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2. NEOGENE PLANKTONIC FORAMINIFER BIOSTRATIGRAPHY AT SITE 999, WESTERN CARIBBEAN SEA[1]

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ABSTRACT

Planktonic foraminifers were examined in at least three samples per core at Site 999 in the western Caribbean Sea (12°45'N, 78°44'W; 2829 m water depth) through sediments representing the last ~18 m.y. An age model for Hole 999A was constructed using the available magnetic reversal record (down to the top of the Gilbert Chron, 3.58 Ma) and selected planktonic foraminifer datum ages. Near 10 Ma an interval of extremely slow accumulation (5 m/m.y.) corresponds to the "carbonate crash" detected in other Leg 165 studies. Planktonic foraminifer datum ages, as calculated with the Hole 999A age model, are compared to the astrochronological ages assigned to datums at Ceara Rise (Leg 154) and to other published ages. Although there is general agreement, some significant differences are found that may be attributed to either regional paleoceanographic conditions or to shortcomings of the age model for this site. In the middle Miocene temperate latitude globoconellids (*Globoconella praescitula, Gc. panda,* and *Gc. miozea*) and in the upper Miocene *Neogloboquadrina pachyderma* (s) are found regularly at Site 999, suggesting the existence of an influx of cool Pacific surface water and/or regional seasonal upwelling before the emergence of the Central American Isthmus. Menardellid species (*Menardella miocenica, M. pertenuis,* and *M. exilis*) endemic to the tropical Atlantic are all encountered at this Caribbean site, although not as regularly or in as large numbers as they were found in the western tropical Atlantic (Leg 154). Several species that were absent from the tropical Atlantic for much of the Pliocene were also found to be missing from the Caribbean record during similar intervals.

INTRODUCTION

Planktonic foraminifer biostratigraphy at Site 999 reveals several unusual biotic events. Leg 165 was the first Ocean Drilling Program (ODP) cruise wholly devoted to study of the Caribbean Sea. The Deep Sea Drilling Project (DSDP) visited the area twice: on Leg 15 (Edgar, Saunders, et al., 1973) and to drill one site, Site 502, on Leg 68 (Prell, Gardner, et al., 1982). Keigwin (1982) mentioned the occurrence of sinistrally coiled *Neogloboquadrina pachyderma* in an interval in the uppermost Miocene of DSDP Site 502 and suggested that its presence was linked to seasonal upwelling. We documented the occurrence of this taxon through this interval at several Leg 165 sites (Sigurdsson, Leckie, Acton et al., 1997) and we examine it more closely in this study. The timing for the last occurrence (LO) of *N. pachyderma* (s) in the western Caribbean suggests that progressive shoaling of the Central American Isthmus may have eliminated postulated seasonal upwelling in the earliest Pliocene. In the middle Miocene sediments we found several members of the temperate-latitude *Globoconella* clade occurring regularly at tropical Site 999. This event is generally coeval with occurrences of this clade in the western equatorial Pacific (Chaisson and Leckie, 1993) and the eastern equatorial Atlantic (Norris, 1998).

Since the time of DSDP Legs 15 and 68 many more planktonic foraminifer datums have been assigned ages either by tying events to the global geopolarity time scale (Berggren et al., 1985; 1995a; 1995b) or by tying events to an astrochronological time scale (e.g., Leg 154 sites; Chaisson and Pearson, 1997, and Pearson and Chaisson, 1997). Reliable magnetic stratigraphy at Site 999 extends down only to the Gilbert Chron (see King et al., Chap. 8, this volume), so at present no independent means of age determination is possible in most of the section. However, ages of datums are estimated between the marker species of zone bases or other species that are deemed reliable and the ages of intervening datums have been estimated by interpolation. Ages thus derived are compared to those that were determined at Ceara Rise (western tropical Atlantic; Leg 154) using the astrochronological time scales of Bickert et al. (1997), Tiedemann and Franz (1997), and Shackleton and Crowhurst (1997) and also compared to published age estimates in Berggren et al. (1995a, 1995b).

Ages of planktonic foraminifer datums (both first and last appearances) at this site were often slightly older than those determined at Site 925 in the western tropical Atlantic using an astrochronological time scale (Chaisson and Pearson, 1997). This holds true even for the interval for which there is the independent control of a magnetic reversal record, which suggests that it is not merely a systematic bias in the Site 999 age model. Two datums, the first occurrence (FO) of *Globigerinoides extremus* and of *Candeina nitida,* are 1.8 and 2.0 m.y. older than their published datum ages, which suggests that these taxa may have evolved in the western Caribbean.

SITE DESCRIPTION

Site 999 (12°45'N, 78°44'W; 2829 m water depth) is located on a previously unnamed rise in the Colombian Basin of the western Caribbean (Fig. 1). The name "Kogi Rise" was suggested during Leg 165, and refers to a tribe of the Sierra Nevada de Santa Maria in nearby Colombia. The rise is 150 km northeast of Mono Rise and southeast of the Hess Escarpment, and its crest lies 1000 m above the floor of the Colombian Basin, which is filled with turbidites from the Magdalen Fan and the Hess Escarpment (Burke et al., 1984; Bowland, 1993).

Site 999 is located beneath the Caribbean Current, an extension of the North Equatorial and North Brazil Currents. The Central American Isthmus diverts the warm saline water in this windblown current northward through the Yucatan Channel into the Gulf of Mexico where it is entrained in the Gulf Stream and brought to the subpolar

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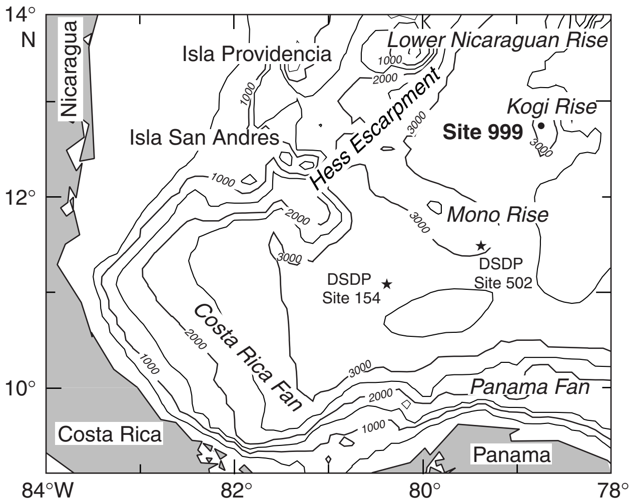

Figure 1. Bathymetric map of the western Colombian Basin including the locations of Site 999 and DSDP Sites 502 and 154. Contours are in meters.

North Atlantic. Several large eddies are present on the flanks of this current, including one in the large embayment between Nicaragua and Colombia (Sverdrup et al., 1942). Through the Cenozoic, changes in the elevation of tectonically controlled gateways have altered the path of surface water through the Caribbean (Berggren and Hollister, 1977; Coates and Obando, 1996). The Aves Ridge and Lesser Antilles arc to the east and the Central American Isthmus to the west have risen and the Nicaraguan Rise to the north has foundered (see summary of tectonic history in Sigurdsson, Leckie, Acton, et al., 1997).

Sediment accumulation at Site 999 was apparently continuous from the late Maastrichtian through the Pleistocene, although there are some condensed intervals. Hole 999A was cored to a depth of 566.1 meters below seafloor (mbsf) and terminated in lower Miocene clayey calcareous chalk. The upper 197.6 m of the hole (to the upper Miocene) was cored with the advanced hydraulic piston corer (APC) and achieved 104.6% recovery. (The figure exceeds 100% because of sediment expansion after decompression.) The remainder was cored with the extended core barrel (XCB) and there was 89% recovery (Sigurdsson, Leckie, Acton, et al., 1997).

The sediments of Hole 999A are divided into three lithostratigraphic units. Unit I extends from Core 165-999A-1H to Section 165-999A-29X-5, 74 cm (0.0–265.1 mbsf; Pleistocene to lower upper Miocene). It consists of nannofossil clayey mixed sediment with foraminifers, foraminiferal clayey mixed sediment with nannofossils, nannofossil clayey mixed sediment with foraminifers and pteropods, clayey nannofossil mixed sediment, and clayey nannofossil ooze. Volcanic ash is found both dispersed and in discrete layers (Sigurdsson, Leckie, Acton, et al., 1997). Three subunits (IA, IB, and IC) are based on variations in the abundance of foraminifers and the occurrence of siliceous microfossils. Unit II extends from Section 165-999A-29X-5, 74 cm, to 38X-2, 63 cm (265.1–346.9 mbsf; lower upper Miocene to lower middle Miocene). It consists of indurated mixed sediments and indurated clays with nannofossils. Two subunits (IIA and IIB) are distinguished by varying abundances of siliceous microfossils plus changes in carbonate content, magnetic susceptibility, and color reflectance. Unit III extends from Section 165-999A-38X-2, 63 cm, to 61X-CC (346.9–566.1 mbsf; lower middle Miocene to lower? lower Miocene). It consists largely of clayey calcareous chalk with foraminifers and clayey nannofossil chalk with foraminifers. Volcanic ash is extremely common in Unit III sediments (Sigurdsson, Leckie, Acton, et al., 1997).

METHODS

Samples were soaked in a neutral mixture of dilute hydrogen peroxide and Calgon for one to six hours. Chalky samples were manually broken up after an initial period of soaking to assist complete disaggregation. All samples below the upper Miocene level were freeze dried before soaking. Disaggregated material was wet sieved through a 63-µm screen, and the >63-µm fraction was dried in an oven at <24°C. The material was then dry sieved through a 150-µm screen and the fractions were archived separately.

The >150-µm fraction was examined thoroughly in order to include rare species. At least two trays of sediment were inspected. Relative abundance estimates are based on the >150-µm fraction. Three categories of abundance were employed: rare (1%–3%), few (4%–15%), and common (16%–30%). Preservation of foraminifers was classed as either good (>90% of specimens unbroken; few signs of dissolution), moderate (30%–90% of specimens unbroken or dissolved), or poor (>90% of specimens broken or dissolved). No samples were examined that meet the ODP criteria for "excellent" preservation.

Generally, three samples per core were examined in detail. Those samples were usually drawn from section 2, section 5, and the core catcher. Datum levels are estimated by interpolation between these sample depths. The ages of samples are determined by interpolating between planktonic foraminifer datums that have reliable age estimates. Reliability is judged by the relative invariability of a datum from site to site at well-dated sites with good preservation and recovery.

ZONAL CRITERIA

We follow the zonal scheme of Blow (1959, 1969) as emended by Srinivasan and Kennett (1981a, 1981b) and Kennett and Srinivasan (1983), excluding the subdivision of Zone 17, which is not possible due to the truncation of the range of *Pulleniatina primalis* in Hole 999A (Fig. 2). This species does not appear until the uppermost Miocene at Site 999, as was the case at Site 925 in the western equatorial Atlantic (Chaisson and Pearson, 1997).

Ages for zonal boundaries are those of Berggren et al. (1995a, 1995b), but with some exceptions, which are noted below. The age of the zone base is included in parentheses below.

Zone N22

Age: latest Pliocene to Holocene (2.0–0.0 Ma)

Definition: total range of Globorotalia truncatulinoides

Discussion: The FO of *Globorotalia truncatulinoides* has been shown to be diachronous between the subtropics and the tropics, but within the tropics this subtropical species seems to have appeared isochronously (Spencer-Cervato et al., 1994).

Occurrence in Hole 999A: Sample 165-999A-1H-2, 42–44 cm, to 8H-2, 42–44 cm (1.92–66.52 mbsf)

Zone N21/N20

Age: middle to late Pliocene (3.6–2.0 Ma)

Definition: interval between the FO of *Menardella miocenica* and the FO of *Globorotalia truncatulinoides*

Discussion: *Globorotalia tosaensis* was found in only one sample (Sample 165-999A-9H-CC). Therefore, Zone N21 cannot be accurately delineated.

