

13. COCCOLITH AGE DETERMINATIONS LEG 2, DEEP SEA DRILLING PROJECT

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This report combines the results of study of 115 coccolith samples from the 78 cores recovered during Leg 2 of the Deep Sea Drilling Project, October-November 1968. Light-microscope techniques were used to identify coccolith assemblages. For each drilling site, age-diagnostic species in selected samples follow a brief summary of the coccolith stratigraphy.

The sample numbers, which identify the relative position of samples in the holes, consist of a series of numbered and lettered entries separated by hyphens 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, 2-9A-1-1, 31-33 cm, means the sample came from Leg 2, Hole 9A (at Site 9), the first barrel of core recovered, the top section of that core, and from 31-33 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.

M. N. Bramlette of Scripps Institution of Oceanography generously helped in the study of the coccolith assemblages. His experience in worldwide stratigraphic correlation was most helpful in evaluating the age determinations presented.

HOLES 8 AND 8A

(lat 35° 23.0'N., long 67° 33.2'W., depth 5184 meters)

Summary of Coccolith Age Determinations

Material examined from this site consists of a sample of drill-collar sediment that contains a sparse assemblage of coccoliths of questionable Pleistocene age. No discoasters are present. A second sample from 279 meters below the bottom is barren of coccoliths.

Age-diagnostic Coccoliths in Selected Samples, Hole 8A (Hole 8: No samples).

Pleistocene(?)

Sample 2-8A, drill collar, 0 to 306 m:

Coccolithus pelagicus (Wallich); *Cyclococcolithus leptoporus* (Murray and Blackman); *Gephyrocapsa oceanica* Kamptner; *Helicopontosphaera kamptneri* Hay and Mohler.

[Sample 2-8A-1-1, 90-92 cm, depth 279 m: Barren.]

HOLES 9 AND 9A

(lat 32° 46.4'N., long 59° 11.7'W., depth 4973 meters)

Summary of Coccolith Age Determinations

The Pleistocene sediment from Core 5 is characterized by the absence of discoaster species and the presence of small coccolith species such as *Coccolithus dornicoides* Black and Barnes and *Gephyrocapsa oceanica* Kamptner. Coccolith assemblages from Cores 7 and 8 indicate an early Pliocene age. Co-occurrence of *Ceratolithus rugosus* Bukry and Bramlette with some bizarre varieties of *C. tricorniculatus* Gartner in material from Core 8 suggests a very early Pliocene age. Much deeper cores, 2A and 3A, contain sparse and generalized coccolith assemblages of late Cretaceous age. The occurrence of *Tetralithus aculeus* (Stradner) and *T. pyramidus* Gardet in this material indicates a late Cretaceous (Campanian or Maestrichtian) age.

Age-diagnostic Coccoliths in Selected Samples, Holes 9 and 9A

Early Pleistocene

Sample 2-9-5-1, 75-76 cm, 32 m:

Coccolithus pelagicus (Wallich); *Cyclococcolithus leptoporus* Murray and Blackman, var. A of McIntyre, Be', and Preikstas; *C. leptoporus* Murray and Blackman, var. C of McIntyre, Be', and Preikstas; *Gephyrocapsa oceanica* Kamptner; *Rhabdosphaera clavigera* Murray and Blackman.

Sample 2-9-5-4, 78-79 cm, 37 m:

Ceratolithus cristatus Kamptner; *Coccolithus dornicoides* Black and Barnes; *Cyclococcolithus leptoporus* Murray and Blackman, var. C of McIntyre, Be', and Preikstas; *Rhabdosphaera stylifera* Lohmann.

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Early Pliocene

Sample 2-9-7-1, 73-74 cm, 195 m:

Ceratulithus rugosus Bukry and Bramlette; *Discoaster challengerii* Bramlette and Riedel; *D. pentaradiatus* Tan; *D. surculus* Martini and Bramlette; *D. sp.*; *Reticulofenestra pseudoumbilica* (Gartner).

