Winterer, E.L., Sager, W.W., Firth, J.V., and Sinton, J.M. (Eds.), 1995
Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 143

33. *DATA REPORT:* CENOZOIC CALCAREOUS NANNOFOSSILS OF HOLE 869A, EQUATORIAL PACIFIC OCEAN[1]

John V. Firth[2]

ABSTRACT

Ocean Drilling Program (ODP) Hole 869A, drilled at abyssal depths in the Marshall Islands of the equatorial western Pacific Ocean, contains moderately preserved calcareous nannofossil assemblages of middle Eocene to early Miocene age. Uppermost Oligocene Zone NP25 appears to be missing because of a hiatus. A possible hiatus is indicated in the lower Oligocene. Zone NP17 of late middle Eocene age is largely missing, either because of a hiatus or because of an unrecovered interval in the core.

INTRODUCTION

Hole 869A (11°0.009′N, 164°44.696′E; water depth of 4826.7 m) was drilled about 45 nmi southwest of the Pikini Atoll and Wodejabato Guyot edifice, in the western equatorial Pacific Ocean (Fig. 1). The objective of Site 869 was to recover a sediment sequence that included sediments shed off the nearby atoll-guyot pair and that would record their history of volcanism, tectonism, and shallow-water carbonate development. From Hole 869A, a sequence of clayey nannofossil and radiolarian oozes of Miocene to Eocene age was recovered (Sager, Winterer, Firth, et al., 1993). The oozes are bioturbated and also show evidence of turbidite deposition. Calcareous nannofossils are abundant and moderately preserved, and radiolarians are abundant and well preserved, from Cores 143-869A-1H to -15X. In Cores 143-869A-16X, -17X, and -18X, only small amounts of chert were recovered and are not included in this biostratigraphic study.

METHODS

Smear slides were made from each sample and were scanned at 1000× magnification. Relative abundances are recorded in Tables 1 and 2 as follows:

R (rare) = <1 specimen/10 fields of view,
F (few) = 1 specimen/1 to 10 fields of view,
C (common) = 1 to 10 specimens/field of view, and
A (abundant) = >10 specimens/field of view.

The zonation of Martini (1971) was followed. In addition, application of the zonation of Okada and Bukry (1980) to the Eocene section of Hole 869A is discussed below.

Cyclicargolithus is treated as a monospecific genus, with one species, *Cyclicargolithus floridanus,* following the results of Firth (1992). Large forms of *Cyclicargolithus,* referred to by others as *C. abisectus,* are few to common in Zones NP23 to NN2 of Hole 869A.

RESULTS

Miocene and Oligocene

Samples 143-869A-1H-1, 76–77 cm, to -1H-7, 3–4 cm, are assigned to lower Miocene Zone NN2, based on the occurrence of *Discoaster druggii* (Table 1). *Triquetrorhabdulus carinatus, Sphenolithus moriformis, Coccolithus pelagicus, Cycicargolithus floridanus,* and *Discoaster deflandrei* are all common to abundant within this zone. Shipboard biostratigraphy reported the occurrence of *D. druggii* down to Section 143-869A-4H-3, 78 cm (Sager, Winterer, Firth, et al., 1993); I believe, however, that such specimens reported below Core 143-869A-1H were either misidentified, overgrown specimens of *Discoaster deflandrei,* or were the result of downhole contamination. Below Core 143-869A-1H, the calcareous nannofossil biostratigraphy of the lower Miocene to upper Oligocene interval is difficult to interpret because of rare, scattered occurrences of marker species and because of reworking.