Occurrence in Hole 999A: Sample 165-999A-8H-5, 42–44 cm, to 11H-5, 42–44 cm (71.02–99.52 mbsf)

Zone N19

Age: early Pliocene to latest Miocene (5.6–3.6 Ma)

Definition: interval between the FO of *Sphaeroidinella dehiscens* s.l. and the FO of *Menardella miocenica*

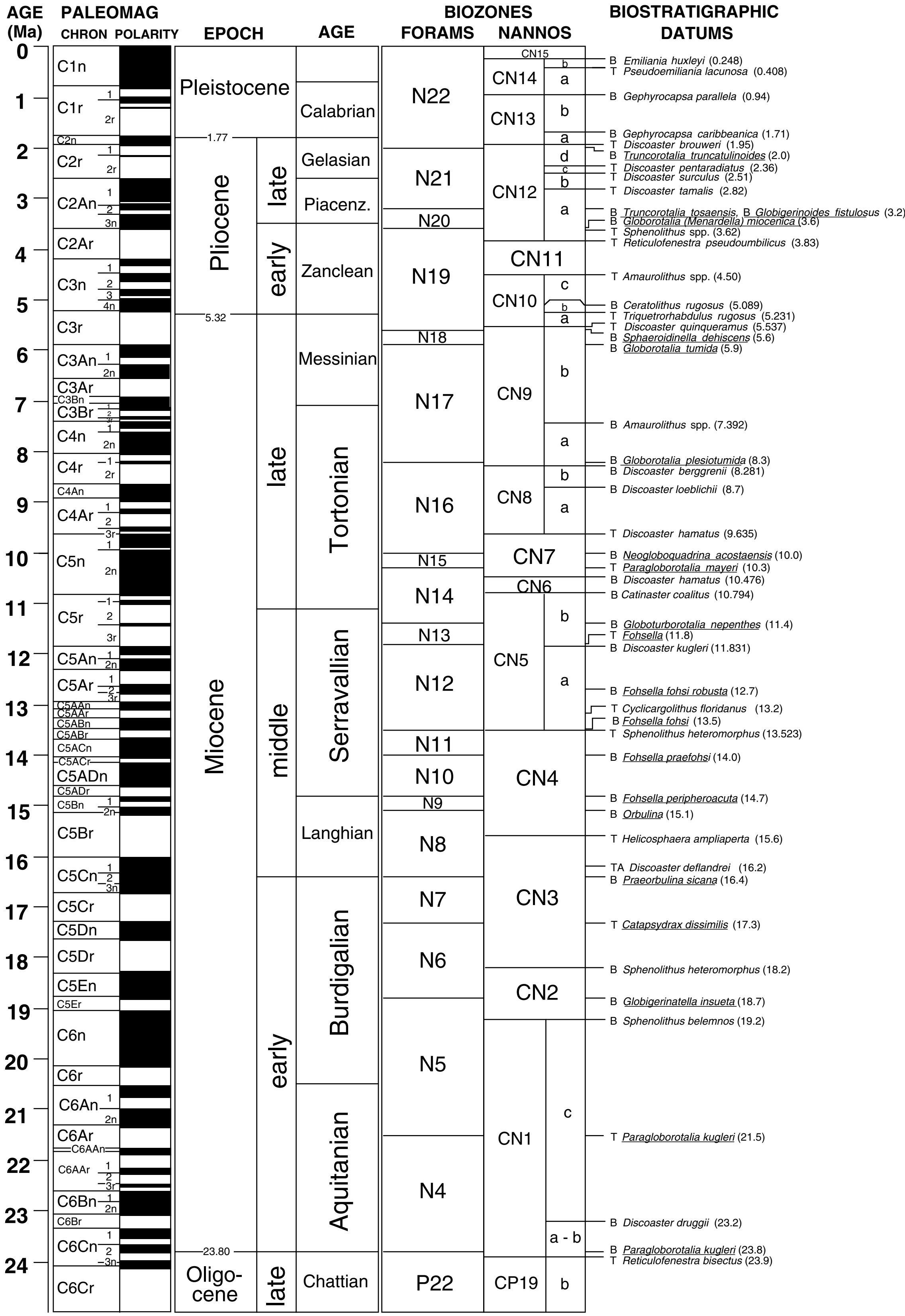

Figure 2. Planktonic foraminifer and nannofossil biozones are shown with the geopolarity time scale and epoch and stage boundaries. Planktonic foraminifer and nannofossils datums are listed with datum ages from Curry, Shackleton, Richter, et al. (1995). Planktonic foraminifer names are underlined. B = base, T = top, TA = top abundant. Figure drafted by M. Leckie for use during Leg 165 (Sigurdsson, Leckie, Acton, et al., 1997).

Discussion: Berggren et al. (1995a) place the first appearance datum (FAD) of *S. dehicens* s.s. at 3.25 Ma. Malmgren et al. (1996) report the occurrence of specimens with minute supplementary apertures (*sensu lato*) as old as 6.08 Ma (Malmgren et al. age revised according to Cande and Kent, 1992) at the western Caribbean DSDP Site 502 (see "Taxonomic Notes"). The base of Zone N19 was drawn beneath the lowest *S. dehiscens* specimen with a secondary aperture visible using light microscopy.

Occurrence in Hole 999A: Sample 165-999A-11H-CC, to 17H-CC (102.58–159.58 mbsf)

Zone N18/17

Age: late Miocene (8.3–5.6 Ma)
Definition: interval between the FO of *Globorotalia plesiotumida* and the FO of *Sphaeroidinella dehiscens* s.l.
Discussion: Zone N18 was not delineated at Site 999 because the stratigraphic range of *Globorotalia tumida* is discontinuous in Hole 999A (as it was at Site 925 in the western tropical Atlantic; Chaisson and Pearson, 1997). It is found in only one sample (Sample 165-999A-18H-2, 42–44 cm) in the late Miocene portion of its range (see "Taxonomic Notes").
Occurrence in Hole 999A: Sample 165-999A-18H-2, 42–44 cm, to 26X-5, 50–52 cm (161.52–236.00 mbsf)

Zone N16

Age: late Miocene (10.0–8.3 Ma)
Definition: interval between the FO of *Neogloboquadrina acostaensis* and the FO of *Globorotalia plesiotumida*
Occurrence in Hole 999A: Sample 165-999A-26X-CC, to 29X-5, 41–43 cm (239.08–264.81 mbsf)

Zone N15

Age: middle to late Miocene transition (10.3–10.0 Ma)
Definition: interval between the LO of *Paragloborotalia mayeri* and the FO of *Neogloboquadrina acostaensis*
Occurrence in Hole 999A: Sample 165-999A-29X-CC (267.98 mbsf)

Zone N14

Age: late middle Miocene (11.4–10.3 Ma)
Definition: interval between the FO of *Globoturborotalita nepenthes* and the LO of *Paragloborotalia mayeri*
Discussion: Zone M13 of Berggren et al. (1995b) is also delineated by the FO of *Globoturborotalita nepenthes,* but the age of this datum is given as 11.8 Ma. This age is probably derived from work done by Berggren (1993) and Miller et al. (1994) on the Buff Bay section in Jamaica (see Schneider et al., 1997). The datum age in Berggren et al. (1985) is given as 11.3 Ma. When that age is converted using the "Leg 154 time scale" (based largely on the astrochronological time scale of Shackleton et al., 1995) it becomes 11.6 Ma.
Occurrence in Hole 999A: Sample 165-999A-30X-2, 43–45 cm, to 32X-5, 42–44 cm (269.93–293.62 mbsf)

Zone N13

Age: middle Miocene (11.8–11.4 Ma)
Definition: interval between the LO of *Fohsella fohsi* s.l. and the FO of *Globoturborotalita nepenthes*
Occurrence in Hole 999A: Sample 165-999A-32X-CC, 37–40 cm, to 33X-1, 41–43 cm (296.68–297.11 mbsf)

Zone N12

Age: middle Miocene (13.5–11.8 Ma)
Definition: the total range of *Fohsella fohsi* s.l.
Discussion: Specimens of *F. fohsi* with complete peripheral keels were quite rare at Site 999. In several samples below Sample 165-999A-33X-CC, 18–20 cm, there were specimens that were incompletely carinate. These specimens were considered *Fohsella praefohsi* to agree with the definition used by Chaisson and Leckie (1993). See "Taxonomic Notes."
Occurrence in Hole 999A: Sample 165-999A-33X-CC, 18–20 cm, and 34X-2, 41–43 cm (306.28–308.21 mbsf)

Zone N11

Age: middle Miocene (14.0–13.5 Ma)
Definition: Interval between the FO of *Fohsella praefohsi* and the FO of *Fohsella fohsi* s.l.
Discussion: Chaisson and Leckie (1993) describe *F. praefohsi* in the western equatorial Pacific (Site 806) with a peripheral keel on the last two or three chambers. At Site 999 the keel is more complete (present on five or six chambers) on many specimens in Core 165-999A-34X, and the top of 35X, but it does not extend 360° around the final whorl. See discussion in "Taxonomic Notes."
Occurrence in Hole 999A: Sample 165-999A-34X-2, 41–43 cm, to 36X-5, 35–37 cm (308.21–331.45 mbsf)

Zone N10

Age: middle Miocene (14.7–14.0 Ma)
Definition: interval between the FO of *Fohsella peripheroacuta* and the FO of *Fohsella praefohsi*
Occurrence in Hole 999A: Sample 165-999A-36X-CC, to 37X-CC (335.18–344.78 mbsf)

Zone N9/N8

Age: early to middle Miocene transition (16.4–14.7 Ma)
Definition: interval between the FO of *Praeorbulina sicana* and the FO of *Fohsella peripheroacuta*
Discussion: *Orbulina universa* is not found below Sample 165-999A-37X-CC (the base of Zone N10) and therefore Zone N9 could not be delineated at this site.
Occurrence in Hole 999A: Sample 165-999A-38X-2, 42–44 cm, to 46X-CC, 27–32 cm (246.72–431.38 mbsf)

Zone N7

Age: early Miocene (17.3–16.4 Ma)
Definition: interval between the LO of *Catapsydrax dissimilis* and the FO of *Praeobulina sicana*
Occurrence in Hole 999A: Sample 165-999A-49X-5, 115–117 cm, to 49X-2, 42–44 cm (433.80–452.66 mbsf)

Zone N6

Age: early Miocene (18.7–17.3 Ma)
Definition: interval between the FO of *Globigerinatella insueta* and the LO of *Catapsydrax dissimilis.* The bottom of Hole 999A is within Zone N6.
Discussion: The definition of *Globigerinatella insueta* has been called into question by Pearson (1995) and Pearson and Chaisson (1997) (see "Taxonomic Notes"). Pearson and Chaisson (1997) assign a new datum age (17.4 Ma) to the *sensu stricto* form (with areal apertures) and another age (20.2 Ma) to the *sensu lato* form (without areal apertures) of this species.
Occurrence in Hole 999A: Sample 165-999A-49X-4, 42–44 cm, to 50X-CC, 37–39 cm (455.62–469.88 mbsf)

SEDIMENT ACCUMULATION RATES

Figure 3 presents the sediment accumulations rates in meters per million years for the last ~18 m.y. at Site 999. Rates are calculated through selected intervals bracketed by planktonic foraminifer datums using datum ages determined at Ceara Rise using the astrochronological time scale for Leg 154 sites. Datums are also plotted for both published ages and the "Ceara Rise ages" determined using the astrochronological time scales of Bickert et al. (1997), Tiedemann and Franz (1997), and Shackleton and Crowhurst (1997). All datums identified in Hole 999A are shown in Table 1. The selected datums used to construct the age/depth relationship in Figure 3 are shown in Table 2.

A short interval of low sediment accumulation is suggested in the middle Pliocene sediments between the FO of *Menardella miocenica*

(3.6 Ma) and the LO of *Dentoglobigerina altispira* (3.0 Ma). However, paleomagnetic datums identified through this interval (King et al., Chap. 8, this volume) show that, in fact, *M. miocenica* enters the record "late" at this site, and the apparent low accumulation rate is an artifact (Fig. 4).

The interval of the "carbonate crash," a period of minimal carbonate accumulation observed at most Leg 165 sites (Sigurdsson, Leckie, Acton, et al., 1997), is partly represented by a low rate of accumulation between the FO of *Neogloboquadrina acostaensis* (9.8 Ma; Ceara Rise age) and the LO of *Paragloborotalia mayeri* (10.5 Ma; Ceara Rise age). However, these datums bracket a shorter interval of minimal carbonate accumulation as determined shipboard (Sigurdsson, Leckie, Acton, et al., 1997) and the calculated accumulation rate does not accurately reflect the period of slowest accumulation at this site.

The relatively high rate of accumulation that is calculated between the FO of *Fohsella fohsi* (13.4 Ma; Ceara Rise age) and LO of *Catapsydrax dissimilis* (17.3 Ma) is accompanied by a shift to chalk and a deterioration of foraminifer preservation at this site to "poor" and "moderate" grades.

PLANKTONIC FORAMINIFER DATUMS

Datums are constrained, on average, to ±1.6 m (Table 1). The age model employed is based on (1) the "Leg 154 time scale" (Curry, Shackleton, Richter, et al., 1995) and uses a combination of several tuned age models (Shackleton et al., 1990; Hilgen, 1991a, 1991b; Shackleton et al., 1995) and the Cande and Kent (1992) revision of the geopolarity time scale to convert ages from tables in Berggren et al. (1985), and (2) selected published ages for planktonic foraminifer datums in Berggren et al. (1995a, 1995b). Some datum ages, especially in the middle to late Miocene transition, may therefore differ from those in Berggren et al. (1995b) for reasons addressed in Schneider et al. (1997). The Ceara Rise ages cited in the results presented below are based on the astrochronological time scales of Bickert et al. (1997), Tiedemann and Franz (1997), and Shackleton and Crowhurst (1997). A comparison of the published ages of datums and those determined at Ceara Rise and at Site 999 is presented in Table 3. The ranges of all species that occur in more than two samples from Hole 999A are presented in Appendix A. Table 4 presents the records of those species that occur in two or fewer samples in Hole 999A. Table 5 is a list of datums (paleomagnetic and foraminifer) used to construct the age model and assign the ages to samples (Appendix B) that are used in the following section. Ceara Rise ages were used for datums in the Miocene below the FO of *G. plesiotumida.*

Candeina

Berggren et al. (1995b) suggest an age of 8.1 Ma for FO of *Candeina nitida* based on results from Site 806 in the western equatorial Pacific, but at Ceara Rise this event was determined to be at 8.44 Ma. At Site 999 the FO of *C. nitida* is between Samples 165-999A-29X-5, 41–43 cm, and 29X-2, 41–43 cm (10.28 ± 0.12 Ma).