Sample 2-9-8-2, 59-60 206 m:

Ceratulithus rugosus Bukry and Bramlette; *C. tricorniculatus* Gartner, emended; *Discoaster pentaradiatus* Tan; *D. surculus* Martini and Bramlette; *D. variabilis* Martini and Bramlette; *Reticulofenestra pseudoumbilica* (Gartner).

[Sample 2-9-9-2, 74-75 cm, 304 m: Barren.]

[Sample 2-9A-1-1, 31-33 cm, 680 m: Barren.]

Late Cretaceous (Campanian or Maestrichtian)

Sample 2-9A-2, core catcher, 759 m:

Cribrosphaera ehrenbergi Arkhangelsky; *Micula decussata* Vekshina; *Prediscosphaera cretacea* (Arkhangelsky); *Tetralithus aculeus* (Stradner); *T. sp. aff. T. murus* Martini; *T. pyramidus* Gardet.

Sample 2-9A-3-2, 135 cm, 768 m:

Micula decussata Vekshina; *Tetralithus aculeus* (Stradner); *Watznaueria barnesae* (Black).

[Sample 2-9A-6, core catcher, 835 m:

Coccoliths too rare and poorly preserved to be identified.]

HOLE 10

(lat 32° 51.7'N., long 52° 12.9'W., depth 4712 meters)

Summary of Coccolith Age Determinations

At Site 10, essentially continuous coring was carried out between subbottom depths of 30 to 100 meters (Cores 1 to 7); two additional cores were taken between 167 and 185 meters below the bottom (Cores 8 and 9); and, after a single core from 291 to 299 meters (Core 10) a final sequence of 10 continuous cores was cut between 378 and 459 meters (Cores 11 to 20).

Cores 1 to 7 recovered sediment ranging in age from late Pliocene to late Middle Eocene. Oligocene sediment was recovered from Coring Runs 3 and 5 (no recovery was made for Coring Run 4) between 48 and 80 meters. The Oligocene coccolith assemblages are assigned to the *Sphenolithus ciperensis* Concurrent-range Zone (2-10-3-3, 74-75 cm), *Sphenolithus distentus* Concurrent-range Zone (2-10-3-4, 74-75 cm), and *Helicopontosphaera reticulata* Concurrent-range Zone (2-10-5-4, 74-75 cm). The early Oligocene *H. reticulata* Zone assemblages from this open-ocean setting at the western flank of the Mid-Atlantic Ridge are quite distinctive

because of limited species composition. Certain coccolith taxa present in age-correlative samples from the Oligocene Vicksburg Group of the Gulf Coast, Blake Plateau boreholes, and Deep Sea Drilling Project Hole 5 east of the Bahama Platform are conspicuously missing in Hole 10 samples. Many of these missing taxa such as *Discolithina macropora* (Deflandre), *Lanternithus minutus* Stradner, *Orthozygus aureus* (Stradner), *Peritracelina joidesa* Bukry and Bramlette, and *Zygrhalthus bijugatus* (Deflandre) are delicately constructed holococcoliths (Gartner and Bukry, in press). Factors of preservation or ecology are believed to chiefly cause the absence of holococcoliths. Other taxa that are missing at Site 10, such as *Braarudosphaera bigelowi* (Gran and Braarud), *B. discula* Bramlette and Riedel, *B. rosa* Levin and Joerger, and *Helicopontosphaera compacta* (Bramlette and Wilcoxon), are strongly constructed, and their absence suggests an ecologic preference by these species for a nearshore pelagic environment—although not necessarily for shallow water (M. N. Bramlette, personal communication, 1967). The assemblage of species common to Site 10 and the other localities that provides the best general means of correlation, includes *Coccolithus bisectus* (Hay, Mohler, and Wade), *Coccolithus eopelagicus* (Bramlette and Riedel), *Cyclococcolithus lusitanicus* (Black), *C. neogammation* Bramlette and Wilcoxon, *Discoaster tani tani* Bramlette and Riedel, *Reticulofenestra umbilica* (Levin), *Sphenolithus predistentus* Bramlette and Wilcoxon, and *S. pseudoradians* Bramlette and Wilcoxon (see Figure 1).

