pseudoumbilica*, *Sphenolithus heteromorphus*.

Taxa representing contamination or reworking from a probable lower Oligocene source: *Coccolithus bisectus*, *Cyclococcolithus lusitanicus*, *Reticulofenestra umbilica*, *Sphenolithus predistentus*.

Age-diagnostic Coccoliths in Selected Samples, Hole 25A

Lower Upper Miocene
(*Triquetrorhabdulus rugosus* Zone)

4-25A-1A-1, 75-76 cm, depth 50 m:

Discoaster challenger, *Discoaster* sp. aff. *D. hamatus*, *Discoaster pentaradiatus*, *Reticulofenestra pseudoumbilica*, *Sphenolithus abies*, *Triquetrorhabdulus rugosus*.

Upper Middle Miocene
(*Discoaster hamatus* Zone)

4-25A-1A-2, 148-150 cm, depth 52 m:

Catinaster calyculus, *Discoaster challenger*, *Discoaster hamatus*, *Reticulofenestra pseudoumbilica*, *Sphenolithus abies*, *Triquetrorhabdulus rugosus*.

HOLE 26
(lat 10° 53.55'N., long 44° 02.57'W., depth 5169 meters)

Summary of Coccolith Age Determinations

Samples from Cores 1, 2, 3, 4 and 5 from this site all contain sparse Pleistocene coccolith assemblages of the *Gephyrocapsa oceanica* Zone. All of the assemblages are greatly diluted by nonorganic, siliceous detritus. Rapid sedimentation from Amazon River outflow and dissolving of calcite fossils at depth accounts for the unusually sparse assemblages in this tropical, open-ocean depositional environment.

Age-diagnostic Coccoliths in Selected Samples, Hole 26

Pleistocene

(Gephyrocapsa oceanica Zone)

4-26-1-1, 148-150 cm, depth 98 m:
Gephyrocapsa oceanica, Helicopontosphaera kampfneri.
4-26, center-bit sample at 229 m:
Gephyrocapsa oceanica, Helicopontosphaera kampfneri.

HOLES 27 AND 27A
(lat 15° 51.39'N., long 56° 52.76'W., depth 5251 meters)

Summary of Coccolith Age Determinations

In Hole 27 at this site, seven cores were recovered. No coccoliths are present in the upper Cores 1, 2, 3 and 4. Core 5, however, contains excellent upper Oligocene assemblages of the *Sphenolithus ciperoensis* Zone. In Cores 6 and 7, middle Eocene assemblages of the upper part of the *Reticulofenestra umbilica* Zone are present. The coccoliths in these two lowermost cores appear to be slightly decalcified. Samples from a redrilling of this site at Hole 27A are all barren of coccoliths.

Age-diagnostic Coccoliths in Selected Samples, Hole 27

Upper Oligocene
(Sphenolithus ciperoensis Zone)

4-27-5-3, 75-76 cm, depth 373 m:
Coccolithus bisectus, Coccolithus sp. aff. C. bisectus, Cyclococcolithus neogammation, Helicopontosphaera parallela, Helicopontosphaera sp. aff. H. seminulum, Helicopontosphaera truncata, Sphenolithus ciperoensis, Sphenolithus moriformis, Triquetrorhabdulus carinatus.

Middle Eocene
(Reticulofenestra umbilica Zone)

4-27-7-1, 10 cm, depth 474 m:
Chiasmolithus grandis, Cyclococcolithus lusitanicus, Discoaster barbadiensis, Discoaster saipanensis, Discoaster tani nodifera, Reticulofenestra umbilica, Sphenolithus furcatolithoides.

HOLE 28
(lat 20° 35.19'N., long 65° 37.33'W., depth 5521 meters)

Summary of Coccolith Age Determinations

Coccoliths are present in Cores 3 and 5. In Core 3 the coccolith assemblages indicate the middle Eocene *Chiphragmalithus quadratus* Zone; and, in the Core 5 core catcher, the lower middle Eocene *Discoaster sublodoensis* Zone. A large variety of species compose these assemblages.

