10. PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY OF THE MIDDLE AMERICA TRENCH REGION, DEEP SEA DRILLING PROJECT LEG 84[1]

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ABSTRACT

Eleven holes were drilled at six sites along a transect of the landward side of the Middle America Trench during DSDP Leg 84. Sites 566–570 are in the same area as DSDP Leg 67 sites offshore from Guatemala, and Site 565 is offshore from Costa Rica. Pleistocene and Pliocene sediments were recovered at Site 565; Pleistocene to upper Miocene sediments at Site 566; Pleistocene and Pliocene, lower Miocene, and Upper Cretaceous sediments at Site 567; Quaternary and middle and lower Miocene sediments at Site 568; Quaternary, lower Pliocene, middle Miocene to upper Oligocene, lower Oligocene and upper Eocene, and middle and lower Eocene sediments at Site 569; and Quaternary to middle Miocene and lower Eocene sediments at Site 570.

Planktonic foraminifers are variably preserved but generally common in all holes, except within several highly dissolved intervals. Both quantitative and semiquantitative analyses of planktonic foraminifers, in addition to the first and last occurrences of index species, were used to establish the biostratigraphy for Leg 84 sites. Biostratigraphic analysis of the planktonic foraminifers provides useful data for reconstructing the tectonostratigraphic history of the southern Guatemalan segment of the Middle America Trench.

The Leg 84 stratigraphic record is fragmentary. The poorly represented Paleogene section is interrupted by several unconformities, and one major Neogene unconformity occurs between the upper lower Miocene and the upper Pliocene. The Neogene unconformity can be related to tectonic activity in the Middle America Trench region associated with a major pulse in volcanic activity between 1 and 4 Ma (peaking from 1 to 2 Ma) and a minor pulse between 14 and 16 Ma.

Despite the fragmentary nature of the sedimentary record, the sequences are not repeated or reversed, and evidence of imbrication of oceanic sequences is lacking. Gravity-induced downslope transport and reworking of older sediments into younger deposits, however, are apparent through analysis of benthic and planktonic foraminifers, suggesting that a slope–trench environment similar to the present one existed during the Cenozoic.

INTRODUCTION

During Leg 84 of the Deep Sea Drilling Project (DSDP), eleven holes were drilled at six sites on the landward slope of the Middle America Trench. Site 565 was drilled offshore from Costa Rica and Sites 566–570 were drilled in the San José Canyon offshore from the Nicoya Peninsula of Guatemala in the same area as DSDP Leg 67 (Figure 1; Table 1).

One of the main objectives of Leg 84 was to establish the age and tectonostratigraphy of the landward slope of the Middle America Trench more conclusively than during the earlier DSDP Leg 67. Leg 67, undertaken specifically to investigate the "type region" of the trench–slope accretionary model of Seely et al. (1974), failed to reveal any imbrication or age reversals in the Eocene and younger sediments of the slope, suggesting that the accretionary model might not apply to this segment of the trench. The presence of gas hydrates, however, had precluded sufficient sampling to confirm this suggestion. Biostratigraphic analysis of planktonic foraminifers recovered from the Leg 84 sites provides data useful for reconstructing the tectonostratigraphic history of the southern Guatemalan segment of the Middle America Trench. Additional data from three Leg 67 sites (499, 500, and 495) are included in this report to complete the transect across the trench into oceanic sediments.

Coring at Leg 84 sites recovered Upper Cretaceous to Pleistocene sediments. The stratigraphic record is fragmentary and interrupted by numerous hiatuses and barren intervals, owing to carbonate dissolution. Little of the Paleogene section is preserved (only at Sites 569 and 570); middle and upper Miocene sediments were recovered essentially only from Site 570. Microfossil assemblages indicate frequent intervals of reworked sediments and downslope transport, as would be expected in a slope–trench environment. Despite the fragmentary nature of the depositional record, the lithologic or age sequences are not repeated or reversed. Preservation is variable throughout the sections analyzed. Some intervals show such severe carbonate dissolution that nearly all foraminifers are dissolved. Dissolution intervals and hiatuses identified in the Cenozoic sediments (upper Paleogene to Pleistocene) can generally be correlated with global cooling events and resultant increases in bottom-current circulation and corrosiveness of bottom waters, and with vertical tectonic activity of the Middle America convergent margin. In this study, dissolution intervals (marked by diagonal lines in the pertinent figures) and hiatuses are related to known episodes of global cooling wherever such inferences appear justified. Recognition of specific dissolution intervals can aid in both paleoceanographic and biostratigraphic interpretations.

Planktonic foraminifers from Leg 84 sites were analyzed quantitatively wherever preservation permitted (Sites

[1] von Huene, R., Aubouin, J., et al., *Init. Repts. DSDP*, 84: Washington (U.S. Govt. Printing Office).
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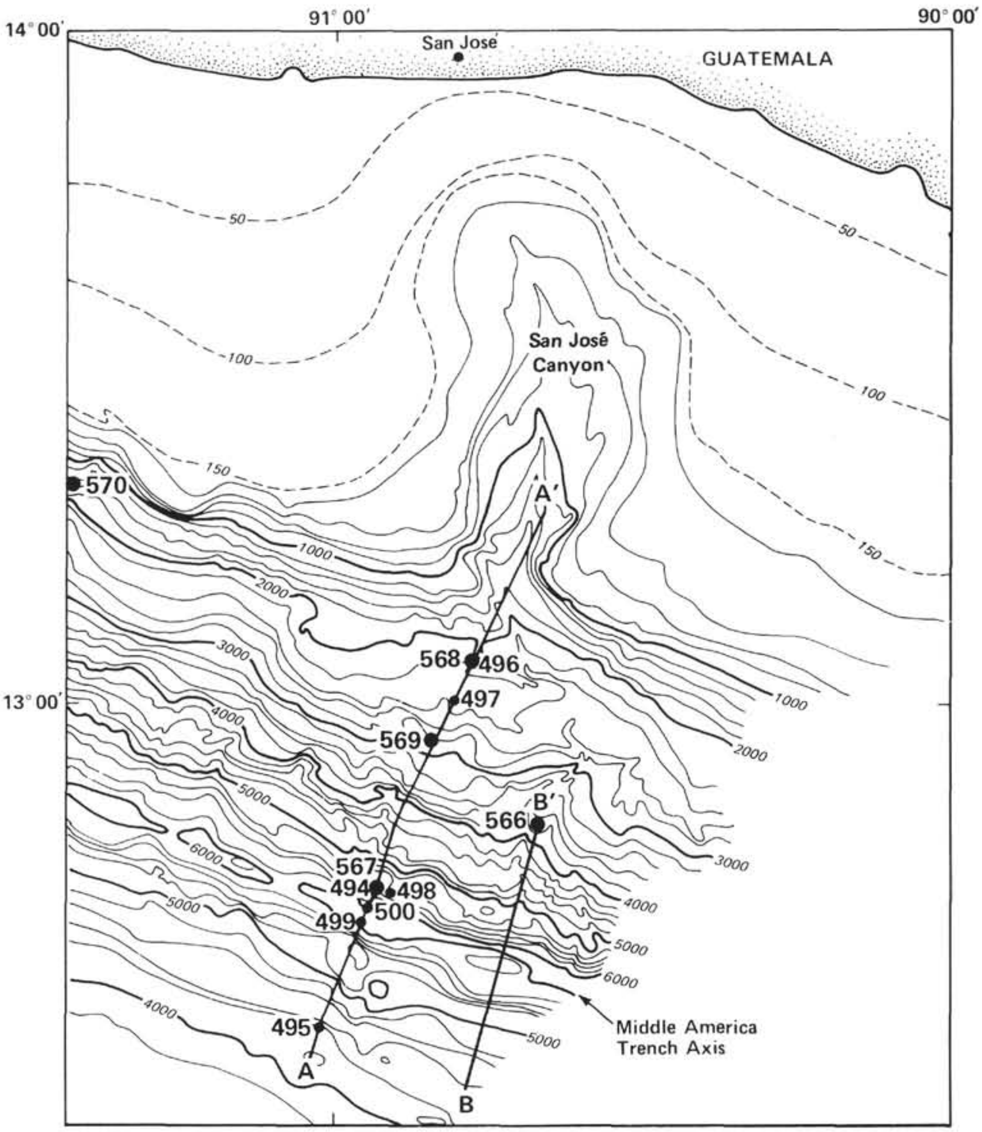

Figure 1. Map showing DSDP Leg 84 sites and some Leg 67 sites (see Table 1 for coordinates).

565, 567, 568, and 570 Neogene), and semiquantitatively for other sites and intervals of poor preservation (Sites 566, 569, and 570 Paleogene). Quantitative analysis for biostratigraphic and paleoceanographic interpretation was relied upon because tropical index species were found to be rare to absent, and because the faunal sequences were disrupted by carbonate dissolution. In such sequences, biostratigraphic interpretation based solely on first and last appearances of zonal index species yields uncertain biostratigraphic correlation and poor time resolution at best. Faunal abundance changes—which are closely related to paleoclimatic oscillations and associated changes in water-mass condition—can, along with first and last appearances, provide a higher stratigraphic resolution than would otherwise be possible. Wherever possible, species frequency oscillations of known warm- or cool-water species were used to aid in biostratigraphic as well as paleoclimatic interpretations.

In the following sections, pertinent biostratigraphic events are discussed for each site, and the major stratigraphic implications of Legs 84 and 67 are summarized in the final section. Key Neogene species are illustrated in Plates 1–12. Stone is responsible for the Neogene sections of the paper, and Keller for the Paleogene.

METHODS

Samples of approximately 20 cm^3 were first soaked in water with about 5 ml of very dilute Calgon solution (1/2 tsp. per quart of water) added. The samples were agitated for about 30 min., washed through a 62-μm sieve, and dried at a low temperature ($< 50°C$). This cycle was repeated if necessary.

Both semiquantitative and quantitative analytical methods were used in studying the Leg 84 samples. Species abundance was estimated by dispersing a representative split of processed material of the ≥ 149-μm size fraction in a picking tray (9 × 5 cm) marked with square centimeters. Semiquantitative abundances were designated as follows: Abundant = several specimens per square; common = one or two specimens per square; few = one or two specimens every 2–3 squares; and rare = specimens found only by searching the sample or present only in the ≤ 149-μm size fraction. Quantitative analysis was based on splits of 300–500 planktonic foraminifers from the ≥ 149 μm size fraction, using a modified Otto splitter. All specimens were picked, mounted on microslides, and identified, and species percentages of the total fauna were calculated. Abbreviated sample designations follow standard DSDP convention.

BIOSTRATIGRAPHY

A modified version of Blow's (1969) standard low-latitude zonation of Neogene planktonic foraminifers is used in this report (Figure 2), with modifications based on new zonal subdivisions by Srinivasan and Kennett (1981a, b) and Keller (in press), and including additional datum events by Keller (1980, 1981c) and Keller et al. (1982). Calibration of Blow's zones to the paleomagnetic time scale is based on calibrations of Barron et al. (in press). Ages for datum events are calculated from sedimentation rate curves based on datum events directly or indirectly tied to the paleomagnetic record. Recent calibrations of Miocene planktonic foraminiferal datum events have been published by Srinivasan and Kennett (1981b); Keller (1980, 1981b, c); Keller et al. (1982); and Barron et al. (in press). Ages of datum events in Figure 2 are based on calibrations to the paleomagnetic time scale of Berggren et al. (1984), as discussed in Barron et al. (in press).

Modifications of Blow's zonation include Srinivasan and Kennet's (1981b) subdivision of Zone N17 into Subzones a and b on the basis of the first appearance of *Pulleniatina primalis*, and subdivision of Zone N4 into Subzones a and b on the basis of the first appearance of *Globoquadrina dehiscens*. Keller (in press) has further subdivided Zone N4 into Subzones a, b, and c on the basis of the first appearance of *Globigerina trilobus* (Subzone a/b boundary); the first appearance of *Globoquadrina dehiscens* now marks the Subzone b/c boundary.

This modified Blow zonation works well for Miocene sediments at Leg 84 sites. In the upper Pliocene and lower Pleistocene interval, however, Blow's primary indicator species are almost completely absent. Zones N21 of the Pliocene and N22 of the Pleistocene are therefore recognized through the following criteria. Zone N22 is based on the first continuous occurrence of *Neogloboquadrina dutertrei* in conjunction with the reduced co-occurrence of *N. humerosa* and *N. atlantica* (Poore, 1979, 1981; Poore and Berggren, 1975). The base of Zone N21 is recognized by the evolutionary bioseries of *Globorotalia puncticulata* evolving to *G. inflata* at approximately the Zone N21/N19 boundary (Berggren, 1972; Ingle, 1973a; Poore and Berggren, 1974; Keller, 1978a; Poore, 1979, 1981), and by the last occurrence of *Globoquadrina altispira* (Blow, 1969; Berggren, 1973).

For Paleogene faunas, the zonations of Berggren (1969) and Stainforth et al. (1975) were used together with Keller's (1983) datum events. For Upper Cretaceous faunas, Sliter's (1968) zonation proved useful.

Site 565

Site 565 is in the Middle America Trench offshore from the Nicoya Peninsula of Costa Rica (Fig. 1; Table 1). Situated on the lower part of the slope, Site 565 is about 20 km landward of the trench axis at a water depth of 3099 m. Hole 565 was continuously cored through Pleistocene and Pliocene sediments to 328 m, with 87.5% recovery, but drilling was abandoned when the drill string became stuck some 500 m short of basement.

The sediment recovered is predominantly a dark greenish gray mudstone. Bioturbation is extensive throughout the hole, and some slump features were evident in the Pleistocene section. Benthic foraminifers indicate common downslope transport (McDougall, this volume). Planktonic foraminifers are present throughout the sequence in variable abundance and preservation. In general, few planktonic foraminifers are present, and they are poorly to moderately well preserved. Numbers are especially reduced in Cores 28 to 9. Dissolution effects are common. Some samples contain numerous specimens filled with pyrite. The quantitative distribution of planktonic foraminifers found in Hole 565 is shown on Table 2 and Figure 3.

The basal sample of Hole 565, Sample 33-1, 109–113 cm, contains *Globorotalia tumida*, and is thus no older than the base of Zone N18. Samples from Cores 33 through 30 are dominated by *Globigerina bulloides, Globigerinita glutinata* s.l., *Globorotalia menardii, Neogloboquadraina humerosa, N. pachyderma*, and *Pulleniatina obliquiloculata*, and are assigned to Zone N18. *Sphaeroidinella dehiscens* first occurs in Sample 29-5, 54–56 cm, and marks the Zone N18/N19 boundary at 4.9 Ma (Saito et al., 1975; Barron et al., in press).

Preservation of planktonic foraminifers in Zone N18 is good to moderate. Samples in Zone N19 show a marked reduction in numbers of specimens and preservation, owing to increased carbonate dissolution (Table 2; Fig. 3). The two intervals that show the most intense dissolution are in Cores 25 and 26 and in Core 22 (Table 2). These intervals may correspond to early Pliocene cool events about 4.0 Ma ago (Keigwin, 1979; Bukry, 1983) and 3.0 Ma ago (Keller, 1978a, b), respectively.

The top of the lower Pliocene Zone N19 is tentatively placed immediately above Sample 21-5, 110–112 cm, on the basis of the last occurrence of *Globoquadrina altispira*, although it is likely that this does not represent a true last appearance of this species, as will be discussed later. According to Blow (1969), the extinction of *G. altispira* occurs at or just above the top of Zone N19, and Berggren (1973) dates this extinction at 2.8 Ma ago. The *Globorotalia puncticulata* to *G. inflata* bioseries, which can be used to approximate the Zone N19/N21 boundary, is poorly developed in this sequence, but a few specimens of this group occur also at this horizon.

Samples from Cores 20 to 9 are placed in Zone N21, with *Neogloboquadrina humerosa, N. pachyderma, N. pachyderma/dutertrei* intergrade, *Globorotalia menardii, Globigerinoides ruber ruber, Globigerina bulloides*, and *Globigerinita glutinata* s.l. making up most of the assemblage. Preservation of planktonic foraminifers is poor to moderate; carbonate dissolution increases in the upper part of Zone N21 (Cores 12 to 10, Fig. 3). This dissolution interval may correlate with a late Pliocene cooling event about 2.6–1.8 Ma ago (Keller, 1978a, b). A late Pliocene warm event (Cores 16 and 15) preceded this cool event, as indicated by increased abundance of the warm-water species of *Globigerinoides* and *Globo-*

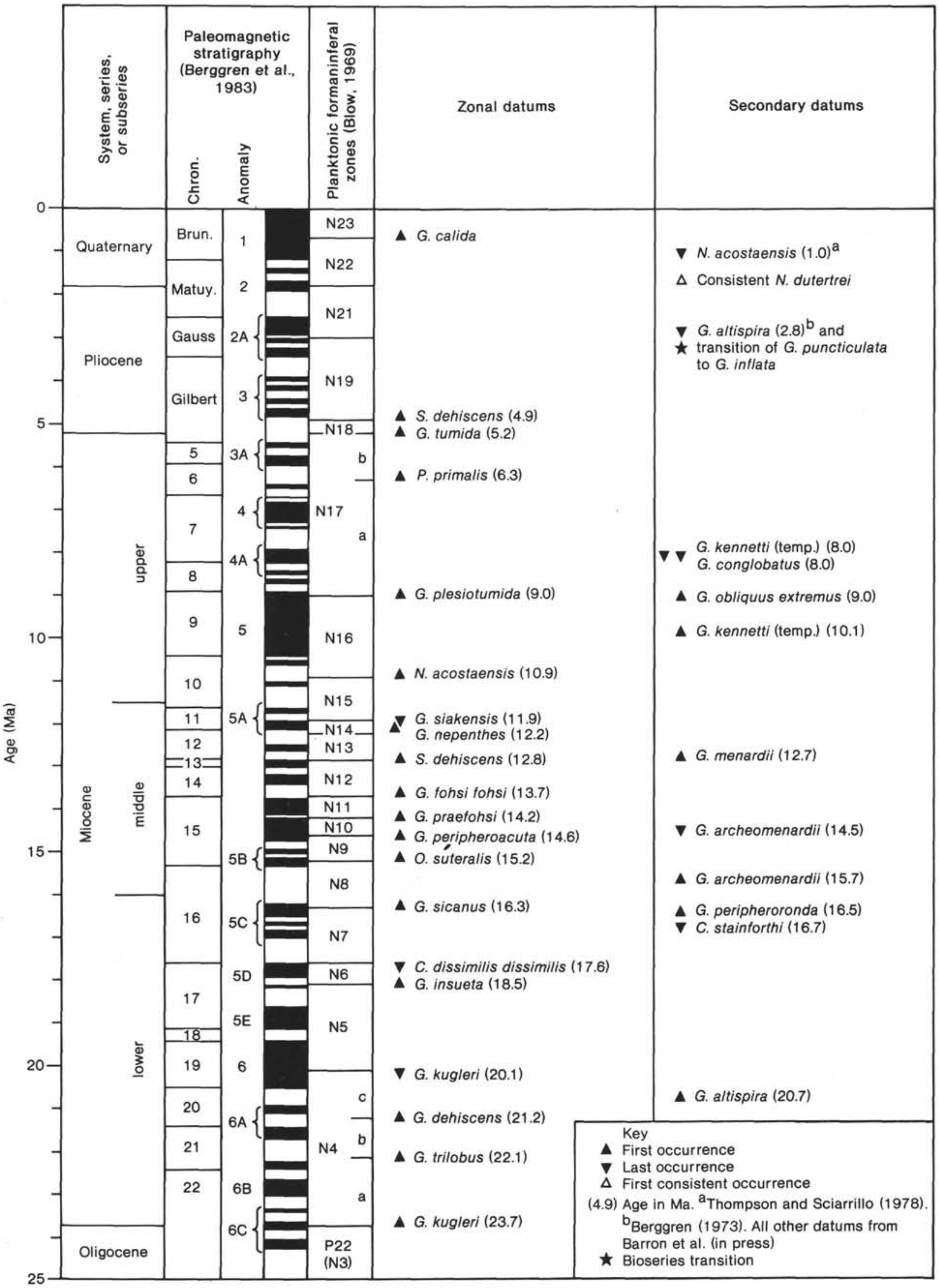

Figure 2. Neogene biostratigraphic zonation used for DSDP Leg 84 planktonic foraminifers (modified from Blow, 1969; see key for symbols and datum references).

Table 1. Location and coring information for DSDP Leg 84 sites.

Hole	Dates (1982)	Latitude	Longitude	Water depth (m)	Penetration (m)
565	13–19 Jan.	09°43.69′N	86°05.44′W	3099	328.3
566	24–25 Jan.	12°48.34′N	90°41.79′W	3745	55.8
566A	25 Jan.	12°47.91′N	90°41.99′W	3826	7.0
566B	25–26 Jan.	12°48.81′N	90°41.50′W	3661	49.0
567	29–30 Jan.	12°42.96′N	90°55.99′W	5500	195.5
567A	30 Jan./7 Feb.	12°42.99′N	90°55.92′W	5500	501.0
568	8–12 Feb.	13°04.33′N	90°48.00′W	2010	417.7
569	12–15 Feb.	12°56.31′N	90°50.35′W	2744	250.7
569A	15–17 Feb.	12°56.22′N	90°50.81′W	2795	364.9
570	17–21 Feb.	13°17.12′N	91°23.57′W	1698	401.9

rotalia and the decreased numbers of the *neogloboquadrinids* (Fig. 3) (Ingle, 1973b; Keller, 1978a, b; Poore, 1981). Poore (1981) dated this warm event at about 2.8 Ma ago for DSDP Holes 470 and 468A. If the warm event recorded in Cores 16 and 15 correlates with Poore's warm event, as is suggested by the relative positions of the sediment records of the 3.0 Ma and 2.6–1.8 Ma cool events, then the N19/N21 zone boundary should be placed below Core 16. This interpretation suggests that the extinction of *Globoquadrina altispira* occurred anomalously early at Site 565.

The Pliocene/Pleistocene boundary is no lower than Sample 10-1, 70–74 cm, according to the first continuous occurrence of *Neogloboquadrina dutertrei*. The boundary could be lower in the dissolution interval, however, because Samples 12-3, 75–77 cm and 11-1, 44–46 cm contain rare nondiagnostic specimens that are highly dissolved, and Samples 11-3, 43–44 cm and 10-4, 86–90 cm are barren of planktonic foraminifers. Calcareous nannoplankton and benthic foraminifers place the boundary within Core 12. Similar intervals of dissolution at the Pliocene/Pleistocene boundary have been recorded at DSDP Sites 173 and 310 (Keller, 1978a, b). The Pleistocene Zone N23 boundary is marked by the first occurrence of *Globigerina calida* in Sample 4,CC.

Similarly to the Pliocene assemblages, Pleistocene assemblages are dominated by *Globigerina bulloides, Globigerinita glutinata* s.l., *Globigerinoides ruber ruber, Globorotalia menardii*, and *Neogloboquadrina pachyderma*. Important accessory species present are *Pulleniatina finalis, Globigerinoides tenellus, Globigerina digitata*, and *Globorotalia bermudezi*. *Neogloboquadrina atlantica* is also present, although its highest recorded occurrence in the Atlantic is in the upper Pliocene (Poore and Berggren, 1975; Poore, 1981). However, this same form (recorded as *N. pachyderma* form 3 by Keller, 1978a, b, c) occurs in Zone N22 and intermittently in Zone N23 in the northeastern Pacific, where its latter occurrences are useful indicators for climatic changes 0.9 Ma and 0.7 Ma ago (Keller and Ingle, 1981). The occurrence of *N. atlantica* and the increased abundances of *N. pachyderma* in Core 2 suggest that this interval may represent the cool event 0.9 or 0.7 Ma ago. A further cool event is recorded in Core 8, as indicated by the high abundances of *N. pachyderma*. This cool event most likely correlates with the event 1.2 Ma ago, evidence of which is widely recognized by ice-rafting in high-latitude deep-sea sediments (Kent, et al., 1971; Ingle, 1973a).

The Pleistocene interval of Hole 565 shows consistent anomalously high occurrences of *Neogloboquadrina acostaensis, N. humerosa*, and *N. atlantica*. *N. acostaensis* is a well-documented and geographically widespread species that became extinct during the early late Pliocene (base of Zone N21; Blow, 1969). *N. humerosa* usually has its highest common occurrence at the Pliocene/Pleistocene boundary, but can be found in reduced numbers in the lower Pleistocene interval (e.g., Keigwin, 1976; Keller, 1978b). Thompson and Scairrillo (1978) place the extinction datum of this species at 1.0 Ma. The apparently anomalous occurrences of *N. acostaensis* and common *N. humerosa* in the Pleistocene of Leg 84 sites are likely the results of reworking, as suggested by extensive downslope transport (McDougall, this volume) and slump features (see Site Report). It is possible, however, that the upper range of *N. acostaensis* extends into Zone N22 (see Taxonomic Notes for further discussion).

The following samples examined from Hole 565 are barren of planktonic foraminifers: 29-3, 19–21 cm; 27-2, 70–74 cm; 25-7, 70–74 cm; 25-4, 70–74 cm; 25-1, 70–74 cm; 23-1, 63–67 cm; 11-3, 43–45 cm; 10-4, 86–90 cm; 9-5, 46–50 cm; 9-2, 34–38 cm; and 7-2, 58–62 cm.

Site 566

Site 566 is offshore from Guatemala about two thirds of the way downslope in the San José Canyon and 22 km landward from the trench axis (Fig. 1; Table 1). Four holes were drilled at this site, but only Holes 566 and 566C yielded planktonic foraminifers. Hole 566 was drilled at a water depth of 3745 m; Hole 566C was drilled at a water depth of 3661 m, approximately one km upslope from Hole 566.

Planktonic foraminifers are rare and of poor to moderate preservation in both holes. Estimated abundances are listed on Table 3.

Site 566 samples examined that are barren of planktonic foraminifers include Sample 1,CC of Hole 566A and Core H2 (wash) of Hole 566C.

Hole 566

Hole 566 was continuously cored to a depth of 56 m; the first five cores contain dark olive-gray siliceous muds. Igneous basement material was encountered in Core 566-6.

Planktonic foraminifers in Core 566-5 include *Globigerina bulloides, Globigerinita glutinata* s.l., *Globigerinoides trilobus trilobus*, and *Globorotalia menardii*, which are common in upper Miocene to Holocene sediments. These species, along with *Neogloboquadrina pachyderma* and *N. pachyderma/dutertrei* intergrade, also dominate the assemblages of Cores 566-4 through 566-1. However, Cores 566-4 through 566-1 are no older than lower Pliocene, as indicated by the presence of *Globorotalia tumida* in Sample 566-4,CC. Forms tentatively identified as *G.* cf. *G. conomiozea* in this interval also range from upper Miocene to lower Pliocene (Kennett, 1966). Questionable forms of *Neogloboquadrina* cf. *N. dutertrei* were found in Cores 566-2 and 566-1, and suggest

Table 2. Percentage abundances of planktonic foraminifers from Hole 565.

Sample (interval in cm)	*Globigerina apertura*	*G. bulloides*	*G. calida*	*G. decoraperta*	*G. digitata*	*G. falconensis*	*G. incisa*	*G. praedigitata*	*G. pseudobesa*	*G. pseudociperoensis*	*G. quadrilatera*	*G. rubescens*	*G. woodi*	*Globigerinella aequilateralis*	*Globigerinita glutinata* s.l.	*G. uvula*	*Globigerinoides bollii*	*G. conglobatus*	*G. kennetti*	*G. obliquus extremus*	*G. obliquus obliquus*	*G. quadrilobatus*
1-1, 70–74																						
1,CC		5			x				x		2		x	2	6			x		x	x	2
2-4, 76–80		12	x			x			x		2			x	7	x						x
3-2, 66–70		(3)													(3)			(1)				
4-3, 10–14															(4)							
4,CC		3	x		x	x						x	x	2	20			x			x	x
5-3, 84–88		7				2						x	x		21					x		x
6-4, 39–43													(1)		(3)							
7-6, 58–62		4													19							x
8-2, 54–58		4				x			x				2	x	12					x		
9-4, 54–58		7				x	x		2				x	x	13					2		
10-1, 70–74		7		x		x			x				x		19	x					x	
11-1, 44–46																						
12-3, 75–77															(5)							
13-3, 70–72		x		3					x				4		15							
14-3, 58–62		(4)					(1)								(3)							
15-3, 77–81		2											2		3							2
16-3, 119–123		6		x					x						3							x
17-3, 33–37		(3)									(2)				(1)					(1)		
18-3, 88–92		4						2	2						x							2
19-3, 76–79	2	6									x		2	x cf.	4	x					x	2
20-3, 71–73	x	x		x					x		2		3	x	x	x				x	x	
21-5, 110–112		5		x									x	x	4						x	
22-3, 56–58		(1)													(2)					(1)		(1)
23-4, 63–67		10									x		5	x	7					2		x
24-3, 52–56		6				x							x		10					4	5	
25-5, 70–74		(5)													(6)						(2)	
26-5, 68–72																						
27-3, 90–94		6		x cf.		x					x		3		6					x	2	
28-2, 56–59															(1)		(1)					
29-5, 54–56		9		x cf.		2					3		5	x	5	x			x	x	x	x
30-5, 66–68	x	10		x cf.		2					x		2		9	x			3	x	2	
31-2, 59–61		17		x		7			x		x		4		2	x	x			x	11	
33-1, 81–85		(2)				(2)				(1) cf.			(2)		(3)							
33-1, 109–113		19				5			x		6		x		7		x			x	4	

Note: x = <2% or present only in ≤149 μm size fraction; ( ) = actual number of specimens (<50 specimens in sample); cf. = tentative identification.

that these intervals may be Pleistocene. However, owing to the uncertainty of this identification, Cores 566-4 through 566-1 are assigned to the Pliocene–Pleistocene.

Calcareous nannoplankton and benthic foraminifers indicate that the material from this hole is assignable to the Pleistocene.

Hole 566C

After the hole was washed down to 49.8 m, four cores of dark olive-gray mud were recovered from Hole 566C. Below these cores, sediment was again washed out until basement was penetrated.

Cores 566C-3 and 566C-2 contain upper Miocene to Pliocene planktonic foraminifers such as *Globorotalia menardii, Neogloboquadrina pachyderma*, and *Globoquadrina venezuelana*. Cores 1 and H1 are assigned to the upper Pliocene Zone N21 based on the absence of Quaternary taxa and the occurrences of *Globorotalia inflata* and *Pulleniatina obliquiloculata* s.s. (Banner and Blow, 1967), which evolved in the middle Pliocene.

Site 567

Site 567, offshore from Guatemala, is 3 km landward of the Middle America Trench axis, near the base of the slope (Fig. 1; Table 1). Two holes (567 and 567A) were drilled at this location at a water depth of 5500 m. Site 567 is the same location as Site 494 of DSDP Leg 67.

Semiquantitative (Hole 567) and percentage (Hole 567A) abundances of planktonic foraminifers from Site 567 are shown in Table 4. Preservation of foraminifers at Site 567 is quite variable; there are numerous dissolved intervals. Reworked specimens and downhole contaminants are common.

Hole 567

Because drilling at Site 567 was a continuation of that for Site 494, the first 176 m was washed, and only two cores of dark olive-gray mud were recovered before the hole was abandoned because of technical difficulties.

Age determination for Samples 567-2,CC and 567-1,CC is equivocal. The few specimens present range from upper Miocene to Holocene. Core 567-H1 is assigned to the Pleistocene on the basis of the occurrence of abundant *Neogloboquadrina dutertrei*. The Pleistocene determination for the washed interval of the hole is in agreement with the earlier results of Hole 494. Calcareous nannoplankton also place Core 567-H1 in the Pleis-

Table 2. (Continued).

G. ruber pyramidalis	*G. ruber ruber*	*G. sacculifer sacculifer*	*G.* sp.	*G. tenellus*	*G. trilobus trilobus*	*Globoquadrina altispira altispira*	*G. conglomerata*	*Globorotalia bermudezi*	*G. continuosa*	*G. crassiformis*	*G. crassula crassula*	*G. exilis*	*G. inflata*	*G. menardii* s.l.	*G. menardii* s.s.	*G. multicamerata* s.l.	*G. puncticulata*	*G. scitula*	*G. suterae*	*G.* sp.	*G. tumida*	*G. ungulata*	*G. wilesi*	*Globorotaloides hexagona*
															(1)									(1)
x	7	3		x	2		x	x				2		24	6			x			4	x		3
x	9	x			2									20				x			2			3
	(1)													(5)	(1)									(1)
	(1)													(1)							(1)			
x	14	x			x		x	x						18	3			2			x	x		3
	23				x		x							10				x			x	x		3
	(3)													(4)										
2	14			x	2							2		5	10						4			3
	13	x			2							x		4	4						x			8
x	20	x			3									6				x			x cf.			3
	10				x									6		x					3			x
	(1)	(1)			(3)									(1)							(1)			
x	13				6		x							3	7						3			x
	(2)				(1)																			(2)
x	27	2			12					x								x			4			2
	10	2			9		x							x	13	x		x			x			5
	(3)													(1)							(2)	(1)		(2)
	5	4			14																			4
	13	x			7		2							3				x			x			2
	10	x			5		3				x		x		9		x	2			x	x	x	3
	x	x			5	x cf.	x							x	21			x		x				7
	(1)				(10)								(1)		(9)									
	12				4	x	x				x cf.						x	2					x	x
	12	2			4									x	6			x					x	2
	(9)	(1)			(4)										(2)									
	(1)													(1)	(1)			(1)					(1)	(1)
	7	2			9	18	x		x			x			11			x			x	x	x	7
(1)					(2)		(2)							(1)				(1)						(1)
	8	2			7	2	x					x		x	13			x				x	x	4
	9	x	x		x		3								4			x			x		x	5
	x	x			x	7				5				x	6			2	x		x	x		6
						(2)			(4)					(6)										
		x			x	4	x		x					24				3	x		x	x		2

tocene and both Samples 567-1,CC and 567-2,CC very near the Pliocene/Pleistocene boundary.