Core 9 contains an early Eocene coccolith assemblage dominated by *Discoaster lodoensis* Bramlette and Riedel and *Discoasteroides kuepperi* (Stradner). In Core 10, a rich Maestrichtian assemblage contains a great abundance of *Lithraphidites quadratus* Bramlette and Martini and *Cribrosphaera ehrenbergi* Arkhangelsky.

Beginning in Core 11, which was cut 79 meters below Core 10, a continuous sequence of 73 meters of sediment from early or middle Campanian to late Campanian or early Maestrichtian age is represented. A number of taxonomic trends can be seen in these recoveries. *Broinsonia parca* (Stradner) dominates the representatives of the subfamily Arkhangelskielloideae in the older, early to middle Campanian cores (16, 17 and 18). But at the top of Core 16 the first *Arkhangelskiella cymbiformis* Vekshina occurs, and this member of the subfamily co-occurs with *B. parca* through the middle Campanian to early Maestrichtian cores (11, 12, 13, 14, 15 and 16). Only *A. cymbiformis* is present in the distinctly Maestrichtian Core 10.

Among the four species of *Tetralithus* present, *T. aculeus* (Stradner) is in all Cretaceous cores. *T. pyramidus* occurs in Core 11, but more commonly in Cores 16, 17 and 18. Finally there appears to be a stratigraphic change from *T. nitidus nitidus* Martini occurring mainly in Cores 16, 17 and 18 to *T. nitidus trifidus* (Stradner) occurring


<p style="text-align: center;">LOWER OLIGOCENE LOCALITIES</p> <p style="text-align: center;">COCCOLITH TAXA</p>	<p style="text-align: center;">Red Bluff Clay and Vicksburg Group, Gulf Coastal Plain</p>	<p style="text-align: center;">JOIDES Blake Plateau Holes J3 (114-151 meters) and J6 (14-72 meters)</p>	<p style="text-align: center;">JOIDES Deep Sea Drilling Project Hole 5 (4 meters) east of Bahama Platform</p>	<p style="text-align: center;">JOIDES Deep Sea Drilling Project Hole 10 (54-76 meters) west flank of Mid-Atlantic Ridge</p>
<i>Discolithina macropora</i>	X	O	O	O
<i>Lanternithus minutus</i>	X	O	O	O
<i>Orthozygus aureus</i>	X	O	O	O
<i>Zygrhablithus bijugatus</i>	X	X	O	O
<i>Peritrachelina joidesa</i>	X	X	X	O
<i>Braarudosphaera bigelowi</i>	X	X	X	O
<i>B. discula</i>	X	X	X	O
<i>B. rosa</i>	X	X	X	O
<i>Helicopontosphaera compacta</i>	X	X	X	O
<i>Coccolithus bisectus</i>	X	X	X	X
<i>Cyclococcolithus lusitanicus</i>	X	X	X	X
<i>C. neogammation</i>	X	X	X	X
<i>Discoaster tani tani</i>	X	X	X	X
<i>Reticulofenestra umbilica</i>	X	X	X	X
<i>Sphenolithus predistentus</i>	X	X	X	X
<i>S. pseudoradians</i>	X	X	X	X
<p style="text-align: center;">Absent - O</p> <p style="text-align: center;">Present - X</p>	<p style="text-align: center;">  Diminishing continental environmental influence </p>			

Figure 1. Lower Oligocene coccolith assemblages showing the influence of factors of ecology and preservation in progressively more offshore areas.

only in Cores 11, 12, 13 and 14. Recent study of the distribution of these *Tetralithus* taxa indicates a similar sequence with *T. aculeus*, *T. pyramidus* and *T. nitidus trifidus* co-occurring near the Campanian-Maestrichtian boundary and with *T. nitidus nitidus* being restricted to, or more abundant in, Campanian sediment (Bukry and Bramlette, 1969; Bukry and Kennedy, 1969). Of the two species of *Eiffellithus* present, *E. augustus* Bukry occurs commonly in Cores 17 and 18 but only *E. turriseiffeli* (Deflandre) is present in the younger cores. This stratigraphic distribution suggests that *E. augustus* may prove to be useful in Campanian age determinations. A distinctive trend observed through these cores is the reduction in size and abundance of *Cribrosphaera ehrenbergi* Arkhangelsky from Core 10 through Core 18.