The base of upper Oligocene zone NP24 is placed at the lowest occurrence (LO) of *Sphenolithus ciperoensis* in Sample 143-869A-4H-4, 113–114 cm. The top of Zone NP24 is defined as the highest occurrence (HO) of *Sphenolithus distentus;* however, this datum is not easily determined in this core. A thin (1–2 cm) layer of white nannofossil ooze occurs at Sample 143-869A-4H-3, 80–82 cm, which separates white nannofossil ooze below from brown radiolarian ooze above. This layer contains *Reticulofenestra umbilicus* and *Coccolithus formosus,* well above their respective HOs in Core 143-869A-7H, indicating that the layer has been reworked (Sager, Winterer, Firth, et al., 1993). Both *S. ciperoensis* and *S. distentus* have common abundances up to this reworked layer (up to Sample 143-869A-4H-3, 83–84 cm), but occur sporadically above it. This suggests that their ranges have been truncated by a hiatus and that Zone NP25 (the interval between the HO of *S. distentus* and the HO of *S. ciperoensis*) is missing from Hole 869A. In the absence of the defined marker species (*Helicosphaera recta*) for the Zone NP25/NN1 (Oligocene/Miocene) boundary, the HO of *S. ciperoensis* has been used as a secondary marker for this boundary (Rio et al., 1990). Thus, Samples 143-869A-2H-1, 145–146 cm, to -4H-3, 81–82 cm, have been tentatively assigned to the lowest Miocene Zone NN1, as they are below the LO of *D. druggii,* and are above the (nonreworked?) HO of *Sphenolithus ciperoensis.* This zone contains the same general assemblage as Zone NN2, but also contains *Sphenolithus conicus, Sphenolithus delphix,* and *Sphenolithus dissimilis.* Rio et al. (1990) and Fornaciari et al. (1993) reported a short acme of *S. delphix* in the upper part of Zone NN1 in the equatorial Indian Ocean and in the western Pacific, respectively. A similar short range of this species in Core 143-869A-3H may indicate the same event.

Radiolarian biostratigraphy (Aitchison and Flood, this volume) indicates the lower Miocene *S. delmontensis* Zone (equivalent to Zone NN2, according to the correlation of Berggren et al., 1985) in Sample 143-869A-4H-1, 90–92 cm. This would suggest a lower placement of the base of Zone NN2 than is indicated by the occurrence of *D. druggii.* This discrepancy may indicate that correlations between the radiolarian and nannofossil zonations need to be revised

[1] Winterer, E.L., Sager, W.W., Firth, J.V., and Sinton, J.M. (Eds.), 1995. *Proc. ODP, Sci. Results,* 143: College Station, TX (Ocean Drilling Program).

[2] Ocean Drilling Program, 1000 Discovery Drive, College Station, TX 77845, U.S.A.

Table 1. Calcareous nannofossil taxa in the Miocene and Oligocene of Hole 869A.