Fohsella

The age of the FO of *Fohsella birnageae* is 16.7 Ma according to Berggren et al. (1995b), but in Hole 999A the FO of this species is between Samples 165-999A-49X-2, 46–48 cm, and 48X-CC, 36–38 cm (17.24 ± 0.05 Ma). Chaisson and Leckie (1993) also found *F. birnageae* at Site 806 (western equatorial Pacific) in sediments dated older than the published age (Berggren et al., 1995b). In the lowest sample in its range at Site 999 it accounts for >3% of the assemblage. At Ceara Rise this species is found down to the base of Zone N5 (21.6 Ma; Pearson and Chaisson, 1997). On the other hand, *F. birnageae* does not extend up into the lower half of Zone N8 at Site 999, as is indicated by Kennett and Srinivasan (1983). Instead, its occurrence is confined to Zone N7 in Hole 999A.

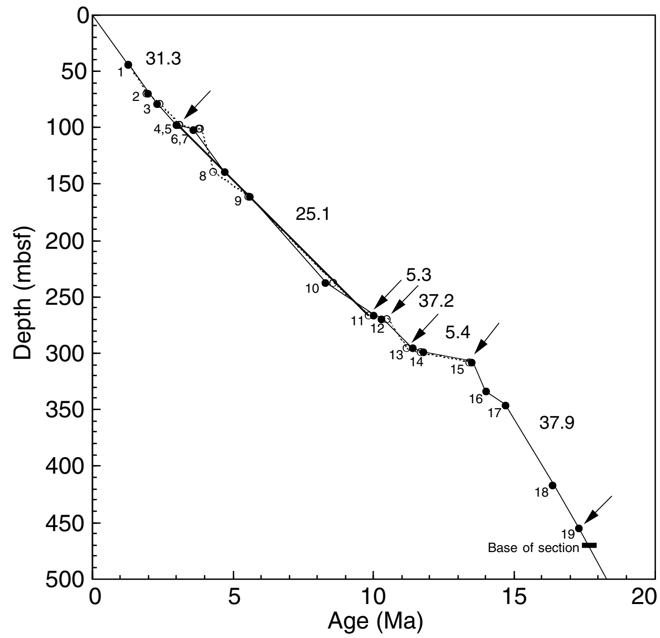

Figure 3. The age/depth relationship for planktonic foraminifer datums in Hole 999A. Filled circles mark positions of datums using the published ages (Curry, Shackleton, Richter, et al., 1995) and open circles mark the positions using Ceara Rise ages (Chaisson and Pearson, 1997). Sediment accumulation rates (m/m.y.) are calculated using published ages between points indicated by arrows. Numbers (1–19) refer to species listed in Table 2.

The age of the LO of *Fohsella peripheroronda* is 14.6 Ma according to Berggren et al. (1995b). In Hole 999A the LO of this species is between Samples 165-999A-37X-2, 60–62 cm, and 36X-CC, 35–37 cm, for an estimated age of 14.16 ± 0.06 Ma. However, stratigraphic problems related to incomplete recovery in Core 165-999A-36X and the presence of several volcanic ash layers in Core 37X may have distorted the position of this datum.

The series of fohsellid FOs that mark the bases of Zones N10, N11, and N12 are all located in Hole 999A, although the interval may be somewhat condensed. The numbers of *Fohsella praefohsi* and *Fohsella fohsi* are low in all samples examined. The FO of *Fohsella peripheroacuta* (14.7 Ma; Pearson and Chaisson, 1997) is between Samples 165-999A-38X-2, 42–44 cm, and 37X-CC, 25–27 cm, and this species' abundance occasionally exceeds 3% of the assemblage. The FO of *Fohsella praefohsi* (14.0 Ma; Pearson and Chaisson, 1997) is between Samples 165-999A-36X-CC, 35–37 cm, and 36X-5, 35–37 cm. The LOs of both *F. peripheroacuta* and *F. praefohsi* are between Samples 165-999A-33X-6, 42–44 cm, and 33X-3, 42–44 cm (12.51 ± 0.41 Ma). These LOs are only one sample (3.44 m) below the LO of *Fohsella fohsi* (11.8 Ma) between Samples 165-999A-33X-3, 42–44 cm, and 32X-CC, 37–40 cm (11.79 ± 0.31). This is one indication of the condensation of this part of Hole 999A. Another indication is the generally poor preservation of fohsellid specimens. The absence and rarity, respectively, of *F. fohsi lobata* and *F. fohsi robusta,* which globally appear in the upper portion of Zone N12 (Kennett and Srinivasan, 1983), suggests that there is sediment missing from this section. In addition, the bottom of Core 165-999A-32X and the top of Core 33X were highly fractured as a result of the coring

Table 1. Planktonic foraminifer datums, Hole 999A.

	Event	Zone (base)		Age (Ma)	Core, section, interval (cm)		Depth (mbsf)			
		1	2		Upper	Lower	Upper	Lower	Interpol.	(±)
					165-999A-	165-999A-				
LO	*Truncorotalia tosaensis*		Pt1b	0.65	Not observed					
LO	*Globigerinoides obliquus*			1.3	5H-5, 42-55	5H-CC, 14-16	42.52	45.58	44.05	1.53
LO	*Globigerinoides fistulosus*		Pt1a	1.7	8H-2, 42-44	8H-5, 42-44	66.52	71.02	68.77	2.25
FO	*Truncorotalia truncatulinoides*	N22		2.0	8H-2, 42-44	8H-5, 42-44	66.52	71.02	68.77	2.25
LO	*Menardella exilis*			2.2	8H-CC, 24-26	9H-2, 42-44	74.08	76.02	75.05	0.97
LO	*Menardella miocenica*		PL6	2.3	9H-2, 42-44	9H-5, 42-44	76.02	80.52	78.27	2.25
Re	*Pulleniatina* spp. in Atlantic			2.3	8H-CC, 24-26	9H-2, 42-44	74.02	76.02	75.02	1.00
LO	*Menardella limbata*			2.4	10H-3, 32-34	10H-5, 42-44	86.92	90.02	88.47	1.55
LO	*Menardella pertenuis*			2.6	10H-3, 32-34	10H-5, 42-44	86.92	90.02	88.47	1.55
LO	*Menardella multicamerata*			3.0	11H-2, 42-44	11H-5, 42-44	95.02	99.52	97.27	2.25
LO	*Dentoglobigerna altispira*		PL5	3.0	11H-2, 42-44	11H-5, 42-44	95.02	99.52	97.27	2.25
LO	*Sphaeroidinellopsis*		PL4	3.12	11H-CC, 22-25	12H-2, 42-44	102.58	104.52	103.55	0.97
FO	*Truncorotalia tosaensis*	N21		3.20	See Table 4					
FO	*Globigerinoides fistulosus*			3.2	10H-3, 32-34	10H-5, 42-44	86.92	90.02	88.47	1.55
FO	*Menardella pertenuis*			3.5	10H-CC, 34-36	11H-2, 42-44	93.08	95.02	94.05	0.97
Di	*Pulleniatina* spp. in Atlantic			3.5	11H-CC, 22-25	12H-2, 42-44	102.58	104.52	103.55	0.97
LO	*Hirsutella margaritae*		PL3	3.58	12H-5, 42-44	12H-CC, 36-38	109.02	112.08	110.55	1.53
FO	*Menardella miocenica*	N20		3.6	11H-5, 42-44	11H-CC, 22-25	99.52	102.58	101.05	1.53
LO	*Globoturborotalita nepenthes*		PL2	4.3	15H-5, 42-44	15H-CC, 28-31	137.55	140.58	139.07	1.52
LO	*Globorotalia plesiotumida*			4.4	13H-CC, 28-31	14H-2, 42-44	121.58	123.52	122.55	0.97
FO	*Menardella exilis*			4.5	15H-5, 42-44	15H-CC, 28-31	137.55	140.58	139.07	1.52
FO	*Truncorotalia crassaformis*			4.7	15H-5, 42-44	15H-CC, 28-31	137.55	140.58	139.07	1.52
LO	*Hirsutella cibaoensis*		PL1b	5.0	15H-5, 42-44	15H-CC, 28-31	137.55	140.58	139.07	1.52
LO	*Globoquadrina baroemoenensis*			5.5	15H-CC, 28-31	16H-2, 42-44	140.58	142.52	141.55	0.97
FO	*Sphaeroidinella dehiscens*	N19		5.6	17H-CC, 21-23	18H-2, 42-44	159.58	161.52	160.55	0.97
FO	*Globorotalia tumida*	*N18*	*PL1a*	5.9 (5.6)	18H-2, 42-44	18H-5, 42-44	161.52	166.05	163.79	2.27
FO	*Hirsutella margaritae*			6.0	17H-CC, 21-23	18H-2, 42-44	159.58	161.52	160.55	0.97
LO	*Globorotalia lenguaensis*		*M14*	6.0	27H-CC, 25-27	28H-2, 42-44	248.68	250.62	249.65	0.97
FO	*Globigernoides conglobatus*			6.2	17H-5, 42-44	17H-CC, 21-23	156.52	159.58	158.05	1.53
FO	*Hirsutella cibaoensis*			7.7	25X-CC, 20-23	26X-2, 40-42	229.48	231.40	230.44	0.96
FO	*Candeina nitida*			8.0	25X-CC, 20-23	26X-CC, 17-20	229.48	239.08	234.28	4.80
FO	*Globorotalia plesiotumida*	N17		8.3	26X-5. 50-52	26X-CC, 17-20	236.00	239.08	237.54	1.54
FO	*Neogloboquadrina acostaensis*	N16	M13	10.6 (10.9)	29X-5, 41-43	29X-6, 40-42	264.81	266.31	265.56	0.75
LO	*Menardella praemenardii*			10.7	31X-5, 42-44	31X-CC, 37-40	284.02	287.18	285.60	1.58
LO	*Paragloborotalia mayeri*	N15	M12	10.8 (11.4)	30X-1, 42-44	30X-2, 30-32	268.42	269.80	269.11	0.69
FO	*Globoturborotalita apertura*			10.8	29X-2, 41-43	29X-4, 42-44	260.31	263.32	261.82	1.51
FO	*Globoturborotalita nepenthes*	N14	*M11*	11.6 (11.8)	32X-5, 42-44	32X-CC, 37-40	293.62	296.68	295.15	1.53
LO	*Fohsella fohsi*	N13		11.8	33X-1, 41-43	33X-3, 42-44	297.11	300.11	298.61	1.50
LO	*Fohsella robusta*		*M10*	11.8	33X-1, 41-43	33X-3, 42-44	297.11	300.11	298.61	1.50
FO	*Globorotalia lenguaensis*			12.6	34X-5, 39-41	34X-CC, 33-37	312.69	315.98	314.34	1.65
FO	*Fohsella robusta*		*M9b*	12.7	33X-1, 41-43	33X-3, 42-44	297.11	300.11	298.61	1.50
FO	*Fohsella lobata*		*M9a*	13.2	Not observed					
FO	*Fohsella fohsi*	N12	*M8*	13.5 (12.7)	33X-CC, 18-20	34X-2, 41-43	306.28	308.21	307.25	1.93
FO	*Fohsella praefohsi*	N11		13.9	36X-5, 35-37	36X-CC, 35-37	331.45	335.18	333.32	1.87
LO	*Menardella archeomenardii*			14.3	37X-CC, 25-27	38X-2, 42-44	344.78	346.72	345.75	0.97
FO	*Fohsella peripheroacuta*	N10	M7	14.8	37X-CC, 25-27	38X-2, 42-44	344.78	346.72	345.75	
FO	*Menardella praemenardii*			14.9	37X-5, 40-42	37X-CC, 25-27	341.60	344.78	343.19	1.59
FO	*Orbulina universa*	*N9*	*M6*	15.1	37X-5, 40-42	37X-CC, 25-27	341.60	344.78	343.19	1.59
FO	*Praeorbulina glomerosa* s.s.		*M5b*	16.1	Not observed					
FO	*Praeorbulina sicana*	N8	M5a	16.4	45X-2, 42-44	45X-5, 38-40	414.02	418.48	416.25	2.23
FO	*Globorotalia birnageae*		M4b	16.7	48X-CC, 36-38	49X-2, 46-48	450.68	452.66	451.67	0.99
LO	*Catapsydrax dissimilis*	N7	M4a	17.3	49X-2, 46-48	49X-4, 42-44	452.66	455.62	454.14	1.48
LO	*Globigerinoides altiapertura*			20.5	43X-CC, 34-37	44X-CC, 38-40	402.48	412.08	407.28	4.80

Notes: Zone 1 = Blow (1969) zonal scheme; Zone 2 = Berggren et al. (1995a, 1995b) zonal scheme. Ages are from Curry, Shackleton, Richter, et al. (1995). Ages in parentheses are those of Berggren et al. (1995a, 1995b). The names of zones that could not be accurately delimited in Hole 999A are italicized. Re = re-entrance, Di = disappearance.