Detailed studies of continuously cored sequences such as this can yield invaluable stratigraphic information and provide long-needed standard reference sections to aid in worldwide correlations and in understanding of the geologic history of the earth.

Age-diagnostic Coccoliths from Selected Samples, Hole 10.

Late Pliocene

Sample 2-10-1-1, 77-78 cm, 31 m:
Ceratolithus rugosus Bukry and Bramlette; *Coccolithus dornicoides* Black and Barnes; *Discoaster brouweri* Tan; *D. pentaradiatus* Tan; *D. surculus* Martini and Bramlette.

Early Pliocene

Sample 2-10-1-2, 90-91 cm, 32 m:
Ceratolithus rugosus Bukry and Bramlette, *C. tricorniculatus* Gartner, emended; *Discoaster challengerii* Bramlette and Riedel; *D. pentaradiatus* Tan; *D. surculus* Martini and Bramlette; *Reticulofenestra pseudoumbilica* (Gartner).

Late Miocene

Sample 2-10-2-2, 75-76 cm, 42 m:
Ceratolithus tricorniculatus Gartner, emended; *Coccolithus eopelagicus* (Bramlette and Riedel); *Discoaster surculus* Martini and Bramlette; *D. challengerii* Bramlette and Riedel; *D. sp.*

Early Miocene

Sample 2-10-2-3, 75-76 cm, 43 m:
Coccolithus eopelagicus (Bramlette and Riedel); *Cyclococcolithus neogammation* Bramlette and Wilcoxon; *Discoaster aulakos* Gartner; *D. deflandrei* Bramlette and Riedel; *D. divaricatus* Hay; *D. druggi* Bramlette and Wilcoxon; *D. exilis* Martini and Bramlette; *D. variabilis* Martini and Bramlette. Taxa representing contamination from younger strata: *Ceratolithus rugosus* Bukry and

Bramlette; *Discoaster pentaradiatus* Tan; *D. surculus* Martini and Bramlette.

Late Oligocene

Sample 2-10-3-3, 74-75 cm, 52 m:
Cyclococcolithus neogammation Bramlette and Wilcoxon; *Discoaster deflandrei* Bramlette and Riedel; *Sphenolithus ciperoensis* Bramlette and Wilcoxon; *S. moriformis* (Brönnimann and Stradner).

Early Oligocene

Sample 2-10-3-4, 74-75 cm, 55 m:
Coccolithus bisectus Hay, Mohler, and Wade; *Cyclococcolithus neogammation* Bramlette and Wilcoxon; *Discoaster deflandrei* Bramlette and Riedel; *Sphenolithus distentus* (Martini); *S. predistentus* Bramlette and Wilcoxon.

Sample 2-10-5-4, 74-75 cm, 78 m:
Bramletteius serraculoides Gartner; *Coccolithus bisectus* (Hay, Mohler, and Wade); *Cyclococcolithus lusitanicus* (Black); *Discoaster tani tani* Bramlette and Riedel; *Reticulofenestra umbilica* (Levin); *Sphenolithus* sp. cf. *S. predistentus* Bramlette and Wilcoxon; *S. pseudoradians* Bramlette and Wilcoxon.

Late Eocene

Sample 2-10-5-5, 74-75 cm, 79 m:
Coccolithus bisectus Hay, Mohler, and Wade; *Cyclococcolithus lusitanicus* (Black); *Cyclolithella* sp.; *Discoaster barbadiensis* Tan; *D. saipanensis* Bramlette and Riedel; *D. tani tani* Bramlette and Riedel; *Isthmolithus recurvus* Deflandre.

