

## 16. FURTHER COMMENTS ON COCCOLITH STRATIGRAPHY, LEG 12, DEEP SEA DRILLING PROJECT<sup>1</sup>

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### INTRODUCTION

Leg 12 of the Deep Sea Drilling Project, June-August 1970, through the North Atlantic Ocean from Boston to Lisbon, recovered 184 cores at nine drilling sites (Figure 1). Light-microscope techniques were used to study the coccoliths of 294 samples from these cores. Zonal assignment of cores from Leg 12 is summarized in Table 1. A discussion of high-latitude coccolith assemblages is followed by a summary of site stratigraphy and by a concluding section where species from selected samples are listed.

Sample numbers for each site consist of elements in the following sequence: cruise-leg number; drill-hole number, composed of site number plus a letter, if more than one hole; core number; core-section number; interval in centimeters below the top of the plastic liner of each core section. For example, 12-117A-3A-2, 117-118 cm, indicates that the sample came from DSDP Leg 12, Hole 117A (at Site 117), the third barrel of core recovered, the second section from the top of that core, and from 117 to 118 centimeters below the top of the section liner. Core sections are 1.5 meters long; most core runs were 9.1 meters long, but some of the core liners are not full. In this report, the tops of incomplete recoveries are arbitrarily placed at the top of core runs, and an approximate depth in meters below the sea floor follows each sample number.

### COMPOSITION OF HIGH-LATITUDE COCCOLITH ASSEMBLAGES

All sites cored by DSDP Leg 12, which range from latitude 45°02'N to latitude 59°56'N, are farther north than any yet attempted by the Deep Sea Drilling Project. The most distinctive feature of high-latitude coccolith assemblages is the paucity of star-shaped discoasters that characterize low-latitude oceanic assemblages. High-latitude assemblages have fewer total species than the low-latitude equivalents and some are numerically dominated by only a few cosmopolitan species that are not ordinarily used as key stratigraphic species at low latitudes. Because of the lack of specialized low-latitude taxa, zonal correlation of high-latitude assemblages commonly must be based on cosmopolitan taxa, usually placoliths, that occur in both high- and low-latitude areas.

Discoaster species that are useful in recognizing zones and subzones throughout essentially all of the Tertiary in tropical areas are generally scarce in post-Eocene samples from Leg 12. As evidence from previous DSDP legs shows discoasters to be among the coccoliths most resistant to

calcite solution, their scarcity here must be mainly a function of paleoecologic exclusion. In Paleocene and Eocene samples, discoasters are present in numbers comparable to more southern samples, but some exclusions exist at the species level, for example, *Discoaster tani tani* Bramlette and Riedel, a typical member of upper Eocene and lower Oligocene assemblages in the tropics.

A striking reduction in the diversity of high-latitude assemblages is indicated by comparison with equivalent-age assemblages from equatorial oceanic areas. Typical warm-water taxa that are missing from Leg 12 sites or are rarely present include: *Bramletteius serraculoides* Gartner, *Campylosphaera dela* (Bramlette and Sullivan), *Ceratolithus cristatus* Kamptner, *C. rugosus* Bukry and Bramlette, *Discoaster asymmetricus* Gartner, *D. perplexus* Bramlette and Riedel, *D. tani tani* Bramlette and Riedel, *Helicopontosphaera compacta* (Bramlette and Wilcoxon), *H. parallela* (Bramlette and Wilcoxon), *H. reticulata* (Bramlette and Wilcoxon), *Oolithotus antillarum* (Cohen), *Pedinocyclus larvalis* (Bukry and Bramlette), *Rhabdosphaera clavigera* Murray and Blackman, *Scyphosphaera globulata* Bukry and Percival, *S. pulcherrima* Deflandre, *Sphenolithus abies* Deflandre, *S. dissimilis* Bukry and Percival, *S. neoabies* Bukry and Bramlette, *S. predistentus* Bramlette and Wilcoxon, *S. pseudoradians* Bramlette and Wilcoxon, *Triquetrorhabdulus carinatus* Martini, and *T. rugosus* Bramlette and Wilcoxon.

Some of these taxa, in addition to having flourished in warm-water areas, are among those coccoliths most susceptible to solution. For example, *Oolithotus antillarum*, *Discoaster perplexus*, *Helicopontosphaera* spp. and *Scyphosphaera* spp. occur commonly in the equatorial Pacific at DSDP Site 62 (latitude 01°52.2'N, depth 2591 meters), in equivalent-age sediment. Among the more solution-resistant coccoliths are the genera *Bramletteius*, *Campylosphaera*, *Discoaster*, and *Triquetrorhabdulus* and their rarity in the Leg 12 samples is clearly related to paleoecologic exclusion rather than dissolution.

The absence of some middle and upper Miocene guide fossils, such as *Catinaster calyculus* Martini and Bramlette, *C. coalitus* Martini and Bramlette, *C. mexicanus* Bukry, and *Discoaster kugleri* Martini and Bramlette, could be merely a result of stratigraphic sampling and not paleoecologic exclusion, as these species mark only short intervals in warm-water cores.

Cosmopolitan taxa that can be used for generalized zonal assignment in post-Eocene areas of both high and low latitude include the following species, for which typical zonal ranges are given: *Ceratolithus tricorniculatus* [*Discoaster quinqueramus* Zone to *Ceratolithus rugosus* Zone], *Coccolithus eopelagicus* [*Chiphragmalithus quadratus* Zone to *Discoaster exilis* Zone], *Cyclococcolithina macintyrei*

<sup>1</sup> Publication authorized by the Director, U. S. Geological Survey.

**TABLE 1**  
**Zonal and Geologic Age Assignments of Cores From Deep Sea Drilling Project**  
**Leg 12 as Indicated by Coccoliths in Examined Samples**

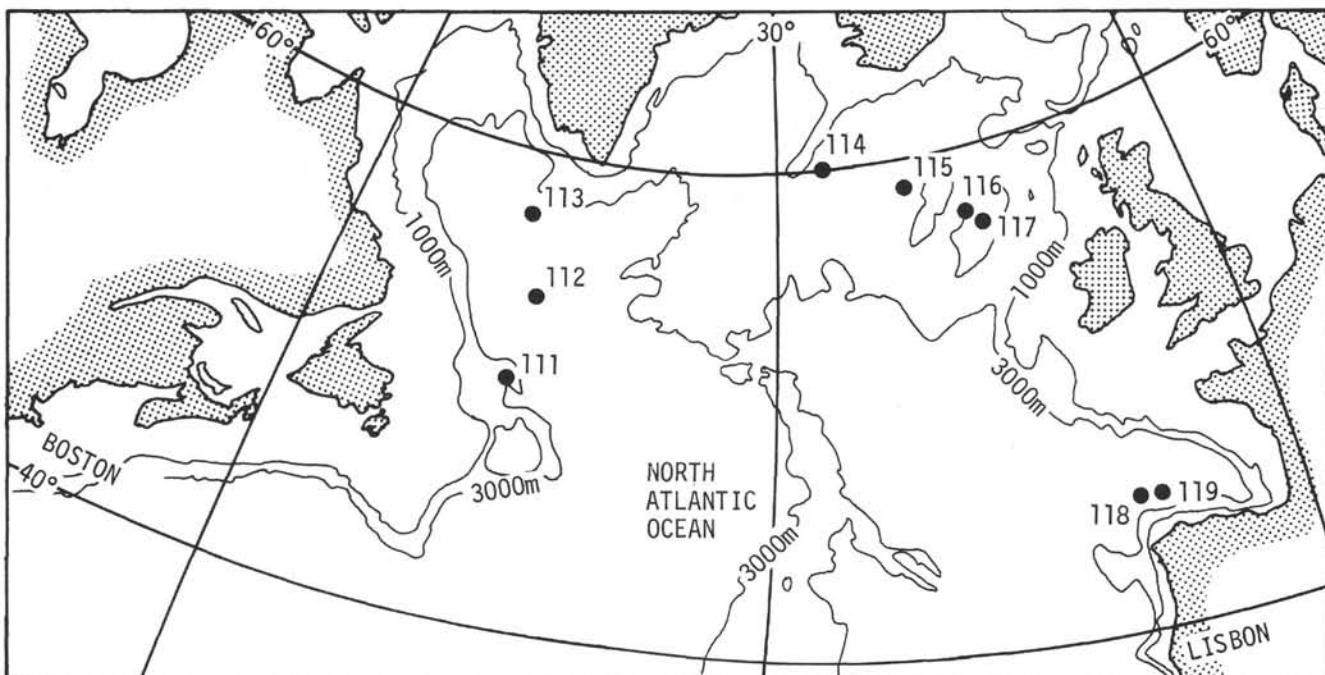


Figure 1. Sites drilled on Leg 12, Deep Sea Drilling Project.