Table 2. Planktonic foraminifer datums used to construct age/depth plot.

Event	Zone (base)	Datum age (Ma)*	Depth (mbsf)	Tuned age (Ma)§
1. LO *Globigerinoides obliquus*		1.3	44.05	1.30
2. FO *Truncorotalia truncatulinoides*	N22	2.0	68.77	1.92
3. LO *Menardella miocenica*		2.3	78.27	2.38
4. LO *Menardella multicamerata*		3.0	97.27	3.10
5. LO *Dentoglobigerna altispira*		3.0	97.27	3.11
6. FO *Menardella miocenica*	N21/N20	3.6	101.05	3.77
7. LO *Hirsutella margaritae*		3.6	110.55	3.85
8. FO *Truncorotalia crassaformis*		4.7	139.07	4.31
9. FO *Sphaeroidinella dehiscens*	N19	5.6	160.55	5.54
10. FO *Globorotalia plesiotumida*	N18/N17	8.2	237.54	8.58
11. FO *Neogloboquadrina acostaensis*	N16	10.0	265.56	9.82
12. LO *Paragloborotalia mayeri*	N15	10.3	269.11	10.49
13. FO *Globoturborotalita nepenthes*	N14	11.4	295.15	11.19
14. LO *Fohsella fohsi*	N13	11.8	298.61	11.68
15. FO *Fohsella fohsi*	N12	13.5	307.25	13.42
16. FO *Fohsella praefohsi*	N11	14.0	333.32	–
17. FO *Fohsella peripheroacuta*	N10	14.7	345.75	–
18. FO *Praeorbulina sicana*	N9/N8	16.4	416.25	–
19. LO *Catapsydrax dissimilis*	N7	17.3	454.14	–

Notes: *Ages are from Curry, Shackleton, Richter, et al. (1995). §Ages are from Site 925, a section tuned by Bickert et al. (1997), Tiedemann and Franz (1997), and Shackleton and Crowhurst (1997).

process (Sigurdsson, Leckie, Acton, et al., 1997). In addition to its rarity, the keel morphology of *F. fohsi* is not well developed at this site (see "Taxonomic Notes"), which makes firm placement of the base of Zone N12 difficult.

Globigerina

Globigerina falconensis occurs through three intervals at Site 999; ~11–9, 6–4, and 2–0.5 Ma. It is almost always rare and its FO at Site 999 (at 12.4 Ma in Zone N12) is well above its published first appearance in Zone N7 (Kennett and Srinivasan, 1983). *Globigerina bulloides* is present more consistently, but its FO at Site 999 coincides with that of *G. falconensis* and is well above its published first appearance in Zone N9. It is usually rare at this site and exceeds 3% of the assemblage in only four samples (two in the late Miocene and the early Pliocene "pachyderma interval" and two in the late Pliocene).

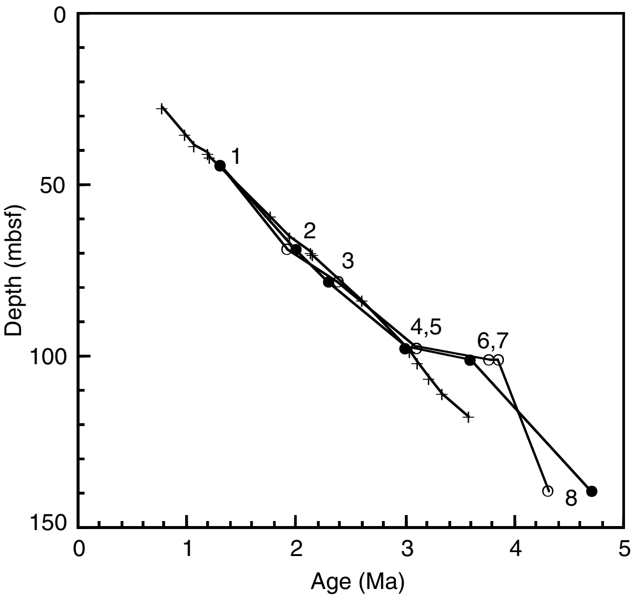

Figure 4. The age/depth relationship for planktonic foraminifer datums (symbols as in Fig. 3) and magnetic reversal onsets and terminations (crosses). Magnetic reversal data is from King et al. (Chap. 8, this volume). Numbers (1–8) refer to species listed in Table 2.

Globigerinoides

The interpolated age of the LO of *Globigerinoides obliquus* above Sample 165-999A-5H-CC, 14–16 cm (1.31 ± 0.05 Ma), corresponds well to its LO at Ceara Rise (1.3 Ma). *Gs. obliquus* is more abundant than *Globigerinoides ruber* below Sample 165-999A-11H-5, 42–44 cm (3.11 ± 0.05 Ma), and is much more abundant than *Gs. ruber* below Sample 165-999A-13H-5, 42–44 cm (3.72 ± 0.08 Ma). It occurs quite consistently to the base of lower Miocene Zone N7, but only one specimen is found in the remaining five samples between Sample 165-999A-49X-2, 46–48 cm, and the bottom of the section examined. Sample 165-999A-31X-2, 42–44 cm (10.78 Ma), represents a transition; above this point *Gs. obliquus* dominates the assemblage compared to *Globigerinoides sacculifer* and below it is subordinate to *Gs. sacculifer.*

The LO of *Globigerinoides extremus* is between Samples 165-999A-10H-5, 42–44 cm, and 10H-3, 42–44 cm (2.74 ± 0.05 Ma), considerably lower than its published last appearance (1.77 Ma; Berggren et al., 1995a) or its LO at Ceara Rise (1.98 Ma). By contrast, this species seems to persist downsection at Site 999 to levels equivalent to ages much older than its published age (8.3 Ma; Berggren et al., 1995b) or its Ceara Rise age (8.58 Ma; Chaisson and Pearson, 1997). The FO of *Gs. extremus* is between Samples 165-999A-29X-CC, 37–39 cm, and 29X-5, 41–43 cm, which corresponds to an age of 10.31 ± 0.11 Ma. *Candeina nitida,* the published age of which is close to that of *Gs. extremus,* is also found lower than expected at this site, which suggests either a problem with the age model or that both of these species evolved in the western Caribbean Sea.

Table 3. Site 999 and Site 925 datum ages compared.

	Datum Ages (Ma)				
Datum	Caribbean Sea Site 999	Western Atlantic Site 925	Difference (Site 999-Site 925)	Published Age	Ref.
LO *Globigerinoides obliquus*	1.31 ± 0.05	1.3	0.01	1.3	3
LO *Globigerinoides fistulosus*	2.10 ± 0.05	1.88	0.22	1.6	2
LO *Globoturborotalita apertura*	2.54 ± 0.05	1.61	0.93	1.9	1
LO *Globigerinoides extremus*	2.74 ± 0.05	1.98	0.76	1.9	2
FO *Truncorotalia truncatulinoides*	2.10 ± 0.05	1.92	0.08	2.0	1
FO *Globoconella inflata*	2.00 ± 0.06	2.18	–0.18	2.09	2
LO *Menardella exilis*	2.31 ± 0.05	2.09	0.22	2.15	2
LO *Globoturborotalita woodi*	2.54 ± 0.05	2.33	0.21	2.3	1
LO *Menardella miocenica*	2.42 ± 0.05	2.38	0.04	2.3	1
LO *Menardella limbata*	2.74 ± 0.05	2.38	0.36	2.38	3
LO *Menardella pertenuis*	2.54 ± 0.05	2.33	0.21	2.6	2
LO *Menardella multicamerata*	3.00 ± 0.05	3.11	–0.11	3	1
LO *Dentoglobigerina altispira*	3.00 ± 0.05	3.11	–0.11	3	1
LO *Globoquadrina venezuelana*	3.00 ± 0.05	3.08	–0.08	—	
LO *Sphaeroidinellopsis seminulina*	3.45 ± 0.06	3.11	0.34	3.12	2
FO *Menardella pertenuis*	3.27 ± 0.06	3.52	–0.25	3.5	1
LO *Hirsutella margaritae*	3.37 ± 0.06	3.85	–0.48	3.6	2
LO *Globoturborotalita nepenthes*	4.69 ± 0.07	4.39	0.37	4.3	2
LO *Globorotalia plesiotumida*	3.84 ± 0.06	3.77	0.07	4.3	1*
FO *Menardella exilis*	4.69 ± 0.06	4.45	0.24	4.45	3
FO *Globigerinoides conglobatus*	6.27 ± 0.04	6.2	0.07	6.2	1
FO *Hirsutella margaritae*	6.27 ± 0.04	6.09	0.18	6.4	2
FO *Hirsutella cibaoensis*	8.05 ± 0.03	—		7.8	4
FO C*andeina nitida*	10.28 ± 0.12	8.44	1.84	8.1	4
FO *Globigerinoides extremus*	10.31 ± 0.11	8.58	2.00	8.3	4
FO *Neogloboquadrina acostaensis*	10.30 ± 0.01	9.82	0.48	10.0	1
FO *Globoturborotalita apertura*	10.05 ± 0.16	11.19	–1.14	10.8	1
FO *Menardella limbata*	10.58 ± 0.06	10.57	0.33	10.57	3
FO *Globorotalia lenguaensis*	13.57 ± 0.04	12.85	0.72	12.3	3
LO *Fohsella peripheroronda*	14.16 ± 0.06	—		14.6	1
FO *Fohsella birnageae*	17.24 ± 0.05	—		16.7	4

Notes: Ages are in millions of years. Site 925 ages from Chaisson and Pearson (1997). References: 1. Curry, Shackleton, Richter, et al., 1995 (Leg 154 time scale); 2. Berggren et al., 1995a; 3. Chaisson and Pearson, 1997; 4. Berggren et al., 1995b. *Original transformed age corrected in this study.

Table 4. Species with infrequent occurrences, Hole 999A.

Species		Core, section, interval (cm)	Depth (mbsf)	Age (Ma)
		165-999A-		
Streptochilus spp.	R	15H-5, 42-44	137.55	4.62
Catapsydrax stainforthi	*	50X-5, 58-60	466.88	17.54
Catapsydrax unicavus	R	50X-CC, 37-39	469.38	17.60
Globigerina praebulloides	R	48X-5, 41-43	447.51	17.14
Globigerinoides mitra	R	47X-2, 40-42	433.80	16.82
Globigerinoides mitra		47X-5, 41-43	437.81	16.91
Truncorotalia tosaensis	R	9H-CC	83.58	2.59
Tenuitellinata quinqueloba	*	29X-5, 41-43	264.81	10.46
Tenuitella munda	R	40X-2, 41-43	365.91	15.26
Paragloborotalia bella	*	49X-4, 42-44	455.62	17.33
Globorotaloides suteri	R	48X-CC, 36-38	450.68	17.22
Globorotaloides suteri	*	50X-2, 42-44	462.22	17.45
Clavatorella bermudezi	R	39X-5, 41-43	360.81	15.14
Globigerinita uvula	*	28X-5, 42-44	255.12	9.69
Globigerinella obesa	*	28X-2, 42-44	250.62	9.34
Globigerinella obesa		29X-CC	267.98	10.71

Note: R = rare; * = single specimen.

Table 5. Datums used to construct age model for Hole 999A.

Event	Zone (base)	Age (Ma)	Depth (mbsf)
Onset C1n "Brunhes" (o)		0.780	27.50
Onset C2r.1n Reunion" (o)		2.150	70.40
Top C2An.1n "Gauss" (t)		2.600	83.85
Top C2Ar "Gilbert" (t)		3.580	117.45
FO *Truncorotalia crassaformis*		4.7	139.07
FO *Sphaeroidinella dehiscens*	N19	5.6	160.55
FO *Globorotalia plesiotumida*	N18/N17	8.3	237.54
LO *Paragloborotalia mayeri*	N15	10.8	269.11
FO *Globoturborotalita nepenthes*	N14	11.6	295.15
FO *Fohsella fohsi*	N12	13.2	307.25
FO *Fohsella praefohsi*	N11	13.9	333.32
FO *Fohsella peripheroacuta*	N10	14.8	345.75
FO *Praeorbulina sicana*	N9/N8	16.4	416.25
LO *Catapsydrax dissimilis*	N7	17.3	454.14

Notes: Biostratigraphic datum ages are taken from Table 1. Chron ages are from Sigurdsson, Leckie, Acton, et al. (1997). o = onset; t = termination.

The LO of *Globigerinoides altiapertura* at Site 999 is between Samples 165-999A-44X-CC, 38–40 cm, and 43X-CC, 34–37 cm (16.20 ± 0.21 Ma), in the lower part of Zone N8/N9, which corresponds to its published range (Kennett and Srinivasan, 1983). This species is usually more abundant than the similar *Gs. obliquus* where their ranges overlap in Hole 999A.