Late Middle Eocene

Sample 2-10-7-1, 127-128 cm, 91 m:
Campylosphaera dela (Bramlette and Sullivan); *Chiasmolithus grandis* (Bramlette and Riedel); *Coccolithus bisectus* (Hay, Mohler, and Wade); *Cyclococcolithus lusitanicus* (Black); *Discoaster barbadiensis* Tan; *D. saipanensis* Bramlette and Riedel; *D. tani tani* Bramlette and Riedel; *Thoracosphaera* sp. [prolate].

Sample 2-10-7-2, 78-79 cm, 92 m:
Bramletteius serraculoides Gartner; *Campylosphaera dela* (Bramlette and Sullivan); *Chiasmolithus grandis* (Bramlette and Riedel); *Coccolithus bisectus* (Hay, Mohler, and Wade); *Discoaster barbadiensis* Tan; *D. saipanensis* Bramlette and Riedel; *Reticulofenestra umbilica* (Levin); *Sphenolithus radians* Deflandre.

Early Eocene

Sample 2-10-9-1, 77-78 cm, 177 m:
Coccolithus crassus Bramlette and Sullivan; *Discoaster barbadiensis* Tan; *D. lodoensis* Bramlette and Riedel; *Discoasteroides kuepperi* (Stradner); *Lophodolichus nascens* Bramlette and Sullivan.

Late Cretaceous (Maestrichtian)

Sample 2-10-10-2, 74-75 cm, 293 m:
Arkhangelskiella cymbiformis Vekshina; *Chiastozygus amphipons* (Bramlette and Martini); *Cribrosphaera ehrenbergi* Arkhangelsky; *Lithraphidites quadratus* Bramlette and Martini; *Prediscosphaera cretacea* (Arkhangelsky); *Watznaueria barnesae* (Black).

Late Cretaceous (Late Campanian or Early Maestrichtian)

Sample 2-10-11-3, 78-79 cm, 382 m:
Arkhangelskiella cymbiformis Vekshina; *Broinsonia parca* (Stradner); *Cribrosphaera ehrenbergi* Arkhangelsky; *Microrhabdulus decoratus* Deflandre; *Tetralithus aculeus* (Stradner); *T. nitidus trifidus* (Stradner).

Sample 2-10-12-2, 69-70 cm, 389 m:
Broinsonia parca (Stradner); *Cribrosphaera ehrenbergi* Arkhangelsky; *Eiffellithus turriseiffeli* (Deflandre); *Microrhabdulus decoratus* Deflandre; *Tetralithus nitidus nitidus* Martini; *T. nitidus trifidus* (Stradner).

Late Cretaceous (Late Campanian)

Sample 2-10-13-3, 78-79 cm, 400 m:
Arkhangelskiella cymbiformis Vekshina; *Broinsonia parca* (Stradner); *Cribrosphaera ehrenbergi* Arkhangelsky; *Cylindralithus gallicus* Bramlette and Martini; *C. serratus* Bramlette and Martini; *Lucianorhabdus cayeuxi* Deflandre; *Tetralithus aculeus* (Stradner); *T. nitidus trifidus* (Stradner).

Late Cretaceous (Campanian)

Sample 2-10-14-3, 77-78 cm, 409 m:
Broinsonia parca (Stradner); *Cribrosphaera ehrenbergi* Arkhangelsky; *Eiffellithus turriseiffeli* (Deflandre); *Tetralithus nitidus trifidus* (Stradner).

Late Cretaceous (Middle Campanian)

Sample 2-10-15-2, 74-75 cm, 416 m:
Apertapetra sp. aff. *A. gronosa* (Stover); *Arkhangelskiella cymbiformis* Vekshina; *Broinsonia parca* (Stradner); *Cribrosphaera ehrenbergi* Arkhangelsky; *Eiffellithus turriseiffeli* (Deflandre); *Tetralithus aculeus* (Stradner).