[*Sphenolithus heteromorphus* Zone to *Discoaster brouweri* Zone], *Cyclococcolithina neogammation* [*Discoaster barbadiensis* Zone to *Sphenolithus heteromorphus* Zone], *Dictyococcites abisectus* [*Sphenolithus distentus* Zone to *Triquetrorhabdulus carinatus* Zone], *Dictyococcites scrippsa* [*Reticulofenestra umbilica* Zone to *Sphenolithus ciperoensis* Zone], *Emiliania annula* [*Discoaster brouweri* Zone to *Gephyrocapsa oceanica* Zone], *Gephyrocapsa oceanica* [*Gephyrocapsa oceanica* Zone to *Emiliania huxleyi* Zone], *Helicopontosphaera kamptneri* [*Sphenolithus heteromorphus* Zone to *Emiliania huxleyi* Zone], *Isthmolithus recurvus* [*Discoaster barbadiensis* Zone to *Helicopontosphaera reticulata* Zone], *Reticulofenestra pseudoumbilica* [*Sphenolithus heteromorphus* Zone to *Reticulofenestra pseudoumbilica* Zone], *Reticulofenestra umbilica* [*Reticulofenestra umbilica* Zone to *Helicopontosphaera reticulata* Zone].

The only coccolith from Leg 12 that is seemingly restricted to cool-water areas is *Coccolithus Neohelis* McIntyre and Bé. Originally described from a living North Atlantic population near Bermuda in water at 18.2°C, it occurs in the upper Pliocene or lower Pleistocene of DSDP Site 113 and DSDP Hole 116A (reported on here), and in sediment of the same age in DSDP Site 36, Leg 5, latitude 40°59'N in the eastern Pacific. All other identified taxa are known from low-latitude areas.

Several coccolith assemblages from the Leg 12 cores are unique in being dominated by only one or two species. An upper Oligocene sample from the Hatton-Rockall Basin at Site 117 is essentially an ooze of the two species *Zygrhablithus bijugatus* Deflandre and *Chiasmolithus altus* Bukry and Percival. Another group of samples near the Pliocene-Pleistocene boundary in Sites 112, 114 and 116 contains a coccolith ooze dominated by *Coccolithus pelagicus* (Wallich) and *Helicopontosphaera sellii* Bukry and Bramlette. Such occurrences are unusual in low-latitude assemblages

but may be useful for regional correlation at high latitudes because of short-term duration and ease of identification.

The Leg 12 coccolith assemblages serve to illustrate that a previously recognized discontinuity in Tertiary discoaster populations is accentuated at high latitudes. Discoasters are common and diversified in the upper Paleocene to upper Eocene and in the middle Miocene and upper Miocene. In the Oligocene, at low latitudes, the discoaster diversity is greatly reduced, and this reduction is even more pronounced in the essentially discoaster-barren Oligocene interval of Leg 12. The striking reduction in *Discoaster* abundance in the high-latitude samples from Leg 12 indicates that reduced ocean-surface temperatures limited *Discoaster* diversity and abundance. Thus the lowered Oligocene diversity of *Discoaster* even in tropical areas, is evidence for a mid-Tertiary period of climatic cooling.

#### SUMMARY OF COCCOLITH STRATIGRAPHY AT LEG 12 SITES

##### HOLES 111 AND 111A (lat 50°25.57' N, long 46°22.05' W., depth 1811 meters)

This site is on an isolated seamount, "Orphan Knoll", about 560 kilometers northeast of Newfoundland. Coring was carried out to determine if the knoll is a continental remnant, possibly stranded during sea-floor spreading.

Coccolith assemblages of samples available from Hole 111 are sparse. The best assemblage, in Sample 12-111-3-1, 136 to 137 centimeters, contains rare specimens of characteristic Upper Cretaceous species. Sediment from Hole 111A ranges in age from Pleistocene to Late Cretaceous. Cores 1A to 5A (105 to 141 meters) contains sparse early? Pleistocene assemblages characterized by *Coccolithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*,

*Emiliania annula*, and *Helicopontosphaera kampfneri*. In the absence of *Ceratolithus* and *Scyphosphaera* and the rare occurrence of *Rhabdosphaera* these assemblages are comparable to the cold-water early Pleistocene assemblages of DSDP Leg 5 (eastern Pacific), which are characterized by the same assemblage of poorly diversified placolithid coccoliths (Bukry and Bramlette, 1970).

Pliocene, Miocene and Eocene assemblages are present in Core 6A. Discoasters are rare in the upper Pliocene samples from Sections 1 and 2, which are dominated by placolith forms. A lower Pliocene sample from the bottom of Section 2 (12-111A-6A-2, 146 to 147 centimeters) has a more diverse assemblage, indicating deposition from warmer water. Both upper Miocene and middle Eocene assemblages occur in Section 3.

Several middle and lower Eocene coccolith zones are present in Cores 6A to 10A. Core 10A contains an upper Campanian to lower Maestrichtian coccolith chalk. Common specimens of *Braarudosphaera bigelowi*, *Kamptnerius magnificus*, and *Lucianorhabdus cayeuxi* indicate that the depositional environment of the chalk was comparable to that of Cretaceous chalk of the Gulf Coastal Plain of the United States. This is the first significant occurrence, in a DSDP core, of *Kamptnerius* which has been used in zonation of shallow oceanic chalk from onshore localities (Bukry, 1969; Cepek and Hay, 1969).

#### HOLES 112 AND 112A

(lat 54°01.00'N., long 46°36.24'W., depth 3667 meters)

Determination of the nature of the sediment section and the age of acoustic reflectors and the basement in the Labrador Sea were the goals at Site 112.

Coccoliths are common to abundant in most samples examined. Age of the sediment ranges from early Pleistocene (*Coccolithus doronicoides* Zone) to middle Eocene (*Discoaster sublodoensis* Zone). The early Pleistocene and late Pliocene assemblages of Cores 1 and 2 (27 to 109 meters) lack the warm-water forms *Ceratolithus*, *Scyphosphaera* and *Thoracosphaera*, and contain *Coccolithus pelagicus* populations dominated by the variety with a central-area crossbar. Discoaster populations of Core 3, which contains *Discoaster hamatus* and *D. neohamatus*, indicate an early late Miocene age. A sample from Core 4 at 203 meters has a poor middle Miocene assemblage belonging to the *Discoaster exilis* Zone. Cores 5 to 11 (270 to 329 meters) contain middle Oligocene diatom-coccolith ooze with placolith-type coccoliths predominant; discoasters are absent or exceedingly rare. Very diverse lower Oligocene to middle Eocene assemblages of Cores 12 to 15 (384 to 579 meters) contain many solution-etched specimens with ragged outlines.

Redrilling of the site, Hole 112A, produced a series of poor early Pleistocene or late Pliocene coccolith assemblages in Cores 1A to 4A (79 to 114 meters). Core 5A (122 meters) contains a more diverse coccolith ooze of early Pliocene age.

#### HOLE 113

(lat 56°47.40'N., long 48°19.91'W., depth 3629 meters)

Site 113 drilled south of the mid-Labrador Sea Ridge, was intended to date the oldest sediments above the

basement but had to be abandoned before basement was reached.

Generally poor coccolith assemblages in the 11 cores examined from this site range in age from late Pleistocene to late Miocene or early Pliocene. Most samples contain sparse coccoliths diluted by a silty or sandy matrix. *Coccolithus pelagicus* and very small coccolith species predominate in the poorly diversified assemblages. *Ceratolithus*, *Rhabdosphaera*, *Scapholithus* and *Scyphosphaera* are absent, suggesting cool-water deposition of these sediments. Reworked Oligocene and Eocene specimens occur sporadically in the cores.

#### HOLE 114

(lat 59°56'N., long 26°48'W., depth 1937 meters)

Drilling on the east flank of the Reykjanes Ridge was for the purpose of determining the nature and age of the unusually thick sediment section in the vicinity of Magnetic Anomaly 5 ( $\cong$  10 million years).