The age of the FO of *Globigerinoides conglobatus* was found to be 6.20 Ma at Ceara Rise. It is consistently present in Hole 999A down to Sample 165-999A-15H-CC, 28–31 cm. Below this point only scattered specimens are encountered, but the lowest specimen found is in Sample 165-999A-19H-CC, 27–30 cm. *Gs. conglobatus* is therefore present consistently at Site 999 only after 4.80 Ma, but its FO at this site is at 6.27 ± 0.04 Ma, agreeing well with the Ceara Rise age (6.20 Ma).

Globigerinoides ruber is present in Hole 999A from Sample 165-999A-15H-2, 42–44 cm, to the top of the section (the last ~4.5 m.y.). It is often a dominant species in the assemblage above Sample 165-999A-11H-2, 42–44 cm (the last ~3 m.y.). But for the first half of its range (Sample 165-999A-30X-2, 43–45 cm, to 15H-5, 42–44 cm; 10.5–4.7 Ma) this species is rare or absent from the record.

Kennett and Srinivasan (1983) tentatively regarded *Globigerinoides subquadratus* as the ancestor of *Gs. ruber* and their ranges are shown as contiguous. But Bolli and Saunders (1985), whose work was based in the Caribbean, did not recognize *Gs. subquadratus* and showed a discontinuous range for *Gs. ruber* that corresponds to the combined ranges of *Gs. ruber* and *Gs. subquadratus* in Kennett and Srinivasan (1983) but with a break in the upper Miocene part of the range. Indeed, the LO of *Gs. subquadratus* is between Samples 165-999A-31X-5, 42–44 cm, and 31X-2, 42–44 cm (10.84 ± 0.6 Ma, is just below (and ~0.4 m.y. before) the FO of *Gs. ruber* at Site 999. *Gs. subquadratus* is consistently present from its LO to the bottom of the section examined and is frequently the dominant species in the assemblage below Sample 165-999A-40X-CC, 28–30 cm (before 15.37 Ma).

Globigerinoides seigliei occurs in four samples in the upper Miocene section of Hole 999A. It was also reported by Keigwin (1978) at DSDP Site 502. The species does not seem to be cosmopolitan; we have never encountered it except at Site 999.

Globigerinoides sacculifer is present in every sample examined in Hole 999A. Saccate specimens are present in nearly all samples above Sample 165-999A-43X-2, 42–44 cm (the last ~16 m.y.), and the FO of saccate *Gs. sacculifer* is between Samples 165-999A-49X-2, 46–48 cm, and 48X-CC, 36–38 cm (17.24 ± 0.03 Ma). This species (mostly non-saccate specimens) dominates the assemblage in the lower to middle Miocene between Samples 165-999A-40X-CC, 28–30 cm, and 49X-2, 46–48 cm (~15.5–17.3 Ma). Saccate specimens are more abundant than non-saccate ones in several samples above Sample 165-999A-14H-CC, 30–35 cm (the last 4.5 m.y.), but not further down the section.

The LO of *Globigerinoides fistulosus* is found between Samples 165-999A-8H-5, 42–44 cm, and 8H-2, 42–44 cm (2.10 ± 0.05 Ma), at Site 999, and this event is marked by a single specimen. In samples examined for this study the species is extremely rare and not well developed morphologically. However, high-resolution work by R.D. Norris (pers. comm., 1998) at Site 999 has revealed a more complete record and also well-developed *Gs. fistulosus* specimens down to its FO.

Globoconella

The members of this normally temperate-zone genus are surprisingly well represented at western Caribbean Site 999. The FO of *Globoconella inflata* is between Samples 165-999A-8H-2, 42–44 cm, and 7H-CC, 42–44 cm (2.00 ± 0.06 Ma). This is closer to the 2.09 Ma age given by Berggren et al. (1995a) than to the FO observed at Ceara Rise (2.18 Ma). *Gs. inflata* at Site 999 are all the "normal" morphotype rather than the *Gc. triangula* ecophenotype that was observed in the lower part of the *Gc. inflata* range at Ceara Rise and in the eastern tropical Atlantic on Leg 108 (Weaver and Raymo, 1989) and Leg 159 (Norris, 1998). No *Globoconella puncticulata* were observed at Site 999, but at Ceara Rise both *Gc. puncticulata* and transitional specimens between *Gc. puncticulata* and *Gc. triangula* were found.

Several middle Miocene globoconellids ordinarily associated with temperate latitudes appear in Hole 999A samples. *Globoconella miozea* is found most consistently and its LO between Samples 165-999A-31X-2, 42–44 cm, and 30X-CC, 42–44 cm (10.76 ± 0.03 Ma), agrees with the LO shown by Kennett and Srinivasan (1983), but is much later than the 15.7 Ma age cited by Berggren et al. (1995b) based on the record at Site 747 on the Kerguelen Plateau. Berggren et al. (1995b) list the LO of *Globoconella praescitula* at 11.9 Ma (based on Site 747), but the LO of this species at Site 999 is between Samples 165-999A-31X-CC, 37–40 cm, and 31X-5, 42–44 cm (11.00 ± 0.05 Ma). Similarly, the LO of *Globoconella panda* is listed by Berggren et al. (1995b) at 11.8 Ma, but this event is between Samples 165-999A-31X-2, 42–44 cm, and 30X-CC, 42–44 cm (10.76 ± 0.03 Ma), the same position as *Gc. miozea.* However, Kennett and Srinivasan (1983) show the range of *Gc. panda* extending into the late Miocene *Globorotalia mayeri* Zone (= part of Zone N17). *Gc. miozea, Gc. panda,* and *Gc. praescitula* are most abundant and most consistently present during a brief interval between their LOs and the level between Samples 165-999A-33X-CC, 18–20 cm, and 33X-6, 42–44 cm (~13.0–10.8 Ma). Below this level they are either absent (*Gc. panda*) or present only sporadically.

Globorotalia

Globorotalia tumida is present only sporadically in the Site 999 record. It is found most consistently with Zone N22 (the last 2 m.y.) and is essentially absent for all of the Pliocene, except the uppermost part. *Gr. tumida* appears in a single sample in the uppermost Miocene in Hole 999A (Sample 165-999A-18H-2, 42–44 cm; 5.63 Ma). The FO of the species marks the base of Zone N18, but this event could not be determined reliably because of the rarity of *Gr. tumida* in Hole 999A. Berggren et al. (1995a) list the age of this datum as 5.6 Ma. The Leg 154 time scale (Curry, Shackleton, Richter, et al., 1995; Chaisson and Pearson, 1997) includes an incorrect conversion of the Berggren et al. (1985) age (5.2 Ma) for this datum. The correct conversion (using Cande and Kent, 1992) should be 5.7 Ma. However, in Hole 925B at Ceara Rise the age of the FO of *Gr. tumida* was found to be 5.82 (Chaisson and Pearson, 1997) according to the astrochronological time scale of Shackleton and Crowhurst (1997).

The LO of *Globorotalia plesiotumida* at Site 999 is between Samples 165-999A-14H-2, 42–44 cm, and 13H-CC, 28–31 cm (3.84 ± 0.06 Ma). Berggren et al. (1995a) do not include an age for this datum, but Berggren et al. (1985) did include this datum age. In Curry, Shackleton, Richter, et al., (1995) and Chaisson and Pearson (1997) this datum age was incorrectly converted to 4.4 Ma. The correctly converted age is 4.3 Ma. At Site 925 on Ceara Rise the age of this datum was 3.77 Ma, fairly close to the age estimated at Site 999.

The FO of *Gr. plesiotumida* marks the base of Zone N17. Some confusion surrounds the age of this datum. Berggren et al. (1985) did not include an age for this datum. Chaisson and Leckie (1993) misplotted the depth of the datum and miscalculated the age. Berggren et al. (1995b) corrected the error of Chaisson and Leckie (1993) and presented a revised age of 8.3 Ma. At Site 925 on Ceara Rise the astrochronological age of this datum was determined to be 8.58 Ma (Chaisson and Pearson, 1997). At Site 999 the event is between Samples 165-999A-26X-CC, 17–20 cm, and 26X-5, 50–52 cm. Plotting the depth against the Ceara Rise age (Fig. 3) results in an unchanging sediment accumulation rate at Site 999 through the late Miocene, whereas using the Berggren et al. (1995b) age results in a faster rate above the LO of *Gr. plesiotumida* and a slower rate below this event.

The FO of *Gr. lenguaensis* is between Samples 165-999A-34X-CC, 33–37 cm, and 34X-5, 39–41 cm (13.57 ± 0.04 Ma). This age is older than the astrochronological age (12.85 Ma) estimated at Site 925 on Ceara Rise (Chaisson and Pearson, 1997). This species is not recorded in Hole 999A above Sample 165-999A-28X-2, 42–44 cm (9.15 ± 0.07 Ma). This range bears no resemblance to the published one (Kennett and Srinivasan, 1983) or to ages for the top of the range suggested by Berggren et al. (1995b) or the Leg 154 results (Chaisson and Pearson, 1997), which suggests that its range truncation is a response by this species to regional paleoceanographic conditions.

Globoquadrina and *Dentoglobigerina*

The LO of *Globoquadrina venezuelana* is between Samples 999A-11H-5, 42–44 cm, and 11H-2, 42–44 cm (3.00 ± 0.05 Ma), in the lower part of Zone N21/N20 at Site 999. This is slightly above the top of the range indicated by Kennett and Srinivasan (1983), but agrees well with the age estimated at Ceara Rise (3.08 Ma; Chaisson and Pearson, 1997).

The LO of *Dentoglobigerina altispira* is listed as identical to that of *Menardella multicamerata* (3.09 Ma) by Berggren et al. (1995a). At Site 999 both events are between Samples 165-999A-11H-5, 42–44 cm, and 11H-2, 42–44 cm (3.00 ± 0.05 Ma), which is close to the age determined on Ceara Rise (3.11 ± 0.02 Ma).

Globoturborotalita

The LOs of *Globoturborotalita* species at Site 999 are earlier than have been recorded at other tropical sites. See Table 2 to compare the estimated ages of these events at Site 999 with those noted at other low-latitude sites. The LOs of *Globoturborotalita woodi* and *Gt. apertura* at Site 999 are in Sample 165-999A-9H-CC, 30–32 cm (2.54 ± 0.05 Ma). *Gt. apertura* first occurs in the Site 999 record in Sample 165-999A-29X-2, 41–43 cm (10.05 ± 0.16 Ma), in late Miocene Zone N16 in agreement with its published first appearance (Kennett and Srinivasan, 1983). By contrast, *Gt. woodi* is not found at Site 999 below Sample 165-999A-33X-CC, 18–20 cm (13.32 ± 0.10 Ma), in middle Miocene Zone N12, well above its published first appearance in the earliest Miocene *Globorotalia kugleri* Zone (= N4) (Kennett and Srinivasan, 1983). However, *Gt. woodi* is much more consistently present in the Miocene portion of Site 999 than is *Gt. apertura.*

The LO of *Globoturborotalita nepenthes* at Site 999 is in Sample 165-999A-15H-CC, 28–31 cm, corresponding to 4.69 ± 0.07 Ma and ~0.3 Ma earlier than in the western tropical Atlantic at Ceara Rise (see Table 2). This species occurs quite regularly in the Site 999 record and its FO in Sample 165-999A-32X-5, 42–44 cm (11.32 ± 0.08 Ma), is considered a reliable datum to mark the base of Zone N14.

Hirsutella

The age of the FO of *Hirsutella margaritae* is listed as 6.4 Ma in Berggren et al. (1995a), somewhat younger than the age in Berggren et al. (1985) (7.0 Ma; when it is adjusted for changes in the geological time scale by astronomical tuning as per Shackleton et al., 1995). The FO of *H. margaritae* is between Samples 165-999A-20H-2, 42–44 cm, and 19H-CC, 27–30 cm (6.27 ± 0.04 Ma), agreeing well with the revised Berggren et al. (1985) age, but older than the age of this event at Ceara Rise (6.09 Ma). By contrast, this species' LO at Site 999 is between Samples 165-999A-12H-CC, 36–39 cm, and 12H-5, 42–44 cm (3.37 ± 0.06 Ma). This is younger than the age of this event (3.6 Ma) as listed by Berggren et al. (1985) and as determined at Ceara Rise (3.85 Ma; Chaisson and Pearson, 1997). It is also younger than the age (3.58 Ma) provided by Berggren et al. (1995a). However, Kennett and Srinivasan (1983) show the range of *H. margaritae* ending just below the base of Zone N21 (3.2 Ma). This event is difficult to constrain at this site because of numerous "transitional" forms that we have called *"praehirsuta"* (see "Taxonomic Notes").

Hirsutella hirsuta ostensibly descends from *H. margaritae,* but Kennett and Srinivasan (1983) show a stratigraphic gap between the base and top of their respective ranges. Berggren et al. (1995a) claim an age of 0.45 Ma for the FO of this species. This young date is refuted by evidence from Leg 172 sites (Keigwin, Rio, Acton, et al., 1998) and at Site 999, where the FO of *H. hirsuta* is between Samples 165-999A-12H-CC, 36–38 cm, and 12H-5, 42–44 cm (3.37 ± 0.06 Ma). This range nearly closes the gap between the FO of *H. hirsuta* at Site 999 and the LO of *H. margaritae* at Site 999, giving some credence to the ancestor-descendant relationship. *H. hirsuta* is a temperate latitude species and occurs only sporadically at Site 999.

