25. CALCAREOUS NANNOFOSSILS FROM THE JAPAN TRENCH UPPER SLOPE, LEG 56, DEEP SEA DRILLING PROJECT

Bilal U. Haq and Margaret Goreau, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

ABSTRACT

Calcareous nannofossils were encountered at only one of the sites (435) drilled during DSDP Leg 56. Cores from Hole 435A yield fairly diverse early and late Pliocene assemblages. The section shows considerable reworking, however. Three to five biostratigraphic datum events provide a reasonable biochronology. The datums range from about 3.3 Ma in Core 11 to about 1.8 Ma in Core 3. Paleobiogeographic data indicate relatively stable and warm climatic conditions in this area in the early Pliocene, becoming more unstable in the late Pliocene when the cosmopolitan species become dominant.

INTRODUCTION AND OBJECTIVES

During Leg 56 of the Deep Sea Drilling Project, first of the two-leg Japan Trench transect, the D/V *Glomar Challenger* drilled three holes in September and in October 1977. Site 434 was drilled on the lower trench slope, Site 435 on the upper slope of the trench wall, and Site 436 on the crest of the outer rise (Figure 1).

The Japan Trench transect was the first of several active margin transects in the Pacific Ocean chosen to study the major trench and volcanic belt systems. The main objectives of Leg 56 were to determine the type and degree of tectonic activity related to the overthrust wall of the actively subducting Japan Trench. These objectives dictated that sites be either where water depth was too great for calcite preservation or where the area was tectonically active and thus too highly disturbed for detailed biostratigraphic studies of calcareous nannoplankton. For example, Sites 434 and 436 were both drilled at water depths in excess of 5000 meters and yielded practically no calcareous nannofossils (with the exception of a thin layer in Hole 434-12-1, 73–75 cm, in which poorly preserved and rare specimens of small coccoliths, *Dictyococcites minutus* and *Sphenolithus neoabies*, were encountered, possibly as contaminants). Only Site 435, on the upper slope of the trench, drilled in water depth of about 3400 meters, contained a relatively better preserved and fairly diverse Pliocene nannoflora.

The purpose of this chapter is to report the calcareous nannofossil assemblages recorded at Site 435. The sediments at this site consist of muddy diatomaceous ooze drilled to a total sub-bottom depth of 244.5 meters. The recovered section also contains thin, intermittent layers of volcanic ash and minor amounts of terrigenous sand.

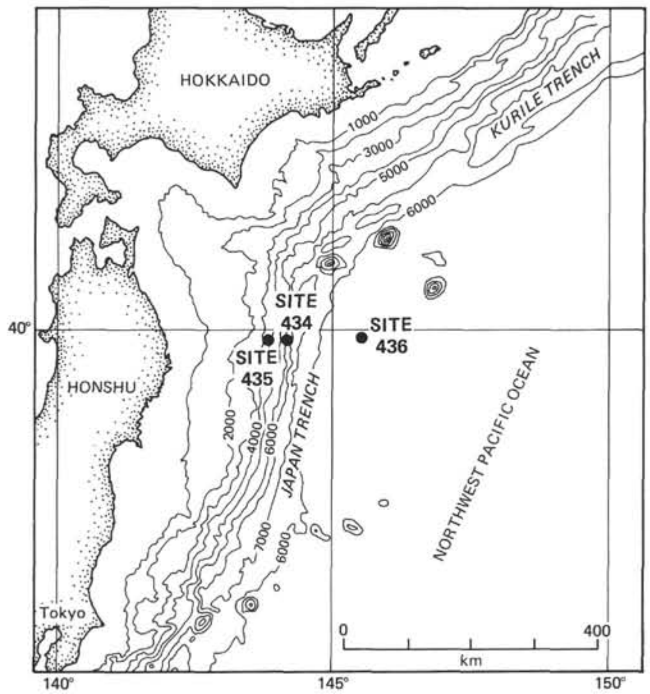

Figure 1. *Location of DSDP Leg 56 sites.*

NANNOFOSSILS AT SITE 435

The nannofossil species recorded at Site 435 are presented in Table 1. Although all sections of Cores 1 through 11 of Hole 435A were examined for nannoflora, barren samples (e.g, Cores 4, 7, and 8) are excluded from the table and only those samples with at least rare amounts of nannofossils are listed. Samples in which frequent nannofossils were encountered in the

TABLE 1
Visual Estimates of Relative Abundance of Various Nannolith Taxa at DSDP Site 435