Hole 869A Sample	Interval (cm)	Abundance	Preservation	*Blackites spinosus*	*Bramlettius serraculoides*	*Chiasmolithus nitidus*	*Clausicoccus fenestratus*	*Coccolithus formosus*	*Coccolithus pelagicus*	*Coronocyclus niticens*	*Cyclicargolithus floridanus*	*Discoaster deflandrei*	*Discoaster druggii*	*Discoaster tani*	*Discoaster tani nodifer*	*Discoaster variabilis*	*Hayaster perplexus*	*Helicosphaera compacta*	*Pedinocyclus larvalis*	*Reticulofenestra bisecta*	*Reticulofenestra umbilicus*	*Sphenolithus ciperoensis*	*Sphenolithus conicus*	*Sphenolithus delphix*	*Sphenolithus dissimilis*	*Sphenolithus distentus*	*Sphenolithus intercalaris*	*Sphenolithus moriformis*	*Sphenolithus predistentus*	*Sphenolithus pseudoradians/radians*	*Sphenolithus tribulosus*	*Striatococcus pacificanus*	*Thoracosphaera sp.*	*Triquetrorhabdulus carinatus*	*Zygrhablithus bijugatus*	Zone	Age
1H-1	76-77	A	M						F		A	A				F												F						R		NN2	early Miocene
1H-2	4-5	A	M						F		A	A	C			R							F					C						F			
1H-3	4-5	A	P						F		C	C	R			F												F						C			
1H-4	47-48	A	P						C		C	A																F						A			
1H-5	4-5	A	M						C		A	A	C															F						A			
1H-6	4-5	A	M						C	R	A	A	C															F						A			
1H-7	3-4	A	P-M						C		C	C	F			R												F						A			
2H-1	145-146	A	M						C		C	A											F					C						A		NN1	
2H-2	127-128	A	P-M						C		C	A											A					C						A			
2H-3	93-94	A	P-M						C		C	A											A					C						A			
2H-4	55-56	A	P-M						C		C	A											C					C						A			
2H-5	8-9	A	P-M						C		C	A											C					A						A			
2H-6	40-41	A	P-M						C		C	A											C					A						A			
2H-7	5-6	A	P-M						C		C	A																C						A			
3H-1	74-75	A	P-M						C		C	A																C						A			
3H-2	120-121	A	M-G						A	R	A	A								R								A						R			
3H-3	25-26	A	P-M						C		R	A																C						A			
3H-4	139-140	A	P-M						A		A	A																C						A			
3H-5	27-28	A	M					R	C		A	A								R	R	R	F	F	R			C						A			
3H-5	29-30	A	M		R				C		A	A								R	R	R	F	R				A	R					A			
3H-5	40-41	A	M		R				C	R	A	A								R			F	R	F			C				R		C			
3H-5	100-101	A	M						C		A	A								R			R					A						A			
3H-5	108-109	A	M			R			C		A	A								R	R		F					C	R					A			
3H-5	138-139	A	G				R		C	R	A	A								R		R	F		F			C						C	R		
3H-6	7-8	A	M				R		R		A	A										R			R			A						A			
3H-6	31-32	A	P-M						F		A	A								R	R							F						A			
3H-6	83-84	A	P-M		R				F		A	A																R						A			
3H-6	135-136	A	P-M						F		A	A								R								F						A			
3H-CC	16-17	A	P						F		R	A																R						A			
4H-1	40-41	A	P						C		A	A													F			C						A			
4H-1	112-113	A	M				R		A	R	A	A										F				C		A	F		C			F			
4H-1	143-144	A	P						C	R	A	A																R						C			
4H-2	7-8	A	M						C	R	A	A								R		R			R			A						A			
4H-2	75-76	A	P-M				F		A		A	A																C			R			C			
4H-3	22-23	A	M						A		A	A																A	R					C			
4H-3	78-79	A	P-M		R				C	R	A	A														R		C	F		R						
4H-3	81-82	A	P-M		R			R	C	R	A	A								C	R							A	C								
4H-3	83-84	A	M-G						C	R	A	A								R		C				C		A	C							NP24	late Oligocene
4H-3	89-90	A	P-M				R		C	F	A	A										F				R		C	R		R			F			
4H-3	108-109	A	M-G				F		A	R	A	A								R		F				F		A	F								
4H-3	146-147	A	M-G						A	R	A	A										R				R		A	F								
4H-4	9-10	A	M-G						A	R	A	A										R				F		A	C								
4H-4	113-114	A	M-G				C		A	C	A	A		R			R					R				C		A	C		C			F			
4H-5	140-141	A	M-G				C		A	R	A	A		R					R							C		A	C		C					NP23	early Oligocene
4H-6	120-121	A	M				F		A	R	A	A		R												C		A	C		C						
5H-1	50-51	A	M-G				F		A		A	A								R						F		A	C		C						
5H-2	51-52	A	M				F		A		A	A		R						R						C		A	C		C						
5H-3	50-51	A	M-G		R		F		A		A	A														C		A	C		C						
5H-5	50-51	A	M				C		A	R	A	A		R			R		R							C		A	C		C						
5H-6	50-51	A	M				C		A	R	A	C								R						C		A	C	R	C	R					
6H-1	140-141	A	M				F		A		A	C		F						R						F		A	A	R							
6H-2	140-141	A	M-G				R		C		A	C														F		A	F		C						
6H-4	100-101	A	M						A		A	A		C						F						R		A	A	R		R					
6H-5	69-70	A	G				F		A	R	A	C		F				R		A								A	A								
6H-6	94-95	A	M-G		C		C	F	A		A	C		F						A	R					R		A	A			R					
6H-6	100-101	A	M-G				F	R	A		A	C		F						A	R							A	A	F		R					
7H-1	8-9	A	M-G				R		A		A	C		R					R	A								A	C			R					
7H-2	56-57	A	P-M	C			C		A		A	C		F						C	F							A	A			F				NP22	
7H-4	50-51	A	M-G	R			C		A		A	C		F				R	R	C	C							A	A			F					
7H-5	50-51	A	M-G	A			C	C	A		A	C		F						A	F							A	A			R				NP21	
7H-6	50-51	A	G	A			C	C	C		A	C		F						A	F							A	A			R					
7H-7	50-51	A	G	C			F	C	C		A	C		C	R					A	R							A	A			R					
7H-8	50-51	A	M-G	A			C	C	C		A	C		C						A	R							A	A			R					
8H-2	50-51	A	M-G		A		C	F	A		A	C		C						A	F							A	A			R					
8H-3	50-51	A	G		A		C	C	A		A	C		F						A	R							A	C			R	R				
8H-4	100-101	A	G		C		C	F	C		A	C		F						A	R							A	C			F					
8H-5	100-101	A	G		A		F	C	C		A	C		F						A	F					R	C	A	F								
8H-6	100-101	A	M-G		C		C	C	C		A	C		F				R		A	R							A	C			F					
8H-7	100-101	A	G		C		F	C	C		A	C		F				R		A	C							A	C			R	R				
8H-8	50-51	A	G		C		F	C	A		A	F		F						A	C							A	C			F					
9H-1	90-91	A	G		C		C	F	C	R	A	C		F						A	C							A	C			R					
9H-2	89-90	A	M-G					F	C		C	C		C	R					A	C							A	C								

Table 2. Calcareous nannofossil taxa in the Eocene of Hole 869A.