Lower Pleistocene (Cores 1 to 3, 100 to 305 meters) and middle Miocene to lower Pliocene (Cores 4 and 6, 400 to 605 meters) coccolith assemblages are present in diatom-ooze sediment of the upper six cores. Core 1 contrasts with Core 2 by the lack of *Coccolithus pelagicus* and *Helicopontosphaera sellii*, species abundant in Core 2. A *pelagicus-sellii* ooze also occurs in Hole 112A (Core 3A) near the Pliocene-Pleistocene boundary in the Labrador Sea and in the same stratigraphic position in Site 116 (Core 1) on the Rockall Bank northwest of Ireland. The unusually thick section is mainly a silty clay attributed to contour-current deposition.

#### HOLE 115

(lat 58°54.4'N., long 21°07.0'W., depth 2893 meters)

Site 115, drilled in the basin between the Reykjanes Ridge and the Rockall Plateau, was chosen to sample and date acoustic reflectors and the acoustic basement. The sediment proved to be alternating hard and soft volcanogenic sandstone, and only small core samples could be recovered.

The single sample available from this site contains rare specimens of long-ranging taxa that indicate the middle Miocene to upper Pliocene, if they are not reworked.

#### HOLES 116 AND 116A

(lat 57°29.7'N., long 15°55.5'W., depth 1161 meters)

Site 116 was drilled to determine whether the Rockall Plateau, located between Iceland and Ireland, is a continental fragment. The holes are in the Hatton-Rockall Basin, which is on the central part of the Rockall Plateau and contains the thickest sediment. By determining the biostratigraphic and paleoecologic history of the section, it was hoped to determine the tectonic history of the plateau.

A nearly complete sequence of Cenozoic coccolith assemblages, ranging in age from Holocene or late Pleistocene to late Eocene, was cored at this site. The usual warm-water indicators, the discoasters, are common in only a few samples of late early Miocene and middle late Miocene age. The occurrence in lower Pliocene placolith-ooze of *Ceratolithus*, *Rhabdosphaera* and *Scyphosphaera*, along with a few discoasters, also suggests slightly warmer water in this area

than for coeval deposits of western North Atlantic sites. Eocene assemblages in Cores 26 to 28 (826 to 841 meters) are similar to moderately deep oceanic assemblages of other areas in lacking *Discolithina*, *Helicopontosphaera* and *Rhabdosphaera*. The absence of *Bramletteius*, which occurs elsewhere in both deep and shallow tropical deposits, suggests an upper Eocene oceanic latitudinal temperature gradient, as non-existence due to solution or salinity factors seems to be ruled out. Coring by the D/V *Glomar Challenger* at still higher latitudes, as proposed by Ewing and Hayes (1970), would provide much-needed additional information on the paleoecology of lower Tertiary coccolith-bearing oceanic nannoplankton, presently considered to be cosmopolitan in distribution.

#### HOLES 117 AND 117A

(lat 57°19.5'N., long 15°23.0'W., depth 1048 meters)

Site 117 was drilled near Site 116 in the Hatton-Rockall Basin to supplement the stratigraphic information obtained in Site 116.

Site 117 extends the DSDP 116 section in the Hatton-Rockall Basin with cores in lower Eocene sediment, some of which contain reworked upper Paleocene taxa. The most significant recovery is lower Eocene *Tribrachiatus orthostylus* Zone sediment of Core 3A (222 to 227 meters). This clay with some plant debris and pyrite contains an unusual coccolith assemblage that shows more affinity with lower Eocene assemblages of the London Clay in England and the Røje Klint in Denmark than with contemporaneous assemblages from oceanic sites (Table 2). The Core 3A assemblage is also similar to that of the Lodo Formation of California. Sullivan (1965) interpreted the Lodo Formation to be a littoral marine deposit.

#### HOLE 118

(lat 45°02.9'N., long 9°00.5'W., depth 4901 meters)

Site 118, in the western part of the Bay of Biscay (Biscay Abyssal Plain), was intended to date prominent acoustic reflectors and the basement in order to provide information about the origin of the Bay of Biscay.

Samples from Cores 2 to 14 (200 to 708 meters) range in age from early Pleistocene to middle Eocene; samples available from the lower part of Core 14 to Core 19 (708 to 750 meters) either contain a mixture of late Paleocene and early Eocene specimens, or are barren of coccoliths. Size-sorting and state of preservation are variable through this section. Preservation is generally poor, with solution-etched and broken specimens throughout that typify abyssal-plain turbidite sediments.

#### HOLE 119

(lat 45°02.3'N., long 7°58.8'W., depth 4447 meters)

Cantabria Seamount, in the western part of the Bay of Biscay, was drilled to sample pre-Tertiary sediment to supplement the Tertiary section cored at Site 118.

Cores 1 to 40, ranging in age from Pleistocene to early Paleocene, were cut from 10 to 711 meters. Most samples are coccolith ooze. Whereas the preservation state of post-Oligocene specimens is generally good, the Oligocene and Eocene assemblages show the effects of calcite solution, many specimens having etched margins, missing central

structures, and broken rims (Cores 16 to 23, in particular). Samples from Core 24 are barren.

Exceptionally well-preserved Paleocene assemblages occur with a matrix of calcite particles in Cores 25 to 40. The preservation state and floral diversity of these Paleocene assemblages are remarkably similar to those described from the Paleocene in the lower part of the Lodo Formation in California (Bramlette and Sullivan, 1961). In Site 119, *Heliolithus riedelii* Bramlette and Sullivan occurs below and above the first occurrence of *Discoaster mohleri* Bukry and Percival, but not above the last *D. mohleri*. Therefore, three upper Paleocene zones are recognized in this hole, based partly on the first occurrences of *Heliolithus kleinpelli* Sullivan, *D. mohleri* and *Discoaster multi-radiatus* Bramlette and Riedel, and partly on the ranges of other species, such as *Discoasteroides bramlettei* Bukry and Percival, *Discoaster delicatus* Bramlette and Sullivan and *Campylosphaera eodela* Bukry and Percival (Table 3).

### COCCOLITHS IN SELECTED SAMPLES

#### HOLE 111

##### Cenozoic

12-111-2-6, 114-116 cm (depth 102 m):

*Coccolithus pelagicus* (Wallich), *Coccolithus* sp. [small].

##### Upper Cretaceous

12-111-3-2, 136-137 cm (depth 191 m):

*Apertapetra gronosa* (Stover), *Biscutum* sp., *Eiffellithus turisseeiffeli* (Deflandre), *Lithastrinus floralis* Stradner, *Parhabdolithus embergeri* (Noël), *Prediscosphaera* sp., *Watznaueria barnesae* (Black), *Zygodiscus* sp. cf. *Z. stenopus* (Stover).

#### HOLE 111A

##### Lower Pleistocene

(*Coccolithus doronicoides* Zone)

12-111A-1A-1, 144-146 cm (depth 106 m):

*Coccolithus pelagicus*, *Cyclococcolithina leptopora* (Murray and Blackman), *Emiliania annula* (Cohen).

12-111A-3A-1, 141-143 cm (depth 120 m):

*Coccolithus doronicoides* Black and Barnes, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyrei* (Bukry and Bramlette), *Discolithina japonica* Takayama, *Emiliania annula*, *Helicopontosphaera kampfneri* Hay and Mohler, *H. sellii* Bukry and Bramlette, *Syracosphaera* sp.

##### Series Unknown

12-111A-3A-4, 144-145 cm (depth 125 m):

Barren.

12-111A-4A-1, 143-144 cm (depth 126 m):

Barren

##### Lower Pleistocene

(*Coccolithus doronicoides* Zone)

12-111A-4A-2, 145-146 cm (depth 128 m):

*Coccolithus doronicoides*, *C. pelagicus*, *Emiliania annula*, *Helicopontosphaera kampfneri*.