Age-diagnostic Coccoliths in Selected Samples, Hole 28

Middle Eocene
(Chiphragmalithus quadratus Zone)

4-28-3-6, 71-72 cm, depth 176 m:
Bramletteius serraculoides, Campylosphaera dela, Chiasmolithus grandis, Coccolithus eopelagicus, Discoaster barbadiensis, Discoaster distinctus, Discoaster saipanensis, Reticulofenestra umbilica [small], Sphenolithus furcatolithoides, Zygolithus dubius.

Middle Eocene
(Discoaster sublodoensis Zone)

4-28-5, core catcher, depth 245 m:
Braarudosphaera discula, Campylosphaera dela, Chiasmolithus gigas, Chiasmolithus grandis, Chiasmolithus staurion, Chiphragmalithus sp., Discoaster barbadiensis, Discoaster lodoensis, Discoaster saipanensis, Discoaster sublodoensis, Reticulofenestra dictyoda, Sphenolithus radians, Triquetrorhabdulus sp.

HOLES 29, 29A, AND 29B
(lat 14° 47.11'N., long 69° 19.36'W., depth 4247 meters)

Summary of Coccolith Age Determinations

Sediment recovered from Hole 29 (18 cores) contains coccolith assemblages ranging from upper Pleistocene (*Gephyrocapsa oceanica* Zone) to the lower middle Eocene (*Discoaster sublodoensis* Zone). Good coccolith assemblages are present in Cores 1 to 4; however, siliceous microfossil ooze dominates in Cores 8 to 18.

Samples from Hole 29A are barren of coccoliths.

Sediment recovered from Hole 29B (10 cores) contains coccolith assemblages ranging from lower upper Miocene (*Triquetrorhabdulus rugosus* Zone) to lower middle (?) Eocene (?*Discoaster sublodoensis* Zone). Most of the coccolith samples (Cores 4B, 5B, 6B) are upper lower Miocene (*Helicopontosphaera ampliaperta* Zone). Siliceous microfossils dominate the sediment below the level of Core 6B. Eocene coccoliths occur with this sediment type in Core 9B.

Age-diagnostic Coccoliths in Selected Samples, Hole 29

Upper Pleistocene

(*Gephyrocapsa oceanica* Zone)

4-29-1-1, 75-76 cm, depth 1 m:

Gephyrocapsa oceanica, *Helicopontosphaera kamptneri*.

Upper Pliocene

(*Discoaster brouweri* Zone)

4-29-4-1, 94-95 cm, depth 28 m:

Ceratolithus cristatus, *Cyclococcolithus leptoporus* var. A, *Discoaster brouweri*, *Discoaster pentaradiatus*, *Discoaster surculus*.

Lower Miocene

(*Helicopontosphaera ampliaperta* Zone)

4-29-7-1, 106-107 cm, depth 118 m:

Coccolithus sp. aff. *C. bisectus*, *Cyclococcolithus neogammation*, *Discoaster deflandrei*, *Sphenolithus heteromorphus* [few], *Sphenolithus moriformis*, *Triquetrorhabdulus carinatus*.

Lower Miocene and Upper Eocene, Mixed

4-29-9-2, 76-77 cm, depth 137 m:

Lower Miocene taxa. *Cyclococcolithus neogammation*, *Discoaster challengerii*, *Discoaster deflandrei*, *Sphenolithus* sp. aff. *S. belemnos* [no stem], *Sphenolithus heteromorphus*.

Upper Eocene taxa. *Chiasmolithus* sp. [rims], *Discoaster barbadiensis*, *Reticulofenestra umbilica*.

Middle Eocene

(*Chiphragmalithus quadratus* Zone)

4-29-12-6, 104-105 cm, depth 171 m:

Chiasmolithus grandis, *Chiasmolithus staurion*, *Coccolithus eopelagicus*, *Discoaster barbadiensis*, *Sphenolithus furcatolithoides*.