Hole 567A

After washing out the first 195.5 m of Pleistocene sediments, Hole 567A was continuously cored through 180.9 m of mixed Pleistocene to Miocene, lower Miocene, and Cretaceous sediments and 124.6 m of basement rocks to a total penetration of 501 m.

Sample 567A-19-1, 77–79 cm, a pale red recrystallized limestone, is assigned to the Upper Cretaceous (upper Campanian–Maestrichtian). Planktonic foraminifers are recrystallized and poorly preserved. *Globotruncana arca, G. fornicata*, and *G. mariei* compose most of the assemblage, with few *G. petaloidea* and rare *Heterohelix globulosa* and *H. pulchra* also present. All species are restricted to the Upper Cretaceous, with an upper age limit of Maestrichtian (Sliter, 1968). *G. petaloidea* first occurs in the upper Campanian (Sliter, 1968) and therefore, sets a lower age limit of late Campanian for this sample. Upper Cretaceous sediments with a similar fauna were also recovered in DSDP Hole 494A.

Cores 567A-18 through 567A-14 comprise a thick sequence of altered serpentinite, which may be an isolated block within the lower Miocene muds or may represent a fault contact with the Cretaceous limestone (see Site Report). The origin and placement of the Cretaceous limestone is also unclear.

Sample 567A-13,CC, an olive-green mud, is assigned to the lower Miocene Subzone N4b (Fig. 2) on the basis of diverse *Globigerinoides* and *Globoquadrina altispira*, indicating a position well into Zone N4, probably near the N4b/N4c Subzone boundary. An unconformity is therefore indicated between the Cretaceous limestone and Sample 567A-13,CC or between the Upper Cretaceous and the lower Miocene interval.

Cores 567A-13 to 567A-8, composed of olive-green muds with abundant redeposited clasts, contain lower Miocene assemblages of Zone N4. Preservation throughout this interval is poor to moderate; most samples show pronounced effects of dissolution. Common species are *Globorotalia siakensis, Globigerinoides parawoodi*, and *G. trilobus* (Table 4; Fig. 4). Less common taxa are *Catapsydrax dissimilis dissimilis, C. stainforthi, Globorotalia birnageae, Globoquadrina baroemoenensis*, and *Globigerina praebulloides praebulloides*. The Subzone N4b/N4c boundary is provisionally placed below Sample 567A-12,CC at the first occurrence of *Globoquadrina dehiscens* (Srinivasan and Kennett, 1981a; Keller, in press). However, inasmuch as *G. altispira*, which usually ap-

Table 2. (Continued).

Sample (interval in cm)	*Neogloboquadrina acostaensis*	*N. atlantica*	*N. dutertrei*	*N. humerosa*	*N. pachyderma*	*N. pachyderma* form 2	*N. pachyderma/dutertrei* intergrade	*Orbulina suturalis*	*O. universa*	*Protentella prolixa*	*Pulleniatina finalis*	*P. obliquiloculata* s.l.	*Sphaeroidinella dehiscens*	*Sphaeroidinellopsis subdehiscens*	*Turborotalita humilis*	*T. quinqueloba*	Non-identifiable	Number of specimens	Zone (Blow, 1969)	Series
1-1, 70-74			(1) cf.														(1)	4		
1,CC		x	9		2	4	7		2		x					x		598		
2-4, 76-80	x	x	7	x	15	3	5		5							x	x	518	N23	
3-2, 66-70			(1)	(5)												(1)	(15)	42		
4-3, 10-14																		7		
4,CC	3	x	5	x	5	3	4		x			x					x	499		
5-3, 84-88	4	2	5	x	5		2		3			x	x			x	3	210	—	Pleistocene
6-4, 39-43						(1)	(2)										(3)	17		
7-6, 58-62	3		2	2	4				4		2	4	x				10	182		
8-2, 54-58	9	x cf.	x	x	30	x	2						x				4	368	N22	
9-4, 54-58			2	5	12	3	4		2								12	125		
10-1, 70-74	7		2	5	13	2	3									x	13	155	—	—
11-1, 44-46	(1)																	1		
12-3, 75-77	(3)			(1)	(4)												(4)	21		
13-3, 70-72	3			8	4	x											21	67		
14-3, 58-62																		13		
15-3, 77-81				12	6	6	7					x					12	129		
16-3, 119-123			2 cf.	5	4	2	10		x			3	x			x	17	185	N21	
17-3, 33-37	(1)			(3)			(3)					(1)					(5)	29		
18-3, 88-92				5	13	2	14		2								27	55		
19-3, 76-79	x			3	15	7	11					3	x	x			9	179		
20-3, 71-73	2			6	7	7	7						x				11	268		
21-5, 110-112	2			x	21	7	7					x					12	162	—	
22-3, 56-58				(1)		(6)	(1)									(1)	(2)	37		Pliocene
23-4, 63-67	x			2	15	6	6					9				x	10	154		
24-3, 52-56	x			x	17	10	2					2		x		x	13	173		
25-5, 70-74					(1)	(2)	(3)									(1)	(3)	40	N19	
26-5, 68-72					(4)							(1)				(1) cf.	(2)	18		
27-3, 90-94				x	3	3						3	x	x	x	x	11	151		
28-2, 56-59					(1)	(1)	(1)											13		
29-5, 54-56	x			x	18	4	2		x			2	x			x	4	621		
30-5, 66-68	2			x	10	11	3	x				10				x	6	296	—	
31-2, 59-61				x	4	5	2					9						258		
33-1, 81-85				(1)	(1)	(3)										(2) cf.	(2)	35	N18	
33-1, 109-113	2			x	7	8	6			x		3				x cf.	7	248		

pears shortly above the first occurrence of *G. dehiscens*, is present in Sample 567A-13,CC, below, the Subzone N4b/N4c boundary could possibly be placed below this sample.

Cores 567A-13 and 567A-12 contain numerous reworked Cretaceous planktonic foraminifers, as for example in Sample 567A-13-3, 105-107 cm, where the reworked Cretaceous specimens make up 24% of the total fauna. In addition, downhole contamination is evident by the presence of middle Miocene and Pliocene species such as *Globorotalia puncticulata, Globigerinoides mitra*, and *G. diminutus*.

A short cool-water event is indicated in the upper part of Zone N4c (Sample 567A-9-3, 50–52 cm) by the sharp decrease in warm-water forms *Globoquadrina altispira, G. venezuelana*, and *Globigerinoides* and the increase in the cool-water *Globigerina woodi* and *G. angustiumbilicata* (Fig. 4).

The Zone N4/N5–6 boundary is questionably placed in Core 567A-8 with the only *in situ* occurrence of *Globorotalia* cf. *G. kugleri* (Blow, 1969) and the only occurrence of *G.* cf. *G. miozea* (Walters, 1965). *Globigerinella aequilateralis, G. praesiphonifera*, and *Globigerinoides sicanus* present in Core 567A-8 are considered to be downhole contaminants. Zones N5–N6 extend to Sample 567A-3-6, 76–80 cm; absence of the index species *Globigerinella insueta* prohibits distinguishing Zone N5 from Zone N6.

Sediments of Zones N5–N6 are commonly affected by carbonate dissolution, partial removal, or both, owing to a widespread hiatus (hiatus NH1 of Keller and Barron, 1983; Keller, 1981b; Barron and Keller, 1982). Hole 567A also shows pronounced dissolution within this interval (Cores 567A-6 and 567A-7), suggesting correlation with the cold event frequently marked by hiatus NH1a (about 18–20 Ma ago). It is not possible, however, to determine whether a hiatus is present in Hole 567A or whether the sediment accumulation rate was unusually slow.

A hiatus is present in Core 567A-3 (Table 4; Fig. 4), where sediments deposited between the late early Miocene and late Miocene are missing. The same unconformity is present at DSDP Site 494. Samples in Core 567A-3 above the unconformity contain mixed Miocene and Pliocene assemblages. Lower and middle Miocene species such as *Catapsydrax dissimilis dissimilis, Globigerina peripheroronda, G. siakensis, G. kugleri, Globigerinoides subquadratus*, and *Globigerina nepenthes* occur together with the Pliocene species *Neogloboquadrina pachyderma, N. pachyderma/dutertrei* intergrade, and

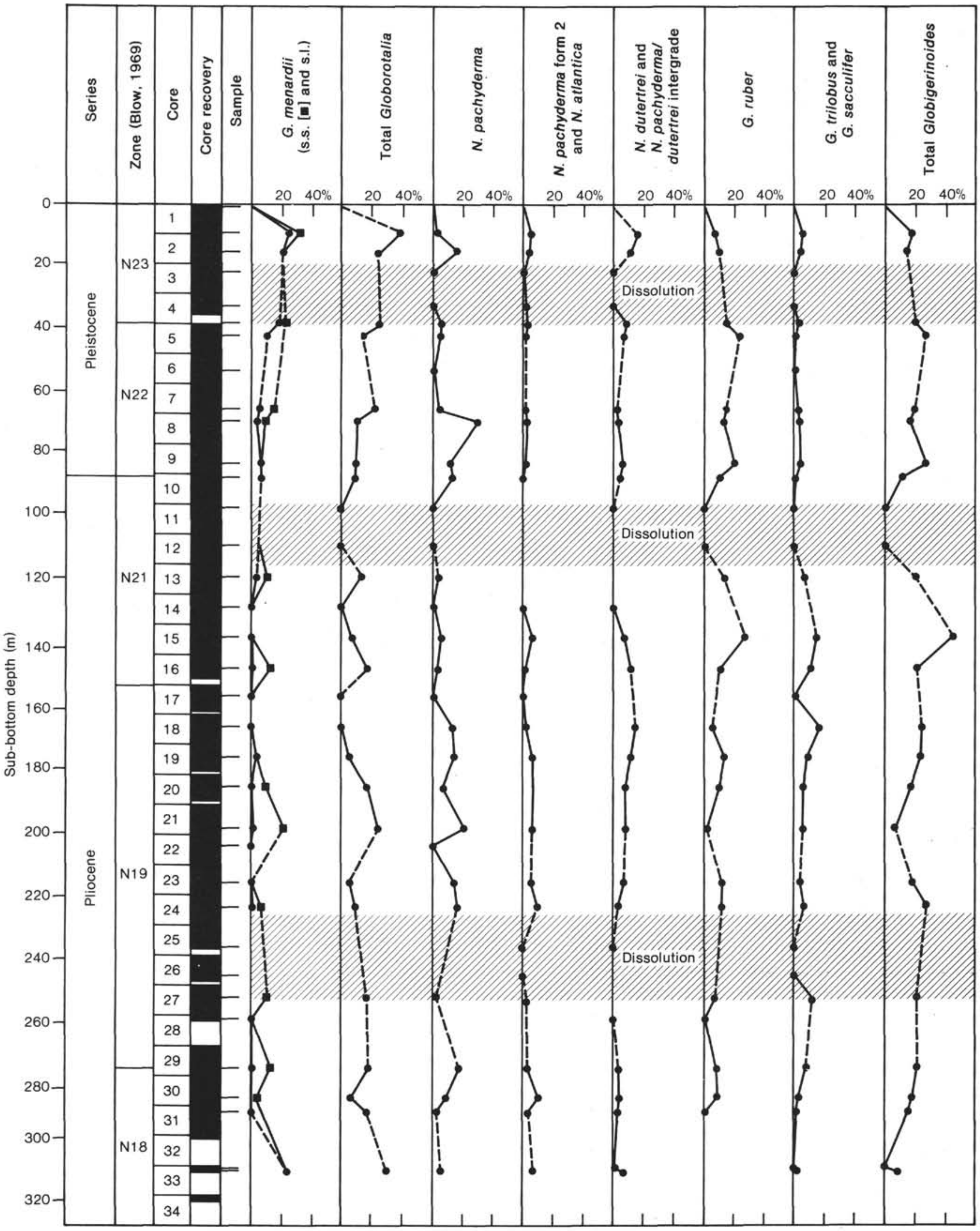

Figure 3. Relative abundances of selected planktonic foraminifers from Hole 565.

Table 3. Estimated abundances of planktonic foraminifers from Site 566.

Sample (interval in cm)	*Globigerina bulloides*	*G. decoraperta*	*G. falconensis*	*G. pseudobesa*	*G. quadrilatera*	*G. woodi*	*Globigerinita glutinata* s.l.	*Globigerinoides obliquus obliquus*	*G. ruber ruber*	*G. sacculifer sacculifer*	*G. trilobus trilobus*	*Globoquadrina venezuelana*	*Globorotalia* cf. *G. conomiozea*	*G. inflata*	*G. menardii* s.l.	*G. menardii* s.s.
Hole 566																
1-3, 22-26	R	R					R		R	R	R		R		R	
2-3, 38-40	R						R						R			
2,CC	R								R		R		R		R	R
3,CC	R			R			R		R		R				R	R
4-1, 59-63	R														R	
4-3, 59-63	R						R						R		R	
4,CC	R								R		R		R		R	
5-1, 24-26							R				R				R	
5-3, 17-19	R										R				R	
Hole 566C																
H1 (wash)	R		R				R	R	R		R				R	R
1,CC	R				R	R	R	R		R	R			R	R	
2-1, 38-40															R	R
2,CC											R	R				
3,CC	R								R						R	R

Note: R = rare; cf. = tentative identification.

Globigerinoides ruber ruber. Preservation is poor in this interval, and planktonic foraminifers are rare.

Samples from the olive-gray siliceous muds of Cores 567A-2 and 567A-1 indicate the upper Miocene to Holocene, and contain such species as *Globorotalia plesiotumida, G. menardii*, and *Pulleniatina primalis*. The continued presence of reworked Miocene species such as *Globigerinoides sicanus, G. subquadratus*, and *G. bollii* and the concurrent occurrences of *Neogloboquadrina dutertrei, N. humerosa*, and *N. atlantica* exemplify the mixed nature of these sediments. Bioturbation and redeposited sedimentary clasts also are common in these two cores. Planktonic foraminifers are generally rare and poorly preserved.

The following samples from Hole 567A are barren of planktonic foraminifers: 18,CC; 17,CC; 16,CC; 14,CC; 14-2, 56–58 cm; 14-2, 0–2 cm; 7,CC; 7-1, 50–52 cm; 6,CC; 6-5, 34–35 cm; 6-3, 71–75 cm; 5-3, 68–70 cm; 4-1, 84–88 cm; 3-2, 76–80 cm; 2,CC; 2-1, 59–63 cm; 1-1, 59–63 cm.

Site 568

Site 568 is on the upper Middle America Trench slope at a water depth of 2010 m, 47 km landward from the trench axis (Fig. 1; Table 1). Hole 568 was continuously cored through Pleistocene, middle Miocene, and lower Miocene sediments to 417.7 m, with 75% recovery.

Sediments in the 20 upper cores are predominantly massive dark olive-gray muds; the lower 24 cores are composed of mottled, bioturbated, grayish olive to blue-green mudstone. Planktonic foraminifers are generally abundant and well preserved in the Pleistocene interval, whereas in the Miocene sediments they are few to common and only moderately preserved. Cores 22 to 25 (in part) are barren of planktonic foraminifers. The Pleistocene part of the hole was studied semiquantitatively and the Miocene part quantitatively; abundances of planktonic foraminifers are shown in Table 5 and Figure 5. Ranges of key species are shown in Figure 6.

The lowest sample containing planktonic foraminifers, Sample 44-1, 138–146 cm, is assigned to the lower Miocene Subzone N4b on the basis of the presence of *Globigerinoides trilobus, Globorotalia kugleri*, and diverse *Globigerinoides* species. The first occurrence of *Globigerinoides trilobus*, which defines the Subzone N4a/N4b boundary (Keller, in press), sets a lower age limit for this sample. The Subzone N4b/N4c boundary is placed between Samples 42-3, 72–76 cm and 41-1, 66–70 cm on the basis of the first occurrence of *Globoquadrina dehiscens* (Srinivasan and Kennett, 1981b) in the latter. *G. altispira*, which evolved shortly after *G. dehiscens*, is present in Sample 40-5, 55–57 cm. The top of Zone N4 is tentatively placed above Sample 40-5, 55–57 cm on the basis of the last occurrence of rare *Globorotalia kugleri*. This interpretation is supported by the presence of *Globigerinoides altiapertúrus*, which becomes extinct in Zone N5, in Sample 39-3, 84–88 cm. *Globigerinoides trilobus trilobus, G. trilobus immaturus, Globorotalia siakensis, G. mayeri*, and *Globigerina praebulloides praebulloides* are the most common species in

Table 3. (Continued).

G. scitula	*G. tumida*	*Globorotaloides hexagona*	*Neogloboquadrina atlantica*	*N. dutertrei*	*N. humerosa*	*N. pachyderma*	*N. pachyderma* form 2	*N. pachyderma/dutertrei* intergrade	*Orbulina bilobata*	*O. universa*	*Pulleniatina obliquiloculata*	*Turborotalita quinqueloba*	Number of specimens	Zones (Blow, 1969)	Series or subseries
	R		R	R cf.	R cf.			R				R	R		
										R			R		
	R			R cf.		R	R	R		R			R		
		R	R		R	R	R	R		R			R		
					R cf.			R					R	N18–N22	Pleistocene–Pliocene
							R	R					R		
	R					R		R					R		
													R		Pleist.–upper Mio.
							R						R		
			R		R	R	R	R			R		R	N21	upper Pliocene
			R		R	R	R	R	R		R		R		
							R						R		
		R				R							R		Plio.–upper Mio.
R		R					R	R					R		

the Zone N4 interval. Calcareous nannoplankton also indicate assignment of this interval to the lower Miocene.

Cores 39 and 38 are indicative of Zones N5 to N7, because of the continued presence of *Catapsydrax* sp. The assemblage is dominated by *Globorotalia siakensis, G. mayeri, Globigerinoides trilobus trilobus*, and *Globigerina praebulloides praebulloides*. A sharp increase in *Globorotalia mayeri* in this interval (Fig. 5) may correlate with a similar short abundance pulse of *G. mayeri* at the top of Zone N6 at DSDP Site 77 (Hole 77B) and Site 296 (Keller, 1980).

The base of Zone N8 is placed below Sample 37-1, 121–125 cm on the basis of the first occurrence of *Globigerinoides sicanus*. Well-preserved *Globorotalia peripheroronda* are present in Sample 38-4, 80–85 cm; the first continuous occurrence of this species marks the uppermost part of Zone N7 (Keller, 1980). The compressed or dissolved sediments representing Zones N5 through N7 (Cores 39 and 38) suggest the presence of a hiatus (NH1 hiatus of Keller and Barron, 1983).

The Zone N8/N9 boundary is recognized by the first occurrence of *Orbulina* in Sample 36-5, 70–74 cm. *Globorotalia archeomenardii*, which evolved in latest Zone N8 (datum of 15.7 Ma), occurs in the sample below and supports this interpretation. Zone N9 is well represented in Hole 568, and extends through Sample 31-1, 19–23 cm. This zone is typified by high percentages of *Globorotalia siakensis, G. peripheroronda, Globoquadrina altispira, Globigerinoides trilobus trilobus*, and *Globigerina bulloides* (Table 5). An abundance pulse in *Globorotalia peripheroronda* in Zones N8 and N9 of Hole 568 (Fig. 5) correlates with a similar pulse observed at DSDP Sites 77 (Hole 77B), 319, and 296 (Keller, 1980).

The Zone N9/N10 boundary is recognized between Samples 29-3, 24–28 cm and 30-3, 19–23 cm, which contain the first *Globorotalia peripheroacuta* and the last *G. archeomenardii*, respectively. The first occurrence of *G. peripheroacuta* defines the base of Zone N10, and has a datum of 14.6 Ma. The extinction of *G. archeomenardii* (datum of 14.5 Ma) near the first occurrence of the zonal marker species is recognized by Keller (1980) as a useful secondary marker for the Zone N9/N10 boundary.

The Zone N10/N11 boundary is placed below Sample 28-5, 128–130 cm on the basis of the first occurrence of *Globorotalia praefohsi*, which has a datum of 14.2 Ma. *Globorotalia peripheroacuta, G. peripheroronda, Globigerinoides trilobus trilobus*, and *Globoquadrina altispira* make up most of the assemblage of Zone N11. Sample 25-5, 51–55 cm, the highest sample containing planktonic foraminifers referrable to Zone N11, shows a sharp reduction in the abundance of planktonic foraminifers. Above this sample is a hiatus representing at least Zones N12 through N21. This extensive hiatus may correlate in part with hiatus NH3 of Keller and Barron (1983). The NH3 hiatus is not recognized, however, at the nearby DSDP Site 495, and therefore this hiatus may represent a much younger local event. Cores 25 (Section 3) through 22 are barren of planktonic fora-

Table 4. Percentage abundances of planktonic foraminifers from Hole 567A and estimated abundances of planktonic foraminifers from Hole 567.

Sample (interval in cm)	*Cassigerinella chipolensis*	*Catapsydrax dissimilis ciperoensis*	*C. dissimilis dissimilis*	*C.* sp.	*C. stainforthi*	*C.* cf. *C. unicavus unicavus*	*Globigerina angustiumbilicata*	*G. bulloides*	*G. ciperoensis*	*G. falconensis*	*G. nepenthes*	*G. obesa*	*G. praebulloides occlusa*	*G. praebulloides praebulloides*	*G.* sp.	*G. tripartita*	*G. woodi*	*Globigerinella aequilateralis*	*G. praesiphonifera*	*Globigerinita glutinata* s.l.	*G. uvula*	*Globigerinoides altiaperturus*	*G. bollii*	*G. bulloideus*	*G. conglobatus*
Hole 567A																									
H1,CC																									
1-1, 23–25								(1)												(2)			(3)*		
1-5, 23–25								(1)																	
1,CC												3											x*	4	x
2-3, 59–63																				(1) cf.					
2-5, 59–63																									
3-1, 76–80			6*				2	x						2						2	3	x	x	4	
3-3, 50–54										(2)												(1) cf.			
3-4, 76–80							(1) cf.														(2)				
3-5, 76–80											(1)										(2)		(2)		
3-6, 76–80				2 cf.			x							4									2	x	
3-7, 22–26		x					x							5					5	3			3		
3,CC		x	4		2				2 cf.					2						4	x	2		6	
4-2, 84–88														(1)								(1)	(1)		
4-3, 84–88		(3)	(2)				(1) cf.							(6)							(1)	(1)			
4,CC		2		x			x cf.	x						5	x	3	x cf.			x	x	x	9		
5-1, 65–72							(1)													(1)					
5-5, 68–72		(1)	(1)											(1)											
5,CC	x	2	7		2		2					x		11						4	2	2	4	5	
6-1, 71–75			(2)																						
6-2, 71–75						(1) cf.		(1) cf.	(3)					(2)							(1)			(1)	
8-1, 48–50		(1)	(2)		(1)							(1)		(2)					(2) cf.				(1)		
8-5, 50–52			x		x		2	4	3					10	x						x		2	8	
8,CC				4	x				2					8			x	x		x	x	x		11	
9-1, 50–52			3		x				x					4			3			4	14			6	
9-3, 50–52				x			8		4						2		14			4	11		x	2	
9,CC				x	x cf.				3			x		5			x				x	8			
10-5, 80–82				5			3							9						x	3				
11-1, 80–84					(1)																				
11,CC				(1)																					
12-1, 101–105		x		3	2		x		2			2		4							x				
12-3, 101–105			x	x	x	x			x				x	4	x					x	x				
12,CC			x						3				3	4			x				x				
13-3, 105–107			2		2				2			4									x				
13,CC			2	x			4		4			4		5	x							x			
19-1, 77–79																									
Hole 567																									
H1,CC								F		R							F								
1,CC								R																	
2,CC																									

Note: A = abundant; C = common; F = few; R = rare. x = <2% or present only in ≤149 μm size fraction; ( ) = actual number of specimens (<50 specimens in sample); * = reworked or downhole contamination; cf. = tentative identification.

minifers. Diatoms in Cores 25 and 24 are middle middle Miocene (J. A. Barron, pers. comm., 1983), suggesting that the hiatus occurs in Core 23 or Core 22.

The interval from Sample 21-1, 97–99 cm to Core 1 above the hiatus contains abundant and well-preserved Pleistocene species. The presence of abundant *Neogloboquadrina dutertrei* in Samples 21-1, 97–99 cm to 6-3, 47–49 cm suggests a Pleistocene Zone N22 assignment. The occurrence of *Globigerina calida* in Sample 6-3, 47–49 cm marks the base of Zone N23. Calcareous nannoplankton and benthic foraminifers also indicate that Cores 21 to 1 are Pleistocene. Calcareous nannoplankton place Sample 21-1, 97–99 cm in the lower middle Pleistocene. It cannot be determined from the planktonic foraminifers whether the lower Pleistocene interval is missing.

Pleistocene faunas in Hole 568 are dominated by *Globigerina bulloides, Globigerinita glutinata* s.l., *Globigerinoides ruber ruber, Globorotalia menardii, Neogloboquadrina dutertrei*, and *N. pachyderma*. Important accessory species are *Globigerina digitata, G. umbilicata, Globigerinita iota, Globigerinoides tenellus*, and *Pulleniatina finalis*. The presence of the middle Miocene species *Globigerinoides bollii* and *G. bulloideus* suggests reworking of Miocene sediments.

As in Hole 565, the Pleistocene sediments of Hole 568 have anomalously young occurrences of *Neogloboquadrina acostaensis* and *N. humerosa*. *N. acostaensis* occurs rarely in three samples in Zone N23, and is probably reworked. *N. humerosa* occurs in the upper part of Zone N22. Normally this species ranges into the lower Pleistocene in reduced abundance.

Hole 568 samples examined for planktonic foraminifers that proved barren include 44-3, 138–146 cm; 43-3, 90–94 cm; 25-6, 51–55 cm; 24-6, 130–134 cm; 24-4, 130–134 cm; 24-1, 130–134 cm; 23,CC; 23-3, 92–96 cm; 23-1, 92–96 cm; 22,CC; 22-5, 32–36 cm.

Site 569

Site 569 is on the middle part of the slope at a water depth of 2744 m, 32 km landward from the Middle America Trench axis (Fig. 1; Table 1). Hole 569 was continuously cored, with moderate recovery, through Pleistocene, Pliocene, middle Miocene, and lower Miocene sediments, to 250.7 m. Hole 569A, 3000 feet west and 600 feet south of Hole 569, was washed for the first

Table 4. (Continued).

G. diminutus	*G. mitra*	*G. obliquus extremus*	*G. obliquus obliquus*	*G. parawoodi*	*G. primordius*	*G. quadrilobatus*	*G. ruber ruber*	*G. sacculifer irregularis*	*G. sacculifer sacculifer*	*G. sicanus*	*G.* sp.	*G. subquadratus*	*G. tenellus*	*G. transitoria*	*G. trilobus bullatus*	*G. trilobus immaturus*	*G. trilobus trilobus*	*Globoquadrina altispira altispira*	*G. baroemoenensis*	*G. dehiscens*	*G.* sp.	*G. venezuelana*	*Globorotalia* cf. *G. acrostoma*	*G.* cf. *G. anfracta*	*G. birnageae*	*G. ciboensis*	*G. continuosa*
			(1)																								
														(1)			(1)										
		4	7						14	3•		7•						x									
																	(1)										
			x	4•			x					2•					16	5		x		4				9	
												(1)•					(1)	(1)									
			(1)																								
			(1)														(1)										
				3								2					18	2				10			2	x cf.	x
										4•	x						11	5		x		8					7
				5							x	2		3			5	5				4					9
																	(7)										
																	(9)			(1)		(1)		(1)•	(3)		
									8			x					22	x		x	3	6			x		x cf.
															(1)												
																									(1)		
				5					6			x		4			9	x		2		7					5
												(1)					(5)				(1)						
				(2)														(3)			(1)						(1) cf.
										(3)•							(9)	(7)				(4)					
								x	x		x	6		2			10	3		x		7					2
								x	4			x			x	4	16	5	5 cf.			5					
									6		x	x		2		9	7	2			4				5		
				4					x			2				2	11	5			x	3			2		
				2	10				5			2					16	24		3		4			7 cf.		2
				3	3			3			1	3				4	5	6	x cf.		4	8					x cf.
											(1)										(1)						
																	(1)	(1)									
				x								x				x	4	9			5	19 cf.	x		6		
x•	x•			x	x				3			2			x	6	8	14		x	x	11	x		3		
				3	4				x			3			x		28	16	3	3 cf.		11	x		x		
				x	7							x			x		5	5	x cf.		2	13					
				x	9				4			8					4	9	2 cf.			5			3		
																	R										
		R	R			F	C		R				R				C				R						
							R																				

246 m, then discontinuously drilled, with poor recovery, for 11 cores, until basement was reached, for a total penetration of 364.9 m. Sediments in Hole 569A range from lower Eocene to lower Miocene.

Planktonic foraminifers are generally rare to few in pre-Pleistocene sediments, and moderately to poorly preserved, with many pyritized specimens. In Pleistocene sediments, planktonic foraminifers are abundant and well preserved. Estimated abundances are shown in Tables 6 and 7.

Hole 569

Cores 569-27 to 569-7 contain firm olive-gray to bluish green muds that are mottled and show evidence of bioturbation. Samples 569-27-1, 16–22 cm through 569-22-1, 84–88 cm indicate Zones P22 through N4, on the basis of *Globorotalia* cf. *G. pseudokugleri, G. siakensis, Globigerina praebulloides praebulloides, G. ciperoensis, G. euapertura*, and *Catapsydrax*. Calcareous nannoplankton from these samples are also indicative of late Oligocene to early Miocene time. Planktonic foraminifers are rare, poorly preserved, and of low diversity in this interval, and preclude a more precise biostratigraphic assignment. Increased carbonate dissolution in this interval may correlate with the latest Oligocene PH hiatus of Keller and Barron (1983).

Sample 569-21-1, 20–24 cm contains *Globigerinoides trilobus*, the marker species for the base of Subzone N4b (Srinivasan and Kennett, 1981b; Keller, in press). Samples 569-21-1, 20–24 cm through 569-17-3, 87–91 cm contain planktonic foraminifers referrable to Subzones N4b and N4c. *Globigerinoides altiaperturus*, which appears in Subzone N4b (Keller, 1980), is first recorded in Sample 569-21-1, 20–24 cm, and Sample 569-20-1, 69–73 cm contains diverse *Globigerinoides*, including *Globigerinoides parawoodi*, which typify Subzone N4b (Fig. 2). Also present in this interval is *Globoquadrina altispira*, a secondary indicator for lower Subzone N4c. *Globoquadrina dehiscens*, the basal marker of Subzone N4c, does not occur until higher in Hole 569, and its true first-occurrence datum is not recorded in this hole. The top of Zone N4 is tentatively placed above Sample 569-17-3, 87–91 cm, which contains a single occurrence of the marker *Globorotalia kugleri*. *Globoquadrina venezuelana, G. baroemoenensis, Globigerinoides trilobus trilobus, G. parawoodi, Globigerina praebulloides praebulloides, G. woodi*, and *Catapsydrax* sp. dominate the assemblages of this Subzone N4b–N4c interval.

Table 4. (Continued).