Hole 869A																																																				
Sample	Interval (cm)	Abundance	Preservation	*Bramletteius serraculoides*	*Calcidiscus protoannulus*	*Campylosphaera dela*	*Chiasmolithus consuetus*	*Chiasmolithus gigas*	*Chiasmolithus grandis*	*Chiasmolithus nitidus*	*Chiasmolithus solitus*	*Chiasmolithus titus*	*Clausicoccus fenestratus*	*Coccolithus formosus*	*Coccolithus pelagicus*	*Coronocyclus nitescens*	*Cyclicargolithus floridanus*	*Discoaster barbadiensis*	*Discoaster binodosus*	*Discoaster deflandrei*	*Discoaster lodoensis*	*Discoaster nonaradiatus*	*Discoaster saipanensis*	*Discoaster spp.*	*Discoaster sublodoensis*	*Discoaster tani*	*Discoaster tani nodifer*	*Fasciculithus sp.*	*Hayaster perplexus*	*Helicosphaera compacta*	*Helicosphaera heezenii*	*Helicosphaera sp.*	*Nannotetrina fulgens*	*Nannotetrina sp.*	*Pedinocyclus larvalis*	*Reticulofenestra bisecta*	*Reticulofenestra dictyoda*	*Reticulofenestra umbilicus*	*Reticulofenestra reticulata*	*Rhabdosphaera sp.*	*Sphenolithus anarrhopus*	*Sphenolithus furcatolithoides*	*Sphenolithus intercalaris*	*Sphenolithus moriformis*	*Sphenolithus pseudoradians/radians*	*Sphenolithus spiniger*	*Striatococcus pacificanus*	*Thoracosphaera sp.*	*Towieus sp.*	*Zygrhablithus bijugatus*	Zone (Martini, 1971)	Age
9H-3	89-90	A	M-G	C										F	C		C	R		C			R			F	R									A		C						C							NP18-20	Late Eocene
9H-4	89-90	A	M-G	F										F	C		A	R		F			R			F	R									C		C						C						R		
9H-5	90-91	A	M	C										C	C		C	C		F			C			F										A		C		F				C	F							
9H-6	89-90	A	P-M	F									R	F	C		F	C		C			C			C										C		F						F	R					F		
9H-7	59-60	A	M-G	R										C	C	R	C	C		F			F			F										F		F						C	R		R					
10X-1	55-56	A	P-M											F	C			C					C			F	C									A	R	R					C	C			R					
10X-1	66-67	A	M											R	C			C	R				C			C	C									A		F					R	C						R		
10X-1	98-99	A	M	F										C	C	R		F					C			R	F									A		F					F	A	R					R		
10X-1	142-143	A	P-M											C	A			C	R				C			R										A	R	F					C	R								
10X-2	28-29	A	M											C	C			A					A													A	R	R						C								
10X-2	52-53	A	M	R										C	C			A					A			R										A	F	C					C	C	R							
10X-2	96-97	A	P-M	R					F					C	A			C	F	C			C			R										A	F	F	R				F	C							NP17	Middle Eocene
11X-1	50-51	A	P-M			F			F		F	R		F	C		F	C			R		C				R			R					R		C	F				F		F		F	R	R			NP16	
11X-2	50-51	A	M			R			R		R	R		F	C		F	C									F										C	C				R		F								
11X-3	40-41	A	P-M			R			R					F	C			C					R				F										C	F				R		C								
11X-4	6-7	A	M	F	R	R		R	F		R			C	C			C					F	F													C	F		F		F		C	F	R	R					
11X-5	50-51	A	M			R		F	F	R	R			C	C		F	C		F									R								C	R		C		F		C	F	F	R			C		
12X-1	53-54	A	M			R			F	R	C			C	A		C	F					C				F										C	F		C		F		C		F	R			C		
12X-2	71-72	A	P-M	R		R		R	F	R	R		R		C		C	C					F			F	F										C	F				F		C	R	F	R					
12X-3	52-53	A	P-M			R			F		F	R			C		C	C																			C	R				F		C		F	R					
12X-4	8-9	A	M					R	F						C		C	C								F	F						R	R			C			R		R		C	R	R	R				NP15	
12X-5	55-56	A	P-M	R	R				F		C				C		C	C			R						F			R							C			C		F		C		C				F		
13X-1	128-129	A	M			R		F	C	F	C			C	C		C	C		F			R	R							R	R	R				C			C		F		C	F	C	R	F		C		
13X-2	137-138	A	M-G						F	R				C	C			C		F				R									R	R			C			C				C	F					C		
13X-4	37-38	A	M	F		R		R	C	R	C			C	C		F	C		R			F														C			C		F		C	R	F	R			C		
13X-5	14-15	A	M	F		R		F	C	F				C	C			C						R													C			F		F		C	R	F				C		
14X-1	129-130	A	M					R	R	F	R			C	C		C	C					F	F				R							R		C			C	F	F		C	R	F	R			R		
14X-2	91-92	A	M					R	R	F	F	R		C	C		F	C					F	F										R			C			C	C	F		C	R	F	F					
14X-4	127-128	A	M					R	R	F	C			C	C		C	C					F	F	R									R	R		C			C	F	F		F	R	R		R				
14X-5	66-67	A	M					F	F		C			C	C			C					F														C			C	R	F		C	R	F						
14X-6	40-41	A	P-M			R		R	R	R	C			C	C		F	F					R	F	R									R			C			C		R		C	R	F		R				
14X-CC	3-4	R	M												R									R																												
14X-CC	11-12	B																																																		
15X-1	118-120	A	M		R			R	R	R				C	C		C	C			R		C										R				C			C				C	R	F	R		R	F		
15X-2	117-119	C	P						R						C			C			R			F													C									R			R		NP14	
15X-3	79-81	A	P-M		R	R	R		F	R				C	A		C	C				R	C														C			C	F			A	F	F	R			C		
15X-4	73-75	A	M-G						F					C	C		C	C			R		F	F										C			C			F				C	F					F		
15X-5	43-45	A	M			R		R	F	R	F	R		C	C		C	C		F				F										R	R		C			F	R			C	F	R				R		
15X-6	43-45	A	M						F					C	C		R	C		R	R			F				R						R			F							C	C	R				C		
15X-7	1-3	C	P						R						F			C						F																				F								

