13. COCCOLITH BIOSTRATIGRAPHY OF THE NORTH ATLANTIC OCEAN, DEEP SEA DRILLING PROJECT LEG 94[1]

Toshiaki Takayama, Department of Geology, Kanazawa University, Japan
and
Tokiyuki Sato, Technical Research Center, Teikoku Oil Co., Tokyo, Japan[2]

ABSTRACT

We studied calcareous nannofossil assemblages in 860 samples recovered during DSDP Leg 94 in order to estimate the age of the sediments at six sites in the North Atlantic Ocean. Twenty-one biohorizons are recognized in the Neogene and Quaternary sequences deposited at middle and high latitudes. Correlation of these biohorizons with the magnetostratigraphy established for the same cores indicates that three of these biohorizons, the Last Appearance Datum (LAD) and First Appearance Datum (FAD) of *Helicosphaera inversa* and the LAD of *Sphenolithus abies*, are ecologically controlled and cannot be used as stratigraphic indicators. In the floral reference list one new species (*Coccolithus streckeri*) is described.

INTRODUCTION

Leg 94 of the IPOD phase of the Deep Sea Drilling Project began at Norfolk, Virginia on 23 June, 1983 and ended at St. Johns, Newfoundland on 17 August. During this leg, 22 holes were drilled at 6 sites on a roughly south-southwest to north-northeast transect in the North Atlantic from 37 to 53°N (Fig. 1, Table 1). Cenozoic sediments were recovered by continuous hydraulic piston coring (HPC) and use of the extended core barrel (XCB). Thick sequences of carbonate ooze and mud were penetrated, and abundant calcareous nannofossils were found throughout the cores at all sites.

The main purpose of this report is to describe the calcareous nannofossil assemblages and their stratigraphic changes, to discuss the basis for biostratigraphic age assignments, and to correlate nannofossil biohorizons defined by the first and last occurrences of selected species with the levels of magnetic reversals.

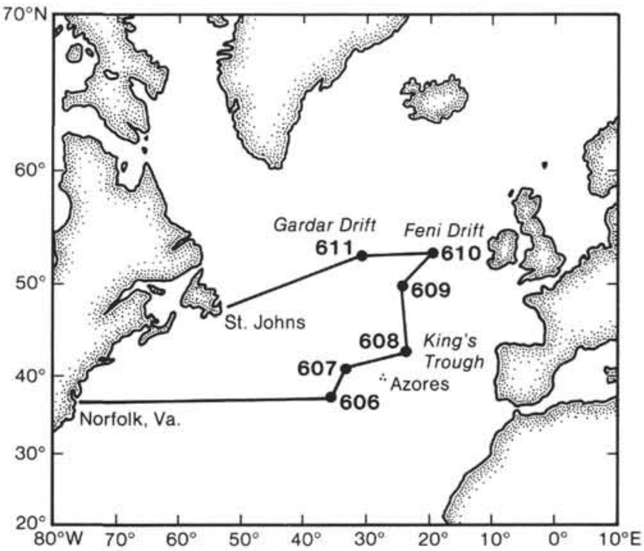

Figure 1. Location map of Sites 606 through 611, Leg 94.

METHODS

On Leg 94 the hydraulic piston corer was used to recover long, undisturbed, continuous sections. At depths below HPC refusal, relatively undisturbed sediment sequences were obtained with the extended core barrel; therefore these cores are well-suited for detailed biostratigraphic sampling.

All samples were taken on board the *Glomar Challenger*. The sample spacing in critical intervals is sufficiently close (usually 1 sample/1.5 m) to determine stratigraphic positions of first and last occurrences of selected species with reasonable accuracy.

The outermost portion of each sample was removed to avoid floral contamination caused by drag of the sediment against the core liner. A total of 860 samples was processed and examined employing commonly accepted techniques as described by Stradner and Papp (1961). Approximately 5 mg of the samples was placed in a beaker and about 20 ml of water was added. This beaker was placed in an ultrasonic cleaner (BRANSONIC 12) at a moderate vibration setting. After 5 s, the beaker was removed from the ultrasonic cleaner; after the heavier particles had settled, about 1 cm^3 was withdrawn from the upper layer of the suspension with a pipette and placed on a square microscopic cover glass (18 mm × 18 mm) and carefully allowed to dry on an electric hot plate set at approximately 40 to 50°C. The mounting reagent "Eukitt" was then spread over it and the cover glass was pressed on a glass slide.

The slide was examined under an Olympus Binocular Polarizing Microscope (BHA-P) at a magnification of 1500×, with an oil-immersion objective lens. Several thousand coccolith and discoaster specimens were identified. In addition, 200 specimens were counted at random and listed in order to determine the relative frequencies of occurrence of the species and their stratigraphic changes.

The relative frequencies were designated by using one of the following codes: A = abundant (more than 32% of the species in total assemblage), C = common (32–8% of the species in total assemblage), F = few (8–2% of the species in total assemblage), R = rare (less than 2% of the species in total assemblage), and + = present (found but not counted).

The overall preservation of nannofossil assemblages was recorded using one of three letter designations (Steinmetz, 1979): G = good preservation—fossils lack evidence of dissolution or overgrowth; M =

[1] Ruddiman, W. F., Kidd, R. B., Thomas, E., et al., *Init. Repts. DSDP*, 94: Washington (U.S. Govt. Printing Office).

[2] Addresses: (Takayama) Dept. of Geology, College of Liberal Arts, Kanazawa University, Kanazawa, 920 Japan; (Sato) Technical Research Center, Teikoku Oil Co., Ltd., Kitakarasuyama, Setagaya-ku, Tokyo, 157 Japan.

Table 1. Locations of Leg 94 sites.

Hole	Latitude	Longitude	Water depth (m)
606	37°20.32'N	35°29.99'W	3007
606A	37°20.29'N	35°30.02'W	3007
607	41°00.07'N	32°57.44'W	3427
607A	41°00.07'N	32°57.44'W	3427
608	42°50.21'N	23°05.25'W	3526
608A	42°50.21'N	23°05.25'W	3526
609	49°52.67'N	24°14.29'W	3884
609A	49°52.67'N	24°14.29'W	3883
609B	49°52.67'N	24°14.29'W	3883
609C	49°52.67'N	24°14.29'W	3883
610	53°13.30'N	18°53.21'W	2417
610A	53°13.30'N	18°53.21'W	2417
610B	53°13.30'N	18°53.21'W	2417
610C	53°13.30'N	18°53.21'W	2417
610D	53°13.47'N	18°53.69'W	2445
610E	53°13.47'N	18°53.69'W	2445
611	52°50.47'N	30°18.58'W	3203
611A	52°50.47'N	30°18.58'W	3201
611B	52°50.15'N	30°19.10'W	3228
611C	52°50.15'N	30°19.10'W	3230
611D	52°50.47'N	30°18.58'W	3195
611E	52°50.47'N	30°18.58'W	3195

moderately good preservation—the majority of the specimens is slightly etched (fine structures are missing, but no diagnostic changes of form are evident in light microscopy; all taxa may be easily identified); and P = poor preservation—the majority of the specimens is deeply etched (identity of many centerless and fragmental specimens is questionable).

Sample material used during the present investigation is permanently in the Micropaleontology Collection of the Department of Geology, College of Liberal Arts, Kanazawa University. Slides are located at Teikoku Oil Co., Ltd., Tokyo and College of Liberal Arts, Kanazawa University.

NANNOFOSSIL ZONATION

Cenozoic calcareous nannofossil zonation schemes, based primarily on land or epicontinental sections, have been established by numerous investigators. Among them, the "Standard Calcareous Nannofossil Zonation" established by Martini (1971) is most applicable and widely used. He summarized the Cenozoic nannofossil zonation, and gave ranges of important species and correlation of his zones with planktonic foraminiferal and radiolarian zones. Another comprehensive zonation was proposed by Bukry (1973, 1975) for low-latitude deep-sea sections. Subsequently Okada and Bukry (1980) introduced code numbers to this zonation, and this scheme proved to be a more practical approach to deep-sea calcareous nannofossil biostratigraphy.

Calcareous nannoplankton attain their maximum diversity in tropical areas, as do planktonic foraminifers. Many tropical forms used as index fossils are not found at higher latitudes, and the number of usable coccolith guide species decreases with increasing latitude; thus zonal intervals must be expanded poleward, with consequent loss of biostratigraphic resolution. This created a serious problem in interpreting the Neogene calcareous nannofossil biostratigraphy of Leg 94 samples.

The zonal scheme established by Martini (1971) is employed throughout this chapter to make zonal and geological age assignments of the samples (Table 2). This zonation, however, was not applicable for the lower Pliocene and most of the Miocene sedimentary sequences recovered during Leg 94 because of the absence of many important index fossils used for zonation at low latitudes (e.g., ceratoliths and asteroliths). Only those stratigraphic intervals characterized by the presence of relevant species are discussed; see Table 2 for overall zonation of Leg 94 samples.

SUMMARY OF NANNOFOSSIL BIOSTRATIGRAPHY

Site 606

Site 606 is located on the upper western flank of the Mid-Atlantic Ridge and consists of two holes. Quaternary and Pliocene calcareous nannofossil assemblages were recovered from this site. Preservation is good in the Pleistocene and upper Pliocene and moderate in the lower Pliocene, because of overgrowth of calcite on many specimens.

Hole 606 (Table 3)

Samples 1-2, 47–48 cm, 1,CC, and 2-2, 47–48 cm are assigned to the *Emiliania huxleyi* Zone (NN21). *Emiliania huxleyi, Calcidiscus leptoporus*, and gephyrocapsids are dominant. *Coccolithus pelagicus, Oolithotus antillarum, Rhabdosphaera clavigera*, and *Scapholithus fossilis* are frequent. In this zone, *Helicosphaera inversa* occurs in Sample 2-2, 47–48 cm. Because of the absence of *Emiliania huxleyi* and *Pseudoemiliania lacunosa*, Samples 2-3, 47–48 cm through 2-5, 47–48 cm are assigned to Zone NN20 (*Gephyrocapsa oceanica* Zone). The presence of *Pseudoemiliania lacunosa* in Samples 2-6, 47–48 cm through 7-6, 47–48 cm indicates an early Pleistocene age (NN19, *Pseudoemiliania lacunosa* Zone). *Helicosphaera sellii* and *Calcidiscus macintyrei* occur consistently below Samples 5-4, 47–48 cm and 6-6, 47–48 cm, respectively, but *Helicosphaera inversa* and *Gephyrocapsa parallela* occur in the interval above Samples 2,CC and 4-3, 47–48 cm, respectively. The top of the acme of *Reticulofenestra*-like species (*Reticulofenestra* sp. A) is in Sample 3,CC. Comparatively large (>6 μm) specimens of *Gephyrocapsa* are limited to the interval from Sample 5-1, 47–48 cm down to Sample 6-1, 47–48 cm. *Gephyrocapsa oceanica* occurs only above Sample 6-5, 47–48cm, and *Calcidiscus macintyrei* is present below Sample 6-6, 47–48 cm.

The Pliocene/Pleistocene boundary is marked sharply—between Samples 7-6, 47–48 cm and 7,CC; below this level *Discoaster brouweri* occurs continually. Samples 7,CC through 9-2, 47–48 cm contain *Calcidiscus leptoporus, Emiliania ovata*, and *Pseudoemiliania lacunosa*, together with *Discoaster brouweri* and *D. triradiatus;* therefore these are assigned to latest Pliocene Zone NN18 (*Discoaster brouweri* Zone). Lower in the section, the assemblage is characterized by the occurrences of various discoasters. The presence of *Discoaster brouweri* and *D. pentaradiatus* places Sample 9-4, 47–48 cm in Zone NN17 (*Discoaster pentaradiatus* Zone). Samples 9,CC through 14,CC contain comparatively diversified discoaster species such as *D. asymmetricus, D. brouweri, D. intercalaris, D. pentaradiatus*, and *D. surculus;*

Reticulofenestra pseudoumbilica also occurs sporadically. This last species, however, is not abundant, and therefore these samples belong in late Pliocene Zone NN16 (*Discoaster surculus* Zone). In this zone, *Discoaster tamalis* is found below Sample 10,CC only. The top of the acme of *Reticulofenestra pseudoumbilica* is recognized in Sample 15-2, 47–48 cm, so all lower samples are assigned to early Pliocene Zone NN15 (*Reticulofenestra pseudoumbilica* Zone). *Sphenolithus abies* occurs in Sample 15-4, 47–48 cm, slightly below the top of Zone NN15 (*Reticulofenestra pseudoumbilica* Zone). In this zone some *Amaurolithus* specimens are recognized.

Hole 606A (Table 4)

Nannofossil assemblages in Hole 606A are similar to those observed in Hole 606. Sample 1,CC is assigned to the late Pleistocene to Holocene *Emiliania huxleyi* Zone (NN21). The presence of *Pseudoemiliania lacunosa* in Samples 2,CC to 6,CC indicates an early Pleistocene age (NN19, *Pseudoemiliania lacunosa* Zone) for these samples.

The Pliocene/Pleistocene boundary is placed between Samples 6,CC and 7,CC. Samples 7,CC is assigned to Zone NN18 (*Discoaster brouweri* Zone). *Discoaster brouweri* and *D. pentaradiatus* co-occur in Sample 8,CC, which is placed in Zone NN17 (*Discoaster pentaradiatus* Zone). Below this, discoasters gradually increase in number of species and in number of specimens. *Reticulofenestra pseudoumbilica* is present. This species, however, increases in Sample 14,CC. Specimens of *R. pseudoumbilica* above the acme of this species are most probably reworked. Consequently, the boundary between the *Discoaster surculus* Zone (NN16) and the *Reticulofenestra pseudoumbilica* Zone (NN15) is tentatively placed between Samples 13,CC and 14,CC. Because *Amaurolithus tricorniculatus* occurs in Samples 19-2, 47–48 cm and 19,CC, the boundary between Zones NN15 (*Reticulofenestra pseudoumbilica* Zone) and NN14 (*Discoaster asymmetricus* Zone) is in the upper part of Core 19.

Site 607

Site 607 is less than 250 n. mi. north of Site 606. Two holes, drilled on the upper middle western flank of the Mid-Atlantic Ridge, provided a largely overlapping and partly composite section down to the upper Miocene. Calcareous nannofossils are abundant throughout. The assemblages are characterized by good to moderate preservation and range from Quaternary to upper Miocene; species diversity is comparatively high.

Hole 607 (Table 5)

Samples 1-2, 47–48 cm through 9-6, 47–48 cm contain Pleistocene to Holocene assemblages such as *Emiliania huxleyi, Pseudoemiliania lacunosa, Gephyrocapsa caribbeanica, G. oceanica, G. parallela, Helicosphaera inversa, H. sellii, Reticulofenestra* sp. A, and *Calcidiscus macintyrei*. The uppermost four samples contain abundant *Emiliania huxleyi* and can be correlated with the late Pleistocene to Holocene *Emiliania huxleyi* Zone (NN21). Because *Emiliania huxleyi* and *Pseudoemiliania lacunosa* are absent in Samples 2-2, 47–48 cm to 2-5, 47–48 cm, they are assigned to the Pleistocene *Gephyrocapsa oceanica* Zone (NN20). The presence of abundant *Pseudoemiliania lacunosa* and the absence of discoasters place Samples 2-6, 47–48 cm down to 9-6, 47–48 cm in the *Pseudoemiliania lacunosa* Zone (NN19). Throughout these three Pleistocene to Holocene zones, *Helicosphaera inversa* is found in the interval between Samples 1,CC and 3-2, 47–48 cm. Peculiar *Reticulofenestra* (*Reticulofenestra* sp. A) dominate below Sample 5-4, 47–48 cm. *Gephyrocapsa parallela* occurs only above Sample 5-4, 47–48 cm. *Gephyrocapsa oceanica* and *G. caribbeanica* do not occur below Samples 8-4, 47–48 cm and 9-1, 47–48 cm, respectively. First occurrences of *Calcidiscus macintyrei* and *Helicosphaera sellii* are recognized in Samples 8-5, 47–48 cm and 6-6, 47–48 cm, respectively. Comparatively large specimens of *Gephyrocapsa* are found in Samples 6-4, 47–48 cm through 7-5, 47–48 cm.

The Pliocene/Pleistocene boundary is placed between Samples 9-6, 47–48 cm and 9,CC, below which *Discoaster brouweri* occurs almost continuously. Samples 9,CC through 11-2, 47–48 cm contain *Discoaster brouweri* together with a few specimens of *D. triradiatus* and, therefore, are assigned to the latest Pliocene *Discoaster brouweri* Zone (NN18). The occurrences of *D. brouweri* and *D. pentaradiatus* place Samples 11-4, 47–48 cm, 11,CC, and 12-2, 47–48 cm in the *Discoaster pentaradiatus* Zone (NN17). Below this level, the assemblage is characterized by the occurrences of various discoasters. Although a few *Reticulofenestra pseudoumbilica* were observed, Samples 12-4, 47–48 cm through 17,CC are assigned to the late Pliocene *Discoaster surculus* Zone (NN16). Abundant occurrences of *Reticulofenestra pseudoumbilica* were first observed in Sample 18-2, 47–48 cm and, therefore, Samples 18-2, 47–48 cm to 21-4, 47–48 cm are all placed in the early Pliocene *Reticulofenestra pseudoumbilica* Zone (NN15). *Sphenolithus abies* also occurs commonly in Sample 18-2, 47–48 cm; therefore the extinction level of this species may coincide with the top of the acme of *Reticulofenestra pseudoumbilica*. The assemblages in Samples 21,CC through 25,CC are characterized by the occurrences of *Amaurolithus tricorniculatus, A. primus*, and *A. delicatus*. As the occurrences of *Ceratolithus rugosus* and *Discoaster asymmetricus* are rare and sporadic, these samples are placed tentatively in the *Discoaster asymmetricus* Zone (NN14) to the *Amaurolithus tricorniculatus* Zone (NN12). Below Sample 25,CC *Discoaster quinqueramus*, the important marker species of the late Miocene *Discoaster quinqueramus* Zone (NN11), is found together with *Discoaster berggrenii*. Although *D. quinqueramus* occurs only occasionally in small numbers and the central stem is not prominent, NN11 seems to extend from Sample 26-2, 47–48 cm on down to the bottom of this hole.

Hole 607A (Table 6)

Sample 1,CC can be correlated with the *Emiliania huxleyi* Zone (NN21), because of the abundant occurrence of *Emiliania huxleyi*. Based on the absence of *E. huxleyi* and *Pseudoemiliania lacunosa*, Sample 2,CC is assigned to the *Gephyrocapsa oceanica* Zone (NN20). Because of the presence of *P. lacunosa* and the absence

Table 2. Geologic age and nannoplankton zone assignment of Leg 94 samples.

Age		Zone	606	606A	607	607A	608	608A	609	609A	609B	609C
Quaternary		NN21	1-1 to 2-2	1,CC	1-2 to 2-1	1,CC	1-2 to 1-4	1,CC	1-2 to 2-2		1,CC to 2,CC	
		NN20	2-3 to 2-5		2-2 to 2-5	2,CC	1-5 to 2-2		2,CC to 3-4		3,CC	
		NN19	2-6 to 7-6	2,CC to 6,CC	2-6 to 9-6	3,CC to 9,CC	2-3 to 5-4; 6-2 to 7,CC	2,CC to 5,CC	3,CC to 15-2	1,CC to 2,CC	4,CC to 15,CC	1,CC
Pliocene	late	NN18	7,CC to 9-2	7,CC	9,CC to 11-2	10,CC to 11,CC	5-5 to 5-6	6,CC	15-4 to 19,CC		16,CC to 17,CC	2,CC to 4,CC
		NN17	9-4	8,CC	11-4 to 12-2	12,CC			20-1 to 20-4			5,CC
		NN16	9,CC to 14,CC	9,CC to 13,CC	12-4 to 17,CC	13,CC to 18,CC	5,CC; 8-2 to 12-4	7,CC to 12,CC	20,CC to 26,CC		19,CC to 27,CC	6,CC to 7,CC
	early	NN15	15-2 to 18,CC	14,CC to 19-1	18-2 to 21-4	19,CC to 20,CC	12,CC to 13,CC	13,CC to 14,CC	27-2 to 27,CC		28,CC to 32,CC	
		NN14		19-2 to 19,CC	21,CC to 25,CC	Washed	14-2 to 15-5	15,CC	28,CC to 32,CC			
		NN13					15,CC to 17-3	16,CC	33,CC to 35-2		33,CC to 34,CC	
		NN12										
Miocene	late	NN11			26-2 to 30,CC	21-2 to 26,CC	17,CC to 22,CC		35,CC to 42,CC		35,CC to 38,CC	
		NN10										
	middle	NN9					23-2 to 24,CC					
		NN8					25-2 to 28-2					
		NN7										
		NN6					28-4 to 32-5					
		NN5					32,CC to 35,CC					
	early	NN4					36-2 to 38-4					
		NN3					38,CC to 43-2					
		NN2					43-4 to 44,CC					
		NN1					45-2 to 45,CC					
Oligocene	late	NP25					46-2 to 48,CC					
		NP24					49-2 to 49-4					
	early	NP23					Missing					
		NP22										
		NP21										
Eocene	late	NP20										
		NP19					50-2 to 52,CC					
		NP18					53-1 to 54-4					
	early	NP17					55,CC to 57-3					

of *Discoaster brouweri*, Samples 3,CC through 9,CC are assigned to NN19 (*Pseudoemiliania lacunosa* Zone). Below these samples, discoasters are found continuously, therefore, the Pliocene/Pleistocene boundary is placed between samples 9,CC and 10,CC.

Samples 10,CC and 11,CC are assigned to the latest Pliocene *Discoaster brouweri* Zone (NN18). In this zone, *D. brouweri* and *D. triradiatus* are found. Sample 12,CC contains *D. brouweri* together with *D. pentaradiatus*. This sample may thus represent the late Pliocene *Discoaster pentaradiatus* Zone (NN17). Samples from 13,CC on down to 18,CC are assigned to NN16 (*Discoaster surculus* Zone) and contain an assemblage rich in asteroliths. *Reticulofenestra pseudoumbilica* occurs sporadically throughout this zone. Its abundance, however, drastically increases in Sample 19,CC. Therefore, specimens in NN16 are regarded as reworked, and Samples 19,CC and 20,CC are placed in NN15 (*Reticulofenestra pseudoumbilica* Zone). Samples 21-2, 47–48 cm through 26,CC, which were obtained after washing down to 258.3 m subbottom, contain *Discoaster quinqueramus* and are referred to the *Discoaster quinqueramus* Zone (NN11).

Site 608

This site is on the southern flank of the King's Trough tectonic complex. The first hole (Hole 608) was continuously cored (HPC to refusal and then XCB) to basement of middle Eocene age in order to elucidate the tectonic history of the King's Trough. Hole 608A was continuously HPC cored, providing overlap to refusal. At this site Quaternary, Pliocene, Miocene, upper Oligocene, and upper to middle Eocene sediments were identified by calcareous nannofossil stratigraphy.

Hole 608

Neogene (Table 7)

The youngest coccolith assemblages at this site belong to the *Emiliania huxleyi* Zone (NN21) and are present in Samples 1-2, 46–47 cm and 1-4, 46–47 cm, where abundant *Emiliania huxleyi* and *Gephyrocapsa oceanica* occur together. Samples 1-5, 46–47 cm to 2-2, 46–47 cm are assigned to the *Gephyrocapsa oceanica* Zone (NN20) based on the absence of *E. huxleyi* and *Pseudoemiliania lacunosa*. The presence of abundant *P. lacunosa* and the absence of discoasters place Samples 2-3, 46–47 cm to 5-4, 46–47 cm in NN19 (*Pseudoemiliania lacunosa* Zone). *Helicosphaera inversa* is found only in Samples 1-4, 46–47 cm to 2-3, 46–47 cm. *Reticulofenestra* sp. A and *Reticulofenestra* sp. B occur in Samples 3-2, 46–47 cm to 3-5, 46–47 cm. Similarly, *Gephyrocapsa* larger than 6 μm is found in Samples 3-6, 46–47 cm, 3,CC, and 4-2, 46–47 cm. *Gephyrocapsa parallela* is recognized above Sample 3-1, 46–47 cm. The last appearance datum (LAD) of

Table 2 (continued).

610	610A	610B	610C	610D	610E	611	611A	611B	611C	611D	611E
1,CC	1-2 to 2-6	1,CC to 2,CC	1,CC	1,CC		1,CC to 2-1	1,CC		1,CC to 2,CC	Washed	Washed
2,CC to 3,CC	2,CC to 3-4	3,CC	2,CC	2,CC		2-3		1,CC	3,CC		
4,CC to 5,CC	3-5 to 11-3	4,CC to 14,CC	3,CC to 4,CC	3,CC to 5,CC		2-4 to 9-2	2,CC to 10,CC		4,CC to 9,CC	1,CC	1,CC to 2,CC
Washed	11-4 to 14-2		5,CC to 6,CC			9-3 to 12,CC	11,CC		11,CC to 13,CC	Washed	
	14-4 to 14,CC				Washed	13-1 to 13-2	12,CC		14,CC		
6,CC to 9,CC	15-2 to 20-2	15,CC to 16,CC				13-3 to 14,CC	13,CC		15-2 to 22-4	2,CC to 11,CC	
	20-4 to 21,CC			Washed					22,CC to 24,CC	12,CC to 14,CC	
Washed											
					1,CC				26-2 to 31-4		
11,CC					2,CC to 6,CC				31,CC to 43,CC		
Washed				6,CC to 7,CC	7,CC				44-2 to 45,CC		
14,CC									46-2 to 47,CC		
Washed											
16,CC											
17,CC to 19,CC											
20,CC to 21,CC											
22,CC to 27,CC											

Helicosphaera sellii and *Calcidiscus macintyrei*, and the first appearance datums (FADs) of *Gephyrocapsa oceanica* and *G. caribbeanica* are in Zone NN19.

The Pliocene/Pleistocene boundary is between Samples 5-4, 46–47 cm and 5-5, 46–47 cm. Samples 5-5, 46–47 cm and 5-6, 46–47 cm contain *Discoaster brouweri* and are assigned to the latest Pliocene *Discoaster brouweri* Zone (NN18). The assemblage in the next lower sample (5,CC) is characterized by the occurrences of *Discoaster brouweri, D. pentaradiatus*, and *D. surculus*, which places this sample in the *Discoaster surculus* Zone (NN16). The *Disoaster pentaradiatus* Zone (NN17) is, therefore, not recognized. Remarkably, there are only few discoasters in Samples 6-2, 46–47 cm through 7,CC, and the presence of *Pseudoemiliania lacunosa* and the absence of *Gephyrocapsa caribbeanica* and *G. oceanica* seem to place these samples again in the lowest part of Zone NN19. Discoasters in these samples are probably reworked. The co-occurrence of *Discoaster brouweri, D. pentaradiatus*, and *D. surculus* places Samples 8-2, 46–47 cm through 12-4, 46–47 cm in NN16. NN16 and the lowest part of NN19 are repeated in this hole, as is evident from Table 7. This repetition is attributed to redeposition or small-scale slumping. *Discoaster tamalis* occurs only in and below Sample 10-4, 46–47 cm in this zone. Although *Reticulofenestra pseudoumbilica* is observed in the overlying zones, this species occurs consistently below Sample 12,CC. Thus Samples 12,CC to 13,CC are assigned to the *Reticulofenestra pseudoumbilica* Zone (NN15). *Sphenolithus abies* occurs in Sample 13-2, 46–47 cm, somewhat below the NN16/NN15 boundary. The assemblage in Samples 14-2, 46–47 cm to 15-5, 46–47 cm is characterized by sporadic occurrences of *Amaurolithus tricorniculatus, A. primus, A. delicatus*, and *Discoaster asymmetricus;* this places these samples in the early Pliocene *Discoaster asymmetricus* Zone (NN14). The underlying NN13 *Ceratolithus rugosus* Zone and NN12 *Amaurolithus tricorniculatus* Zone cannot be distinguished because ceratoliths are very rare or absent. Thus Samples 15,CC through 17-3, 46–47 cm are tentatively placed in NN13–NN12. Based on the occurrences of *Discoaster quinqueramus*, NN11 (*Discoaster quinqueramus* Zone) is represented from Sample 17,CC on down to Sample 22,CC. The first appearance datums (FADs) of *Discoaster pentaradiatus* and *D. surculus* are recognized in this zone. Although the number of specimens is very limited, the occurrence of *Discoaster hamatus* seems to place Samples 23-2, 46–47 cm through 24,CC in NN9 (*Discoaster hamatus* Zone). Therefore NN10 (*Discoaster calcaris* Zone) is not recognized clearly in this hole. Throughout the section ranging from Samples 25-2, 46–47 cm down to 32-5, 26–27 cm, age-diagnostic species are few. In this interval, however, the LADs of *Coccolithus miopelagicus* (between Samples 26-3, 46–47 cm and 26-4, 46–47 cm) and of *Cyclicargolithus floridanus* (between 28-2, 46–47 cm and 28-4, 36–37 cm) are clearly

Table 3. Distribution of calcareous nannofossils, Hole 606.

Age		Nannofossil zone	Sample (interval in cm)	Preservation	*Acanthoica* spp.	*Amaurolithus delicatus*	*A. primus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus cristatus*	*C. rugosus*	*C. telesmus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Cyclicargolithus floridanus*	*Discoaster asymmetricus*	*D. brouweri*	*D. challengeri*	*D. intercalaris*	*D. pansus*	*D. pentaradiatus*	*D. quadramus*	*D. quinqueramus*	*D. surculus*	*D. tamalis*	*D. triradiatus*
Quaternary		NN21	1-2, 47–48	G				F					+	R		+		+												
			1,CC	G	+			C				+	+	R				+												
			2-2, 47–48	M				F					+	+		+		+												
		NN20	2-3, 47–48	G				F					+	+																
			2-4, 47–48	G				R					+	+		+		+												
			2-5, 47–48	G				F										R												
		NN19	2-6, 47–48	G				F					+	+																
			2,CC	G				F					+	+				+												
			3-2, 47–48	M				F					+	+				+												
			3-4, 47–48	P				R																						
			3,CC	G				F						+				+												
			4-2, 47–48	M				F																						
			4-3, 47–48	M				F										+												
			4-4, 47–48	M				F										+												
			4,CC	M				F		+								+												
			5-1, 47–48	G				C										+												
			5-2, 47–48	P				F						+				+												
			5-3, 47–48	G				F					+	+				+												
			5-4, 47–48	M				F					+	+				+												
			5,CC	M				F					+	R				+												
			6-1, 47–48	G				F						R				+												
			6-2, 47–48	G				F					+	R																
			6-4, 47–48	M	+			F					+	R																
			6-5, 47–48	G				C		+				+				R												
			6-6, 47–48	G				C	R				+																	
			6,CC	G				F	R				+	+				R												
			7-1, 47–48	G				F	R				+	+	+			+												
			7-2, 47–48	P				C	R					+				R												
			7-4, 47–48	G				C	R				+	+				+												
			7-6, 47–48	M				F	R					F																
Pliocene	late	NN18	7,CC	M				C	F					R				+			R									+
			8-2, 47–48	G				C	R		+		+	+	+			+			+									
			8-4, 47–48	M				F	R				+	R				+			+									
			8,CC	G				C					R	F				+		+	R									R
			9-2, 47–48	M				C	R		+		R	R		+		+			R									
		NN17	9-4, 47–48	M				C	R				+	R							+				+					
		NN16	9,CC	M				C	+					F	+						R				R			+		
			10-2, 47–48	M				C	+		R		+	F		+		+			+		+		R			+		
			10-4, 47–48	M				C	R		+		+	+				+			+		+		R			+		
			10,CC	M				C	R	+				R				R		+	R				R	+		+	+	
			11-2, 47–48	M				C	R				R	R				R		R	+		+		+			R	+	
			11-4, 47–48	M				C	F				+	R	+	+		R		+	+		+		R			+	R	+
			11,CC	M				C	R					R				R		+	R				R		+	+	R	
			12-2, 47–48	M				C	R				R	R				F		+	+		+		R			R	R	R
			12-4, 47–48	M				C	+		R		+	R				R		R	R		+		+			+	+	
			12,CC	M				C	R				+	R				+		+	+				+			+	R	+
			13-2, 47–48	M				F	R		+			R				R		R	+	+	+		R			+	+	
			13-4, 47–48	M				F	+				+	+				+		+	+		R		+			+	R	
			13,CC	M				F	R					R	R			R		R	R				+			+	+	+
			14-2, 47–48	M				C	+		R		+	+			+	+		R	+		R		+			+	+	+
			14-4, 47–48	M				C	+				+	+			+	R		+	+		+		+			+	+	
			14,CC	M				C	R					+				R		+	+	+			+			+	+	
	early	NN15	15-2, 47–48	M				C								+		F		R	+		+		+			+	R	
			15-4, 47–48	M				C	R		+			+				R		+	+		+		R			+		
			15,CC	M			+	C	R				+	R				R		R	+				R			+	+	
			16-2, 47–48	M				C	R	+	+			R				R		+	+	+	+		R			+		+
			16-4, 47–48	M				C	+		+		R	R			+	R		R	R		+		R			+	+	+
			16,CC	M		+		C	R		+			+				R	+	+	+	+	+	+	R			R		
			17-2, 47–48	M				C	R				+	F		+		F		+	+				+			+		
			17-4, 47–48	M				F	+	+				+			+	+			+	+			R			+		
			17,CC	M				F	R		+			R				R			+				+			+		
			18-2, 47–48	M				C	R				R	R	+			R			+	+	+	+	+			+		
			18-4, 47–48	M				C	R				+	+		+		R		+		+		+	+	+		+		
			18,CC	M			+	C	R		+		+	R			+	R		+	+	+	+		R			+		+

Note: A = abundant, C = common, F = few, R = rare, + = present; G = good, M = moderate, P = poor.

Table 3 (continued).