Sample (interval in cm)	G. kugleri	G. mayeri	G. menardii s.l.	G. menardii s.s.	G. merotumida	G. minutissima	G. cf. G. miozea	G. opima nana	G. peripheroronda s.l.	G. peripheroronda s.s.	G. plesiotumida	G. praescitula	G. pseudokugleri	G. puncticulata	G. scitula	G. siakensis s.l.	G. siakensis s.s.	G. sp.	G. tumida	G. ungulata	Globorotaloides hexagona	G. suteri	Globotruncana arca	G. fornicata	G. mariei
Hole 567A																									
H1,CC				(1)																					
1-1, 23-25											(1)														
1-5, 23-25					(1)	(1) cf.																			
1,CC			4		x						8														
2-3, 59-63																									
2-5, 59-63																									
3-1, 76-80	x*		x							8*							4*					2 cf.			
3-3, 50-54										(3)*								(1)							
3-4, 76-80																									
3-5, 76-80			(1)			(1)																			
3-6, 76-80		5				x											19					2 cf.			
3-7, 22-26		19															17								
3,CC		10				4										x	15					3			
4-2, 84-88																						(1)			
4-3, 84-88		(1)								(3)							(7)								
4,CC						x											8	x				6			
5-1, 65-72						(1)										(1)	(2)								
5-5, 68-72																	(3)					(1)			
5,CC									x								9				2				
6-1, 71-75								(1)																	
6-2, 71-75		(1)														(4)	(3)					(1) cf.			
8-1, 48-50	(1) cf.																(1)								
8-5, 50-52							2	4	x							19	6	x							
8,CC								x	x							15	x					x cf.			
9-1, 50-52															x	17	8								
9-3, 50-52		x										x				6	11					x			
9,CC													x				4								
10-5, 80-82						x		10									18								
11-1, 80-84																									
11,CC																									
12-1, 101-105		x						3									10					2 cf.	5*	6*	
12-3, 101-105		2						3								5	12						3*	2*	
12,CC		3						x	x							3	4					x			
13-3, 105-107		2														5	9						9*	7*	x* cf.
13,CC														2*		4	7					3			
19-1, 77-79																							C	C	F
Hole 567																									
H1,CC			A	F															R	R	R				
1,CC			R																		R				
2,CC																									

Samples 569-16,CC through 569-14-2, 53–57 cm are assigned to Zones N5–N6. This interval contains *Catapsydrax, Globigerinoides altiaperturus, G. parawoodi, G. subquadratus, Globorotalia siakensis, G. mayeri, Globoquadrina venezuelana*, and *G. altispira* (Table 6). *Globigerinoides parawoodi* and *G. altiaperturus* are typical of Zones N4 to N5–N6 (Keller, 1981a). The top of N5-N6 is tentatively placed just above Sample 569-14-2, 53–57 cm, at the extinction of the zonal marker *Catapsydrax dissimilis dissimilis*. Rare reworked Eocene specimens of *Globigerina eocaena* are present in Sample 569-15-3, 104–108 cm.

Zones N7–N8 are represented in Samples 569-13-2, 6–10 cm and 569-12-1, 20–24 cm. The first occurrence of well-developed *Globorotalia peripheroronda*, which evolves near the top of Zone N7 (Keller, 1980), is in Sample 569-13-2, 6–10 cm. *Globorotalia zealandica incognita*, whose last occurrence is in Zone N7 (Keller, 1981c), is also present in this sample. *Globigerinoides parawoodi* and *G. altiaperturus*, whose upper ranges possibly extend into Zone N7 (Keller, 1981a), have their last occurrences in this sample. The assemblage also contains *Globoquadrina altispira, Globigerinoides trilobus trilobus, G. sacculifer irregularis*, and *Globigerina praebulloides praebulloides*. Calcareous nannoplankton in Sample 569-12,CC are assigned to the *Helicosphaera ampliaperta* Zone, which correlates with the middle of Zone N7 to mid-N8, and hence supports our age interpretation.

Samples 569-11-1, 30–34 cm and 569-10-1, 11–15 cm are referable to the middle Miocene Zone N9 on the basis of the first occurrence of *Globorotalia scitula*, which evolves in Zone N9 (Blow, 1969), in Sample 569-11-1, 30–34 cm. Diversity of planktonic foraminifers is low; those present are primarily *Globorotalia siakensis, G. peripheroronda, Globoquadrina venezuelana, Globigerinoides trilobus trilobus, G. bulloideus*, and *Globigerina praebulloides praebulloides*. Calcareous nannoplankton from Sample 569-10,CC indicate the *Sphenolithus heteromorphus* Zone, which is in part correlative with Zone N9.

Above Sample 569-10-1, 11–15 cm is a hiatus which removed middle Miocene (Zone N10) to Pliocene sediments. Core 569-9 is barren of planktonic foraminifers, and Sample 569-8-1, 19–22 cm contains the Pliocene species *Globorotalia tumida, G. menardii, Neogloboquadrina humerosa, N. pachyderma, Globoquadrina altispira, Globigerinoides trilobus trilobus, G. ruber ruber, G.*

Table 4. (Continued).

G. petaloidea	*G.* sp.	*Hastigerinella bermudezi*	*Heterohelix globulosa*	*H. pulchra*	*Neogloboquadrina acostaensis*	*N. atlantica*	*N. dutertrei*	*N. humerosa*	*N. pachyderma*	*N. pachyderma* form 2	*N. pachyderma/dutertrei* intergrade	*Orbulina bilobata*	*O. universa*	*Pulleniatina obliquiloculata*	*P. primalis*	*Sphaeroidinellopsis disjuncta*	*S. seminulina*	*Turborotalia quinqueloba*	Non-identifiable	Number of specimens	Zone (Blow, 1969)	System, series, or subseries
						(1) cf.	(1)													3		
					(1) cf.	(1) cf.		(2) cf.	(5)								(1)			18		Pleistocene-
																				5		upper
						20	8	3			x				4	3*			4	76	N17–N22	Miocene
																				1		
								(1)	(1)		(1)									4		
									x										18	170		
																			(3)	13		Pliocene-
											(1)	(1)								6		Miocene
									(1)											11		
																			27	133		
																			8	75		
		x																	4	93		
																			(1)	12		
									(1)											41		
																x			9	143		
																			(1)	8	N5–N6	
																			(3)	11		
																			8	126		
																				10		
																			(5)	30		
																			(7)	42		
																			8	180	/	lower Miocene
																			3	142		
																		x	2	108		
																			5	194		
																			x	265		
																			8	77	c	
																			(1)	4	N4	
																			(1)	4		
x* cf.			2*																10	109		
	x*		x*																11	448		
																			4	233		
x*	5*																		12	85		
	x*																		18	113	b	
R			R	R																C		U. Cret.
																						Pleisto.
						R	A	R	R	C	F		θ	F						A		
									R cf.											R		Pleisto.-
																				R		upper Mio.

obliquus obliquus, and *Globigerinita glutinata* s.l. The occurrence of *Globoquadrina altispira* indicates that this sample is no younger than Zone N19 or possibly lowermost Zone N21, or about 2.8 Ma (Berggren, 1973).

Sample 569-7-3, 20–24 cm contains common *Neogloboquadrina dutertrei*, which is characteristic of the Pleistocene, and *Globorotalia bermudezi*, which is restricted to the Pleistocene. Because sediments below Sample 569-8-1, 18–22 cm contain a Pliocene assemblage no younger than 2.8 Ma, the upper Pliocene and lower Pleistocene section appears to be either very compressed or removed by a hiatus. A lithologic color change occurs in Sample 569-7-6, 49 cm, and may coincide with the Pliocene/Pleistocene boundary.

Sample 569-4-5, 30–34 cm contains the first occurrence of *Globigerina calida*, which defines the base of Zone N23 (Fig. 2). Species common throughout the Pleistocene interval are *Neogloboquadrina dutertrei, N. pachyderma, N. pachyderma/dutertrei* intergrade, *N. atlantica, Globorotalia menardii, Globigerinoides ruber ruber, Globigerinita glutinata* s.l., *Globigerina bulloides*, and *Orbulina universa*. Other important accessory species are *Pulleniatina obliquiloculata, Hastigerinopsis riedeli, Globorotalia tumida, Globigerinita iota, Globigerina umbilicata*, and *Globorotaloides hexagona* (Table 6).

As in the Pleistocene sections of Holes 565 and 568, *Neogloboquadrina acostaensis* and *N. humerosa* occur somewhat higher than expected. Since reworking is not significant in this hole, we suspect that these species have a longer range in the low-latitude eastern North Pacific region (see Taxonomic Notes and discussions of Holes 565 and 568 for further comments).

Hole 569 samples examined that proved barren of planktonic foraminifers are 25-1, 20–24 cm and 9-1, 20–24 cm.

Hole 569A

Paleogene sediments are present in Sample 569A-10-1, 0–2 cm to 569A-H1, 30–34 cm (Table 7). Sample 569A-10-1, 0–2 cm contains a moderately well preserved assemblage of *Globorotalia aragonensis, G. broedermanni, G. pseudotopilensis, G. pentacamerata, G. nitida*, and *G. linaperta*, indicating upper lower Eocene (Zone P8), as suggested by the overlap of *G. pseudotopilensis* and *G. pentacamerata*. Poorly preserved and rare planktonic foraminifers are present in Sample 569A-9-1, 18–19 cm (*Globigerina linaperta* and *Globorotalia pentacamerata*) and Sample 569A-8,CC (*Globigerina linaperta, G. primitiva*, and *Catapsydrax pera*), indicating lower to middle Eocene of Zones P8 to P13. Sample 569A-7-1, 30–

Table 5. Percentage abundances and estimated abundances of planktonic foraminifers from Hole 568.

Sample (interval in cm)	*Cassigerinella chipolensis*	*Catapsydrax dissimilis dissimilis*	*C.* sp.	*C. stainforthi*	*C. unicavus unicavus*	*Globigerina angustiumbilicata*	*G. bulloides*	*G. calida*	*G. ciperoensis*	*G.* cf. *G. decoraperta*	*G. digitata*	*G. falconensis*	*G. obesa*	*G. praebulloides praebulloides*	*G. praecalida*	*G. pseudobesa*	*G. pseudociperoensis*	*G. quadrilatera*	*G. rubescens*	*G.* sp.	*G. umbilicata*	*G. woodi*	*Globigerinella aequilateralis*	*G. praesiphonifera*	*Globigerinita glutinata* s.l.	*G. iota*
1-3, 30-34							A	C				F						F	R		F		R		A	R
2-5, 80-84							C	R				F						F	R		F		R		A	R
3-3, 121-125							C	R				F				R		F					R		C	R
4-3, 108-112							C	R cf.								R		F	R				R		C	
5-3, 73-77							F									R		R							F	R
6-3, 47-49							C	F				R				R		F		R		R	F		C	
7-3, 40-44							C	R cf.				R				R		F	R	R			R		A	
8-3, 84-88							F											R				R			F	
9-2, 32-36							C								R			C	R	R		R	R		C	R
10-3, 65-69							F								R					R					R	
11-1, 48-52							F					R				R cf.		R	R			R	R		A	R
12-3, 72-76							C				R	R						R		R		R			C	R
13-3, 29-33							F					R				R		F	R			R	R		A	
14-3, 8-12							C					R						F	R	R					C	
15-3, 57-61							R					R				R		R	R				R		F	
16-3, 33-37							F											R							C	
17-3, 15-19							F											R	R						C	
18-3, 21-25							F					R						R	R	R			R		A	
19-3, 21-25							C					R				R		F	R				R		A	
20-3, 57-61							F											R	R	R		R	R		F	
21-1, 97-99							C											F	R						F	
25-4, 51-55																										
27-3, 76-80										11			x				4									
28-5, 128-130										x			x	6			x					x				
29-3, 24-28										2			3									22			3	
30-3, 19-23										x			2	17			2					2				
31-1, 19-23										2		3										6		x	4	
32-5, 83-87										3			5	6			3					14				
33,CC										x		2		4								2				
34-5, 90-94										x				3			3					2			x	
35-3, 97-99													4	4			8							x	x	
36-5, 70-74													x	x			2									
37-1, 121-125			x										2	9			3					5			x	
38-4, 80-85			x		x	x			7					10								6		x		
39-3, 84-88									5 cf.					5								2			x	
40-5, 55-57	x		x	x					3					2						x		6				
41-1, 66-70	x				x				6			x	8	4								3			x	
42-3, 72-76				(1)		x			(1) cf.													(2)			x	
43-3, 40-44			2	2					7					10								2				
44-1, 138-146		x		4		x							5	14								5				

Note: A = abundant; C = common; F = few; R = rare. x = <2% or present only in ≤149 μm size fraction; ( ) = actual number of specimens (<50 specimens in sample); * = reworked; cf. = tentative identification.

34 cm contains an uppermost Eocene (Zones P16–P17) or lower Oligocene (Zones P18–P19) assemblage consisting of *Catapsydrax pera, Globorotaloides suteri, Globorotalia opima nana, Globoquadrina tripartita*, and *G. venezuelana.*

Globigerina ciperoensis, G. praebulloides praebulloides, Globoquadrina cf. *G. altispira, G. venezuelana, G. tripartita*, and *Globorotalia opima nana* are present in the interval of Samples 569A-6-1, 30–34 cm and 569A-H1, 30–34 cm, and indicate upper Oligocene to lower Miocene (Zones P22–N4). The presence of diverse *Globigerinoides* such as *G. trilobus, G. subquadratus*, and *G. parawoodi*, and the absence of *Globoquadrina tripartita* in Core 569A-H1, suggest lower Miocene (Zone N4). The single specimen of the Cretaceous *Globotruncana* sp. is reworked.

Site 570

Site 570, on the upper slope of the Middle America Trench offshore from Guatemala, was drilled at a water depth of 1698 m, 40 km landward of the trench axis (Fig. 1; Table 1). Hole 570 was continuously cored through Pleistocene, Pliocene?, upper Miocene, middle Miocene, and lower Eocene sediments until drilling was halted in the serpentinite basement at 401.9 m sub-bottom. Recovery was moderate, averaging 41%.

Preservation of planktonic foraminifers varies throughout the hole. In the Paleogene interval, planktonic foraminifers are rare and poorly preserved. In the Neogene section, Cores 35 to 28 are intensely dissolved, but Cores 26 to 1 contain moderately well preserved to well-preserved planktonic foraminifers. Estimated abundances of the Paleogene section of Hole 570 are shown in Table 8, and percentage abundances of Neogene planktonic foraminifers are shown in Table 9. Faunal abundance curves are shown in Figure 7, and ranges of key Neogene species are shown in Figure 8.

The silty black muds, olive-gray sands, and blue-green limestones of Cores 38 through 36 are assigned to the lower Eocene (Table 8). A single specimen of *Globigerina pentacamerata* was recovered from Sample 38,CC. Sample 37-1, 126–128 cm contains rare specimens of *Globorotalia velascoensis, G. aequa*, and *Globigerina primitiva*, indicating Zones P4–P6. Sample 37-1, 88–90 cm contains rare specimens of *Globorotalia angulata*, which becomes extinct at the top of Zone P4 (Stainforth et al., 1975). This suggests that the lower part of Section 37-1 may be as old as Zone P4, but if *G. angulata* is not in place, then this interval could be as young as Zones P5–P6. Sample 37-1, 25–30 cm contains *Globorotalia lensiformis* (which restricts this sample to Zones P6–P7) as well as common *G. aequa, G. broedermanni, G. formo-*

Table 5. (Continued).

G. parkerae	*G. uvula*	*Globigerinoides altiaperturus*	*G. bollii*	*G. bulloideus*	*G. conglobatus*	*G. obliquus extremus*	*G. obliquus obliquus*	*G. parawoodi*	*G. primordius*	*G. quadrilobatus*	*G. ruber pyramidalis*	*G. ruber ruber*	*G. sacculifer irregularis*	*G. sacculifer sacculifer*	*G. sicanus*	*G. subquadratus*	*G. tenellus*	*G. trilobus bullatus*	*G. trilobus immaturus*	*G. trilobus trilobus*	*Globoquadrina altispira altispira*	*G. altispira globosa*	*G. baroemoenensis*	*G. dehiscens*	*G.* sp.	*G. venezuelana*	*Globorotalia* cf. *G. acrostoma*	*G. anfracta*
	R									R	R	F		R			R			R								
	R					R				R	R	C		R			R			R								
	R									R	R	F																
	R											F		R														
	R									R		R		R														
	R									F	R	C		R			R			R								
	R									R	R	C		R			R			R								
	R									R		F		R														
	R				R	R	R			R	R	C		R			R			R								
	R									R		R																
	R									C	R	C		F			R			R								
R	R									R		F																
	R				F					F		C		C			R			F								
	R									C	R	C		C			R			C								R
	R									R		F		R						F								
	R										R	F		R			R			R								
	R											F		R			R			R								
	R		R*							F	R	A		C			R			C								
	R			R*						F	R	A		F			R			F								
				R*	R					F		F		R			R			F								
						R						A		F						C								
																									(1)			
				x																16	26					11		
				x						x				x						16	26			7		28		
				3												2				11				2		6		
			x	4										6		x			x	20	10			3		5		
	x			7				x						4					2	13	13					3		
	2			5						x				6					3	13	3	7		x		2		
				7						7				7	3			x	12	23	4		x	2		10		
				2				x		x				x		x				17	10		2	x		4		
										x				3	2	x			3	12	4		4	11		2	x	
			x	x										3		8			3	11	7		x	x		4		
	x		x					x						5	x	8		x	6	11	x	7	6			3		
	x													2		4			7	14	x	4		x cf.		x		
	x	5		x				x					x	x		2			x	20	x	25	3	x		5		
	x	3		2				2						3		6		x	3	12	4	27	8	3		x		
	x			x				2						2		3		x	12	26		10	3	3		x cf.		
									(1)							(2)			(1)	(2)		(1)						
									5				2			x		x	x	6		x						
								2	4							2		2	x	x						3		

sa gracilis, and few *G. soldadoensis*. *Globorotalia angulata*, *G. compressa*, and *G. pusilla* also occur, however, suggesting that some reworking has occurred. Calcareous nannoplankton and benthic foraminifers also indicate lower Eocene assignment for these cores.

Sample 35,CC contains lower Miocene species referable to Subzone N4b to Zone N6, thus indicating that lower Eocene to lower Miocene sediments are absent because of a hiatus. This hiatus may be correlative with the PH hiatus of Keller and Barron (1983), which occurs near the Oligocene/Miocene boundary (P22/N4a). The presence of *Globigerinoides trilobus* in Sample 35,CC indicates an age no older than Zone N4b, whereas the presence of *Catapsydrax dissimilis dissimilis* limits the upper range of this sample to Zone N6 (Table 9).

Sediments representing at least Zones N7–N11 are missing because of a second hiatus between Samples 35,CC and 35-4, 12–14 cm. Core 35 contains several different lithologies; numerous redeposited clasts also suggest a hiatus.

Sample 35-4, 12–14 cm contains *Globorotalia fohsi fohsi*, whose first occurrence defines the base of middle Miocene Zone N12, and thus sets a lower age limit for this sample. The occurrence of *G. fohsi fohsi* with *G. praefohsi*, which ranges to the top of Zone N12 (?N13), restricts this sample to Zone N12. These middle Miocene assemblages are dominated by *Globoquadrina altispira*, *G. venezuelana*, and *G. baroemoenensis*, which make up 35% of the assemblages, and common *Globigerinoides trilobus trilobus* and *Globorotalia peripheroacuta* (Table 8). Calcareous nannoplankton data are in agreement with a middle Miocene assignment.

Sediments of Cores 35 (Section 1) through 28 (Section 1) are dissolved (Fig. 7), and correspond to the upper middle Miocene to lower upper Miocene dissolution interval commonly observed in other deep-sea sections (Barron and Keller, 1982).

Planktonic foraminifers recovered in Samples 35-1, 20–24 cm through 33,CC are not age-diagnostic. But the occurrence of *Globorotalia praemenardii* in Sample 33,CC suggest middle middle Miocene, an age no older than the top of Zone N12 (?N13) (Keller, 1981a). Calcareous nannoplankton present in this interval (and up to Sample 28,CC) indicate the much younger upper Miocene *Discoaster quinqueramus* Zone. This age difference could be due to downhole contamination of the nannoplankton assemblages, because samples in Core 32 contain middle Miocene and lower upper Miocene planktonic foraminiferal species probably of Zones N13–N14. For instance, Sample 32-1, 17–21 cm contains *Globorotalia siakensis* and *G. menardii*. *G. menardii* first evolves near the base of Zone N13 (first appearance datum of 12.7 Ma), and the last occurrence of *G. siakensis* defines the top of Zone N14 (last appearance datum of

Table 5. (Continued).

Sample (interval in cm)	*G. archeomenardii*	*G. bermudezi*	*G. birnageae*	*G. continuosa*	*G. crassiformis*	*G. crassula crassula*	*G. exilis*	*G. fimbriata*	*G. inflata*	*G. kugleri*	*G. mayeri*	*G. menardii* s.l.	*G. menardii* s.s.	*G. minutissima*	*G. opima nana*	*G. peripheroacuta*	*G. peripheroronda*	*G. praefohsi*	*G. praemenardii*	*G. praescitula*	*G. scitula*	*G. siakensis* s.l.	*G. siakensis* s.s.	*G. subscitula*	*G. tumida*	*G. ungulata*
1-3, 30-34		R					F					C	F	R							R				R	F
2-5, 80-84					R		R		R			A	F	R							R				R	F
3-3, 121-125												C	F	R							R					R
4-3, 108-112					R							C	F	R												R
5-3, 73-77						R						F	R													R
6-3, 47-49							F					F	C	R							F					F
7-3, 40-44							R	R				R	F	R												F
8-3, 84-88							R	R				F	F	R												
9-2, 32-36					R		R					F	F	R											R	R
10-3, 65-69							R					F	R												R	
11-1, 48-52							R					F	C	R												R
12-3, 72-76							R					F	C	R												
13-3, 29-33							R						A	R							R				R	R
14-3, 8-12												A		R											R	F
15-3, 57-61												C	R	R												R
16-3, 33-37												A		R							R				R	R
17-3, 15-19												C	F								R					R
18-3, 21-25							R		R			A	C								C				R	F
19-3, 21-25							F					A									F				R	F
20-3, 57-61							R						F													R
21-1, 97-99												C	C	R											R	R
25-4, 51-55																(2)										
27-3, 76-80																16	4									
28-5, 128-130				x												11	4	3			x	x				
29-3, 24-28											3			2			12		2			9	14			
30-3, 19-23	x			x												x	18		x		x					
31-1, 19-23	x																21		4					6		
32-5, 83-87	6													x			13							5		
33,CC	3													x			12									
34-5, 90-94	2			4							x						10				x	14	18			
35-3, 97-99	11			6							4			x							'	19	14			
36-5, 70-74	3		x cf.	x										x			19			x		13	16			
37-1, 121-125	5										x						22						x			
38-4, 80-85											23						7			x			4			
39-3, 84-88			2								17										x		2			
40-5, 55-57			x							x	6						x cf.					x	3			
41-1, 66-70			2								3			x												
42-3, 72-76			(1)								(1)				(1)							(1)		(1) cf.		
43-3, 40-44				6							10											14	21			
44-1, 138-146				x						x				x								19	22			

11.9 Ma) (Fig. 2). Planktonic foraminifers therefore indicate that Sample 32-1, 17–21 cm is no younger than 11.9 Ma, or the top of Zone N14.

Sample 31-1, 10–14 cm contains nondiagnostic planktonic foraminifers, and is tentatively assigned to Zone N15 on the basis of its stratigraphic position.

Samples 30-3, 10–14 cm through 28-6, 42–52 cm are assigned to the upper Miocene Zones N16 to N17 because of the presence of *Neogloboquadrina acostaensis*, the zonal marker for the base of Zone N16 (Fig. 2), and *Globigerinoides obliquus extremus*, which appears near the base of Zone N17 (Keller, 1980).

Globigerinoides conglobatus, which first occurs near the base of Zone N17, is also present in Sample 28-6, 42–52 cm. *Globorotalia plesiotumida*, the zonal marker for the base of Zone N17, does not occur, however, until Sample 28-1, 21–24 cm. This is not surprising, since Keller et al. (1983) have shown that the first occurrence of this species is diachronous outside tropical and subtropical waters. The age assignment of planktonic foraminifers of this interval is in agreement with the calcareous nannoplankton assignment to the upper Miocene *Discoaster quinqueramus* Zone.

The occurrence of *Pulleniatina primalis* in Sample 26-1, 14–16 cm marks the base of Subzone N17b (Srinivasan and Kennett, 1981a). The first appearance datum for this species is 6.3 Ma (Fig. 2). This interval marks a dramatic improvement in the abundance and preservation of planktonic foraminifers, as well as a change in lithology to an olive-gray to olive-brown mudstone. *Neogloboquadrina pachyderma, N. humerosa, N. acostaensis, Globigerinoides trilobus trilobus, G. ruber ruber, Globigerinita glutinata* s.l., *Globigerina bulloides*, and *Pulleniatina primalis* characterize the assemblages of Zone N17.

The uppermost part of Zone N17 and probably all of Zone N18 are evidently missing, owing to a hiatus. The missing interval correlates with the NH7 hiatus of Keller and Barron (1983), which affects uppermost Zone N17 to Zone N18.

The association of *Sphaeroidinella dehiscens, Globorotalia plesiotumida*, and *Globigerina nepenthes* in Sample 24-1, 20–24 cm indicates a Pliocene Zone N19 assignment. The first appearance datum of *Sphaeroidinella dehiscens*, 4.9 Ma (Fig. 2), is the zonal marker for the Zone N18/N19 boundary. *Globorotalia plesiotumida* and *Globigerina nepenthes* become extinct in Zone N19 (Blow, 1969). The first occurrence of *Globorotalia tumida* in Sample 23-1, 20–24 cm apparently does not represent the true first-appearance datum.

Sample 23-3, 20–24 cm is either Pliocene or Pleistocene. Calcareous nannoplankton indicate assignment of Samples 26,CC and 25,CC to the lower Pliocene and of Samples 24,CC and 23,CC to the upper Pliocene.

Table 5. (Continued).

G. wilesi	*G. zealandica zealandica*	*Globorotaloides hexagona*	*G. suteri*	*Hastigerinella bermudezi*	*Hastigerinopsis riedeli*	*Neogloboquadrina acostaensis*	*N. atlantica*	*N. dutertrei*	*N. humerosa*	*N. pachyderma*	*N. pachyderma* form 2	*N. pachyderma/dutertrei* intergrade	*N.* sp.	*Orbulina bilobata*	*O. suteralis*	*O. universa*	*Pulleniatina finalis*	*P. obliquiloculata*	*Sphaeroidinella dehiscens*	*Turborotalita cristatae*	*T. quinqueloba*	Non-identifiable	Number of specimens	Zone (Blow, 1969)	Series or subseries
R		R				R	F	A		F	C	A				R		F			R		A	N23	Pleistocene
		R			R	R	F	A		C	A	A				F	R	F			R		A		
R		R					F	A		F	F	C				R		R			R		A		
R		R				R	R	C		F	C	F									R		C		
							F	F		R	R	F								R	R		F		
R		F					R	A		F	A	C				F	R	F			R		A		
R		F					F	A		C	C	C				F	R	F			R		A	N22	
							R	F		R	F	F					R						F		
R		R					R	A		F	C	F				F	R	R			F		A		
		R					R	F		F	R	F				R					R		F		
R		R					F	A		F	A	C				C					R		A		
R		R					F	A		C	C	C				C					R		A		
		F					F	A		R	A	A				C	R	R			R		A		
R		F						A	C	F	C	A				A		R			R		A		
R		R					R	C	R	F	F	C				F		R			R		C		
R		R					F	C		C	A	A		R		C					R		A		
		R						C	R	F	F	F			R	F					R		C		
R		R					F	A	R	R	F	C				C	R	R			R		A		
R		F					R	C			F	C				A		R			R		A		
		R					F	R	R	R	F	R	R			R					R		F		
R		R						A	R	R	C	C				R		R	R		R		A		
																							3		middle Miocene
																						9	70	N11	
															x							3	619		
																						5	64	N10	
		2													2							2	344		
		2													2							6	114	N9	
				x											x								107		
																						x	133		
																						4	298		
		x														x						3	211		
															x							4	323		
																							215	N8	lower Miocene
																						2	118	N5–N7	
																							240		
			x																			2	356	N4 c	
			x																			6	178		
	(1)		(3)																			(5)	25	N4 b	
			2																			8	105		
	x																					14	100		

The massive olive-gray muds and sandy muds of Samples 22-1, 22–26 cm through 1,CC are assigned to the Pleistocene. *Neogloboquadrina dutertrei*, which characterizes the Pleistocene, occurs in Sample 22-1, 22–26 cm. A single specimen of *Catapsydrax* sp. found in this sample indicates reworking. The first occurrence of *Globigerina calida* in Sample 7,CC defines the base of Zone N23 (Fig. 2). *Globigerina bulloides, Globigerinita glutinata* s.l., *Globigerinoides ruber ruber, Globorotalia menardii, Neogloboquadrina dutertrei, N. pachyderma, N. pachyderma/dutertrei* intergrade, and *N. atlantica* are the main components of the Pleistocene assemblages (Fig. 7; Table 9). Less abundant species restricted to the Pleistocene are *Globigerina umbilicata, G. cariacoensis, G. digitata, Globigerinita iota, Globigerinoides tenellus, Pulleniatina finalis, Hastigerinopsis riedeli*, and *Turborotalita humilis*.

As in the other Pleistocene sections of Leg 84 sites, the occurrences of *Neogloboquadrina acostaensis* and *N. humerosa* are abnormally high in Hole 570. *N. acostaensis* and *N. humerosa* become extinct in the Zone N22 interval of Hole 570. Reworking is not a tenable explanation for these unusual occurrences in Hole 570, because the two species consistently occur into Zone N22.

Hole 570 samples examined that proved barren of planktonic foraminifers include 39,CC; 39-1, 70–74 cm; 38,CC; and 37,CC.

DSDP Leg 67 Sites

Summary data from three Leg 67 sites (Aubouin, von Huene, et al, 1982) are included in this chapter to complete the transect from upper slope across the trench floor to the seaward side of the Middle America Trench (Fig. 9). Sites from Leg 84 cover the upper to lower slope. Sites from Leg 67 cover the slope–trench-floor junction (Site 500), trench floor (Site 499), and seaward side (Site 495). Modified biostratigraphic interpretation is from Thompson (1982).

Site 500

Site 500 lies at a water depth of 6090 m, at the junction of the landward slope and the trench base. Three holes were drilled at this site, each terminating in basalt. Coring in Hole 500 recovered lower Miocene (Zones N4 to N8?) hemipelagic sediments and Quaternary turbidites; in Hole 500A, hemipelagic lower Miocene (Zone N7) sediments were recovered. Hole 500B yielded hemipelagic lower Miocene (Zones N4 to N5/6) sediments. In Hole 500, the Quaternary sequence is either faulted or deposited against a fault scarp formed of lower Miocene sediments.

Site 499

Five holes were cored at Site 499, which lies at a water depth of about 6125 m on the trench floor, about

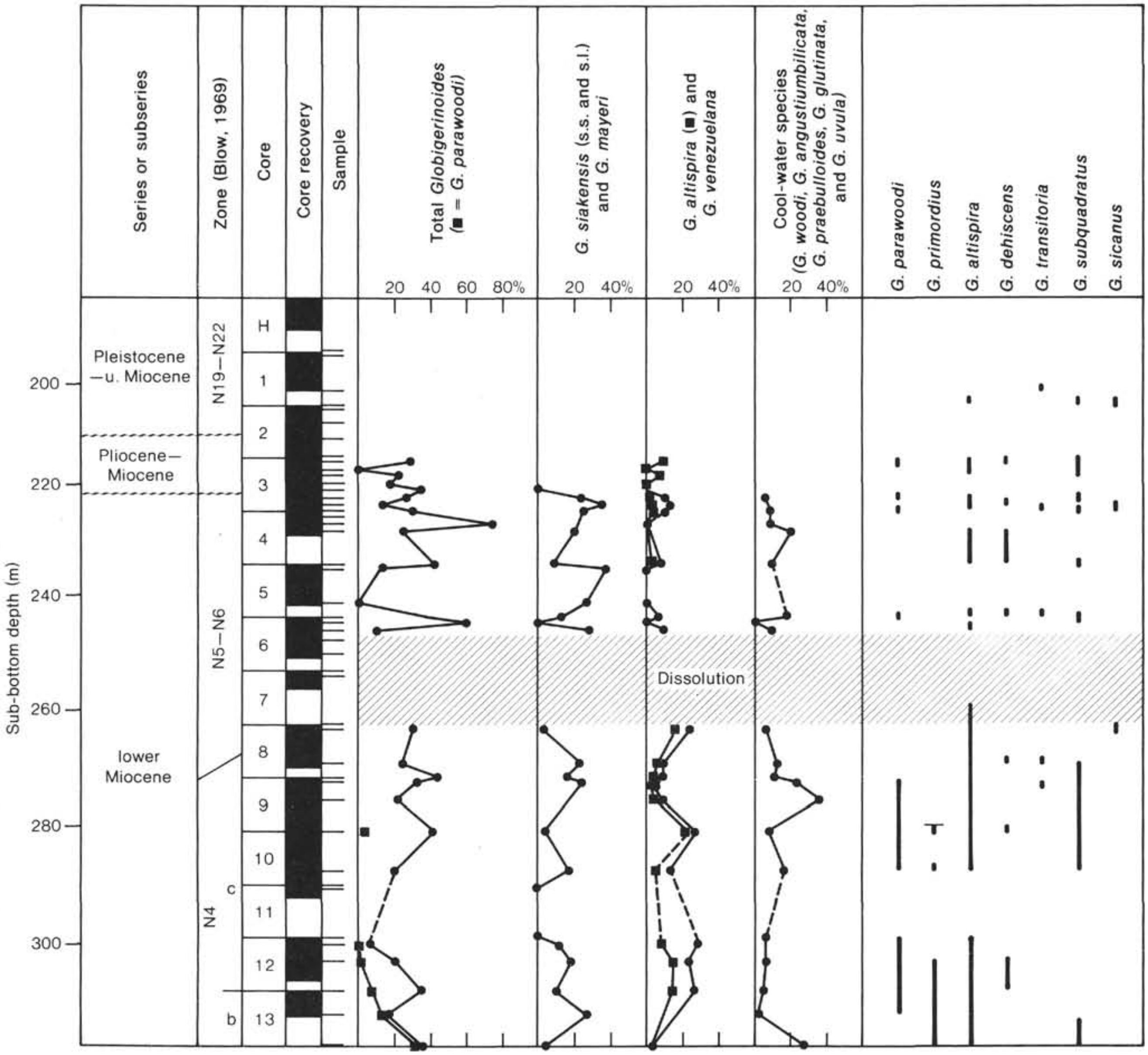

Figure 4. Relative abundances and range chart of selected Miocene and Pliocene planktonic foraminifers from Hole 567A.