The FO of *Hirsutella cibaoensis* is either between Samples 165-999A-26X-2, 40–42 cm, and 25X-CC, 20–23 cm (8.05 ± 0.03 Ma), or between Samples 165-999A-31X-2, 42–44 cm, and 30X-CC, 38–40 cm (10.76 ± 0.03 Ma). This taxon is not present in any of the intervening samples. However, similarly "deep" specimens were found in several samples at Ceara Rise. The younger Site 999 age is close to the one provided by Berggren et al. (1995b); their age is 7.8 Ma for this datum based on (corrected) data from Site 806 (western equatorial Pacific; Chaisson and Leckie, 1993). *H. cibaoensis* occurs too sporadically at the top of its range at Site 999 to determine an age for its LO.

The FO of *Hirsutella juanai* is between Samples 165-999A-28X-5, 42–44 cm, and 28X-2, 42–44 cm (9.37 ± 0.16 Ma). Berggren et al. (1995b) supply an age of 8.1 Ma for this datum based on replotted data from Site 806 (as above), but the age of this datum was determined to be 9.76 Ma at Ceara Rise (Chaisson and Pearson, 1997).

Menardella

Only sinistrally coiled *Menardella menardii* are present at Site 999 in upper Pliocene and Pleistocene samples (with the exception of lower Pleistocene Sample 165-999A-6H-5, 42–44 cm; 1.56 Ma). *M. menardii* is present only sporadically between Samples 165-999A-17H-2, 42–44 cm, and 8H-2, 42–44 cm (~5.3–2.0 Ma), but when it is present the specimens are dextrally coiled. The record is dominated by sinistrally coiled specimens below Sample 165-999A-17H-2, 42–44 cm, to the FO of *M. menardii* between Samples 165-999A-33X-6, 42–44 cm, and 33X-3, 42–44 cm (~12.5–5.3 Ma).

The FO of *Menardella limbata* is between Samples 165-999A-30X-5, 42–44 cm, and 30X-2, 42–44 cm (10.58 ± 0.06 Ma), if a single suspect specimen in Sample 165-999A-31X-CC, 37–40 cm, is not considered. The FO at Site 999 is quite close to the FO determined at Ceara Rise (10.57 Ma; Chaisson and Pearson, 1997). The LO of this species at Site 999 is between Samples 165-999A-10H-5, 42–44 cm, and 10H-3, 42–44 cm (2.74 ± 0.05 Ma). This is older than the age that was established for the LO of *M. limbata* at Ceara Rise (2.38 Ma; Chaisson and Pearson, 1997). The Site 999 record is dominated by dextrally coiled *M. limbata* from between Samples 165-999A-18H-2, 42–44 cm, and 17H-CC, 21–23 cm (5.60 ± 0.06 Ma) to its LO. Below the level between Samples 165-999A-21H-CC, 41–44 cm, and 21H-5, 42–44 cm (6.85 ± 0.06 Ma), nearly all *M. limbata* specimens are sinistrally coiled.

The LO of *Menardella multicamerata* is between Samples 165-999A-11H-5, 42–44 cm, and 11H-2, 42–44 cm (3.00 ± 0.05 Ma), which corresponds well with the age determined at Ceara Rise (3.11 Ma; Chaisson and Pearson, 1997). The FO of *M. multicamerata* at Site 999 is between Samples 999A-18H-2, 42–44 cm, and 17H-CC, 21–23 cm (5.60 ± 0.06 Ma), slightly younger than at Ceara Rise (~6.2 Ma; Chaisson and Pearson, 1997).

Menardella exilis seems to enter the record slightly earlier at Site 999 than it does at Site 925 in the western tropical Atlantic, while *Menardella pertenuis* and *Menardella miocenica* seem to enter later. At Ceara Rise the FO of *M. exilis* is 4.45 Ma, but at Site 999 its FO is between Samples 165-999A-15H-CC, 28–31 cm, and 15H-5, 42–44 cm (4.69 ± 0.06 Ma). At Ceara Rise the FOs of *M. pertenuis* and *M. miocenica* are 3.52 and 3.77 Ma, but the FO of *M. pertenuis* is between Samples 165-999A-12H-5, 42–44 cm, and 12H-2, 42–44 cm (3.27 ± 0.06 Ma), and the FO of *M. miocenica* (which marks the base of Zone N20/N21) is between Samples 165-999A-11H-CC, 22–25 cm, and 11H-5, 42–44 cm (3.11 ± 0.06 Ma), at Site 999. The LO of *M. exilis* is between Samples 165-999A-9H-2, 42–44 cm, and 8H-CC, 24–26 cm (2.31 ± 0.05 Ma), significantly older than the 2.09 Ma age determined at Ceara Rise (Chaisson and Pearson, 1997). The published age for the LO of *M. pertenuis* is 2.60 Ma (Berggren et al., 1995a), but at Ceara Rise this event was determined to be at 2.33 Ma. At Site 999 it is between Samples 165-999A-9H-CC, 30–32 cm, and 9H-5, 30–32 cm (2.54 ± 0.05 Ma), (i.e. an age closer to the Ceara Rise age). *M. pertenuis* is always quite rare at Site 999 and is absent in several samples within its range. *Menardella miocenica* never exceeds 15% of the assemblage at Site 999 (as it did at Ceara Rise), but it is the most abundant Atlantic-endemic menardellid when it is present. In addition to not being as abundant as it was in the western equatorial Atlantic, *M. miocenica* is not as morphologically well developed at Site 999. Its LO is between Samples 165-999A-9H-5, 42–44 cm, and 9H-2, 42–44 cm (2.42 ± 0.05 Ma), older than published last appearance (2.3 Ma; Berggren et al., 1995a), but quite close to its LO at Ceara Rise (2.38 Ma; Chaisson and Pearson, 1997).

Neogloboquadrina

Keigwin (1978, 1982a) recorded the occurrence of sinistrally coiled *Neogloboquadrina pachyderma* at Site 502, which is ~200 km south-southwest of Site 999. Keigwin (1982a) suggested that this normally polar to subpolar species might have been associated with seasonal upwelling events in the western Caribbean. At Site 999 the sinistrally coiled specimens are common (15%–20% of the assemblage) in Sample 165-999A-23X-CC, 33–35 cm (7.34 Ma), and constitute 3%–14% of the assemblage in several samples between Samples 165-999A-20H-CC, 41–44 cm, and 18H-2, 42–44 cm (~6.6–5.6 Ma). The LO of sinistrally coiled specimens is between Samples 165-999A-15H-5, 42–44 cm, and 15H-2, 42–44 cm (4.51 ± 0.06 Ma). Dextrally coiled specimens also disappear from the Site 999 record at this level, but only temporarily. They are present in most samples examined between Sample 165-999A-12H-CC, 36–38 cm (3.42 Ma), and 2H-2, 42–44 cm (0.27 Ma).

Reconstructions of the paleogeography of the Central American Isthmus (Coates and Obando, 1996) show that during late Miocene (7–6 Ma) an archipelago existed west of Site 999. Subsequent uplift of the Cocos Ridge created a more continuous landmass in what is now Costa Rica and western Panama (Coates and Obando, 1996). The boundary between the North Equatorial Current (NEC) and the North Equatorial Countercurrent (NECC) in the Pacific is a zone of upwelling. In the modern ocean this boundary is at ~10°N, but during the late Miocene it may have been further north (Hovan, 1995). It is therefore possible that although there was enough surface flow through the seaway to allow the passage of the NEC and NECC, this upwelling band may have extended into the western Caribbean in the late Miocene until regional uplift in Central America halted the movement of significant amounts of surface water across the emerging isthmus. The timing of greatest sinistrally coiled *N. pachyderma* abundance (~6.5–5.6 Ma) corresponds to the late stage in the existence of the "Central American archipelago."

The age of the LO of *Neogloboquadrina acostaensis* was determined to be 5.1 Ma based on data from Site 806 in the western equatorial Pacific (Chaisson and Leckie, 1993), but at Ceara Rise aberrant neogloboquadrinids were misidentified as *N. acostaensis* and the LO datum of the species was not accurately placed. Similar small neogloboquadrinids at Site 999 were identified as dextrally coiled *N. pachyderma* or the "aco-pac" morphotype of Loubere (1988), and the top of the *N. acostaenis* range in Hole 999A was found between Samples 165-999A-12H-5, 42–44 cm, and 12H-2, 42–44 cm (3.27 ± 0.06 Ma). This age is younger than both the one determined in the western Pacific (Site 806; Chaisson and Leckie, 1993) and another age determined for the LO of *N. acostaensis* in the eastern Pacific at Site 847 (~3.6 Ma) (Chaisson, 1996). The FO of *N. acostaensis* is between Samples 165-999A-29X-5, 41–43 cm, and 29X-6, 40–42 cm (10.30 ± 0.01 Ma).

Praeorbulina and *Orbulina*

The FO of *Praeorbulina sicana* marks the base of Zone N8. In Hole 999A this has been drawn between Samples 165-999A-45X-5, 38–40 cm, and 45X-2, 42–44 cm (16.4 Ma), instead of below Sample 165-999A-46X-CC, 27–32 cm, although a single specimen of *P. sicana* was found there. It was assumed that this specimen was an aberrant *Gs. sacculifer* as no other *P. sicana* specimens were found in spite of extensive searching.

The first appearance of *Orbulina* spp. delimits the base of Zone N9 (15.1 Ma), but at Site 999 this species enters the record between Samples 165-999A-37X-CC, 25–27 cm, and 37X-5, 40–42 cm (14.56 ± 0.09 Ma). This species was extremely rare in the lowest part of its range at Ceara Rise (Pearson and Chaisson, 1997) and poor to moderate preservation in Hole 999A may have dissolved any rare Orbulina specimens just above the base of its range.

Sphaeroidinellopsis and *Sphaeroidinella*

The LO of *Sphaeroidinellopsis seminulina* is between Samples 165-999A-13H-2, 42–44 cm, and 12H-CC, 36–8 cm (3.45 ± 0.06

Ma). This corresponds to a level older than either its published age (Berggren et al., 1995a) of 3.12 Ma or the Ceara Rise age of 3.11 Ma (Chaisson and Pearson, 1997).

At Ceara Rise the age of the LO of *Sphaeroidinellopsis kochi* was determined to be 4.45 Ma, but at Site 999 the event is between Samples 165-999A-16H-4, 42–44 cm, and 16H-2, 42–44 cm, corresponding to a significantly older age (4.91 ± 0.06 Ma).

The development from *Sphaeroidinellopsis paenedehiscens* to *Sphaeroidinella dehiscens* involves the appearance and gradual increase in size of a dorsal secondary aperture. Malmgren et al. (1996) document a 3–8 fold increase in the size of the secondary aperture after 3.6 Ma (their published age adjusted to accord with the Leg 154 time scale). Specimens with dorsal secondary apertures are entirely absent or quite rare at this site below Sample 165-999A-12H-2, 42–44 cm (before 3.77 Ma). At Site 999 rare sphaeroidinellid specimens with minute dorsal apertures were found down to Sample 165-999A-17H-CC, 21–23 cm (5.60 ± 0.04 Ma).

Truncorotalia

At Site 999 dextrally coiled *Truncorotalia truncatulinoides* are more consistently present than sinistrally coiled specimens, and the FO of this species between Samples 165-999A-8H-5, 42–44 cm, and 8H-2, 42–44 cm (2.1 ± 0.05 Ma), is marked by dextrally coiled specimens. This is slightly older than the age determined at Ceara Rise (1.92 Ma). Sinistrally coiled specimens are more numerous than dextrally coiled specimens in only two samples (Samples 165-999A-5H-CC, 14–16 cm, and 4H-CC, 16–20 cm. The FO of *T. truncatulinoides* (s) is between Samples 165-999A-8H-2, 42–44 cm, and 7H-CC, 42–44 cm (2.00 ± 0.04 Ma).

The FO of *Truncorotalia crassaformis* is between Samples 165-999A-15H-CC, 28–31 cm, and 15H-5, 42–44 cm. This position suggests an age close to 4.7 Ma as per Berggren et al. (1985; adjusted with the Leg 154 time scale; Curry, Shackleton, Richter, et al., 1995), and therefore this datum is used as a tie-point for constructing the biostratigraphic age model. However, Berggren et al. (1995a) suggests an age of 4.5 Ma for this datum and the FO of *T. crassaformis* was determined to be 4.31 Ma at Ceara Rise (Chaisson and Pearson, 1997).

TECTONIC AND PALEOCEANOGRAPHIC IMPLICATIONS

Table 3 lists several apparently diachronous datums at Site 999, which casts doubt on the reliability of the ages of the marker species used in construction of the age model. Until independent means of dating the record are used (e.g., complete magnetostratigraphy, isotopic stratigraphy, multiple radiometrically dated ash layers), the age model presented here can only be regarded as provisional. The diachronies are generally on the order of 10^5 years, which permits some broad conclusions about the relationship between the timing of biotic events at this site and paleoceanographic and tectonic events in the Caribbean region.