for this part of the western equatorial Pacific. Alternatively, the basal range of *D. druggii* in this hole may be diachronous, compared to other areas, because of its scattered occurrence (see Takayama, 1993, for similar situation in the western equatorial Pacific).

Samples 143-869A-4H-5, 140–141 cm, through -7H-1, 8–9 cm, lie between the HO of *Reticulofenestra umbilicus* and the LO of *S. ciperoensis,* and are assigned to lower Oligocene Zone NP23. Rare specimens of *R. umbilicus* and *Coccolithus formosus* in Samples 143-869A-6H-6, 94–95 cm, and -6H-6, 100–101 cm, are considered to have been reworked. Zone NP22 is thin and consists only of Samples 143-869A-7H-2, 56–57 cm, and -7H-4, 50–51 cm, which suggests a hiatus may have truncated this zone. Zone NP21 contains *C. formosus* and lies above the HOs of *Discoaster barbadiensis* and *Discoaster saipanensis,* and includes Samples 143-869A-7H-5, 50–51 cm, through -9H-2, 89–90 cm. Overall, the Oligocene of Hole 869A is characterized by common to abundant *R. bisecta* (in the lower Oligocene), *S. predistentus, C. pelagicus, C. floridanus, D. deflandrei,* and *S. moriformis.*