4-29-15-1, 68-69 cm, depth 194 m:

Chiphragmalithus austriacus, *Chiphragmalithus mexicanus*, *Discoaster barbadiensis*, *Discoaster* sp. aff. *D. colleti*.

Lower Middle Eocene

(*Discoaster sublodoensis* Zone)

4-29-16-1, 140-141 cm, depth 203 m:

Chiasmolithus sp. [rims], *Chiphragmalithus mexicanus*, *Coccolithus eopelagicus*, *Discoaster barbadiensis*, *Discoaster sublodoensis* [few].

Age-diagnostic Coccoliths in Selected Samples, Hole 29B

Upper Middle Miocene

(*Discoaster hamatus* Zone)

4-29B-2B-4, 74-75 cm, depth 73 m:

Discoaster brouweri, *Discoaster calcaris* [common] *Discoaster challengerii*, *Discoaster* sp. aff. *D. hamatus*,

Discoaster perclarus, *Reticulofenestra pseudoumbilica*, *Triquetrorhabdulus rugosus*.

4-29B-3B-1, 74-75 cm, depth 79 m:

Discoaster bollii, *Discoaster brouweri*, *Discoaster calcaris*, *Reticulofenestra pseudoumbilica*.

Upper Lower Miocene

(*Helicopontosphaera ampliaperta* Zone)

4-29B-4B-4, 138-139 cm, depth 93 m:

Coccolithus eopelagicus, *Cyclococcolithus neogammation*, *Discoaster deflandrei*, *Discoaster exilis*, *Helicopontosphaera ampliaperta*, *Sphenolithus heteromorphus*.

Lower Middle (?) Eocene

(? *Discoaster sublodoensis* Zone)

4-29B-9B-1, 110-111 cm, depth 219 m:

Discoaster barbadiensis, ? *Discoaster sublodoensis*, *Discoasteroides kuepperi*.

HOLE 30

(lat 12° 52.92' N., long 63° 23.00' W., depth 1218 meters)

Summary of Coccolith Age Determinations

Coccolith assemblages in sixteen cores from this hole range from upper Pleistocene (*Gephyrocapsa oceanica* Zone) to lower Miocene (*Helicopontosphaera ampliaperta* Zone). Pliocene sediment may be present in Cores 7 and 8, but Cores 1 through 6 are all Pleistocene and Cores 9 through 16 are all Miocene. The sediment in Cores 10 through 16 is poorly sorted as to size and may represent slump deposits, although the general sequence of lower to middle Miocene coccolith assemblages is proper order.

Age-diagnostic Coccoliths in Selected Samples, Hole 30

Upper Pleistocene

(*Gephyrocapsa oceanica* Zone)

4-30-2-4, 75-76 cm, depth 64 m:

Ceratolithus cristatus, *Gephyrocapsa oceanica*, *Helicopontosphaera kamptneri*, *Rhabdosphaera clavigera*.

Lower Pleistocene

(*Coccolithus doronicoides* Zone)

4-30-5-1, 74-75 cm, depth 165 m:

Coccolithus doronicoides, *Helicopontosphaera kamptneri*, *Rhabdosphaera clavigera*.

Pliocene to Miocene

(*Ceratolithus rugosus* Zone)

4-30-8-1, 23-24 cm, depth 318 m:

Ceratolithus rugosus, *Ceratolithus tricorniculatus*, *Discoaster brouweri*, *Discoaster* sp. aff. *D. brouweri*, *Discoaster challengerii*, *Discoaster pentaradiatus*, *Discoaster*

surculus, *Reticulofenestra pseudoumbilica*, *Sphenolithus abies*.