**TABLE 2**  
**Lower Eocene *Tribrachiatus Orthostylus* Zone Coccolith Assemblage of**  
**Hole 117A. This Assemblage is More Similar to Shallow-Marine**  
**Assemblages Than to an Oceanic Assemblage From The Northwestern Pacific**

Lower Eocene Localities	North Pacific Hole DSDP 47.2 (73 meters)	North Atlantic Hole DSDP 117A (222 to 227 meters)	London Clay, England	Røjle Klint, Denmark
Coccolith Taxa				
<i>Discoaster binodosus</i>		X	X	X
<i>Lophodolithus nascens</i>		X	X	X
<i>Micrantholithus spp.</i>		X	X	X
<i>Syracosphaera cf. S. fimbriata</i>		X	X	X
<i>Zyglolithus dubius</i>		X	X	X
<i>Zyglolithus protenus</i>		X	X	X
<i>Chipragmalithus calathus</i>		X	X	
<i>Discoaster? obscurus</i>		X		X
<i>Discoaster? aff. D? obscurus</i>		X	X	
<i>Discolithina ocellata</i>		X	X	
<i>Transversopontis pulcher</i>		X		X
<i>Transversopontis pulcherooides</i>		X	X	
<i>Discoasteroides kuepperi</i>	X	X	X	X
<i>Tribrachiatus orthostylus</i>	X	X	X	X
<i>Zygrhablithus cf. Z. bijugatus</i>	X	X	X	
<i>Coccolithus crassus</i>	X	X	X	
<i>Discoaster barbadiensis</i>	X	X		X
<i>Discoaster lodoensis</i>	X			X
<i>Chiasmolithus grandis</i>	X	X		
<i>Markalius inversus</i>	X	X		
<i>Sphenolithus radians</i>	X	X		
<i>Campylosphaera dela</i>	X			
<i>Cyclolithella bramlettei</i>	X			

12-111A-5A-1, 142-143 cm (depth 135 m):

*Coccolithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*, *Rhabdosphaera clavigera* Murray and Blackman.

**Upper Pliocene**  
**(*Discoaster brouweri* Zone)**

12-111A-6A-1, 141-142 cm (depth 144 m):

*Coccolithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreui*, *Discoaster* sp. cf. *D. brouweri* Tan, *Discoaster* sp. aff. *D. exilis* Martini and Bramlette [webbed rays].

12-111A-6A-2, 38-39 cm (depth 144 m):

*Ceratolithus rugosus* Bukry and Bramlette, *Coccolithus pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreui*, *Discoaster pentaradiatus* Tan, *D. surculus* Martini and Bramlette, *Discolithina* sp.

**Lower Pliocene**  
**(*Ceratolithus rugosus* Zone)**

12-111A-6A-2, 146-147 cm (depth 145 m):

*Ceratolithus rugosus*, *C. tricorniculatus* Gartner, *Coccolithus pelagicus* [abundant], *Cyclococcolithina leptopora*,

TABLE 3

Occurrence of Selected Upper Paleocene Coccoliths in Representative Samples From North Atlantic DSDP Site 119 Compared With South Atlantic DSDP Site 21, Northwestern Pacific DSDP Site 47.2, Pont Labau in France (Hay and Mohler, 1967), Lodo Formation in California (Bramlette and Sullivan, 1961)

Zone	Sample	Upper Paleocene Coccoliths														
		<i>Discoasteroides bramlettei</i>	<i>Fasciculithus tympaniformis</i>	<i>Heliolithus kleinpellii</i>	<i>Zyglolithus chiasius</i>	<i>Brauradysphaera bigelowi</i>	<i>Fasciculithus involutus</i>	<i>Discoaster mohleri</i>	<i>Heliolithus riedelii</i>	<i>Zyglolithus juncus</i>	<i>Campylosphaera eodelta</i>	<i>Discoaster lenticularis</i>	<i>D. multiradiatus</i>	<i>Rhomboaster cuspis</i>	<i>Discoaster delicatus</i>	<i>D. falcatus</i>
<i>Discoaster multiradiatus</i>	DSDP 119-26-1, 144-145 cm Pont Labau, 834 and 835 Lodo Formation, 30 DSDP 47.2-8-3, 73-74 cm DSDP 21-2-1, 148-150 cm	X		X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Discoaster mohleri</i>	DSDP 119-30-5, 44-46 cm Pont Labau, 823 DSDP 47.2-9-1, 81-82 cm	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Heliolithus kleinpellii</i>	DSDP 119-31-4, 146-150 cm Pont Labau, 813 DSDP 47.2-9-5, 77-78 cm	X	X	X	X	X	X									

*C. macintyreai*, *Discoaster brouweri*, *D. pentaradiatus*, *Discoaster* sp. cf. *D. surculus*, *D. variabilis variabilis* Martini and Bramlette, *Discolithina japonica*, *D. multipora* (Kamptner ex Deflandre) s. l., *Helicopontosphaera kamptneri*, *H. sellii*, *Reticulofenestra pseudoumbilica* (Gartner), *Rhabdosphaera* sp. cf. *R. procer* Martini, *Scyphosphaera intermedia* Deflandre, *Sphenolithus neoabies* Bukry and Bramlette.

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

12-111A-6A-3, 74-75 cm (depth 146 m):

*Ceratolithus tricorniculatus* [rare], *Coccolithus pelagicus*, *Cyclococcolithus leptopora*, *C. macintyreai*, *Discoaster berggrenii* Bukry, *D. braarudii* Bukry, *D. brouweri* s. l., *D. pentaradiatus*, *D. quinqueramus* Gartner, *D. surculus*, *D. variabilis variabilis*, *Helicopontosphaera granulata* Bukry and Percival, *H. kamptneri*, *Reticulofenestra pseudoumbilica*.

**Middle Eocene**  
**(*Discoaster sublodoensis* Zone)**

12-111A-6A-3, 135-136 cm (depth 147 m):

*Campylosphaera dela* (Bramlette and Sullivan), *Chiasmolithus grandis* (Bramlette and Riedel), *Cyclococcolithina formosa* (Kamptner), *Cyclolithella bramlettei* (Hay and Towe), *Discoaster barbadiensis* Tan, *D. distinctus* Martini, *D. lodoensis* Bramlette and Riedel, *D. sublodoensis* Bramlette and Sullivan, *D. wemmelensis* Acuthan and Stradner, *Reticulofenestra samodurovi* (Hay, Mohler, and Wade).

**Lower Eocene**  
**(*Discoaster lodoensis* Zone)**

12-111A-8A-2, 143-144 cm (depth 164 m):

*Campylosphaera dela*, *Chiasmolithus grandis*, *C. solitus* Bramlette and Sullivan, *Coccolithus crassus* Bramlette and Sullivan, *Cyclolithella bramlettei*, *Discoaster cruciformis* Martini, *D. elegans* Bramlette and Sullivan, *D. lodoensis*, *D. nonaradiatus* Klumpp, *Discoasteroides kuepperi* Stradner, *Ellipsolithus lajollaensis* Bukry and Percival, *Helicopontosphaera* sp. cf. *H. lophota* (Bramlette and Sullivan), *H. seminulum* (Bramlette and Sullivan), *Lophodolithus mochlophorus* Deflandre, *L. nascens* Bramlette and Sullivan, *Reticulofenestra* sp. aff. *R. umbilica* [structurally similar species, but two zones lower than typical first occurrence], *Rhabdosphaera* sp. cf. *R. perlona* (Deflandre), *Sphenolithus radians* Deflandre, *Syracopshaera fimbriata* (Bramlette and Sullivan), *Syracosphaera* sp., *Transversopontis pulcheroides* (Sullivan), *Zygolithus dubius* Deflandre.

**Lower Eocene**  
**(*Tribrachiatus orthostylus* Zone)**

12-111A-10A-1, 146-147 cm (depth 174 m):

*Campylosphaera dela*, *Chiasmolithus grandis*, *Cyclolithella bramlettei*, *Discoaster elegans*, *D. lodoensis*, *Discoasteroides kuepperi*, *Discolithina plana* Bramlette and Sullivan, *Helicopontosphaera seminulum*, *Lophodolithus nascens*, *Syracosphaera fimbriata*, *Transversopontis pulcher* (Deflandre), *Tribrachiatus orthostylus* Shamrai [non. subst. pro *Discoaster tribrachiatus* Bramlette and Riedel], *Zygolithus dubius*.

**Upper Cretaceous [Maestrichtian]**  
**(*Lithraphidites quadratus* Zone)**

12-111A-11A-4, 143-144 cm (depth 187 m):

*Apertapetra gronosa*, *Arkhangelskiella cymbiformis* Vekshina, *Biscutum testudinarium* Black and Barnes, *Braarudosphaera bigelowi* (Gran and Braarud), *Cretarhabdus conicus* Bramlette and Martini, *C. crenulatus* Bramlette and Martini, *Cribrosphaera ehrenbergii* Arkhangelsky, *Cylindralithus gallicus* Bramlette and Martini, *Eiffellithus turrisieiffeli*, *Kamptnerius magnificus* Deflandre, *Lithraphidites quadratus* Bramlette and Martini, *Lucianorhabdus cayeuxi* Deflandre, *Marthasterites inconspicuus* Deflandre, *Microrhabdulus decoratus* Deflandre, *M. stradneri* Bramlette and Martini, *Micula decussata* Vekshina, *Prediscosphaera cretacea cretacea* (Arkhangelsky), *P. cretacea lata* Bukry, *P. spinosus* Bramlette and Martini, *Watznaueria barnesae*.