D. variabilis	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Hayaster perplexus*	*Helicosphaera carteri*	*H. granulata*	*H. hyalina*	*H. inversa*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. heimi*	*T. saxe*	*Triquetrorhabdulus rugosus*	*Umbilicosphaera mirabilis*
	+		+	C			C		F		R			R		+			+	R					+		+	R							+		
	+		+	C		F	F		F		R			F		+			+	+					R		+	+				+			+		F
	+	+	+	C		F	F		F		R	R		+		+	+		+	R					+	+	+	+				R			+		
		+	+			F	C		C					R		R			+	+					+		+	+				+			+		+
			+			F	C		C			R		R		+	+		+	+					+	+	+	+				R		+	+		
	+		+			R	R		R		+			+			+			R					R		+	+				+	R		R		R
	+		+		+		C		F					+			+		+	+	F				+	+	+	+				R			+		+
	+		+		+	R	C		C		+			+		+	+		+	+	R		+		+		+	+				+					+
	+	+	+		F	+	C		C			+		R					+	R	R				R	+	+	R	+			R		+	+		+
	+		R		F	F	F		F		F	R		R						+	F				+		+	+	+			R			R		
	+		+		R	F	F		R					R					+		R		+		+	+	+	+				+					+
	+	R	R		C	F	R		C		R	R		R						+	F		R		+		+	R				+			+		
	+		+		F	C	R		R		+	F		R						R	F		C	+	R	+	+	+	+			+	+				+
	+		+		R	F	+					F		R						+	R		F	R	R		+					+		+			+
	R		R		F	C	+		+			F		R		+			+	+	F		R	+		+	+	R				+		+			+
	+	+	R		R	F		+				R		R		R			+	R	F				+	+	R	+	+			R					R
	+	+	+		R	R	+	+	+	+		F		+		+				R	R		+		+	+	+	+	+			R		R			+
	+	+	R		F	F	+	F	+	+		R		R						R	C				+	+	+	+						+			+
	+	+	R		F	F	F	R	F	F		R		R				+		+	F				+		+		+			R		+			
	+	+	R		C	C	C	+	C	R				F		R		R	+	+	F				+	+	+	+	+			+					+
	+	+	+		R	F	C		C	R		R		+				R	+	+	F				+		+	R				R		+			R
		+	+		F	F	C		F			+		R				R	+	+	F				+	+	+	+				+		R			R
	R	+	R		F	C	C		F			R		F		+		+	+	+	F				+		+	+	+			+					R
	+	+	+		R	F	C		F			R		+				R	+	+	F				+	+	+	+	R				+				+
	+	+	+		R	F	F					R		R				R	+	R	F				+		R		+			+	+	+			+
	+	+	F		F	C	F					R		F		R		F	+	+	F				+		+	+	+			R		+			R
	+	R	R		F	F						R		F		F		+	+	R	C				R	+	+	+	+			+	+	+			R
	+		+		F	F						F		R		+		R	+	R	R				R		R	R	+			R					
	+	+	R		A	R						R		R		+		R	R	+	F		+		+	R	+	+	+			R					+
	+	+	+		R	F						R		R		+		+	+	+	F				R	+	+		+			R		+			R
	+		+		C	R						R		R		+		R	+	+	F				R		+	+	+			+					+
	R		R		F	R								R				R	+	R	F				+	R	+	R	+			F					R
	+		R		F	R	R							R				+	R		F				R		R	+	+			F					+
	R		R		F	R								R	R			R	+	F	F				R				+			F		+			R
			R		F	R								R				R	+	F	F	+			+	R	+		+			F		+			F
	+		R		C									R				R	+	R	F				+	+		+				F		+			+
			+		R									+	R			+	+	+	R				R	+	+		+			R		+			+
			+		R									F				R		+	R	+			+	+	R		+			R					
			+		F									R				R	+	R	R	+					+	+	+			F			+		
	+		+											R	+			+	+	R	+				R		R		+			R					
+			R		+									R				R		F	R	F				+	+	R	+			R					
	+		+		R									R				+		R	R					+			+			R					
			R		R									+	R			+	R		R	+						R	+			F					
			R		F	R							+	F	+			+		R	F	+				+	+	+				R					R
+			R		F		R							R				R		R	F	R			+	+	+	R	+	R		+					
			+											F	+			+	+		+	+			R				+		+	R					
			R		R									R				R			R	R				+		+	+			R					
			R		R	R								R	R			+	+		+	+				+		+	+			R			+		
+	+		R		+									R	+			+		+	R				R		R	+	+	+		+					R
			R		F		R							F	+			+			R	+			+	+	+		R			R					
			R		R	R								R	+			R			F	+				+	+	R	+			+					R
			+		R	R						R		F	R				+		F				R				+			R	+				R
			R		R	R						R		R							F	R					+	+	+		R						
+			+		R	F							+	R				+	+	R	R	F				+	+	+	+	R		R					
	+		R		R							R		R	+				+		R	F					+		+	R		R	+				
R			+		F	R							+	R	R						+	R					+		+	R	+	R		+			
			R		+	R								R							R	F				+	+		+	+	R	F		+	+		R
			R		R	R						R		R	+				R		R	F					+	+	+	+	+	R				+	R
+			R		R	R								R	+			+			R	F			+	+			+	+	+	+					
+			R		R									R	R			+		+	R	F				+	+	+	+	R	+	+					
+			R											R	+			+	+		+	F					+		+	R	+	R					
+			R		R									R	R							F					+		+	R	R	R					
+			R											+	+						+	F				+			+	+	R	R			+		
+			+		R									+	+			+	+			F					+		+	R	+	R	+	+			

Table 4. Distribution of calcareous nannofossils, Hole 606A.

Age		Nanno-fossil zone	Sample (interval in cm)	Preservation	*Acanthoica* spp.	*Amaurolithus delicatus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus cristatus*	*C. rugosus*	*C. telesmus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Cyclicargolithus floridanus*	*Discoaster adamanteus*	*D. asymmetricus*
Quaternary		NN21	1,CC	G				F				+	+	+				+			
		NN19	2,CC	G				C					+	R							
			3,CC	G	+			C										+			
			4,CC	M				C		+								R			
			5,CC	G				F						+							
			6,CC	M				F	R				+	+							
Pliocene	late	NN18	7,CC	M				C	R					F							
		NN17	8,CC	P				C	R				+	R	+	R		+			
		NN16	9,CC	M				C	+				+	R				R		+	+
			10,CC	M				C	R				+	R				R			R
			11,CC	M				C	R				+	R		+		R			R
			12,CC	M				F	+				+	R	+			+		+	+
			13,CC	M				C	R				+	R	+	+	R	R			+
	early	NN15	14,CC	M				C	R		+		+	+		+		R			R
			15,CC	M				C	R		+		+	+				R			+
			16,CC	M				C	+		+		R	R				+		+	R
			17-1, 47-48	M				C	R					F	+	+		F			+
			17-2, 47-48	M				C						+				+			+
			17-4, 47-48	M				C	R									R			+
			17,CC	M				F	+									R			+
			18-5, 47-48	M				F	R									+			
			18,CC	M		+		C	R					+				R			
			19-1, 47-48	M				F	F					+				+			
		NN14	19-2, 47-48	M			+	C	R									F			+
			19,CC	M			+	C	R					R				R	+		

Sample (interval in cm)	*D. brouweri*	*D. challengeri*	*D. intercalaris*	*D. pansus*	*D. pentaradiatus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. oceanica*	*G. parallela*
1,CC										+	+	+	F		R	R	R	R
2,CC										+		+		+	R	C	C	
3,CC											R	+		R	+	+	F	R
4,CC											+	+		R	R			
5,CC										+	+	+		R	F	C	C	
6,CC											R	R		F	F			
7,CC	+							+		R	+	R		R	F			
8,CC	+				+					+		R		F	R			
9,CC	+				+	+		+				R		F				
10,CC	R		+		+	+	+	+				R		F				
11,CC	+				R	+	R	+				R		R				
12,CC	+				+	+	+					+		R				
13,CC	+		+			+	R					R		R				
14,CC	R	+	+		+	+	+					+		R	F			
15,CC	+				+	+		+				+		R	R			
16,CC	R	+			+	+		+	+			R		F	R			
17-1, 47-48	+				R	+			+	+		+		F				
17-2, 47-48	R				R	+						R						
17-4, 47-48	+	+			R	+			+									
17,CC	+	+			+	+			+			R						
18-5, 47-48		+			+	+						+						
18,CC	+				R	R	+		+			+						
19-1, 47-48	+				R	+			+			F						
19-2, 47-48	+	+			+	+			+			R						
19,CC	F			+	R	+			+			+						

Sample (interval in cm)	*G. sinuosa*	*Hayaster perplexus*	*Helicosphaera carteri*	*H. granulata*	*H. hyalina*	*H. inversa*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*T. haimi*	*T. saxea*	*Umbilicosphaera mirabilis*
1,CC	R		R			+		+	R					+		+	+	+			+		+	+
2,CC			R			+			R	F						+	+				R		+	R
3,CC			R						F	C		+	+	R	+	+	R				R	+	+	+
4,CC									F	C		R	+	+	+	+	+	+			+	+		+
5,CC			R				+	+	R	F				+	+	+	+				+	+		R
6,CC	+		R		R		+	+	+	F				R	+	+	+	+						R
7,CC	R		F				R	R		C				F	+	+	R	+						+
8,CC			R				R	+	F	F	+			+	+			R			R			R
9,CC	R		R				R	R	R	F				R	+	+	+	+	+		R			R
10,CC			F	+			+			R	C				+	+		+	+		R			
11,CC			R				+	+	F	R	+				+	+	+	R			R			
12,CC	+		R	+			+	+		F	+				+		+	R			R			
13,CC		+	R				+			R	+				+	+	R	+	+		+			
14,CC		+	R	+				+		R	R				+	+		+	R		R			+
15,CC	R	R	+				+			R	F				+	+	+	+	+		R	+	+	R
16,CC			F	R			+			F	R				+	+		+	R	+				
17-1, 47-48			R	R			R	R		R	F				+	+	+	+	R	+				
17-2, 47-48			R	+				+		+	F				R	+		+	R	R	+			
17-4, 47-48			R	+							F				+	+		+	+	+	+			
17,CC			R	R					R		F				+	+		+	R	+				
18-5, 47-48			+	+							F				+	+		+	R	+	+			
18,CC		+	R					+			C				R			+	+	R	+			
19-1, 47-48			+	+							C					+			+					
19-2, 47-48			R	+				+			A				+		+	+			+	+		
19,CC			R	+				+		+	C				+			+	R	+	+	+		

Note: For explanation of symbols see Table 3 and text.

recognizable. According to Bukry's (1973) zonation, the LAD of *Cyclicargolithus floridanus* coincides with the FAD of *Discoaster kugleri*, which marks the boundary between NN7 (*Discoaster kugleri* Zone)/NN6 (*Discoaster exilis* Zone). *Sphenolithus heteromorphus* occurs continuously below Sample 32,CC, and Samples 32,CC to 35,CC are placed in NN5 (*Sphenolithus heteromorphus* Zone). *Helicosphaera ampliaperta* first occurs in Sample 36-2, 46–47 cm, and the first occurrence of *Sphenolithus belemnos* is recognized in Sample 38,CC. Thus Samples 36-2, 46–47 cm through 38-4, 46–47 cm and Samples 38,CC through 43-2, 46–47 cm are assigned to the early Miocene *Helicosphaera ampliaperta* Zone (NN4) and *Sphenolithus belemnos* Zone (NN3), respectively. *Triquetrorhabdulus carinatus* is present in the overlying zones, but this species occurs continuously below Sample 43-4, 46–47 cm together with *Discoaster druggii*, which identifies the early Miocene *Discoaster druggii* Zone (NN2). Samples 45-2, 44–45 cm through 45,CC contain no *Discoaster druggii;* these samples may thus be assigned to the earliest Miocene *Triquetrorhabdulus carinatus* Zone (NN1).

Paleogene (Table 8)

There is a remarkable change in species composition of calcareous nannofossils between Samples 44,CC and 45-2, 44–45 cm (Table 7). In contrast to the previous samples, sediments below Sample 45-2, 44–45 cm contain abundant *Dictyococcites bisectus* together with *Cyclicargolithus abisectus, C. floridanus, Coccolithus pelagicus, C. miopelagicus, Sphenolithus ciperoensis*, and *S. moriformis*. The marker species *Helicosphaera recta* is very rare; therefore the Neogene/Paleogene boundary (NN1/NP25) is tentatively placed between Samples 45,CC and 46-2, 46–47 cm, based on the LAD of *Sphenolithus ciperoensis*. This species is found in Samples 46-2, 46–47 cm through 49-4, 46–47 cm. *Sphenolithus distentus* occurs together with *S. ciperoensis* below Sample 49-2, 46–47 cm. Therefore the boundary between the late Oligocene *Sphenolithus ciperoensis* Zone (NP25) and *Sphenolithus distentus* Zone (NP24) is placed between Samples 48,CC and 49-2, 46–47 cm.

There is another remarkable change in species composition between Samples 49-4, 46–47 cm and 50-2, 46–47 cm. Below Sample 50-2, 46–47 cm, calcareous nannofossils are represented by abundant Eocene assemblages with relatively low species diversity. Samples 50-2, 46–47 cm through 52,CC are assigned to the late Eocene *Isthmolithus recurvus* Zone (NP19) based on the occurrences of *Isthmolithus recurvus, Discoaster barbadiensis, D. saipanensis, D. tani nodifer, Chiasmolithus oamaruensis*, and *Calcidiscus formosus*. Samples 53-1, 42–43 cm through 54-4, 46–47 cm are all placed in the *Chiasmolithus oamaruensis* Zone (NP18) based on the absence of *Isthmolithus recurvus*. The lowest three samples recovered from the bottom of this hole contain *Chiasmolithus grandis* and no *C. oamaruensis* and are placed in the *Discoaster saipanensis* Zone (NP17). The geological age of the sediments at the bottom of this hole is middle Eocene.

Samples 49,CC and 50-1, 36–37 cm contain the following species: *Calcidiscus formosus, Cyclicargolithus floridanus, C. abisectus, Discoaster barbadiensis, Helicosphaera euphratis, H. perch-nielseniae, Isthmolithus recurvus, Reticulofenestra hillae, R. umbilica, Sphenolithus distentus, S. predistentus*, and *Chiasmolithus oamaruensis*. These species constitute a mixed assemblage of the *Sphenolithus distentus* Zone (NP19) and *Isthmolithus recurvus* Zone (NP24). The *Sphenolithus predistentus* Zone (NP23) through *Sphenolithus pseudoradians* Zone (NP20) are missing; therefore, a middle Oligocene to late Eocene hiatus occurs at this site. The calcareous nannofossil mixed interval referred to earlier is attributed to this hiatus.

Hole 608A (Table 9)

Sample 1,CC is assigned to the *Emiliania huxleyi* Zone (NN21), because *Emiliania huxleyi* and gephyrocapsid specimens are dominant. Based on the presence of *Pseudoemiliania lacunosa* and the absence of discoasters, Samples 2,CC to 5,CC belong to the *Pseudoemiliania lacunosa* Zone (NN19).

In contrast to the previous hole, the Pliocene/Pleistocene boundary is sharply marked between Samples 5,CC and 6,CC. Sample 6,CC, in which *Discoaster brouweri* is found, is assigned to NN18 (*Discoaster brouweri* Zone). The occurrence of *D. pentaradiatus* together with *D. surculus* indicates NN16 (*Discoaster surculus* Zone) for Samples 7,CC to 12,CC. The abundance of *Reticulofenestra pseudoumbilica* drastically increases in Sample 13,CC, and Samples 13,CC and 14,CC belong to the *Reticulofenestra pseudoumbilica* Zone (NN15). Sample 15,CC contains *Amaurolithus tricorniculatus* and *Discoaster asymmetricus* and is assigned to the *Discoaster asymmetricus* Zone (NN14). Because of the absence of *D. asymmetricus*, Sample 16,CC may be placed in the *Ceratolithus rugosus* Zone (NN13).

Site 609

Site 609 is located on the upper-middle part of the eastern flank of the Mid-Atlantic Ridge. Four holes were drilled at this site. Continuous sequences were obtained down to the upper Miocene from Holes 609 and 609B. Holes 609A and 609C cover coring gaps in the upper Pleistocene and upper Pliocene, respectively. All sediments yielded abundant calcareous nannofossils in good to moderate states of preservation and moderate to high diversity; an almost complete sequence was recovered ranging from late Pleistocene–Holocene NN21 (*Emiliania huxleyi* Zone) to late Miocene NN11 (*Discoaster quinqueramus* Zone). Because of discontinuous occurrences of some marker species, however, the zonal boundaries were difficult to establish in the lower Pliocene.

Hole 609 (Table 10)

Samples 1-2, 43–45 cm through 2-2, 43–45 cm are assigned to the *Emiliania huxleyi* Zone (NN21). The next lower sample is at 2-5, 43–45 cm and is barren of coccoliths. Based on the absence of *Emiliania huxleyi* and *Pseudoemiliania lacunosa*, Samples 2,CC to 3-4, 43–45

Table 5. Distribution of calcareous nannofossils, Hole 607.

Age	Nannofossil zone	Sample (interval in cm)	Preservation	*Acanthoica* spp.	*Amaurolithus amplificus*	*A. delicatus*	*A. primus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus acutus*	*C. cristatus*	*C. rugosus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggreni*	*D. brouweri*	*D. challengeri*	*D. exilis*	*D. intercalaris*	*D. pansus*	*D. pentaradiatus*	*D. quinqueramus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*D. variabilis*
Quaternary	NN21	1-2, 47-48	G						F					+	+																		
		1-4, 47-48	M						F						+				+														
		1,CC	G						F					+	R	R	+		+														
		2-1, 51-52	G						R					+	+	+			+														
	NN20	2-2, 47-48	M						F					+	+		+																
		2-4, 47-48	G						F					R	+		+		R														
		2-5, 47-48	M						F					+	+				R														
	NN19	2-6, 47-48	G						F					+	+																		
		2,CC	G						R						+																		
		3-2, 47-48	G						R					+	+																		
		3-4, 47-48	M						C					R	+		+		+														
		3,CC	G	+					F						+				+														
		4-2, 47-48	M	+					C			+		+	+				R														
		4-4, 47-48	M						F					+	+																		
		4,CC	G						F										+														
		5-3, 47-48	M						F										+														
		5-4, 47-48	M						F					+	+																		
		5,CC	M	+					C						+		+		+														
		6-2, 47-48	M	+					F						+				+														
		6-3, 47-48	G						C										+														
		6-4, 47-48	M						F										+														
		6-5, 47-48	G						F					+	+				+														
		6-6, 47-48	M						F			+			+																		
		6,CC	G						F					+	R				+														
		7-2, 47-48	G						F					+	+		+		+														
		7-4, 47-48	G						R					+	+																		
		7-4, 47-48	M						F					+	F	+																	
		7-6, 47-48	G						C					+	+	+			+														
		7,CC	G						F						R		+																
		8-2, 47-48	M						F						+																		
		8-4, 47-48	G						F						R	+			+														
		8-5, 47-48	G						F	R				+	+				+														
		8-6, 47-48	G						F	F					R	+			R														
		8,CC	M						F	+				F	R	+	+		+														
		9-1, 47-48	M						C	+				+	+	+			R														
		9-2, 47-48	P						F	+				+	R		+		+														
		9-4, 47-48	P						C	+				+	R	R	+		+														
		9-6, 47-48	M						C	R				+	+		+																
Pliocene late	NN18	9,CC	M						F	R				+	+				+				+									+	
		10-2, 47-48	M						F	+					+		+						+										+
		10-4, 47-48	M						C	R			+	R	F	+	+		R				+										
		10,CC	M						C	+				+	R				R				+										
		11-2, 47-48	M						C	+				R	F		+		+				R										

Sample (interval in cm)	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Hayaster perplexus*	*Helicosphaera carteri*	*H. granulata*	*H. hyalina*	*H. inversa*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*
1-2, 47-48	+	+	+	A			C		F		+			+		+			+	R
1-4, 47-48	+	+		C		R	F		F		+	R		F		R			+	R
1,CC	+	+	+	A		C	F		R		R			R		+	+		+	+
2-1, 51-52			+	C		R	C		F		R	+		R		+	+		+	R
2-2, 47-48	+		+			R	C		F					+		+	+		+	+
2-4, 47-48	+		R			R	C		F					R		+	R		+	+
2-5, 47-48	+		+			R	F		R		+			+		+	+		+	+
2-6, 47-48	+		+		+		C		F					R		R	+		+	+
2,CC	+		+		+	R	C		F		+			+		+	+		+	+
3-2, 47-48	+		+		R	R	C		C					+			R		+	+
3-4, 47-48	R		+		C	R	F		F		R			R						R
3,CC	+	+	R		C	R	R		F		F			R		R			+	+
4-2, 47-48	+		+		F	R	+		F		R	R		+					+	R
4-4, 47-48	+		R		F	R	+		+		+	F		R		+				+
4,CC	+		R		C	F	+		R		R			R		+			+	+
5-3, 47-48	+	R	+		F	R	F		C		F	R		+						+
5-4, 47-48	+	R	R		F	F	R		F		R	R		R						R
5,CC	+	+	R		C	R	R					R		R		+				+
6-2, 47-48	+	R	+		F	F			+			F		R		+				F
6-3, 47-48	R	R	+		R	F						F		R		R			+	R
6-4, 47-48	+	+	+		F	F	+	+	+	+		F		+		+				R
6-5, 47-48	+	+	+		C	F						R		F		+			+	R
6-6, 47-48	R	F	+		F	C	R	F	R	R		R		R				R		+
6,CC	+	+	+		C	F	F	R	F	F		F		R		+		+		+
7-2, 47-48	+	+	+		F	F	C	R	F	R		R		R		+		+	+	
7-4, 47-48	+	+			F	C	F	+	F	R		F		R		+		R	+	R
7-4, 47-48		+	+		R	F	C	R	C	+		R		R		R		R	+	R
7-6, 47-48	+	R	R		R	F	C		C			R		R		+		R	R	R
7,CC		+	R		C	R	C		C					R				R	+	+
8-2, 47-48	+	+	+		R	R	C		F			F		F		+		R	+	R
8-4, 47-48	+	+	R		C	C	C		R			R		R		R		R	R	+
8-5, 47-48	+	R	R		R	F	F					R		+		+		+		+
8-6, 47-48	+		R		C	F	R							R		+		R		
8,CC	+	+	R		C	F	R					R		R		+		+	+	+
9-1, 47-48	+	R	+		R	F						F		R				R		+
9-2, 47-48	R	+	R		C	F								R		+		R	+	
9-4, 47-48	R	R	R		R	F						R		F				R	+	R
9-6, 47-48	+	R	+		R	F						R		+		+		R	+	+
9,CC	+	+	R		F	R						R				R		R	+	+
10-2, 47-48		+	+		R	R								R	+			R	+	+
10-4, 47-48		+	R		F	C								R				F		R
10,CC	+	+			F	R								R				F	+	
11-2, 47-48		R	R		R	F			R			R		F				F		

Sample (interval in cm)	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. heimi*	*T. saxea*	*Triquetrorhabdulus rugosus*	*Umbellosphaera* spp.	*Umbilicosphaera mirabilis*
1-2, 47-48					R		+	+				+			+			F
1-4, 47-48					R		+	+				+			R			R
1,CC					+		+	+	+			R			+		R	
2-1, 51-52					+		+	+	+			R			+			+
2-2, 47-48					R		R	+				+						+
2-4, 47-48					R	+	+	+				+		R	+			+
2-5, 47-48					R		+	+				R						+
2-6, 47-48	+				+		+	+				R	+		+			R
2,CC	+		+		+		+	+	+				+					
3-2, 47-48	R				+		+	+				R			+			+
3-4, 47-48	F		R		+		+	+				R			+			R
3,CC	R				+	+	+	+				+			+			R
4-2, 47-48	F		R		+	+	+	R				+			R			R
4-4, 47-48	R		R	+	+	+	+	+				+			+			R
4,CC	R		+		+	+	+	+	R			+			+		R	
5-3, 47-48	F		+	+	+	+	+	+				+						
5-4, 47-48	R		F	R	+		+					+			+			+
5,CC	R		F	R	+	+	+	+	+			+			R		R	
6-2, 47-48	F		R	+	+		+	+				R			+			R
6-3, 47-48	F		R	+	R	+	+	+				R			+			+
6-4, 47-48	R		R		+	+	+					+		+				+
6-5, 47-48	C		+		+	+	+	+	+			R						R
6-6, 47-48	C				+	+	+					+			+			R
6,CC	R		+		+		+	+	+			+		+			+	
7-2, 47-48	+				+		+	+				R			+		R	
7-4, 47-48	F				R	+	+	+				R			+			+
7-4, 47-48	R				+							+						+
7-6, 47-48	F				R	+			+			R	+					+
7,CC	R				+		+	R	+			+		+			R	
8-2, 47-48	+				+		+	+	+			+						+
8-4, 47-48	R		+		+	+	+	R	+			R	+				R	
8-5, 47-48	F				+		+					+		+				
8-6, 47-48	R				R			+				+		R			R	
8,CC	+				R		+	+	R			+	+	+			R	
9-1, 47-48	F				R	+	+	+	+			R	+					
9-2, 47-48	R				+	R	+	+	+				+				+	
9-4, 47-48	R				R		+	R	R			+		R				R
9-6, 47-48	F				R	+	+	+				+	+					+
9,CC	+				R	+	+	+	+			+	+				+	
10-2, 47-48	R	+			+	+	+	+	+						+			+
10-4, 47-48	F	+			+	+		+				F						R
10,CC	F				+		+		+			R						
11-2, 47-48	R				+		+					F						R

Pliocene	late	NN17	11-4, 47-48	M		C +	R +	+	+		+ R R F		R	+ +	R +	+ + +	R +	+
			11,CC	G		C R	R F +	+ +	+ +	+	R R F		R	R	F R	R R +	R + +	R
			12-2, 47-48	M		C R +	+ F	+ + +	+ +		+ R C	+	+ R +	+ + +	F R +	+ + + +	F +	R
		NN16	12-4, 47-48	M		F +	+ F + +	+ +	R	+	+ F		R	R	F	+ + R	R +	R
			12,CC	G		F R +	+ F	R + + +	+ R	+	R F		R R	+ R	F	+ R R	R	+
			13-2, 47-48	M		F +	+ F +	+ +	+	R +	+ R R		R	+ R	F	+ R +	F	
			13-4, 47-48	M		C R	+ F	R + +	+ R	+ + +	R R		R	+ +	R + +	+ + + +	F	R
			13,CC	M		C R +	F	R + +	R	+ + +	+ R R		R	R +	R F +	+ +	R	
			14-2, 47-48	G		F F	+ R	+ +	+	+	R R	R	R	R	+ R	+ + +	F	R
			14-4, 47-48	G		C F +	R F +	R R +	+	+ +	R F	R	R	R +	R R +	+ + +	R +	R
			14,CC	M		F R	F	R + +	+ +	+ + + + +	R R F		+ +	R + R	F	+ + +	R	
			15-2, 47-48	M		C R +	R F	R R +	+ + +	+ +	R F	R	F	R +	R	+ + + +	R +	
			15-4, 47-48	M		F F + +	+ F	R + +	+ R	R +	R F		+	R + R	R F	+ +	R	
			15,CC	M		F R +	R +	+ R R	+	+ + +	R R		R R	R + R	+ R	R + + +	F	
			16-2, 47-48	M		F R	R +	+ + +	+ +	+ + +	+ R		R	+ R	F + +	+ +	R	
			16-4, 47-48	M		F R	+ R +	+ +	R	+ +	+ R	R	R	R	R	+ + + +	R	
			16,CC	M		C + + +	R +	+ + + +	+	R + + +	+ + R		+ +	+ +	R	+ + +	R +	
			71-3, 47-48	M		F R	F +	R + + +	+ +	+ +	R R	R	R	R +	R	R + + + +	R	
			17,CC	M		C R +	+	R + +	+ +	+ + +	R R		R +	+ +	R +	+	R	
	early	NN15	18-2, 47-48	M		C R	R + R	R + +	+	+ + + +	+ F	C	R	+ +	F R	+ R + + R		
			18-4, 47-48	M		C R +	+	+ + +	+ + +	+ +	R R	F	R +	+	+ R	+ R	F	R
			18,CC	M		F F + +	F + +	R + R	+ +	+ R	R R		+ R	+	R R +	+ + +	R +	
			19-2, 47-48	M		C R +	R +	R +	+	+ +	+ R		R +	R +	R F +	+ R	R R +	R
			19-4, 47-48	M		C R		+ +	+	+	+		R R	R	F	+ +	+ F +	R
			19,CC	M		C R	R +	R	+ +	+ +	+		R	+	F	+ + R	+	
			20-2, 47-48	M	+	F F	R	R	+ +	+ + +	+		+ +	R	F	+ + +	+ +	
			20-4, 47-48	M		C F	R	+ +	+ +	+ +	R R		R R	+	F	+ R	R R +	+
			20,CC	M	+	C R +	R R	R + + +	+ + R	R	R		R R	R	F	+ + R	+ R +	
			21-2, 47-48	M		F R		R + +	+ + R	+	R		R +	+ +	F	+ + +	+ +	
			21-4, 47-48	M	+ +	C F	+ R	R	+	+	R		R R	+	F	+ +	+ R	
		NN14 to NN12	21,CC	M	+ + +	C R +	+ F	R R	R		+		F +	R	C	+ R	+ R	
			22-2, 47-48	M		C R +	+ R	R	+ +	R +	R		R +	+	C	+ R	R R +	
			22-4, 47-48	M	+ +	C F	+ F + +	F	R	+ +	R		R	+	C	+ +	R R	+ +
			22,CC	M	+	C R +	+ F +	R +	+ + R	R	R		R R		C +	+ +	+ R	
			23-2, 47-48	M	+	C F	R	R + R	+	+	R		R R	+	C	+ +	R R	
			23-4, 47-48	M	+	C R	+ F	R +	+		+		F R	R	C	+ + +	R +	
			23,CC	M	R R	C R +	F +	F + +	+ + R	+	+		R R	+	F	+ R	R R +	
			24-2, 47-48	M	+ +	C F	C +	R + R	+ + R +	+ +	R		R R	+	C	+ F	+ R + +	
			24-4, 47-48	M	+ + +	C F	+ F	F + +	+ R	+ +	R		R R	R R	C	+ + R	R	
			24,CC	M	+ +	C R	F	F R	+ +	+ R	R		R R	+	C	+ R F	R R	
			25-2, 47-48	M		C F	R C	F +	R	+ +	R		F +	R	C	R	+ R +	
			25,CC	M	+ + +	F R	F +	R +	+ + +	+ +			R	+	C	+ F	+ R	
late Miocene		NN11	26-2, 47-48	M	+	C R	F R	R +	+ R	+ + +	R		R R	R	F	+ F	R +	
			26-4, 47-48	M	+	C R	F +	R	+ + + R	+ R			R R		C	+ +	+	
			26,CC	M		F R	R +	+ +	+ + +	+ R R			R R	+	C	R R	+ +	R
			27-2, 47-48	M		F R	R +	R +	+ +	+			R +		C	+ R	R	
			27-4, 47-48	M	+	F R	F	+ +	+	+	+		R R		C	R		
			27,CC	M	+ + +	C R	R F +	+ R + +	+ R +	+ + + +			+ +		C	+	+	
			28,CC	G		C R	+ F +	R +	+ + + +	+ + +	+		R R		C	R	R	
			29-2, 57-58	M	+	F R	+ F + +	R +	+ +	+ +	+		+ R		C	+	R	
			29,CC	M	+ +	F R	+ F	R + +	+ + + +	+ R			R R		F	+ R	R +	
			30-2, 70-71	M		F +	F +	+ +	+ +	+ +	+		R R	+	C	+ + + R	+ R	
			30,CC	M		F F	R +	R +	+ + +	+ + +			R		C	R	+	

Note: See Table 3 and text for an explanation of symbols.

Table 6. Distribution of calcareous nannofossils, Hole 607A.

Age		Nannofossil zone	Sample (interval in cm)	Preservation	*Amaurolithus amplificus*	*A. delicatus*	*A. primus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus cristatus*	*C. rugosus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggreni*	*D. berggreni*	*D. challengeri*	*D. intercalaris*	*D. pansus*	*D. pentaradiatus*	*D. quinqueramus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. granulata*	*H. hyalina*	*H. intermedia*	*H. inversa*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. heimi*	*T. saxea*	*Triquetrorhabdulus rugosus*	*Umbilicosphaera mirabilis*
Quaternary		NN21	1,CC	G					F				+	F	+			+														+	+	+	F		R	R		F		+	R	+		+				R	+					+		+	+	+			R		+	+		+
		NN20	2,CC	M					R				+	+		+		+														R		+			R	C		F		+	R	+		+		+		+	+					+		+	+				+			+		R
		NN19	3,CC	G					F				+	+				+														R	+	+		R		C		R		+	+	R						+	R	R				+	+	+	R				+			+		R
			4,CC	GM					F				+	+				+														R		R		F	R	F		F		F	R	R						+	R	F		+		R		+	+				+			+		R
			5,CC	G					F					+				+														+	F	+		F	F			R		+	F	R							R	C		+	+		R	+	+				+					+
			6,CC	M					F									+														+	R	R		F	R						F	+							F	F		F	R	+	R	+	+	+			+		+			+
			8,CC	M					F				+	+	+	+																+	F	+		F	F	C	R	C	R		R	R					F		R	R				+				+			R					+
			9,CC	M					F	F	+		+	R																		+	R	+		R	F						R	F					F			F				R	+	+	+					R				+
Pliocene	late	NN18	10,CC	M					C	R			+	F	+	R		+				+										+		R		F	R						R	R		+			F	R	+	R				R	+		+	+								+
			11,CC	G					C	F			+	F	+							+								+		+		+		F								+					+	R		F				+	+	R	+	+			F		+			R
		NN17	12,CC	G					F	+			+	+			+	+				+				+						R		+		R								R					R	R		F	+			+	+	+		+			R		+			R
		NN16	13,CC	G					F	R		+	+	R		+	+	+		+		+		+		+		+						+		R								R					+	+		F	+			+	+	+		+	+		+					R
			14,CC	G					C	+			+	R	+			R	+	+		+		+		+		+						+		+								+					+	+		R					+			+			R					
			15,CC	G					C	R			+	F					+	+		+		+		+		+	+		+			+		R								R					+	+		F				+	+		+	+			+		+			
			16,CC	G					F	+				+				+		+		+				+		+	+	+				+		+								+					+	+		+	+				+	+		+			+					
			17,CC	M					F	F		+		R				R		+		+		+		+		+	+			+		+		+								R	+				+	+		+	+				+	+		+			R					
			18,CC	M					F	R				R	+			+		+		R	+	+		+		+	+		+			+		R								+	+				+	+		R	+				+	+		+	+		R					
	early	NN15	19,CC	M					F	F		+		R	+	+	+	R		+		+				+		+	+					+										R					+	+		R	R				+	+		+	+		R	+				
			20,CC	M					C	R		+		R				+		R		+				+		+	+					+										R	R							F	F					+		+	R							
Miocene	late	NN11	21-2, 47–48	M			+	+	C	R				F		+		R				+				+	+	+			+			R										R	+								C								R						+	
			21,CC	M		+	+	+	C	F				F				R				+	+		+	R	+	+			+														+								C				R				R	R						
			22-2, 47–48	M					F	+				F				R				+	+			+		+			+			+										R	R								C				R			+	R	+					+	
			22-4, 47–48	M					F	R			+	F	+	+		+				+			+	+	+				+														R								F								R	+						
			22,CC	M		+			F	R				F				R				+		+		+	+	+			+			R										+	R		+						C				+				+	+						
			23-2, 47–48	M					F	R				R				R				+	+		+	R	+				+													R	+								C								+							
			23,CC	P	+		+		F	+				F	+			R			+					R					+			+										+	R								F								R	+						
			24-2, 47–48	M					F	R				R	+	+		+				+	+		+	+	+				+													R	+								F					+			+	+		+				
			24-5, 47–48	M				+	C	R					+			+			+	+				+	+				+			R										R	R								C			+				+	+	R						
			24,CC	M					F	F				F				R								+	+				+													+	R								C							+	F	+						
			25-2, 47–48	M			+		F	F								+				+			+	+	+	+			+													R	R		+						+					+		+	F						+	
			25-4, 47–48	M				+	F	F			+	R		+		+			+	+			+	+	+																	+	+								C								R	R					+	
			25,CC	M		+			F	F				F	+			+	+	+	+	+				R	R			R	+													R	R								C							+	R	R		+				
			26-2, 47–48	M			+	+	F	F		+	+	R				+				+			+	+	+				+			+										+	+								A								+			+				
			26,CC	M	+	+		+	F	F				+				+	R				+	+	+	+	+	+			+													+	+								+								+			+			+	

Note: For an explanation of symbols, see Table 3 and text.

cm are placed in NN20 (*Gephyrocapsa oceanica* Zone). *Helicosphaera inversa* occurs in the lower part of this zone. Samples 3,CC through 15-2, 43–45 cm contain abundant *Pseudoemiliania lacunosa* and no discoasters, which places this interval in NN19 (*Pseudoemiliania lacunosa* Zone). *Helicosphaera inversa* is also found in the uppermost part of this zone. Among these samples, Samples 6,CC down to 9-2, 43–45 cm contain fairly abundant *Reticulofenestra* sp. A. *Gephyrocapsa parallela* is found only in and above Sample 6-4, 43–45 cm. Comparatively large *Gephyrocapsa* are concentrated in the middle of this zone. *Helicosphaera sellii* and *Calcidiscus macintyrei* are found as high as Samples 9-4, 43–45 cm and 12,CC, respectively. The interval below Sample 12,CC contains no *Gephyrocapsa oceanica* and samples below 13-4, 43–45 cm only yield *Gephyrocapsa aperta* and *G. sinuosa*.