1 km from the seaward wall; but cores from only three holes contained planktonic foraminifers. Hole 499 yielded lower and middle Miocene (Zones N7 to N10) chalk, hemipelagic upper Pliocene sediments, and hemipelagic and trench-fill Quaternary sediments. Coring in Hole 499A yielded a short Quaternary turbidite sequence, and Hole 499B material included lower and middle Miocene (Zones N4 to N10) chalks, which were found to overlie basalt. No middle Miocene, upper Miocene, or Pliocene planktonic foraminifers were noted. Upper Pliocene sediments from Hole 499 were recognized through their nannoplankton. Sediments representing Zones N11 through N19 are absent.

Site 495

Site 495, at a water depth of 4140 m on the seaward side (Cocos Plate) of the Middle America Trench, serves as the reference site for oceanic sediments. Coring at Site 495 yielded the most continuous sequence investigated of lower Miocene through Quaternary hemipelagic sediments. These sediments overlie basalt. Lower Miocene sediments were reexamined in detail by Stone and Keller (unpublished data), and middle Miocene sediments were reexamined by E. Barrera and G. Keller (unpublished data). The results for the lower and middle Miocene sediments agree closely with those of Thompson (1982), and include in addition the recognition of a hiatus (between Cores 495-28 and 495-29) in Zone N7 (NH1b hiatus of Keller and Barron, 1983), a dissolved interval in Zones N12–N13 (Cores 495-18 through 495-20), and a second hiatus where upper middle Miocene (Zone N15) sediments are missing (NH4 hiatus of Keller and Barron, 1983). From Thompson's (1982) data, sediments referable to the upper Miocene (Zones N16–N17) are found

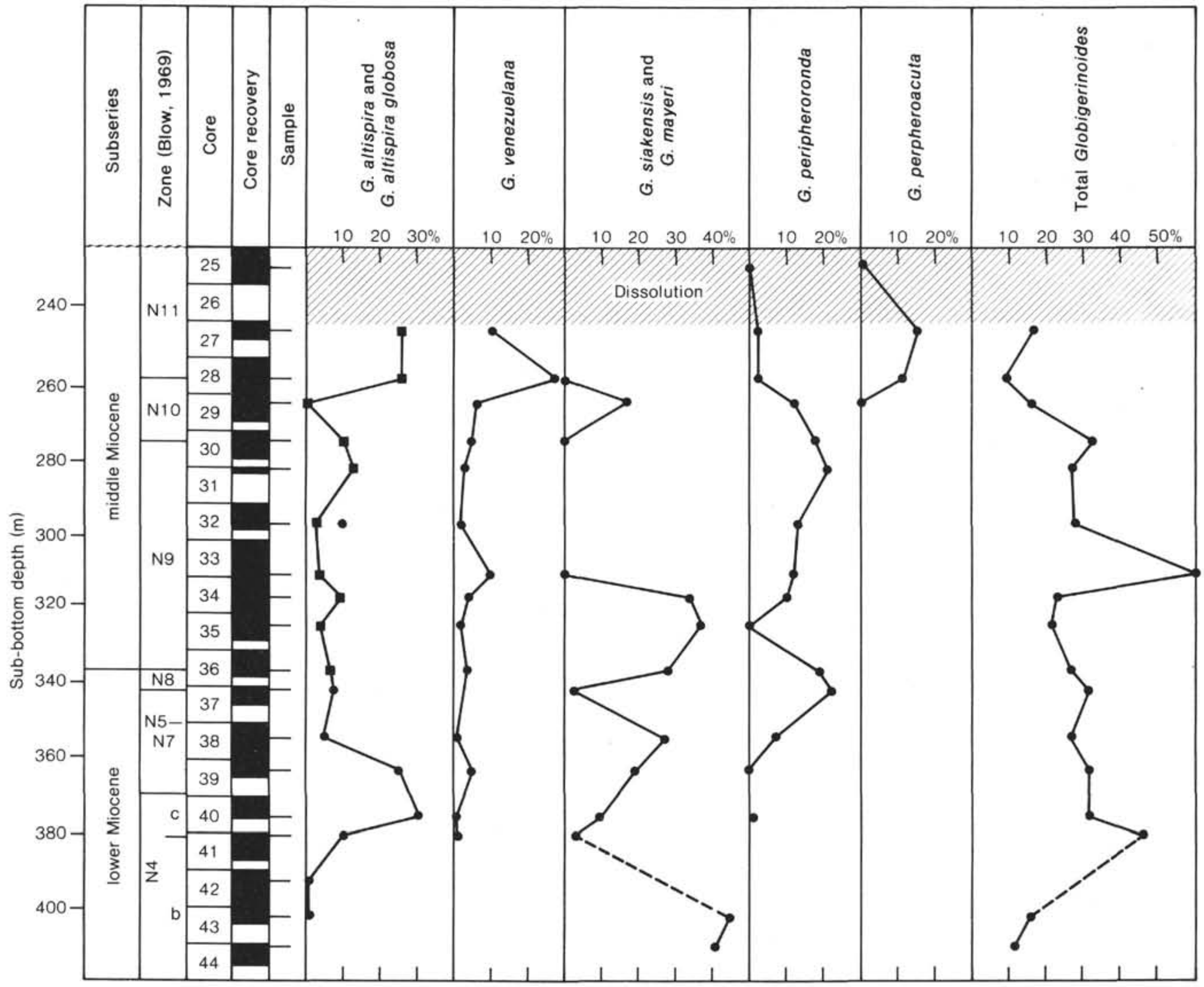

Figure 5. Relative abundances of selected Miocene planktonic foraminifers from Hole 568.

in Sections 495-17-2? to 495-13-1?. Cores 495-11 and 495-12 are extensively dissolved, and planktonic foraminifers referable to Zone N19 are found in Section 495-11-3, thus indicating that part of the lower Pliocene and upper Miocene interval is absent (NH7 hiatus of Keller and Barron, 1983). No further interruptions were found in the upper Pliocene and Quaternary sequence.

STRATIGRAPHY DISCUSSION

Figure 9 illustrates selected sedimentary sequences recovered on DSDP Legs 84 and 67, representing a transect from upper-slope to oceanic sediments across the Middle America Trench. Site 495 (Leg 67) serves as the oceanic reference section. Figure 9 also illustrates major episodes of volcanic activity (Cadet et al., 1982) in the Middle America region and widespread deep-sea hiatuses associated with global cooling and intensification of bottom currents (Keller and Barron, 1983). Identification of hiatuses associated with global cooling events aids in separation of major unconformities caused by local tectonic events from those attributable to oceanic events, and thus aids in interpreting the depositional history of the Middle America Trench and slope region.

Site 495 of Leg 67 is on the seaward side of the trench, and has the most complete sedimentary sequence. We have reexamined the planktonic foraminifers of Hole 495, and our results differ from Thompson's (1982) primarily in the identification of several hiatuses (Fig. 9). These hiatuses occurred about 16.5–17.5, 11.0–12.5, and 4.8–6.0 Ma ago, and can be correlated with widespread deep-sea hiatuses NH1b, NH4, and NH7 (NH = Neogene hiatus), respectively, of Keller and Barron (1983). Therefore, interruption of sedimentation of the seaward side of the trench can be attributed to global oceanic events, that is, erosion associated with intensification of bottom currents during polar cooling phases.

On the landward side of the Middle America Trench, the stratigraphic record is fragmentary and interrupted by numerous unconformities and intervals that have been subjected to carbonate dissolution. Sediments recovered represent the Late Cretaceous, early Eocene, late Eocene and early Oligocene, and latest Oligocene to Qua-

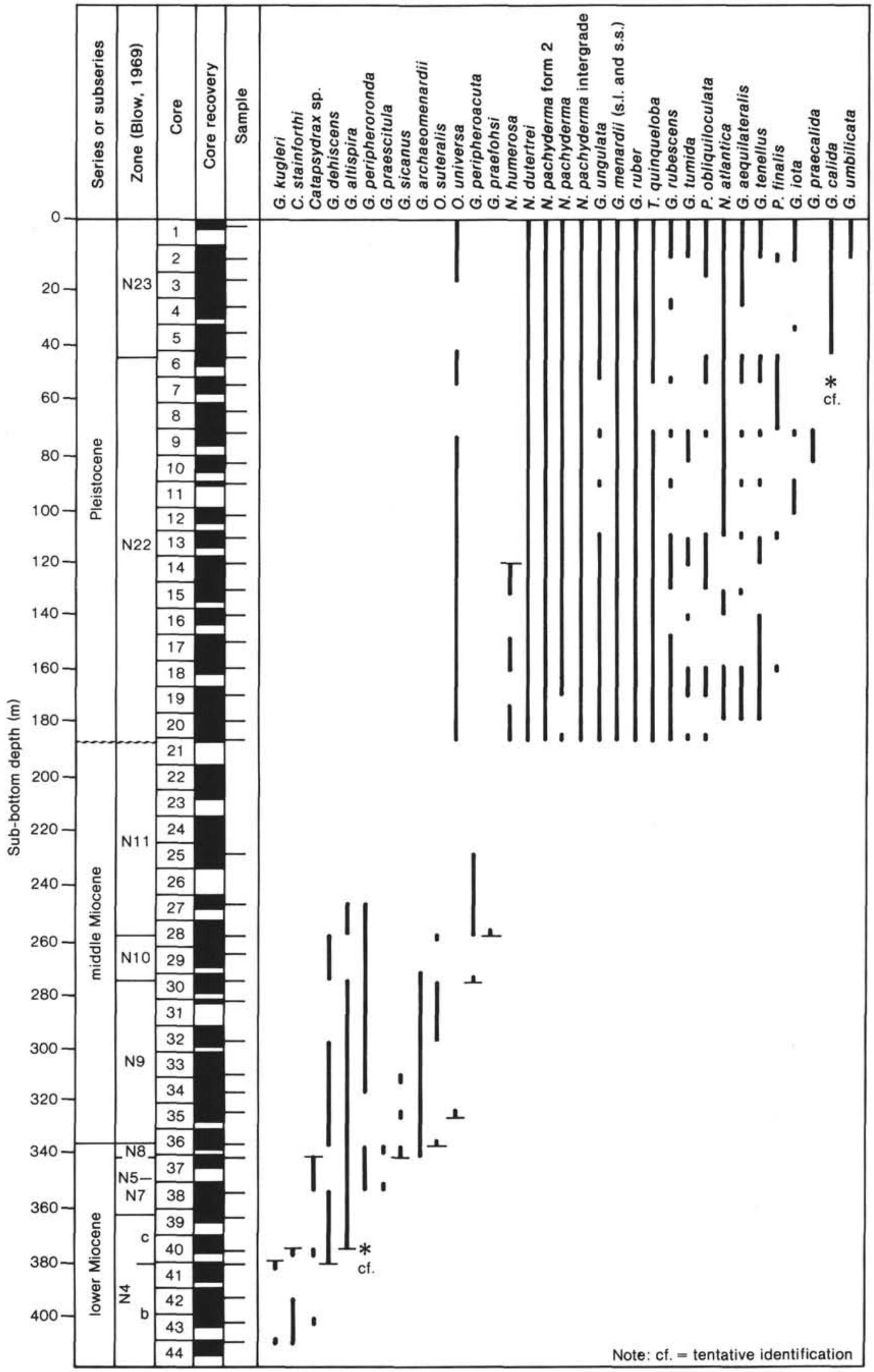

Figure 6. Range chart of selected planktonic foraminifers from Hole 568.

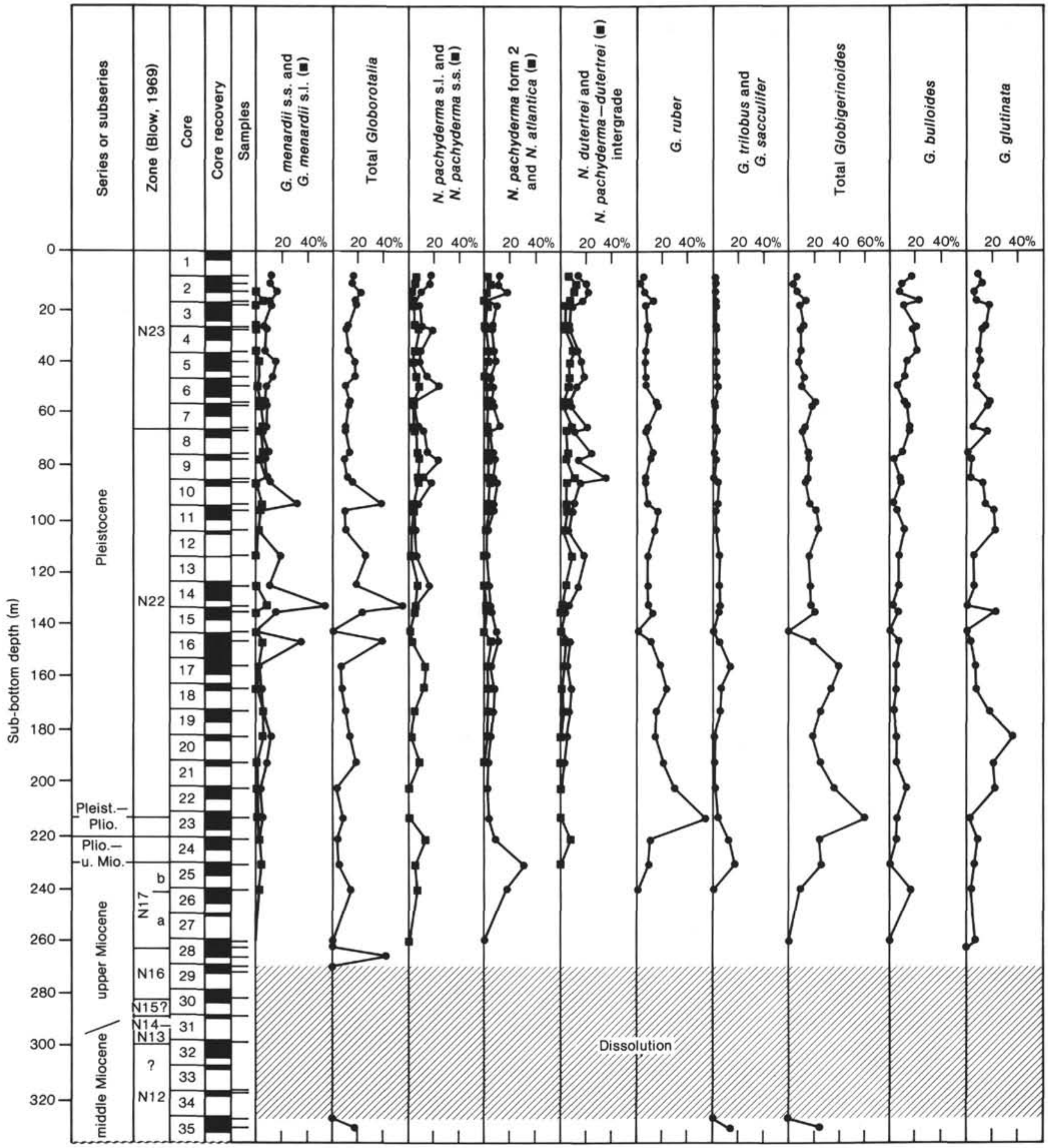

Figure 7. Relative abundances of selected Neogene planktonic foraminifers from Hole 570.

ternary time intervals. Only tenuous correlations can be made with widespread deep-sea hiatuses. For instance, the early Miocene NH1a and NH1b hiatuses are often represented by one major hiatus and/or calcium carbonate dissolution (Keller and Barron, 1983). Because carbonate dissolution is often severe, stratigraphic resolution is insufficient to identify this hiatus, as is the case at sites of Legs 84 and 67. However, this oceanic event may be represented by the severely reduced sedimentation rates (Zones N5 to N8, 16–19 Ma) at sites of Legs 84 and 67. It is also possible that the Miocene/Pliocene boundary erosion at Sites 567 and 570 could be associated with the NH7 hiatus; but the stratigraphic resolution at this interval is poor. Stratigraphic resolution of

Table 6. Estimated abundances of planktonic foraminifers from Hole 569.

Sample (interval in cm)	*Catapsydrax dissimilis ciperoensis*	*C. dissimilis dissimilis*	*C. stainforthi*	*C.* sp.	*C. unicavus primitivus*	*C. unicavus unicavus*	*Globigerina angustiumbilicatus*	*G. bulloides*	*G. calida*	*G. ciperoensis*	*G. eocaena*	*G. euapertura*	*G. falconensis*	*G. foliata*	*G. obesa*	*G. praebulloides praebulloides*	*G. praedigitata*	*G. pseudobesa*	*G. pseudociperoensis*	*G. quadrilatera*	*G. rubescens*	*G.* sp.	*G. umbilicata*
1-1, 91-95								C	F				F							R	R		R
2-3, 62-66								F	R				F					R		F		R	
3-3, 40-44								C	R				F					R		F			R
4-5, 30-34								C	R				F				R	F		F	R		
5-3, 21-25								F					R	R						F	R	R	
6-5, 20-24													R					F			F		R cf.
7-1, 20-24								F					R										
7-3, 20-24								F						R						R			
8-1, 18-22								R												R		R	
10-1, 11-15																R							
11-1, 30-34				R*						R						R			R				
12-1, 20-24																R							
13-2, 6-10				R						R cf.						F						R	
14-2, 53-57	R	R	R	F		R				R						R							
15-3, 104-108	R	R		R			R			R	R				R	F							
16,CC			R	R		R				R						R							
17-3, 87-91	R	R														R							
18-3, 38-42																						R	
19-1, 14-16			R	R						R						R							
20-1, 69-73	R	R	R	F						R			R			R							
21-1, 20-24										R						R							
22-1, 84-88	R	R			R											R						R	
23-1, 25-29					R cf.					R						R							
24-1, 30-34				R						R						R							
26-3, 65-69				R						R		R				R						R	
27-1, 16-22	R		R	R			R									R							

Note: A = abundant; C = common; F = few; R = rare. * = reworked; cf. = tentative identification.

middle and upper Miocene sediments of Sites 570 and 495 is also poor, and does not allow identification of short sediment gaps (Fig. 9).

Local tectonism is probably responsible for the major Neogene unconformity which spans from 2-2.5 Ma to about 15-16 Ma at most sites (Fig. 9). A major tectonic episode is reflected by volcanic activity that spanned the Pliocene and Pleistocene and reached a maximum between 2 and 1 Ma ago (Cadet et al., 1982). This volcanic activity correlates well with erosion at all sites landward from the trench, except Site 567 (poor resolution) and Site 565 (Fig. 9), and suggests that a major tectonic uplift occurred at this time. Uplift during the late Pliocene and Pleistocene is also indicated by a progressive shallowing in benthic foraminifers at this time (McDougall, this volume). Another significant, although less severe, period of volcanism occurred between 14 and 16 Ma ago (Cadet et al., 1982), and may correlate with an early episode of erosion (Fig. 9).

The Paleogene record recovered is very sparse and fragmentary. In Hole 569A, uppermost Oligocene (25 Ma) sediments overlie undivided uppermost Eocene and lower Oligocene sediments, which in turn overlie lower and middle Eocene sediments. At Site 570, middle Miocene sediments overlie lower Eocene deposits, and in Hole 567A, lower Miocene deposits overlie Upper Cretaceous deposits. Without a more complete Paleogene stratigraphic sequence in this region, it is not possible to infer the depositional history of these deposits.

Despite the fragmentary nature of the depositional record, the lithologic or age sequences are not repeated or reversed, and evidence of imbrication of oceanic rocks is lacking. There is, however, ample indication of downslope transport and reworking of older sediments into younger deposits. Thus, our results support the suggestion that the trench-slope accretionary model of Seely et al. (1974) does not apply to this segment of the trench.

SUMMARY OF DEPOSITIONAL HISTORY

The Neogene depositional history of the Middle America region can be summarized as follows. Early Miocene sedimentation began on basement rocks at Sites 495, 499, and 500, and upon major unconformities at Sites 567 and 569 (Hole 569A). And normal hemipelagic sedimentation proceeded during a tectonically stable period through most of the early Miocene, with increased carbonate dissolution (associated with polar cooling), resulting in condensed sedimentation and possible hiatus-

Table 6. (Continued).

G. woodi	*Globigerinella aequilateralis*	*Globigerinita glutinata*	*G. iota*	*G. uvula*	*Globigerinoides altiaperturus*	*G. bollii*	*G. bulloideus*	*G. conglobatus*	*G. obliquus extremus*	*G. obliquus obliquus*	*G. parawoodi*	*G. primordius*	*G. quadrilobatus*	*G. ruber pyramidalis*	*G. ruber ruber*	*G. sacculifer irregularis*	*G. sacculifer sacculifer*	*G.* sp.	*G. subquadratus*	*G. tenellus*	*G. trilobus bullatus*	*G. trilobus immaturus*	*G. trilobus trilobus*	*Globoquadrina altispira altispira*	*G. altispira globosa*
R	R	F	R	R		R		R	R				F	R	C		F			R			R		
	R	F		R				R					C		C		C			R			F		
	R	C		R		R							F		C		F			R			R		
R	R	C		R									F		C		F			R			R		
R	R	C		R				R					C		C		F			R			F		
R	F	C		R				R					A		C		C			R			F		
R	R	C		R									R		C		F						F		
F	R	C		R									F	R	C		R						F		
F		F								F			F		F		R						F	F	
							R																R	R	
							R			R							R						R		
																			R						
R		R		R	R		R				R						F	R	F		R		F	F	
R				R	R	R					R					R	R		R			R	F	F	
R				R		R					R	R				R			R		R	R	F	F	
					R						R	R				R			R				R	R	
R				R	R						R	R				R	F		R		R	R	F	R	
											R												R		
R				R							R					R		R					R		R
F				R		R					R	R				R	R		R				F	R cf.	R
R	R				R																		R		
																									R cf.

es between 20 and 17 Ma. Moderate volcanic activity between 16 and 14 Ma may have resulted in uplift and erosion of sediments on the Middle America slope. Sedimentation continued at Site 495, seaward of the trench, and was interrupted only by intensified oceanic circulation associated with global cooling. The presence of middle and upper Miocene sediments at Site 570 and their absence at other slope sites suggest local ponding of sediments. Major volcanic activity during the Pliocene and Pleistocene, reaching a maximum between 2 and 1 Ma, was accompanied by a tectonically active phase resulting in uplift and erosion of middle Miocene to Pliocene sediments on the Middle America Trench and slope. The late Quaternary appears to have been characterized by quiescent conditions.

TAXONOMIC NOTES

Cassigerinella chipolensis (Cushman and Ponton)
(Plate 12, Fig. 11)

Cassidulina chipolensis Cushman and Ponton, 1932a, p. 98, pl. 15, fig. 2.

Catapsydrax dissimilis ciperoensis (Blow and Banner)
(Plate 12, Fig. 2)

Globigerinita dissimilis ciperoensis Blow and Banner, 1962, p. 107, pl. 14, figs. A–C.

Catapsydrax dissimilis dissimilis (Cushman and Bermudez)
(Plate 12, Fig. 1)

Globigerina dissimilis Cushman and Bermudez, 1937, p. 25, pl. 3, figs. 4–6.

Catapsydrax pera Todd

Globigerina pera Todd, 1957, p. 301, pl. 70, figs. 10–11.

Catapsydrax stainforthi Bolli, Loeblich, and Tappan

Catapsydrax stainforthi Bolli, Loeblich, and Tappan, 1957, p. 36, pl. 7, fig. 11.

Catapsydrax unicavus primitivus (Blow and Banner)

Globigerinita unicava (Bolli, Loeblich, and Tappan) subsp. *primitiva* Blow and Banner, 1962, pp. 114–115, pl. 14, figs. J–L.

Catapsydrax unicavus unicavus Bolli, Loeblich, and Tappan
(Plate 12, Figs. 5, 6)

Catapsydrax unicavus Bolli, Loeblich, and Tappan, 1957, p. 37, pl. 7, fig. 9.

Globigerina angustiumbilicata Bolli
(Plate 9, Figs. 6, 7)

Globigerina ciperoensis angustiumbilicata Bolli, 1957a, p. 109, pl. 22, figs. 12, 13.

Globigerina apertura Cushman
(Plate 9, Figs. 14, 15)

Globigerina apertura Cushman, 1918, p. 57, pl. 12, fig. 8.

Table 6. (Continued).

Sample (interval in cm)	*G. baroemoenensis*	*G. dehiscens*	*G. praedehiscens*	*G.* sp.	*G. venezuelana*	*Globorotalia* cf. *G. acrostoma*	*G. archeomenardii*	*G. bermudezi*	*G. birnageae*	*G. conoidea*	*G. continuosa*	*G. exilis*	*G. kugleri*	*G. mayeri*	*G. menardii* s.l.	*G. menardii* s.s.	*G. minutissima*	*G. peripheroronda*	*G.* cf. *G. pseudokugleri*	*G. scitula*	*G. siakensis* s.l.	*G. siakensis* s.s.	*G. tumida*
1-1, 91–95											R				A	C				R			R
2-3, 62–66								R		R cf.					A	C							F
3-3, 40–44											R				A	F							F
4-5, 30–34										R		R			A	C				C			F
5-3, 21–25															C	C				R			R
6-5, 20–24								R							A	C	R						F
7-1, 20–24											R cf.				C	C				R			F
7-3, 20–24								R							C	F				R			F
8-1, 18–22					R						R	R			F	F				R			R
10-1, 11–15					R						R			R			R	R		R		R	
11-1, 30–34			R		R		R											R		R			
12-1, 20–24					R																		
13-2, 6–10		R			R				R									R					
14-2, 53–57					R									R							F	F	
15-3. 104–108	R	R			R									R								R	
16,CC	R				R									R							R	R	
17-3, 87–91	R				R								R									R	
18-3, 38–42					R																		
19-1, 14–16	R													R									
20-1, 69–73	F				F	R			R		R			R							R		
21-1, 20–24			R		R									R									
22-1, 84–88			R											R							R	R	
23-1, 25–29																							
24-1, 30–34				R										R cf.					R				
26-3, 65–69											R			R			R		R				
27-1, 16–22																					R		

Globigerina bulloides d'Orbigny
(Plate 10, Figs. 3, 4)

Globigerina bulloides d'Orbigny, 1826, p. 277.

***Globigerina calida* Parker**
(Plate 10, Figs. 11, 12)

Globigerina calida Parker, 1962, p. 221, pl. 1, figs. 9–13, 15.

***Globigerina cariacoensis* Rögl and Bolli**

Globigerina megastoma cariacoensis Rögl and Bolli, 1973, p. 564, pl. 2, figs. 1–10, pl. 12, figs. 5, 6; text-fig. 4.

***Globigerina ciperoensis* Bolli**
(Plate 9, Figs. 4, 5)

Globigerina ciperoensis Bolli, 1954, p. 1, figs. 3–6.

***Globigerina connecta* Jenkins**

Globigerina woodi connecta Jenkins, 1964, p. 72, text-fig. 1.

***Globigerina decoraperta* Takayanagi and Saito**
(Plate 9, Figs. 12, 13)

Globigerina druryi decoraperta Takayanagi and Saito, 1962, p. 85, pl. 28, fig. 10.

***Globigerina digitata* Brady**
(Plate 10, Fig. 13)

Globigerina digitata Brady, 1879, p. 286.

***Globigerina druryi* Akers**

Globigerina druryi Akers, 1955, p. 654, pl. 65, fig. 1.

***Globigerina eocaena* Gümbel**

Globigerina eocaena Gümbel, 1868, p. 662, pl. 2, fig. 109.

***Globigerina euapertura* Jenkins**

Globigerina euapertura Jenkins, 1960, p. 351, pl. 1, fig. 8.

***Globigerina falconensis* Blow**
(Plate 10, Figs. 5, 6)

Globigerina falconensis Blow, 1959, p. 177, pl. 9, figs. 40, 41.

***Globigerina foliata* Bolli**

Globigerina foliata Bolli, 1957a, p. 111, pl. 24, figs. 1a–c.

***Globigerina incisa* (Brönnimann and Resig)**
(Plate 9, Figs. 8, 9)

Globorotalia (Turborotalia) incisa Brönnimann and Resig, 1971, pp. 1278–1279, pl. 45, figs. 5, 7; pl. 46, figs. 1–8.

***Globigerina linaperta* Finlay**

Globigerina linaperta Finlay, 1939a, p. 125, pl. 13, figs. 54–57.

***Globigerina nitida* Martin**

Globigerina nitida Martin, 1943, p. 115, pl. 7, figs. 1a–c.

Table 6. (Continued).

G. ungulata	*G. wilesi*	*G. zealandica incognita*	*G. zealandica zealandica*	*Globorotaloides hexagona*	*G. suteri*	*Hastigerinopsis riedeli*	*Neogloboquadrina acostaensis*	*N. atlantica*	*N. dutertrei*	*N. humerosa*	*N. pachyderma*	*N. pachyderma* form 2	*N. pachyderma/dutertrei* intergrade	*Orbulina bilobata*	*O. universa*	*Pulleniatina obliquiloculata*	*P. primalis*	*Sphaeroidinella dehiscens*	*Turborotalita quinqueloba*	Number of specimens	Zone (Blow, 1969)	Series or subseries
F	R			F					A		F	F	C		A	R				A	N23	Pleistocene
F	R			F		R cf.			A		F	F	C	R	A	R			R	A		
R	R			R					A		F	C	C		C				R	A		
R				R		R		C	A	R	C	A	C		C	R			R	A		
R				F				F	A		F	C	C		C	R		R	R	A	N22	
F	R			F			R	F	C	F	F	F	F		C	F	F		R	A		
				R			R	C	F	C	R	F	F		R	C			R	C		
	R			F			R	C	F	C	R	F	C		F	C	F		R	C		
				R			R cf.			F	F	F	F		R		R			F		lower Plio.
																				R	N9	middle Mio.
																				R		
				R																R	N8–N7	lower Miocene
		R	R		R															F		
					R															F	N6–N5	
					R															F		
					R															R		
																				F	N4b–N4c	
																				R		
																				R		
				R																F		
																				R		
																				R	P22–N4a	lower Miocene–upper Oligocene
																				R		
																				R		
																				R		
																				R		

Globigerina nepenthes Todd
(Plate 9, Figs. 10, 11)

Globigerina nepenthes Todd, 1957, p. 301, pl. 78, fig. 7.

Globigerina obesa (Bolli)

Globorotalia obesa Bolli, 1957a, p. 119, pl. 29, figs. 2, 3.

Globigerina praebulloides occlusa Blow and Banner

Globigerina praebulloides occulusa Blow and Banner, 1962, p. 93, pl. IX, figs. O–W.

Globigerina praebulloides praebulloides Blow
(Plate 9, Figs. 2, 3)

Globigerina praebulloides Blow, 1959, p. 180, pl. 8, fig. 47; pl. 9, fig. 48.

Globigerina praecalida Blow

Globigerina praecalida Blow, 1969, pp. 380–381, pl. 13, figs. 7, 8; pl. 14, fig. 3.

Globigerina praedigitata Parker

Globigerina praedigitata Parker, 1967, p. 151, pl. 19, figs. 5–8.

Globigerina primitiva (Finlay)

Globoquadrina primitiva Finlay, 1947, p. 291, pl. 8, figs. 129–134.

Globigerina pseudobesa (Salvatorini)

Turborotalia pseudobesa Salvatorini, 1967, p. 10, pl. 2, figs. 6–15.

Globigerina pseudociperoensis Blow

Globigerina praebulloides pseudociperoensis Blow, 1969, p. 381, pl. 17, figs. 8, 9.

We follow Poore's (1981) usage of *G. pseudociperoensis* in favor of *G. concinna* Reuss (see Poore, 1981, p. 426 for discussion).

Globigerina pseudodruryi Brönnimann and Resig

Globigerina pseudodruryi Brönnimann and Resig, 1971, p. 1270, pl. 7, figs. 1, 2.