**Upper Cretaceous [Campanian]**  
**(*Tetralithus gothicus trifidus* Zone)**

12-111A-11A-6, 138-139 cm (depth 190 m):

*Arkhangelskiella cymbiformis*, *Biscutum testudinarium*, *Broinsonia parca* (Stradner), *Cretarhabdus crenulatus*, *Cribrosphaera ehrenbergii*, *Cylindralithus gallicus*, *Eiffellithus turrisieiffeli*, *Kamptnerius magnificus*, *Microrhabdulus decoratus*, *Micula decussata*, *Prediscosphaera cretacea cretacea*, *Tetralithus aculeus* (Stradner), *T. gothicus trifidus* Stradner and Papp, *Watznaueria barnesae*, *Zygodiscus meudini* Bukry.

**HOLE 112**

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

12-112-1-1, 147-148 cm (depth 28 m):

*Coccolithus pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Gephyrocapsa caribbeanica* Boudreux and Hay, *Helicopontosphaera kamptneri*, *H. sellii*, *Rhabdosphaera clavigera*, *Scapholithus* sp.

**Upper Pliocene**  
**(*Discoaster brouweri* Zone)**

12-112-2-2, 142-143 cm (depth 103 m):

*Coccolithus pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster brouweri*, *Discolithina japonica*, *Emiliania annula*, *Helicopontosphaera kamptneri*, *H. sellii*, *Rhabdosphaera clavigera*, *Syracosphaera* sp.

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

12-112-3-3, 142-143 cm (depth 153 m):

*Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster bellus* Bukry and Percival, *D. bollii* Martini and Bramlette, *D. braaruddi*, *D. brouweri* s. l., *D. calcaris* Gartner, *D. neohamatus* Bukry and Bramlette, *D. obtusus* Gartner, *D. prepentaradiatus* Bukry and Percival, *D. variabilis variabilis*, *Reticulofenestra pseudoumbilica*, *Sphenolithus neoabies*, *Triquetrorhabdulus rugosus* Bramlette and Wilcoxon.

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

12-112-3-6, 129-131 cm (depth 158 m):

*Cyclococcolithina leptopora*, *Discoaster bellus*, *D.*

*braarudii* *D. hamatus* Martini and Bramlette, *D. variabilis variabilis*, *R. pseudoumbilica*, *Triquetrorhabdulus rugosus*.

#### Middle Miocene

##### (*Discoaster exilis* Zone)

12-112-4-2, 138-139 cm (depth 203 m):

*Braarudosphaera bigelowi* [rare, transported?], *Coccocithus eopelagicus* (Bramlette and Riedel), *Cyclococcolithina leptopora*, *Discoaster deflandrei* Bramlette and Riedel, *D. exilis*, *D. variabilis variabilis*, *Reticulofenestra pseudoumbilica*, *Triquetrorhabdulus rugosus*.

#### Middle Oligocene

##### (*Sphenolithus distentus* Zone)

12-112-5-1, 136-137 cm (depth 271 m):

*Chiasmolithus altus* Bukry and Percival, *Coccocithus eopelagicus*, *Cyclococcolithina neogammation* (Bramlette and Wilcoxon), *Dictyococcites abisectus* (Müller), *D. bisectus* (Hay, Mohler and Wade), *D. scrippsae* Bukry and Percival, *Discoaster deflandrei* [5-and 6-rayed], *Reticulofenestra gartneri* Roth and Hay, *Sphenolithus moriformis* (Brönnimann and Stradner).

12-112-11-4, 144-145 cm (depth 329 m):

*Cyclococcolithina neogammation*, *Dictyococcites bisectus*, *Reticulofenestra gartneri*.

#### Lower Oligocene

##### (lower *Helicopontosphaera reticulata* Zone)

12-112-12-1, 141-142 cm (depth 385 m):

*Chiasmolithus altus*, *C. oamaruensis* (Deflandre), *Coccocithus eopelagicus*, *Dictyococcites bisectus*, *D. scrippsae*, *Discoaster tani nodifer* Bramlette and Riedel, *Helicopontosphaera* sp. cf. *H. intermedia* Martini, *H. reticulata* Bramlette and Wilcoxon, *Isthmolithus recurvus* Deflandre, *Polycladolithus* sp., *Reticulofenestra hillae* Bukry and Percival, *R. insignita* Roth and Hay, *R. umbilica* (Levin), ?*Rhabdosphaera tenuis* Bramlette and Sullivan [stems], *R. spinula* Levin and Joerger, *Sphenolithus moriformis* [small], *Transversopontis ponticus* (Deflandre).

#### Upper Eocene

##### (*Discoaster barbadiensis* Zone)

12-112-13-2, 138-140 cm (depth 443 m):

*Chiasmolithus oamaruensis*, *Coccocithus eopelagicus*, *Cyclococcolithina neogammation*, *Cyclococcolithina* sp. cf. *C. reticulata* (Gartner and Smith), *Dictyococcites bisectus*, *D. scrippsae*, *Discoaster barbadiensis*, *D. saipanensis* Bramlette and Riedel, *Isthmolithus recurvus*, *Pontosphaera vadosa* Hay, Mohler and Wade, *Reticulofenestra hillae*, *R. umbilica*, *Transversopontis pulcheroides*.

12-112-14-2, 142-144 cm (depth 499 m):

*Campylosphaera dela* [rare], *Chiasmolithus* sp. cf. *C. expansus*, *Coccocithus eopelagicus*, *C. fenestratus* (Deflandre), *Cyclococcolithina formosa* (Kamptner), *C. neogammation*, *C. sp.* cf. *C. reticulata*, *Dictyococcites bisectus*, *D. scrippsae*, *Discoaster barbadiensis*, *D. distinctus*, *D. saipanensis*, *Goniolithus fluckigeri* Deflandre, *Helicopontosphaera compacta* (Bramlette and Wilcoxon), *H. sp.* cf. *H. intermedia*, ?*Isthmolithus recurvus*, *Markalius inversus* (Deflandre), *Micrantholithus stradneri* Chang, *Reticulofenestra samodurovi*, *R. umbilica*, *Rhabdosphaera spinula*,

?*R. tenuis* [stems], *Sphenolithus predistentus* Bramlette and Wilcoxon, *Transversopontis pulcher*, *T. pulcheroides*, *Zygolithus dubius*.

#### Middle Eocene

##### (*Discoaster sublodoensis* Zone)

12-112-15-1, 47-48 cm (depth 578 m):

*Chiasmolithus expansus*, *C. solitus*, *Coccocithus pseudogammation* Bouché, *C. staurion* Bramlette and Sullivan, *Cyclococcolithina formosa*, *C. luminis* (Sullivan), *Discoaster barbadiensis*, *D. nonaradiatus* Klumpp, *D. saipanensis*, *D. sublodoensis* Bramlette and Sullivan, *Rhabdosphaera inflata* Bramlette and Sullivan, *Transversopontis pulcher*, *Zygolithus dubius*, *Zygrhablithus bijugatus* Deflandre.

#### HOLE 112A

#### Lower Pleistocene

##### (*Coccocithus doronicoides* Zone)

12-112A-1A-1, 144-145 cm (depth 79 m):

*Coccocithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discolithina japonica*, *Emiliania annula*, *Helicopontosphaera kamptneri*, *H. sellii*.

#### Upper Pliocene

##### (*Discoaster brouweri* Zone)

12-112A-3A-1, 140-141 cm (depth 98 m):

*Coccocithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster brouweri* [rare], *Discolithina japonica*, *Emiliania annula*, *Helicopontosphaera sellii*.

#### Lower Pliocene

##### (*Reticulofenestra pseudoumbilica* Zone)

12-112A-5A-5, 139-140 cm (depth 122 m):

*Ceratolithus rugosus*, *Coccocithus pelagicus*, *Coccocithus* sp. [tiny], *Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster brouweri*, *D. challengerii* Bramlette and Riedel, *D. pentaradiatus*, *D. surculus*, *D. variabilis pansus* Bukry and Percival, *Helicopontosphaera kamptneri*, *Reticulofenestra pseudoumbilica*, *Rhabdosphaera procera* Martini, *Sphenolithus abies*.