Sample No.	Hole 435A (Interval in cm)	Abundance	*Cyclococcolithus macintyrei*	*Dictyococcites minutus*	*Discoaster brouweri*	*D. calcaris*	*D. challengeri*	*D. deflandrei*	*D. intercalaris*	*D. latus*	*D. pseudovariabilis*	*D. surculus*	*D. variabilis*	*Reticulofenestra haqii*	*R. pseudoumbilica*	*Coccolithus miopelagicus*	*Cyclolithella rotula*	*Sphenolithus abies*	*D. pentaradiatus*	*Coronocyclus nitescens*	*Coccolithus pateus*	*C. radiatus*	*Discolithina japonica*	*C. pelagicus*	*Helicosphaera sellii*	*H. carteri*	*Hayaster perplexus*	*Cyclococcolithus leptoporus*	*Gephyrocapsa aperta*	*Pseudoemiliania lacunosa*	*Triquetrorhabdulus* sp.	Datums (After Haq et al., 1977; Haq & Berggren, 1978)	Zonation (NN Equivalents after Martini, 1971)	
1	2-1, 13–15	C	R	C										R		R			R					R		R		R					?	Late Pliocene
2	3-2, 20–22	F	R	F	R									R										R								Top? *D. brouweri* (~ 1.8 Ma)	NN 17–18	
3	3-3, 20–22	A	R	A	R							R		R					R			R		F		R		R		R	R			
4	3-4, 20–22	A	R	A	R									R		R						R		R							R			
5	5-1, 30–32	A	R	A	R							R	R	R		R								R							R			
6	5-3, 30–32	A	R	A	R							R		R		R								R		R				R				
7	5-4, 30–32	A		A	R				R			R	R	F		R			R			R		R										
8	6-1, 18–20	A	R	A										R	R									R	R	R			R	R		Bottom? *G. aperta* (~2.3 Ma)		
9	6-3, 18–20	A	C	A	R				R						R				R			R		R	R			R		R				
10	9-1, 30–32	R	R	R									R		R																			
11	9-2, 30–32	C	F	C	R				R				R									R	R	C	R			R				Bottom *P. lacunosa* (~3.1 Ma)	NN 16	
12	9-3, 10–12	F	F	F					R			R	R		R					R			R	R										
13	10-1, 57–59	A	F	A									R		R	F		R	R		R	R	R	F	R		R							
14	11-1, 11–13	C	R	C	R				R			R	R	R	C	C		R	R	R	R	R												
15	11-2, 11–13	R			R									R				R																
16	11-3, 11–13	F	R	R	F	R	F		F	R	R	F	R	R	C	C	R	R														Top *S. abies*	NN 15	Early Pliocene
17	11-4, 11–13	R	R	R				R										R														Top (common occurrence) *R. pseudoumbilica* (~3.3 Ma)		

Note: A = abundant, C = common, F = few, R = rare.

light microscope were also examined with a scanning electron microscope to ascertain the presence of small, biostratigraphically important species such as *Gephyrocapsa* spp. Preservation of nannofossils in those samples not totally devoid of coccoliths ranges from poor to relatively good (see scanning electron micrographs in Plates 1 and 2).

A fairly diverse Pliocene nannoflora is recorded in the cores from Hole 435A (see Table 1). The common, more easily distinguishable elements of the assemblage at Site 435 are quite similar to the early and late Pliocene assemblages recorded from Japan—for example, the southern Kwanto Region (Takayama, 1967) and along the coast of the Sea of Japan (Nishida, 1971). However, in these studies some of the smaller, less easily distinguishable taxa were not recorded, probably because they were undescribed at that time. The assemblage at this site is dominated by the small placoliths of *Dictyococcites minutus*, which occur in common to abundant quantities in most samples. Other relatively prominent coccolith species are *Reticulofenestra pseudoumbilica* (s. str.) and a smaller, related form which has been recently described as a separate species, *Reticulofenestra haqii*, by Backman (1978). *R. pseudoumbilica* is common in Core 11 but becomes rare and sporadic upward, and its presence above its last common occurrence (Core 11) is attributed to reworking. *R haqii* occurs in rare numbers in Core 11, then disappears between Core 10 and Core 6, Section 3, reappearing again in Core 6, Section 1. Its presence above Core 11 can probably also be attributed to reworking. Other prominent coccolith species are *Cyclococcolithus macintyrei*, which is common to rare through most of the section, and *Coccolithus pelagicus*, which occurs in mostly rare numbers from Cores 10 through 2. *C. miopelagicus, C. radiatus, Cyclococcolithus leptoporus,* and *Helicosphaera* spp. also occur sporadically through most of the section.