Globigerina quadrilatera Galloway and Wissler
(Plate 10, Figs. 7, 8)

Globigerina quadrilatera Galloway and Wissler, 1927, p. 44, pl. 7, figs. 11a–c.

Globigerina rubescens Hofker

Globigerina rubescens Hofker, 1956, p. 234, pl. 25, figs. 18–21.

Globigerina tripartita Koch

Globigerina bulloides var. *tripartita* Koch, 1926, p. 746, fig. 21.

Globigerina umbilicata Orr and Zaitzeff
(Plate 10, Figs. 9, 10)

Globigerina umbilicata Orr and Zaitzeff, 1971, p. 18, pl. 1, figs. 1–3.

Globigerina woodi Jenkins
(Plate 10, Figs. 1, 2)

Globigerina woodi Jenkins, 1960, p. 352, pl. 2, fig. 2.

Table 7. Estimated abundances of planktonic foraminifers from Hole 569A.

Sample (interval in cm)	*Catapsydrax dissimilis ciperoensis*	*C. dissimilis dissimilis*	*C. pera*	*C.* sp.	*C. stainforthi*	*C. unicavus unicavus*	*Globigerina angustiumbilicata*	*G. ciperoensis*	*G. falconensis*	*G. linaperta*	*G. nitida*	*G. obesa*	*G. ouchitaensis*	*G. praebulloides praebulloides*	*G. primitiva*	*G.* sp.	*G. woodi*	*Globigerinella aequilateralis*	*Globigerinita glutinata* s.l.	*G. uvula*	*Globigerinoides parawoodi*	*G. primordius*	*G. sacculifer irregularis*	*G. sacculifer sacculifer*	*G.* sp.
H1				R	R		R	R	R				R	R		R		R	R	R	R	R	R	R	R
H1, 30-34				R	R			R	R			R		R			R								
6-1, 30-34	R	R			R			F				R		F											
7-1, 30-34			R		R*	R																			
8,CC				R						C					R										
9-1, 18-19										R															
10-1, 0-2										C	F														

Note: C = common; F = few; R = rare; cf. = tentative identification; * = reworked.

***Globigerinella aequilateralis* (Brady)**

Globigerina aequilateralis Brady, 1879, p. 285.

***Globigerinella praesiphonifera* Blow**

Hastigerina (Hastigerina) siphonifera (d'Orbigny) subsp. *praesiphonifera* Blow, 1969, pp. 408-409, pl. 54, figs. 7-9.

***Globigerinita glutinata* (Egger) s.l.**
(Plate 10, Fig. 14)

Globigerina glutinata Egger, 1893, p. 371, pl. 13, figs. 19-21.

No attempt was made to distinguish *Globigerinita glutinata* s.s. from the closely related species *G. ambitacrena* (Loeblich and Tappan), *G. incrusta* Akers, *G. naparimaensis* Brönimann, and *G. juvenilis* Bolli, and they are all recorded under *Globigerinita glutinata* s.l. for this chapter.

***Globigerinita iota* Parker**
(Plate 10, Fig. 16)

Globigerinita iota Parker, 1962, p. 250, pl. 10, figs. 26-30.

***Globigerinita parkerae* Loeblich and Tappan**

Globigerinita parkerae Loeblich and Tappan, 1957, pp. 113, 115, text-fig. 1a-c.

***Globigerinita uvula* (Ehrenberg)**
(Plate 10, Fig. 15)

Pylodexia uvula Ehrenberg, 1861, p. 308.

***Globigerinoides altiapertурus* Bolli**
(Plate 7, Figs. 7, 8)

Globigerinoides triloba (Reuss) subsp. *altiapertura* Bolli, 1957a, p. 113, pl. 25, figs. 7, 8; p. 112, text-fig. 21, nos. 3a, b.

***Globigerinoides bollii* Blow**
(Plate 7, Figs. 15, 16)

Globigerinoides bollii Blow, 1959, p. 189, pl. 10, fig. 65.

***Globigerinoides bulloideus* Crescenti**
(Plate 8, Figs. 9, 10)

Globigerinoides bulloideus Crescenti, 1966, p. 43, text-fig. 8, no. 3; text-fig. 9.

***Globigerinoides conglobatus* (Brady)**

Globigerina conglobata Brady, 1879, p. 286.

***Globigerinoides diminutus* Bolli**

Globigerinoides diminuta Bolli, 1957a, p. 114, pl. 25, figs. 11a-c.

***Globigerinoides kennetti* Keller and Poore**
(Plate 8, Figs. 1, 2)

Globigerinoides kennetti Keller and Poore, 1980, pp. 189-192, pl. 1, figs. 1-10.

In their original description, Keller and Poore (1980) listed *G. kennetti* as occurring in the upper Miocene of the North Atlantic and Pacific Oceans and in the upper Miocene to basal Pliocene of the South Atlantic. We also find *G. kennetti* in the lowermost Pliocene (Hole 565, Zone N18/N19 boundary) in the Pacific Ocean.

***Globigerinoides mitra* Todd**

Globigerinoides mitra Todd, 1957, p. 302, pl. 78, figs. 3, 6.

***Globigerinoides obliquus extremus* Bolli and Bermudez**
(Plate 8, Figs. 5, 6)

Globigerinoides obliquus extremus Bolli and Bermudez, 1965, p. 139, pl. 1, figs. 10-12.

***Globigerinoides obliquus obliquus* Bolli**
(Plate 8, Figs. 3, 4)

Globigerinoides obliqua Bolli, 1957a, p. 113, pl. 25, figs. 9, 10; text-fig. 21, no. 5.

***Globigerinoides parawoodi* Keller**
(Plate 7, Figs. 11, 12)

Globigerinoides parawoodi Keller, 1981a, p. 304, pl. 4, figs. 1-11.

***Globigerinoides primordius* Blow and Banner**
(Plate 7, Figs. 3, 4)

Globerinoides quadrilobatus primordius Blow and Banner, 1962, p. 115, pl. 9, figs. D-F; text-fig. 14, nos. iii-viii.

***Globigerinoides quadrilobatus* (d'Orbigny)**
(Plate 8, Figs. 11, 12)

Globigerina quadrilobata d'Orbigny, 1846, p. 164, pl. 9, figs. 7-10.

Table 7. (Continued).

G. subquadratus	*G. trilobus immaturus*	*G. trilobus trilobus*	*Globoquadrina* cf. *G. altispira altispira*	*G. altispira globosa*	*G.* sp.	*G. tripartita*	*G. venezuelana*	*Globorotalia aragonensis*	*G. broedermanni*	*G. mayeri*	*G.* cf. *G. mendacis*	*G. opima nana*	*G. pentacamerata*	*G. pseudokugleri*	*G. pseudotopilensis*	*G. siakensis* s.l.	*G. siakensis* s.s.	*Globorotaloides suteri*	*Globotruncana* sp.	Number of specimens	Zone (Berggren, 1969; Stainforth et al., 1975)	Subseries
F	R	F		F	R		F			R		R				R	F	R	R*	F	N4	lower Mio.
			R	R	R		R				R	R		R			R			R	N4–P22	lower Mio.–upper Olig.
			F	R		R	F cf.				R	R				R	R	F		F		
						R cf.	R					R						R		R	P16–P19	lower Olig.–upper Eoc.
																				C	P8–P13	middle Eoc.–lower Eoc.
													R							R		
								R	C				C		F					C	P8	lower Eoc.

Table 8. Estimated abundances of Paleogene planktonic foraminifers from Hole 570.

Sample (interval in cm)	*Catapsydrax unicavus unicavus*	*Globigerina linaperta*	*G. nitida*	*G. primitiva*	*Globorotalia aequa*	*G. angulata*	*G. aragonensis*	*G. broedermanni*	*G. compressa*	*G. formosa gracilis*	*G. lensiformis*	*G. pentacamerata*	*G. pseudotopilensis*	*G. pusilla*	*G. similatilis*	*G. soldadoensis*	*G. velascoensis*	*G. wilcoxensis*	*Pseudohastigerina wilcoxensis*	Number of specimens	Zone (Berggren, 1969; Stainforth et al., 1975)	Subseries
36-2, 48–50							R	R				R				R				R	P8–P9	
37-1, 28–30		R	R		C	F*	R	C	R*	C	R	R	R	R*	R	F		R	R	C	P6–P7	lower Eocene
37-1, 88–90						R														R	P6	
37-1, 126–128	R			R	R												R			R		
38,CC												R								R	P5–P6	

Note: C = common; F = few; R = rare. * = reworked.

Globigerinoides ruber pyramidalis (Broeck, van den)

Globigerina bulloides d'Orbigny var. *rubra* d'Orbigny subvar. *pyramidalis* van den Broeck, 1876, p. 127, pl. 3, figs. 9, 10.

Globigerinoides ruber ruber (d'Orbigny)
(Plate 8, Figs. 7, 8, 13, 14)

Globigerina rubra d'Orbigny, 1839a, p. 82, pl. 4, figs. 12–14.

No attempt was made to distinguish *G. elongata* (d'Orbigny) or *G. cyclostomas* (Galloway and Wissler) from *G. ruber ruber* for this chapter.

Globigerinoides sacculifer irregularis LeRoy
(Plate 7, Figs. 9, 10)

Globigerinoides sacculiferus (Brady) var. *irregularis* LeRoy, 1944, p. 40, pl. 3, figs. 42, 43; pl. 6, figs. 45–46.

Globigerinoides sacculifer sacculifer (Brady)
(Plate 9, Fig. 1)

Globigerina sacculifer Brady, 1877, p. 535.

Globigerinoides sicanus de Stefani
(Plate 7, Figs. 13, 14)

Globigerinoides sicana de Stefani, 1952, note 4, p. 9 (type figure designated as *Globigerinoides conglobata* of Cushman and Stainforth, 1945, p. 68, pl. 13, fig. 6).

Globigerinoides subquadratus Brönnimann
(Plate 7, Figs. 5, 6)

Globigerinoides subquadrata Brönnimann, 1954, *in* Todd et al., 1954, p. 680, pl. 1, figs. 5, 8.

Globigerinoides tenellus Parker

Globigerinoides tenellus Parker, 1958, p. 280, pl. 6, figs. 7–11.

Globigerinoides transitoria Blow

Globigerinoides transitoria Blow, 1956, p. 65, text-fig. 2, nos. 12–15.

Globigerinoides trilobus bullatus Chang

Globigerinoides trilobus (Reuss) subsp. *bullatus* Chang, 1962, pp. 110–111.

Table 9. Percentage abundances of Neogene planktonic foraminifers from Hole 570.

Sample (interval in cm)	*Catapsydrax dissimilis ciperoensis*	*Globigerina angustiumbilicata*	*G. apertura*	*G. bulloides*	*G. calida*	*G. cariacoensis*	*G. decoraperta*	*G. digitata*	*G. druryi*	*G. falconensis*	*G. foliata*	*G. nepenthes*	*G. praebulloides praebulloides*	*G. pseudobesa*	*G. pseudociperoensis*	*G. quadrilatera*	*G. rubescens*	*G.* sp.	*G. umbilicata*	*G. woodi*
1,CC				16	x cf.					3				2			x		x	
2-3, 20–24				10						2				x		2	x			
2-5, 20–25				7	x					6							x		x	
2,CC				23	x					x	x			2		2	x			
3-1, 60–64				10	x					7				x		2	x		x	
3,CC				20						5						2	x			
4-1, 40–44				18	x					5				x		2	x			
4,CC				21	x					3						x	x	2		
5-3, 20–24				13	x			x		2						2		x		
5,CC				11	x					x						x	x			
6-3, 20–24				6	2					4						2		2		
6,CC				12	x					5							2	x		
7-1, 20–24				13	1					4						2	2			x
7,CC				15	x					2						2	x	2		x
8-1, 20–24				14						7				2		x	x			x
8,CC				9						x						x		x		x
9-2, 20–24				3						3	x					3		x		x
9,CC				9						2				x		x				x
10-1, 41–45				8						5				x cf.						x
10,CC				2						x	x			x cf.						x
11-2, 20–24				6						5						x	3	3		
11,CC				12						7				x		2		x		x
12,CC				7				x		5	x			x						
14-2, 138–142				7		x				2				x		3				x
14,CC				2			x cf.			2										
15-2, 90–92				7					x cf.	4				x		3		x		x
15,CC																				
16-3, 104–108				7			x cf.			2	x					x				x
17-3, 56–60				4						2				x		3				x
18-2, 20–24		x		4						x						2				x
19-1, 10–14		x cf.	x	3						x						x				5
20-1, 50–52				5												3		x		x
21-1, 70–74				5					x	2								x		
22-1, 22–26	x*			13						2				x		x				x
23-3, 20–24				5			x			1								x		
24-1, 20–24			x	5			x		x	8		x				x				8
25-1, 20–24									x				3							x
26-1, 14–16				16						6			x		x	x		2		3
28-1, 20–24													(2)							
28-3, 48–52										(2)			(1)					(3)		
28-6, 42–52										4			2					2		
29-1, 20–24																				
29-3, 42–46																				
30-1, 10–14																				
30-3, 10–14															(1)					
31-1, 19–23													(1)		(1)					
32-1, 17–21																				
33,CC				(2)									(1)							
34-1, 121–125																				
35-1, 20–22				(1)									(3)							
35-4, 12–14									2	2			4		3					
35,CC	(2)												(4)	(2)						

Note: x = <2% or present only in ≤149 μm size fraction; ( ) = actual number (<50 specimens in sample); * = reworked; cf. = tentative identification.

Globigerinoides trilobus immaturus **LeRoy**

Globigerinoides sacculiferus (Brady) var. *immatura* LeRoy, 1939, p. 263, pl. 3, figs. 19–21.

Globigerinoides trilobus trilobus **(Reuss)**
(Plate 7, Figs. 1, 2)

Globigerina triloba Reuss, 1850, p. 374, pl. 47, fig. 11.

Globoquadrina altispira altispira **(Cushman and Jarvis)**
(Plate 6, Figs. 4, 8)

Globigerina altispira Cushman and Jarvis, 1936, p. 5, pl. 1, figs. 13, 14.

Globoquadrina altispira globosa **Bolli**

Globoquadrina altispira (Cushman and Jarvis) subsp. *globosa* Bolli, 1957a, p. 111, pl. 24, figs. 9a–c, 10a–c.

Table 9. (Continued).

Globigerinella aequilateralis	*Globigerinita glutinata* s.l.	*G. iota*	*G. uvula*	*Globigerinoides bollii*	*G. bulloideus*	*G. conglobatus*	*G. obliquus extremus*	*G. obliquus obliquus*	*G. quadrilobatus*	*G. ruber ruber*	*G. sacculifer irregularis*	*G. sacculifer sacculifer*	*G.* sp.	*G. subquadratus*	*G. tenellus*	*G. trilobus bullatus*	*G. trilobus trilobus*	*Globoquadrina altispira altispira*	*G. baroemoenensis*	*G. praedehiscens*	*G.* sp.
x	10		x			x		x	x	4		x									
x	13	x	x			x			x	2		x									
x	6	x	x						x	5		x					x				
x	7		x						3	11		x									
x	18	x	x						x	6		x			x						
x	15		x		x	x			2	8		x									
x	13		x		x				x	8		x									
x	11		x	x					x	6		x			x		x				
x	12		x							6		x			x		x				
x	8		x						3	7		x			x		x				
x	8		x	x					x	7		x					2				
x	20		x						5	15		x			x						
x	16		x	x				x	x	16		x									
x	4		x	x		x		x	4	8		x									
x	16		x						x	7		x					2				
x	2		x	x	x				x	12		x					x				
x	5		x						4	10		2									
	3		x	x	2				4	6		x					2				
	13		x	x					3	6		x					3				
	15		x	x					6	8		x					2				
x	21		x		2	x				16		x					2				
x	22		x	2	2	x			3	14		x					2				
	6		x						3	8		3					2				
x	7		x	x				x	4	8		2	x				2				
	x			x					3	9		x					5				
x	23		x	x					6	12		2					x				
x	3		x	x	x cf.				x	11		x					4				
x	7		x	x		x			7	19		4					9				
x	8		x					x	3	23		4	x				x				
x	17		x	x		x		x	3	15		2					3				
x	36		x			x			3	15		x									
	21			x			x		2	21		2									
x	22		x	2		x		x	3	30		x									
	2			2				x		55							3				
	8				x		2	2		9		x					10				
	5			x				2		8							15				2
	2			x	3			3								x	x				
	(2)											(1)						(2)			
	(3)					(1)		(1)									(1)				
	6																				
	(1)																(1)				
	(2)		(1)				(1)	(2)													
(1)																					
	(1)			(1)				(1)					(1)								
								(2)													
			(1)		(1)						(1)							(1)			
				x	3							x		5		x	11	23	4	x	
													(1)	(2)			(1)				

***Globoquadrina baroemoenensis* (LeRoy)**
(Plate 6, Figs. 9, 10)

Globigerina baroemoenensis LeRoy, 1939, p. 263, pl. 6, figs. 1, 2.

***Globoquadrina conglomerata* (Schwagger)**
(Plate 6, Figs. 13–15)

Globigerina conglomerata Schwagger, 1866, p. 255, pl. 7, fig. 113.

***Globoquadrina dehiscens* (Chapman, Parr, and Collins)**
(Plate 6, Figs. 11, 12)

Globorotalia dehiscens Chapman, Parr, and Collins, 1934, p. 569, pl. 11, fig. 6.

***Globoquadrina praedehiscens* Blow and Banner**

Globoquadrina dehiscens praedehiscens Blow and Banner, 1962, p. 116, pl. 15, figs. Q–S.

Table 9. (Continued).

Sample (interval in cm)	*G. venezuelana*	*Globorotalia bermudezi*	*G. continuosa*	*G. crassula crassula*	*G. exilis*	*G. fohsi fohsi*	*G. menardii* s.l.	*G. menardii* s.s.	*G. minutissima*	*G. plesiotumida*	*G. praefohsi*	*G. praemenardii*	*G. peripheroacuta*	*G. scitula*	*G. siakensis* s.l.	*G. tumida*	*G. ungulata*	*Globorotaloides hexagona*	*Hastigerinella riedeli*	*Neogloboquadrina acostaensis*
1,CC			x cf.				12	x						x		x	x	x		
2-3, 20–24							11	x	x					x		x	x	x		
2-5, 20–25							17							x		3	2	x		
2,CC			x cf.				6	6						x		x	4	x		
3-1, 60–64							12		x					x		2	3	x	x	
3,CC					x		5	2	x					x			3	2	x	
4-1, 40–44							7	1	x					x		x	x	2		
4,CC					x		7	x						x		x	2	x		
5-3, 20–24					x		14	2	x					x		x	x	2		
5,CC				x	x		11	3	x							x	2	2		
6-3, 20–24							7	x						x		x	x	2		
6,CC			3 cf.		x		3	4						x			x	x		
7-1, 20–24			x cf.				5	4						x			x	2		
7,CC							2	6						x			2	x		
8-1, 20–24			x cf.					5	x					x			x	3		2 cf.
8,CC			x cf.		x		4	6								x	x	2		
9-2, 20–24							4	3	x					x		x		2	x	
9,CC					x		x	9	x					x		x	x			
10-1, 41–45		x	x cf.				11							x		2	x	2		
10,CC							28	5								6	x	x		
11-2, 20–24			2 cf.		x			3	x					x		x	2	x		
11,CC			x cf.		x			2	2 cf.					x		x	x	x		
12,CC							19									5	2	x		
14-2, 138–142							10		x					x		4	3	2		
14,CC							46	9						x		x	x	2		
15-2, 90–92			2 cf.				15		x cf.							x	2	x		
15,CC							(6)									(2)				
16-3, 104–108							32	5						x		x	x	x		
17-3, 56–60			x cf.					2	x					2		x		x		3
18-2, 20–24			x					4						x		x		x		6
19-1, 10–14			x					5	2					x		2		x		6
20-1, 50–52			x				6	6	x							2		x		x
21-1, 70–74		x	x				8							x		7		2		
22-1, 22–26			x cf.				x	x								x		3		x
23-3, 20–24			3 cf.				2									3				3
24-1, 20–24			x					2	x	x								x		x
25-1, 20–24								4		x cf.								x		2
26-1, 14–16	x		14					x										x		9
28-1, 20–24	(3)							(3)		(1 cf.)				(1)						(4)
28-3, 48–52			(1)											(2)						(22)
28-6, 42–52			42															2		28
29-1, 20–24														(1)						(1)
29-3, 42–46			(1)																	
30-1, 10–14			(1)																	
30-3, 10–14	(1 cf.)		(8)					(17)												(2)
31-1, 19–23			(1)											(2)				(1)		
32-1, 17–21								(1)							(2)					
33,CC												(1)						(3)		
34-1, 121–125																				
35-1, 20–22			(2)															(1)		
35-4, 12–14	8		2			5					2		7					2		
35,CC															(5)					

Globoquadrina venezuelana (Hedberg)
(Plate 6, Figs. 5–7)

Globigerina venezuelana Hedberg, 1937, p. 681, pl. 92, fig. 7.

Globorotalia aequa Cushman and Renz

Globorotalia crassata var. *aequa* Cushman and Renz, 1942, p. 12, pl. 3, figs. 3a–c.

Globorotalia acrostoma Wezel

Globorotalia acrostoma Wezel, 1966, p. 1298, pl. 101, figs. 1–12; text-fig. 1.

Globorotalia anfracta Parker

Globorotalia anfracta Parker, 1967, p. 175, pl. 28, figs. 3–8.

The single specimen tentatively assigned to this species occurs in the lower Miocene (Zones N5–N6) of Hole 567A. The specimen has

Table 9. (Continued).

N. atlantica	*N. dutertrei*	*N. humerosa*	*N. pachyderma*	*N. pachyderma* form 2	*N. pachyderma/dutertrei* intergrade	*Orbulina suturalis*	*O. universa*	*Pulleniatina finalis*	*P. obliquiloculata*	*P. primalis*	*Sphaeroidinella dehiscens*	*Sphaeroidinellopsis subdehiscens*	*Turborotalita humilis*	*T. quinqueloba*	Non-identifiable	Number of specimens	Zone (Blow, 1969)	Series or subseries
2	7		16	10	7		x		x					x	x	367		
5	8		16	6	14		x							x	2	369		
x	11		8	16	11		x		x					x	3	290		
	11		6	3	7		x		x					x	2	313		
2	4		9	8	5		x	x	x					x	2	343		
	4		10	6	4		x		2					x	3	313		
2	4		20	4	4		x	x	2				x	x	3	332		
4	4		9	4	11		x		x					x	2	336	N23	
2	9		9	8	8		x		2					x	2	303		
x	11		15	4	8		2		x					x	2	321		
2	6		26	6	7		x		x					x	3	312		
2	6		3	5	2		x		x		x			x	3	324		
3	7		4	5	3		x		x					x	x	300		
2	12		7	11	11		x		x					x	2	313		
3	5		12	2	5		x		x					2	3	305		
3	20		15	4	6		3							x	x	345		
3	9		25	6	5		3		x					x	3	298		Pleistocene
3	25		11	4	11		x							x	2	300		
5	10		17	5	5		x		x					x	x	302		
2	5		4	6	5		x		x					x	x	316		
4	5	x	3	3	5		2	x	x					x	4	293		
x	5		4	1	3		x	x	x					x	5	323		
	10	x	6	2	10		5		x					x	x	294		
	10	x	17	4	4		5		x					x	2	358		
2	6		5	3	x	x	x		x						x	333	N22	
2	3	x	4	4			x		x					x	3	324		
															x	11		
5	4	x	2	6	4		x		2		x			x	4	313		
2	3	x	13	3	2		5		x					x	2	297		
3	7	3	11	5	2		x	x	4					x	3	311		
x	5	4	3	7	2		x		2					x	5	316		
3	4	6	x	3	x				x					x	2	288		
	3	3	9	3			2		5					x	5	314		
	x	7		2		x	x		3		x				4	315		
		4	x	4	x	x	x	x	2					x	3	288		Pleisto.-Plio.
		3	13	8	9					5	x				6	326		Plio.-upper Mio.
		2	4	32						4					10	93	b	
		4	6	16						2		x			6	245	N17	
							(1)								(1)	21		
			(1)													38	a	
		2 cf.													12	50		upper Miocene
															(1)	3		
																3	N16	
																1		
		(2 cf.)														37		
															(2)	9	N15?	
																2	N14-N13	
																11		
															(1)	3	?	middle Miocene
																11		
						6						x			7	150	N12	
																17		

a rounded periphery, four chambers in the final whorl, and slightly curved sutures. Because *Globorotalia anfracta* is not found in sediments older than Zone N18, this occurrence is considered downhole contamination. The rounded periphery excludes possible designation as either *G. baurensis* Quilty, 1976 or *G. galapagosensis* Quilty, 1978.

Globorotalia angulata (White)

Globigerina angulata White, 1928, p. 191, pl. 27, figs. 13a–c.

Globorotalia aragonensis Nuttall

Globorotalia aragonensis Nuttall, 1930, p. 288, pl. 24, figs. 6–8, 10, 11.

Globorotalia archeomenardii Bolli

(Plate 2, Figs. 4, 8, 12)

Globorotalia archeomenardii Bolli, 1957a, p. 119, pl. 28, figs. 11a–c.

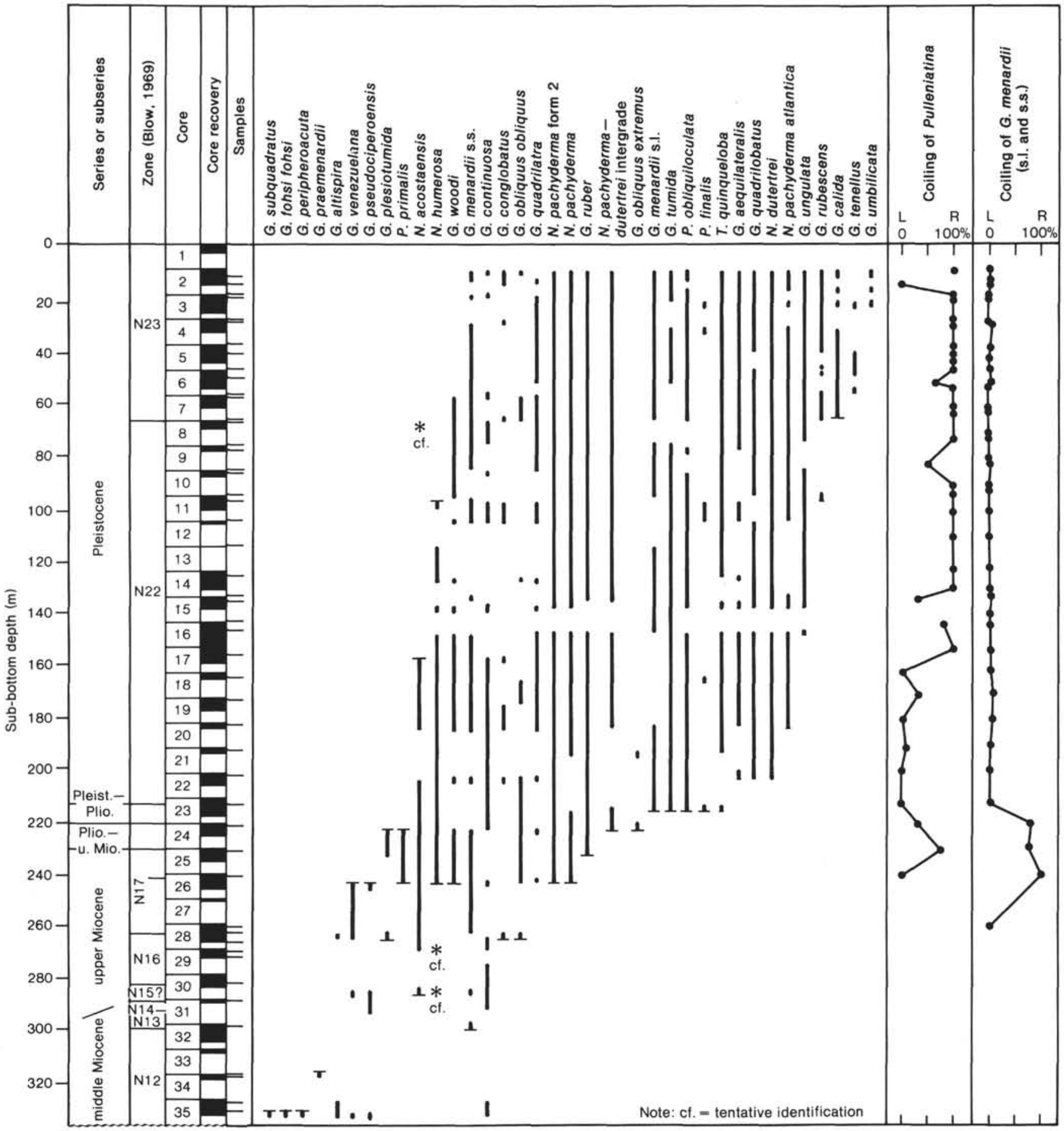

Figure 8. Range chart of selected Neogene planktonic foraminifers from Hole 570.

***Globorotalia bermudezi* Rögl and Bolli**
(Plate 4, Figs. 12, 16)

Globorotalia bermudezi Rögl and Bolli, 1973, p. 567, pl. 6, figs. 16–20; pl. 16, figs. 1, 2; text-fig. 6.

***Globorotalia birnageae* Blow**
(Plate 1, Figs. 8, 12, 16)

Globorotalia birnageae Blow, 1959, p. 210, pl. 17, fig. 108.

***Globorotalia broedermanni* Cushman and Bermudez**

Globorotalia broedermanni Cushman and Bermudez, 1949, p. 40, pl. 7, figs. 22–24.

***Globorotalia cibaoensis* Bermudez**

Globorotalia cibaoensis Bermudez, 1949, p. 285, pl. 22, figs. 21–23.

***Globorotalia compressa* (Plummer)**

Globorotalia compressa Plummer, 1926, p. 135, pl. VIII, figs. 11a–c.

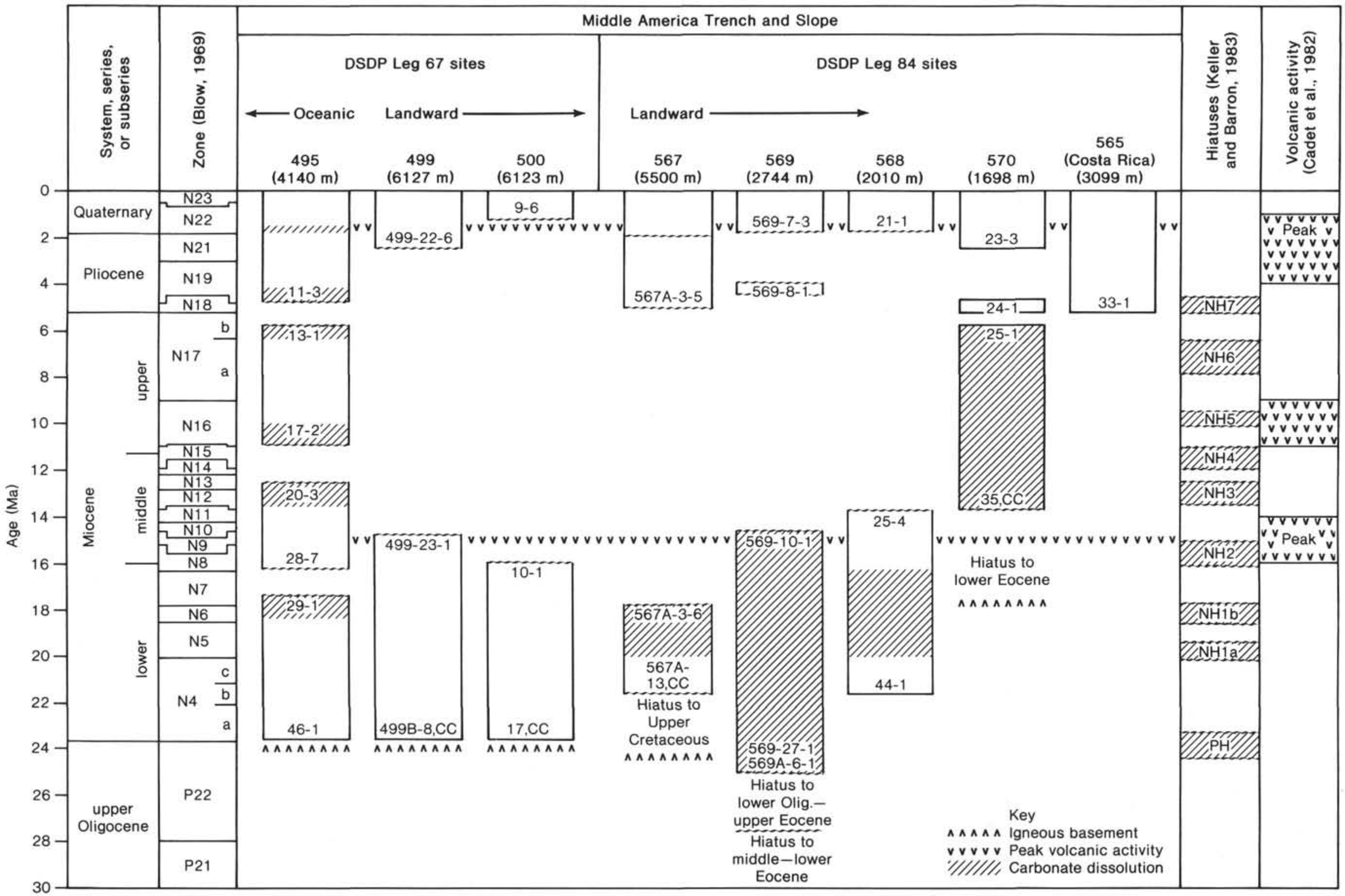

Figure 9. Stratigraphic sequences of DSDP Leg 84 and selected Leg 67 sites, Middle America Trench, showing intervals of carbonate dissolution, local volcanic activity, and hiatuses.