#### HOLE 113

#### Upper Pleistocene

##### (*Gephyrocapsa oceanica* Zone)

12-113-1-1, 145-146 cm (depth 50 m):

*Coccocithus pelagicus*, *Coccocithus* sp. [tiny], *Gephyrocapsa* sp. cf. *G. caribbeanica*, *G. oceanica* Kamptner, *Syracosphera* sp. Reworked Eocene or Oligocene taxa: *Dictyococcites scrippsae*, *Reticulofenestra hillae*.

#### Upper Pliocene(?)

12-113-3-3, 141-142 cm (depth 159 m):

*Coccocithus pelagicus*, *Coccocithus* sp. cf. *C. neohelis* McIntyre, *Cyclococcolithina macintyreai* [well-preserved].

#### Upper Pliocene

##### (*Discoaster brouweri* Zone)

12-113-4-2, 114-115 cm (depth 206 m):

*Coccocithus pelagicus*, *Cyclococcolithina macintyreai*,

*Discoaster brouweri*, *Discoaster* sp. cf. *D. variabilis variabilis*.

#### Upper Miocene or Lower Pliocene

12-113-5-1, 144-145 cm (depth 254 m):

12-113-8-4, 13-15 cm (depth 667 m):

12-113-9-3, 6-9 cm (depth 712 m):

12-113-11-2, 100-110 cm (depth 811 m):

These above samples contain rare specimens of long-ranging coccoliths. The most common taxa are *Coccolithus pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai* and *Reticulofenestra pseudoumbilica*; also present are *Discoaster* fragments assigned to *D. pentaradiatus* and *D. surculus*.

#### HOLE 114

##### Lower Pleistocene (*Coccolithus doronicoides* Zone)

12-114-1-5, 81 cm (depth 107 m):

*Cyclococcolithina leptopora*, *Discolithina* sp. cf. *D. japonica*, *Emiliania annula*, *Gephyrocapsa caribbeanica*, *Helicopontosphaera kamptneri*.

##### Upper Pliocene or Lower Pleistocene (Transitional)

12-114-2-6, 128-130 cm (depth 209 m):

*Coccolithus pelagicus* [abundant], *Cyclococcolithina leptopora*, *C. macintyreai*, *Discolithina* sp., *Helicopontosphaera sellii* [abundant].

12-114-3-5, 103-104 cm (depth 305 m):

*Coccolithus doronicoides*, *C. pelagicus*, *Coccolithus* sp. [tiny], *Cyclococcolithina leptopora*, *C. macintyreai*, *Discolithina* sp. cf. *D. japonica*, *D. multipora*, *Helicopontosphaera kamptneri*, *H. sellii*, *Scyphosphaera* sp. Reworked Oligocene taxon: *Chiasmolithus altus*.

#### HOLE 115

##### Middle Miocene to Upper Pliocene

12-115-1-1, 63-64 cm (depth 59 m):

*Coccolithus* sp. [small], *Cyclococcolithina macintyreai*, *Discolithina japonica*, *Helicopontosphaera kamptneri*, *Reticulofenestra* sp. cf. *R. pseudoumbilica* [small].

#### HOLE 116

##### Upper Pliocene (*Discoaster brouweri* Zone)

12-116-1-6, 140-141 cm (depth 79 m):

*Coccolithus doronicoides*, *C. pelagicus* [abundant], *Coccolithus* sp. [tiny], *Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster brouweri*, *D. variabilis variabilis*, *Helicopontosphaera sellii* [common], *Scyphosphaera apsteinii* Lohmann, *Syracosphaera pulchra* Lohmann.

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

12-116-10-6, 139-140 cm (depth 518 m):

*Coccolithus eopelagicus*, *Cyclococcolithina neogammation*, *Discoaster* sp. cf. *D. deflandrei*, *D. sp.* cf. *D. exilis*, *Discolithina segmenta* Bukry and Percival,

*Helicopontosphaera granulata* Bukry and Percival, *H. sp.* cf. *H. kamptneri*, *Sphenolithus heteromorphus* Deflandre.

##### Lower Miocene

##### (*Triquetrorhabdulus carinatus* Zone)

12-116-18-4, 140-141 cm (depth 695 m):

*Coccolithus pelagicus* [abundant], *Cyclococcolithina neogammation*, *Dictyococcites abiseptus*, *D. scrippsae*, *Discoaster deflandrei*, *Discolithina* sp., *Helicopontosphaera parallela* (Bramlette and Wilcox), *Sphenolithus moriformis*, *Triquetrorhabdulus* sp. cf. *T. carinatus* Martini, *Zygrhablithus bijugatus* [abundant].

##### Upper Oligocene

##### (*Sphenolithus ciperoensis* Zone)

12-116-21-4, 140-141 cm (depth 716 m):

*Chiasmolithus altus*, *Coccolithus fenestratus*, *C. pelagicus*, *Cyclococcolithina neogammation*, *Dictyococcites abiseptus*, *D. bisectus*, *D. scrippsae*, *Discoaster deflandrei*, *Discolithina segmenta*, *Reticulofenestra gartneri*, *Sphenolithus moriformis*, *Zygrhablithus bijugatus* [abundant].

##### Lower Oligocene

##### (*Helicopontosphaera reticulata* Zone)

12-116-25-5, 141-142 cm (depth 812 m):

*Chiasmolithus oamaruensis*, *Coccolithus fenestratus*, *C. pelagicus*, *Cyclococcolithina formosa*, *Dictyococcites bisectus*, *D. scrippsae*, *Discoaster tani nodifer*, *Isthmolithus recurvus*, *Pontosphaera vadosa*, *Reticulofenestra hillae*, *R. umbilica*, *Zygrhablithus bijugatus*.

##### Upper Eocene

##### (*Discoaster barbadiensis* Zone)

12-116-26-1, 66-67 cm (depth 826 m):

*Coccolithus eopelagicus*, *Cyclococcolithina formosa*, *C. neogammation*, *C. sp.* cf. *C. reticulata*, *Dictyococcites bisectus*, *D. scrippsae*, *Discoaster* sp. cf. *D. tani nodifer*, *D. saipanensis*, *Isthmolithus recurvus*, *Laternithus minutus* Stradner, *Pontosphaera vadosa*, *Reticulofenestra hillae*, *R. umbilica*, *Zygrhablithus bijugatus*.

12-116-28-1, 90-91 cm (depth 840 m):

*Chiasmolithus* sp. cf. *C. expansus*, *C. oamaruensis*, *Coccolithus pelagicus*, *Cyclococcolithina formosa*, *C. sp.* cf. *C. reticulata* [small], *Dictyococcites bisectus*, *D. scrippsae*, *Discoaster saipanensis*, *Reticulofenestra umbilica*, *Zygrhablithus bijugatus*.

#### HOLE 116A

##### Upper Pleistocene or Holocene

12-116A-1A-2, 133-134 cm (depth 2 m):

*Coccolithus pelagicus*, *Cyclococcolithina leptopora*, ?*Emiliania huxleyi* Kamptner, ?*Gephyrocapsa ericsonii* McIntyre and Bé, *Helicopontosphaera kamptneri*, *Syracosphaera* sp. cf. *S. histricalis*.

##### Lower Pleistocene

##### (*Coccolithus doronicoides* Zone)

12-116A-4A-6, 140-141 cm (depth 35 m):

*Coccolithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discolithina japonica*, *D.*

*multipora s. l.*, *Emiliania annula*, *Gephyrocapsa caribeanica*, *Helicopontosphaera kampfneri*, *Scyphosphaera* sp., *Syracosphaera histricalis*.

12-116A-7A-2, 140-141 cm (depth 56 m):

*Coccilithus neohelis*, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Helicopontosphaera sellii*, *Rhabdosphaera clavigera*, *Syracosphaera* sp.

12-116A-8A-3, 141-142 cm (depth 66 m):

*Acanthoica* sp. aff. *A. acanthos* Schiller, *Coccilithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Helicopontosphaera sellii*, *Rhabdosphaera* sp. cf. *R. stylifera* Lohmann, *Syracosphaera* sp.

#### Upper Pliocene(?)

12-116A-8A-4, 147-148 cm (depth 68 m):

*Coccilithus pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster* sp. cf. *D. brouweri* [rare], *Discoolithina japonica*, *Emiliania annula*, *Helicopontosphaera kampfneri* [rare].

#### HOLE 117

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

12-117-2-3, 146-148 cm (depth 102 m):

*Braarudosphaera discula* Bramlette and Riedel [rare], *Chiasmolithus altus* [fantastically abundant], *Coccilithus eopelagicus*, *Cyclococcolithina neogammation*, *Dictyococcites abisectus*, *D. bisectus*, *D. scrippsae*, *Discoaster deflandrei*, *Sphenolithus moriformis*, *Zygrhablithus bijugatus* [abundant].