Sample 2-10-16-1, 110-111 cm, 424 m:
Arkhangelskiella cymbiformis Vekshina; *Broinsonia parca* (Stradner); *Cribrosphaera ehrenbergi* Arkhangelsky; *Eiffellithus turriseiffeli* (Deflandre); *Tetralithus aculeus* (Stradner); *T. pyramidus* Gardet.

Late Cretaceous (Early Campanian or Middle Campanian)

Sample 2-10-17-1, 102-103 cm, 433 m:
Apertapetra sp. aff. *A. gronosa* (Stover); *Broinsonia parca* (Stradner); *Cribrosphaera ehrenbergi* Arkhangelsky;
ehrenbergi

Eiffellithus augustus Bukry; *E. turriseiffeli* (Deflandre); *Tetralithus aculeus* (Stradner); *T. nitidus nitidus* Martini; *T. pyramidus* Gardet.

Sample 2-10-18-5, 75-76 cm, 448 m:
Broinsonia parca (Stradner); *Cribrosphaera ehrenbergi* Arkhangelsky; *Eiffellithus augustus* Bukry; *E. turriseiffeli* (Deflandre); *Tetralithus aculeus* (Stradner); *T. pyramidus* Gardet.

HOLES 11 AND 11A

(lat 29° 56.6'N., long 44° 44.8'W., depth 3571 meters)

Summary of Coccolith Age Determinations

Coccolith-bearing samples were available from only two of the cores collected at Site 11. In Core 1 of Hole 11 a sequence of very early Pleistocene sediment was recovered from 12 to 17 meters below the sea floor. In Core 4A of Hole 11A a poorly preserved series of coccolith assemblages indicates a Middle to late Miocene age for the upper part of the core and a Middle Miocene age for the lower part of the core. Poor preservation prevents precise correlation of this recovery, but a change in the dominant *Cyclococcolithus* species between the top and bottom of the core indicates the Middle Miocene affinity of the contained assemblages.

Age-diagnostic Coccoliths in Selected Samples, Holes 11 and 11A

Early Pleistocene

Sample 2-11-1-2, 75 cm, 14 m:
Ceratolithus rugosus Bukry and Bramlette; *Coccolithus daronicoides* Black and Barnes; *Cyclococcolithus leptoporus* (Murray and Blackman), var. C of McIntyre, Be', and Preikstas; *Helicopontosphaera kamptneri* Hay and Mohler.

Sample 2-11-1-4, 75-76 cm, 17 m:
Ceratolithus rugosus Bukry and Bramlette; *Cyclococcolithus leptoporus* Murray and Blackman, var. A of McIntyre, Be', and Preikstas; *C. leptoporus*, var. C of McIntyre, Be', and Preikstas; *Discoaster* species; *Helicopontosphaera kamptneri* Hay and Mohler; *Rhabdosphaera clavigera* Murray and Blackman.

Middle or Late Miocene

Sample 2-11A-4-1, 0-10 cm, 258 m:
Coccolithus eopelagicus (Bramlette and Riedel); *Cyclococcolithus leptoporus* (Murray and Blackman); *Discoaster brouweri* Tan; *D.* sp. aff. *D. challengeri* Bramlette and Riedel; *D. pentaradiatus* Tan; *Reticulofenestra pseudoumbilica* (Gartner).

Middle Miocene

Sample 2-11A-4-4, 39-49 cm, 263 m:
Coccolithus eopelagicus (Bramlette and Riedel);

Cyclococcolithus leptoporus Murray and Blackman; *C. neogammation* Bramlette and Wilcoxon; *Discoaster* sp. aff. *D. exilis* Martini and Bramlette; *D.* sp. aff. *D. variabilis* Martini and Bramlette; *Reticulofenestra pseudumbilica* (Gartner); *Sphenolithus* sp. cf. *S. abies* Deflandre.