Eocene

Samples 143-869A-9H-3, 89–90 cm, through -10X-2, 52–53 cm, contain *D. barbadiensis, D. saipanensis,* and common to abundant *R. bisecta* (Table 2) and lie above the HO of *Chiasmolithus grandis.* The HO of *C. grandis* has been used by Okada and Bukry (1980) as an alternative marker to the LO of *Chiasmolithus oamaruensis,* to mark the top of Zone CP14. According to the correlation of Martini and Müller (1986), the top of Zone CP14 corresponds to the top of the middle Eocene Zone NP17. However, Martini and Müller (1986) also adopted the HO of *C. grandis* as an alternative marker for the Zone NP18/NP19 boundary, in lieu of the LO of *Isthmolithus recurvus.* Although it seems that exact correlation of the HO of *C. grandis* to the other two datums is uncertain, I use it here to approximate the top of Zone NP17, in place of the LO of *C. oamaruensis,* which is absent from Hole 869A. In Hole 869A, *I. recurvus* also is absent, and the LO of *Sphenolithus pseudoradians* is not considered useful (see Martini and Müller, 1986, for discussion); therefore, further subdivision of

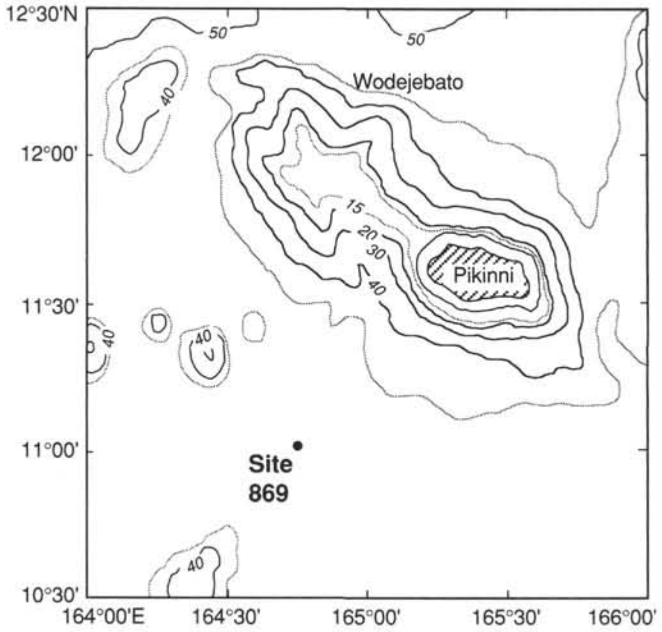

Figure 1. Bathymetric map showing the location of Site 869. Bathymetric contours (in hundreds of meters) at 1000-m intervals are shown as dark lines: auxiliary 500-m contours shown in gray.

the upper Eocene in this hole is not possible. Sample 143-869A-10X-2, 96–97 cm, contains *C. grandis,* but lies above the HO of *Chiasmolithus solitus;* it has been assigned to Zone NP17. This sample contains abundant *R. bisecta.* Core 143-869A-10X had recovery of only 28%, and the lost interval may include the rest of Zone NP17. Immediately below, in Sample 143-869A-11X-1, 50–51 cm, middle Eocene species *Campylosphaera dela, Chiasmolithus solitus,* and *Sphenolithus furcatolithoides* all have their HOs.

Samples 143-869A-11X-1, 50–51 cm, through -15X-7, 1–3 cm, are of middle Eocene age, based on the co-occurrence of *S. furcatolithoides, C. grandis,* and *C. solitus.* However, subdivision of this interval, based on either Martini's (1971) or Okada and Bukry's (1980) zonations, is not straightforward, because of the absence of some marker species and because some species' ranges do not show the same stratigraphic relationship as is stated in their zonations:

1. Marker species *Rhabdosphaera inflata, Rhabdosphaera gladius*, and *Discoaster bifax* do not occur in Hole 869A.

2. *Chiamolithus gigas* is supposed to have a short range that subdivides Zone CP13 and should not overlap the range of *R. umbilicus* (Okada and Bukry, 1980). Applegate and Wise (1987), however, found that *C. gigas* can overlap the range of *R. umbilicus.* In Hole 869A, the range of *C. gigas* overlaps the range of *R. umbilicus* (defined as placoliths >14 µm; Backman and Hermelin, 1986). This may be explained by reworking of *C. gigas.* Rare occurrences of *Discoaster lodoensis* as high as Sample 143-869A-11X-1, 50–51 cm (Table 2) give other evidence for reworking in this core.

The top of Zone NP16 is marked by the HO of *C. solitus* in Sample 143-869A-11X-1, 50–51 cm. In the absence of *R. gladius,* the base of Zone NP16 is approximated by the HO of *Nannotetrina fulgens* (Perch-Nielsen, 1985) and the LO of *R. umbilicus,* and is placed in Sample 143-869A-12X-3, 52–53 cm. Zone NP15 ranges from Sample 143-869A-12X-4, 8–9 cm, to the LO of *N. fulgens* in Sample 143-869A-15X-1, 118–120 cm. The interval from Sample 143-869A-15X-2, 117–119 cm, to -15X-7, 1–3 cm, has been assigned to Zone NP14. *Discoaster sublodoensis* is very rare and overgrown in Hole 869A and cannot be used to mark the base of Zone NP14.