Lower Upper Miocene
(*Triquetrorhabdulus rugosus* Zone)

4-30-10-2, 75-76 cm, depth 377 m:
Discoaster brouweri, *Discoaster challengerii*, *Discoaster* sp. aff. *D. hamatus*, *Discoaster pentaradiatus*, *Discoaster variabilis*, *Reticulofenestra pseudoumbilica*, *Sphenolithus abies*, *Triquetrorhabdulus rugosus*.

Middle Miocene
(?*Discoaster kugleri* Zone)

4-30-12-1, 27-30 cm, depth 393 m:
Cyclococcolithus leptoporus, *Discoaster* sp. aff. *D. bollii*, *Discoaster brouweri*, *Discoaster challengerii*, *Discoaster subsurculus*, *Reticulofenestra pseudoumbilica*, *Triquetrorhabdulus* sp. aff. *T. rugosus*.

Middle Miocene
(?*Sphenolithus heteromorphus* Zone)

4-30-14-1, 83-85 cm, depth 408 m:
Coccolithus eopelagicus, *Cyclococcolithus leptoporus* [rare], *Cyclococcolithus neogammation*, *Discoaster* sp. aff. *D. bollii*, *Discoaster variabilis*.

Lower Miocene
(*Helicopontosphaera ampliaperta* Zone)

4-30-15-1, 80-83 cm, depth 413 m:
Cyclococcolithus neogammation, *Discoaster exilis*, *Sphenolithus heteromorphus*.

HOLE 31
(lat 14° 56.60'N., long 72° 01.63'W., depth 3369 meters)

Summary of Coccolith Age Determinations

Sediment recovered from Hole 31 (10 cores) ranges from upper Pleistocene (*Gephyrocapsa oceanica* Zone) to the Oligocene (basal *Triquetrorhabdulus carinatus* Zone). Lower Pleistocene, lower Pliocene, upper Miocene, and most of the lower Miocene are missing.

Age-diagnostic Coccoliths in Selected Samples, Hole 31

Upper Pleistocene
(*Gephyrocapsa oceanica* Zone)

4-31-1-5, 74-75 cm, depth 7 m:
Ceratolithus cristatus, *Gephyrocapsa oceanica*, *Rhabdosphaera clavigera*, *Scapholithus fossilis*.

Upper Pliocene
(*Discoaster brouweri* Zone)

4-31-1, 75-76 cm, depth 61 m:
Cyclococcolithus leptoporus var. A, *Discoaster brouweri*, *Discoaster pentaradiatus* [rare], *Rhabdosphaera clavigera*.

4-31-7-1, 66-67 cm, depth 98 m:
Ceratolithus rugosus, *Cyclococcolithus leptoporus* var. A, *Discoaster brouweri*, *Discoaster pentaradiatus*.

Middle Miocene
(?*Catinaster coalitus* Zone)

4-31-8-1, 74-75 cm, depth 156 m:
Cyclococcolithus leptoporus, *Discoaster bollii*, *Discoaster brouweri*, *Reticulofenestra pseudoumbilica*, *Triquetrorhabdulus* sp. aff. *T. rugosus*.

Miocene to Oligocene
(*Triquetrorhabdulus carinatus* Zone)

4-31-9-2, 1-4 cm, depth 214 m:
Cyclococcolithus neogammation, *Discoaster deflandrei*, *Triquetrorhabdulus carinatus*.

Oligocene
(basal *Triquetrorhabdulus carinatus* Zone)

4-31-10-5, 0-3 cm, depth 276 m:
Coccolithus sp. aff. *C. bisectus*, *Cyclococcolithus neogammation*, *Discoaster deflandrei*, *Sphenolithus ciperensis* [rare], *Triquetrorhabdulus carinatus*.

REFERENCE

Bukry, D. and Bramlette, M. N., 1970. Coccolith age determinations Leg 3, Deep Sea Drilling Project. In Maxwell, A. E. et al., 1970, Initial Reports of the Deep Sea Drilling Project. Volume III, Washington (U. S. Government Printing Office). p. 5890.