The Pliocene/Pleistocene boundary is placed between Samples 15-2, 43–45 cm and 15-4, 43–45 cm. As at the previous sites, the nannoflora changes progressively below this boundary with an increasing abundance of discoasters. The assemblage in Samples 15-4, 43–45 cm through 19,CC is characterized by the occurrence of *Discoaster brouweri;* this assemblage places these samples in the late Pliocene *Discoaster brouweri* Zone (NN18). The presence of *D. brouweri* and *D. pentaradiatus* in Samples 20-1, 43–45 cm and 20-4, 43–45 cm places these samples in NN17 (*Discoaster pentaradiatus* Zone). Samples 20,CC through 26,CC contain comparatively diversified discoaster species such as *Discoaster brouweri, D. pentaradiatus, D. surculus*, and *D. asymmetricus*. Therefore these samples are assigned to the late Pliocene *Discoaster surculus* Zone (NN16). In this zone, *Discoaster tamalis* is recognized in Samples 24-1, 43–45 cm through 25,CC. *Reticulofenestra pseudoumbilica* occurs sporadically throughout NN16. This species, however, is first found abundantly in Sample 27-2, 43–45 cm, and thus this sample marks the top of the early Pliocene *Reticulofenestra pseudoumbilica* Zone (NN15). *Sphenolithus abies* occurs in Sample 26,CC, slightly above the NN16/NN15 boundary. Samples 28,CC through 32,CC contain *Amaurolithus tricorniculatus* and *Discoaster asymmetricus* and are assigned to NN14 (*Discoaster asymmetricus* Zone). The distinction between NN13 (*Ceratolithus rugosus* Zone) and NN12 (*Amaurolithus tricorniculatus* Zone) is uncertain. Sample 35,CC down to the bottom of this hole is assigned to the late Miocene *Discoaster quinqueramus* Zone (NN11) because of the presence of the nominate species, *D. quinqueramus*.

Hole 609A (Table 11)

In this hole only two core-catcher samples were examined. These samples contain abundant *Pseudoemiliania lacunosa*. As a single specimen of *Discoaster brouweri* in Sample 1,CC is regarded as reworked, these samples are assigned to the Pleistocene *Pseudoemiliania lacunosa* Zone (NN19). In these samples, *Calcidiscus macintyrei* and *Helicosphaera sellii* were not found.

Hole 609B (Table 12)

Nannofossil assemblages in this hole are similar to those in Hole 609. The abundant occurrence of *Emiliania huxleyi* suggests that Samples 1,CC and 2,CC can be correlated with NN21 (*Emiliania huxleyi* Zone). Sample 3,CC is placed in NN20 (*Gephyrocapsa oceanica* Zone) because *Emiliania huxleyi* and *Pseudoemiliania lacunosa* are absent. Samples 4,CC through 15,CC belong to NN19 (*Pseudoemiliania lacunosa* Zone) because of the presence of *Pseudoemiliania lacunosa* and the absence of discoasters. *Helicosphaera sellii* and *Calcidiscus macintyrei* are found only in the lower part of this zone. Comparatively large specimens of *Gephyrocapsa caribbeanica* and *G. oceanica* occur in the middle of this zone. *G. parallela* occurs above Sample 5,CC.

Cores 16 and 17 are assigned to the latest Pliocene *Discoaster brouweri* Zone (NN18). *Discoaster brouweri* is present throughout, and *D. triradiatus* is found in Sample 16,CC. From sample 19,CC on down to Sample 27,CC, the *Discoaster surculus* Zone (NN16) is represented by an assemblage rich in asteroliths, including *Discoaster brouweri, D. pentaradiatus, D. surculus*, as well as *D. challengeri*. *Discoaster asymmetricus* is present throughout this zone. *Discoaster tamalis* occurs in Samples 24,CC and 25,CC. *Reticulofenestra pseudoumbilica* is continuously found below Sample 21,CC. The abundance of this species, however, increases drastically in Sample 28,CC. We interpret this as the top of the acme of this species and designate it as the top of the *Reticulofenestra pseudoumbilica* Zone (NN15). The NN14 (*Discoaster asymmetricus* Zone)/NN13 (*Ceratolithus rugosus* Zone) boundary is placed between Samples 32,CC and 33,CC based on the lowest occurrence of *Discoaster asymmetricus* in Sample 32,CC. From Sample 35,CC on down to the bottom of this hole the *Discoaster quinqueramus* Zone (NN11) seems to be represented, although typical *Discoaster quinqueramus* is still rare at this level. Because ceratoliths are rare, the NN15/NN14 and NN13/NN12 boundaries are not clear in this hole.

Hole 609C (Table 13)

Sample 1,CC contains abundant *Pseudoemiliania lacunosa* and no discoasters, which places this sample in NN19 (*Pseudoemiliania lacunosa* Zone). The sample also contains *Calcidiscus macintyrei, Helicosphaera sellii*, and no gephyrocapsids; therefore it is assigned to the earliest Pleistocene. The assemblage in Samples 2,CC and 4,CC is characterized by the occurrences of *Calcidiscus leptoporus, Coccolithus pelagicus, Emiliania ovata, Helicosphaera carteri, H. sellii, Pseudoemiliania lacunosa*, and *Syracosphaera pulchra* together with *Discoaster brouweri*. This assemblage places these samples in the late Pliocene *Discoaster brouweri* Zone (NN18), and the Pliocene/Pleistocene boundary is placed between Samples 1,CC and 2,CC. The co-occurrence of *Discoaster brouweri* and *D. pentaradiatus* in Sample 5,CC places that sample in NN17 (*Discoaster pentaradiatus* Zone). Samples 6,CC and 7,CC contain comparatively diversified discoaster species such as *Discoaster asymmetricus, D. brouweri, D. pentaradiatus, D. surculus*, and *D. variabilis* and they are assigned to the late Pliocene *Discoaster surculus* Zone (NN16). A few specimens of *Reticulofenestra pseudoumbilica* were recognized in these samples.

Table 7. Distribution of Neogene calcareous nannofossils, Hole 608.

Age	Nannofossil zone	Sample (interval in cm)	Preservation	*Amaurolithus delicatus*	*A. primus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Catinaster coalitus*	*Ceratolithus rugosus*	*Chiasmolithus altus*	*Coccolithus crassipons*	*C. miopelagicus*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Cyclicargolithus abisectus*	*C. floridanus*	*Dictyococcites bisectus*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggreni*	*D. brouweri*	*D. challengeri*	*D. deflandrei*	*D. druggii*	*D. exilis*	*D. hamatus*	*D. intercalaris*	*D. kugleri*	*D. loeblichi*	*D. neohamatus*	*D. pansus*	*D. pentaradiatus*	*D. quinqueramus*	*D. surculus*	*D. tamalis*	*D. triradiatus*
Quaternary	NN21	1-2, 46–47	M				C					R		R		+																								
		1-4, 46–47	M				F					+		+	+			+																						
	NN20	1-5, 46–47	G				C					+		+																										
		1,CC	M				F					+						+																						
		2-2, 46–47	M				F					+		+																										
	NN19	2-3, 46–47	M				F							+																										
		2-4, 46–47	M				F																																	
		2,CC	M				C					+		+																										
		3-1, 46–47	M				C					+		R		+																								
		3-2, 46–47	M				F																																	
		3-4, 46–47	M				C																																	
		3-5, 46–47	M				C																																	
		3-6, 46–47	M				C							+		+																								
		3,CC	M				C					+		+																										
		4-2, 46–47	M				F					+		R	+																									
		4-3, 46–47	M				F					+		R																										
		4-4, 46–47	P				C	+				+		+		+		+																						
		4-5, 46–47	M				C					R		+																										
		4-6, 46–47	M				F	R				+		R																										
		4,CC	P				F	R						R				+																						
		5-2, 46–47	M				C	R				+		C	+	+																								
		5-4, 46–47	M				C	R						R																										
Pliocene late	NN18	5-5, 46–47	M				C	+				F		+	+										R															
		5-6, 46–47	G				C	+				+		F	R										R															+
	NN16	5,CC	M				C	R				+		F		+		+							R											+		+		+
	NN19 ?	6-2, 46–47	M				C	+				+		F	+										+															
		6-4, 46–47	M				C	R		+		+		R	+	+		R					+		+						+					+				
		6,CC	M				C	R				R		F		+		+					+		+						+					+		+		+
		7-2, 46–47	M				C	R				R		F	+	R	+								+															
		7-4, 46–47	M				C	R				+		F		+																								
		7,CC	M				F	R				+		R	+																									
	NN16	8-2, 46–47	M				C	+				+		R		+		R							+						+					+		+		
		8-4, 46–47	M				F	+				+		F		+		+					+													+		+		
		8,CC	M				C	R				+		R	+										+											+				
		9-2, 46–47	M				C	R				R		R		+		R					+								+					R		+		
		9-4, 46–47	P				C	+				R		R		+																				+		R		
		9,CC	G				C	R				+		F	+			+					+		+						+					+		+		
		10-2, 46–47	M				C	R				+		R				R					+		R						+					+		+		
		10-4, 46–47	M				C	R				+		F				R					+		+											R		+	+	
		10,CC	M				C	R				+		F	+			R					+		+											+		+	+	
		11-2, 46–47	M				C	R				R		F				+					+		+						+					+		+	+	
		11-4, 46–47	M				C	+				+		F				R							+													+	+	
		11,CC	M				C	R		+				R				+					+		+											+		+	+	
		12-2, 46–47	M				C	R						R				R																				+		
		12-4, 46–47	M				C	R				+		R				R					R		+											+		+	+	
Pliocene early	NN15	12,CC	M				C	+		+		+		R				+				+	R		+													+	+	+
		13-2, 46–47	M	+	+		C	R		R				F				R					+			+					+					+		+		
		13-4, 46–47	M	+			C	R						R				R							+						R					+		+		
		13,CC	M	+			C	R		+				R			+	F				+	+		+											+		R		
	NN14	14-2, 46–47	M		+	+	C	F				+		F				+																		+				
		14-4, 46–47	P				C	R				+		R				+				+	+		+											+		+		
		14,CC	P	+		+	C	F						R				R				R	+		+						+					R		R		+
		15-3, 46–47	P		+		C	R						F				R				+									+					+		+		
		15-5, 46–47	M		+		C	+				+		F				R					+															+		
	NN13 to NN12	15,CC	M			+	C	F						C			C	+													+									
		16-2, 46–47	M				C	F						C			+	R													+					+				
		16-4, 46–47	M		+		F	F						C			R	F											+											
		16,CC	M				F	R						C			+	+				+							+		+					+		+		
		17-3, 46–47	M		+		F	F				R		F	R			R													+									
Miocene late	NN11	17,CC	M	+		+	F	F						C			+							+	+	+					+					+	+	+		
		18-2, 46–47	M				F	F						C				+						+							+									
		18-4, 46–47	P			+	F	F						C			+	R							+	+							+		+	+	+	+		
		18,CC	M				C	F						C			+	+				+			+	+					+			+	+	R	+	+		
		19-2, 46–47	P				C	F				+		C			+	R						+		+									+	+	+			
		19-4, 46–47	P				C	F				R		A			+	R							R	+							+		+			R		
		19,CC	M				C	F						A	+			R							R		+						R	+	+	+	+			
		20-2, 46–47	M				C	F						A			+	+							+		+						+					+		
		20-4, 46–47	P				C	R						A				R							+											+				
		20,CC	M				C	F						A				R				+		+	+	+					+				+		+			
		21-2, 46–47	M				C	R	+					A		+	+	+							+	+							R			+	+	+		
		21-4, 46–47	M				C	R						A	R		+	+							R	+									+		+			
		21,CC	M				C	R						A	R		+	+							R									+	+					

Note: For an explanation of symbols, see Table 3 and text.

Table 7 (continued).

D. variabilis	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Helicosphaera ampliaperta*	*H. carteri*	*H. euphratis*	*H. granulata*	*H. hyalina*	*H. intermedia*	*H. inversa*	*H. perch-nielseniae*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*R.* sp. C	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. belemnos*	*S.* cf. *ciperoensis*	*S. conicus*	*S. delphix*	*S. dissimilis*	*S. heteromorphus*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. heimi*	*T. saxea*	*Triquetrorhabdulus carinatus*	*T. rugosus*	*Umbilicosphaera mirabilis*	*Zygrhablithus bijugatus*
	+			C			C		F		+			R									+						+												R						+	
			R	A		F	F		F		+			R					R			R	+						R		+	+	+								R			+				
			+			R	F		R			R		+									+						+			+									+							
	+		+			F	C		F					+					+				R						R	+	R	+									+						+	
						R	C		F					+					+				R						R		R																R	
			R		+		C		F					R					+				R	R					+		R										+							
	+	+	+		R	R	C		F					+									+	R					R																		+	
			+		F	F	R		R		R	F		R			+						F	R					+			+	+								R						+	
		+	R		F				+		R			R			+						R	C					+		+	+									+						+	
	+	+	+		C	F						F		R									R	R		F	R		+			+									+							
	+		+		C	R	+					F		F								+	F	R		F	+		R		R	R															+	
	R		+		R	R								R									R	F		F	+		R		+										+			+			+	
	R	+	+		F	F	R	F	R	F				R							R		F	C					R			+									R							
	+	+	+		F	F	F	+	F	+		F		R							+		R	F					+		+		+										+				+	
		+	R		F	F	C	+	C	+		R		R							R	R		R					+												+							
	R		R		R	F	C		C					+							+		R	F					+			+															+	
		+	R		R	R	R					R		R							+		R	+					+		+		+								R						+	
	+	+	+		R	R	C		+			R		R							R	+		F					R		+	+									R						+	
	R		R		R	F						R		R							R		+	F					+												+						R	
	+		+		R	R						R		R							+		R	R					R		+	+															R	
	+		R		R	R						R		F							+	+		C					+	+		+																
	+	R	+		R	R						R		R							R	+		F					R	+	+	+									+						+	
	R		R		R	F								R							F			F					R	+		+																
	+		+		R	R								F							R			F					R	+	+	+	+															
	+		+		R	R								+							R	+		R					R	+	+																	
			+		F	R								R							+		F	F					+		+	+	+								F						+	
			R		R									+		+					R		R	R						+	+										F							
			R		C									R							+		F	F					+		R										F							
			R		R	R								R							R	+	F	R	+				+	+	+		+	+							C							
			R		F									R							R		F	F																	F							
	+		+		R									R							+		R	C	C				+		+		+								F							
	+		+		R	R						R		R		+					+		F	R	+					+	R		+							+	F						R	
			R		F									R							+		F	R	R						+	+	+								F							
			R											R							R	+		R									+								R	+						
			+		F									R		+					+		R	R	R					+	+		+								F							
			R		F									+		+					+	+		F						+	R		+								+							
			+		R									F		R					+	+		F									+								F	+						
+			+		R									R		R					R		R	R	R					R	+		+								F							
			R											+							+			R	+						+		+								R							
			R		R									R		R					+	+	+	R							+	+	+								F	+					R	
			R											+		+					+			R						R		+	+								F							
+			+		F		R							R		R					+			F	R					+			+								R							
			+		R									R		R						+		+							+		+								R							
			+		R									+		+					R			+						R	+		+								+							
			+		R		R							R		R					R		R	+						+	+	R	+								R							
R			+		R									+		+					R								+				+								R						R	
+			+		R									R		R								+	F					+		+	+	R						+	R		+					
R			+											R		R								+	F					R	+	+	+	R							R							
			R											R		R						+			F				R		+	+	+	+							R							
+			+											R		R									F									R						R								
R			+											+		R									C									R						R	R							
R														R		R						+			C									+						+								
+																+									C									R															
+			+													+						R			C									R						+								
R			R																						C									+						R								
+																R									A									+						+				+				
+			R											+		+									A									R						R								
+																									A																							
R																F									C									R						+								
+																R									C									R						R						+		
R																+									C									+						+								
R														+		+									F									R												+		
R														+	+	+									F									F						+						+		
R																R									C									+						+						+		
R																+									F									R												+		
+																R									R									+						R						+		
R															+	F		+							F									R												+		
+																F									F									F						+					+	+		
F														+	+	F		+							R					+				R						R								
R														+		F									F									F												+		
+														+		R									F									R						R						+		
+																R									R									R						+								

Table 7 (continued).

Age		Nanno-fossil zone	Sample (interval in cm)	Preservation	*Amaurolithus delicatus*	*A. primus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Catinaster coalitus*	*Ceratolithus rugosus*	*Chiasmolithus altus*	*Coccolithus crassipons*	*C. miopelagicus*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Cyclicargolithus abisectus*	*C. floridanus*	*Dictyococcites bisectus*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggreni*	*D. brouweri*	*D. challengeri*	*D. deflandrei*	*D. druggii*	*D. exilis*	*D. hamatus*	*D. intercalaris*	*D. kugleri*	*D. loeblichi*	*D. neohamatus*	*D. pansus*	*D. pentaradiatus*	*D. quinqueramus*	*D. surculus*	*D. tamalis*	*D. triradiatus*
Miocene	late	NN11	22-2, 46-47	M				F	F						A				R							R	+								+	+					
			22-4, 46-47	M				R	F						C				R		+					+										R		+			
			22,CC	M				F	R						C				+							+	+			+					+			+			
	middle	NN9	23-2, 46-47	M				C	F						C				+											+	R										
			23-4, 46-47	P				C	F						C				+												+				+						
			23,CC	M				F	F	+					F			+									+			+	+										
			24-2, 46-47	M				F	C						C				R											+											
			24-4, 46-47	M				C	F						C				R											+	+				+						
			24,CC	M				F	F				R		C								+				+			R	+	+									
		NN8 to NN7	25-2, 46-47	M				R	F						C				R									+													
			25-4, 46-47	P				C	F						C	R		R	R																						
			25,CC	M					R						A				+								+														
			26-2, 46-47	G				F	R						C																										
			26-3, 46-47	G				F	R						C				R																						
			26-4, 46-47	G				+	F					R	C				R											+											
			26,CC	M				R	F					R	C				+																						
			27-2, 46-47	G				F	R					+	F																										
			27-4, 46-47	M				R	R					+	F			+	R																						
			27,CC	M				R	R					R	C				+				+						+	R			+								
			28-2, 46-47	M				F	R					+	F				R				+							+		+									
		NN6	28-4, 36-37	M				C	R					+	C				R		R					+															
			28-5, 46-47	M				R	R					R	C	+			R		+					+				+											
			28-6, 46-47	M				F	R					+	C			+	R		+									+											
			28,CC	M				R	R					R	C				+		+		+					+		+		+			+						
			29-2, 46-47	M				R	R					R	F				R		F											R									
			29-4, 46-47	M				F	R					R	C				R		+																				
			29,CC	M				F	+					R	C				R		+		+					+													
			30-2, 46-47	M				F						R	C			+	R		+									R											
			30-4, 46-47	M				C	R					R	C	+		+	R		+							+													
			30,CC	M				F	R					R	C				R		R		+					+		+											
			31-2, 46-47	M				R						R	C	+			R		C																				
			31-4, 46-47	M				+						R	C	+		+	+		C		+					R													
			31,CC	P				F	R					R	F			R	R		R							+		+											
			32-2, 46-47	P				F	+					R	C				+		+									R											
			32-4, 26-27	M				F	R					R	C			+	R		+							+	+	+											
			32-5, 26-27	M				F						+	C	R			F		F									R											
		NN5	32,CC	M					R				+	+	A	+	+	+	R		+		+					+	+	+											
			33-2, 46-47	M				F	R					R	A	+		+	+		R									+											
			33,CC	M				F	R					R	A						F							+	R	R											
			34-2, 46-47	P				F							A				+		F							R		R											
			34-4, 46-47	M				C	+					F	C				F		F																				
			34,CC	M				F						R	A			+	R		F							+	+	+											
			35-2, 46-47	M				F	+					R	A				R		F		R							F											
			35-4, 46-47	M				R	+					R	A			R	+		F							+		+											
			35,CC	M				F						F	A			R	R		C		+					R	+	+											
	early	NN4	36-2, 46-47	M				R	R					F	A				R		F							R		R											
			36-4, 46-47	M				F	F					+	C			+	F		F							+													
			36,CC	M					+					R	C				+		C							F	+	+											
			37-2, 46-47	M				R						F	C				+		C							F													
			37-4, 46-47	M				F							C			R			R							R													
			37,CC	P				F					+	+	A			+	+		R							R	+												
			38-2, 46-47	P				F	R					+	A			R		F	F							F													
			38-2, 83-84	P				F						R	C			R		R	R							F	R												
			38-4, 46-47	P				R						+	A			R		+	C							+													
		NN3	38,CC	P										R	C			+		F	C		+					F	+												
			39-3, 46-47	P				R					R	+	A			F		R	C							F	R												
			39,CC	P				F	F					+	C			+		R	R		+					+	+												
			40-2, 46-47	P										R	C				+	R	R		+					R	+												
			40-4, 46-47	P				F					+		C			+		R	C							R													
			40,CC	P				R	R				+		C					+	F		+					R	R												
			41-2, 47-48	M				F						+	A					F	C							R	R												
			41-4, 47-48	M										+	C					C	A							F													
			41,CC	M				R						R	C					R	A		R					F	R												
			42-2, 47-48	M				F						R	C					R	C							R													
			42-2, 47-48	M				F							C					F	A							R													
			42,CC	M				R						C				+		F	A							F	+												
			43-2, 46-47	M				F													A							F	R												
		NN2	43-4, 46-47	M				R						R	C					F	A							R	+												
			43,CC	M										R	A						A							+	R												
			44-3, 84-85	M										R	C			+			A							+	R												
			44,CC	M				R						R	C			+		+	A							+	R												
		NN1	45-2, 44-45	M										R	C			+		F	A	F						F													
			45-4, 44-45	M										+	C			+		F	A	+						R													
			45,CC	M								+		+	C			+		R	A	F						+													

Table 7 (continued).

D. variabilis	Discolithina japonica	D. cf. japonica	D. spp.	Emiliania huxleyi	E. ovata	Gephyrocapsa aperta	G. caribbeanica	G. caribbeanica (large)	G. oceanica	G. oceanica (large)	G. parallela	G. sinuosa	Helicosphaera ampliaperta	H. carteri	H. euphratis	H. granulata	H. hyalina	H. intermedia	H. inversa	H. perch-nielseniae	H. sellii	H. wallichii	Oolithotus antillarum	Pseudoemiliania lacunosa	Reticulofenestra pseudoumbilica	R. sp. A	R. sp. B	R. sp. C	Rhabdosphaera clavigera	R. longistylis	R. stylifera	Scapholithus fossilis	Scyphosphaera spp.	Sphenolithus abies	S. belemnos	S. cf. ciperoensis	S. conicus	S. delphix	S. dissimilis	S. heteromorphus	S. moriformis	Sycracosphaera pulchra	Thoracosphaera deflandrei	T. heimi	T. saxea	Triquetrorhabdulus carinatus	T. rugosus	Umbilicosphaera mirabilis	Zygrhablithus bijugatus
+																R									F									+													+		
+			+													R									R									+							R							+		
+																+		+							F					+				F							+									
+			+											+		+									R					+				F							+									
+																R									R					+				F							R									
R														+		+									R					+				F							F						+			
F														+		F									F					+				R							R									
R																R									R					+				+							+									
+			+													R									F					+				F							R							+		
+														R	R	+									F								+	F							F									
																R									R																R									
+																+									F									F							+							+		
+																R									F									R							F									
																F									C									F							R									
+																									F									R							+									
+																									+									R							+					+	+		
R																									F																									
+															+	R									F									F													+		
+														+		R									C								+	R							+						+	+		
+														R		R									C									R							+									
R														R	R	R									F									F							+							+		
R																+									C									F							R							+		
														+	+	F									F									F							R							R		
+														F	+	R									F									R							+							+		
+														R	+	R									C									+							+							+		
R															+	R									C									F																
+															+	F		+							C									F							+						+	+		
R														R	R	R									F									R							R									
F														R	R	F									F								+	R							R									
+																+									+									R							+						+	+		
R														R		+									F									R							F									
+														+	+	R									C									R							+									
R														R	+	F									F					+				F							+									
															F	R		R							F					+				R							R									
R														R	R	R									C									F							R									
R														+	+	R									F									+							+									
+														R	+	R									C									F						R	R									
+														R	+	+			+						C									R						F	R	+							
+															+	+									F									R						F	+								
R			R													R									C									F						+	+								
F															R	F									R									R						R	+								
R			+											+	+	F									R															F	R								
R															R	R									R									F						R									
R														R	R	F									R									R						R	F								
R															+	+									F									F						R	R								
F													R		R	R									F									F						F	R								
R															R	R									F									R						F	F								
F													+		+	+									+									R						F	+					+	+		
+													+		R	F									F									F						F	F								
+													+		+	R									R														R	R	R		+						
+													+	+	R	+									C									F						R	F								
													+		+	F									C															R	R								
														R	+			R							C									R					+	R	R								
+														+	+	+									F									F							F									
															R	+									+									F	F				R		R						+			
													R												C									F	R						R									
													+	+											C									+	+				+		R						+			
+													+		+	+									R									R					+		+									
															+																			R	+						+									
+																												R						F	+					+									
																												+											+		R									
R																																							R		+									
																R																							F		+									
																+																							R		R									
														R														+											+		R						+			
R															R													F											+		F									
R														+	+	R												F						R							F									
															R													R													F						+			
																F																							+		R						R			
															R																										F						R			
															R													R													R						+			
															R			+		+								+									+	+	F		R									+
															+			+		+								R									R		C		R									+
															+					R								F								+			C		F						+			+

Table 8. Distribution of Paleogene calcareous nannofossils, Hole 608.

Age	Nannofossil zone	Sample (interval in cm)	Preservation	*Braarudosphaera bigelowii*	*Calcidiscus formosus*	*Chiasmolithus altus*	*C. grandis*	*C. oamaruensis*	*Coccolithus eopelagicus*	*C. miopelagicus*	*C. pelagicus*	*Coronocyclus nitescens*	*C.* sp.	*Cruciplacolithus* spp.	*Cyclicargolithus abisectus*	*C. floridanus*	*Dictyococcites bisectus*	*Discoaster barbadiensis*	*D. binodosus*	*D. deflandrei*	*D. saipanensis*	*D. tani*	*D. tani nodifer*	*Discolithina* spp.	*Helicosphaera compacta*	*H. euphratis*	*H. intermedia*	*H. obliqua*	*H. perch-nielseniae*	*H. recta*	*Isthmolithus recurvus*	*Reticulofenestra dictyoda*	*R. hillae*	*R. reticulata*	*R. umbilica*	*R.* sp. C	*Rhabdosphaera* sp.	*Sphenolithus ciperoensis*	*S. dissimilis*	*S. distentus*	*S. moriformis*	*S. predistentus*	*S. radians*	*Thoracosphaera heimi*	*Triquetrorhabdulus carinatus*	*Zygrhablithus bijugatus*
late Oligocene	NP25	46-2, 46–47	M							+	C	R			F	A	R									F	R	R	R							R		R	R		R				+	R
		46-4, 27–28	M							R	C	R			F	A	F			F						R			R							R		R	F		F					
		46,CC	M							R	C	C			F	A	F			R				R					R							F		R	F		R					+
		48-2, 46–47	M						+		C				C	A	F			R				+		+			R							R		R	F		R					R
		48-4, 46–47	M			R			R	R	C				C	A	F			R						+			R							R		F	F		F					F
		48,CC	M						R		C	+			C	C	F			R				R		+				+						F		+	F		R					R
	NP24	49-2, 46–47	M			+			R		C				C	C	F			F				R	R	+				+						F		R	R	R	R	R	R			R
		49-2, 85	M						+		C				C	A	C			R		+				R			+	R						F		+	F	+	R	R				R
		49-3, 63	M						+		C				F	A	C			+		+				R			R		R					F			R	+	R	+				
		49-4, 46–47	M			+			R		C				C	A	F			+		+			+				R	+	R					R		+			R	+		R		
?	Mixed	49,CC	M		+			R	R		C				R	A	C	+		+		+			+	R			+		R	F	R		R	R				+	+	F				
		50-1, 36–37	M					+	R		C		R		F	A	F			R		+		+	R	+			R		R	R	R		R	F				+	R	F				R
middle–late Oligocene	NP19	50-2, 46–47	M		F			R	F		C					F	A	R			R	F									F	F	R		F	F								R		R
		50,CC	M		F				F		C		+			C	A	R			F	R	R		+						F	C	+	+	F	F					+			+		F
		51,CC	M		R				F		C					C	C	+		R	R	R	+		+						R	F	R	+	F	F					R					F
		52-2, 57–58	M		F			R	R		C					F	C	R			F	R			R						R	F	R	F	F						R			R		F
		52-4, 69–70	M		F			+	F		C					C	C	R			F										+	F	R	C	+	F					+			R		F
		52,CC	M		F			+	F		C					C	C	R			F										+	F	R	C	+	F					+			R		F
	NP18	53-1, 42–43	M		F			R	F		C		+			C	F	+			F		+		R							C	R	C	C						F		+	R		F
		53-2, 63–64	M		F			R	F		C					C	F	F			R	R	+		+							C	R	A	F						+			R		F
		53,CC	M		F		+	R	F		C					F	F	R			R	R	+	R								C	F	C	F						R			R		F
		54-2, 46–47	M		C		+	+	F		C					F	C	+	R		F	R			R							C	F	C	F									+		F
		54-4, 46–47	M		F			+	F		C		+			F	C	R			R	+			+							C	F	C	F		+							+		F
	NP17	55,CC	M	R	C		+		R		F					C	C	R	+		F		+		+							F	R	C	R						R			R		R
		56,CC	M		F		+		F		C					C	C	F	R		F	+	R									F	R	C	C						R		R	+		+
		57-3, 69–70	M		F		R		F		C			+		C	C	F	R		R				+							C	F	C	C											+
		57-3, 99–100	M		+						+					+	+															+		+	+											

Note: For an explanation of symbols, see Table 3 and text.

Table 9. Distribution of calcareous nannofossils, Hole 608A.

Age		Nannofossil zone	Sample	Preservation	*Amaurolithus delicatus*	*A. primus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus cristatus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Cyclolithella annula*	*Discoaster adamanteus*	*D. asymmetricus*	*D. brouweri*	*D. challengeri*
Quat.		NN21	1,CC	G					F		R	R	+		+				
		NN19	2,CC	G				F			+	R							
			3,CC	M				F											
			4,CC	G				F			+	R							
			5,CC	M				F	R			F							
Pliocene	late	NN18	6,CC	M				F	R		+	R	+					+	
		NN16	7,CC	M				C	F	+	R	F			R	+		+	
			8,CC	M				C	R			R			+			+	
			9,CC	M				F	+		+	R			R		R	+	
			10,CC	M				C	F			F				+	+	+	
			11,CC	M				C	F			F		+			+	R	
			12,CC	M				F	R			+			+		+	+	
	early	NN15	13,CC	M				C	R			R	+		F	+	+	+	
			14,CC	M				C	R			F			R	+	+	+	+
		NN14	15,CC	M	+	+	+	C	F			R			F		+	+	
		NN13	16,CC	M	R	R		C	R			R			R			+	+

Sample	*D. intercalaris*	*D. pentaradiatus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. oceanica*	*G. parallela*
1,CC									+	C		R	C	F	R
2,CC							R		+		+		C	F	
3,CC								+	+		F	F	F	R	R
4,CC									+		R	F	C	C	
5,CC							R		R		R	R			
6,CC									R		F				
7,CC		+	+	+					R						
8,CC	+	+	+						R		+				
9,CC	+	R	+	+	+				+						
10,CC		R	+	+					R		R				
11,CC	+	+	+	+		+			+						
12,CC		+	+	+		+			+		+				
13,CC		+	+	+	+				+						
14,CC		+	+			R			+						
15,CC	+	R	+			+			+						
16,CC		+	+		+	+									

Sample	*G. sinuosa*	*Helicosphaera carteri*	*H. granulata*	*H. hyalina*	*H. inversa*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera saxea*
1,CC		+			+	+		+					+							R	+
2,CC		R				R		R	+				+	+	+					+	
3,CC	R					+	+	+	F		R	+	+								
4,CC	F	R		R			+	+	C				R	+	R						
5,CC	R	R							F				R	R	+	+					
6,CC		+		R					F				+	R						+	
7,CC		+				+			R	R			+		+		+			R	
8,CC		+				R			F					+	+		+			F	
9,CC		R				R			R					R	+		+			R	
10,CC		+	+			+	+		R					+	R		+			F	
11,CC		R	+			R	+		R					R	+		+			F	
12,CC		+				+				R				+	+					R	
13,CC		+	+							F							+			+	
14,CC		+	+							F				+			+	R	R		
15,CC		R	+			R				C							+	+		R	
16,CC		R	F							F							+	R	R		

Note: For an explanation of the symbols, see Table 3 and text.

Table 10. Distribution of calcareous nannofossils, Hole 609.