HOLES 12, 12A, 12B, 12C AND 12D
(lat 19° 41.7'N., long 26° 00.0'W., depth 4557 meters)

Summary of Coccolith Age Determinations

Cores from 3 to 37 meters below the sea floor (Cores 1, 2R and 4 of Hole 12C) contain sediment of Pleistocene to late Miocene or early Pliocene age. All core samples examined from greater depths are barren of coccoliths. Core 1 (Hole 12C) contains an early Pleistocene assemblage. In a redrilling of Core 2 (Hole 12C)—called Core 2R—an unnatural sequence with late Pliocene sediment overlying Pleistocene sediment was obtained. This out-of-place Pleistocene sediment is younger than the Pleistocene recovered in Core 1 (Hole 12C) and probably represents surficial material introduced during oscillation of the drill pipe before it became seated at the bottom.

Age-diagnostic Coccoliths from Selected Samples, Holes 12B and 12C (Holes 12, 12A, 12D: No samples)

Early Pleistocene

Sample 2-12C-1-3, 145-150 cm, 5 m:
Ceratolithus rugosus Bukry and Bramlette; *Coccolithus daronicoides* Black and Barnes; *Cyclococcolithus leptoporus* Murray and Blackman; *Gephyrocapsa oceanica* Kamptner; *Rhabdosphaera stylifera* Lohmann.

Late Pliocene

Sample 2-12C-2R-1, 142 cm, 16 m:
Ceratolithus rugosus Bukry and Bramlette; *Coccolithus daronicoides* Black and Barnes; *Cyclococcolithus leptoporus* Murray and Blackman; *Discoaster brouweri* Tan.

Sample 2-12C-2R-2, 145-150 cm, 17 m:
Ceratolithus rugosus Bukry and Bramlette; *Coccolithus daronicoides* Black and Barnes; *Cyclococcolithus leptoporus* Murray and Blackman; *Discoaster brouweri* Tan; *D. pentaradiatus* Tan; *D. surculus* Martini and Bramlette.

Pleistocene

Sample 2-12C-2R-3, 145-150 cm, 18 m:
Cyclococcolithus leptoporus Murray and Blackman; *Gephyrocapsa oceanica* Kamptner; *Helicopontosphaera kamptneri* Hay and Mohler.

Sample 2-12C-2R-4, 145-150 cm, 19 m:
Cyclococcolithus leptoporus Murray and Blackman; *Gephyrocapsa oceanica* Kamptner; *Helicopontosphaera kamptneri* Hay and Mohler.

Late Pliocene

Sample 2-12C-4-1, 99-100 cm, 34 m:
Ceratolithus rugosus Bukry and Bramlette; *Coccolithus daronicoides* Black and Barnes; *Cyclococcolithus leptoporus* (Murray and Blackman); *Discoaster brouweri* Tan; *D. challengerii* Bramlette and Riedel; *D. pentaradiatus* Tan; *D. surculus* Martini and Bramlette.

Early Pliocene

Sample 2-12C-4-2, 73-74 cm, 35 m:
Ceratolithus rugosus Bukry and Bramlette; *Cyclococcolithus leptoporus* Murray and Blackman; *Discoaster brouweri* Tan; *D. challengerii* Bramlette and Riedel; *D. pentaradiatus* Tan; *D. surculus* Martini and Bramlette; *Reticulofenestra pseudumbilica* (Gartner).

Late Miocene or Early Pliocene

Sample 2-12C-4-3, 77-78 cm, 36 m:
Ceratolithus rugosus Bukry and Bramlette; *C. tricorniculatus* Gartner, emended; *Cyclococcolithus leptoporus* Murray and Blackman; *Discoaster brouweri* Tan; *D. challengerii* Bramlette and Riedel; *D. pentaradiatus* Tan; *D. surculus* Martini and Bramlette; *D.* sp. (undescribed); *Reticulofenestra pseudumbilica* (Gartner).

[Sample 2-12C-5-3, 73-74 cm, 46 m: Barren.]