12-117-2-4, 144-145 cm (depth 103 m):

*Chiasmolithus altus*, *Coccilithus eopelagicus*, *Cyclococcolithina neogammation*, *Dictyococcites abisectus*, *D. bisectus*, *D. scrippsae*, *Discoaster deflandrei*, *Discolithina* sp., *Reticulofenestra gartneri*, *Sphenolithus ciperoensis*, *S. moriformis*, *Zygrhablithus bijugatus*.

#### HOLE 117A

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

12-117A-1A-1, 54-55 cm (depth 147 m):

*Chiasmolithus altus*, *Coccilithus eopelagicus*, *Cyclococcolithina neogammation*, *Dictyococcites bisectus*, *D. scrippsae*, *Helicopontosphaera truncata* (Bramlette and Wilcoxon), *Zygrhablithus bijugatus*.

12-117A-1A-1, 70-71 cm (depth 147 m):

*Chiasmolithus altus*, *Cyclococcolithina neogammation*, *Reticulofenestra gartneri*. Reworked Lower Eocene taxa: *Discoaster lodoensis*, *D. sp. aff. D. obscurus* Martini, *Discoasteroides kuepperi*, *Tribrachiatus orthostylus*.

##### Lower Eocene (*Tribrachiatus orthostylus* Zone)

12-117A-3A-1, 131-132 cm (depth 222 m):

*Chiasmolithus grandis*, *Coccilithus crassus*, *Cyclococcolithina luminis*. *Discoaster binodosus*, *Markalius inversus*, *Micrantholithus* sp., *Syracosphaera fimbriata*, *Transversopontis pulcheroides*, *Tribrachiatus orthostylus*, *Zyglolithus dubius*, *Zygrhablithus bijugatus*.

12-117A-3A-4, 137-138 cm (depth 226 m):

*Chiphragmalithus calathus* Bramlette and Sullivan, *Discoaster obscurus*, *D. sp. aff. D. obscurus*, *Discoasteroides kuepperi*, *Lophodolithus nascens*, *Syracosphaera fimbriata*, *Tribrachiatus orthostylus*, *Zyglolithus dubius*, *Zygrhablithus bijugatus*.

12-117A-3A-6, 140-141 cm (depth 229 m):

*Discolithina ocellata* (Bramlette and Sullivan), *Micrantholithus* sp., *Syracosphaera fimbriata*, *Transversopontis pulcheroides*, *T. pulcheroidea*, *Zyglolithus dubius*, *Z. protensus* (Bramlette and Sullivan).

#### Upper Paleocene or Lower Eocene

12-117A-4A-1, 136-137 cm (depth 271 m):

*Braarudosphaera bigelowi*, *Chiasmolithus bidens* (Bramlette and Sullivan), *Discoaster multiradiatus* Bramlette and Riedel, *D. ornatus* Stradner, *Ellipsolithus distichus* (Bramlette and Sullivan), *Zyglolithus chiastus* Bramlette and Sullivan, *Z. dubius*, *Z. junctus* Bramlette and Sullivan.

12-117A-6A-1, 144-145 cm (depth 276 m):

*Braarudosphaera bigelowi*, *Chiasmolithus bidens*, *Discoaster* sp. cf. *D. diastypus* Bramlette and Sullivan, *Discolithina ocellata*, *Ellipsolithus macellus* Bramlette and Sullivan, *Markalius inversus*, *Transversopontis pulcheroides*, *Tribrachiatus contortus* (Stradner), [basionym: *Discoaster contortus* Stradner, 1958, Erdöel-Z. 74: p. 187, Figures 35-36], *Tribrachiatus orthostylus*, *Zygrhablithus bijugatus*.

#### HOLE 118

##### Lower Pleistocene (*Coccilithus doronicoides* Zone)

12-118-2-6, 147-148 cm (depth 209 m):

*Coccilithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discolithina japonica*, *D. multiorpida* s. l., *Gephyrocapsa caribeanica*, *Helicopontosphaera kampfneri*, *H. sellii*, *Rhabdosphaera clavigera*, *Scapholithus* sp.

##### Upper Pliocene (*Discoaster brouweri* Zone)

12-118-3-2, 149-150 cm (depth 303 m):

*Coccilithus doronicoides*, *C. pelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster brouweri* s. l. [rare].

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

12-118-4-3, 147-148 cm (depth 354 m):

*Ceratolithus tricorniculatus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster brouweri* s. l., *D. pentaradiatus*, *D. sp. cf. D. variabilis variabilis*, *Helicopontosphaera kampfneri*, *Reticulofenestra pseudoumbilica*.

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

12-118-6-1, 144-145 cm (depth 449 m):

*Coccilithus eopelagicus*, *Cyclococcolithina leptopora*, *C. macintyreai*, *Discoaster* sp. cf. *D. aulokos* Gartner, *D. braarudii*, *D. challengerii*, *D. deflandre*, *D. exilis*, *D. variabilis variabilis*, *Helicopontosphaera kampfneri*, *Lithostromation perdurum* Deflandre, *Reticulofenestra*

*pseudoumbilica*, *Triquetrorhabdulus rugosus*. Reworked Eocene taxon: *Discoaster saipanensis*.

12-118-8-1, 92-93 cm (depth 506 m):

*Coccolithus eopelagicus*, *Cyclococcolithina macintyreai*, *Discoaster braarudii*, *D. challengerii*, *D. sp. cf. D. dilatus* Hay, *D. sp. cf. D. exilis*, *D. variabilis variabilis*, *Discolithina multipora* s. l., *Reticulofenestra pseudoumbilica*. Reworked Miocene taxon: *Sphenolithus heteromorphus*.

12-118-10-1, 111-112 cm (depth 605 m):

*Coccolithus eopelagicus*, *Cyclococcolithina leptopora*, *Discoaster braarudii*, *D. deflandrei*, *D. exilis*, *Reticulofenestra pseudoumbilica*, *Sphenolithus neoabies*, *Triquetrorhabdulus rugosus*.

#### Series unknown

12-118-11-1, 28-29 cm (depth 650 m):

Barren.

12-118-12-1, 0.5 cm (depth 687 m):

Barren.

12-118-12-2, 71-74 cm (depth 688 m):

Barren.

#### Middle Eocene

##### (*Chiphragmalithus quadratus* Zone)

12-118-12-4, 141-142 cm (depth 692 m):

*Campylosphaera dela*, *Chiasmolithus expansus*, *C. gigas* (Bramlette and Sullivan), *C. grandis*, *C. solitus* [small], *Ciphragmalithus cristatus* (Martini), *C. quadratus* Bramlette and Sullivan, *Coccolithus pseudogammation*, *C. staurion* Bramlette and Sullivan, *Cyclococcolithina formosa*, *Discoaster barbadiensis*, *D. gemmeus* Stradner, *D. saipanensis*, *D. wemmelensis*.

#### Middle Eocene

##### (*Discoaster sublodoensis* Zone)

12-118-13-2, 148-150 cm (depth 696 m):

*Chiasmolithus* sp. cf. *C. expansus*, *C. solitus*, *Chiphragmalithus cristatus*, *Coccolithus pseudogammation*, *C. staurion*, *Cyclococcolithina formosa*, *Discoaster barbadiensis*, *D. sp. cf. D. lodoensis*, *D. sp. cf. D. sublodoensis*, *Triquetrorhabdulus inversus* Bukry and Bramlette.

#### Lower Eocene

##### (*Discoaster lodoensis* Zone)

12-118-14-1, 140-141 cm (depth 696 to 708 m):

*Chiasmolithus grandis*, *Coccolithus crassus*, *Cyclococcolithina formosa*, *Discoaster barbadiensis*, *D. lodoensis* [large, abundant], *D. stradneri* Noël, *Discoasteroides kueppeli* [rare], *Tribrachiatus orthostylus* [rare].

#### Mixed Upper Paleocene and Lower Eocene

12-118-14-2, 132-134 cm (depth 696 to 708 m):

Eocene taxa: *Chiasmolithus grandis*, *Coccolithus crassus*, *Discoaster barbadiensis*, *D. diastypus*, *Tribrachiatus orthostylus*. Paleocene taxa: *Campylosphaera eodela* Bukry and Percival, *Discoaster multiradiatus*, *D. ornatus*. Eocene and Paleocene taxa: *Chiasmolithus consuetus*, *Ellipsolithus macellus*.