Age		Nannofossil zone	Sample (interval in cm)	Preservation	*Acanthoica* spp.	*Amaurolithus delicatus*	*A. primus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus cristatus*	*C. rugosus*	*Coccolithus crassipons*	*C. miopelagicus*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Cyclicargolithus floridanus*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggreni*	*D. brouweri*	*D. challengeri*	*D. deflandrei*	*D. exilis*	*D. intercalaris*	*D. loeblichi*	*D. neohamatus*	*D. pansus*	*D. pentaradiatus*	*D. quinqueramus*
Quaternary		NN21	1-2, 43-45	P					F				+		R		+																
			1-4, 43-45	G					R				+		+																		
			1,CC	G					C																								
			2-2, 43-45	P					F				R		R																		
			2-5, 43-45																														
		NN20	2,CC	G					F				+		+	+																	
			3-2, 43-45	M					F				+		R																		
			3-4, 43-45	G					F						+																		
		NN19	3,CC	G					R				R		R	+																	
			4-2, 43-45	G					R				+		+																		
			4-4, 43-45	M					R				R		R	+	+																
			4,CC	M					F				+		+				R														
			5-2, 43-45	P					F																								
			5-4, 43-45	P					C				+		R	+																	
			5,CC	G					R																								
			6-2, 43-45	M					F						+																		
			6-4, 43-45	P					F						+																		
			6,CC	M					F																								
			7-2, 43-45	G					F																								
			7-4, 43-45	M	+				C						+																		
			7,CC	M					F										+														
			8-2, 43-45	M					F																								
			8-4, 43-45	M					C																								
			8,CC	M					C						+																		
			9-2, 43-45	P					C				+		+																		
			9-4, 43-45	M					R				R		+																		
			9,CC	M					F				+		+	+																	
			10-2, 43-45	P					C				R		F																		
			10-4, 43-45	M					F				+		F																		
			10,CC	M					C				+		F																		
			11-4, 43-45	M					C				+		R		+		+														
			11,CC	M					C				+		R		+																
			12-2, 43-45	M					R				R		C	+	+																
			12-4, 43-45	P					F				+		F		+		+														
			12,CC	M					F	+					+																		
			13-2, 43-45	P					F	+					R																		
			13-4, 43-45	M					C	R			+		R																		
			13,CC	G					F	R			+		F																		
			14-2, 43-45	M					F	R			+		C	+																	
			14-4, 43-45	M					C	R			+		F	+			+														
			14,CC	M					F	R			R		A	R	+																
			15-2, 43-45	M					F	+			R		F		R																
Pliocene	late	NN18	15-4, 43-45	M					F	+			+		R	+																	
			15,CC	M	+				F	+			+		R	+								+									
			16-2, 43-45	M					C	R			R		F									+									
			16-4, 43-45	M					C	+			R		C																		
			16,CC	M					C	R			R		F									+									
			17-2, 43-45	M					C				R		C		+		+					+									
			17-4, 43-45	M					F	+			+		C		+							+									
			17,CC	M					F	F	+		R		C									+									
			18-1, 43-45	M					C	+			+		F	+	R							+									
			18,CC	M					F	F			R		A	+																	
			19-2, 55-57	M					F	+			F		C	R	+																
			19-2, 110-115	M					F	+	+		R		F	+								+									
			19,CC	M					R				R		F									+									
		NN17	20-1, 43-45	M					R	+			R		F	+	+		R					+								+	
			20-4, 43-45	M					F	+			+		R			+	+			+										+	
		NN16	20,CC	M					F	R			+		F		+		+					+								+	
			22-1, 23-25	M					C	+			R		F		R		+			+		+				+				+	
			22,CC	M					F	+	+	+	+		F		+		R					+								+	
			24-1, 43-45	M					F	R			+		F				+			+		+				+				+	
			24-3, 43-45	M					F	+			R		F	+	+		+			+		+								+	
			24,CC	M					F	R					C				+			+		+								+	
			25,CC	M					F	+					C						+	+		+				+				R	
			26-2, 43-45	P					F	R			+		F		R					+						+					
			26-4, 43-45	P					C	+					F		+		R									+					
			26,CC	P					C	R					C	+	+		R			+		+								+	
	early	NN15	27-2, 43-45	P					C	R			R		C	+			R			+		+								R	
			27-4, 43-45	P					C	+			+		F				R	R		+		+				R				R	
			27,CC	M					C	R					F				+			+		+								+	
		NN14	28,CC	M			+	+	F	F					F		R							+								+	
			29,CC	M		+			C	F		+			C				+					+								+	
			30,CC	M		+		+	C	F					C	R			R					R								+	
			31,CC	M			+	+	C	+					F				F			+		+	+							+	
			32,CC	M		+		+	C	R					F				R		+	+		+						+		+	
		NN13 to NN12	33,CC	M		+			C	F					F				R					+	+			+				+	+
			34,CC	M					F	R					F				R						+							+	+
			35-2, 43-45	M					F	R			+		F				R									+				+	
Miocene	late	NN11	35,CC	M			+		F	F					C								+					+				+	+
			36,CC	M		+			F	F					C		R		R				+		+		+	R					R
			37,CC	M		+			F	R					A		R	+	R						+								+
			38-2, 43-45	P					C	F			R		C				R				+	+				+			+	+	+
			38-4, 43-45	M					F	F					C				R				+	+									R
			38,CC	M					F	R					C						R		+	R			+						+
			39-2, 43-45	M					C	C				+	C		+																+
			39-4, 43-45	M					C	C					C								+	+				+					+
			39,CC	M		+			F	C					F			R	R				+	+	+	+	+						+
			40,CC	M					C	F					A			+					+		+			+					R
			41,CC	M					F	F				+	A					+	+		+	R	+		+	+			+		
			42,CC	M					F	F				+	A					+			+	+	+			+	R	+	+		+

Note: For an explanation of symbols, see Table 3 and text.

Table 10 (continued).

D. surculus	D. tamalis	D. triradiatus	D. variabilis	Discolithina japonica	D. cf. japonica	D. spp.	Emiliania huxleyi	E. ovata	Gephyrocapsa aperta	G. caribbeanica	G. caribbeanica (large)	G. oceanica	G. oceanica (large)	G. parallela	G. sinuosa	Helicosphaera carteri	H. granulata	H. hyalina	H. intermedia	H. inversa	H. sellii	H. wallichii	Oolithotus antillarum	Pseudoemiliania lacunosa	Reticulofenestra pseudoumbilica	R. sp. A	R. sp. B	Rhabdosphaera clavigera	R. longistylis	R. stylifera	Scapholithus fossilis	Scyphosphaera spp.	Sphenolithus abies	S. moriformis	Syracosphaera pulchra	Thoracosphaera deflandrei	T. heimi	T. saxea	Triquetrorhabdulus rugosus	Umbellosphaera spp.	Umbilicosphaera mirabilis
							A		R	F		R		+		R						R	+												+			+			+
						+	C			F		R		+		+						+	+								+				+						+
				+	+		F		R	F		R		+	+	R		+				+	+					+							R			+		+	
				+			R		F	R		R		R	F	R						+	R					+							R			+			+
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Table 11. Distribution of calcareous nannofossils, Hole 609A.

Age	Nanno-fossil zone	Sample	Preservation	*Calcidiscus leptoporus*	*Coccolithus crassipons*	*C. pelagicus*	*C.* sp.	*Cyclolithella annula*	*Discoaster brouweri*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. oceanica*	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. hyalina*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra* sp. A	*Rhabdosphaera clavigera*	*R. stylifera*	*Syracosphaera pulchra*	*Thoracosphaera saxea*	*Umbilicosphaera mirabilis*
Quat.	NN19	1,CC	G	F	R	R	+	+	+	+		+	R	R	R	R	+	+	R			C	R	+	+	R	+	+
		2,CC	M	F		R				+	+	+	R	F	+	R	R	R	F	R	+	C		+		+	R	+

Note: For an explanation of symbols, see Table 3 and text.

Site 610

Six holes were drilled near the axis of the Feni sediment drift in Rockall Trough. Holes 610, 610A, 610B, and 610C were located on the crest of a sediment wave, and two offset holes—Holes 610D and 610E—were drilled in an adjacent trough, 0.7 km to the northwest and in water 28 m deeper.

All sediments yielded abundant calcareous nannofossils in various states of preservation and moderate diversity. An almost complete sequence of current-deposited sediments was identified, from late Pleistocene to Holocene NN21 (*Emiliania huxleyi* Zone) to early Miocene NN3 (*Sphenolithus belemnos* Zone). The calcareous nannoflora at this site contrasts sharply with the assemblages at previous sites, as indicated by the following criteria: discoasters are missing or extremely rare in the upper Pliocene sequences, and comparatively common Cretaceous reworked specimens and fairly abundant Oligocene–Eocene reworked specimens are found in the Quaternary and in the upper Miocene, respectively.

Hole 610 (Table 14)

The abundant occurrence of *Emiliania huxleyi* suggests that Sample 1,CC can be placed in the late Pleistocene to Holocene *Emiliania huxleyi* Zone (NN21). This sample also contains *Gephyrocapsa caribbeanica, G. oceanica, Coccolithus pelagicus, Calcidiscus leptoporus*, and *Discolithina japonica*. In addition to these species, Cretaceous specimens such as *Watznaueria barnesae, Prediscosphaera cretacea*, and *Microrhabdulus decoratus* are present. Samples 2,CC and 3,CC are placed in the Pleistocene *Gephyrocapsa oceanica* Zone (NN20) based on the abundant occurrences of *Gephyrocapsa caribbeanica* and *G. oceanica* and the absence of *Pseudoemiliania lacunosa*. In Sample 3,CC, the Cretaceous species *Prediscosphaera cretacea, Arkhangelskiella cymbiformis, Eiffellithus turriseiffeli*, and *Watznaueria barnesae* also occur. Samples 4,CC and 5,CC contain abundant *Pseudoemiliania lacunosa* and gephyrocapsid specimens and represent the Pleistocene *Pseudoemiliania lacunosa* Zone (NN19). Cretaceous reworked specimens such as *Watznaueria barnesae* and *Eiffellithus turriseiffeli* also occur in these samples.

Judging by the co-occurrence of *Calcidiscus macintyrei* and a few discoasters (such as *Discoaster surculus, D. brouweri, D. tamalis*, and *D. variabilis*), and the absence of gephyrocapsids, Samples 6,CC through 9,CC are late Pliocene in age and are assigned to NN16 (*Discoaster surculus* Zone). Although *Reticulofenestra pseudoumbilica* is found throughout this zone, the number of specimens is limited. Core 10 was recovered after washing down 48 m; Sample 10,CC contains some *Reticulofenestra pseudoumbilica* together with *Sphenolithus abies*. The geological age of this sample, however, is not definite because no age-diagnostic species are present. The next lower sample, also obtained after washing down, is dominated by placoliths, particularly *Coccolithus pelagicus, Calcidiscus leptoporus*, and *C. macintyrei*. The presence of *Discoaster quinqueramus* places this sample within the late Miocene *Discoaster quinqueramus* Zone (NN11). Samples 12,CC and 13,CC contain no age-diagnostic species; the ages of these samples are therefore uncertain. The absence of five-rayed discoasters, however, suggests that these samples may be from below NN11. Sample 14,CC may belong to NN9 (*Discoaster hamatus* Zone), on the basis of the occurrence of *Discoaster* cf. *hamatus*. *Coccolithus miopelagicus* occurs continuously below Sample 15,CC, but the age of this sample is again uncertain. *Cyclicargolithus floridanus* is found continuously below Sample 16,CC. According to Bukry (1973), the LAD of this species coincides with the FAD of *Discoaster kuglerii*, which marks the boundary between NN7 and NN6. Therefore, Sample 16,CC is placed in the middle Miocene *Discoaster exilis* Zone (NN6). Samples 17,CC through 19,CC contain *Sphenolithus heteromorphus* and are placed in the *Sphenolithus heteromorphus* Zone (NN5). Samples 20,CC and 21,CC belong to the *Helicosphaera ampliaperta* Zone (NN4) on the basis of the presence of *Helicosphaera ampliaperta*. Sample 23,CC on down to the bottom of this hole belong to the early Miocene *Sphenolithus belemnos* Zone (NN3) based on the occurrence of *Sphenolithus belemnos* and the absence of *Triquetrorhabdulus carinatus*.

Hole 610A (Table 15)

The nannofossil assemblage in this hole is similar to that observed in Hole 610.

Samples 1-2, 50–51 cm through 2-6, 70–71 cm are placed in the late Pleistocene to Holocene *Emiliania huxleyi* Zone (NN21), where *Emiliania huxleyi, Gephyrocapsa caribbeanica*, and *G. oceanica* occur together with several specimens reworked from the Cretaceous such as *Watznaueria barnesae, W. britannica, Eiffellithus turriseiffeli, Arkhangelskiella cymbiformis*, and *Prediscosphaera cretacea*. Samples 2,CC, 3-2, 50–51 cm, and 3-4, 50–51 cm are assigned to the *Gephyrocapsa oceanica* Zone (NN20) based on the coccolith assemblage without *Emiliania huxleyi* and *Pseudoemiliania lacunosa*. Cretaceous specimens such as *Micula decussata, Arkhangelskiella cymbiformis, Watznaueria barnesae*, and *Prediscosphaera cretacea* are also found in 2,CC. The occurrence of abundant *Pseudoemiliania lacunosa* places Samples 3-5, 50–51 cm on down to 11-3, 50–51 cm in the early Pleistocene *Pseudoemiliania lacunosa* Zone (NN19). *Reticulofenestra* sp. A and *R.* sp. B are dominant in Samples 5,CC through 7-4, 50–51 cm. *Gephyrocapsa parallela* occurs only in the upper half of the Quaternary sequence. Large-sized *Gephyrocapsa* are especially concentrated in Samples 7-4, 50–51 cm through 9-1, 50–51 cm. *Helicosphaera sellii* and *Calcidiscus macintyrei* occur below Samples 8-1, 50–51 cm and 10-2, 50–51 cm, respectively. Samples 10-2, 50–51 cm and 10-3, 50–51 cm contain no *Gephyrocapsa oceanica* and below Sample 10-4, 50–51 cm no gephyrocapsid specimen except *Gephyrocapsa aperta* and *G. sinuosa* occurs.

As discoasters are missing or extremely rare in the upper Pliocene in this hole, the Pliocene/Pleistocene boundary is not marked as clearly as it was at previous sites. However, a single specimen of *Discoaster triradiatus* is present in Sample 11-4, 50–51 cm and, therefore, the Pliocene/Pleistocene boundary is tentatively placed between Samples 11-3, 50–51 cm and 11-4, 50–51 cm in this hole. Below this boundary, the nannoflora changes progressively, with a gradual increase in the number of species and the number of specimens of discoasters. In the interval from Samples 11-4, 50–51 cm through 14-2, 50–51 cm, the number of discoaster specimens is still limited; only *Discoaster brouweri* occurs. Thus these samples are assigned to the *Discoaster brouweri* Zone (NN18). Based on the co-occurrence of *Discoaster brouweri* and *D. pentaradiatus*, Samples 14-4, 50–51 cm and 14,CC are placed in the late Pliocene *Discoaster pentaradiatus* Zone (NN17). The occurrence of *Discoaster pentaradiatus* together with *D. surculus* indicates a late Pliocene age (NN16, *Discoaster surculus* Zone) for Samples 15-2, 50–51 cm through 20-2, 50–51 cm. In this hole *Discoaster tamalis* is rare and found in and below Sample 16-4, 50–51 cm. Comparatively abundant *Reticulofenestra pseudoumbilica* occurs throughout NN16. Its abundance, however, increases in Sample 20-4, 50–51 cm. Therefore samples from 20-4, 50–51 cm and on down to the bottom of this hole are assigned to early Pliocene NN15 (*Reticulofenestra pseudoumbilica* Zone). *Sphenolithus abies* occurs in Sample 21-2, 50–51 cm, well below the NN16/NN15 boundary.

Hole 610B (Table 16)

Samples 1,CC and 2,CC contain abundant *Emiliania huxleyi* and are assigned to the late Pleistocene to Holocene *Emiliania huxleyi* Zone (NN21). Based on a coccolith assemblage without *Emiliania huxleyi* and *Pseudoemiliania lacunosa*, Sample 3,CC is assigned to the *Gephyrocapsa oceanica* Zone (NN20). The presence of abundant *Pseudoemiliania lacunosa* and the absence of discoasters may place Samples 4,CC to 14,CC in NN19 (*Pseudoemiliania lacunosa* Zone), but 11,CC to 14,CC do not contain *Gephyrocapsa caribbeanica* and *G. oceanica*. *Helicosphaera sellii* and *Calcidiscus macintyrei* are found only below Samples 8,CC and 11,CC, respectively. Comparatively large specimens of *Gephyrocapsa* are found in Sample 8,CC, and *Reticulofenestra* sp. A occurs also in Samples 6,CC and 7,CC. Cretaceous reworked specimens are present throughout the Quaternary.

Samples 15,CC and 16,CC contain *Discoaster brouweri, D. pentaradiatus*, and *D. surculus* and belong in the late Pliocene *Discoaster surculus* Zone (NN16). As at the previous holes of this site, discoasters are absent or extremely rare, and nannofossil Zones NN18 and NN17 cannot be recognized.

Hole 610C (Table 17)

The uppermost sample from Hole 610C, Sample 1,CC, is assigned to the *Emiliania huxleyi* Zone (NN21). Sample 2,CC belongs to the *Gephyrocapsa oceanica* Zone (NN20) based on a coccolith assemblage without *Emiliania huxleyi* and *Pseudoemiliania lacunosa*. The presence of abundant *Pseudoemiliania lacunosa* and the absence of discoasters place Samples 3,CC and 4,CC in the *Pseudoemiliania lacunosa* Zone (NN19). One of these samples (4,CC) has no gephyrocapsid specimen. A few specimens of *Discoaster brouweri* occur in Samples 5,CC and 6,CC, and these samples are assigned to NN18 (*Discoaster brouweri* Zone). The Pliocene/Pleistocene boundary is placed between Samples 4,CC and 5,CC. As at the previous holes, Cretaceous specimens are also present in this hole.

Hole 610D (Table 18)

Sample 1,CC is assigned to the late Pleistocene to Holocene *Emiliania huxleyi* Zone (NN21). A few Cretaceous reworked specimens also occur. The presence of gephyrocapsids and absence of *Emiliania huxleyi* and *Pseudoemiliania lacunosa* place Sample 2,CC in NN20 (*Gephyrocapsa oceanica* Zone). In this sample, *Watznaueria barnesae, Micula decussata, Prediscosphaera cretacea*, and *Eiffellithus turriseiffeli* are present. The occurrence of *Pseudoemiliania lacunosa* in Samples 3,CC to 5,CC indicates an early Pleistocene (NN19, *Pseudoemiliania lacunosa* Zone) age for these samples, which also contain Cretaceous specimens.

Samples 6,CC and 7,CC, which were obtained from the bottom of this hole after washing down, contain a calcareous nannoflora characterized by the occurrence of *Discoaster loeblichi* and the absence of *Discoaster quinqueramus*. Thus these two samples may be assigned to the late Miocene *Discoaster calcaris* Zone (NN10).

Hole 610E (Table 19)

In this hole, we detected five calcareous nannofossil datum levels. These datums are as follows in descending order: LAD of *Discoaster quinqueramus* (between Samples 1,CC and 2,CC), FAD of *Amaurolithus* spp. (be-

Table 12. Distribution of calcareous nannofossils, Hole 609B.

Age		Nanno-fossil zone	Sample (interval in cm)	Preservation	*Amaurolithus amplificus*	*A. delicatus*	*A. primus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus acutus*	*C. cristatus*	*C. rugosus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggreni*	*D. brouweri*	*D. challengeri*	*D. exilis*	*D. intercalaris*	*D. pansus*	*D. pentaradiatus*	*D. quinqueramus*
Quaternary		NN21	1,CC	G					F					R	+	+	+												
			2,CC	G					C					R	R		+												
		NN20	3,CC	G					R						+														
		NN19	4,CC	G					C						+														
			5,CC	M					C			+		+	+														
			6,CC	M					F					+	+														
			7,CC	M					F																				
			8,CC	P																									
			9,CC	M					F					+	+														
			10,CC	G					F					+	R		+												
			11,CC	M					F					+	R														
			12,CC	M					F	R				+	F				+										
			13,CC	M					C	+				+	F	+			+										
			14,CC	M					C	R				R	F	+			+										
			15,CC	M					C	R		+		+	C	+	+												
Pliocene	late	NN18	16,CC	M					F	R				+	R				+				+						
			17-1, 120–121	M					R	R				R	F								+						
			17,CC	G					C	R				R	F		+						+						
		NN16	19,CC	G					R	R				+	F	+			+		+		+					+	
			20,CC	G					F	R				+	F	+			+	+	+		+	+				+	
			21,CC	G					F	F				+	R	+			R		+		+					+	
			22,CC	G					R	+				+	R				+		+		+					+	
			23,CC	G					R	R					F	+			+		+		+	+				+	
			24,CC	G					F	R					F				+		+		+	+				+	
			25,CC	G					C	F				+	C				+		+		R	+		R		+	
			26,CC	M					F						C			+	+		+		+					+	
			27,CC	M					F	R					F				+		+		+						
	early	NN15 to NN14	28,CC	P					C	R				+	C		+		+		+		+			+			
			29,CC	P					F	R				+	F	+	+	+	R									+	
			30,CC	M					C	R					C	+	+		F		+					+		+	
			31,CC	M	+				C	R			+		C				+				R			+		R	
			32,CC	M			+	+	C	F	+		+		C				+		+		+	+		+	+	+	
		NN13 to NN12	33,CC	M					C						C			+	R				+		+	+		+	
			34,CC	M					C	R					A			+	R			+				+		R	
Mio.	late	NN11	35,CC	M					F	R					C				+			+	+			+		+	+
			36,CC	M		+			C						C							+		+	+	+			F
			37,CC	M					C	R					C								+	+	+	+		+	R
			38,CC	M					C	F					C				+			+		+	+	+		+	+

Note: For an explanation of symbols, see Table 3 and text.

tween Samples 3,CC and 4,CC), FAD of *Discoaster surculus* (between Samples 5,CC and 6,CC), LAD of *Discoaster neohamatus* (between Samples 5,CC and 6,CC), and FAD of *Discoaster berggrenii* and/or *D. quinqueramus* (between Samples 6,CC and 7,CC). According to these data, Sample 1,CC, Samples 2,CC through 6,CC, and Sample 7,CC are placed in NN12 (*Amaurolithus tricorniculatus* Zone), NN11 (*Discoaster quinqueramus* Zone), and NN10 (*Discoaster calcaris* Zone), respectively.

Site 611

Six holes were drilled on the lower southeastern flank of the Gardar Drift. Four were drilled on the broad crest of a sediment wave at 3201 m water depth and the remaining two holes were located in an adjacent trough half a nautical mile to the southeast and in water 29 m deeper.

Samples examined contain middle Miocene to Holocene calcareous nannofossils. The state of preservation is generally good to moderate, and the species diversity is moderate.

Hole 611 (Table 20)

The calcareous nannoflora in Samples 1,CC through 4-4, 50–51 cm is characterized by an abundance of poorly preserved small and fragile specimens. Preservation of coccoliths in Sample 4-4, 50–51 cm is especially poor.

The uppermost two samples from this hole, Samples 1,CC and 2-1, 60–61 cm, are correlated with the *Emiliania huxleyi* Zone (NN21). These samples also contain

Table 12 (continued).

D. surculus	*D. tamalis*	*D. triradiatus*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. granulata*	*H. hyalina*	*H. inversa*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. saxea*	*Umbellosphaera* spp.	*Umbilicosphaera mirabilis*
					+		A			C		F		R		R		+			+	R					+		+	R				R		+	R	+
				R		+	C		R	R		R		R	R	F		+			+	R					+		+	+				R		+		+
				+						C		F				+			+			R					+		+	R	+			+		+		+
			+			+		R	F	C		F		R	R	+		+			+	+	R				+							R		+		R
				+		+		R	F	R		R		R	R	F					+		F				+	+	+	+				R		+		+
					F		R	F	R	+		R			R	+							F				+	+						R				
				+	R	R		R	R						F	+		+				+	C		C	+	+	+	+	+				R			R	+
				+	R	+		F	F	F	F	F	F		R	+				R			C				R		+	+	+			R				R
					R	R		F	R	F	R	F	R		F	+				R	+		C				+		+					R				R
				+	R	R		+	F	C		C			R	+				R			F				+	+	+					R				R
				+	R	R		R	R	C					R	R				+		F	C				R		R	+	+			R				+
				+	R	+		F	F						R	+				F	+	R	F				R	+	R					R	R			+
				+	F	R		R	R						R	+				F	+		F				R	+	+	+				F				+
				+	+	R		R	F						R	+				R	+		F				+		+	+	+			F		+		+
		R		R	R	+		R	R						R	R				+	R		F				R	R	+	R								+
				+	+	R		F	+	+						R				F	R	F	+				R	+	+		+			+				+
				R	+	R		R								F				R		R	+				+	+	+					R				
+				+		+										+				+	+		+					+	+		+			+				
+				+		+		F								+				+			+					+	R					+				R
+				R		R		R								R	+			+	+	F	+	R				+	+		+			F				R
+				+		+										+	+			R			R	R			+	+				+		+				
+		+				+														R			R	F										+				
+	+	+				+										+				R			+	R			+	+						R				R
+	+					+		R								+	+			+			R	R										+				
+								R									+			R				R				+						R				
+						+		+								+	+					+	+	R				+			+			+	+			
		+				R										R	R				+			F								+		R				
+																	+							C				+			+	+	R					
+																	R							A				+				R	+					
+																	+							A								R	+	+				
+			+																					C								R	+					
+			+																					C								R	+					
+		+	+													+	+							C							+	R	R					
+			+																		+			A								R	+					
			+																					A								+	R					
+			+																					A								+	+					
			+																					A								+						

Cretaceous reworked specimens such as *Watznaueria barnesae, Arkhangelskiella cymbiformis*, and *Eiffellithus turriseiffeli.* Sample 2-3, 50–51 cm is placed in NN20 (*Gephyrocapsa oceanica* Zone), because *Emiliania huxleyi* and *Pseudoemiliania lacunosa* were not found. The occurrence of *Pseudoemiliania lacunosa* and the absence of discoasters suggest that Samples 2-4, 50–51 cm through 9-2, 50–51 cm can be correlated with the early Pleistocene *Pseudoemiliania lacunosa* Zone (NN19). In this zone, Samples 4-4, 50–51 cm through 5,CC contain fairly abundant *Reticulofenestra pseudoumbilica*-like specimens (*Reticulofenestra* sp. A. and *R.* sp. B), which were also recognized in previous holes. *Gephyrocapsa parallela* occurs nearly continuously from the top of this hole on down to Sample 4-5, 50–51 cm. The assemblages of Samples 6-2, 50–51 cm through 6,CC are characterized by the fairly abundant occurrences of large *Gephyrocapsa* specimens. The last appearance datums (LADs) of *Helicosphaera sellii* and *Calcidiscus macintyrei* were detected in this hole (6-3, 50–51 cm/6-4, 50–51 cm, and 7,CC/8-1, 50–51 cm). The first appearance datums (FADs) of *Gephyrocapsa oceanica* and *G. caribbeanica* are present between Samples 7,CC and 8-1, 50–51 cm, and 8-4, 50–51 cm and 8-5, 50–51 cm. The Cretaceous specimens are similar to those found in the upper part of this zone. *Helicosphaera inversa* was not found.

The Pliocene/Pleistocene boundary is not clearly detected in this hole because of the scarcity of discoasters. Sample 9-3, 50–51 cm contains *Discoaster brouweri* together with *D. triradiatus*, and thus the Tertiary/Quaternary boundary may occur between Samples 9-2, 50–51 cm and 9-3, 50–51 cm. Samples 9-3, 50–51 cm to

Table 13. Distribution of calcareous nannofossils, Hole 609C.

Age	Nannofossil zone	Sample	Preservation	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus cristatus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckerii*, n. sp.	*C.* sp.	*Cyclolithella annula*	*Discoaster asymmetricus*	*D. brouweri*	*D. pentaradiatus*	*D. surculus*	*D. tamalis*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania ovata*	*Gephyrocapsa aperta*	*G. sinuosa*	*Helicosphaera carteri*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*Umbilicosphaera mirabilis*
Quat.	NN19	1,CC	M	F	R		R	C		R									R	+	R	F	R	R	R	+		F		R	+	+	R		R		R
late Pliocene	NN18	2,CC	M	F			+	C		+			R						+	R	F	R	+	F	F	+		F		+	R	+	R		R		+
		4,CC	M	F	R			R	+	+			+				+	R	R	+	R			+	R	R	R	R	R	+	+	+		+	F		R
	NN17	5,CC	M	F	+		+	F	+	+			+	+				R		+	F			R	+		R	F		+	+	+			+		
	NN16	6,CC	P	F	+		R	F	+	+	+		+	+	+			+	R	+	R			R	R			R	+	+	+	+			R	+	R
		7,CC	M	F	R	+	+	+			+	+	+	+	+	+		+		R				+	+	+	+	+	F		+	+			R	+	

Note: See Table 3 and text for explanation of symbols.

12,CC are assigned to NN18 (*Discoaster brouweri* Zone). The co-occurrence of *Discoaster brouweri* and *D. pentaradiatus* in Samples 13-1, 50–51 cm and 13-2, 50–51 cm places this interval in NN17 (*Discoaster pentaradiatus* Zone). Below this, discoasterid assemblages gradually change, with an increase in the number of species and the number of specimens. Samples from 13-3, 50–51 cm on down to the bottom of this hole contain *Discoaster surculus* and are assigned to the late Pliocene *Discoaster surculus* Zone (NN16). *Reticulofenestra pseudoumbilica* occurs sporadically throughout Zones NN18, NN17, and NN16.

Hole 611A (Table 21)

Samples from this hole contain abundant calcareous nannofossils, except Sample 5,CC. Sample 1,CC may represent the *Emiliania huxleyi* Zone (NN21). The occurrence of *Pseudoemiliania lacunosa* and the absence of discoasters suggest that Samples 2,CC through 10,CC can be correlated with NN19 (*Pseudoemiliania lacunosa* Zone). Samples 4,CC and 5,CC contain fairly abundant *Reticulofenestra* sp. A. Cretaceous specimens are found in the upper part of this zone.

Discoasters are extremely rare, and it is therefore very difficult to detect the LAD of *Discoaster brouweri*. The Pliocene/Pleistocene boundary is placed between Samples 10,CC and 11,CC. *Discoaster brouweri* occurs in Sample 11,CC, *D. pentaradiatus* in 12,CC, and *D. surculus* in 13,CC; therefore Samples 11,CC, 12,CC, and 13,CC are assigned to Zones NN18, NN17, and NN16, respectively.

Hole 611B (Table 22)

Only one of the core-catcher samples examined contains Quaternary calcareous nannofossils. This sample contains no *Emiliania huxleyi* and *Pseudoemiliania lacunosa*, and belongs in NN20 (*Gephyrocapsa oceanica* Zone). The preservation of coccoliths is poor.

Hole 611C (Table 23)

Abundant occurrences of *Emiliania huxleyi* suggest that Samples 1,CC and 2,CC can be correlated with the late Pleistocene to Holocene *Emiliania huxleyi* Zone (NN21). A few specimens of *Eiffellithus turriseiffeli* and *Watznaueria barnesae* in Sample 2,CC are reworked from Cretaceous outcrops. Sample 3,CC belongs to NN20 (*Gephyrocapsa oceanica* Zone), based on the absence of *Emiliania huxleyi* and *Pseudoemiliania lacunosa.* The next five samples down (Samples 4,CC through 9,CC) contain abundant *Pseudoemiliania lacunosa* and are placed in the early Pleistocene *Pseudoemiliania lacunosa* Zone (NN19). Several Cretaceous reworked specimens are also found in this zone (in Sample 5,CC). Sample 6,CC contains abundant *Reticulofenestra* sp. A and *R.* sp. B. Sample 10,CC is barren of calcareous nannofossils, except for a few undiagnostic specimens.

As in previous holes, discoasters are missing or extremely rare in the upper Pliocene. As a result, the Pliocene/Pleistocene boundary cannot be identified precisely. Sample 11,CC, however, does contain *Discoaster brouweri* and *D. triradiatus*, and the Pliocene/Pleistocene boundary is placed between Samples 9,CC and 11,CC. Samples 11,CC through 13,CC are assigned to NN18 (*Discoaster brouweri* Zone). Judging by the co-occurrence of *Discoaster brouweri* and *D. pentaradiatus*, Sample 14,CC is placed in NN17 (*Discoaster pentaradiatus* Zone). Below this, discoasterid assemblages gradually change and *Discoaster surculus* is found together with *Discoaster variabilis, D. asymmetricus*, and *D. tamalis. Reticulofenestra pseudoumbilica* is relatively abundant, but the abundance of this species increases in Sample 22,CC. Consequently, the boundary between NN16 (*Discoaster surculus* Zone) and NN15 (*Reticulofenestra pseudoumbilica* Zone) is placed between Samples 22-4, 50–51 cm and 22,CC. Because *Discoaster asymmetricus* is not found below Sample 26-2, 50–51 cm, the NN14 (*Discoaster asymmetricus* Zone)/NN13 (*Ceratolithus rugosus* Zone) boundary is placed between Cores 24 and 26.

Table 14. Distribution of calcareous nannofossils, Hole 610.