Globorotalia conoidea Walters

Globorotalia miozea conoidea Walters, 1965, p. 124, text-figs. 8I–M.

Globorotalia conomiozea Kennett

Globorotalia conomiozea Kennett, 1966, p. 235, pl. 1, figs. 8–18; pl. 2, figs. 6–13; text-fig. 10.

Globorotalia continuosa Blow
(Plate 3, Figs. 5–7)

Globorotalia opima continuosa Blow, 1959, p. 218, pl. 19, fig. 125.

Globorotalia crassaformis (Galloway and Wissler)

Globigerina crassaformis Galloway and Wissler, 1927, p. 41, pl. 7, fig. 12.

Globorotalia crassula Cushman and Stewart

Globorotalia crassula Cushman and Stewart, 1930, *in* Cushman et al., 1930, p. 77, pl. 7, fig. 1.

Globorotalia exilis Blow
(Plate 4, Figs. 13–15)

Globorotalia (Globorotalia) cultrata (d'Orbigny) subsp. *exilis* Blow, 1969, pp. 396–397, pl. 7, figs. 1–3; pl. 42, figs. 1, 5.

Globorotalia fimbriata (Brady)

Pulvinulina menardii d'Orbigny var. *fimbriata* Brady, 1884, p. 691, pl. 103, fig. 3.

Globorotalia fohsi fohsi Cushman and Ellisor
(Plate 2, Fig. 16; Plate 3, Figs. 1–3)

Globorotalia fohsi Cushman and Ellisor, 1939, p. 12, pl. 2, figs. 6a–c.

Globorotalia formosa gracilis Bolli

Globorotalia formosa gracilis Bolli, 1957c, p. 75, pl. 18, figs. 4–6.

Globorotalia inflata (d'Orbigny)

Globigerina inflata d'Orbigny, 1839b, p. 134, pl. 2, figs. 7–9.

Globorotalia kugleri Bolli
(Plate 1, Figs. 1–4)

Globorotalia kugleri Bolli, 1957a, p. 118, pl. 28, figs. 5, 6.

Globorotalia lensiformis Subbotina

Globorotalia lensiformis Subbotina, 1953, p. 214, pl. 18, figs. 4, 5.

Globorotalia mayeri Cushman and Ellisor

Globorotalia mayeri Cushman and Ellisor, 1939, p. 11, pl. 2, fig. 4.

Globorotalia menardii (Parker, Jones, and Brady)
(Plate 4, Figs. 1–3, 5–7)

Rotalia menardii Parker, Jones, and Brady, 1865, p. 20, pl. 3, fig. 81.

Two forms of *Globorotalia menardii, G. menardii* s.s., and *G. menardii* s.l. were recorded during this study. *G. menardii* s.s. is thin, slightly biconvex, "smooth-walled" in appearance, has five chambers in the final whorl, and has a thin, even keel. Specimens designated as *G. menardii* s.l. are somewhat more biconvex, have a thicker keel, and a more "crystalline" wall structure. *G. menardii* is one of the most common elements of the Pliocene and Pleistocene faunas of DSDP Leg 84. This species first evolved in the late middle Miocene, but did not become common until the Pliocene. Both forms occur together and no apparent differences in distribution were noted.

Globorotalia merotumida Blow and Banner

Globorotalia merotumida Blow and Banner, 1965, *in* Banner and Blow, 1965, p. 1352, fig. 1.

Globorotalia minutissima Bolli
(Plate 3, Figs. 4, 8)

Globorotalia minutissima Bolli, 1957a, p. 119, pl. 29, fig. 1.

Globorotalia miozea Finlay

Globorotalia miozea Finlay, 1939b, p. 326, pl. 29, figs. 159–161.

Globorotalia multicamerata Cushman and Jarvis

Globorotalia menardii (d'Orbigny) var. *multicamerata* Cushman and Jarvis, 1930, p. 367, pl. 34, figs. 8a–c.

Globorotalia opima nana Bolli
(Plate 1, Figs. 5–7)

Globorotalia opima nana Bolli, 1957a, p. 118, pl. 28, fig. 3.

Globorotalia pentacamerata Subbotina

Globorotalia pentacamerata Subbotina, 1947, pp. 128–129, pl. 7, figs. 12–17; pl. 9, figs. 24–26.

Globorotalia peripheroacuta Blow and Banner
(Plate 2, Figs. 5–7, 9–11)

Globorotalia (Turborotalia) peripheroacuta Blow and Banner, 1966, p. 294, pl. 1, figs. 2a–c.

Globorotalia peripheroronda Blow and Banner
(Plate 2, Figs. 1–3)

Globorotalia peripheroronda Blow and Banner, 1966, p. 294, pl. 1, fig. 1; pl. 2, figs. 1–3.

Globorotalia plesiotumida Blow and Banner

Globorotalia tumida plesiotumida Blow and Banner, 1965, *in* Banner and Blow, 1965, p. 1353, text-figs. 2a–c.

Globorotalia praefohsi Blow and Banner
(Plate 2, Figs. 13–15)

Globorotalia (Globorotalia) praefohsi Blow and Banner, 1966, p. 295, pl. 1, figs. 3, 4; pl. 2, figs. 6, 7, 10, 11.

Globorotalia praemenardii Cushman and Stainforth

Globorotalia praemenardii Cushman and Stainforth, 1945, p. 70, pl. 13, fig. 14.

Globorotalia praescitula Blow

Globorotalia scitula praescitula Blow, 1959, p. 221, pl. 19, fig. 128.

Globorotalia pseudokugleri Blow

Globorotalia pseudokugleri Blow, 1969, p. 391 (type figure designated as *Globorotalia* cf. *G. kugleri* of Bolli, 1957a, pl. 28, fig. 7).

Globorotalia pseudotopilensis (Subbotina)

Acarinina pseudotopilensis Subbotina, 1953, p. 227, pl. 27, figs. 8, 9; pl. 22, figs. 1–3.

Globorotalia puncticulata (Deshayes)
(Plate 4, Figs. 4, 8)

Globigerina puncticulata Deshayes, 1832, p. 170.

Globorotalia pusilla Bolli

Globorotalia pusilla pusilla Bolli, 1957b, p. 78, pl. 20, figs. 8–10.

Globorotalia scitula (Brady)
(Plate 3, Figs. 12, 13, 17)

Pulvinulina scitula Brady, 1882, p. 716.

***Globorotalia siakensis* (LeRoy)**
(Plate 1, Figs. 9–11, 13–15)

Globigerina siakensis LeRoy, 1939, p. 262, pl. 4, figs. 20–22.

Two forms of *Globorotalia siakensis, G. siakensis* s.s., and *G. siakensis* s.l. were identified for this report. *G. siakensis* s.s. has a rounded periphery, flat dorsal and convex ventral side, 5 to 6 chambers in the final whorl, radial depressed sutures, and an umbilical-extraumbilical aperture with a lip. Specimens with identical characteristics except only 4 to 4½ chambers in the final whorl were designated as *G. siakensis* s.l. These forms commonly occur together, and no apparent differences in distribution were detected.

***Globorotalia simulatilis* (Schwagger)**

Discorbina simulatilis Schwagger, 1883, p. 120, pl. 29, fig. 15.

***Globorotalia soldadoensis* (Brönnimann)**

Globigerina soldadoensis Brönnimann, 1952, p. 9, pl. 9, figs. 1–9.

***Globorotalia subscitula* Conato**

Globorotalia scitula subscitula Conato, 1964, p. 290, pl. 2, fig. 16.

***Globorotalia suterae* Catalano and Sprovieri**
(Plate 3, Figs. 9–11)

Globorotalia suterae Catalano and Sprovieri, 1971, p. 241, pl. 1, figs. 1, 2; text-fig. 18.

***Globorotalia tumida* Brady**
(Plate 4, Figs. 9–11)

Pulvinulina menardii var. *tumida* Brady, 1877, p. 535.

***Globorotalia ungulata* Bermudez**
(Plate 5, Figs. 1, 2)

Globorotalia ungulata Bermudez, 1961, p. 1304, pl. 15, figs. 6a, b.

***Globorotalia velascoensis* (Cushman)**

Pulvinulina velascoensis Cushman, 1925, p. 19, pl. 3, figs. 5a–c.

***Globorotalia wilcoxensis* Cushman and Ponton**

Globorotalia wilcoxensis Cushman and Ponton, 1932b, p. 71, pl. 9, figs. 10a–c.

***Globorotalia wilesi* Thompson**

Globorotalia wilesi Thompson, 1980, p. 785, pl. 4, figs. 1–3.

***Globorotalia zealandica incognita* Walters**

Globorotalia zealandica incognita Walters, 1965, p. 120, text-figs. 6a–j.

***Globorotalia zealandica* Hornibrook**

Globorotalia zealandica Hornibrook, 1958, p. 667, figs. 18, 19, 30.

***Globorotaloides hexagona* (Natland)**
(Plate 11, Figs. 5–8)

Globigerina hexagona Natland, 1938, p. 149, pl. 7, fig. 1.

In Leg 84 holes, *G. hexagona* ranges from lower Miocene (Zones N5–N6) to Pleistocene (Zone N23). The Miocene specimens (Plate 11, Figs. 7, 8) exhibit typical characteristics of *G. hexagona:* coarse reticulate surface texture; low trochospiral, almost planispiral coiling; chambers increasing rapidly in size; radial sutures; umbilical (sometimes umbilical-extraumbilical) aperture with apertural teeth sometimes developed. They are therefore not referable to *G. variabilis* Bolli 1957a.

***Globorotaloides suteri* Bolli**

Globorotaloides suteri Bolli, 1957a, p. 117, pl. 27, figs. 9–13.

***Globotruncana arca* (Cushman)**

Pulvinulina arca Cushman, 1926, p. 23, pl. 3, fig. 1.

***Globotruncana fornicata* Plummer**

Globotruncana fornicata Plummer, 1931, p. 198, pl. 13, figs. 4–6.

***Globotruncana mariei* Banner and Blow**

Globotruncana mariei Banner and Blow, 1960, p. 8.

***Globotruncana petaloidea* Gandolfi**

Globotruncana (Rugoglobigerina) petaloidea Gandolfi, 1955, p. 52, pl. 3, fig. 13.

***Hastigerina pelagica* (d'Orbigny)**

Nonionina pelagica d'Orbigny, 1839a, p. 27, pl. 3, figs. 13, 14.

***Hastigerinella bermudezi* Bolli**

Hastigerinella bermudezi Bolli, 1957a, p. 112, pl. 25, figs. 1a–c.

***Hastigerinopsis riedeli* (Rögl and Bolli)**
(Plate 12, Fig. 12)

Hastigerinella riedeli Rögl and Bolli, 1973, p. 567, text-fig. 5; pl. 4, fig. 1.

Poore (1979) noted that this minute, yet distinctive species appears to be restricted to the Quaternary. Our findings on DSDP Leg 84 support this observation and extend the geographic distribution of *H. riedeli* to the Pacific Ocean, in addition to its known occurrence in the Caribbean (DSDP Leg 15) and North Atlantic (DSDP Leg 49). Although this species is usually rare, it does have potential as a secondary indicator of the Quaternary.

***Heterohelix globulosa* (Ehrenberg)**

Textularia globulosa Ehrenberg, 1838 (1840), p. 135, pl. 4, fig. 4b.

***Heterohelix pulchra* (Brotzen)**

Gumbelina pulchra Brotzen, 1936, p. 121, pl. 9, figs. 2–3.

***Neogloboquadrina acostaensis* (Blow)**
(Plate 5, Figs. 13–15)

Globorotalia acostaensis Blow, 1959, p. 208, pl. 17, figs. 106, 107.

In Holes 565, 568, and 570, forms identifiable as *N. acostaensis* (five chambers, comma-shaped aperture with distinctive lip) occur in Pleistocene sediments. The normal upper range of *N. acostaensis*, which is a geographically widespread and well-documented species, is only into Zone N21, and these occurrences are considered the result of reworking.

***Neogloboquadrina atlantica* (Berggren)**
(Plate 5, Figs. 8–12)

Globigerina atlantica Berggren, 1972, p. 972, pl. 1, figs. 1–7; pl. 2, figs. 5–8.

Specimens referable to *N. atlantica* occur in the Pliocene to Pleistocene sediments of Leg 84. Poore (1981) states that *N. atlantica* appears to be restricted to the Pliocene in the North Pacific and is predominantly right-coiling; in the North Atlantic, this species is right-coiling in the upper Miocene and left-coiling in the Pliocene. Virtually all specimens encountered in the samples examined for this report are right-coiling, but occur in Pleistocene as well as Pliocene sediments. Some of the Pleistocene occurrences are undoubtedly the result of reworking (see Hole 565), but other Pleistocene occurrences (see Hole 568) are too common and consistent to be entirely the result of reworking. Keller (1978c) also identified this form (recorded as *N. pachyderma* form 3) in Zone N22 sediments of DSDP Site 173, and associates this taxa with warm waters. The upper age range of *N. atlantica* most likely extends at least into Zone N22.

***Neogloboquadrina dutertrei* (d'Orbigny)**
(Plate 6, Fig. 3)

Globigerina dutertrei d'Orbigny, 1839a, p. 84, pl. 4, figs. 19–21.

In Hole 566, forms assigned to *N. dutertrei* and *N. humerosa* show great similarity and intergradation, and are considered transitional forms between these two species.

Neogloboquadrina humerosa (Takayanagi and Saito)
(Plate 6, Figs. 1, 2)

Globorotalia humerosa Takayanagi and Saito, 1962, p. 78, pl. 78, figs. 1, 2.

Neogloboquadrina pachyderma (Ehrenberg)
(Plate 5, Figs. 3-7)

Aristerospira pachyderma Ehrenberg, 1861, p. 303.

Neogloboquadrina pachyderma is most common in high-latitude assemblages. The typical cold-water forms are small, compact, four-chambered, and encrusted with a circular to oval outline; they are absent in the temperate to subtropical waters of Leg 84 sites. The coiling patterns of *N. pachyderma*, where the left-coiling mode is preferred in cold waters, are well documented (e.g., Bandy, 1960; Ericson, 1959; Keller, 1978c). With rare exceptions, all *N. pachyderma* specimens in the Leg 84 samples are right-coiling. These warmer-water forms of *N. pachyderma* are small, subquadrate in outline, have 4 to 4½ chambers in the final whorl, and are not as compact or encrusted as the cold-water forms.

N. pachyderma form 2 (*fide* Keller, 1978c) was tabulated separately, and is distinguished by its larger size (230-300 μm), more globular chambers, and subquadrate to slightly lobulate outline (Plate 5, Figs. 5-7). *N. pachyderma* form 2 occurs consistently with *N. pachyderma;* Keller (1978c) noted its common association with dextrally coiled *N. pachyderma* (Keller's form 1) as indicative of warmer waters.

Neogloboquadrina pachyderma/dutertrei intergrade

This category is used for Pliocene and Quaternary specimens that are intergrades between *Neogloboquadrina pachyderma* and *N. dutertrei*. The specimens are right-coiling (with very rare exceptions), have 4½ to 5 chambers in the final whorl, and they have a moderately open umbilicus.

Orbulina bilobata (d'Orbigny)

Globigerina bilobata d'Orbigny, 1846, p. 164, pl. 9, figs. 11-14.

Orbulina suteralis Brönnimann

Orbulina suteralis Brönnimann, 1951, p. 135, text-fig. IV, figs. 15, 16, 20.

Orbulina universa d'Orbigny

Orbulina universa d'Orbigny, 1939a, Vol. 8, p. 2, pl. 1, fig. 1.

Pseudohastigerina wilcoxensis (Cushman and Ponton)

Nonion wilcoxensis Cushman and Ponton, 1932b, p. 64, pl. 8, fig. 11.

Protentella prolixa Lipps
(Plate 12, Fig. 13)

Prontentella prolixa Lipps, 1964, p. 124, pl. 2, figs. 8a-c, 9a-c.

A single pyritized specimen of this unusual species was found in Sample 565-33-1, 109-113 cm.

Pulleniatina finalis Banner and Blow
(Plate 11, Figs. 12, 15)

Pulleniatina obliquiloculata finalis Banner and Blow, 1967, p. 140, pl. 2, figs. 4-10; pl. 3, fig. 5; pl. 4, fig. 10.

Pulleniatina obliquiloculata (Parker and Jones)
(Plate 11, Figs. 13, 14)

Pullenia sphaeroides var. *obliquiloculata* Parker and Jones, 1865, pp. 365, 368, pl. 19, fig. 4.

For Hole 565, specimens referable to *P. obliquiloculata* are designated as *P. obliquiloculata* s.l. because the specimens occurring in the Pliocene section of the hole display a morphology transitional with *P. primalis*.

Pulleniatina primalis Banner and Blow
(Plate 11, Figs. 10, 11)

Pulleniatina primalis Banner and Blow, 1967, pp. 142-143, pl. 1, figs. 3-8; pl. 3, figs. 2a-c.

Sphaeroidinella dehiscens (Parker and Jones)
(Plate 12, Fig. 10)

Sphaeroidina bulloides var. *dehiscens* Parker and Jones, 1865, p. 369, pl. 19, fig. 5.

Sphaeroidinellopsis disjuncta (Finlay)
(Plate 12, Figs. 7, 8)

Sphaeroidinella disjuncta Finlay, 1940, p. 469, pl. 67, figs. 224-228.

Sphaeroidinellopsis seminulina (Schwagger)

Globigerina seminulina Schwagger, 1866, p. 267, pl. 7, fig. 112.

Sphaeroidinellopsis subdehiscens (Blow)
(Plate 12, Fig. 9)

Sphaeroidinella dehiscens subdehiscens Blow, 1959, p. 195, pl. 12, figs. 71, 72.

Turborotalita cristata (Heron-Allen and Earland)

Globigerina cristata Heron-Allen and Earland, 1929, p. 331, pl. 4, fig. 37.

Turborotalita humilis (Brady)
(Plate 11, Figs. 3, 4)

Truncatulina humilis Brady, 1884, p. 665, pl. 94, fig. 7.

Turborotalita quinqueloba (Natland)
(Plate 11, Figs. 1, 2)

Globigerina quinqueloba Natland, 1938, p. 149, pl. 6, fig. 7.

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REFERENCES

Akers, W. H., 1955. Some planktonic Foraminifera of the American Gulf Coast and suggested correlations with the Caribbean Tertiary. *J. Paleontol.*, 29:647-664.

Aubouin, J., von Huene, R., et al., 1982. *Init. Repts. DSDP*, 67: Washington (U.S. Govt. Printing Office).

Bandy, O. L., 1960. The geologic significance in coiling ratios in the foraminifer *Globigerina pachyderma* (Ehrenberg). *J. Paleontol.*, 34:671-681.

Banner, F. T., and Blow, W. H., 1960. Some primary types of species belonging to the superfamily Globigerinacea. *Cushman Found. Foram. Res. Contr.*, 11:1-41.

________, 1965. Two new taxa of the Globorotaliinae (Globigerinacea, Foraminifera) assisting determination of the late Miocene/middle Miocene boundary. *Nature*, 207:1351-1354.

________, 1967. The origin, evolution and taxonomy of the foraminiferal genus *Pulleniatina* Cushman, 1927. *Micropaleontology*, 13: 133-162.

Barron, J. A., and Keller, G., 1982. Widespread Miocene deep-sea hiatuses: Coincidence with periods of global cooling. *Geology*, 10: 577-581.

Barron, J. A., Keller, G., Dunn, D. A., Kennett, J. P., and Vincent, E., in press. A multiple microfossil biochronology for the Miocene. *Mem. Geol. Soc. Am. CENOP*.

Berggren, W. A., 1969. Rates of evolution in some Cenozoic planktonic Foraminifera. *Micropaleontology*, 15:351-365.

________, 1972. Cenozoic biostratigraphy and paleobiogeography of the North Atlantic. *In* Laughton, A. S., Berggren, W. A., et al., *Init. Repts. DSDP*, 12: Washington (U.S. Govt. Printing Office), 965-999.

________, 1973. The Pliocene time scale: Calibration of planktonic foraminiferal and calcareous nannoplankton zones. *Nature*, 243: 391-397.

Berggren, W. A., Kent, D. V., and Flynn, J. J., 1984. Paleogene geochronology and chronostratigraphy. *In* Snelling, N. J. (Ed.), *Geochronology and the Geologic Record*. Geol. Soc. Spec. Pap. (London).

Bermudez, P. J., 1949. Tertiary smaller Foraminifera of the Dominican Republic. *Cushman Lab. Foram. Res. Spec. Publ.*, 25:285.

________, 1961. Contribución al estudio de las Globigerinidea de la región Caribe-Antillana (Paleoceno-Reciente). *Bol. Geol. Publi. Espec. (Venez. Dir. Geol.)*, 3 (Third Cong. Geol. Venez. Caracas, 1959, Mem. 3), 1119–1393.

Blow, W. H., 1956. Origin and evolution of the foraminiferal genus *Orbulina*. *Micropaleontology*, 2:57–70.

________, 1959. Age, correlation, and biostratigraphy of the upper Tocuyo (San Lorenzo) and Pozon formations, eastern Falcon, Venezuela. *Bull. Am. Paleontol.*, 39:1–251.

________, 1969. Late middle Eocene to Recent planktonic foraminiferal biostratigraphy. *In* Brönnimann, P., and Renz, H. H. (Eds.), *Proc. First Planktonic Conference:* Leiden (E. J. Brill), pp. 199–422.

Blow, W. H., and Banner, F. T., 1962. The mid-Tertiary (upper Eocene–Aquitanian) Globigerinaceae. *In* Eames, F. E., Banner, F. T., Blow, W. H., and Clarke, W. J. (Eds.), *Fundamentals of Mid-Tertiary Stratigraphical Correlation:* Cambridge (Cambridge University Press), pp. 61–151.

________, 1966. The morphology, taxonomy, and biostratigraphy of *Globorotalia barisanensis* LeRoy, *Globorotalia fohsi* Cushman and Ellisor, and related taxa. *Micropaleontology*, 12:286–302.

Bolli, H. M., 1954. Note on *Globigerina concinna* Reuss, 1850. *Cushman Found. Foram. Res. Contr.*, 5:1–3.

________, 1957a. Planktonic Foraminifera from the Oligocene-Miocene Cipero and Lengua formations of Trinidad, B.W.I. *U.S. Nat. Mus. Bull.*, 215:97–124.

________, 1957b. The genera *Globigerina* and *Globorotalia* in the Paleocene–lower Eocene Lizards Springs Formation of Trinidad, B.W.I. *U.S. Nat. Mus. Bull.*, 215:61–81.

________, 1957c. Planktonic Foraminifera from the Eocene Navet and San Fernando formations of Trinidad, B.W.I., *U.S. Nat. Mus. Bull.*, 215:155–172.

Bolli, H. M., and Bermudez, P. J., 1965. Zonation based on planktonic Foraminifera of middle Miocene to Pliocene warm-water sediments. *Assoc. Venez. Geol. Min. Pet. Bol. Inf.*, 8:119–149.

Bolli, H. M., Loeblich, A. R., and Tappan, H., 1957. Planktonic foraminiferal families Hantkeninidae, Orbulinidae, Globorotaliidae and Globortruncanidae. *U.S. Nat. Mus. Bull.*, 215:3–50.

Brady, H. B., 1877. Supplementary note on the Foraminifera of the chalk(?) of the New Britain Group. *Geol. Mag. New Ser. Decade II*, 4:534–536.

________, 1879. Notes on some of the reticulation rhizopoda of the *Challenger* expedition. *Q. J. Microsc. Sci.* (London), 19:20–26, 261–299,, pl. 3–5, 8.

________, 1882. Report on the Foraminifera. *In* Tizard and Murray, J., *Exploration of the Faröe Channel During the Summer of 1880 in H.M.S.* "Knight Errant," *with Subsidiary Reports.* Proc. R. Soc. Edinburgh, 11 (1880–1882):708–717.

________, 1884. Report on the Foraminifera dredged by H.M.S. *Challenger* during the years 1873–1876. *Report on the Scientific Results of the Voyage of H.M.S.* Challenger *During the Years 1873–1876:* London, Zoology, 9, Pt. 22.

Broeck, E. van den, 1876. Etude sur les foraminifères de la Borbade (Antilles), *Soc. Belge Micr., Ann.* (Brussells), 1(1875–1876):55–152.

Brönnimann, P., 1951. The Genus *Orbulina* d'Orbigny in the Oligo-Miocene of Trinidad, B.W.I. *Cushman Found. Foram. Res. Contr.*, 2:132–138.

________, 1952. Trinidad Paleocene and lower Eocene Globigerinidae. *Bull. Am. Paleontol.*, 34:1–34.

Brönnimann, P., and Resig, J., 1971. A Neogene globigerinacean biochronologic time-scale of the southwestern Pacific. *In* Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 1235–1469.

Brotzen, F., 1936. Foraminifera aus dem Schwedischen untersten Senon von Eriksdal in Schonen. *Sver. Geol. Unders.*, Arsb. 30, no. 3, Ser. C, no. 396.

Bukry, D., 1983. Upper Cenozoic silicoflagellates from offshore Ecuador, Deep Sea Drilling Project, Site 504. *In* Cann, J. R., Langseth, M. G., Honnorez, J., Von Herzen, R. P., White, S. M., et al., *Init. Repts. DSDP*, 69: Washington (U.S. Govt. Printing Office), 321–342.

Cadet, J. P., Pauclet, A., Thisse, Y., Berdintzeff, J. M., and Azema, J., 1982. Middle America Neogene explosive volcanism and ash layers: Evidence from the Middle America Trench transect, Deep Sea Drilling Project Leg 67. *In* Aubouin, J., von Huene, R., et al, *Init. Repts. DSDP*, 67: Washington (U.S. Govt. Printing Office), 475–492.

Catalano, R., and Sprovieri, R., 1971. Biostratigrafia dialcune serie Sahelieane (Messiniano Inferiore) in Sicilia. *In* Farinacci, A. (Ed.), *Proceedings of Second Planktonic Conference:* Roma (Tecnoscienza), pp. 211–249.

Chang, Li-Sho, 1962. Tertiary planktonic foraminiferal zones of Taiwan and overseas correlation. *Mem. Geol. Soc. China*, 1:107–112.

Chapman, F., Parr, W. J., and Collins, A. C., 1934. Tertiary Foraminifera of Victoria, Australia—the Balcombian deposits of Port Phillip, Pt. 3. *Linn. Soc. London J., Zoology*, 38:553–557.

Conato, V., 1964. Alcuni foraminiferi nuovi nel Pliocene nordappenninico. *Geol. Romana*, 3:279–302.

Crescenti, U., 1966. Sulla biostratigrafia del Miocene affiorante al confine marchigiano-abruzzese. *Geol. Romana*, 5:1–54.

Cushman, J. A., 1918. Some Pliocene and Miocene Foraminifera of the coastal plain of the United States. *U.S. Geol. Surv. Bull.*, 676: 1–100.

________, 1925. New Foraminifera from the Upper Eocene of Mexico. *Cushman Lab. Foram. Res. Contr.*, 2:16–26.

________, 1926. Some Foraminifera from the Mendez Shale of Mexico. *Cushman Lab. Foram. Res. Contr.*, 2:16–26.

Cushman, J. A., and Bermudez, 1937. Further new species of Foraminifera from the Eocene of Cuba. *Cushman Lab. Foram. Res. Contr.*, 13:1–29.

________, 1949. Some Cuban species of *Globorotalia*. *Cushman Lab. Foram. Res. Contr.*, 25:26–45.

Cushman, J. A., and Ellisor, A. C., 1939. New species of Foraminifera from the Oligocene and Miocene. *Cushman Found. Foram. Res. Contr.*, 15:1–14.

Cushman, J. A., and Jarvis, P. W., 1930. Miocene Foraminifera from Buff Bay, Jamaica. *J. Paleontol.*, 4:353–368.

________, 1936. Three new Foraminifera from the Mioene, Bowden marl, of Jamaica. *Cushman Found. Foram. Res. Contr.*, 12:3–5.

Cushman, J. A., and Ponton, G. M., 1932a. The Foraminifera of the upper, middle, and part of the lower Miocene of Florida. *Fla. Geol. Surv. Bull.*, 9:7–147.

________, 1932b. An Eocene foraminiferal fauna of Wilcox age from Alabama. *Cushman Lab. Foram. Res. Contr.*, 8:51–72.

Cushman, J. A., and Renz, H. H., 1942. Eocene, Midway, Foraminifera from Soldado Rock, Trinidad. *Cushman Lab. Foram. Res. Contr.*, 18:1–20.

Cushman, J. A., and Stainforth, R. M., 1945. The Foraminifera of the Cipero Marl Formation of Trinidad, British West Indies. *Cushman Found. Foram. Res. Spec. Publ.*, 14:1–75.

Cushman, J. A., Stewart, R. E., and Stewart, K. C., 1930. Tertiary Foraminifera from Humboldt County, California. *San Diego Soc. Nat. Hist. Trans.*, 67:43–90.

Deshayes, G. P., 1832. *Encyclopedie methodique; histoire naturelle des vers* (Vol. 2, Pt. 2, and Vol. 3): Paris (Mme. v. Agasse).

de Stefani, T., 1952. Su alcune manifestazioni di idrocarburi in provincia de Palermo e descrizione di foraminiferi nuovi. *Plinia* (Palermo, Italy), 3:1–12.

d'Orbigny, A., 1826. Tableau méthodique de la classe de Cephalopondes. *Ann. Sci. Nat. Paris*, Ser. 1, 7:95–314., pl. 10–17.

________, 1839a. Foraminifères. *In* Sagra, R. de la (Ed.), *Historire Physique, Politique et Naturelle de l'île de Cuba:* Paris (A. Bertrand).

________, 1839b. Foraminifères des Iles Canaries. *In* Barker-Webb, P., and Berthelot, S. (Eds.), *Histoire Naturelle des Iles Canaries* (Vol. 2, Pt. 2, Zool.): Paris (Bethune), 119–146, pl. 1–3 (*fide* Banner and Blow, 1960a).

________, 1846. *Foraminifères fossiles du bassin tertiaire de Vienne (Autriche)*: Paris (Gide et Cie).

Egger, J. G., 1893. Foraminiferen aus Meeresgrundproben, gelothet von 1874 vis 1876 von S. M. Sch. Gazelle. *Kon. Bayer. Akad. Wiss., Math.-Physik. Kl. Abh.*, 18:193–458 (1–266), pl. 1–27.

Ehrenberg, C. G., 1838 (1840). Ueber die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *Kon. Preuss. Adak. Wiss. Berlin Abh.*, Jahrg., 1838:59–147.

———, 1861. Elemente des tiefen Meeresgrundes im Mexikanischen Golfstrome bei Florida: Ueber die Tiefgrunde-Verhaltnisse des Oceans am Eingange der Davisstrasse und bei Island. *Kon. Preuss. Akad. Wiss. Berlin, Meber.*, pp. 222–240, 275–315, with map and chart.

Ericson, D. B., 1959. Coiling direction of *Globigerina pachyderma* as a climatic index. *Science*, 130(no. 3369):219–220.

Finlay, H. J., 1939a. New Zealand Foraminifera: Key species in stratigraphy, no. 2. *R. Soc. New Zealand Trans.*, 69:89–128.

———, 1939b. New Zealand Foraminifera: Key species in stratigraphy, no. 3. *R. Soc. New Zealand Trans.*, 69:309–329.

———, 1940. New Zealand Foraminifera: Key species in stratigraphy, no. 4. *R. Soc. New Zealand Trans.*, 69:448–472.

———, 1947. New Zealand Foraminifera: Key species in stratigraphy, no. 5. *New Zealand J. Sci. Technol.*, 28:259–292.

Galloway, J. J., and Wissler, S. G., 1927. Pleistocene Foraminifera from the Lomita quarry, Palos Verdes Hills, California. *J. Paleontol.*, 1:35–87.

Gandolfi, R., 1955. The genus *Globotruncana* in northeastern Columbia. *Bull. Am. Paleontol.*, 36.