The gradual shoaling of the Central American Isthmus and the consequent diversion of the Caribbean Current (= North Equatorial Current) northward into the Gulf of Mexico and discontinuation of surface-water flow from the eastern Pacific into the Caribbean seems to have left several marks on the biostratigraphic record of Site 999.

The "Pachyderma Interval"

Left-coiling *Neogloquadrina pachyderma* were present at several Leg 165 sites during the late Miocene (~6.5–5.6 Ma) (Sigurdsson, Leckie, Acton, et al., 1997). The presence of sinistrally coiled *Neogloboquadrina pachyderma* at a tropical site is unusual in itself. The fact that these specimens sometimes constituted a significant portion of the assemblage suggests the presence of unusually cold water, probably on a seasonal basis (Keigwin, 1982). Further investigation is needed to first establish the existence and then determine the cause of this late Miocene upwelling in the western Caribbean. Such research may help to better constrain the timing of tectonic uplift in the Central American region.

Temperate-Latitude Globoconellids

Globoconella miozea, Globoconella panda, and *Globoconella praescitula* were encountered in the fine fraction and more rarely in the coarse fraction (>125 µm) of some samples at Site 806 (Chaisson and Leckie, 1993), but the specimens at Site 999 (particularly *Gc. panda*) are often quite large (>315 µm), which (along with their relative abundance) suggests they were well within their limits of environmental tolerance. Their presence therefore suggests that the surface waters of the western Caribbean Sea were connected to the cooler waters of either the California or Peru Current system (depending on the contemporary position of the intertropical convergence zone) until at least the end of the middle Miocene. Norris (1998) also found temperate latitude globoconellids at Leg 159 sites in the eastern equatorial Atlantic where the Benguela Current could have brought them up the east coast of Africa.

Endemic Atlantic Menardellids

It is generally known (Lamb and Beard, 1972; Stainforth et al., 1975; Kennett and Srinivasan, 1983) that several species of *Menardella* are confined to the tropical Atlantic. The timing of the first appearances of these species, beginning at 4.77 Ma (date at this site; 4.45 Ma at Ceara Rise) with the FO of *Menardella exilis,* follow a period of reorganization of carbonate deposition in the eastern Pacific (Farrell et al., 1995) and the Atlantic (Haug and Tiedemann, 1998) that has been linked to the closing of the Central American Seaway and isolation of the tropical Atlantic. Isolation is an important factor in the development of endemic species.

The "Atlantic Hiatus"

Several species of planktonic foraminifers were absent from Atlantic sites, including Site 999, for much of the Pliocene. The best documented members of this group are the pulleniatinids, which were absent between 3.5 and 2.3 Ma (Bolli and Saunders, 1985). *Globorotalia tumida* was largely absent at Ceara Rise between 3.7 and 2.1 Ma (Chaisson and Pearson, 1997) and between 5.6 and 2.0 Ma at Site 999. *Globorotaloides hexagona* was absent from the Site 999 record between 3.1 and 1.4 Ma. At Ceara Rise this species was largely absent between 3.1 and 1.5 Ma, but was found in one sample in that interval. Norris (1998) reports that it is absent from a similarly bracketed interval in the eastern tropical Atlantic at Site 959 (Leg 159). Finally, there are no sinistrally coiled *Menardella menardii* at either Ceara Rise or Site 999 through this period, although they are found at Pacific sites at this time (Chaisson, 1996).

Caribbean Originations?

A less pervasive phenomenon than the "Atlantic hiatus" is the very early (deep stratigraphic) occurrence of several species at Site 999, which suggests that they may have evolved in the western Caribbean and then spread to other regions. The most significant members of this group are *Globigerinoides extremus* and *Candeina nitida*. Both of these species have published dates of first appearances at 8.1 Ma, but they appear at depths corresponding to much greater ages in the Site 999 (and Site 1000; Sigurdsson, Leckie, Acton, et al., 1997) record.

TAXONOMIC NOTES

Listed below are all species that occur in more than two samples in the interval examined in Hole 999A. The original reference for the species is given, as are subsequent references germane to the progression toward the currently used species concept. The "stratigraphic range" is the range of the species in Hole 999A. "Remarks" are intended to aid other workers in identifying irregular specimens and distinguishing between similar taxa. Specific samples are listed that include irregular or otherwise noteworthy specimens. See Table 4 for the stratigraphic occurrences of species found in only one or two samples. Taxa are listed in alphabetical order by genus name. Under the genus subheading taxa are listed in alphabetical order by species name.

BEELLA

Beella digitata

Globigerina digitata Brady, 1879, p. 599, pl. 80, figs. 6–10.

Beella digitata (Brady). Kennett and Srinivasan, 1983, p. 232, pl. 58, figs. 2, 6–8.

Stratigraphic range: Sample 165-999A-6H-CC, 23–25 cm.

Remarks: *B. "praedigitata"* in the top two cores of Hole 999A may well be immature *B. digitata.* That is, they had not yet added the radially elongate chambers that characterize the descendant species.

Beella praedigitata

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

Beella praedigitata (Parker). Kennett and Srinivasan, 1983, p. 232, pl. 58, figs. 2–5.

Stratigraphic range: Sample 165-999A-7H-5, 42–44 cm, to 1H-5, 42–44 cm.

CANDEINA

Candeina nitida

Candeina nitida d'Orbigny, 1839, p. 107, pl, 2, figs. 27–28; Kennett and Srinivasan, 1983, p. 228, pl. 57, figs. 6–8.

Stratigraphic range: Sample 165-999A-29X-2, 41–43 cm, to 1H-2, 42–44 cm.

Remarks: The specimens at the FO have definite sutural apertures, but chambers are less embracing than higher samples. In Sample 165-999A-28X-5, 42–44 cm, we found a specimen of *Ga. glutinata* with a very inflated bulla and the suggestion of sutural apertures. This is a transitional specimen toward *C. nitida.* The occurrence of *C. nitida 'praenitida'* specimens in Zone N16 (below the published FAD), which is also observed at Site 1000 (Leg 165; Sigurdsson, Leckie, Acton, et al., 1997), suggests that this is a species that may have evolved in the Caribbean.

CATAPSYDRAX

Catapsydrax dissimilis

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

Catapsydrax dissimilis (Cushman and Bermudez). Kennett and Srinivasan, p. 22, pl. 2, figs. 1, 3–8.

Stratigraphic range: Bottom of section examined to Sample 165-999A-49X-4, 42–44 cm.

CLAVORATELLA

Clavoratella bermudezi

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

Clavoratella bermudezi (Bolli). Kennett and Srinivasan, 1983, p. 218, pl. 54, figs. 2, 6–8.

Stratigraphic range: Found only in Sample 165-999A-39X-5, 41–43 cm.

Remarks: Specimens were close to *Gd. hexagona,* but with slightly clavate chambers, very low trochospire and more peripheral position of aperture. See Pearson (1995).

DENTOGLOBIGERINA

Dentoglobigerina altispira

Globigerina altispira Cushman and Jarvis, 1936, p. 5, pl. 1, figs. 13a–c.

Globoquadrina altispira globosa Bolli, 1957, p. 111, pl. 24, figs. 9a–10c.

Dentoglobigerina altispira altispira (Cushman and Jarvis). Kennett and Srinivasan, 1983, p. 188, pl. 46, figs. 4–6.

Dentoglobigerina altispira globosa (Bolli). Kennett and Srinivasan, 1983, p. 189, pl. 44, fig. 4; pl. 46, figs. 7–9.

Stratigraphic range: Bottom of the section examined to Sample 165-999A-11H-5, 42–44 cm.

Remarks: Immature specimens of *D. altispira* lacking the final whorl of toothed, inflated chambers and resemble primitive *Neogloboquadrina dutertrei.* These specimens are especially common in Samples 165-999A-29X-4, 42–44 cm; 27X-2, 42–44 cm; and 26X-5, 50–52 cm.

FOHSELLA

Fohsella birnageae

Globorotalia birnageae Blow, 1959, p. 210, pl. 17, figs. 108a–c.

Globorotalia (Fohsella) birnageae Blow. Kennett and Srinivasan, p. 94, pl. 21, figs. 6–8.

Fohsella birnageae (Blow). Pearson and Chaisson, 1997, p. 58.

Stratigraphic range: Sample 165-999A-48X-CC, 36–38 cm, to 47X-2, 40–42 cm.

Fohsella fohsi

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

Globorotalia (Fohsella) fohsi Cushman and Ellisor. Kennett and Srinivasan, 1983, p. 100, pl. 23, figs. 1–3.

Fohsella fohsi (Cushman and Ellisor). Pearson and Chaisson, 1997, p. 58.

Stratigraphic range: Sample 165-999A-33X-CC, 18–20 cm, to 33X-3, 42–44 cm.

Remarks: The fohsellids are not well developed at this site. The end members of the lineage, *F. fohsi lobata* and *F. fohsi robusta* are missing and rare, respectively. Full development of a peripheral keel on *F. fohsi* specimens is uncommon. In order for a specimen to be designated *F. fohsi* the keel must extend around the entire final whorl. Specimens with incomplete keels were designated *F. praefohsi.* In Sample 165-999A-34X-CC, 33–37 cm, some specimens had faint, discontinuous keels that resemble beaded threads. Specimens lacking a peripheral keel or imperforate band, but having a pinched periphery were designated *F. peripherocuta. F. peripheroronda* lacked the pinched periphery.

F. praefohsi was erected by Blow and Banner (1966) as a form intermediate between *F. fohsi* (fully carinate) and *F. peripheroacuta* (noncarinate). Bolli and Saunders (1985) argued that the Venezuelan holotype used by Blow and Banner (1966) looked more like a transition between *F. fohsi* and *F. fohsi lobata* because it had "cockscomb" final chambers. However, Bolli and Saunders (1985) also noted that a paratype from Sumatra did agree with Blow and Banner's (1966) definition. Sections from the western equatorial Pacific (Site 806; Chaisson and Leckie, 1993) and the western equatorial Atlantic (Site 925; Pearson and Chaisson, 1997) yield sequences of *F. fohsi* specimens that also conform to the Blow and Banner (1966) definition for *F. praefohsi.* The specimens recovered at Site 999, however, resemble the description of Bolli and Saunders (1985), whose work was largely based on Caribbean sections. Evidently the Caribbean Sea was a suboptimal environment for this lineage and it was not well developed morphologically in this region.

Fohsella peripheroacuta

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

Globorotalia (Fohsella) peripheroacuta Blow and Banner. Kennett and Srinivasan, p. 96, pl. 22, figs. 4–6.

Fohsella peripheroacuta (Blow and Banner). Pearson and Chaisson, 1997, p. 58.

Stratigraphic range: Sample 165-999A-37X-CC, 25–27 cm, to 33X-6, 42–44 cm.

Fohsella peripheroronda

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

Globorotalia (Fohsella) peripheroronda Blow and Banner. Kennett and Srinivasan, p. 96, pl. 22, figs. 1–3.

Fohsella peripheroronda (Blow and Banner). Pearson and Chaisson, 1997, p. 58.

Stratigraphic range: Bottom of section examined to Sample 165-999A-37X-2, 60–62 cm.

Fohsella praefohsi

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

Globorotalia (Fohsella) praeiohsi Blow and Banner. Kennett and Srinivasan, p. 98, pl. 22, figs. 7–9.

Fohsella praefohsi (Blow and Banner). Pearson and Chaisson, 1997, p. 58.

Stratigraphic range: Sample 165-999A-36X-5, 35–37 cm, to 33X-6, 42–44 cm.

GLOBIGERINA
Globigerina bulloides

Globigerina bulloides d'Orbigny, 1826, p. 3, pl. 1, figs. 1–4.

Globigerina (Globigerina) bulloides d'Orbigny. Kennett and Srinivasan, 1983, p. 36, pl. 6, figs. 4–6.

Stratigraphic range: Sample 165-999A-33X-CC, 18–20 cm, to 1H-2, 42–44 cm.

Remarks: Large, typical specimens are found in Sample 165-999A-4H-5, 42–44 cm. Specimens in many samples tend to grade toward *G. falconensis.*

Globigerina falconensis

Globigerina falconesis Blow, 1959, p. 177, pl. 9, figs. 40a–c, 41.

Globigerina (Globigerina) falconensis Blow. Kennett and Srinivasan, 1983, p. 40, pl. 7, figs. 1–3.

Stratigraphic range: Sample 165-999A-31X-5, 42–44 cm, to 3H-2, 42–44 cm.

GLOBIGERINATELLA
Globigerinatella insueta

Globigerinatella insueta Cushman and Stainforth, 1945, p.69, pl. 13, figs. 7–9. Kennett and Srinivasan, p. 228, pl. 56, fig. 2, pl. 57, figs. 4, 5.

Stratigraphic range: Bottom of section examined to Sample 165-999A-39X-2, 41–43 cm.

Remarks: Specimens with multiple apertural bullae, but lacking areal apertures, were more commonly encountered than those with areal apertures. The presence of areal apertures is required for *sensu stricto* status (Pearson, 1995). See Pearson (1995) and Pearson and Chaisson (1997) for discussion of *Gn. insueta* vs. *Gn.* sp.