Age	Nanno-fossil zone	Sample	Preservation	*Acanthoica* spp.	*Amaurolithus primus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Coccolithus crassipons*	*C. miopelagicus*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Cyclicargolithus abisectus*	*C. floridanus*	*Dictyococcites bisectus*	*Discoaster adamanteus*	*D. asymmetricus*
Quaternary	NN21	1,CC	G			F		R		R									
	NN20	2,CC	M			F		R		+	+								
		3,CC	M	+		F		+		+	+								
	NN19	4,CC	G	+		R		+		+									
		5,CC	G	+		F		+		+									
late Pliocene	NN16	6,CC	M			F	R	R		C				R					+
		7,CC	M			+	R	R		C	+	+		+				+	
		8,CC	M		+	F	+			F				+					
		9,CC	G			C	R	+		C	+			+					
Miocene	?	10,CC	G			C	C			C	+			+					
	NN11	11,CC	M			C	F	R		A	R	+		+				+	
	?	12,CC	M			F	+	R		A				+					
		13,CC	P			F	+	R		A				R					
	NN9?	14,CC	M			F	F			C									
	?	15,CC	M			R		+	+	C			+	+	+		+		
	NN6	16,CC	P						+	C				+	+	+			
	NN5	17,CC	P			R	R		+	A						+			
	NN5	18,CC	M				R		F	A					R	R			
	NN5	19,CC	M			R			R	A				+		F			
	NN4	20,CC	M			R	+		+	A				+	+	F		+	
		21,CC	P			R			R	A						+			
	NN3	22,CC	P						+	A						R			
		23,CC	P				R		+	C						F			
		24,CC	P						+	A	+					+			
		25,CC	P						+	A						+			
		26,CC	P						R	C	R				+	+			
		27,CC	P			R		+		A	+	+				R			

Sample	*D. brouweri*	*D. deflandrei*	*D. druggi*	*D. exilis*	*D.* cf. *hamatus*	*D. intercalaris*	*D. quinqueramus*	*D. surculus*	*D. tamalis*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*
1,CC											+			C		R
2,CC																F
3,CC													+			F
4,CC													+		R	+
5,CC												R	R		R	R
6,CC								+	+							
7,CC	+							+		+			+			
8,CC													+			
9,CC													+			
10,CC						+		+		+						
11,CC							+			+						
12,CC										+						
13,CC	+	+		+	+					+						
14,CC		+	+		+					R						
15,CC		+								+						
16,CC		+														
17,CC		+								R						
18,CC		+								R			+			
19,CC		+	+													
20,CC		R								+						
21,CC		R														
22,CC		+	+													
23,CC		F														
24,CC		F	+													
25,CC		F	+													
26,CC		R	+													
27,CC		+											+			

Sample	*G. caribbeanica*	*G. oceanica*	*G. parallela*	*G. sinuosa*	*Helicosphaera ampliaperta*	*H. carteri*	*H. euphratis*	*H. granulata*	*H. hyalina*	*H. intermedia*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra hillae*	*R. pseudoumbilica*
1,CC	F	R		R		+			+				+			
2,CC	C	C		R		+						+	+			
3,CC	F	F		R		+						+				
4,CC	+	+	R	R		R							R	F		
5,CC		R	+	R		R							R	F		
6,CC						+		R			+			R		
7,CC						+		+						R		+
8,CC						+		+						+		+
9,CC								R						R		+
10,CC								+								F
11,CC																+
12,CC						R		+								F
13,CC						+		R								R
14,CC						+		+								C
15,CC						+		+								A
16,CC								+							+	C
17,CC						F	+									C
18,CC						F	R			+						F
19,CC						R		F								C
20,CC					+	R		F								A
21,CC					+	F										C
22,CC						R										A
23,CC																A
24,CC					+											A
25,CC																A
26,CC						+		R								A
27,CC										R						A

Sample	*R. umbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. belemnos*	*S. dissimilis*	*S. heteromorphus*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*Triquetrorhabdulus rugosus*	*Umbilicosphaera mirabilis*
1,CC						+							R			
2,CC													R			
3,CC					+								F			
4,CC				+	+								F			+
5,CC		+	+	+		+	+						R			
6,CC					+		+						+			
7,CC													+			
8,CC							+						R			
9,CC	+			+	+		+						+	+		
10,CC								+				+				
11,CC								+				+				
12,CC								R						+		
13,CC								F				+	R		+	
14,CC								F				R			+	
15,CC								+				+			+	
16,CC	+							+				+			+	
17,CC											+	+				
18,CC								R			+	F				
19,CC								R			F	R				
20,CC								+			R	R				
21,CC	+										F	R			+	
22,CC									+	F	+	F				
23,CC									+	+		F				
24,CC									+			F				
25,CC								R	+	+		R				
26,CC								R		+		+				
27,CC										+					+	

Note: See Table 3 and text for an explanation of symbols.

Table 15. Distribution of calcareous nannofossils, Hole 610A.

Age	Nannofossil zone	Sample (interval in cm)	Preservation	*Acanthoica* spp.	*Calcidiscus leptoporus*	*C. macintyrei*	*Coccolithus crassipons*	*C. miopelagicus*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Cyclolithella annula*	*Cyclicargolithus floridanus*	*Discoaster asymmetricus*	*D. brouweri*	*D. pentaradiatus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.
Quaternary	NN21	1-2, 50-51	P		F				R														
		1-4, 50-51	M		R		R		+	+													
		1,CC	M	+	F				+														
		2-5, 60-61	P		F		R		F	+	+												
		2-6, 70-71	G		F		+		R														
	NN20	2,CC	G		F		+		R	+													
		3-2, 50-51	M		R		+		+												+		
		3-4, 50-51	P		R				F														
	NN19	3-5, 50-51	M		R		+		+														+
		3,CC	G		R		+		+														+
		4-2, 50-51	M		R		+		+														+
		4-4, 50-51	M		F		+		+														
		4,CC	P		F		+		+	+													+
		5-2, 50-51	M		F				+													+	R
		5-4, 50-51	P																				
		5-5, 50-51	G		F																		+
		5,CC	P		R				R												F	F	
		6-2, 50-51	M		F				+												R	R	
		6-3, 50-51	M		F																+	+	+
		6-4, 50-51	P		+																+		
		6,CC	G		R																+	+	+
		7-2, 50-51	M		F				+													+	+
		7-3, 50-51	M		F				+														
		7-4, 50-51	M		C		+		+												+	R	+
		7,CC	M		C		R		+												+	+	+
		8-1, 50-51	M		F		+		R		+											R	+
		8-2, 50-51	P		F		+		R												R	+	+
		8-4, 50-51	M		F		R		F	+												R	+
		8,CC	M		R		R		C	R	+											+	+

Age	Nannofossil zone	Sample (interval in cm)	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. granulata*	*H. hyalina*	*H. intermedia*	*H. sellii*	*H. wallichii*
Quaternary	NN21	1-2, 50-51	A			F		F				R					
		1-4, 50-51	A			C		F				R					
		1,CC	F			C		R			F	+		+			+
		2-5, 60-61	C		R	F		R				R					+
		2-6, 70-71	R			F		F		R	R	+					
	NN20	2,CC			F	C		F			R	+		+			+
		3-2, 50-51			F	C		C			+	+					
		3-4, 50-51				F		R				R					
	NN19	3-5, 50-51		+		C		C		R		+					
		3,CC		+		F		+				+		+			
		4-2, 50-51		+	R	C		C				+					R
		4-4, 50-51		+		C		F				+					
		4,CC		R	R	C		F		+		+					
		5-2, 50-51		R	+	+		+		+	R	+		+			
		5-4, 50-51				+		+									
		5-5, 50-51		R							R	+		+			
		5,CC		F		R					R	R					
		6-2, 50-51		F	R	+		+		+		+					
		6-3, 50-51		+	R			R			R	+					
		6-4, 50-51										+					
		6,CC		F	R						R	+					
		7-2, 50-51		F	F						F	+					
		7-3, 50-51		R	R						R	R		R			
		7-4, 50-51		F	R				+		F	R					
		7,CC		F	F	+	+	R	+		F	+					
		8-1, 50-51		+	R	F	+	F	R		F	+				R	
		8-2, 50-51		F		C	F	F	R		R	+				+	
		8-4, 50-51		+	R	C	F	C	F		R	+				+	
		8,CC		R	R	C	R	C	R		F	+				R	

Age	Nannofossil zone	Sample (interval in cm)	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. heimi*	*T. saxea*	*Umbellosphaera* spp.	*Umbilicosphaera mirabilis*
Quaternary	NN21	1-2, 50-51							+						F					
		1-4, 50-51	+						+	+	+				R				+	
		1,CC	+					+			+				R			+		+
		2-5, 60-61	+					+							R		+			
		2-6, 70-71	+												R					
	NN20	2,CC	+						+		+				F					
		3-2, 50-51	R						+	+	+				+					
		3-4, 50-51				R									R			+		
	NN19	3-5, 50-51	+	R							+				R					
		3,CC	+	R				+		+	+				R					+
		4-2, 50-51		+				+			+				F					
		4-4, 50-51		R				+		+					+					
		4,CC	+	R											+					+
		5-2, 50-51	F	R							R	+			F					
		5-4, 50-51																		
		5-5, 50-51		R				+				+			R					
		5,CC	R	C		F	R								R					
		6-2, 50-51	+	R		F	R								R					+
		6-3, 50-51	R	R		R	+	+		+	+	+			+					
		6-4, 50-51				+	+													
		6,CC	R	F		R	+	+	+	+	+	+			R					
		7-2, 50-51	R	C		F	+	+	+	+	+				F					+
		7-3, 50-51	R	C		F	R		R						F				R	
		7-4, 50-51	+	F		R	R			+	+				R					+
		7,CC	R	F				+	+	+	+				+					
		8-1, 50-51		R				+			+				+					
		8-2, 50-51	+	F				+							R					
		8-4, 50-51	R	R				+		+					R					
		8,CC		R				+		+					+					

Quaternary		NN19	9-1, 50-51	M		F		+		+	+												+	R		+	F	A	R	C			R						+		R				+		+					+						
			9-2, 50-51	M		F		+		+													+	+		R	F	C		C			F	+				R	+	+	R				R			+				R						
			9-4, 50-51	M		R		+		F		+											+	+		R	F	C		C			F	+				R		R	R				+							+						
			9,CC	M		F				F												+	+	+		R	R	F		R			F	+				+		R	R				+							R						
			10-1, 50-51	G		F		+		F		+										R	R	+		R	R	C		R			F	+				R		R	F				+		+		+			R						
			10-2, 50-51	M		F	+																+			R	F	C					F	+				R		R	F											+						
			10-3, 50-51	P		F				F												R				+		+					R					R			R				R													
			10-4, 50-51	M		F	+	R		F		+	F									R	+	+		R	R						R					+		R	R		+		+	R	+					R						
			10,CC	M		R	+	+		C	R												F			R	F						F	R				F	+	R	R						+					R						
			11-2, 50-51	M		F	+	R		C		+										+	R	R		F	R						R	R				F		R	F				R	+	R	R				F						
			11-3, 50-51	M		C	+	+		A		+										R	+	+		F	F						R	R		+		R			F				+			+				R						+
Pliocene	late	NN18	11-4, 50-51	M		F	+	+		R										+		+		R		R	+						+	+				R	+	R	R				R		+					+	+				
			11,CC	M		F	+	+		F												+	R	+		F	+						R	+				F		F	F					+	+	+				F						
			12-2, 50-51	M	+	C	F	F		C						+							+	+		C								+				F			F				+	+						F						
			12-4, 50-51	M	+	C	+	+		C		+										R	F	R		F								R				R	+		+				+	+	+					R						
			12,CC	M		F	R	F		C						+										R												C	R		F											R						
			13-2, 50-51	M	+	C	R	+		C		+										+		R		+								+				+			+				+	+	+					F						
			13-4, 50-51	M		C	R	+		A	+	+										+				R								R					+		F											F						R
			13,CC	M		F		+		F	+	+			+							+		+		R								+							F					R	+		+			+						R
			14-2, 50-51	M		R	+	+		R	+	+												+										R				R			F	+					+		+			R						
		NN17	14-4, 50-51	M		F	+	R		F	+					+	+					+		R		R								+				R			R					+	+					R						
			14,CC	M		R	R	R		+							+							+		+								+				+			R	+			+	+					+	+						+
		NN16	15-2, 50-51	M		R	+			F	R	+				+		+						+										R				R			+	+					+	+				R						
			15-4, 50-51	M		R	+	R		F	+	+				+		+			+					R								+				+			R	+				+	+					+						
			15,CC	M		F	R	+		F							+				+			+										+				+			+	+				+						+						
			16-2, 50-51	M		+	F	+		+	+					+																		+				+			+	+					+					+						
			16-4, 50-51	M		F	R	R		R	+	+				+	+	+	+					+														+			+	R				+	+					+						
			16,CC	M		F	+	+	+	F	+	R	+			+		+	+					+		+								+	+		+	R			R	R				+		+				R						
			17-2, 50-51	M		F	R			F	+	+	+		+	+	+							+		+								+				F	+		R					+						R						
			17-4, 50-51	M		F	R	+		C	+		+			+	+	+	+		+			+		F									+			F			R	+				+	+		+			+						
			17,CC	M		F	R	R		A	+	+														F								+				+			R	R				+						R						
			18-2, 50-51	M		R	F			C			+											+		F								+				+			R	+				+	+	+				R						
			18-4, 50-51	M		F	+	+		C		+	R	+										+											+			R				R				+		+				+						
			18,CC	M		F	F			C	+	+	R											+		R												+				R										+						
			19-2, 50-51	M		F	F			F	+	+	+		+	+										+												+	+		+	+			R	R		+				R						
			19-4, 50-51	M		R	R			F		+	+											+		+								+	+			+				+				+						F	+					
			19,CC	M		C	R	+		C	R	+	+		+	+			+					+		R								+	+						R	R					+					R						
			20-2, 50-51	M		C	R			F	+	+											R			R								R	+			+								+			+			R						
	early	NN15	20-4, 50-51	M		C	C	+		C							+						+			R												+				R				+												
			20-6, 50-51	M		C	F			F	+	R	+											R		R								+							+	+				+	+		+			+						
			20,CC	M		C	R			C			+									+																				F					+	+	+			+						
			21-2, 50-51	M		C	F	R		C	+	+	R											R										+	+							F					+			+		+						
			21-4, 50-51	P		F	F			F			+		+							+												R				R				R						+	+	+	+	R						
			21,CC	P		C	R			C	+		F								+													+	R							F							+	+		R	+					

Note: See Table 3 and text for an explanation of symbols.

Table 16. Distribution of calcareous nannofossils, Hole 610B.

Age	Nanno-fossil zone	Sample	Preservation	*Acanthoica* spp.	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus cristatus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Cyclolithella annula*	*Discoaster asymmetricus*	*D. brouweri*	*D. pentaradiatus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. granulata*	*H. hyalina*	*H. inversa*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Sphenolithus moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. saxea*	*Umbilicosphaera mirabilis*
Quaternary	NN21	1,CC	G		R			+	R													A			C		F		R		+					+	+										R			
		2,CC	G		F			+	R									+				C		+	+		+			+	R					+	+					+	+	+			R		+	
	NN20	3,CC	G		R			+	+															R	C		F			R	+			+		+	+					+			+		R			
	NN19	4,CC	M		R			+	+	+	+	+							+		+		+	R	C		F			+	+					+	R	R				+					R			
		5,CC	M		F			R	R												+		R	R	R		R		+	R	F		+					F									+			+
		6,CC	M		F															+	R		R	C	+		R		+	F	+							F		F	R	+		+			+			
		7,CC	M	+	C															+	R		F	F	R					R	R					+		C		R	R						R			
		8,CC	G	+	F			+	R	+									+	R	R		F	F	F	R	F	R		R	+				+			F				R		+			R			+
		9,CC	G		F			+	F		+									+	R		+	F	C		C			R	R				+			F				+		+			+			
		10,CC	M		F		+	+	F										+	R	+		R	R	C		R			R	+				+			C				+		R			R			
		11,CC	M	+	C	+		R	C	+	+								+	R			F	R						+	R		+			F		C				+	+	R	R		+	+		R
		12,CC	M	+	F	R		+	F		+								+	R			F	R						R	R				R		R	C				+	+	+	R		R			
		13,CC	P		F	R	R		F	+	+								+	+	+		C								+	+			R		R	F				+	R	+			+			
		14,CC	P		F	+	+		R	+	+								+	+	+		F								+				R	+	R	C				+	+				R			
late Plio.	NN16	15,CC	M		F	R	R		F		+			+	+	+							+								+	+			+	+		+	+											
		16,CC	M		R	+	+		F	+	+	+	+	+	+	+	+				+														+			+	R				R	+		+	R			

Note: See Table 3 and text for explanation of symbols.

Table 17. Distribution of calcareous nannofossils, Hole 610C.

Age	Nanno-fossil zone	Sample	Preservation	*Acanthoica* spp.	*Calcidiscus leptoporus*	*C. macintyrei*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Cyclolithella annula*	*Discoaster brouweri*	*D. deflandrei*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. oceanica*	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Syracosphaera pulchra*	*Umbilicosphaera mirabilis*
Quat.	NN21	1,CC	G		F		+	+							+	+	C			R	+			R		+	R			+		R	+	R	
	NN20	2,CC	G		F		R	R	+	+						+			R	F	F	R	+	+		+	+					+		+	
	NN19	3,CC	M		F		+	R	+	+								R		C	F			R	+		+	F			+			+	+
		4,CC	M	+	F						+							R	F				F	+				C						R	
late Plio.	NN18	5,CC	M		F	R	C	A		+		R	+		+	R		R	R					+	+			R		+	R			F	+
		6,CC	M		F	F	C	A		R				R				R									R	+	+		R			F	

Note: See Table 3 and text for an explanation of symbols.

Table 18. Distribution of calcareous nannofossils, Hole 610D.

Age	Nanno-fossil zone	Sample	Preservation	*Acanthoica* spp.	*Calcidiscus leptoporus*	*C. macintyrei*	*Coccolithus crassipons*	*C. miopelagicus*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Cyclolithella annula*	*Discoaster brouweri*	*D. challengeri*	*D. intercalaris*	*D. loeblichii*	*D. pansus*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. sinuosa*	*Helicosphaera carteri*	*H. euphratis*	*H. granulata*	*H. inversa*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*Scapholithus fossilis*	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera saxea*	*Triquetrorhabdulus rugosus*	*Umbilicosphaera mirabilis*
Quat.	NN21	1,CC	M		F		R		R	+	R											F		R	R		R	R	+				+	R									R			
	NN20	2,CC	G	+	F		+		F	+	+												R	F		F			R			+	+						+				+			
	NN19	3,CC	G		R														+		R		+	R	F		R	+	+					R	+					+			R	+		
		4,CC	G		F														+	+	+		R	R					R						R		R	+					R			+
		5,CC	G		C		+		+											R	+		F	F				R	+					+	C		R			+			R			
Mio.?	NN10?	6,CC	M		F	F			A			R	+			+		+			+								R	+	+					F					R	+			+	
		7,CC	P		R	R		+	A			+	+	+	+		+	+													+					C					F	R			+	

Note: See Table 3 and text for an explanation of symbols.

Table 19. Distribution of calcareous nannofossils, Hole 610E.

Age	Nannofossil zone	Sample	Preservation	*Amaurolithus delicatus*	*A. primus*	*A. tricorniculatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Chiasmolithus* sp.	*Coccolithus crassipons*	*C. miopelagicus*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Cyclicargolithus abisectus*	*Dictyococcites bisectus*	*Discoaster adamanteus*	*D. berggreni*	*D. deflandrei*	*D. exilis*	*D. intercalaris*	*D. loeblichii*	*D. neohamatus*	*D. pansus*	*D. quinqueramus*	*D. surculus*	*D. triradiatus*	*D. variabilis*	*Helicosphaera carteri*	*H. granulata*	*H. intermedia*	*Reticulofenestra pseudoumbilica*	*Sphenolithus abies*	*S. moriformis*	*Triquetrorhabdulus rugosus*
Plio.	NN12	1,CC	M	+		+	C	F			F	C			+	+					+	R	+					+		+		R		C			+
late Miocene	NN11	2,CC	M	+	+		C	R		R	+	C				+				+							+	+	+	+		+		C	F	R	+
		3,CC	M		+		F	+			F	A	+							+						+	+			+		+		F	R	+	+
		4,CC	M				F	F	+	+	R	A		+		+		+		+			+					+		+	+	R		F	R	+	+
		5,CC	M				F	F		+	R	A				+								+			R	+		+	+			F	F	+	
		6,CC	M				F	+	+	+		A				R	+	+	+	+				+	+		+			R		R	+	+	R	+	
	NN10	7,CC	M				F	+		+		A				R					+				+					+	F	+		C	R	+	

Note: See Table 3 and text for an explanation of symbols.

Amaurolithus and *Ceratolithus* are absent or extremely rare in this hole, and thus the boundaries between NN15/NN14 and NN13/NN12 are uncertain. *Discoaster quinqueramus* first occurs in Sample 31,CC, and the interval from this sample down to 43,CC is assigned to the NN11 (*Discoaster quinqueramus* Zone). Below this, Samples 44-2, 34–35 cm through 45,CC contain no *Discoaster quinqueramus* specimens and may belong to NN10 (*Discoaster calcaris* Zone). In samples from Cores 46 and 47, a few specimens of *Discoaster hamatus* are found. If these are not reworked specimens, these cores can be assigned to the middle Miocene (NN9, *Discoaster hamatus* Zone): the bottom sediments of this hole are slightly older than 11 Ma.

Hole 611D (Table 24)

The uppermost sample (Sample 1,CC), which was obtained after washing down to 5.5 m sub-bottom, is assigned to the early Pleistocene *Pseudoemiliania lacunosa* Zone (NN19). This sample, characterized by the abundant occurrence of *Pseudoemiliania lacunosa* and the absence of discoasters, also contains *Gephyrocapsa oceanica* and *G. caribbeanica*, but *Calcidiscus macintyrei* and *Helicosphaera sellii* are not present. Core-catcher samples from Cores 2 through 11, which were continuously cored after washing down to 128.9 m sub-bottom, are all placed in the late Pliocene *Discoaster surculus* Zone (NN16), based on the occurrences of discoasters such as *Discoaster brouweri, D. pentaradiatus*, and *D. surculus*. Although *Reticulofenestra pseudoumbilica* is present throughout this zone, samples below 12,CC contain comparatively abundant *Reticulofenestra pseudoumbilica*. Therefore, the lowest three samples are assigned to NN15 (*Reticulofenestra pseudoumbilica* Zone).

Hole 611E (Table 25)

Hole 611E, the last hole drilled during Leg 94, was washed down to 6.5 m sub-bottom, and two cores were obtained. Core-catcher samples from these cores contain *Pseudoemiliania lacunosa, Emiliania ovata, Helicosphaera carteri, Calcidiscus leptoporus, Gephyrocapsa caribbeanica, G. oceanica*, and *Syracosphaera pulchra* together with abundant small placoliths referred to *Gephyrocapsa*. Therefore these samples are placed in the early Pleistocene *Pseudoemiliania lacunosa* Zone (NN19).

DATUM PLANES AND THEIR CALIBRATION TO MAGNETOSTRATIGRAPHY

The relatively undisturbed cores recovered on Leg 94 are ideally suited for accurate, detailed, and direct correlation of paleomagnetic stratigraphy and biostratigraphy. A detailed paleomagnetic investigation was carried out by Clement and Robinson (this volume).

On the basis of piston cores from numerous ocean basins and land-based marine sections, a late Neogene biochronology was developed over a decade ago. In 1974, Ryan et al. synthesized the available paleomagnetic and biostratigraphic data from numerous piston cores from the equatorial Pacific and Neogene sections in Europe and New Zealand. They presented a compilation of datums for the planktonic foraminifers, radiolarians, and calcareous nannofossils. Until recently these data have been used essentially unchanged as a good working model. Gartner (1973) carried out the first direct correlations of paleomagnetic data and upper Neogene nannofossil biostratigraphy in piston cores from the equatorial Pacific. Subsequently Pleistocene nannofossil biochronology was further investigated and widely documented. Gartner (1977) presented a summary of nannofossil biostratigraphy and suggested a new zonation for this interval.

For the Pliocene and Miocene, however, detailed correlation of coccolith events with magnetostratigraphy was incomplete until Mazzei et al. (1979) investigated the Miocene–Pliocene sequences at DSDP Site 397 (Leg 47, Cape Bojador, eastern Atlantic) for nannofossil and planktonic foraminiferal biostratigraphy together with paleomagnetics. Backman (1979) studied foraminifers and nannofossils from DSDP Sites 111 and 116 (North Atlantic Ocean) and calibrated the ages of some of the

Table 20. Distribution of calcareous nannofossils, Hole 611.

Age	Nannofossil zone	Sample (interval in cm)	Preservation	Acanthoica spp.	Calcidiscus leptoporus	C. macintyrei	Ceratolithus rugosus	Coccolithus crassipons	C. pelagicus	C. streckeri, n. sp.	C. sp.	Cyclolithella annula	Cyclicargolithus floridanus	Discoaster asymmetricus	D. brouweri	D. pentaradiatus	D. surculus	D. triradiatus	Discolithina japonica	D. cf. japonica	D. spp.	Emiliania huxleyi	E. ovata	Gephyrocapsa aperta	G. caribbeanica	G. caribbeanica (large)	G. oceanica	G. oceanica (large)	G. parallela	G. sinuosa	Helicosphaera carteri	H. hyalina	H. sellii	H. wallichii	Oolithotus antillarum	Pseudoemiliania lacunosa	Reticulofenestra pseudoumbilica	R. sp. A	R. sp. B	Rhabdosphaera clavigera	R. longistylis	R. stylifera	Scapholithus fossilis	Scyphosphaera spp.	Syracosphaera pulchra	Thoracosphaera deflandrei	T. saxea	Umbellosphaera spp.	Umbilicosphaera mirabilis
Quaternary	NN21	1,CC	P		C			+	+													A			F		+	+	+		R	R		+	R					+	+		+	+	R	+	+		+
		2-1, 60-61	P		F				F												+	F			R		F		R		R				+					R							R		
	NN20	2-3, 50-51	P		R				R															R	C		F		R		R									+									
	NN19	2-4, 50-51	P		R			+	+	+		+									+		+		C		F				+				+	R									R				+
		2,CC	P		F				+										+	+	+		F		C		R		R		+	+			+	R				R		+			R		R		+
		3-2, 50-51	P		F			F	F	+		R									R		+	F	F		F		R	R	+				R	+							R		R		R		+
		3-4, 50-51	P		R			+	+												+		F	R	R		R		R	F	R	R			R	R									+				+
		3,CC	M		F														+		+		R	R	R		R				+			+	R	+						+			+				+
		4-2, 50-51	M		F																+		R	R	R				+	R	R	+		+	+	+									+				+
		4-3, 50-51	P		C														F	F	R		R		F		F		R		+					F									R				
		4-4, 50-51	P		C														F	R	R		F	R	F		F		+		R					R		C	F										
		4-5, 50-51	G	+	F				+											R	+		R		+		R		+		+				+	R		R	+		+	+	+		R				+
		4-6, 50-51	M		F															R	+		R	R	+		+			R	+				+	F		R	+	+			+		+				+
		4,CC	M		F							R							+	+	+		F	F			+			F	R				R	R		F	R	+			R		R				R
		5-2, 50-51	M		F														+	R			R	R	+					F	+				R	R		R	R						R		+		+
		5-4, 50-51	M		F							+							R	+	+		+	F						F	+				R	R		R	+	R	+	+	+		R			+	+
		5,CC	M		F			+											R	R	R		C	+	+					R	R				F	F		+					+		R				R
		6-2, 50-51	P		F			+	R										R		R		F	F	F	F	R	F		R					R	R							R						R
		6-3, 50-51	M		F			+	R										R		R		R	F	F	F	R	F			R				R	F				+			+		R				+
		6-4, 50-51	G		F			+	+										+	+	R		F	R	F	F	F	F		F	R		R		R	R				+					+				+
		6,CC	M		C			+	R			+							+	R	R		F	R	C	R	F	R		F	+		R	+	+	R				+		+	+		+		+		+
		7-1, 50-51	G		C			R	C		+								+	+	R		R	R	F		F			R	+	+	R	+	R	R				+	+	+	+		+		+		R
		7-2, 50-51	P		F			R	F	+	+								+	R	R		R	F	C		C			F	R		F	+	R	+		+		R	+	+			+				R
		7-4, 50-51	M		F			+	F		+								+	+			+	R	C		C			F	R		R		R	R				+									+
		7,CC	M		R			R	C		R								+	R	R		+	R	F		+			F	R		R			R							R		R				
		8-1, 50-51	M		F	R		+	F											+	+		+	F	+					F	+		R	+	F	R				+		+			R				R
		8-2, 50-51	P		F	+		+	+			+							+	R			R	F	F					F	R		+		+	R				+		+							+
		8-4, 50-51	P		F	R		F	C										+	+			F	R	R					R	+		F		R	R				R					R	+			
		8-5, 50-51	G		C	+		R	F	+	+									+	R		R	R						R	R	+	R	+	+	R				+			+		R	+			R
		8,CC	G		C	+		F	C	+	+	+							+	R			F	R							R		F			R				R			R		R	+			+
		9-2, 50-51	G		R	+		C	A	R		+								R			R	R						R	+		+	+		R									+				R
late Pliocene	NN18	9-3, 50-51	G		F	R		+	F	+					+			+	+	R	+		+	R							R	R	+			R				+		+	+		R				+
		9-4, 50-51	M		C	R		+	F										+	R	+		R	R						F	R	+	R	+		F				R		+	+		+				R
		9,CC	M		C	+		F	A	+	+									F			R	R							R		F		R	F				+		+			R				R
		10-2, 50-51	M		F	+		R	F						+					F			R	R						R	R		C	+	R	R				+		+		+	R				F
		10-4, 50-51	G		F	R		F	A	+	+				+				+	F	+		R								+		F	+	R	F				R	+	+			F				R
		10,CC	P		C	R		F	C	+					+				F	R			R							R	R		F	+	R	F													R
		11-2, 50-51	G		F	+		R	F											R	F		F	R							+		R			R				+		+			R				
		11-4, 50-51	G		F	R		F	C	R	+	+									R		F								R		R			R					+	R			R				F
		11,CC	G		C	+		F	C		+				+			+	+	+	+		R								R		F	+		R						R			R				+
		12-2, 50-51	M		F	R	+	+	C	+																									R	R	+												R
		12-4, 50-51	G		C	+		R	C	R	R	+			+				R	F	+		F								R		F	R		R					+	+		+	F				
		12,CC	G		F	R			F	+					+				F	C			F								R					F					+				R				
	NN17	13-1, 50-51	G		R	A					+		R			+																					R								R				
		13-2, 50-51	M		F	R		+	C	R				+	+	+			+	+	+		F	R							R		F			F				+	R	+			R				R
	NN16	13-3, 50-51	M		R	R		+	F	+	+	+				+	+		+		+		F								+		+	+		F				+	+	+		+	+				
		13-4, 50-51	M		F	R		F	F	+	R				+	+	+			+	+		F								R		R	+		F	R								R				
		13,CC	G		R	R		R	C	+					+	+	+		+	+			R								R		R	+		F	R			+					R				+
		14-2, 50-51	G		F	+		R	F	+	+	+			+	R	+		+				R								R		R			R	+				+	+			+				+
		14-4, 50-51	G		F	R		R	F						+	+	+		R	+	+		F								+		R	+		F				+	R				F				R
		14,CC	M		F	+			A						+	+	+						F													R	R												

Note: See Table 3 and text for an explanation of symbols.

Table 21. Distribution of calcareous nannofossils, Hole 611A.

Age	Nannofossil zone	Sample	Preservation	*Acanthoica* spp.	*Calcidiscus leptoporus*	*C. macintyrei*	*Ceratolithus rugosus*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Cyclolithella annula*	*Discoaster brouweri*	*D. pentaradiatus*	*D. surculus*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. hyalina*	*H. sellii*	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. saxea*	*Umbilicosphaera mirabilis*
Quaternary	NN21	1,CC	G		F			+	+	+	+					+	+		F		F	+		+		+	R	+	+		+	R				+			+		R		+	+
	NN19	2,CC	M		F											+					+	C		F		R	+	+			+	+	R			+					+			+
		3,CC	P						+																								+											
		4,CC	G	+	R							+					R	+		R	F	+					R	+					F	R	R	+	+	+	R	+	R			+
		5,CC	P		+				+											+		+	+	+	+			+					+	+										+
		6,CC	G		F			R	F		+						R	+		R	F	C		F			R				F		F			+		+			R			R
		7,CC	M		F	+		+	R								+			R	R	F						R		+	+		R			+		+			R			+
		8,CC	M		R	+		+	R		+						R	R		R	R	+					+	+	+	R		R	F			+		+			+	+		+
		9,CC	M		R	+		F	A		+						+	R		+								R		R			R								R			+
		10,CC	M		F	+		R	C		+						F	R		F	+						+	R		R			F			+		R			R		+	R
late Plio.	NN18	11,CC	M		F	R		F	A				R				R			R								+		F			C											R
	NN17	12,CC	M		F	+		+	R		+		+	+		+	+	+		C								+		F	+		C			+	+			+	+			
	NN16	13,CC	G		C	R	+	R	F	+	+		+	+	+	+				R								+		F	+		R			R					+			R

Note: See Table 3 and text for an explanation of symbols.

Table 22. Distribution of calcareous nannofossils, Hole 611B.

Age	Nannofossil zone	Sample	Preservation	*Calcidiscus leptoporus*	*Coccolithus crassipons*	*C. pelagicus*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. oceanica*	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. inversa*	*Oolithotus antillarum*	*Rhabdosphaera clavigera*	*Syracosphaera pulchra*
Quat.	NN20	1,CC	P	C	+	R	C	F	F	+	R	+	R	+	R	F

Note: See Table 3 and text for an explanation of symbols.

nannofossil datums. He also investigated some of the coccolith species biometrically (Backman, 1980). Haq et al. (1980) worked on several upper Miocene piston cores and clarified the relationships of coccolith bio- and magnetostratigraphy. Stradner and Allram (1982) and Niitsuma (1982) studied the lower Miocene from DSDP Leg 66, Site 493 in the North Guatemala Basin in the Pacific and correlated the coccolith biostratigraphy with the magnetostratigraphy there. In 1983, Backman and Shackleton estimated the ages of early Pleistocene and Pliocene nannofossil datums by interpolation between magnetic reversals. Site 516 on the Rio Grande Rise cored during Leg 72 was studied by Berggren et al. (1983), and was also investigated by Haq and Takayama (1984) together with paleomagnetically dated piston cores recovered from the equatorial Pacific. In this report, they summarized the Miocene to Recent nannofossil datum events, their correlation with magnetic stratigraphy and their inferred ages, and demonstrated that datum levels in the Pacific and Atlantic oceans seem to be synchronous. DSDP Leg 73 cores allow direct calibrations of magneto- and biostratigraphy for the latest Cretaceous to Cenozoic in the midlatitude South Atlantic Ocean, although the record of the Cenozoic was incomplete (Poore et al., 1984).

Throughout this chapter, we attempted to apply the zonal scheme established by Martini (1971), but many of his zonal marker species are warm-water forms. At Sites 610 and 611, asteroliths and ceratoliths are extremely rare or absent, and this makes it difficult to identify Martini's zones in the lower Pliocene and the upper and middle Miocene sequences.

The following Pliocene–Pleistocene coccolith events were easily recognized (in descending order):

LAD *Helicosphaera inversa*
FAD *Emiliania huxleyi*
LAD *Pseudoemiliania lacunosa*
FAD *Helicosphaera inversa*
Top of acme *Reticulofenestra* sp. A
FAD *Gephyrocapsa parallela*
LAD *Gephyrocapsa* (large)
LAD *Helicosphaera sellii*
FAD *Gephyrocapsa* (large)
FAD *Gephyrocapsa oceanica*/LAD *Calcidiscus macintyrei*
FAD *Gephyrocapsa caribbeanica*
LAD *Sphenolithus abies*

Although the following four events were rather difficult to detect at high latitudes (at Sites 610 and 611), they are usable in the present investigation;

LAD *Discoaster brouweri*
LAD *Discoaster pentaradiatus*
LAD *Discoaster surculus*
LAD *Discoaster tamalis*

The LAD of *Reticulofenestra pseudoumbilica* is one of the most important datums, which designates the boundary between the late Pliocene *Discoaster surculus* Zone (NN16) and the early Pliocene *Reticulofenestra pseudoumbilica* Zone (NN15). This species, however, occurs throughout the upper Pliocene sequences at all sites studied, which may be attributed to reworking. Therefore we used the top of the acme of this species and interpreted it as the NN16/NN15 boundary, but some-

Table 23. Distribution of calcareous nannofossils, Hole 611C.