12-118-15-1, 99-100 cm (depth 714 m):

Paleocene taxa: *Campylosphaera eodela*, *Chiasmolithus*

*bidens*, *Discoaster lenticularis* Bramlette and Sullivan, *D. multiradiatus*, *D. ornatus*, *Rhomboaster cuspis* Bramlette and Sullivan, *Toweius eminens* Bramlette and Sullivan. Eocene or Paleocene taxa: *Chiasmolithus consuetus*, *?Tribrachiatus contortus*.

#### Series unknown

12-118-16-1, 52-53 cm (depth 723 m):

Barren.

12-118-17-1, 143-144 cm (depth 732 m):

Barren.

12-118-19-1, 8-9 cm (depth 750 m):

Barren.

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#### Upper Pleistocene

12-119-1-2, 143-144 cm (depth 12 m):

*Coccolithus pelagicus*, *Cyclococcolithina leptopora*, *Gephyrocapsa* spp., *Helicopontosphaera kamptneri*. Reworked Upper Cretaceous taxa: *Chiastozygus disgratus* (Stover), *Cretarhabdus crenulatus*, *Prediscosphaera cretacea cretacea*.

#### Middle Miocene

##### (*Discoaster exilis* Zone)

12-119-5-1, 132-133 cm (depth 199 m):

*Coccolithus eopelagicus*, *Cyclococcolithina leptopora*, *Discoaster exilis*, *Discoaster subsurculus* Gartner, *Helicopontosphaera granulata*, *H. kamptneri*, *Reticulofenestra pseudoumbilica*, *Sphenolithus neoabies*, *Triquetrorhabdulus rugosus*.

#### Middle Oligocene

##### (*Sphenolithus distentus* Zone)

12-119-14-5, 148-150 cm (depth 318 m):

*Chiasmolithus altus*, *Coccolithus eopelagicus*, *C. fenesstratus*, *Cyclococcolithina neogammation*, *Dictyococcites abisectus*, *D. bisectus*, *D. scrippsae*, *Discoaster deflandrei*, *Reticulofenestra gartneri*, *Sphenolithus distentus* (Martini), *S. moriformis*, *S. predistentus*. Reworked Cretaceous taxon: *Cretarhabdus crenulatus*.

#### Lower Oligocene

##### (*Helicopontosphaera reticulata* Zone)

12-119-18-3, 142-143 cm (depth 353 m):

*Chiasmolithus altus*, *C. oamaruensis*, *Coccolithus eopelagicus*, *C. fenestratus*, *Cyclococcolithina neogammation*, *Dictyococcites bisectus*, *D. scrippsae*, *Discoaster deflandrei*, *D. tani nodifer*, *D. tani tani* Bramlette and Riedel, *Helicopontosphaera compacta*, *Isthmolithus recurvus*, *Reticulofenestra hillae*, *R. umbilica*, *?Rhabdosphaera tenuis* [stems].

#### Middle Eocene

##### (*Chiphragmalithus quadratus* Zone)

12-119-19-1, 140-141 cm (depth 357 m):

*Campylosphaera dela*, *Chiasmolithus gigas*, *C. grandis*, *Chiphragmalithus mexicanus* (Stradner), *C. sp. cf. C. spinosus* (Stradner), *Cyclococcolithina formosa*, *Discoaster barbadiensis*, *D. martinii* Stradner, *D. saipanensis*,

*D. tani nodifer*, *D. wemmelensis*, *Reticulofenestra samodurovi*.

Middle Eocene  
(*Discoaster sublodoensis* Zone)

12-119-21-1, 143-144 cm (depth 375 m):

*Chiasmolithus grandis*, *Chiphragmalithus cristatus*, *Coccilithus pseudogammation*, *C. staurion*, *Discoaster barbadiensis*, *D. mirus* Deflandre, *D. sublodoensis*, *D. wemmelensis*, *Rhabdosphaera inflata*, *Sphenolithus radians*, *Triquetrorhabdulus inversus*.

Lower Eocene  
(*Discoaster lodoensis* Zone)

12-119-21-4, 149-150 cm (depth 380 m):

*Coccilithus* sp. [rim fragments resulting from solution], *Discoaster barbadiensis*, *D. lodoensis*, *D. nonaradiatus*, *D. septemradiatus* (Klumpp), *Discoasteroides kuepperi*.

Lower Eocene  
(*Tribrachiatus orthostylus* Zone)

12-119-23-1, 141-142 cm (depth 392 m):

*Coccilithus* sp. [rare rim fragment], *Discoaster barbadiensis*, *D. lodoensis*, *D. nonaradiatus* [rare], *Discoasteroides kuepperi*, *Tribrachiatus orthostylus* [abundant, late variety].

Series unknown

12-119-24-1, 21-22 cm (depth 401 m):

Barren.

12-119-24-2, 139-140 cm (depth 402 m):

Barren.

12-119-24-3, 94-95 cm (depth 402 m):

Barren.

Upper Paleocene  
(*Discoaster multiradiatus* Zone)

12-119-26-1, 144-145 cm (depth 420 m):

*Braarudosphaera bigelowi*, *Campylosphaera eodela*, *Chiasmolithus bidens*, *C. californicus* (Sullivan), *C. consuetus*, *Discoaster delicatus* Bramlette and Sullivan, *D. falcatus* Bramlette and Sullivan, *D. helianthus* Bramlette and Sullivan, *D. limbatus* Bramlette and Sullivan, *D. multiradiatus*, *Discolithina plana*, *D. solida* (Deflandre), *Ellipsolithus distichus*, *Fasciculithus involutus* Bramlette and Sullivan, *F. schaubi* Hay and Mohler, *Scapholithus apertus* Hay and Mohler, *Toweius eminens*, *Zygodiscus plectopons* Bramlette and Sullivan, *Z. sigmoides* Bramlette and Sullivan, *Zyglithus chiastus* Bramlette and Sullivan, *Z. distentus* Bramlette and Sullivan, *Z. junctus* Bramlette and Sullivan, *Zygrhablithus bijugatus*, *Z. simplex* Bramlette and Sullivan. The preservation and diversity of this assemblage matches that of the lower Lodo Formation in California (Bramlette and Sullivan, 1961). Reworked Upper Cretaceous taxa: *Arkhangelskiella cymbiformis*, *Prediscosphaera cretacea cretacea*, *Zygodiscus deflandrei* Bukry.

Upper Paleocene  
(*Discoaster mohleri* Zone)

12-119-30-6, 63-64 cm (depth 500 m):

*Braarudosphaera bigelowi*, *Chiasmolithus bidens*, *C.*

*californicus*, *C. consuetus*, *Coccilithus pelagicus s. l.*, *Discoaster mohleri* Bukry and Percival, *Discoasteroides megastypus* Bramlette and Sullivan, *Ellipsolithus distichus*, *E. macellus*, *Fasciculithus tympaniformis*, *Heliolithus kleinpellii*, *H. riedelii* Bramlette and Sullivan, *Scapholithus apertus*, *Toweius eminens*, *Zygodiscus plectopons*, *Zyglithus chiastus*. Reworked Upper Cretaceous taxa: *Broinsonia parca*, *Watznaueria barnesae*.

Upper Paleocene  
(*Heliolithus kleinpellii* Zone)

12-119-31-1, 104-108 cm (depth 544 m):

*Chiasmolithus* sp. cf. *C. bidens*, *C. consuetus*, *Cruciplacolithus tenuis* (Stradner), *Cyclolithella* sp. cf. *C. robusta* (Bramlette and Sullivan), *Ellipsolithus macellus*, *Fasciculithus involutus*, *F. tympaniformis*, *Heliolithus kleinpellii*, *H. riedelii* [rare], *Toweius eminens*, *Zygodiscus* sp. aff. *Z. plectopons* Bramlette and Sullivan, *Z. sigmoides*, *Zyglithus chiastus*. Reworked Upper Cretaceous taxa: *Broinsonia parca*, *Micula decussata*, *Watznaueria barnesae*.

Lower Paleocene  
(*Cruciplacolithus tenuis* Zone)

12-119-40-4, 51-56 cm (depth 704 m):

*Braarudosphaera bigelowi*, *Coccilithus pelagicus s. l.*, *Cruciplacolithus tenuis*, *Ericsonia?* *subpertusa* Hay and Mohler, *Zygodiscus sigmoides*. Reworked Upper Cretaceous taxa: *Prediscosphaera cretacea cretacea*, *Watznaueria barnesae*.

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