A diverse discoaster assemblage is recorded in Core 11, Section 3 (see Table 1). At other levels the discoaster assemblage is essentially composed of *Discoaster brouweri* and *D. pentaradiatus. Discoaster surculus* and *D. variabilis* are also present sporadically, probably partially as reworked elements. *Sphenolithus abies* is recorded in Cores 11 and 10 only.

Scanning electron microscopic examination revealed the presence of *Pseudoemiliania lacunosa* in samples from Core 6, Sections 1 and 3; Core 5, Section 3; and Core 3, Section 3; and the presence of *Gephyrocapsa aperta* in Core 6, Section 1, with some fragments in the upper levels that can be attributed to this species. The preservational state in most samples is generally poor, and there is evidence of mechanical breakage of species which selectively fragments the smaller, more delicate forms such as *G. aperta.*

SEDIMENT AGE AT SITE 435

In spite of the obvious reworking of many species in the younger parts of the section in this tectonically active area, a few nannofossil datums can be used to assign age estimates to various levels of the section. We

TABLE 2
Paleobiogeographic Census Data from Pliocene of Site 435

Age	Late Pliocene									Early Pliocene	
Census Taxa / Samples Hole 435A (Interval in cm)	3-3, 20–22	3-4, 20–22	5-1, 30–32	5-3, 30–32	5-4, 30–32	6-1, 18–20	6-3, 18–20	9-2, 30–32	10-1, 57–59	11-1, 11–13	11-3, 11–13
Dictyococcites minutus	84	96	95	85	89	82	69	36	69	17	4
Reticulofenestra pseudoumbilica						2	2		3	46	20
R. haqii	4	+	3	4	5	+				+	+
Cyclococcolithus macintyrei	2	+	1	3	1	4	10	7	5	8	6
Coccolithus miopelagicus	1	+	+	1	1	+	2	4	5	11	12
C. pelagicus	7	2	+	3	+	2	2	41	6		
Discoaster spp.	+	+	+	+	+	+	3	3	4	13	50
Sphenolithus abies									+	+	+
Helicosphaera spp.	+			+	+	2	3	4	+		
Others	+	+	+	3	3	6	9	5	7	4	6

Note: Numbers refer to percentage of total assemblage. + indicates in trace quantities, less than 1 per cent.

have used the last common occurrence of *Reticulofenestra pseudoumbilica,* last occurrence of *Sphenolithus abies,* first occurrence of *Pseudoemiliania lacunosa* and the first occurrence of *Gephyrocapsa aperta* as our selected datums to assign ages to the sediment (see Table 1, right-hand columns). The choice of last common occurrence of *R. pseudoumbilica* in Core 11 as the last appearance datum of this species is more reasonable than its sporadic and rare occurrence above this level up to Core 6, in view of the problem of reworking in the section. This is corroborated by the last occurrence datum of *Sphenolithus abies* in Core 10, since elsewhere both these species disappear approximately at the same level at about 3.3 Ma (Haq and Berggren, 1978).

P. lacunosa first occurs in Core 6, Section 3; however, the actual first appearance datum of this species may be within the barren interval between Core 9, Section 1 and Core 6, Section 3. An approximate age of 3.1 Ma can be assigned to this datum following the biochronology established by Haq and Berggren (1978).

G. aperta has been shown first to appear in the late Pliocene at about 2.3 Ma (Haq et al., 1977). We found this species definitely only in one sample (Core 6, Section 1), where it may occur as downhole contaminant. However, if we assume this to be its true first appearance datum, we can assign an age of about 2.3 Ma to this level. This seems reasonable in view of the first occurrence of *Globorotalia truncatulinoides* in Core 4, Section 1, as reported by the shipboard scientists. *G. truncatulinoides* first appears at about 1.85 Ma (Haq et al., 1977). The last occurrence of *Discoaster brouweri* in Core 3, Section 2, if used as a true extinction level would assign an age of about 1.8 Ma to this sample (Haq et al., 1977).

Since the zone-diagnostic nannofossil species of the Pliocene interval are lacking, we can assign the sediments in Hole 435A only tentatively to biostratigraphic zones. Thus Core 11 is tentatively assigned to NN15 *(D. asymmetricus)* Zone, because elsewhere both *S. abies* and *R. pseudoumbilica* disappear at the top of this zone. Cores 10 through Core 6, Section 3, are assigned to NN16 (*D. surculus*) Zone and Core 6, Section 1, through Core 3, Section 2, to a composite NN17 and 18 (*D. pentaradiatus* and *D. brouweri*) Zones.