Age		Nannofossil zone	Sample (interval in cm)	Preservation	*Amaurolithus delicatus*	*Calcidiscus leptoporus*	*C. macintyrei*	*Coccolithus crassipons*	*C. pelagicus*	*C. streckeri*, n. sp.	*C.* sp.	*Coronocyclus nitescens*	*Cyclolithella annula*	*Discoaster adamanteus*	*D. asymmetricus*	*D. berggreni*	*D. brouweri*	*D. challengeri*	*D. deflandrei*	*D. druggii*	*D. exilis*	*D.* cf. *hamatus*	*D. intercalaris*	*D. loeblichi*	*D. pansus*	*D. pentaradiatus*
		NN21	1,CC	G		R		+	R																	
			2,CC	M		F		R	F																	
		NN20	3,CC	M		F		R	R																	
Quaternary			4,CC	G		R		+	+		+															
			5,CC	P		+		+	+																	
		NN19	6,CC	M		F		+	+																	
			8,CC	G		F		R	+				+													
			9,CC	M		F		+	F				+													
			10,CC	P																						
			11,CC	M		F	+	+	F		+						+									
		NN18	12,CC	G		R	R	C	A		+															
			13,CC	G		F	+	R	C	+	+						+									
		NN17	14,CC	M		F	+		C	+	+						+									+
			15-2, 50-51	G		R	R	R	F	+	+		+													+
			15-4, 50-51	G		F	+	+	F		+						+						+			+
			15,CC			R	+	+	F						+											+
			16-2, 50-51	P		R	R	R	A	R																R
			16-4, 50-51	M		F	+		+				+		+		+									+
			16,CC	G		R	R		F				+		+		+									+
			17-2, 40-41	M		R	R	+	F						+											+
	late		17,CC	G		R	+		R								+									+
			18-2, 50-51	G		F	R		F	+							+									+
		NN16	18-4, 50-51	G		F	R		C		+				+		+						+			+
			18,CC	G		F	R	+	C	+					+		+									+
			19-2, 50-51	G		F	R		C		+				+		+						+			+
			19,CC	G		R	+		C	+	+				+		+									R
			20-2, 50-51	G		+	R		C		+		R		+		+						+			+
			20,CC	G		F	+		F	+	R		R		+		+									+
			21-1, 50-51	G		R	+		F		+		+		+		+									+
			21,CC	G		F	+		C	+			+		+		+									+
			22-2, 50-51	G		C	R		C	+	R		+		+		+	+								
Pliocene			22-4, 50-51	G		C	R	+	R				+		+		+									
			22,CC	G		F	R		R				+				+									+
			23-2, 40-41	G		C	R		C	+			+				+						+			+
		NN15 to NN14	23,CC	G		C	R	+	C	+					+		+	R								+
			24-2, 50-51	M		C	+	+	F		+		+		+		+									+
			24-4, 50-51	M		C	R		C		+		+													+
			24,CC	M		F	R		C		+		+		+											+
			26-2, 50-51	M		C	R	R	F	+	+		+													+
			26-4, 50-51	M		C	R		C				+				+									+
			26,CC	M		C	F	+	C		+		R										+			+
			27-2, 50-51	M		C	R		C	+	+		R				+									+

Sample (interval in cm)	*D. quinqueramus*	*D. surculus*	*D. tamalis*	*D. triradiatus*	*D. variabilis*	*Discolithina japonica*	*D.* cf. *japonica*	*D.* spp.	*Emiliania huxleyi*	*E. ovata*	*Gephyrocapsa aperta*	*G. caribbeanica*	*G. caribbeanica* (large)	*G. oceanica*	*G. oceanica* (large)	*G. parallela*	*G. sinuosa*	*Helicosphaera carteri*	*H. granulata*	*H. intermedia*	*H. inversa*	*H. sellii*
1,CC									A			F		F		+		R				
2,CC									F		F	F		F		R	R	R				
3,CC											R	F		R				+				
4,CC						+		+		+		C		F		R		R			+	
5,CC										+	+	+		+		+		+				
6,CC						R	F	R		R	R	+		R		+	R	R				
8,CC							+	+		R	F	C	+	C	+		R	R				R
9,CC							R	+		+	F	C		F				+				F
10,CC																						
11,CC				+			+			R	R							R				R
12,CC											R	R										+
13,CC						+	R	R		R	R							+				F
14,CC						+	+	R		R								R				R
15-2, 50-51		+								F								R				+
15-4, 50-51		+				R	+	+		R												R
15,CC		+				+	+			F								R				R
16-2, 50-51																		+				+
16-4, 50-51		R		+			+	+		+								R				+
16,CC		R		+			+	+		+								R				+
17-2, 40-41						R	+			R												R
17,CC		+				+		+		+												+
18-2, 50-51			+					+		R								+				+
18-4, 50-51		+	+			+		R		R								+				R
18,CC		+	+		+	+	+	R		+								R				+
19-2, 50-51		+	+			R	R	R		R												R
19,CC		+	+		+			+		F												+
20-2, 50-51		+	+					+		R								R				+
20,CC		+	+		+			+		R								+				R
21-1, 50-51		+	+					R		R								+				+
21,CC		+	+					+		R								R				F
22-2, 50-51			+					R		R								+				R
22-4, 50-51		+						R		F							C	+				+
22,CC		+			+			R			R							+	+			+
23-2, 40-41		+						+										+	+			
23,CC					+			R										R				R
24-2, 50-51																		+	R			
24-4, 50-51		+						+														
24,CC					+													R	+			
26-2, 50-51																			+			
26-4, 50-51																						
26,CC		+			+			+										+	+			
27-2, 50-51																		+	+			

Sample (interval in cm)	*H. wallichii*	*Oolithotus antillarum*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*R.* sp. A	*R.* sp. B	*Rhabdosphaera clavigera*	*R. longistylis*	*R. stylifera*	*Scapholithus fossilis*	*Scyphosphaera* spp.	*Sphenolithus abies*	*S. moriformis*	*Syracosphaera pulchra*	*Thoracosphaera deflandrei*	*T. heimi*	*T. saxea*	*Triquetrorhabdulus rugosus*	*Umbellosphaera* spp.	*Umbilicosphaera mirabilis*
1,CC	+	R												R					R	R
2,CC		R					+							R						R
3,CC	+	R					+			R				+						
4,CC	+	+	R							+				+			+			+
5,CC			+																	+
6,CC			R		F	+			+					+						R
8,CC	R		F				+							R			+			R
9,CC			R				+		+					R						R
10,CC																				
11,CC			F				+	+	+	+				R						R
12,CC			+											+						
13,CC			F											R						
14,CC			F				+		+		+			R						
15-2, 50-51	+		F						+					R						
15-4, 50-51	+		F						+		+			R						
15,CC			F											R						
16-2, 50-51			F	+																
16-4, 50-51	+		R	+					+					R						
16,CC	+		R	+					+					+						
17-2, 40-41			R	+																
17,CC																				
18-2, 50-51	+		+	+								+								
18-4, 50-51			R	R										+						
18,CC			R	+														+		
19-2, 50-51			R	R			+													
19,CC			R						+					R						
20-2, 50-51	+		+	R					+					R						
20,CC			R	+			R							+						
21-1, 50-51			F											+						
21,CC	R		R	+					+					R		+				
22-2, 50-51	R		R	+					+					R						
22-4, 50-51			R	+					+			+								
22,CC			R	R					+					+						
23-2, 40-41				R					+			+		+						
23,CC				R					+		+	+		+						
24-2, 50-51	R			F					+		+	+	+							
24-4, 50-51				R					+			R	+							
24,CC				R					+		+	R	+					+		
26-2, 50-51				F								+		R						
26-4, 50-51				C								R		R						
26,CC			C									+	+	R						
27-2, 50-51				C								+		+						

Miocene	early	NN13 to NN12	27-4, 50-51	M		C			C			+	+				+									+		+																+	R							C										+		
			27,CC	M	+	F	F	+	C				+				+									+		+			+													F	R							C								R		+		
			28-2, 50-51	M		C	+	+	F				R				R									+		+						R										R	+				+			C							+	R	R	R		
			28-4, 50-51	M		F		+	C		+		R				+									+								+										R					+			C					+		+	+		R		
			28,CC	M	+	C	R	+	F				+				+						+	+				+			+			R										R	+							C								+		R		
			29-2, 50-51	M		C	R		F				R				+									+		+			+			+										R								C					+			+		+		
			29-4, 50-51	M		C	+		C		+		+				+									+																		R	R							C								R		+		
			29,CC	M	+	C	R		R			R	+				+						+			+		+		+	+													R	F							C								+	+	R		
			30-2, 50-51	M		C	R		F		+		+				+									+		+			+			+										F	R							C							+	R				
			30-4, 50-51	M		C	R		C				+													+																		R	+							A								+	+			
			30,CC	M		C	R		C				R			+	+	+					+			+		+			+			R											R				+			C								R	+			
			31-2, 50-51	M		C	F		C	+	+		+				+									+		+						R										+	F							F								+	+	R		
			31-4, 50-51	M		F	F		C				+													+					+			+										+	R							F								R	+			
	late	NN11	31,CC	P		C	+	R	C		+	R					+						+		+	+	+	+			+													R								C					+			+	+			
			32-2, 50-51	P		C	+	+	C		+		R					+								+	+				+													+								C								+	R			
			32-4, 50-51	P		C	R		C		+		R													+								+										R								F								+	R			
			32,CC	G		F	R	+	+				+										+			+	+	+			+													R	+							F								+	+			
			33-2, 50-51	M		F	+	R	F				+				+									+	+							+										R	+							F								+	+			
			33-4, 50-51	M		R	R		C				R																					+											R							F					+			+			+	
			33,CC	M		R	+		C				+		+			+								+		+			+			R										+	+							F								+	+			
			35-2, 50-51	M		F			R				+																		+			R										+	+							F								+				
			35,CC	M		F	R	+	C				R										+				+				R			R											+	+						C												
			36-2, 70-71	M		C	F	R	C																	+	R	+																	+							C								R	+			
			36-4, 70-71	M		F	F		C			R	R	+	+																+			R																		C								R				
			36,CC	M		C	F	R	C				R		R								+				+				+													+	+							C								F	+			
			37-3, 50-51	M		C	F	R	A		+	R															+				+			R											R							C												
			37,CC	M		C	F		A		+		+														+	+			+														+							C								+				
			38-2, 50-51	M		F	F	+	C				R	+			+										+				R													+	+				R			A										R		
			38-4, 50-51	M		C	R		C				+	+	+								+				+				+														R						C													
			38,CC	M		C	R	+	C				+				R						+				+				+														+							C								+				
			39-2, 52-53	P		C	R		C				R		+		+	+								+	+				+													R	R				+			C								+	R			
			39-4, 44-45	P		+		+	+						+		+	+									R				+													+								C								+	+			
			39,CC	M		F	R	+	C	+	+				+		+	+					+				+				+																			R		C								R				
			40-2, 44-45	M		C	R		C		+				+		+									+	+				R																					C									+			
			40,CC	M		F	F		C		+		+		+											+	+																									C								+	+			
			44-2, 50-51	M		F	F		A				R		+			+			+						+				+																					C								+	+			
			44-4, 48-49	M		F	F		C		+				+						+						+				+			R											+							A												
			41,CC	M		F	R	R	A	+	+				+		+	+					+				+	+			+			F											+						C	C								R	+			
			42-2, 50-51	M		C	R	+	C		+				+			+			+						+	+			+																					C								+				
			42-4, 52-53	M		F	F		A						+		R	+								+	+	+			F													+	+				+			C								+	+			
			42,CC	M		R			A				+	R	+		+	+					+		+		+				+														+				R											R	+			
			43-2, 52-53	G		F	R		A						+		+	+					+				+	R			R																					C								R	+			
			43-4, 30-31	M		F	R	R	A																		+	+			+																					C								F	+			
			43,CC	G		F	F		A		R			R	+			+					R	+		+	+				R													R					+			C								R	+			
		NN10	44-2, 34-35	M		F		R	A		R		R				+						+								+													R								C								R				
			44-4, 43-44	M		F	+		A																						+													F		+						F								R	+			
			44,CC	M		R	+		A								+		+												+													R		+			+	+		F								R				
			45-2, 77-78	P		F	+		A			+					+																											R					+			C								F	R			
			45-4, 61-62	P		+	+		A								+														+			+										R					+			F								F	+			
			45,CC	M		+			A		+		R			+		+													R			+										+					R			F								+	+	R		
	middle	NN9?	46-2, 50-51	M		R			A										R																									R								C								R	R			
			46-4, 50-51	P		+	R		A																						+																					C								F	F			
			46-6, 50-51	P		R	R	R	A																																			+								C								R	R			
			46,CC	P		F	R	+	C													+									+													R								C								+	+			
			47-2, 50-51	P		F	R		A											+		+			+						+													+		R						C								R				
			47-4, 50-51	P		F	F		C																																			+								C								F	F			
			47,CC	P		F	F		C					+								+									+													+					+			C								F	R			

Note: See Table 3 and text for an explanation of symbols.

Table 24. Distribution of calcareous nannofossils, Hole 611D.

Age		Nannofossil zone	Sample	Preservation	Amaurolithus delicatus	Calcidiscus leptoporus	C. macintyrei	Coccolithus crassipons	C. pelagicus	C. streckeri, n. sp.	C. sp.	Cyclolithella annula	Discoaster asymmetricus	D. brouweri	D. challengeri	D. intercalaris	D. pentaradiatus	D. surculus	D. tamalis	D. triradiatus	D. variabilis	Discolithina japonica	D. cf. japonica	D. spp.	Emiliania ovata	Gephyrocapsa aperta	G. caribbeanica	G. oceanica	G. sinuosa	Helicosphaera carteri	H. granulata	H. sellii	H. wallichii	Oolithotus antillarum	Pseudoemiliania lacunosa	Reticulofenestra pseudoumbilica	Rhabdosphaera clavigera	R. longistylis	R. stylifera	Scyphosphaera spp.	Sphenolithus abies	S. moriformis	Syracosphaera pulchra	Umbilicosphaera mirabilis
Quat.		NN19	1,CC	M		F																		+	+	R	C	F	+	R			+	+	R		+	R					R	+
Pliocene	late	NN16	2,CC	G		F	R		F			+					+	+				+		R	R					R		+	+		F	R	+	+					R	
			3,CC	G		F	+	+	R			+	+				+	+				R	+	+	R					+		R			R	R							+	
			4,CC	G		R	R	+	F	+	+	R	+	+			+	+				+		R	R					+		R	+		+	+							R	
			5,CC	G		F	+	+	F	+	+	+	+				+	+	+			+		+	+					+		+		R	+	R	+	+	+				R	
			6,CC	G		F	F	R	C	+	+	+	+	+		+	+	+				R		R	F					+		R			F				+				+	
			7,CC	G		F	+	+	A		+	+		+				+	+						F					+		+			R									
			8,CC	G		+	+		C	+	+	+	+	+			+		+	+		+		R	R					+		+	+		F		+	+	+				F	
			9,CC	G		R	+		F	+	+	+	+	R			+	+	+		+			+	R					+		R	R	R	+			+					R	
			10,CC	G		F	R		F	+	+	R	+	+				+	+					+						+		R		R	+	R		+	+	+			+	
			11,CC	G		F	R	R	C	+	+	R	+	+			+	+						+	+			R	R	R		+	+		F	+		F	R	+	+		+	
	early	NN15	12,CC	M	+	F		+	F	+		+	+	+	+		+					+		R	+					+		F			+	R		+	+		+		R	
			13,CC	G		C	F		C	+	+	+	+	+			R	+	+					+							+	+				F			R		+			
			14,CC	G		F	R		C	+	R	+		+	+		+							+						R	+	+			R	R			R		R	+	R	

Note: See Table 3 and text for an explanation of symbols.

Table 25. Distribution of calcareous nannofossils, Hole 611E.

Age	Nannofossil zone	Sample	Preservation	Calcidiscus leptoporus	Coccolithus pelagicus	Discolithina japonica	D. spp.	Emiliania ovata	Gephyrocapsa aperta	G. caribbeanica	G. oceanica	G. parallela	G. sinuosa	Helicosphaera carteri	H. hyalina	H. wallichii	Oolithotus antillarum	Pseudoemiliania lacunosa	Rhabdosphaera clavigera	Scapholithus fossilis	Scyphosphaera spp.	Syracosphaera pulchra	Thoracosphaera saxea	Umbilicosphaera mirabilis
Quat.	NN19	1,CC	G	F	+	+	+	+	R	F	F	R		R	+	+	R	F	+			R	+	+
		2,CC	G	+		+	+	R	F	R	+	R	R	+	+		+	R		+	+	+		+

Note: See Table 3 and text for an explanation of symbols.

times it is difficult to recognize the top of the acme precisely.

A continuous Miocene sequence was recovered from Hole 608, where the following nannofossil events were easily recognized:

LAD *Coccolithus miopelagicus*
LAD *Cyclicargolithus floridanus*
LAD *Sphenolithus heteromorphus*
LAD *Sphenolithus belemnos*

The stratigraphic range of *Discoaster quinqueramus* marks the late Miocene *Discoaster quinqueramus* Zone (NN11). In the upper part of this zone, the central stem of this species is not prominent, and the upper limit of this zone is difficult to determine. *Catinaster coalitus, Discoaster kuglerii*, and *D. hamatus* are very rare. *Helicosphaera ampliaperta* occurs sporadically.

The stratigraphic levels of all useful calcareous nannofossil events mentioned above are tabulated for each site in Table 26. The magneto- and biostratigraphic relationships of Pliocene and Pleistocene sequences at each site are shown in Figure 2.

Helicosphaera inversa is found only at Sites 606, 607, and 608. The FAD of *Emiliania huxleyi* and the LAD of *Pseudoemiliania lacunosa* are recognized in the Brunhes Chronozone. Seven nannofossil datums in Hole 608 (from the LAD of *Helicosphaera sellii* to the LAD of *Discoaster surculus*) are recognized at much higher levels compared to the other sites. This discrepancy may be attributed to redeposition or a small-scale slump, as already mentioned. The FAD of *Gephyrocapsa oceanica* and the LAD of *Calcidiscus macintyrei* occur just above the Olduvai Event. At Site 611, however, this datum is slightly below and within the Olduvai Event. The LAD of *Discoaster brouweri* occurs at around the base of the Olduvai Event, and its synchroneity at different latitudes is demonstrated. The LAD of *Discoaster tamalis* occurs in the upper part of the Gauss Chronozone. The LAD of *Sphenolithus abies* is within the uppermost reversed polarity interval of the Gilbert Chronozone and is synchronous at all sites except at Site 610. At this site, this datum occurs well below the expected level, which may be ecologically controlled.

Early and middle Miocene magneto- and biostratigraphic relationships in Hole 608 are shown in Figure 3. The LAD of *Coccolithus miopelagicus* and *Cyclicargolithus floridanus* are useful in correlating Miocene sediments at high latitudes; both occur in Chron C5. The LAD of *Sphenolithus heteromorphus* is in Core 32, which

Table 26. Calcareous nannofossil events at each site.

Datum	606	607	608	609	610A	611 and 611C
Helicosphaera inversa top	1,CC/2-2, 47–48	1-4, 47–48/1,CC	1-2, 46–47/1-4, 46–47	—	—	—
Emiliania huxleyi base	2-2, 47–48/2-3, 47–48	2-2, 51–52/2-2, 47–48	1-4, 46–47/1-5, 46–47	2-2, 43–45/2,CC	2-6, 70–71/2,CC	2-1, 60–61/2-3, 50–51
Pseudoemiliania lacunosa top	2-5, 47–48/2-6, 47–48	2-5, 47–48/2-6, 47–48	2-2, 46–47/2-3, 46–47	3-4, 43–45/3,CC	3-4, 50–51/3-5, 50–51	2-3, 50–51/2-4, 50–51
Helicosphaera inversa base	2,CC/3-2, 47–48	3-2, 47–48/3-4, 47–48	2-3, 46–47/2-4, 46–47	—	—	—
Reticulofenestra sp. A (acme) top	4-2, 47–48/4-3, 47–48	5-3, 47-48/5-4, 47–48	2,CC/3-1, 46–47	6-4, 43-45/6,CC	5-5, 50-51/5,CC	4-3, 50–51/4-4, 50–51
Gephyrocapsa parallela base	4-3, 47–48/4-4, 47–48	5-4, 47-48/5,CC	3-1, 46–47/3-2, 46–47	6-4, 43–45/6,CC	6-2, 50–51/6-3, 50–51	4-5, 50–51/4-6, 50–51
Gephyrocapsa (large) top	5-1, 47–48/5-2, 47–48	6-3, 47–48/6-4, 47–48	3-5, 46–47/3-6, 46–47	8,CC/9-2, 43–45	7-3, 50–51/7-4, 50–51	5,CC/6-2, 50–51
Helicosphaera sellii top	5-3, 47–48/5-4, 47–48	6-5, 47–48/6-6, 47–48	3-5, 46–47/3-6, 46–47	9-2, 43–45/9-4, 43–45	7,CC/8-1, 50–51	6-3, 50–51/6-4, 50–51
Gephyrocapsa (large) base	6-1, 47–48/6-2, 47–48	7-5, 47–48/7-6, 47–48	4-2, 46–47/4-3, 46–47	10-4, 43–45/10,CC	9-1, 50–51/9-2, 50–51	6,CC/7-1, 50–51
Calcidiscus macintyrei top / *Gephyrocapsa oceanica* base	6-5, 47–48/6-6, 47–48	8-4, 47–48/8-5, 47–48	4-5, 46–47/4-6, 46–47	12-4, 43–45/12,CC	10-1, 50–51/10-2, 50–51	7,CC/8-1, 50–51
Gephyrocapsa caribbeanica base	6,CC/7-1, 47–48	8,CC/9-1, 47–48	4-5, 46–47/4-6, 46–47	13-2, 43–45/13-4, 43–45	10-3, 50–51/10-4, 50–51	8-4, 50–51/8-5, 50–51
Discoaster brouweri top	7-6, 47–48/7,CC	9-6, 47–48/9,CC	5-4, 46–47/5-5, 46–47	15-2, 43–45/15-4, 43–45	11-3, 50–51/11-4, 50–51	9-2, 50–51/9-3, 50–51
Discoaster pentaradiatus top	9-2, 47–48/9-4, 47–48	11-2, 47–48/11-4, 47–48	5-6, 46–47/5,CC	19,CC/20-1, 43–45	14-2, 50–51/14-4, 50–51	12,CC/13-1, 50–51
Discoaster surculus top	9-4, 47–48/9,CC	12-2, 47–48/12-4, 47–48	5-6, 46–47/5,CC	20-4, 43–45/20,CC	14,CC/15-2, 50–51	13-2, 50–51/13-3, 50–51
Discoaster tamalis top	10-4, 47–48/10,CC	13-4, 47–48/13,CC	10-2, 46–47/10-4, 46–47	22,CC/24-1, 43–45	16-2, 50–51/16-4, 50–51	17,CC/18-2, 50–51
Sphenolithus abies top	15-2, 47–48/15-4, 47–48	17,CC/18-2, 47–48	12,CC/13-2, 46–47	26-4, 43–45/26,CC	20,CC/21-2, 50–51	22-2, 50–51/22-4, 50–51
Coccolithus miopelagicus top	—	—	26-3, 46–47/26-4, 46–47	—	—	—
Cyclicargolithus floridanus top	—	—	28-2, 46–47/28-4, 36–37	—	—	—
Sphenolithus heteromorphus top	—	—	32-5, 26–27/32,CC	—	—	—
Helicosphaera ampliaperta top	—	—	35,CC/36-2, 46–47	—	—	—
Sphenolithus belemnos (top)	—	—	28-4, 46–47/38,CC	—	—	—

Note: — indicates no data; top indicates LAD; base indicates FAD.

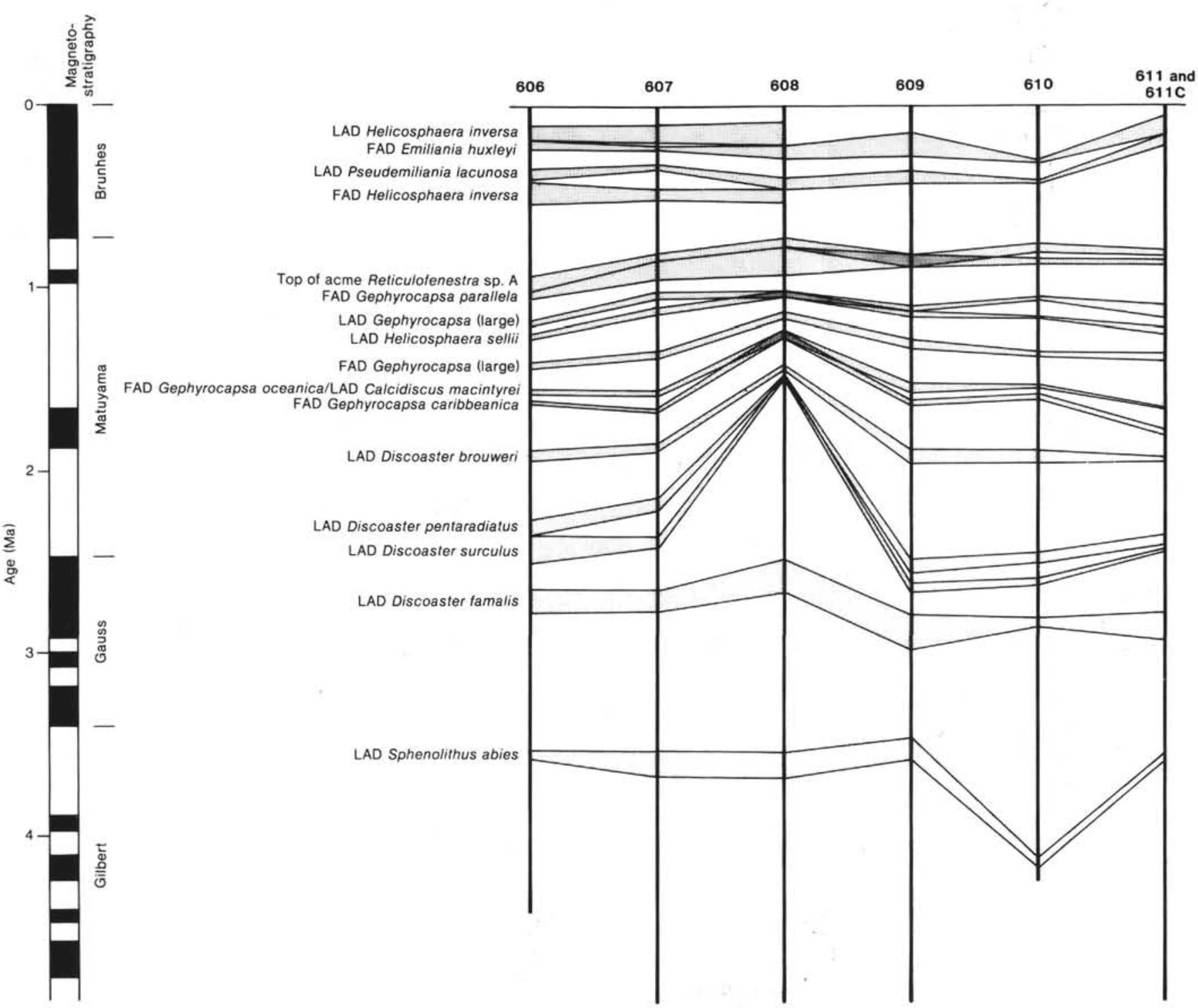

Figure 2. Pliocene–Pleistocene magneto- and biostratigraphic relationships at each site.

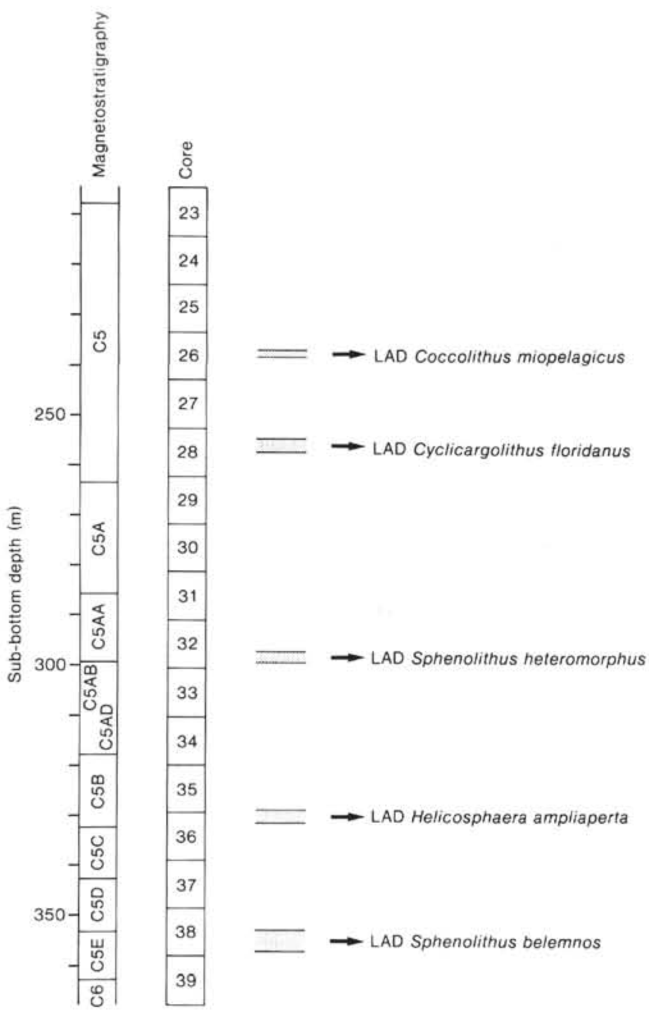

Figure 3. Early to middle Miocene magneto- and biostratigraphic relationships at Site 608.

corresponds to Chron C5AA. *Helicosphaera ampliaperta* disappears in Cores 35 or 36, and in Chron C5B. We found the LAD of *Sphenolithus belemnos* in the upper part of Chron C5E or the lowest part of Chron C5D.

The ages of all datums mentioned are estimated at every site by interpolation between magnetic reversals using the time scale of Berggren et al. (in press); the ages are shown in Table 27. Finally we derived tentatively average ages of these Pleistocene to Miocene calcareous nannofossil events from Table 27 and tabulated them in Table 28.

Helicosphaera inversa is absent at Sites 610 and 611; and therefore the LAD and the FAD of this species cannot be used at high latitudes. The LAD of *Sphenolithus abies* may be ecologically controlled, and thus this event is not reliable for age assignments.

FLORAL REFERENCE LIST

Thirty-one genera and 108 species were recognized during the investigation of the core samples from the Leg 94 holes. One new species is described. The original references are given for each of the species, and brief remarks are added to some. Bibliographic references of previously described species may be found by consulting Loeblich and Tappan (1966, 1968, 1969, 1970a, 1970b, 1971, 1973) and *Catalogue of Calcareous Nannofossils* by Farinacci (1976–1983).

Genus *ACANTHOICA* Lohmann, 1903

***Acanthoica* spp.**

Genus *AMAUROLITHUS* Gartner and Bukry, 1975

***Amaurolithus amplificus* (Bukry and Percival)**

Ceratolithus amplificus Bukry and Percival, 1971, p. 125, pl. 1, figs. 9–11.
Amaurolithus amplificus (Bukry and Percival) Gartner and Bukry, 1975, pp. 454, 456, figs. 6g–l.

***Amaurolithus delicatus* Gartner and Bukry**
(Plate 6, Figs. 1a, b)

Ceratolithus primus Bukry and Percival, 1971. Bukry 1973, p. 676, pl. 1, fig. 11.
Amaurolithus delicatus Gartner and Bukry, 1975, pp. 456, 457, figs. 7a–f.

***Amaurolithus primus* (Bukry and Percival)**
(Plate 6, Figs. 2a, b)

Ceratolithus primus Bukry and Percival, 1971, p. 126, pl. 1, figs. 12–14.
Amaurolithus primus (Bukry and Percival) Gartner and Bukry, 1975, p. 457, figs. 7g–l.

***Amaurolithus tricorniculatus* (Gartner)**
(Plate 6, Figs. 3a, b)

Ceratolithus tricorniculatus Gartner, 1967, p. 5, pl. 10, figs. 4–6.
Amaurolithus tricorniculatus (Gartner) Gartner and Bukry, 1975, pp. 457, 458, figs. 8c–h.

Genus *BRAARUDOSPHAERA* Deflandre, 1947

***Braarudosphaera bigelowii* (Gran and Braarud)**

Pontosphaera bigelowii Gran and Braarud, 1935, p. 389, fig. 67.
Braarudosphaera bigelowii (Gran and Braarud) Deflandre, 1947, p. 439, figs. 1–5.

Genus *CALCIDISCUS* Kamptner, 1952

***Calcidiscus formosus* (Kamptner)**
(Plate 1, Figs. 9a, b)

Cyclococcolithus formosus Kamptner, 1963, p. 163, pl. 2, fig. 8.
Cyclococcolithina formosa (Kamptner) Wilcoxon, 1970, p. 82.
Calcidiscus formosus (Kamptner) Loeblich and Tappan, 1978, p. 1391.

***Calcidiscus leptoporus* (Murray and Blackman)**
(Plate 1, Figs. 6a, b, 7a, b; Plate 8, Figs. 1a, b)

Coccosphaera leptopora Murray and Blackman, 1898, p. 430, pl. 15, figs. 1–7.
Cyclococcolithus leptoporus (Murray and Blackman) Boudreaux and Hay, 1969, pp. 263, 264, pl. 2, figs. 13, 14; pl. 3, figs. 1–6.
Calcidiscus leptoporus (Murray and Blackman) Loeblich and Tappan, 1978, p. 1391.

***Calcidiscus macintyrei* (Bukry and Bramlette)**
(Plate 1, Figs. 8a, b)

Cyclococcolithus macintyrei Bukry and Bramlette, 1969, p. 132, pl. 1, figs. 1–3.
Calcidiscus macintyrei (Bukry and Bramlette) Loeblich and Tappan, 1978, p. 1392.

Genus *CATINASTER* Martini and Bramlette, 1963

***Catinaster coalitus* Martini and Bramlette**

Catinaster coalitus Martini and Bramlette, 1963, p. 851, pl. 103, figs. 7–10.

Table 27. Calcareous nannofossil events and their ages (Ma) calculated for each site.