[Sample 2-12C-6-2, 73-74 cm, 53 m: Barren.]

[Sample 2-12C-7-1, 70-71 cm, 61 m: Barren.]

[Sample 2-12C-8-1, 130-131 cm, 71 m: Barren.]

[Sample 2-12C-10-1, 142-144 cm, 89 m: Barren.]

[Sample 2-12C-11-1, 130-131 cm, 98 m: Barren.]

[Sample 2-12B-2, core catcher, 158 m: Barren.]

REFERENCES

- Bramlette, M. N. and Martini, E., 1964. The great change in calcareous nannoplankton fossils between the Maestrichtian and Danian. *Micropaleontology*, **10** (3), 291.
- Bramlette, M. N. and Sullivan, F. R., 1961. Coccolithophorids and related nannoplankton of the early Tertiary in California. *Micropaleontology*, **7** (4), 129.
- Bramlette, M. N. and Wilcoxon, J. A., 1967. Middle Tertiary calcareous nannoplankton of the Ciper section, Trinidad, W. I. *Tulane Studies Geology*, **5**, 93.
- Bukry, D., 1969. Upper Cretaceous coccoliths from Texas and Europe. (*Univ. Kansas Publ. State Geol. Surv. Kansas Bull.* Paleont. Contr., Protista, art. 2, 79.

- Bukry, D. and Bramlette, M. N., 1968. Stratigraphic significance of two genera of Tertiary calcareous nanofossils. *Tulane Studies Geology*, 6, 149.
- . 1969. Coccolith age determinations Leg I, Deep Sea Drilling Project. In *Initial Reports of the Deep Sea Drilling Project—Vol. 1*. Washington (National Science Foundation), 369.
- Bukry, D. and Kennedy, M. P., 1969. Cretaceous and Eocene coccoliths at San Diego, California. *California Div. Mines and Geology Spec. Rept. 100*, 33.
- Gartner, S., Jr., 1967. Calcareous nanofossils from Neogene of Trinidad, Jamaica, and Gulf of Mexico. *Univ. Kansas Publ. State Geol. Surv. Kansas Bull. Paleont. Contr.*, Paper 29, 1.
- . 1968. Coccoliths and related calcareous nanofossils from Upper Cretaceous deposits of Texas and Arkansas. *Univ. Kansas Publ. State Geol. Surv. Kansas Bull. Paleont. Contr.* 48, Protista, art. 1, 56.
- Gartner, S., Jr. and Bukry, D., (in press) 1969. Tertiary holococcoliths. *J. Paleontology*.
- Hay, W. W., Mohler, H., Roth, P. H., Schmidt, R. R. and Boudreaux, J. E., 1967. Calcareous nannoplankton zonation of the Cenozoic of the Gulf Coast and Caribbean-Antillean area, and transoceanic correlation. In Symposium on the geological history of the Gulf of Mexico. Antillean-Caribbean region. *Trans. Gulf Coast Assoc. Geol. Soc.* 17, 428.
- Levin, H. L., 1965. Coccolithoporidae and related microfossils from the Yazoo formation (Eocene) of Mississippi. *J. Paleontology*. 39, 265.
- Levin, H. L., and Joerger, A. P., 1967. Calcareous nannoplankton from the Tertiary of Alabama. *Micro-paelontology*. 13, (2), 163.
- Martini, E. and Bramlette, M. N., 1963. Calcareous nannoplankton from the experimental Mohole drilling. *J. Paleontology*. 37, (4), 845.
- McIntyre, A., Be, A. W. H. and Preikstas, R., 1967. Coccoliths and the Pliocene-Pleistocene boundary. In *Progress in oceanography—V. 4, The Quaternary history of the ocean basins*. London and New York (Pergamon Press), 3.
- Stradner, H., 1964. New contributions to Mesozoic stratigraphy by means of nanofossils. *World Petroleum Cong., 6th, Frankfurt am Main, Proc.*, sec. 1, 167.