PALEOBIOGEOGRAPHY OF NANNOFOSSIL ASSEMBLAGES

Census data for the major biogeographic taxa is presented in Table 2. Only those samples with relatively better preserved and more common nannofossils were counted. Thus two levels of the early Pliocene and nine levels of the late Pliocene are listed in the table.

In the early Pliocene the discoasters and *R. pseudoumbilica* alternatively dominate the assemblage, other taxa being relatively less important quantitatively. Both these taxa indicate relatively warmer climatic conditions during this time interval. In the late Pliocene, however, *Coccolithus pelagicus* temporarily becomes prominent. Elsewhere *Dictyococcites minutus* assemblage first becomes prominent in the middle and late Miocene (Haq et al., 1976). It is a cosmopolitan taxon occurring in low to mid-high latitudes and becomes prominent during times and in areas of greater environmental/climatic instability when other, more sensitive taxa are selectively removed from the environment (Haq, unpublished data). This implies that the late Pliocene was generally a time of environmental instability in the area of the Japan Trench.

ACKNOWLEDGMENTS

This research was supported by the National Science Foundation under Grants Number 20/21274 and 20/19769. This chapter was reviewed by W. A. Berggren and G. P. Lohmann It is Woods Hole Oceanographic Institution Contribution No. 4306.

REFERENCES

Backman, J., 1978. Late Miocene-early Pliocene nannofossil biochronology and biogeography in the Vera Basin, Southeast Spain. *Stockholm Contrib. in Geol.,* 32, 93–114.

Haq, B. U., and Berggren, W. A., 1978. Late Neogene calcareous plankton biochronology of the Rio Grande Rise, S. W. Atlantic Ocean. *J. Paleont.,* 52, 1167–1194.

Haq, B. U., Berggren, W. A., and Van Couvering, J. A., 1977. Corrected age of the Pliocene/Pleistocene boundary. *Nature,* 269, 483–488.

Haq, B. U., Lohmann, G. P., and Wise, S. W., 1976. Calcareous nannoplankton biogeography and its paleoclimatic implications: Cenozoic of the Falkland Plateau (DSDP Leg 36) and Miocene of the Atlantic Ocean. *In* Barker, P. F., and Dalziel, I. W. D., et al., *Init. Repts. DSDP,* 36: Washington (U.S. Govt. Printing Office), 745–759.

Martini, E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proc. 2nd Plankton. Conf. Rome, 1970,* 2, 739–785.

Nishida, S., 1971. Neogene calcareous nannofossils from the coast along the Sea of Japan. *Bull. Nara Univ. Educ.,* 20(2), 71–89.

Takayama, T., 1967. First report on nannoplankton of the upper Tertiary and Quaternary of the southern Kwanto Region, Japan. *J. Geol. B. A.,* 110, 169–198.

PLATE 1
Nannoflora from the Japan Trench Upper Slope
(Bar represents 1μm.)

Figures 1, 2	*Reticulofenestra* sp. Proximal views. 1. Sample 435A-6-1, 18–20 cm. 2. Sample 435A-5-3, 30–32 cm.
Figures 3, 10	*Cyclococcolithus leptoporus* (Murray and Blackman) Kamptner. Distal views. Sample 435A-6-1, 18–20 cm.
Figures 4, 5, 7	*Pseudoemiliania lacunosa* (Kamptner) Gartner. Sample 435A-6-1, 18–20 cm. 4. Proximal view. 5, 7. Distal view.
Figure 6	*Umbilicosphaera sibogae* (Weber van Bosse) Gaarder. Proximal view. Sample 435A-6-1, 18–20 cm.
Figure 8	*Reticulofenestra pseudoumbilica* Gartner. Proximal view. Sample 435A-6-1, 18–20 cm.
Figure 9	*Coccolithus miopelagicus* Bukry. Distal view. Sample 435A-6-1, 18–20 cm.