Datum	606	607	608	609	610A	611 and 611C
Helicosphaera inversa top	0.10/0.18	0.10/0.20	0.09/0.22	—	—	—
Emiliania huxleyi base	0.18/0.23	0.21/0.24	0.22/0.29	0.15/0.28	0.30/0.32	0.06/0.16
Pseudoemiliania lacunosa top	0.34/0.40	0.32/0.35	0.40/0.46	0.36/0.43	0.41/0.43	0.16/0.22
Helicosphaera inversa base	0.41/0.53	0.45/0.51	0.46/0.53	—	—	—
Reticulofenestra sp. A (acme) top	0.91/1.01	0.81/0.85	0.73/0.78	0.82/0.89	0.76/0.81	0.80/0.83
Gephyrocapsa parallela base	1.01/1.05	0.85/0.95	0.78/0.93	0.82/0.89	0.84/0.87	0.85/0.88
Gephyrocapsa (large) top	1.17/1.20	1.02/1.06	1.02/1.05	1.10/1.13	1.05/1.07	1.10/1.17
Helicosphaera sellii top	1.24/1.27	1.10/1.14	—	1.13/1.16	1.16/1.17	1.22/1.26
Gephyrocapsa (large) base	1.39/1.43	1.34/1.38	—	1.28/1.33	1.35/1.38	1.36/1.40
Calcidiscus macintyrei top, *Gephyrocapsa oceanica* base	1.54/1.57	1.55/1.58	—	1.52/1.57	1.53/1.55	1.66/1.67
Gephyrocapsa caribbeanica base	1.60/1.62	1.65/1.67	—	1.61/1.64	1.58/1.61	1.78/1.81
Discoaster brouweri top	1.87/1.93	1.84/1.89	—	1.88/1.93	1.89/1.96	1.93/1.96
Discoaster pentaradiatus top	2.25/2.34	2.14/2.21	—	2.48/2.55	2.45/2.50	2.38/2.41
Discoaster surculus top	2.34/2.47	2.35/2.41	—	2.60/2.65	2.58/2.62	2.43/2.45
Discoaster tamalis top	2.63/2.76	2.64/2.76	2.48/2.66	2.78/2.97	2.80/2.85	2.77/2.92
Sphenolithus abies top	3.51/3.56	3.52/3.66	3.53/3.67	3.45/3.57	4.10/4.16	3.54/3.58
Coccolithus miopelagicus top	—	—	10.19/10.26	—	—	—
Cyclicargolithus floridanus top	—	—	10.97/11.09	—	—	—
Sphenolithus heteromorphus top	—	—	13.14/13.19	—	—	—
Helicosphaera ampliaperta top	—	—	15.89/16.12	—	—	—
Sphenolithus belemnos top	—	—	18.57/18.91	—	—	—

Note: Seven datums at Site 608, which are recognized at much higher levels compared to the other sites, are excluded. Dashes at other sites indicate no data available; top indicates LAD; base indicates FAD.

Table 28. Cenozoic calcareous nannofossil datum levels and their average ages derived from Table 27.

Datum	Age (Ma)
LAD *Helicosphaera inversa*	0.15
FAD *Emiliania huxleyi*	0.24
LAD *Pseudoemiliania lacunosa*	0.39
FAD *Helicosphaera inversa*	0.48
Top of acme *Reticulofenestra* sp. A	0.83
FAD *Gephyrocapsa parallela*	0.89
LAD *Gephyrocapsa* (large)	1.10
LAD *Helicosphaera sellii*	1.19
FAD *Gephyrocapsa* (large)	1.36
LAD *Calcidiscus macintyrei*, FAD *Gephyrocapsa oceanica*	1.57
FAD *Gephyrocapsa caribbeanica*	1.66
LAD *Discoaster brouweri*	1.91
LAD *Discoaster pentaradiatus*	2.37
LAD *Discoaster surculus*	2.49
LAD *Discoaster tamalis*	2.75
LAD *Sphenolithus abies*	3.56
LAD *Coccolithus miopelagicus*	10.23
LAD *Cyclicargolithus floridanus*	11.03
LAD *Sphenolithus heteromorphus*	13.17
LAD *Helicosphaera ampliaperta*	16.01
LAD *Sphenolithus belemnos*	18.74

Genus *CERATOLITHUS* Kamptner, 1950

***Ceratolithus acutus* Gartner and Bukry**

Ceratolithus acutus Gartner and Bukry, 1974, p. 115, pl. 1, figs. 1-4.

***Ceratolithus cristatus* Kamptner**

Ceratolithus cristatus Kamptner, 1950, p. 154; Bukry and Bramlette, 1968, p. 150, pl. 1, figs. 1, 2, 4.

***Ceratolithus rugosus* Bukry and Bramlette**
(Plate 5, Figs. 10a, b)

Ceratolithus rugosus Bukry and Bramlette, 1968, p. 152, pl. 1, figs. 5-9.

***Ceratolithus telesmus* Norris**
(Plate 5, Figs. 9a, b)

Ceratolithus telesmus Norris, 1965, p. 21, pl. 11, figs. 5-7; pl. 13, figs. 1-3.

Genus *CHIASMOLITHUS* Hay, Mohler, and Wade, 1966

***Chiasmolithus altus* Bukry and Percival**
(Plate 7, Figs. 4a, b)

Chiasmolithus altus Bukry and Percival, 1971, p. 126, pl. 2, figs. 1, 2.

***Chiasmolithus grandis* (Bramlette and Riedel)**
(Plate 7, Figs. 7a, b)

Coccolithus grandis Bramlette and Riedel, 1954, p. 391, pl. 38, figs. 1a, b.
Chiasmolithus grandis (Bramlette and Riedel) Radomski, 1968, p. 560, pl. 44, figs. 3, 4.

***Chiasmolithus oamaruensis* (Deflandre)**
(Plate 7, Figs. 6a, b)

Tremalithus oamaruensis Deflandre in Deflandre and Fert, 1954, p. 154, pl. 11, fig. 22, text-figs. 72-74.
Chiasmolithus oamaruensis (Deflandre) Hay, Mohler, and Wade, 1966, p. 388, pl. 7, fig. 1.

Genus *COCCOLITHUS* Schwarz, 1894

***Coccolithus crassipons* Bouché**
(Plate 1, Figs. 1a, b)

Coccolithus crassipons Bouché, 1962, p. 83, pl. 1, figs. 14a, b; text-fig. 3.

***Coccolithus eopelagicus* (Bramlette and Riedel)**
(Plate 1, Figs. 3a, b)

Tremalithus eopelagicus Bramlette and Riedel, 1954, p. 392, pl. 38, figs. 2a, b.
Coccolithus eopelagicus (Bramlette and Riedel) Bramlette and Sullivan, 1961, p. 141.

***Coccolithus miopelagicus* Bukry**
(Plate 1, Figs. 2a, b)

Coccolithus miopelagicus Bukry, 1971, p. 310, pl. 2, figs. 6-9.

Coccolithus pelagicus (Wallich)

Coccosphaera pelagica Wallich, 1877, p. 348, pl. 17, figs. 1, 2, 5, 11, 12.
Coccolithus pelagicus (Wallich) Schiller, 1930, p. 246, figs. 123, 124.

Coccolithus streckeri Takayama and Sato, n. sp.
(Plate 1, Figs. 4a, b; Plate 2, Figs. 1–10; Plate 8, Fig. 3)

Name. For Mr. Heinrich Strecker (1892–1981), Austrian composer.
Description. Placolith consisting of two elliptical narrow shields of which the distal shield is slightly larger than the proximal one. A large central opening approximately 3/5 the diameter of the distal shield, spanned by a narrow bridge occupying the minor axis of the ellipse.
Remarks. *C. streckeri* differs from *C. pelagicus* in having a bridge and a large central opening. The new species resembles *C. crassipons* but differs in having a more prominent bridge. The bridge is fragile, can be easily broken, and was not recognized in many specimens of this new species.
Occurrence. *C. streckeri* is never abundant but occurs in middle Miocene to Recent sediments of DSDP Leg 94.
Size. 5.5 to 7.5 μm.
Holotype. TOCCN 3538(1) (Plate 1, Figs. 4a, b).
Paratypes. TOCCN 3538(2) to 3538(11) (Plate 2, Figs. 1–10) and TOCCNS 367 (Plate 8, Fig. 3).
Type locality. DSDP Leg 94, Site 608 (608-5-5, 46–47 cm).
Depository. Technical Research Center, Teikoku Oil Co., Ltd., Tokyo.

Genus _CORONOCYCLUS_ Hay, Mohler, and Wade, 1966

Coronocyclus nitescens (Kamptner)

Umbilicosphaera nitescens Kamptner, 1963, pp. 187, 188, pl. 1, fig. 5.
Coronocyclus nitescens (Kamptner) Bramlette and Wilcoxon, 1967, p. 103, pl. 1, fig. 5; pl. 5, figs. 7, 8.

Genus _CRUCIPLACOLITHUS_ Hay and Mohler, 1967

Cruciplacolithus spp.

Genus _CYCLICARGOLITHUS_ Bukry, 1971

Cyclicargolithus abisectus (Müller)
(Plate 3, Figs. 1a, b)

Coccolithus? abisectus Müller, 1970, p. 92, pl. 9, figs. 9, 10; pl. 12, fig. 1.
Cyclicargolithus abisectus (Müller) Bukry, 1973, p. 703.

Cyclicargolithus floridanus (Roth and Hay)
(Plate 3, Fig. 2a, b)

Coccolithus floridanus Roth and Hay in Hay, Mohler, Roth, Schmidt, and Boudreaux, 1967, p. 445, pl. 6, figs. 1–4.
Cyclicargolithus floridanus (Roth and Hay) Bukry, 1971, pp. 312, 313.

Genus _CYCLOLITHELLA_ Loeblich and Tappan, 1963

Cyclolithella annula (Cohen)

Coccolithites annulus Cohen, 1964, pp. 237, 238, pl. 3, figs. 1a–e.
Cyclolithella annulus (Cohen) McIntyre and Bé, 1967, p. 568, pl. 5, figs. A–C.

Genus _DICTYOCOCCITES_ Black, 1967

Dictyococcites bisectus (Hay, Mohler, and Wade)
(Plate 1, Figs. 10a, b)

Syracosphaera bisecta Hay, Mohler, and Wade, 1966, p. 393, pl. 10, figs. 1–6.
Dictyococcites bisectus (Hay, Mohler, and Wade) Bukry and Percival, 1971, p. 127, pl. 2, figs. 12, 13.

Genus _DISCOASTER_ Tan Sin Hok, 1927

Discoaster adamanteus Bramlette and Wilcoxon

Discoaster adamanteus Bramlette and Wilcoxon, 1967, p. 108, pl. 7, fig. 6.

Discoaster asymmetricus Gartner
(Plate 6, Fig. 9)

Discoaster asymmetricus Gartner, 1969, p. 598, pl. 1, figs. 1–3.

Discoaster barbadiensis Tan Sin Hok
(Plate 6, fig. 16)

Discoaster barbadiensis Tan Sin Hok, 1927, p. 119.

Discoaster berggrenii Bukry
(Plate 6, Fig. 12)

Discoaster berggrenii Bukry, 1971, p. 45, pl. 2, figs. 4–6.

Discoaster binodosus Martini

Discoaster binodosus Martini, 1958, p. 361, pl. 4, fig. 18b.

Discoaster brouweri Tan Sin Hok
(Plate 6, Fig. 6)

Discoaster brouweri Tan Sin Hok, 1927, p. 120, figs. 8a, b. Bramlette and Riedel, 1954, p. 402, pl. 39, fig. 12.

Discoaster challengeri Bramlette and Riedel

Discoaster challengeri Bramlette and Riedel, 1954, p. 401, pl. 39, fig. 10.

Discoaster deflandrei Bramlette and Riedel

Discoaster deflandrei Bramlette and Riedel, 1954, p. 399, pl. 39, fig. 6; text-figs. 1a–c.

Discoaster druggii Bramlette and Wilcoxon

Discoaster druggii Bramlette and Wilcoxon, 1967, p. 110, pl. 8, figs. 2–8. Bramlette and Wilcoxon, 1967, p. 220.

Discoaster exilis Martini and Bramlette

Discoaster exilis Martini and Bramlette, 1963, p. 852, pl. 104, figs. 1–3.

Discoaster hamatus Martini and Bramlette
(Plate 6, Fig. 13)

Discoaster hamatus Martini and Bramlette, 1963, p. 852, pl. 105, figs. 8, 10, 11.

Discoaster intercalaris Bukry

Discoaster intercalaris Bukry, 1971, p. 315, pl. 3, fig. 12; pl. 4, figs. 1, 2.

Discoaster kuglerii Martini and Bramlette
(Plate 6, Fig. 15)

Discoaster kugleri Martini and Bramlette, 1963, p. 853, pl. 102, figs. 11–13.

Discoaster loeblichi Bukry
(Plate 6, Fig. 14)

Discoaster loeblichi Bukry, 1971, pp. 315, 316, pl. 4, figs. 3–5.

Discoaster pansus (Bukry and Percival)

Discoaster variabilis pansus Bukry and Percival, 1971, p. 129, pl. 3, figs. 8, 9.
Discoaster pansus (Bukry and Percival) Bukry, 1973, p. 678.

Discoaster pentaradiatus Tan Sin Hok
(Plate 6, Fig. 7)

Discoaster pentaradiatus Tan Sin Hok, 1927, p. 120, fig. 2; *sens. emend.* Bramlette and Riedel, 1954, p. 401, pl. 39, fig. 11; text-figs. 2a, b.

Discoaster quadrams Bukry

Discoaster quadrams Bukry, 1973, p. 307, pl. 1, figs. 5, 6.

***Discoaster quinqueramus* Gartner**
(Plate 6, Fig. 11)

Discoaster quinqueramus Gartner, 1969, p. 598, pl. 1, figs. 6, 7.

***Discoaster saipanensis* Bramlette and Riedel**
(Plate 6, Fig. 17)

Discoaster saipanensis Bramlette and Riedel, 1954, p. 398, pl. 39, fig. 4.

***Discoaster surculus* Martini and Bramlette**
(Plate 6, Fig. 8)

Discoaster surculus Martini and Bramlette, 1963, p. 854, pl. 104, figs. 10-12.

***Discoaster tamalis* Kamptner**
(Plate 6, Fig. 5)

Discoaster tamalis Kamptner, 1967, p. 166, text-fig. 29.

***Discoaster tani* Bramlette and Riedel**
(Plate 7, Fig. 1)

Discoaster tani Bramlette and Riedel, 1954, p. 397, pl. 39, fig. 1.

***Discoaster tani nodifer* Bramlette and Riedel**

Discoaster tani nodifer Bramlette and Riedel, 1954, p. 397, pl. 38, fig. 2.

***Discoaster triradiatus* Tan Sin Hok**
(Plate 6, Fig. 4)

Discoaster triradiatus Tan Sin Hok, 1927, p. 417.

***Discoaster variabilis* Martini and Bramlette**
(Plate 6, Fig. 10)

Discoaster variabilis Martini and Bramlette, 1963, p. 854, pl. 104, figs. 4-9.

Genus *DISCOLITHINA* Loeblich and Tappan, 1963

***Discolithina japonica* Takayama**
(Plate 4, Figs. 6a, b)

Discolithina japonica Takayama, 1967, p. 189, pls. 9, 10; text-fig. 7.

Genus *EMILIANIA* Hay and Mohler in Hay et al., 1967

***Emiliania huxleyi* (Lohmann)**
(Plate 3, Figs. 6a, b)

Pontosphaera huxleyi Lohmann, 1902, p. 130, pl. 4, figs. 1-6; pl. 6, fig. 69.
Coccolithus huxleyi (Lohmann) Kamptner, 1943, p. 44.
Emiliania huxleyi (Lohmann) Hay and Mohler, in Hay, Mohler, Roth, Schmidt, and Boudreaux, 1967, p. 447, pls. 10, 11, figs. 1, 2.

***Emiliania ovata* Bukry**

Emiliania ovata Bukry, 1973, p. 678, pl. 2, figs. 10-12.

Genus *GEPHYROCAPSA* Kamptner, 1943

***Gephyrocapsa aperta* Kamptner**

Gephyrocapsa aperta Kamptner, 1963, p. 173, pl. 6, figs. 32-35.

***Gephyrocapsa caribbeanica* Boudreaux and Hay**

Gephyrocapsa caribbeanica Boudreaux and Hay, in Hay, Mohler, Roth, Schmidt, and Boudreaux, 1967, p. 447, pls. 12, 13, figs. 1-4.

Remarks. Calcareous nannofossil assemblages in the Leg 94 Pleistocene to Holocene sequence are characterized by dominance of *Gephyrocapsa*. Most of these *Gephyrocapsa* are smaller than 4 μm. In this study, *Gephyrocapsa caribbeanica* was identified by the characteristic features such as the size (larger than 4 μm) and orientation of the diagonal bar (over 45° angle with the short axis). Specimens that are larger than 6 μm are put in "*Gephyrocapsa caribbeanica* (large type)."

***Gephyrocapsa oceanica* Kamptner**
(Plate 3, Figs. 9a, b)

Gephyrocapsa oceanica Kamptner, 1943, pp. 43-49.

Remarks. *Gephyrocapsa oceanica* was identified by size (larger than 4 μm) and orientation of the diagonal bar (less than 45° angle with the short axis). Specimens that are larger than 6 μm were put in "*Gephyrocapsa oceanica* (large type)."

***Gephyrocapsa parallela* Hay and Beaudry**
(Plate 3, Figs. 8a, b)

Gephyrocapsa parallela Hay and Beaudry, 1973, p. 672, pl. 1, figs. 10-12.

***Gephyrocapsa sinuosa* Hay and Beaudry**
(Plate 3, Figs. 10a, b)

Gephyrocapsa sinuosa Hay and Beaudry, 1973, p. 672, pl. 1, figs. 13, 14.

Genus *HAYASTER* Bukry, 1973

***Hayaster perplexus* (Bramlette and Riedel)**

Discoaster perplexus Bramlette and Riedel, 1954, p. 400, pl. 39, fig. 9.
Hayaster perplexus (Bramlette and Riedel) Bukry, 1973, p. 308, pl. 27, fig. 1.

Genus *HELICOSPHAERA* Kamptner, 1954

***Helicosphaera ampliaperta* Bramlette and Wilcoxon**

Helicosphaera ampliaperta Bramlette and Wilcoxon, 1967, p. 105, pl. 6, figs. 1-4.

***Helicosphaera carteri* (Wallich)**
(Plate 4, Figs. 2a, b)

Coccosphaera carteri Wallich, 1877, p. 348.
Coccolithus carteri (Wallich) Kamptner, 1941, pp. 93, 111, pl. 13, fig. 136.
Helicosphaera carteri (Wallich) Kamptner, 1954, p. 21, text-figs. 17-19.

***Helicosphaera compacta* Bramlette and Wilcoxon**

Helicosphaera compacta Bramlette and Wilcoxon, 1967, p. 105, figs. 5-8.
Helicopontosphaera compacta (Bramlette and Wilcoxon) Hay, 1970, p. 458.

***Helicosphaera euphratis* Haq**

Helicosphaera euphratis Haq, 1966, p. 33, pl. 2, figs. 1, 3.
Helicopontosphaera euphratis (Haq) Martini, 1969, p. 136.

***Helicosphaera granulata* (Bukry and Percival)**

Helicopontosphaera granulata Bukry and Percival, 1971, p. 132; pl. 5, figs. 1, 2
Helicosphaera granulata (Bukry and Percival) Jafar and Martini, 1975, p. 390.

***Helicosphaera hyalina* Gaarder**

Helicosphaera hyalina Gaarder, 1970, p. 113, 114; text-figs. 1-3.

***Helicosphaera intermedia* Martini**

Helicosphaera intermedia Martini, 1965, p. 404; pl. 35, figs. 1, 2.

***Helicosphaera inversa* (Gartner)**
(Plate 4, Figs. 3a, b)

Helicopontosphaera inversa Gartner, 1977, p. 23, pl. 1, figs. 4, 5.
Helicosphaera inversa (Gartner) Haq, in Haq and Berggren, 1978, p. 1192.

***Helicosphaera obliqua,* Bramlette and Wilcoxon**

Helicosphaera obliqua Bramlette and Wilcoxon, 1967, p. 106; pl. 5, figs. 13, 14.

Helicopontosphaera obliqua (Bramlette and Wilcoxon) Haq, 1973, p. 40; pl. 4, fig. 6; pl. 5, figs. 7, 8.

***Helicosphaera perch-nielseniae* (Haq)**
(Plate 4, Figs. 5a, b)

Helicopontosphaera perch-nielseniae Haq, 1971, p. 116; pl. 10, figs. 5-7.
Helicosphaera perch-nielseniae (Haq) Jafar and Martini, 1975, p. 391.

***Helicosphaera recta* Haq**

Helicosphaera recta Haq, 1966, p. 34, pl. 2, fig. 6; pl. 3, fig. 4.

***Helicosphaera sellii* (Bukry and Bramlette)**
(Plate 4, Figs. 4a, b)

Helicopontosphaera sellii Bukry and Bramlette, 1969, p. 134, pl. 2, figs. 3-7.
Helicosphaera sellii (Bukry and Bramlette) Jafar and Martini, 1975, p. 391.

***Helicosphaera wallichi* (Lohmann)**
(Plate 4, Figs. 1a, b)

Coccolithophora wallichi Lohmann, 1902, p. 138, pl. 5, figs. 58-60.
Helicopontosphaera wallichi (Lohmann) Boudreaux and Hay, 1969, pp. 272, 273, pl. 6, fig. 9.
Helicosphaera wallichi (Lohmann) Okada and McIntyre, 1977, pp. 14, 15, pl. 4, fig. 8.

Genus *ISTHMOLITHUS* Deflandre in Deflandre and Fert, 1954

***Isthmolithus recurvus* Deflandre**
(Plate 7, Figs. 2, 3)

Isthmolithus recurvus Deflandre, in Deflandre and Fert, 1954, p. 169, pl. 12, figs. 9-13; text-figs. 119-122.

Genus *OOLITHOTUS* Reinhardt, 1968

***Oolithotus antillarum* (Cohen)**
(Plate 4, Figs. 7a, b)

Discolithus antillarum Cohen, 1964, p. 236, pl. 1, figs. 3a-e; pl. 2, figs. 2a-b.
Oolithotus antillarum (Cohen) Reinhardt, 1968, p. 297, pl. 31, fig. 8.

Genus *PSEUDOEMILIANIA* Gartner, 1969

***Pseudoemiliania lacunosa* (Kamptner)**
(Plate 3, Figs. 7a, b; Plate 8, Fig. 2)

Ellipsoplacolithus lacunosus Kamptner, 1963, p. 172, pl. 9, fig. 50.
Pseudoemiliania lacunosa (Kamptner) Gartner, 1969, p. 598, pl. 2, figs. 9, 10.

Genus *RETICULOFENESTRA* Hay et al., 1966

***Reticulofenestra dictyoda* (Deflandre and Fert)**

Discolithus dictyoda Deflandre and Fert, 1954, p. 140, text-figs. 15, 16.
Reticulofenestra dictyoda (Deflandre and Fert) Stradner, in Stradner and Edwards, 1968, p. 19. Perch-Nielsen, 1971, p. 30, pl. 25, figs. 1-3. Romein, 1979, p. 128, pl. 4, fig. 6.

***Reticulofenestra hillae* Bukry and Percival**

Reticulofenestra hillae Bukry and Percival, 1971, p. 136, pl. 6, figs. 1-3.

***Reticulofenestra pseudoumbilica* (Gartner)**
(Plate 3, Figs. 4 a, b)

Coccolithus pseudoumbilicus Gartner, 1967, p. 4, pl. 6, fig. 3.
Reticulofenestra pseudoumbilica (Gartner) Gartner, 1969, pp. 587-598.

***Reticulofenestra reticulata* (Gartner and Smith)**
(Plate 3, Figs. 5a, b)

Cyclococcolithus reticulata Gartner and Smith, 1967, p. 4, pl. 5 figs. 1-4.
Reticulofenestra reticulata (Gartner and Smith) Roth, in Roth and Thierstein, 1972, p. 436.

***Reticulofenestra umbilica* (Levin)**
(Plate 7, Figs. 5a, b)

Coccolithus umbilicus Levin, 1965, p. 265, pl. 41, fig. 2.
Reticulofenestra umbilica (Levin) Martini and Ritzkowski, 1968, p. 245, pl. 1, figs. 11, 12.

***Reticulofenestra* sp. A**
(Plate 3, Figs. 3a, b)

Remarks. *Reticulofenestra* sp. A is distinguished from *Crenalithus doronicoides* (Black and Barnes) Roth by its larger size (larger than 6 μm). *R.* sp. A is rare to common near the base of occurrence of *Gephyrocapsa parallela.*

***Reticulofenestra* sp. B**

Remarks. *Reticulofenestra* sp. B, which appears in the same horizon as *Reticulofenestra* sp. A, is distinguished from *R.* sp. A by its circular form.

***Reticulofenestra* sp. C**

Remarks. *Reticulofenestra* sp. C differs from *R. pseudoumbilica* (Gartner) Gartner in being smaller. Although this form appears closely related to *R. gartneri* Roth and Hay, its diagnostic character is not clear under the light microscope. This form is, therefore, put in *R.* sp. C in the present investigation.

Genus *RHABDOSPHAERA* Haeckel, 1894

***Rhabdosphaera clavigera* Murray and Blackman**
(Plate 4, Figs. 9a, b)

Rhabdosphaera clavigera Murray and Blackman, 1898, p. 438, pl. 15, figs. 13-15.

***Rhabdosphaera longistylis* Schiller**

Rhabdosphaera longistylis Schiller, 1925, p. 40, pl. 4, fig. 40.

***Rhabdosphaera stylifera* Lohmann**
(Plate 4, Figs. 10a, b)

Rhabdosphaera stylifer Lohman, 1902, p. 143, pl. 5, fig. 65.
Aspidorhabdus stylifer (Lohman) Boudreaux and Hay, 1969, p. 269, pl. 5, figs. 11-15.

Genus *SCAPHOLITHUS* Deflandre in Deflandre and Fert, 1954

***Scapholithus fossilis* Deflandre**

Scapholithus fossilis Deflandre, in Deflandre and Fert, 1954, p. 165, pl. 8, figs. 12, 16, 17.

Genus *SCYPHOSPHAERA* Lohmann, 1902

***Scyphosphaera* spp.**

Genus *SPHENOLITHUS* Deflandre, 1952

***Sphenolithus abies* Deflandre**
(Plate 5, Fig. 1a, b)

Sphenolithus abies Deflandre, 1953, p. 1785. Deflandre in Deflandre and Fert, 1954, p. 164, pl. 10, figs. 1-4.

***Sphenolithus belemnos* Bramlette and Wilcoxon**
(Plate 5, Figs. 4a, b)

Sphenolithus belemnos Bramlette and Wilcoxon, 1967, p. 118, pl. 2, figs. 1-3.

***Sphenolithus ciperoensis* Bramlette and Wilcoxon**
(Plate 5, Figs. 5a, b)

Sphaerolithus ciperoensis Bramlette and Wilcoxon, 1967, p. 120, pl. 2, figs. 15-18.

***Sphenolithus conicus* Bukry**

Sphenolithus conicus Bukry, 1971, p. 320, pl. 5, figs. 10-12.

***Sphenolithus delphix* Bukry**

Sphenolithus delphix Bukry, 1973, p. 679, pl. 3, figs. 19-22.

***Sphenolithus dissimilis* Bukry and Percival**

Sphenolithus dissimilis Bukry and Percival, 1971, p. 140, pl. 6, figs. 7-9.

***Sphenolithus distentus* (Martini)**
(Plate 5, Figs. 6a, b)

Furcatolithus distentus Martini, 1965, p. 407, pl. 35, figs. 7-9.
Sphenolithus distentus (Martini) Bramlette and Wilcoxon, 1967, p. 122, pl. 1, fig. 5.

***Sphenolithus heteromorphus* Deflandre**
(Plate 5, Figs. 3a, b)

Sphenolithus heteromorphus Deflandre, 1953, pp. 1785, 1786, figs. 1, 2.

***Sphenolithus moriformis* (Brönniman and Stradner)**
(Plate 5, Figs. 2a, b)

Nannoturbella moriformis Brönniman and Stradner, 1960, p. 368, figs. 11-16.
Sphenolithus moriformis (Brönniman and Stradner) Bramlette and Wilcoxon, 1967, pp. 124-126, pl. 3, figs. 1-6.

***Sphenolithus predistentus* Bramlette and Wilcoxon**
(Plate 5, Figs. 7a, b, 8a, b)

Sphenolithus predistentus Bramlette and Wilcoxon, 1967, p. 126, pl. 1, fig. 6; pl. 2, figs. 10, 11.

***Sphenolithus radians* Deflandre**

Sphenolithus radians Deflandre in Grassé, 1952, p. 466, figs. 343J-K, 363A-G.

Genus *SYRACOSPHAERA* Lohmann, 1902

***Syracosphaera pulchra* Lohmann**

Syracosphaera pulchra Lohmann, 1902, p. 134; pl. 4, figs. 33, 36, 37.

Genus *THORACOSPHAERA* Kamptner, 1927

***Thoracosphaera deflandrei* Kamptner**

Thoracosphaera deflandrei Kamptner, 1956, p. 448, figs. 1-4.

***Thoracosphaera heimi* (Lohmann)**
(Plate 4, Figs. 8a, b)

Syracosphaera heimi Lohmann, 1919, p. 117, fig. 29.
Thoracosphaera heimi (Lohmann) Kamptner, 1954, pp. 40-42; figs. 41, 42.

***Thoracosphaera saxea* Stradner**

Thoracosphaera saxea Stradner, 1961, p. 84, fig. 71.

Genus *TRIQUETRORHABDULUS* Martini, 1965

***Triquetrorhabdulus carinatus* Martini**

Triquetrorhabdulus carinatus Martini, 1965, p. 408, pl. 36, figs. 1-3.

***Triquetrorhabdulus rugosus* Bramlette and Wilcoxon**

Triquetrorhabdulus rugosus Bramlette and Wilcoxon, 1967, p. 128, pl. 9, figs. 17, 18.

Genus *UMBELLOSPHAERA* Paasche in Markali and Paasche, 1955

***Umbellosphaera* spp.**

Genus *UMBILICOSPHAERA* Lohmann, 1902

***Umbilicosphaera mirabilis* Lohmann**

Umbilicosphaera mirabilis Lohmann, 1902, p. 139, pl. 5, figs. 66, 66a.

Genus *ZYGRHABLITHUS* Deflandre, 1959

***Zygrhablithus bijugatus* (Deflandre)**

Zygolithus bijugatus Deflandre, in Deflandre and Fert, 1954, p. 148, pl. 11, figs. 20, 21; text-fig. 59.
Zygrhablithus bijugatus (Deflandre) Deflandre, 1959, p. 135.

ACKNOWLEDGMENTS

We are grateful to many of the scientific staff on board the *Glomar Challenger*. Thanks are also due to Dr. Stefan Gartner, Department of Oceanography, Texas A&M University, Dr. M.-P. Aubry, Woods Hole Oceanographic Institution, and Dr. Ellen Thomas, Lamont-Doherty Geological Observatory, for their constructive reviews of this chapter. Deep appreciation is expressed to Drs. Naomoto Komatsu and Yoshihiko Fujita, Teikoku Oil Co., Ltd., for their help and encouragement. We are especially grateful to Miss Reiko Takamatsu, College of Liberal Arts, Kanazawa University, for slide preparation and bookkeeping of samples. Last, but not least, thanks to Mr. Koji Kameo, Faculty of Science, Kanazawa University, for assistance in table preparation.

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Date of Initial Receipt: 25 April 1985
Date of Acceptance: 5 December 1985

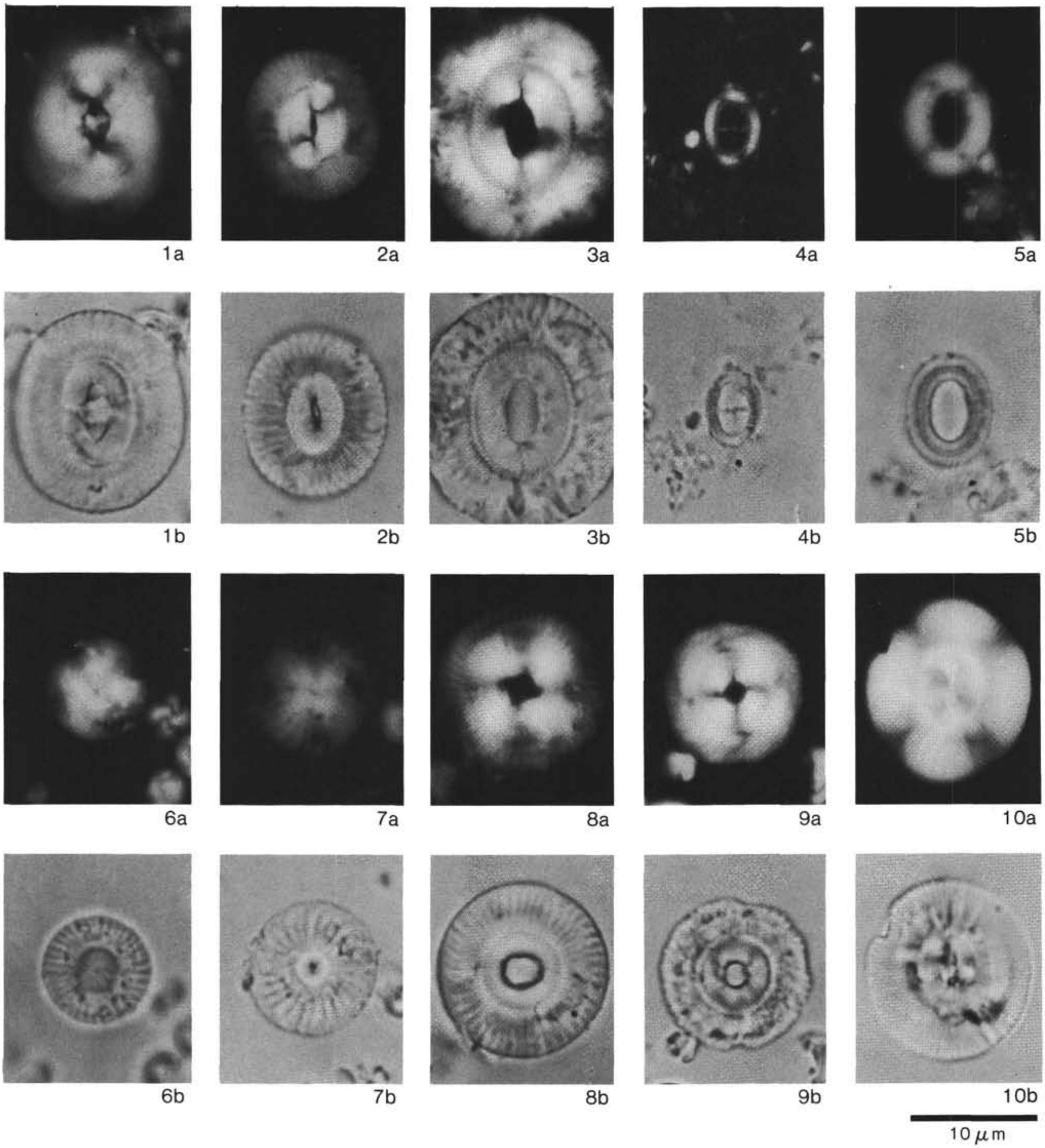

Plate 1. (All figures are same magnification; a = crossed nicols, b = without nicols.) **1.** *Coccolithus crassipons* Bouché, Sample 606-2,CC. **2.** *Coccolithus miopelagicus* Bukry, Sample 608-28-6, 46–47 cm. **3.** *Coccolithus eopelagicus* (Bramlette and Riedel) Bramlette and Sullivan, Sample 608-49-2, 85 cm. **4.** *Coccolithus streckerii* Takayama and Sato, n. sp., Holotype, TOCCN 3538(1), Sample 608-5-5, 46–47 cm. **5.** *Coccolithus* sp., Sample 611-10-4, 50–51 cm. **6, 7.** *Calcidiscus leptoporus* (Murray and Blackman) Loeblich and Tappan, (6) Sample 606-2,CC; (7) Sample 607-7-4, 47–48 cm. **8.** *Calcidiscus macintyrei* (Bukry and Bramlette) Loeblich and Tappan, Sample 606-6,CC. **9.** *Calcidiscus formosus* (Kamptner) Loeblich and Tappan, Sample 608-50-2, 46–47 cm. **10.** *Dictyococcites bisectus* (Hay, Mohler, and Wade) Bukry and Percival, Sample 608-46,CC.