Gümbel, C. W., 1868 (1870). Beiträge zur Foraminiferenfauna der nordalpinen, älteren Eocängebilde oder der Kressenberger Nummulitenschichten. *Bayer. Akad. Wiss. Abh., Math.-Physik. Kl.*, 10:579–730.

Hedberg, H. D., 1937. Foraminifera of the middle Tertiary Carapita Formation of northeastern Venezuela. *J. Paleontol.*, 11:661–697.

Heron-Allen, E., and Earland, A., 1929. Some new foraminifera from the South Atlantic. *R. Microsc. Soc. London*, Ser. 3, 49: Pt. I, 102–108; Pt. II, 324–334.

Hofker, J., 1956. Foraminifera Dentata: Foraminifera of Santa Cruz and Thatch Island, Virginia-Archipelago West Indies. *Copenhagen Univ. Zool. Mus. Spolia* (Skrifter), 15:234.

Hornibrook, N. de B., 1958. New Zealand Foraminifera: Key species in stratigraphy, no. 6. *New Zealand J. Geol. Geophys.*, 1:653–676.

Howe, H. V., and Wallace, W. E., 1932. Foraminifera of the Jackson Eocene at Danville Landing on the Ouachita, Catahoula Parish, Louisiana. *Louisiana Dept. Conserv. Geol. Bull.*, 1–188.

Ingle, J. C., Jr., 1973a. Neogene Foraminifera from the northeastern Pacific Ocean, Leg 18, Deep Sea Drilling Project. *In* Kulm, L. D., von Huene, R., et al., *Init. Repts. DSDP*, 18: Washington (U.S. Govt. Printing Office), 517–567.

———, 1973b. Summary comments on Neogene biostratigraphy, physical stratigraphy, and paleo-oceanography in the marginal northeastern Pacific Ocean. *In* Kulm, L. D., von Huene, R., et al., *Init. Repts. DSDP*, 18: Washington (U.S. Govt. Printing Office), 949–960.

Jenkins, D. G., 1960. Planktonic Foraminifera from the Lakes Entrance oil shaft, Victoria, Australia. *Micropaleontology*, 6:345–371.

———, 1964. A new planktonic foraminiferal subspecies from the Australasian Lower Miocene. *Micropaleontology*, 10:72.

Keigwin, L. D., Jr., 1976. Late Cenozoic planktonic foraminiferal biostratigraphy and paleoceanography of the Panama Basin. *Micropaleontology*, 22:419–442.

———, 1979. Late Cenozoic stable isotope stratigraphy and paleoceanography of DSDP sites from the east equatorial and central North Pacific Ocean. *Earth Planet. Sci. Lett.*, 45:361–382.

Keller, G., 1978a. Late Neogene biostratigraphy and paleoceanography of DSDP Site 310, central North Pacific, and correlation with the southwest Pacific. *Mar. Micropaleontol.*, 3:97–119.

———, 1978b. Late Neogene planktonic foraminiferal biostratigraphy and paleoceanography of the northeastern Pacific: Evidence from DSDP Sites 173 and 310 at the North Pacific Front. *J. Foram. Res.*, 8:332–349.

———, 1978c. Morphologic variation of *Neogloboquadrina pachyderma* (Ehrenberg) in sediments of the marginal and central northeast Pacific Ocean and paleoclimatic interpretation. *J. Foram. Res.*, 8:208–224.

———, 1980. Early to middle Miocene planktonic foraminiferal datum levels of the equatorial and subtropical Pacific. *Micropaleontology*, 26:372–391.

———, 1981a. Origin and evolution of the genus *Globigerinoides* in the early Miocene of the northwestern Pacific, DSDP Site 292. *Micropaleontology*, 27:293–304.

———, 1981b. Planktonic foraminiferal faunas of the equatorial Pacific suggest early Miocene origin of present oceanic circulation. *Mar. Micropaleontol.*, 6:269–295.

———, 1981c. Miocene biochronology and paleoceanography of the North Pacific. *Mar. Micropaleontol.*, 6:535–551.

———, 1983. Biochronology and paleoclimatic implications of middle Eocene to Oligocene planktic foraminiferal faunas. *Mar. Micropaleontol.*, 7:463–487.

———, in press. The Oligocene/Miocene boundary in the equatorial Pacific Ocean. *In* Steinger, F. F., and Gelati, R. (Eds.), *In Search of the Paleogene/Neogene Boundary Stratotype. Part 2: Potential Boundary Stratotype Sections in Italy, Spain, and Rumania and Comparison with Results from the Deep Sea*. Riv. Ital. Paleontol. Stratig. Spec. Publ.

Keller, G., and Barron, J. A., 1983. Paleoceanographic implications of Miocene deep-sea hiatuses. *Geol. Soc. Am. Bull.*, 94:590–613.

Keller, G., Barron, J. A., and Bruckle, L. H., 1982. North Pacific late Miocene correlations using microfossils, stable isotopes, percent $CaCO_3$, and magnetostratigraphy. *Mar. Micropaleontol.*, 7:327–357.

Keller, G., and Ingle, J. C., Jr., 1981. Planktonic foraminiferal biostratigraphy, paleoceanographic implications, and deep-sea correlation of the Pliocene-Pleistocene Centerville Beach section, northern California. *Geol. Soc. Am. Spec. Pap.*, 184:127–135.

Keller, G., and Poore, R. Z., 1980. *Globigerinoides kennetti:* A new late Miocene to earliest Pliocene planktonic Foraminifera from the Atlantic and Pacific oceans. *Micropaleontology*, 26:189–192.

Kennett, J. P., 1966. The *Globorotalia crassaformis* bioseries in north Westland and Marlborough, New Zealand. *Micropaleontology*, 12: 235–245.

Kent, D., Opdyke, N. D., and Ewing, M., 1971. Climate change in the North Pacific using ice-rafted detritus as a climatic indicator. *Geol. Soc. Am. Bull.*, 82:2741–2754.

Koch, R. E., 1926. Mitteltertiare Foraminiferen aus Bulongan, Ost-Borneo. *Eclogae Geol. Helv.*, 19:722–751.

LeRoy, L. W., 1939. Some small Foraminifera, Ostracoda, and otoliths from the Neogene ("Miocene") of the Tokan-Tapanoeli area, central Sumatra. *Natuurwet. Tijdschr. Ned.-Indie*, 99 (No. 6): 215–296, pl. 1–14 (*fide* Stainforth et al., 1975).

———, 1944. Miocene Foraminifera from Sumatra and Java, Netherlands East Indies—Part 1. Miocene Foraminifera of Central Sumatra, Netherlands East Indies. *Colorado School Mines Quart.*, 39:9–69.

Lipps, J. H., 1964. Miocene planktonic Foraminifera from Newport Bay, California. *Tulane Stud. Geol.*, 2:109–132.

Loeblich, A. R., Jr., and Tappan, H., 1957. The new planktonic foraminiferal genus *Tinophodella* and an emendation of *Globigerinita* Brönnimann. *Washington Acad. Sci. J.*, 47:112–116.

Martin, L. T., 1943. Eocene Foraminifera from the type Lodo Formation, Fresno County, California. *Stanford Univ. Publ. Geol. Sci.*, 3:93–125.

Natland, M. L., 1938. New species of Foraminifera from off the west coast of North America and from the later Tertiary of the Los Angeles Basin. *Univ. Calif. Scripps Inst. Oceanogr. Bull., Tech. Ser.*, 4:137–164.

Nuttall, W. L. F., 1930. Eocene Foraminifera from Mexico. *J. Paleontol.*, 4:271–293.

Orr, W. N., and Zaitzeff, J. B., 1971. A new planktonic foraminiferal species from the California Pliocene. *J. Foram. Res.*, 1:17–19.

Parker, F. L., 1958. Eastern Mediterranean Foraminifera. *Swedish Deep-Sea Exped. Repts.*, 8:219–283.

———, 1962. Planktonic foraminiferal species in Pacific sediments. *Micropaleontology*, 8:219–254.

———, 1967. Late Tertiary biostratigraphy (planktonic Foraminifera) of tropical Indo-Pacific deep-sea cores. *Bull. Am. Paleontol.*, 52:115–208.

Parker, W. K., and Jones, T. R., 1865. On some Foraminifera from the North Atlantic and Arctic Oceans, including Davis Straits and Baffin's Bay. *Philos. Trans. R. Soc. London*, 155:325–441, pl. 13–19 (*fide* Banner and Blow, 1960).

Parker, W. K., Jones, T. R., and Brady, H. B., 1865. On the nomenclature of the Foraminifera; Pt. 12 [misprinted as Pt. 10 continued]—The species enumerated by d'Orbigny in the *Annales des Sciences Naturelles*, Vol. 7, 1826. *Annual Magazine of Natural*

History (London), Ser. 3, 16:15-41, pl. 1-3 (*fide* Banner and Blow, 1960).

Plummer, H. J., 1926. Foraminifera of the Midway Formation in Texas. *Univ. Texas Bull.*, 2644:1-206.

________, 1931. Some Cretaceous Foraminifera in Texas. *Univ. Texas Bull.*, 3101:109-236.

Poore, R. Z., 1979. Oligocene through Quaternary planktonic foraminiferal biostratigraphy of the North Atlantic: DSDP Leg 49. *In* Luyendyk, B. P., Cann, J. R., et al., *Init. Repts. DSDP*, 49: Washington (U.S. Govt. Printing Office), 447-518.

________, 1981. Miocene through Quaternary planktonic foraminifers from offshore southern California and Baja California. *In* Yeats, R. S., Haq, B. U., et al., *Init. Repts. DSDP*, 63: Washington (U.S. Govt. Printing Office), 415-436.

Poore, R. Z., and Berggren, W. A., 1974. Pliocene biostratigraphy of the Laborador Sea: Calcareous plankton. *J. Foram. Res.*, 4:91-108.

________, 1975. Late Cenozoic planktonic foraminiferal biostratigraphy and paleoclimatology of Hatton-Rockall Basin: DSDP Site 116. *J. Foram. Res.*, 5:270-293.

Quilty, P., 1976. Planktonic Foraminifera DSDP Leg 34—Nazca Plate. *In* Yeats, R. S., Hart, S. R., et al., *Init. Repts. DSDP*, 34: Washington (U.S. Govt. Printing Office), 629-703.

________, 1978. *Globorotalia galapagosensis* replacement name for *Globorotalia akersi* Quilty, 1976 not *Globorotalia akersi* Snyder, 1975. *Micropaleontology*, 24:332.

Reuss, A. E., 1850. Neue Foraminiferen aus den Schichten des Österreichischen Tertiärbecken. *Akad. Wiss. Wien Denkschr., Math.-Nat. Kl.*, 1:365-390.

Rögl, F., and Bolli, H. M., 1973. Holocene to Pleistocene planktonic Foraminifera of Leg 15, Site 147 (Cariaco Basin [Trench], Caribbean Sea) and their climatic interpretation. *In* Edgar, N. T., Saunders, J. B., et al., *Init. Repts. DSDP*, 15: Washington (U.S. Govt. Printing Office), 553-615.

Saito, T., Burckle, L. H., and Hays, J. D., 1975. Late Miocene to Pleistocene biostratigraphy of equatorial Pacific sediments. *In* Saito, T., and Burckle, L. H. (Eds.), *Late Neogene Epoch Boundaries:* New York (Micropaleontology Press), pp. 226-244.

Salvatorini, G., 1967. Alcune nuove specie di foraminiferi del Miocene superiore della Toscana Marittima. *Atti Soc. Toscana Scienze Naturali, Pisa, Italy, Mem. A*, 73:3-13.

Schwagger, C., 1866. Fossile Foraminiferen von Kar Nikobar. *Novara Exped. 1857-1859* (Vol. 2): Wien (Geol. Theil), 187-268.

________, 1883. Die Foraminiferen aus den Eocaen-Ablagerungen der Lybischen Wüste und Agyptens. *Paleontographica*, 30:79-154.

Seely, D. R., Vail, P. R., and Walton, G. G., 1974. Trench slope model. *In* Burke, C. A., and Drake, C. L. (Eds.), *The Geology of Continental Margins:* New York (Springer Verlag), pp. 249-260.

Sliter, W. V., 1968. Upper Cretaceous Foraminifera from southern California and northwestern Baja California, Mexico. *Univ. Kans. Paleontol. Contrib.*, Ser. 49 (Protozoa), article 7:1-141.

Srinivasan, M. S., and Kennett, J. P., 1981a. Neogene planktonic foraminiferal biostratigraphy and evolution: Equatorial to subarctic, South Pacific. *Mar. Micropaleontol.*, 6:499-533.

________, 1981b. A review of Neogene planktonic foraminiferal biostratigraphy: Applications in the equatorial and South Pacific. *Soc. Econ. Paleontol. Mineral. Spec. Publ.*, 32:395-432.

Stainforth, R. M., Lamb. J. L., Luterbacher, H., Beard, J. H., and Jeffords, R. M., 1975. Cenozoic planktonic foraminiferal zonation and characteristics of index forms. *Univ. Kans. Paleontol. Contrib.*, article 62.

Subbotina, N. N., 1947. Foraminifery datskikh i paleongenovikh otlozhenii severnogo Kavkaza [Foraminifers of the Danian and Paleogene deposits of northern Caucasus]. Mikrofauna Kavkaza, Emby i sryednei Azii [Microfauna of the Caucasus, Emba region, and central Asia]. *Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst.* Trudy: 39-160.

________, 1953. Iskopaemye foraminifery SSSR; Globigerinidae Hantkeninidae i Globorotaliidae (Fossil foraminifers of the USSR; Globigerinidae, Hantkeninidae, and Globorotaliidae). *Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst.* Trudy, n. ser., no. 76.

Takayanagi, Y., and Saito, T., 1962. Planktonic Foraminifera from the Nobori Formation, Shikoku, Japan. *Tohoku Univ. Sci. Rep. Ser. 2 (Geology)*, Spec. Vol. 5:67-105.

Thompson, P. R., 1980. Foraminifers from Deep Sea Drilling Project Sites 434, 435, and 436, Japan Trench. *In* Scientific Party, *Init. Repts. DSDP*, 56, 57, Pt. 2: Washington (U.S. Govt. Printing Office), 775-808.

________, 1982. Foraminifers of the Middle America Trench. *In* Aubouin, J., von Huene, R., et al., *Init. Repts. DSDP*, 67: Washington (U.S. Govt. Printing Office), 351-381.

Thompson, P. R., and Sciarrillo, J. R., 1978. Planktonic foraminiferal biostratigraphy in the equatorial Pacific. *Nature*, 276 (5683): 29-33.

Todd, R., 1957. Smaller Foraminifera. *U.S. Geol. Surv. Prof. Pap.*, 280-H:265-320.

Todd, R., Cloud, P. E., Jr., Low, D., and Schmidt, R. G., 1954. Probable occurrence of Oligocene of Saipan. *Am. J. Sci.*, 252:673-682.

Walters, R., 1965. The *Globorotalia zealandica* and *G. miozea* lineages. *New Zealand J. Geol. Geophys.*, 8:109-127.

Wezel, F. C., 1966. *Globorotalia acrostoma*, nuova specie dell' Oligomiocene italiano. *Riv. Ital. Paleontol. Stratig.*, 72:1298-1306.

White, M. P., 1928. Some index Foraminifera of the Tampico embayment area of Mexico. *J. Paleontol.*, 2:177-215.

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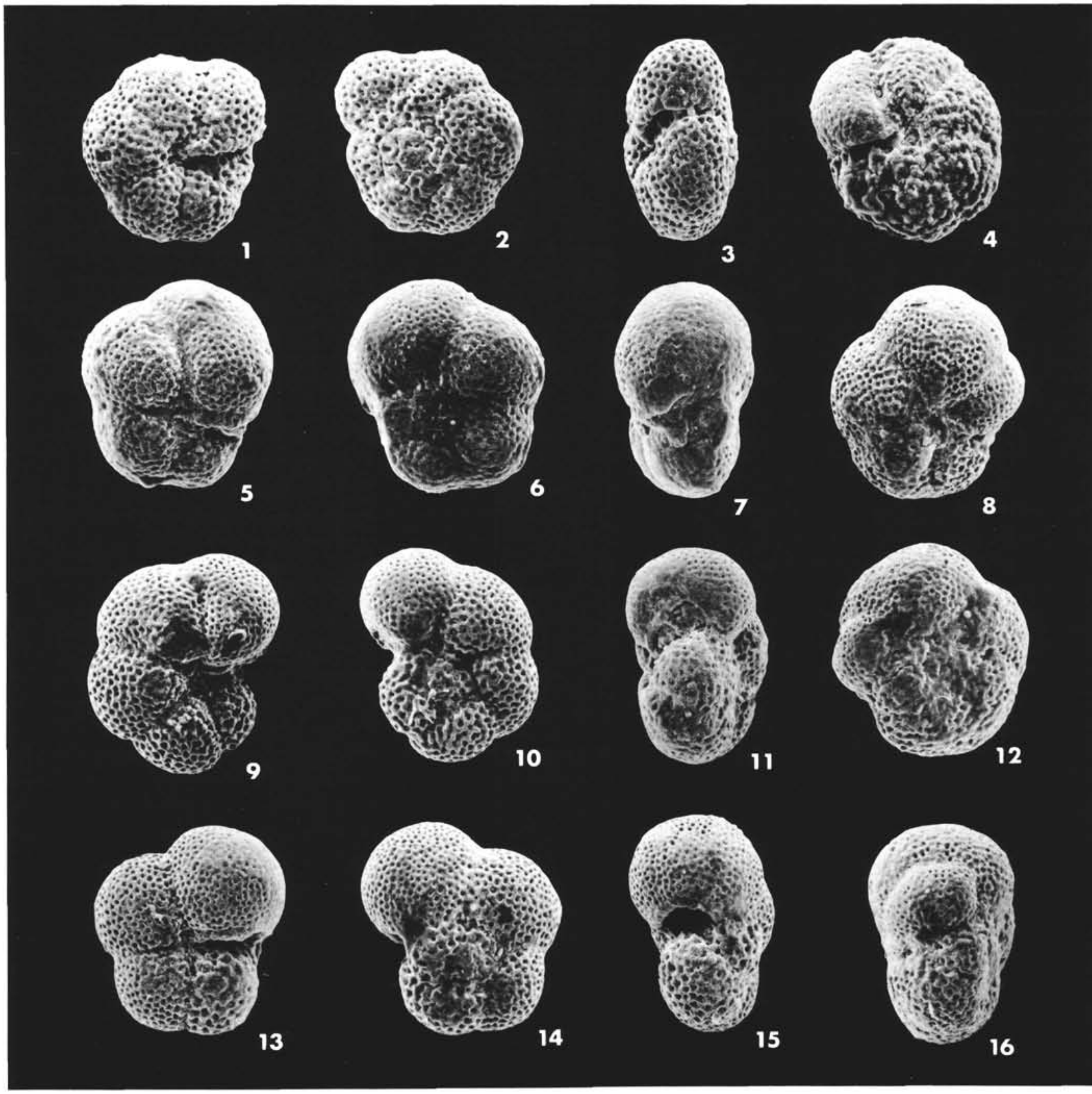

Plate 1. **1-4.** *Globorotalia kugleri*, (1-3) ×213, Sample 568-40-5, 55-57 cm, (4) ×246, Sample 567A-3-1, 76-80 cm. **5-7.** *Globorotalia opima nana*, ×149, Sample 567A-8-5, 50-52 cm. **8, 12, 16.** *Globorotalia birnageae*, ×165, Sample 567A-9-1, 50-52 cm. **9-11.** *Globorotalia siakensis* s.s., ×153, Sample 567A-12-3, 101-105 cm. **13-15.** *Globorotalia siakensis* s.l., ×150, Sample 568-34-5, 90-94 cm.

Plate 2. **1-3.** *Globorotalia peripheroronda*, ×121, Sample 568-36-5, 70–74 cm. **4, 8, 12.** *Globorotalia archeomenardii*, ×139, Sample 568-35-3, 97–99 cm. **5–7, 9–11.** *Globorotalia peripheroacuta*, (5–7) ×111, Sample 568-28-5, 128–130 cm, (9–11) ×162, Sample 568-28-5, 128–130 cm. **13–15.** *Globorotalia praefohsi*, ×132, Sample 568-28-5, 128–130 cm. **16.** *Globorotalia fohsi fohsi*, ×130, Sample 570-35-4, 12–14 cm.

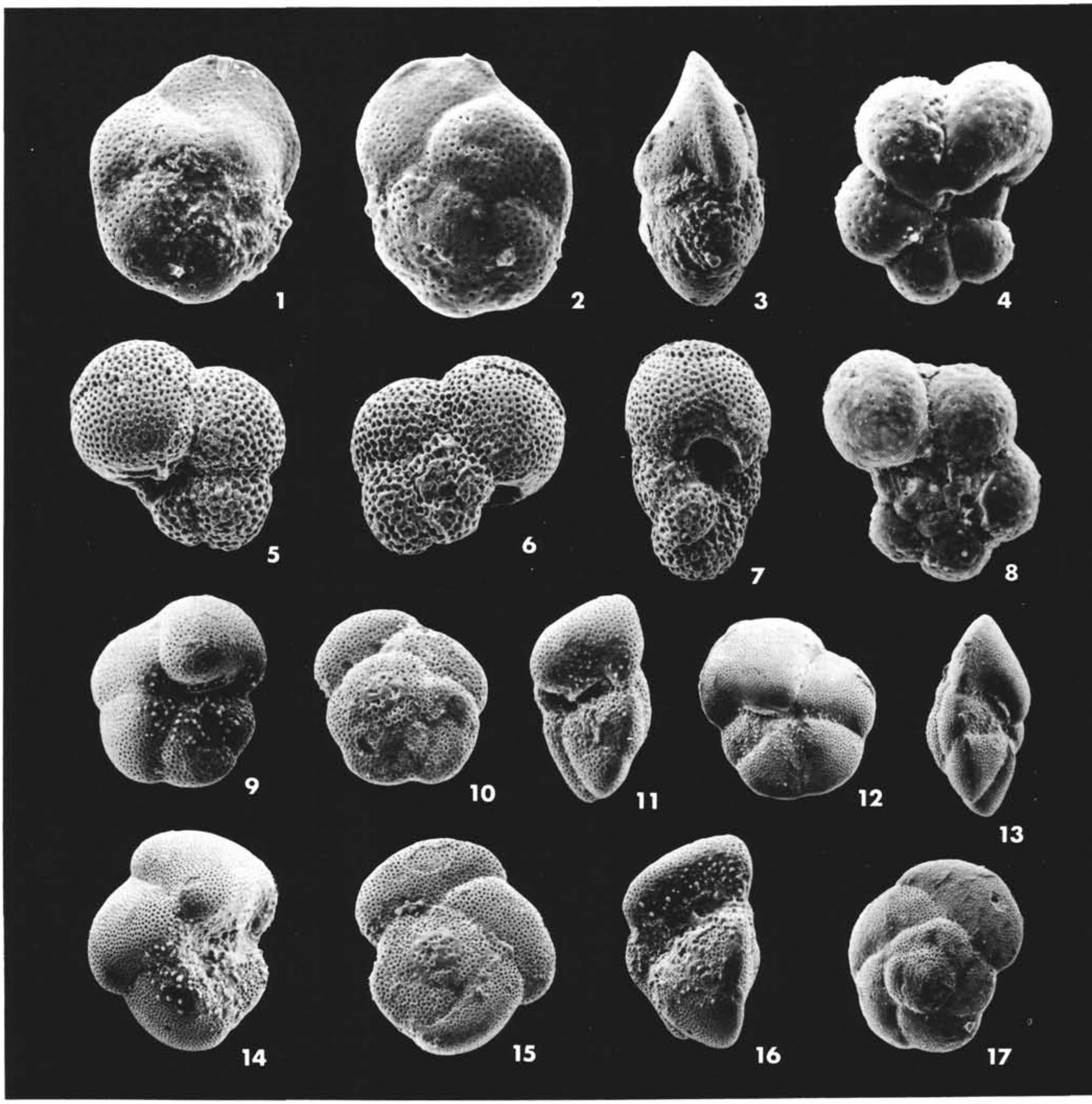

Plate 3. **1-3.** *Globorotalia fohsi fohsi*, ×160, Sample 570-35-4, 12-14 cm. **4, 8.** *Globorotalia minutissima*, ×266, Sample 568-1-3, 30-34 cm. **5-7.** *Globorotalia continuosa*, ×149, Sample 568-35-3, 97-99 cm. **9-11.** *Globorotalia suterae*, ×136, Sample 565-31-2, 59-61 cm. **12, 13, 17.** *Globorotalia scitula*, ×95, Sample 565-1,CC. **14-16.** *Globorotalia crassiformis*, ×121, Sample 565-31-2, 59-61 cm.

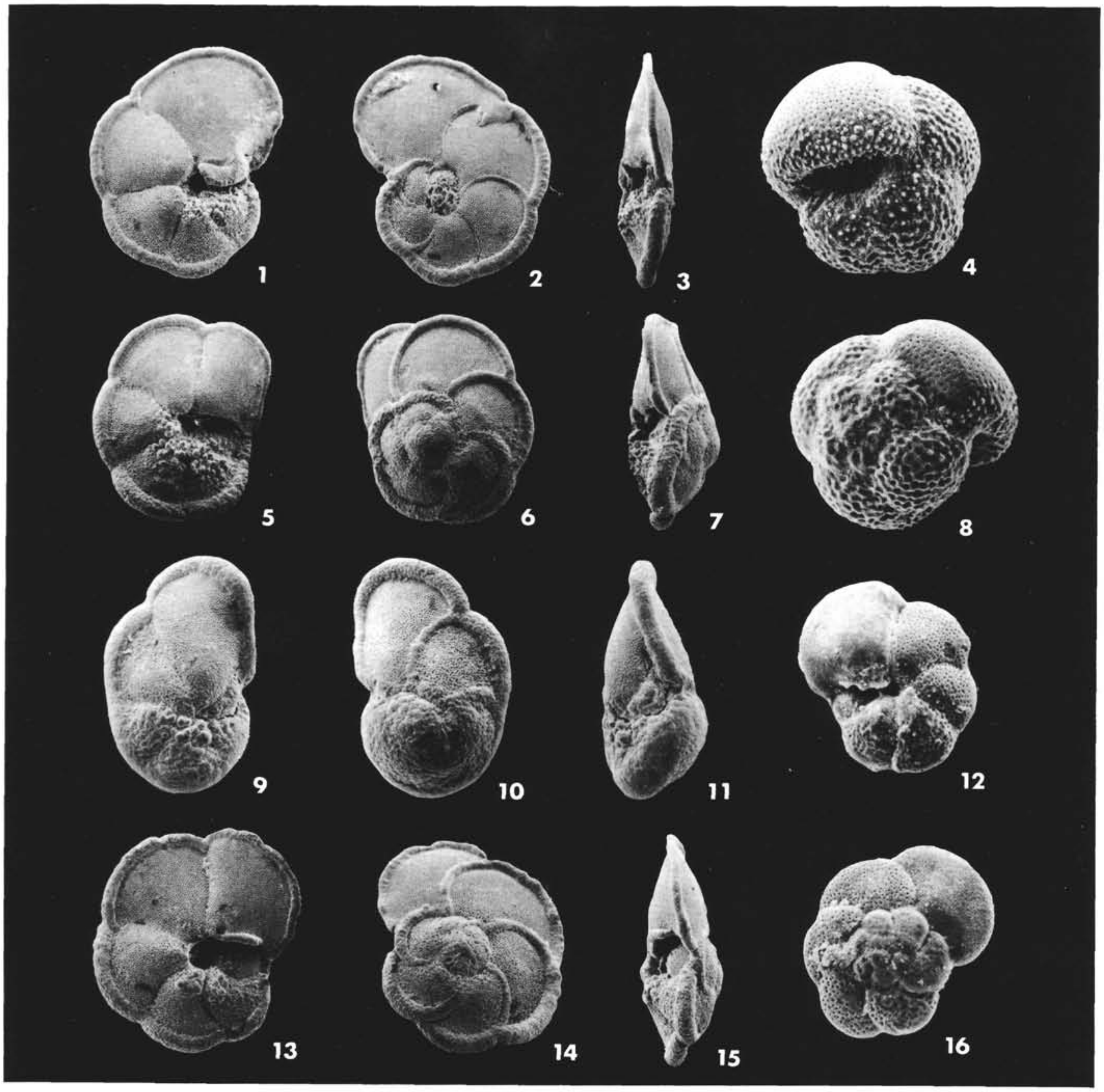

Plate 4. **1–3.** *Globorotalia menardii* s.s., ×48, Sample 568-1-3, 30–34 cm. **4, 8.** *Globorotalia puncticulata*, ×152, Sample 565-20-3, 71–73 cm. **5–7.** *Globorotalia menardii* s.l., ×48, Sample 568-1-3, 30–34 cm. **9–11.** *Globorotalia tumida*, ×50, Sample 565-1,CC. **12, 16.** *Globorotalia bermudezi*, ×176, Sample 570-10-1, 41–45 cm. **13–15.** *Globorotalia exilis*, ×53, Sample 570-5,CC.

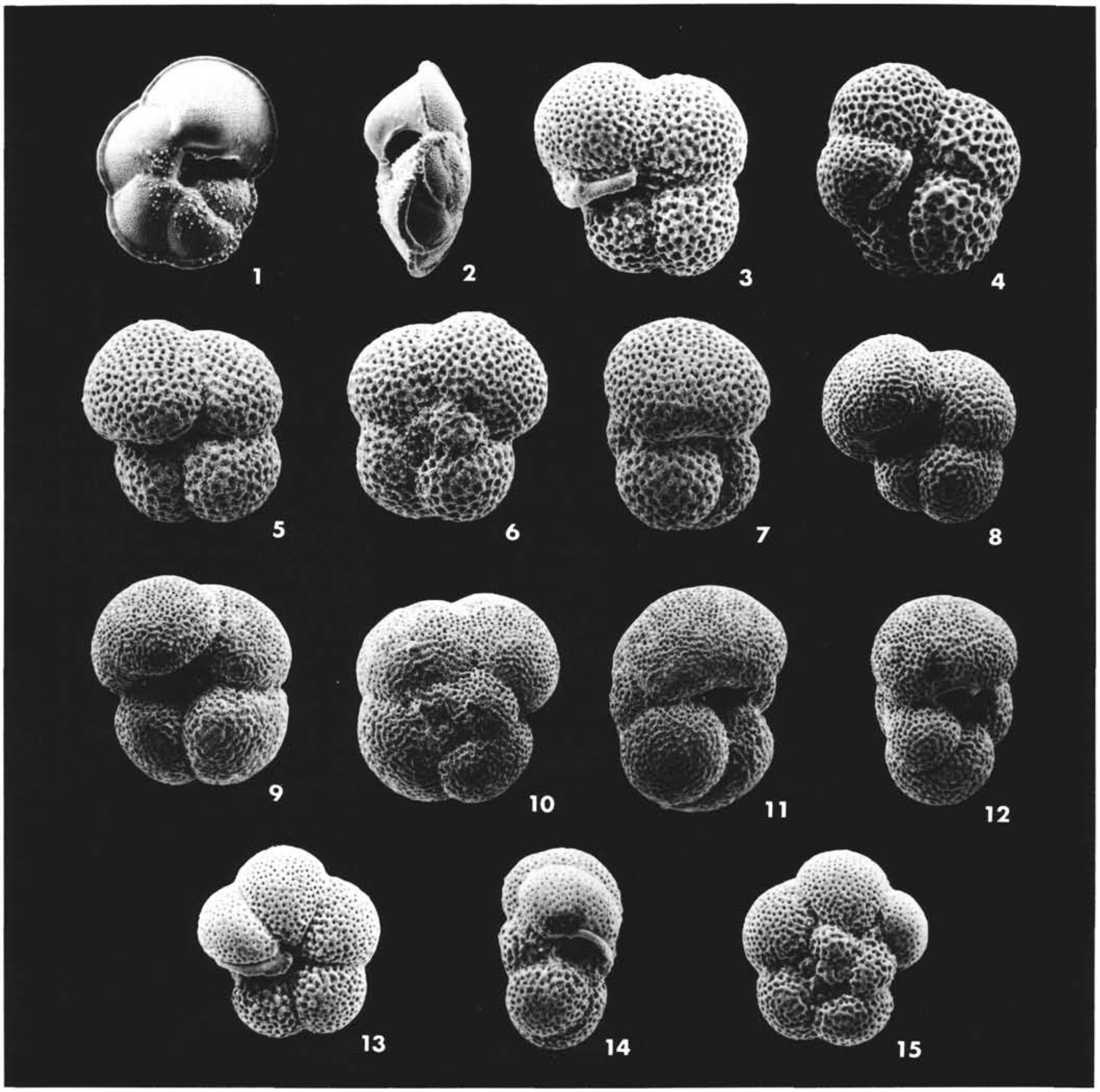

Plate 5. **1, 2.** *Globorotalia ungulata*, ×92, Sample 568-1-3, 30–34 cm. **3, 4.** *Neogloboquadrina pachyderma*, (3) ×174, Sample 568-1-3, 30–34 cm, (4) ×193, Sample 568-2-5, 80–85 cm. **5–7.** *Neogloboquadrina pachyderma* form 2, ×116, Sample 568-2-5, 80–84 cm. **8–12.** *Neogloboquadrina atlantica*, (8, 12) ×86, Sample 565-1,CC, (9–11) ×80, Sample 568-3-3, 121–125 cm. **13–15.** *Neogloboquadrina acostaensis*, ×138, Sample 568-2-5, 80–84 cm.