PLATE 1

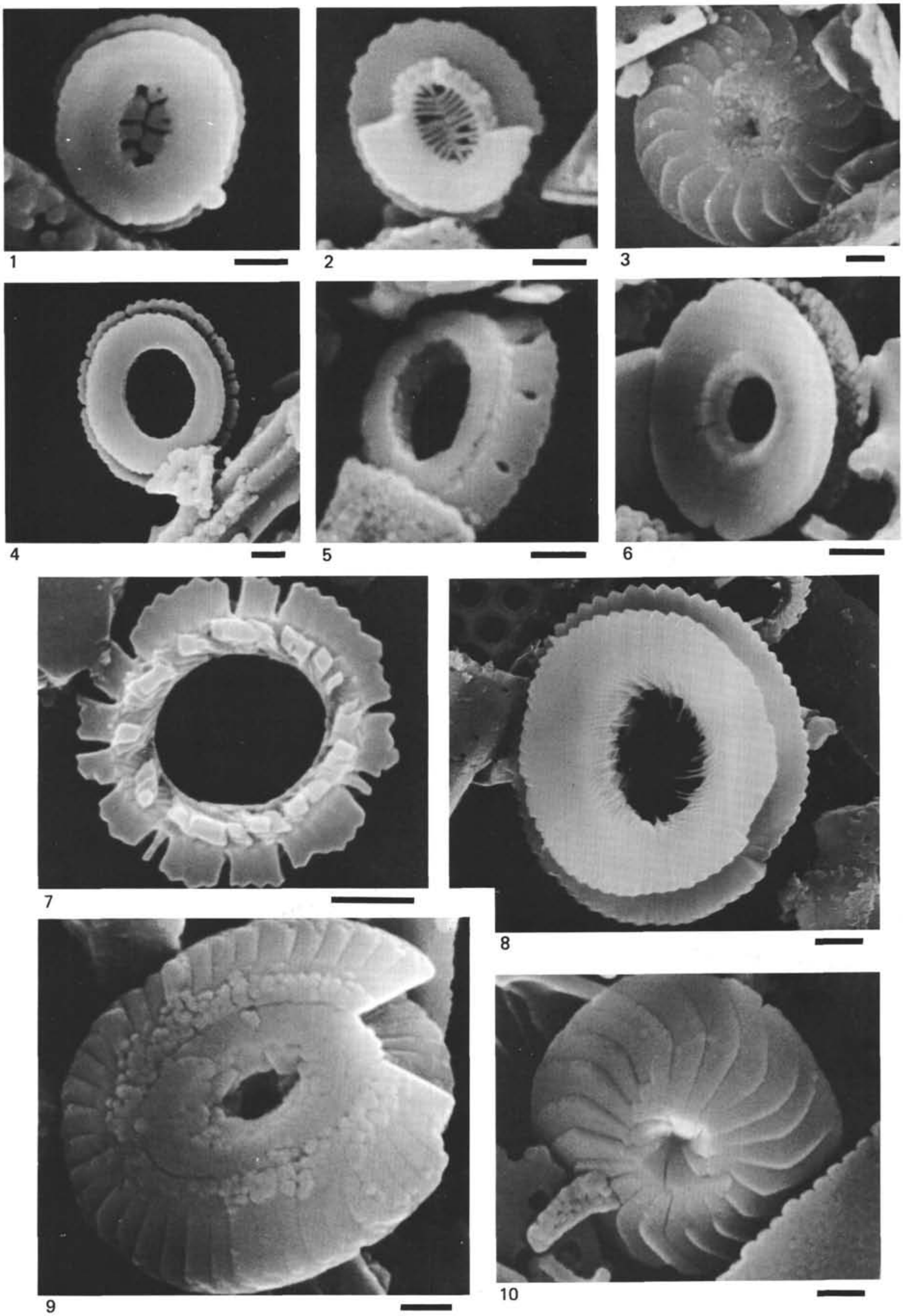

PLATE 2
Nannoflora from the Upper Slope of Japan Trench
(Bar represents 1 μm.)

Figures 1, 3, 7, 8	*Reticulofenestra haqii* Backman. 1. Proximal view. Sample 435A-6-1, 18–20 cm. 3. Distal view. Sample 435A-5-1, 30–32 cm. 7. Distal view. Sample 435A-6-1, 18–20 cm. 8. Distal view. Sample 435A-4-1, 20–22 cm.
Figure 2	*Dictyococcites minutus* Haq. Distal view. Sample 435A-4-1, 20–22 cm.
Figures 4–6	*Gephyrocapsa aperta* Kamptner. Distal view. Sample 435A-6-1, 18–20 cm.
Figure 9	*Coccolithus pelagicus* (Wallich) Schiller. Proximal view. Sample 435A-6-1, 18–20 cm.
Figure 10	*Coccolithus miopelagicus* Bukry. Proximal view. Sample 435A-6-1, 18–20 cm.
Figure 11	*Cyclococcolithus* sp. Distal view. Sample 435A-6-1, 18–20 cm.

PLATE 2