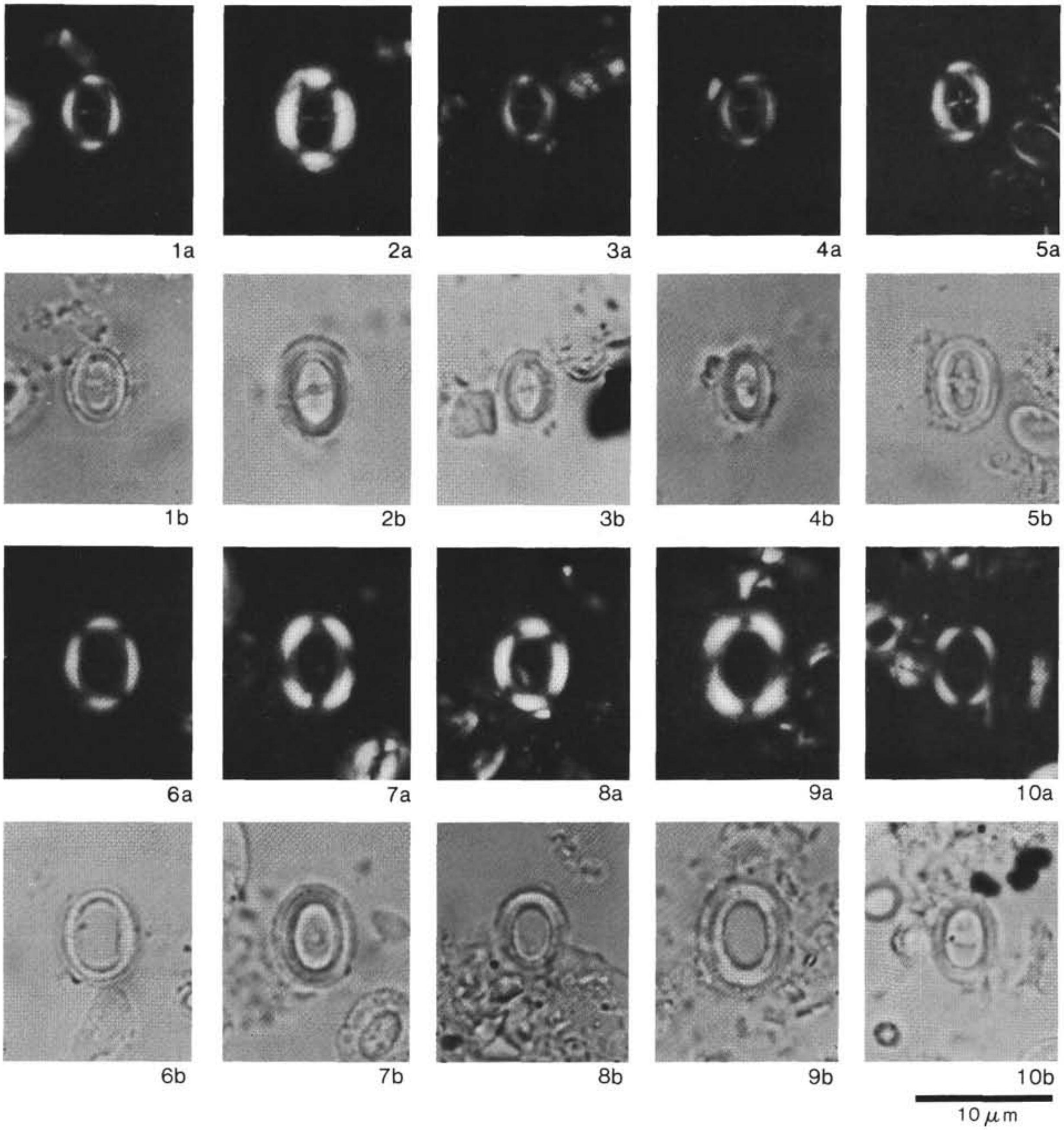

Plate 2. (All figures are same magnification; a = crossed nicols, b = without nicols.) **1-10.** *Coccolithus streckerii* Takayama and Sato, n. sp., Paratypes, TOCCN 3538(2) to 3538(11), Sample 608-5-5, 46-47 cm.

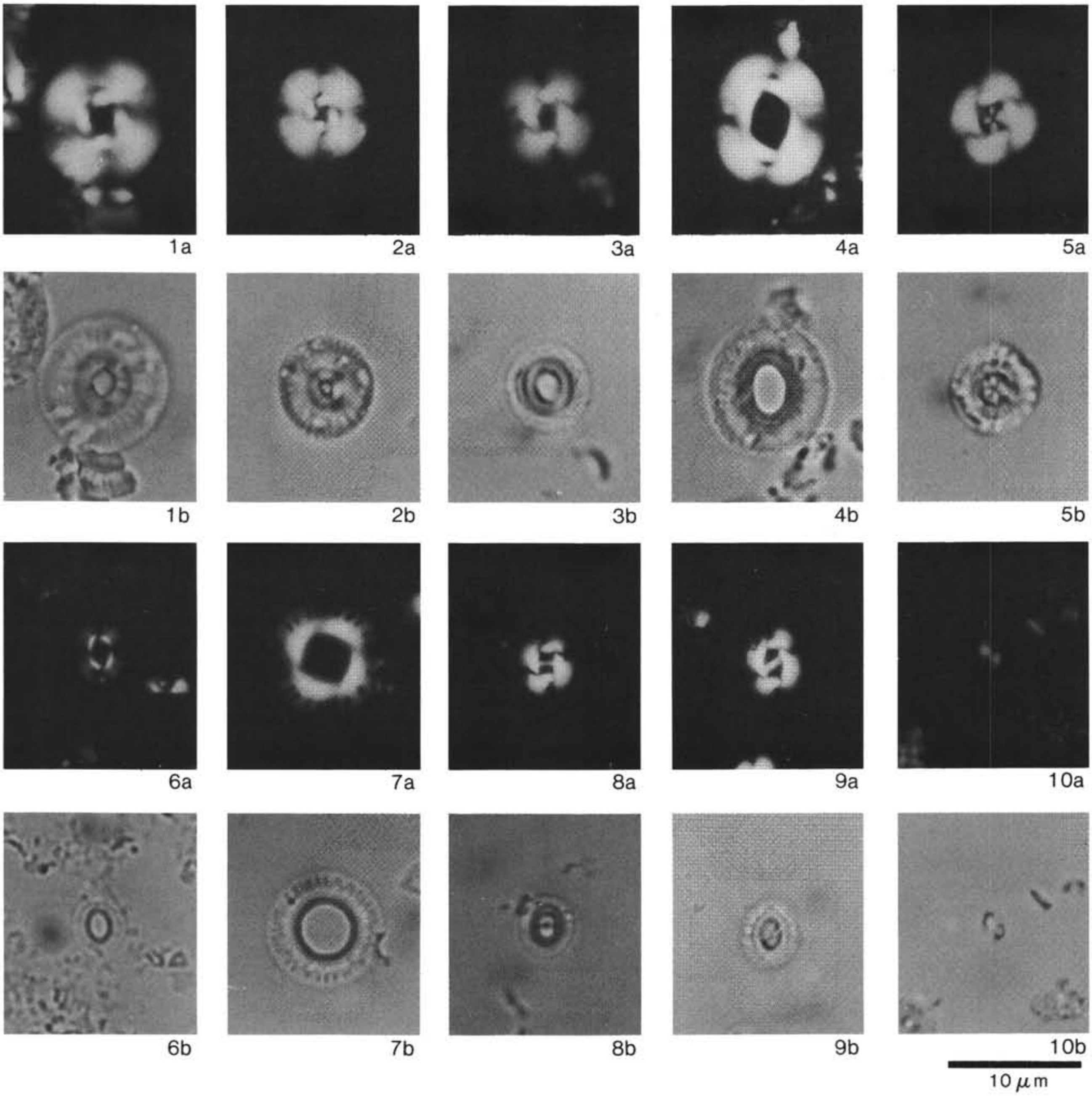

Plate 3. (All figures are same magnification; a = crossed nicols, b = without nicols.) **1.** *Cyclicargolithus abisectus* (Müller) Bukry, Sample 608-49-2, 85 cm. **2.** *Cyclicargolithus floridanus* (Roth and Hay) Bukry, Sample 608-33-2, 46–47 cm. **3.** *Reticulofenestra* sp. A, Sample 607A-5,CC. **4.** *Reticulofenestra pseudoumbilica* (Gartner) Gartner, Sample 608-28-2, 46–47 cm. **5.** *Reticulofenestra reticulata* (Gartner and Smith) Roth, Sample 608-52,CC. **6.** *Emiliania huxleyi* (Lohmann) Hay and Mohler, Sample 607-1-2, 47–48 cm. **7.** *Pseudoemiliania lacunosa* (Kamptner) Gartner, Sample 606A-2,CC. **8.** *Gephyrocapsa parallela* Hay and Beaudry, Sample 606-3-4, 47–48 cm. **9.** *Gephyrocapsa oceanica* Kamptner, Sample 606-2-6, 47–48 cm. **10.** *Gephyrocapsa sinuosa* Hay and Beaudry, Sample 607-7-4, 47–48 cm.

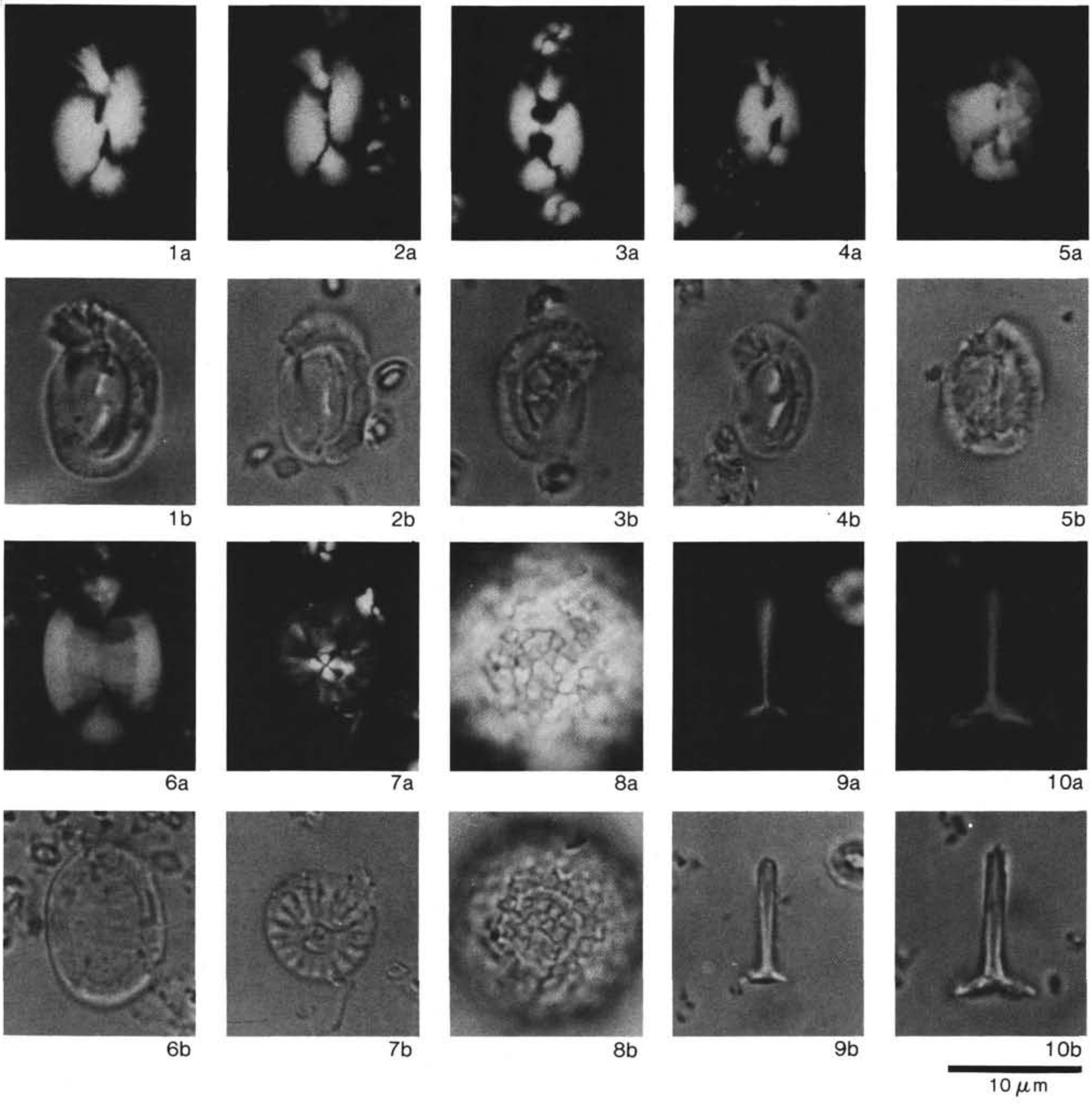

Plate 4. (All figures are same magnification; a = crossed nicols, b = without nicols.) **1.** *Helicosphaera wallichi* (Lohmann) Okada and McIntyre, Sample 606-5-1, 47–48 cm. **2.** *Helicosphaera carteri* (Wallich) Kamptner, Sample 606-2-6, 47–48 cm. **3.** *Helicosphaera inversa* (Gartner) Haq, Sample 607-2-4, 47–48 cm. **4.** *Helicosphaera sellii* (Bukry and Bramlette) Jafar and Martini, Sample 607-10-1, 47–48 cm. **5.** *Helicosphaera perch-nielseniae* (Haq) Jafar and Martini, Sample 608-49-2, 46–47 cm. **6.** *Discolithina japonica* Takayama, Sample 607-4-4, 47–48 cm. **7.** *Oolithotus antillarum* (Cohen) Reinhardt, Sample 606-9-4, 47–48 cm. **8.** *Thoracosphaera heimi* (Lohmann) Kamptner, Sample 606-9-4, 47–48 cm. **9.** *Rhabdosphaera clavigera* Murray and Blackman, Sample 606-5-1, 47–48 cm. **10.** *Rhabdosphaera stylifera* Lohmann, Sample 606-5-1, 47–48 cm.

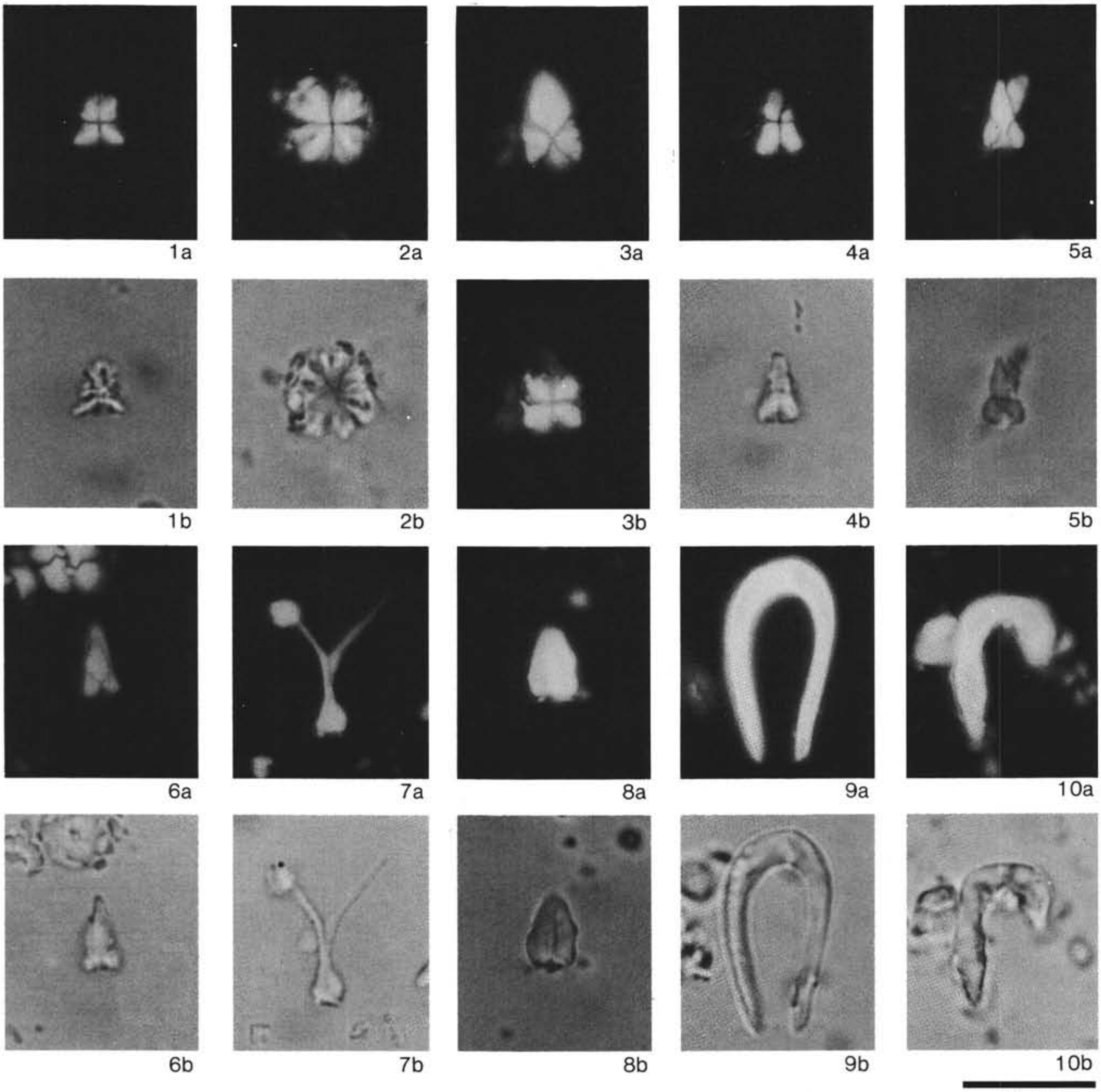

Plate 5. (All figures are same magnification. In Figs. 1, 2, and 4–10, a = crossed nicols, b = without nicols; in Fig. 3, a = long axis 45° to crossed nicols; b = long axis 0° to crossed nicols.) **1.** *Sphenolithus abies* Deflandre, Sample 606-16-2, 47–48 cm. **2.** *Sphenolithus moriformis* (Brönniman and Stradner) Bramlette and Wilcoxon, Sample 607-20-2, 47–48 cm. **3.** *Sphenolithus heteromorphus* Deflandre, Sample 608-33-2, 46–47 cm. **4.** *Sphenolithus belemnos* Bramlette and Wilcoxon, Sample 608-39-3, 46–47 cm. **5.** *Sphenolithus ciperoensis* Bramlette and Wilcoxon, Sample 608-49-2, 46–47 cm. **6.** *Sphenolithus distentus* (Martini) Bramlette and Wilcoxon, Sample 608-49-2, 46–47 cm. **7, 8.** *Sphenolithus predistentus* Bramlette and Wilcoxon, (7) Sample 608-49-2, 46–47 cm; (8) Sample 608-49-4, 46–47 cm. **9.** *Ceratolithus telesmus* Norris, Sample 606-1,CC. **10.** *Ceratolithus rugosus* Bukry and Bramlette, 607-15-4, 47–48 cm.

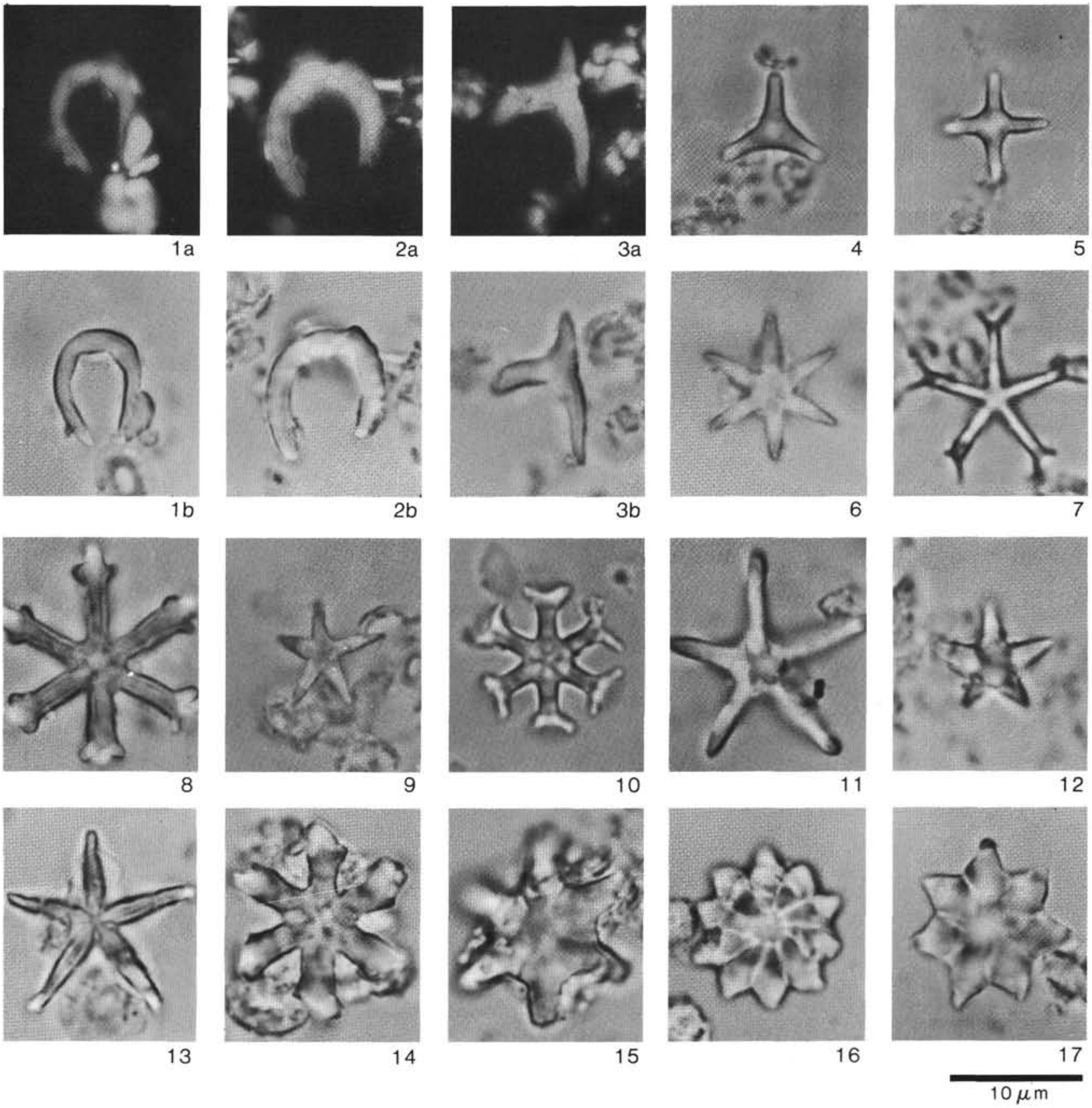

Plate 6. (All figures are same magnification. In Figs. 1-3, a = crossed nicols, b = without nicols; Figs. 4-17, without nicols.) **1.** *Amaurolithus delicatus* Gartner and Bukry, Sample 607-23-4, 47-48 cm. **2.** *Amaurolithus primus* (Bukry and Percival) Gartner and Bukry, Sample 607-25,CC. **3.** *Amaurolithus tricorniculatus* (Gartner) Gartner and Bukry, Sample 607-23,CC. **4.** *Discoaster triradiatus* Tan Sin Hok, Sample 606-7,CC. **5.** *Discoaster tamalis* Kamptner, Sample 607-15-2, 47-48 cm. **6.** *Discoaster brouweri* Tan Sin Hok, Sample 606-11,CC. **7.** *Discoaster pentaradiatus* Tan Sin Hok, Sample 606A-15,CC. **8.** *Discoaster surculus* Martini and Bramlette, Sample 607-22-4, 47-48 cm. **9.** *Discoaster asymmetricus* Gartner, Sample 611C-21,CC. **10.** *Discoaster variabilis* Martini and Bramlette, Sample 611C-39-2, 52-53 cm. **11.** *Discoaster quinqueramus* Gartner, Sample 611C-40-2, 44-45 cm. **12.** *Discoaster berggrenii* Bukry, Sample 607-27,CC. **13.** *Discoaster hamatus* Martini and Bramlette, Sample 608-23-4, 46-47 cm. **14.** *Discoaster loeblichii* Bukry, Sample 608-19,CC. **15.** *Discoaster kugleri* Martini and Bramlette, Sample 607-20-2, 47-48 cm. **16.** *Discoaster barbadiensis* Tan Sin Hok, Sample 608-52,CC. **17.** *Discoaster saipanensis* Bramlette and Riedel, Sample 608-52-2, 57-58 cm.

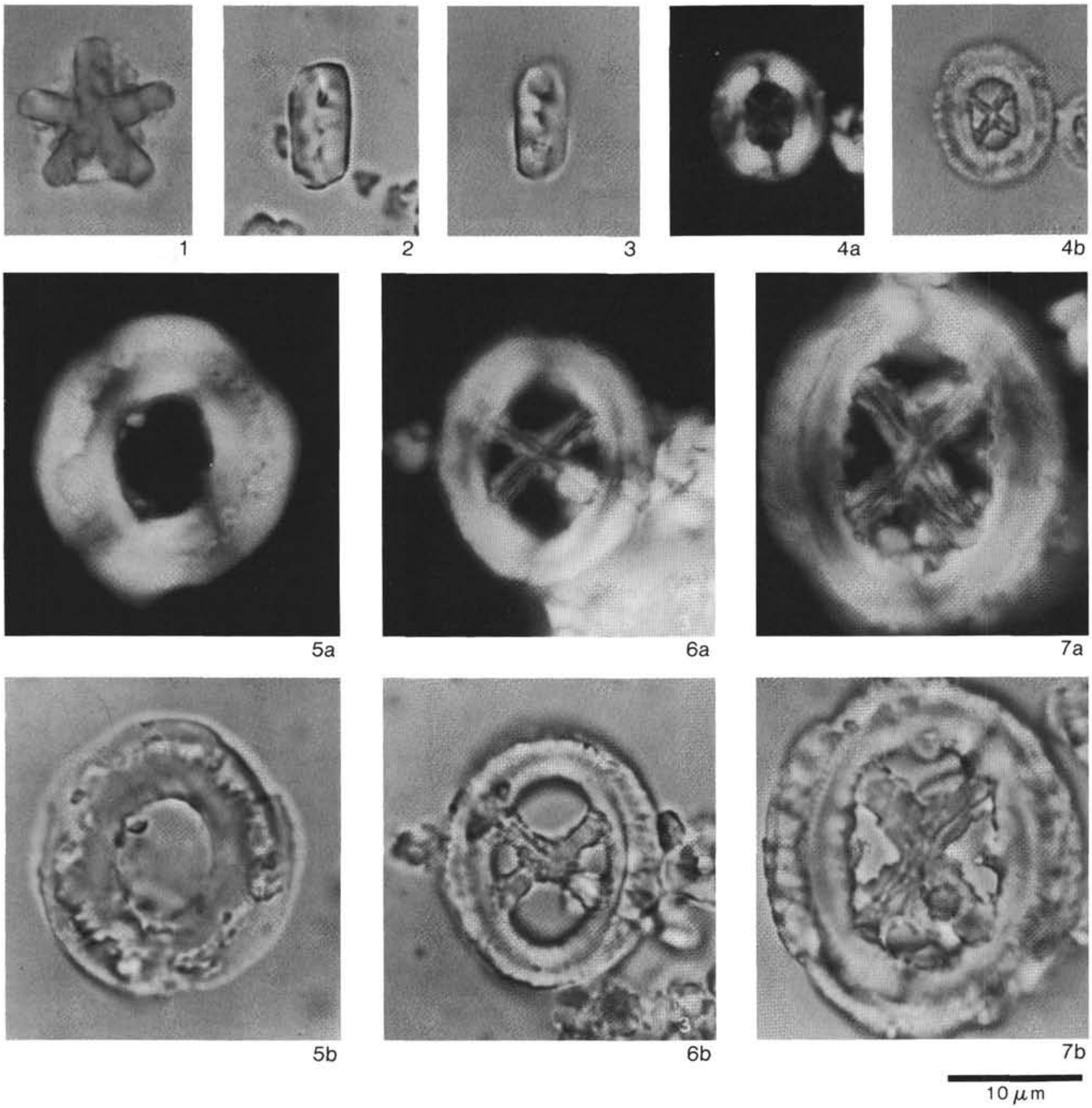

Plate 7. (All figures are same magnification; in Figs. 4–7, a = crossed nicols, b = without nicols; Figs. 1–3, without nicols.) **1.** *Discoaster tani* Bramlette and Riedel, Sample 608-52-2, 57–58 cm. **2, 3.** *Isthmolithus recurvus* Deflandre, (2) Sample 608-52,CC; (3) 608-52-2, 57–58 cm. **4.** *Chiasmolithus altus* Bukry and Percival, Sample 608-49-2, 46–47 cm. **5.** *Reticulofenestra umbilica* (Levin) Martini and Ritzkowski, Sample 608-50-2, 46–47 cm. **6.** *Chiasmolithus oamaruensis* (Deflandre) Hay, Mohler, and Wade, Sample 608-53-2, 63–64 cm. **7.** *Chiasmolithus grandis* (Bramlette and Riedel) Radomski, Sample 608-55,CC.

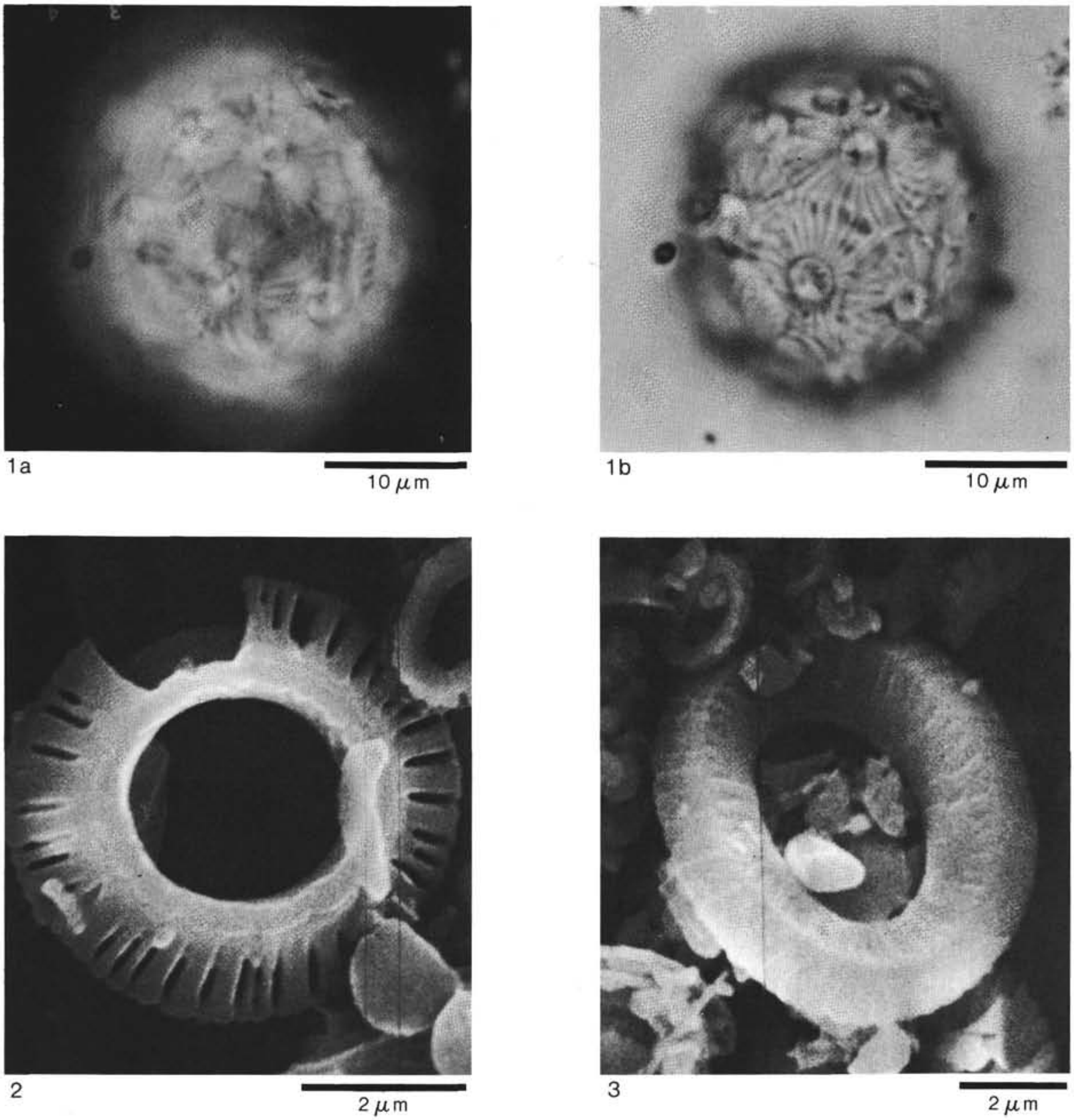

Plate 8. (In Fig. 1, a = crossed nicols, b = without nicols; Figs. 2 and 3 are SEM photographs.) **1.** *Calcidiscus leptoporus* (Murray and Blackman) Loeblich and Tappan, Sample 606A-3,CC. **2.** *Pseudoemiliania lacunosa* (Kamptner) Gartner, Sample 608-5-5, 46–47 cm. **3.** *Coccolithus streckerii* Takayama and Sato, n. sp., Paratype, TOCCNS 367, Sample 608-5-5, 46–47 cm.