CONCLUSIONS

A middle Eocene (Zone NP14) to lower Miocene (Zone NN2) sequence was recovered in Hole 869A. A hiatus between the upper Oligocene and lower Miocene sequence, which includes uppermost Oligocene Zone NP25, is indicated by calcareous nannofossils. Lower Oligocene Zone NP22 is very thin, which suggests that it may be truncated by a hiatus. Zones NP14 to NP18-20, of middle to late Eocene age, are recognized in Hole 869A, although Zone NP17 may be either truncated by a hiatus or was largely not recovered in Core 143-869A-10X.

REFERENCES*

Applegate, J.L., and Wise, S.W., Jr., 1987. Eocene calcareous nannofossils, Deep Sea Drilling Project Site 605, upper continental rise off New Jersey U.S.A. *In* van Hinte, J.E., Wise, S.W., Jr., et al., *Init. Repts. DSDP,* 93: Washington (U.S. Govt. Printing Office), 685–698.

Backman, J., and Hermelin, J.O.R., 1986. Morphometry of the Eocene nannofossil *Reticulofenestra umbilicus* lineage and its biochronological consequences. *Palaeogeogr., Palaeoclimatol., Palaeoecol.,* 57:103–116.

Berggren, W.A., Kent, D.V., Flynn, J.J., and Van Couvering, J.A., 1985. Cenozoic geochronology. *Geol. Soc. Am. Bull.,* 96:1407–1418.

Firth, J.V., 1992. Analysis of the taxonomic, biostratigraphic and evolutionary relationships of species of the calcareous nannofossil genus *Cyclicargolithus* Bukry (1971) from the upper Eocene and Oligocene of the North Atlantic. *Mem. Sci. Geol.,* 43:237–259.

Fornaciari, E., Backman, J., and Rio, D., 1993. Quantitative distribution patterns of selected lower to middle Miocene calcareous nannofossils from the Ontong Java Plateau. *In* Berger, W.H., Kroenke, L.W., Mayer, L.A., et al., *Proc. ODP, Sci. Results,* 130: College Station, TX (Ocean Drilling Program), 245–256.

Martini, E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In* Farinacci, A. (Ed.), *Proc. 2nd Int. Conf. Planktonic Microfossils Roma:* Rome (Ed. Tecnosci.), 2:739–785.

Martini, E., and Müller, C., 1986. Current Tertiary and Quaternary calcareous nannoplankton stratigraphy and correlations. *Newsl. Stratigr.,* 16:99–112.

Okada, H., and Bukry, D., 1980. Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973; 1975). *Mar. Micropaleontol.,* 5:321–325.

Perch-Nielsen, K., 1985. Cenozoic calcareous nannofossils. *In* Bolli, H.M., Saunders, J.B., and Perch-Nielsen, K. (Eds.), *Plankton Stratigraphy:* Cambridge (Cambridge Univ. Press), 427–554.

Rio, D., Fornaciari, E., and Raffi, I., 1990. Late Oligocene through early Pleistocene calcareous nannofossils from western equatorial Indian Ocean (Leg 115). *In* Duncan, R.A., Backman, J., Peterson, L.C., et al., *Proc. ODP, Sci. Results,* 115: College Station, TX (Ocean Drilling Program), 175–235.

Sager, W.W., Winterer, E.L., Firth, J.V., et al., 1993. *Proc. ODP, Init. Repts.,* 143: College Station, TX (Ocean Drilling Program).

Takayama, T., 1993. Notes on Neogene calcareous nannofossil biostratigraphy of the Ontong Java Plateau and size variations of *reticulofenestra* coccoliths. *In* Berger, W.H., Kroenke, L.W., Mayer, L.A., et al., *Proc. ODP, Sci. Results,* 130: College Station, TX (Ocean Drilling Program), 179–229.

*Abbreviations for names of organizations and publications in ODP reference lists follow the style given in *Chemical Abstracts Service Source Index* (published by American Chemical Society).

Date of initial receipt: 11 November 1993
Date of acceptance: 27 June 1994
Ms 143SR-205