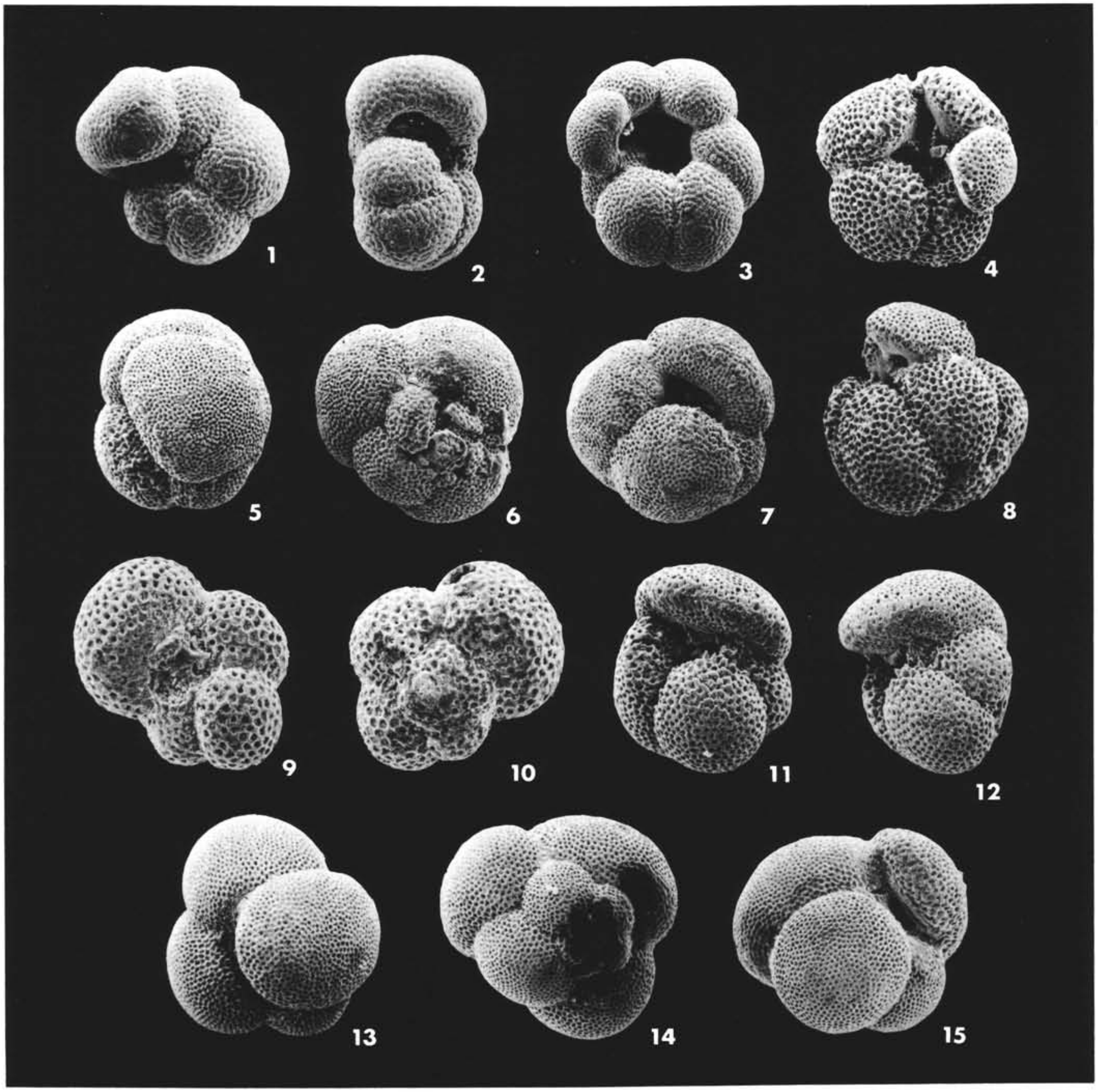

Plate 6. **1, 2.** *Neogloboquadrina humerosa*, ×90, Sample 565-8-2, 54–58 cm. **3.** *Neogloboquadrina dutertrei*, ×71, Sample 567-H1,CC. **4, 8.** *Globoquadrina altispira*, ×101, Sample 568-28-5, 128–130 cm. **5–7.** *Globoquadrina venezuelana*, ×90, Sample 568-28-5, 128–130 cm. **9, 10.** *Globoquadrina baroemoenensis*, ×158, Sample 569-15-3, 104–108 cm. **11, 12.** *Globoquadrina dehiscens*, ×124, Sample 568-39-3, 84–88 cm. **13–15.** *Globoquadrina conglomerata*, 94, Sample 565-20-3, 71–73 cm.

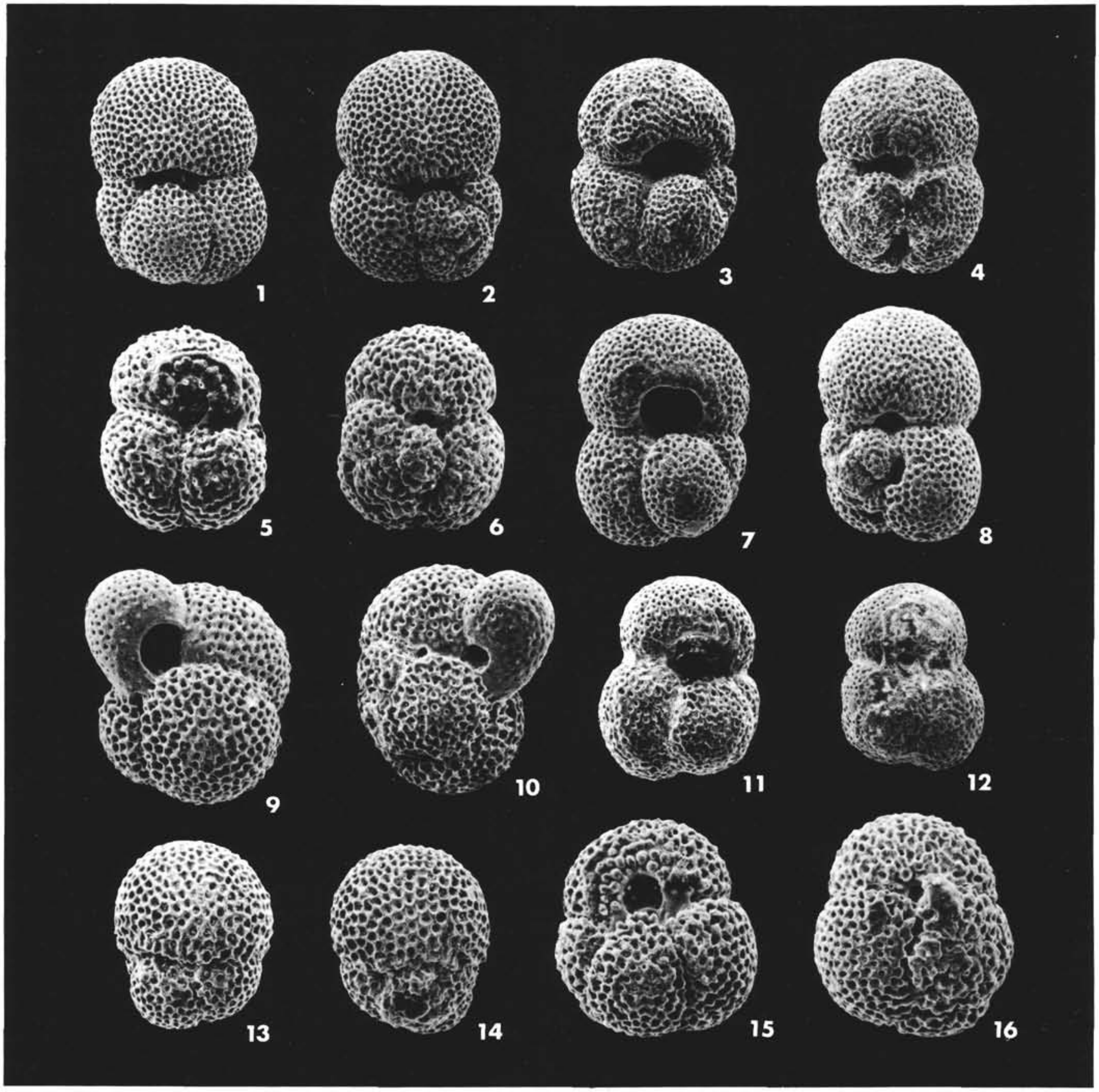

Plate 7. **1, 2.** *Globigerinoides trilobus trilobus*, ×172, Sample 568-28-5, 128–130 cm. **3, 4.** *Globigerinoides primordius*, ×100, Sample 567A-9,CC. **5, 6.** *Globigerinoides subquadratus*, ×153, Sample 568-37-1, 121–125 cm. **7, 8.** *Globigerinoides altiaperturus*, ×125, Sample 569-21-1, 20–24 cm. **9, 10.** *Globigerinoides sacculifer irregularis*, ×173, Sample 568-37-1, 121–125 cm. **11, 12.** *Globigerinoides parawoodi*, ×102, Sample 567A-5,CC. **13, 14.** *Globigerinoides sicanus*, ×127, Sample 568-33,CC. **15, 16.** *Globigerinoides bollii*, ×183, Sample 568-37-1, 121–125 cm.

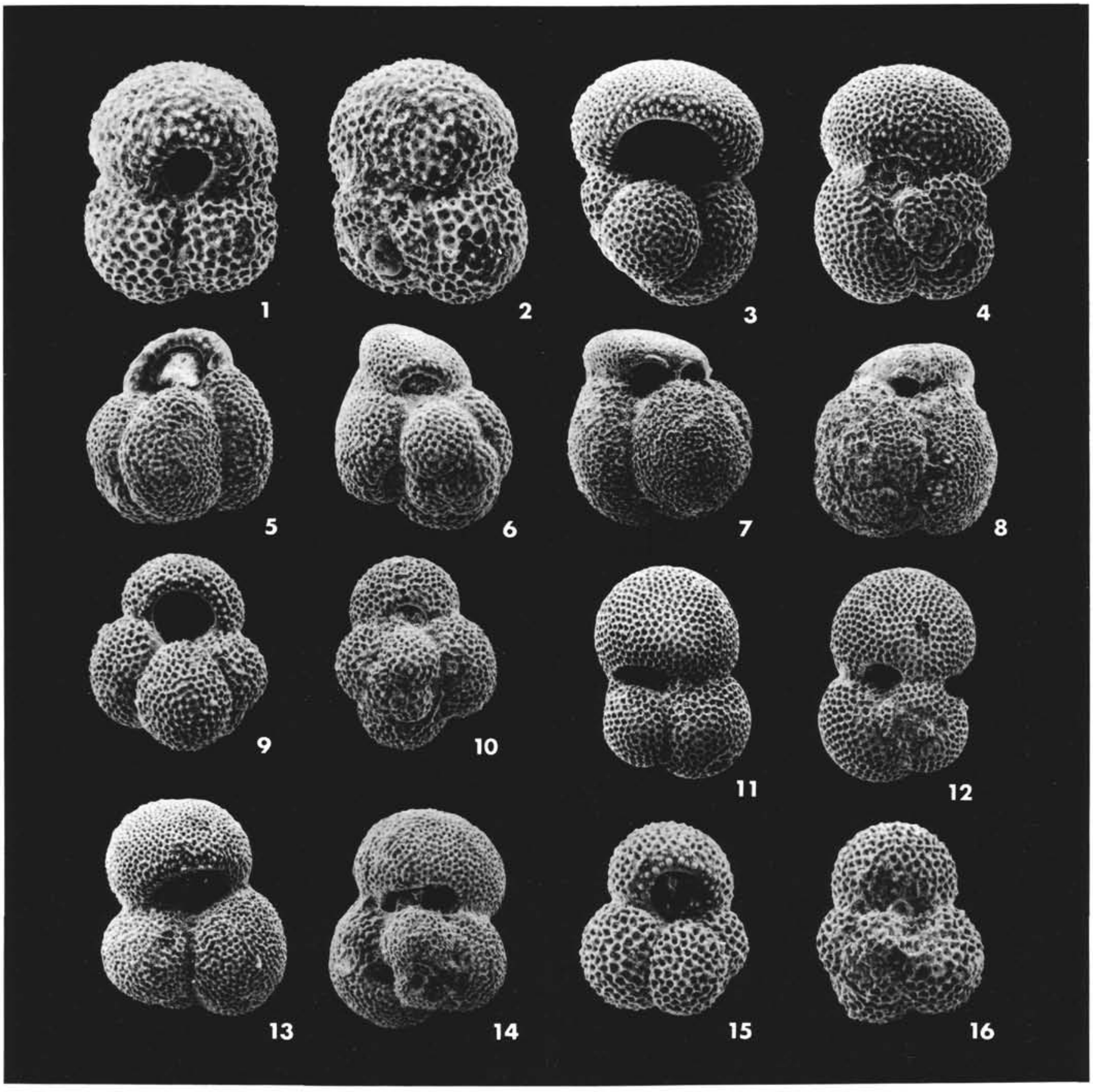

Plate 8. **1, 2.** *Globigerinoides kennetti*, ×180, Sample 565-29-5, 54–56 cm. **3, 4.** *Globigerinoides obliquus obliquus*, ×123, Sample 565-31-2, 59–61 cm. **5, 6.** *Globigerinoides obliquus extremus*, ×106, Sample 565-23-4, 63–67 cm. **7, 8, 13, 14.** *Globigerinoides ruber ruber*, (7, 8) ×73, Sample 565-4,CC, (13, 14) ×88, Sample 565-1,CC. **9, 10.** *Globigerinoides bulloideus*, ×103, Sample 570-11,CC. **11, 12.** *Globigerinoides quadrilobatus*, ×77, Sample 568-14-3, 8–12 cm. **15, 16.** *Globigerinoides tenellus*, ×140, Sample 568-1-3, 30–34 cm.

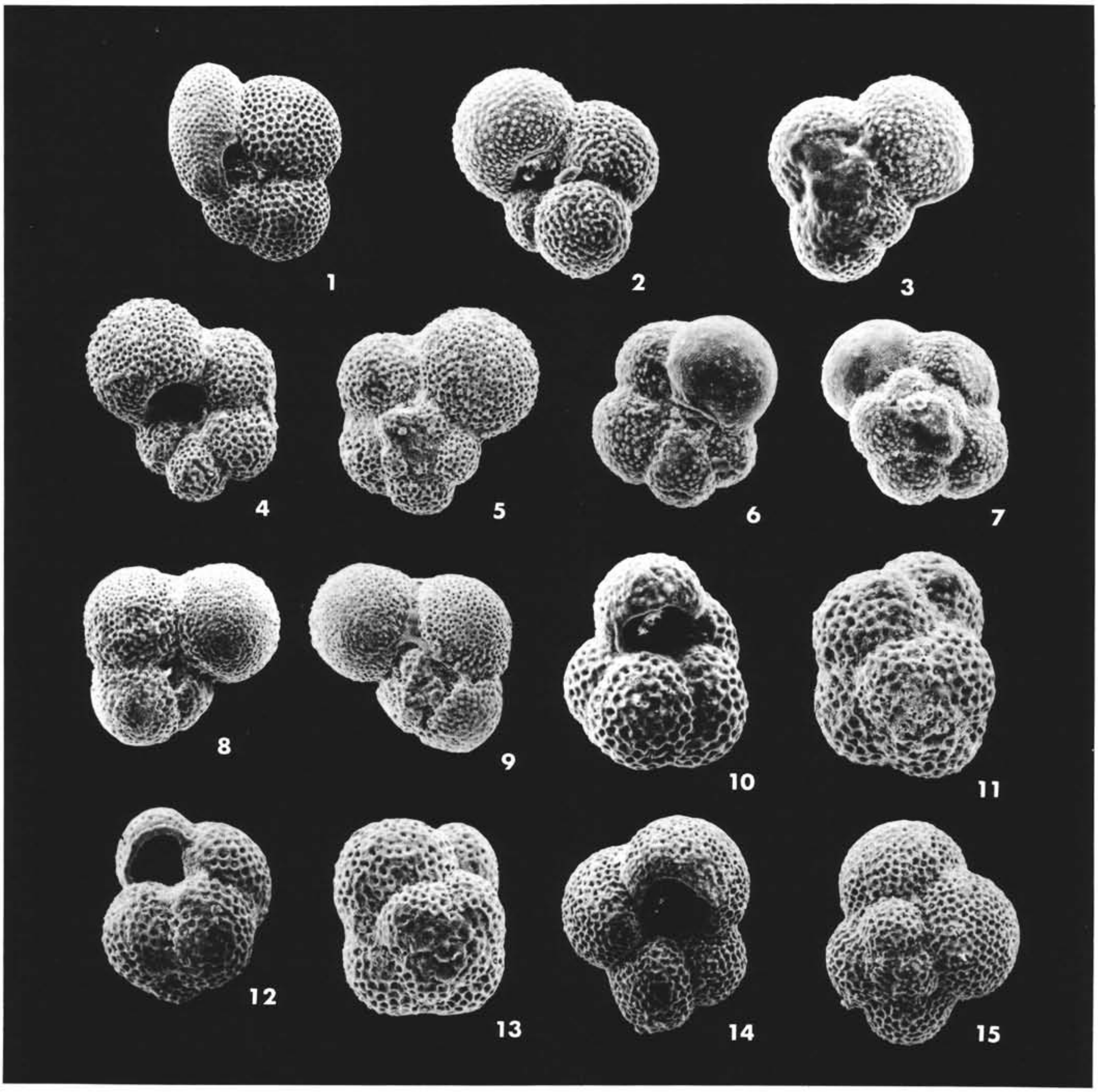

Plate 9. **1.** *Globigerinoides sacculifer sacculifer*, ×90, Sample 565-1,CC. **2, 3.** *Globigerina praebulloides praebulloides*, ×190, Sample 568-28-5, 128–130 cm. **4, 5.** *Globigerina ciperoensis*, ×164, Sample 568-38-4, 80–85 cm. **6, 7.** *Globigerina angustiumbilicata*, ×233, Sample 567A-10-5, 80–84 cm. **8, 9.** *Globigerina incisa*, ×145, Sample 565-14-3, 58–62 cm. **10, 11.** *Globigerina nepenthes*, ×206, Sample 570-24-1, 20–24 cm. **12, 13.** *Globigerina decoraperta*, ×176, Sample 565-13-3, 70–72 cm. **14, 15.** *Globigerina apertura*, ×136, Sample 570-19-1, 10–14 cm.

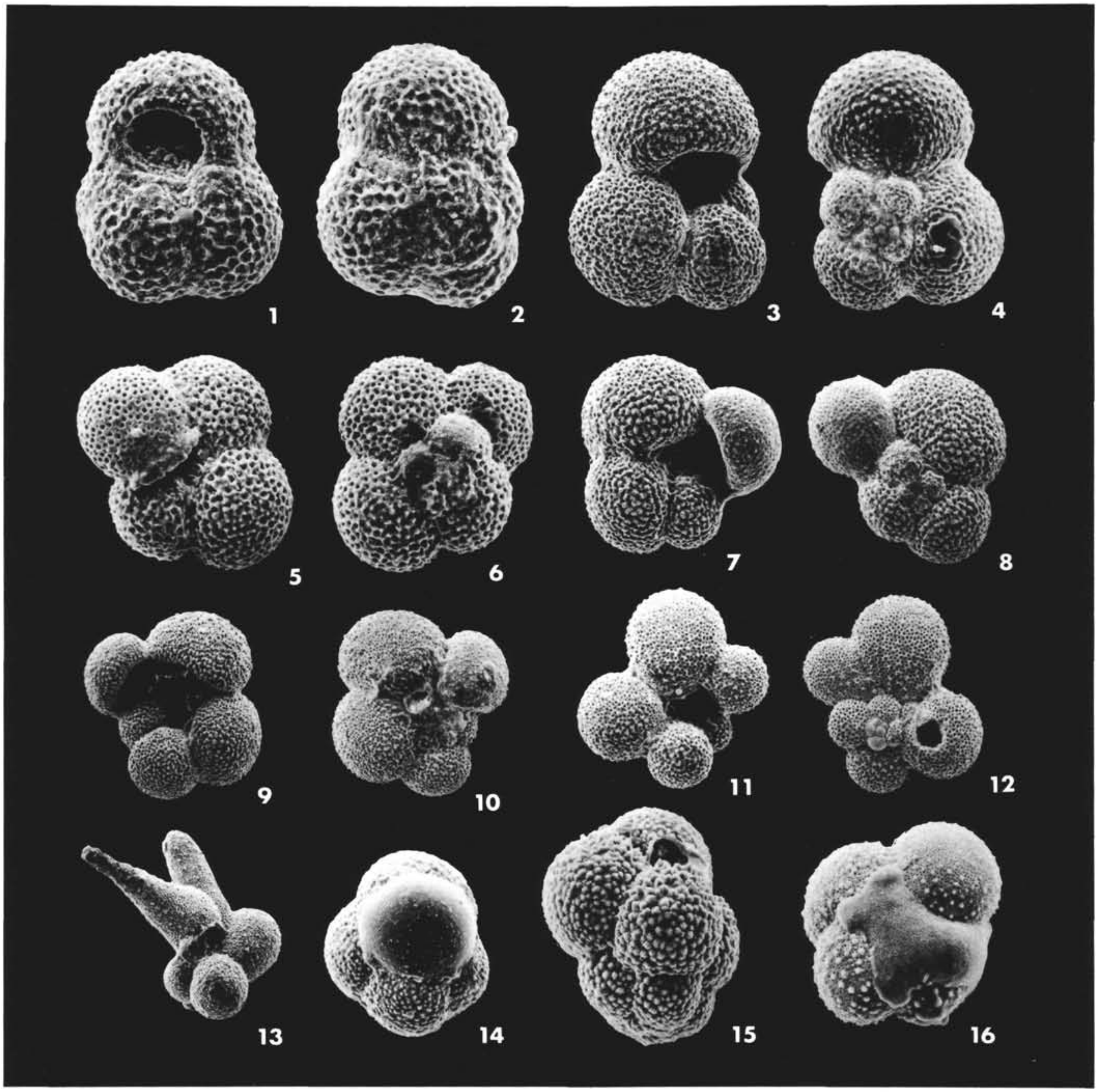

Plate 10. **1, 2.** *Globigerina woodi*, ×226, Sample 565-29-5, 54–56 cm. **3, 4.** *Globigerina bulloides*, ×136, Sample 570-2,CC. **5, 6.** *Globigerina falconensis*, ×200, Sample 568-3-3, 121–125 cm. **7, 8.** *Globigerina quadrilatera*, ×127, Sample 568-3-3, 121–125 cm. **9, 10.** *Globigerina umbilicata*, ×80, Sample 568-1-3, 30–34 cm. **11, 12.** *Globigerina calida*, ×95, Sample 570-6,CC. **13.** *Globigerina digitata*, ×80, Sample 565-1,CC. **14.** *Globigerinita glutinata* s.l., ×186, Sample 565-30-5, 66–68 cm. **15.** *Globigerinita uvula*, ×286, Sample 569-13-2, 6–10 cm. **16.** *Globigerinita iota*, ×300, Sample 568-3-3, 121–125 cm.

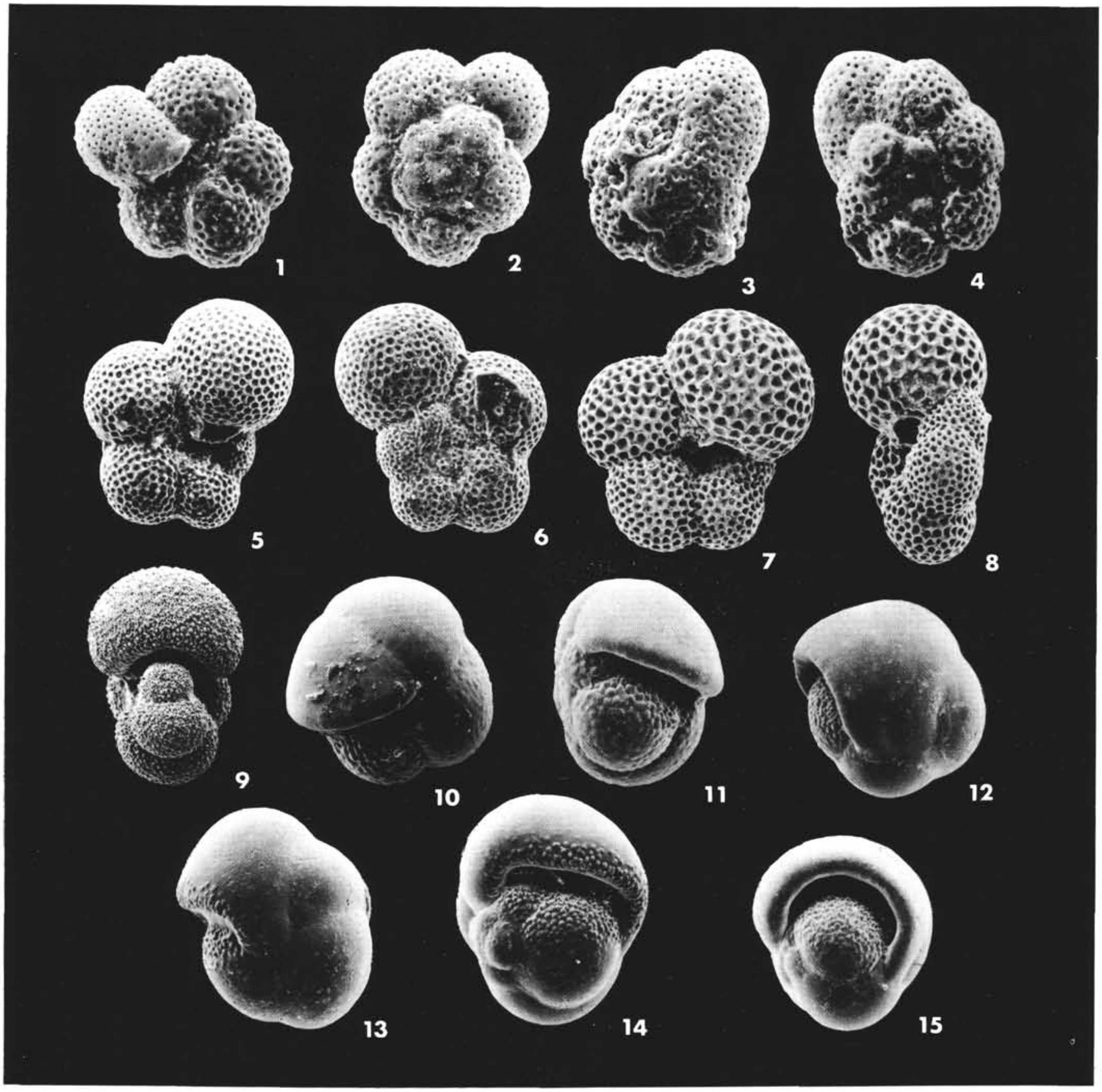

Plate 11. **1, 2.** *Turborotalita quinqueloba*, ×240, Sample 568-9-2, 32–36 cm. **3, 4.** *Turborotalita humilis*, ×87, Sample 565-27-3, 90–93 cm. **5–8.** *Globorotaloides hexagona* (5, 6) ×130, Sample 565-8-2, 54–58 cm, (7, 8) ×173, Sample 569-20-1, 69–73 cm. **9.** *Globigerinella aequilateralis*, ×68, Sample 565-1,CC. **10, 11.** *Pulleniatina primalis*, ×136, Sample 569-8-1, 18–22 cm. **12, 15.** *Pulleniatina finalis*, ×74, Sample 570-11,CC. **13, 14.** *Pulleniatina obliquiloculata*, ×82, Sample 570-3,CC.

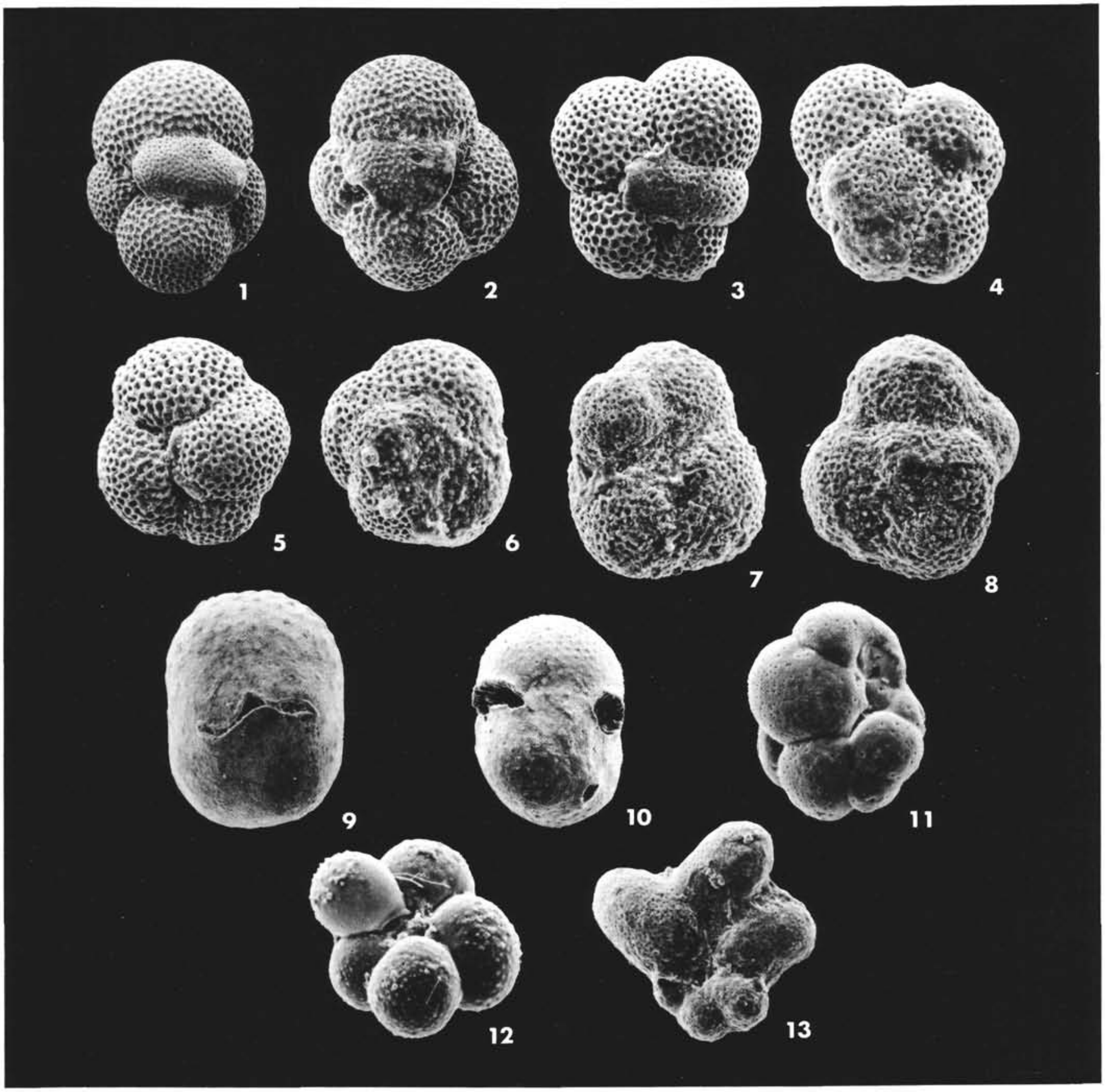

Plate 12. **1.** *Catapsydrax dissimilis dissimilis*, ×78, Sample 567A-4-3, 84–88 cm. **2.** *Catapsydrax dissimilis ciperoensis*, ×100, Sample 567A-4-3, 84–88 cm. **3, 4.** *Catapsydrax stainforthi*, ×197, Sample 568-40-5, 55–57 cm. **5, 6.** *Catapsydrax unicavus unicavus*, ×176, Sample 569-14-2, 53–57 cm. **7, 8.** *Sphaeroidinellopsis disjuncta*, ×196, Sample 567A-4,CC. **9.** *Sphaeroidinellopsis subdehiscens*, ×157, Sample 565-24-3, 52–56 cm. **10.** *Sphaeroidinella dehiscens*, ×78, Sample 565-7-67, 58–62 cm. **11.** *Cassigerinella chipolensis*, ×373, Sample 568-41-1, 66–70 cm. **12.** *Hastigerinopsis riedeli*, ×300, Sample 570-9-2, 20–24 cm. **13.** *Protentella prolixa*, ×164, Sample 565-33-1, 109–113 cm.