GLOBIGERINELLA
Globigerinella aequilateralis

Globigerina aequilateralis Brady, 1879, p. 285 (figs. *in* Brady, 1884) pl. 80, figs. 18–21.

Globigerinella aequilateralis (Brady). Kennett and Srinivasan, 1983, p. 238, p. 59, fig. 1; pl. 60, figs. 4–6.

Stratigraphic range: Sample 165-999A-50X-5, 58–60 cm, to 1H-2, 42–44 cm.

Remarks: *Globigerinella (= Hastergina) aequilateralis* and *Globigeriniella (= Hastigerina) siphonifera* (*Globigerinella aequilateralis* “A” and “B”) were not distinguished in this study (cf. Bolli and Saunders, 1985). See Huber et al. (1997) for a discussion of phylogeny of these morphotypes.

GLOBIGERINITA
Globigerinita glutinata

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

Globigerinita glutinata (Egger). Kennett and Srinivasan, 1983, p. 224, pl. 56, figs. 1, 3–5.

Stratigraphic range: Throughout section examined.

GLOBIGERINOIDES
Globigerinoides altiaperturus

Globigerinoides triloba altiapertura Bolli, 1957, p. 113, pl. 25, figs. 7a–c.

Globigerinoides altiapertura Bolli. Kennett and Srinivasan, 1983, p. 54, pl. 11, figs. 1–3.

Stratigraphic range: Bottom of section examined to Sample 165-999A-44X-CC, 38–40 cm.

Globigerinoides extremus

Globigerinoides obliquus extremus Bolli and Bermudez, 1965, p. 139, pl. 1, figs. 10–12; Bolli and Saunders, 1985, p. 194, fig. 20.11

Globigerinoides extremus Bolli. Kennett and Srinivasan, 1983, p. 58, p. 12, figs. 1–3.

Stratigraphic range: Sample 165-999A-29X-CC, 37–39 cm, to 10H-5, 42–44 cm.

Remarks: *Globigerinoides extremus* is considered a variant of *Gs. obliquus* by Bolli and Saunders (1985) and their figured holotypes are quite similar in appearance. The transition from the parent species to the descendant is gradual. At Site 999 specimens *Globigerinoides* spp. with appressed chambers and small, flattened final chambers are found well below the FO of *Globorotalia plesiotumida* (8.2 Ma).

Globigerinoides conglobatus

Globigerina conglobata Brady, 1879, p. 28b.

Globigerinoides conglobatus (Brady). Kennett and Srinivasan, 1983, p. 58, pl. 12, figs. 4–6.

Stratigraphic range: Sample 165-999A-19H-CC, 27–30 cm, to 1H-2, 42–44 cm.

Globigerinoides fistulosus

Globigerina fistulosa Schubert, 1910, p. 323, text fig. 1.

Globigerinoides fistulosus (Schubert). Kennett and Srinivasan, 1983, p. 68, pl. 14, figs. 7–9.

Stratigraphic range: Sample 165-999A-10H-3, 32–34 cm, to 8H-5, 42–44 cm.

Remarks: No well-developed (i.e., with several fistulose chambers) specimens were observed at Site 999 in the course of shipboard or postcruise work for this study. However, Norris (pers. comm., 1998) reports that they are well developed in samples that he has examined in Core 165-999A-10H. At the lower resolution used for this study *Gs. fistulosus* appears to always be rare and its range appears truncated.

Globigerinoides obliquus

Globigerinoides obliqua Bolli, 1957, p. 113, pl. 25, figs. 10a–c

Globigerinoides obliquus Bolli. Kennett and Srinivasan, 1983, p. 56, pl. 11, figs. 7–9.

Stratigraphic range: Bottom of section examined to Sample 165-999A-6H-5, 42–44 cm.

Remarks: The morphology of this species is quite variable. In Sample 165-999A-29X-7, 42–44 cm, three morphotypes were observed: (1) a *sensu stricto* form, (2) a form that grades toward *Globigerinoides extremus* (see above), and (3) specimens with rounded chambers and very small secondary apertures that otherwise closely resemble *Globoturborotalita woodi.* In Sample 165-999A-28X-2, 42–44 cm, many Type 2 specimens were found and in Sample 165-999A-28X-5, 42–44 cm, many *Gs. obliquus* specimens have very large, high-arched primary apertures. In summary, the interval of transition from ancestor to descendant species is marked by a usual range of morphological variation at this site.

Globigerinoides ruber

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

Globigerinoides ruber (d’Orbigny). Kennett and Srinivasan, 1983, p. 78, pl. 4, figs. 12–14.

Stratigraphic range: Sample 165-999A-30X-2, 43–45 cm, to 1H-2, 42–44 cm.

Remarks: The high-trochospired *“pyramidalis”* form of *Gs. ruber* was found in Samples 165-999A-2H-2, 42–44 cm, and 8H-2, 42–44 cm. In Sample 165-999A-10H-3, 32–34 cm, specimens with a very small final chamber were found. These resembled *Globigerinoides extremus,* except that the primary aperture was over a suture.

Globigerinoides sacculifer

Globigerina sacculifera Brady, 1877, p. 164, pl. 9, figs. 7–10.

Globigerinoides sacculifer (Brady). Kennett and Srinivasan, 1983, p. 66, pl. 14, figs. 4–6.

Stratigraphic range: Non-saccate specimens were observed throughout the section examined.

Remarks: Saccate specimens were not observed below Sample 165-999A-48X-CC, 36–38 cm. In Sample 165-999A-48X-2, 41–43 cm, saccate specimens appear to be beaded with euhedral calcite. The final chamber is not well developed, but is less inflated and slightly smaller than previous chambers. Phylogenetic relationship with the sphaeroidinellopsids is strongly suggested in several samples at Site 999. In Samples 165-999A-37X-5, 40–42 cm; 25X-CC, 20–23 cm; and 17H-5, 42–44 cm, incomplete cortices (i.e., granular coatings) were observed on saccate *Gs. sacculifer* tests. See "Discussion" under *Sphaeroidinellopsis seminulina* and *Ss. kochi.* Before the FO of *Praeorbulina sicana* many specimens of non-saccate *Gs. sacculifer* can be found that have an enlarged final chamber. Only specimens lacking the third supplementary aperture were assigned to *Gs. sacculifer.* See *P. sicana* "Discussion."

Globigerinoides seigliei

Globigerinoides rubra (d'Orbigny) *seigliei* Bermudez and Bolli, 1969, p. 164, pl. 8, figs. 10–12.

Globigerinoides seigliei Bermudez and Bolli. Kennett and Srinivasan, p. 78, pl. 17, figs. 4–6.

Stratigraphic range: Sample 165-999A-28X-5, 42–44 cm, to 24X-CC, 35–37 cm.

Remarks: This species resembles an "over-inflated" *Gs. ruber*. The test has a finer pored texture and the apertures are higher arched than the latter species.

Globigerinoides subquadratus

Globigerinoides subquadratus Brönnimann, 1954, p. 680, pl. 1, figs. 8a–c. Kennett and Srinivasan, 1983, p. 74, pl. 16, figs. 1–3.

Stratigraphic range: Bottom of section examined to Sample 165-999A-31X-5, 42–44 cm.

Remarks: This species has four chambers in the final whorl, while *Gs. ruber* has only three to three and a half. The two species are never coeval in Hole 999A.

GLOBOCONELLA

Globoconella inflata

Globigerina inflata d'Orbigny, 1839, p. 134, pl. 12, figs. 7–9.

Globorotalia (Globoconella) inflata (d'Orbigny). Kennett and Srinivasan, 1983, p. 118, pl. 27, figs. 7–9.

Globoconella inflata (d'Orbigny). Chaisson and Pearson, 1997, p. 14, pl. 2, figs. 14–17.

Stratigraphic range: Sample 165-999A-7H-CC, 23–25 cm, to 1H-2, 42–44 cm.

Remarks: *"Globorotalia" triangula* of Weaver and Raymo (1989), an ecophenotype of *"Gr." inflata,* was not observed at Site 999, and is perhaps confined to the open Atlantic. Rather, specimens at this site are similar to the temperate latitude morphotype, but often with a less well-developed cortex.

Globoconella miozea

Globorotalia miozea (Finlay), 1939, p. 326, p. 29, figs. 159–161.

Globorotalia (Globoconella) miozea (Finlay). Kennett and Srinivasan, 1983, p. 112, pl. 26, figs. 1–3.

Stratigraphic range: Sample 165-999A-39X-2, 41–43 cm, to 31X-2, 42–44 cm.

Remarks: This is ordinarily a temperate-ocean species, and it is therefore not surprising that specimens at Site 999 often have an irregular morphology. *Gc. miozea* in Samples 165-999A-34X-2, 41–43 cm, and 31X-CC, 37–40 cm, are not keeled, but have acute peripheries. Smaller specimens in Sample 165-999A-30X-7, 42–44 cm, have a thin, distinct keel and therefore resemble *Globoconella conoidea.* Many tropical specimens are not strongly conical on the umbilical side and their earlier chambers either lack pustules or are only lightly pustulose.

Globoconella panda

Globorotalia menardii (d'Orbigny) sub sp. *panda* (Jenkins), 1960, p. 364, pl. 4, figs. 10a–c.

Globorotalia (Globoconella) panda (Jenkins). Kennett and Srinivasan, 1983, p. 110, pl. 25, figs. 7–9.

Stratigraphic range: Sample 165-999A-33X-6, 42–44 cm, to 31X-2, 42–44 cm.

Globoconella praescitula

Globorotalia scitula (Brady) sub sp. *praescitula* (Blow), 1959, p. 221, pl. 19, figs. 128a–c.

Globorotalia (Globoconella) praescitula (Blow). Kennett and Srinivasan, 1983, p. 108, pl. 24, fig. 1, pl. 25, 4–6.

Stratigraphic range: Sample 165-999A-46X-2, 42–44 cm, to 31X-CC, 37–40 cm.

Globoconella zealandica

Globorotalia zealandica (Hornibrook), p. 667, figs. 18, 19, 30.

Globorotalia (Globoconella) zealandica (Hornibrook). Kennett and Srinivasan, 1983, p. 108, pl. 25, figs. 1–3.

Stratigraphic range: Sample 165-999A-44X-CC, 38–40 cm, to 40X-2, 41–43 cm.

GLOBOQUADRINA

Globoquadrina baroemoenensis

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

Globoquadrina baroemoenensis (LeRoy). Kennett and Srinivasan, 1983, p. 186, pl. 6, figs. 1–3.

Stratigraphic range: Bottom of the section examined to Sample 165-999A-25X-2, 40–42 cm.

Remarks: *Gq. baroemoenensis* has only four chambers in its final whorl, which distinguishes it from *Dentoglobigerina altispira.* It is distinguished from *Gq. venezeulana* by a smaller increase in chamber size between the penultimate and final whorl and by a shallower umbilicus.

Globoquadrina dehiscens

Globorotalia dehiscens Chapman, Parr, and Collins, 1934, p. 569, pl. 11, figs. 36a–c.

Globoquadrina dehiscens (Chapman, Parr, and Collins). Kennett and Srinivasan, 1983, p. 184, pl. 44, fig. 2; pl. 45, figs. 7–9.

Stratigraphic range: Sample 165-999A-50X-5, 58–60 cm, to 21H-2, 42–44 cm.

Globoquadrina venezuelana

Globigerina venezuelana Hedberg, 1937, p. 681, pl. 92, fig. 72b.

Globoquadrina venezuelana (Hedberg). Kennett and Srinivasan, 1983, p. 180, pl. 44, figs. 5–7.

Stratigraphic range: Sample 165-999A-50X, 37–39 cm, to 11H-5, 42–44 cm.

Remarks: Gasperi and Kennett (1993) document a shift in the depth ecology of *Gq. venezuelana* during the Miocene, but do not make reference to any accompanying morphological shifts. This species exhibits a broad range in the degree of chamber inflation, but the large increase in the size of the chambers between the penultimate and the final whorl is a consistent characteristic, regardless of chamber shape or inflation. In Sample 165-999A-42X-5, 42–44 cm, two types of *Gq. venezuelana* were found: (1) with larger, more inflated chambers and (2) with smaller, appressed chambers and a flat spiral side. In Sample 165-999A-30X-1, 42–44 cm, there are many specimens with kummerform final chambers and a low trochospire that creates a shallower umbilicus than usual.

GLOBOROTALIA

Globorotalia lenguaensis

Globorotalia lenguaensis Bolli, 1957, p. 120, pl. 29, figs. 5a–c.

Globorotalia (Globorotalia) paralenguaensis Blow, 1969, p. 402, pl. 46, figs. 1–6.

Globorotalia (Globorotalia) lenguaensis Bolli. Kennett and Srinivasan, 1983, p. 152, pl. 29, figs. 5a–c.

Globorotalia (Globorotalia) paralenguaensis Blow. Kennett and Srinivasan, 1983, p. 154, pl. 37, figs. 1–3.

Stratigraphic range: Sample 165-999A-34X-5, 39–41 cm, to 28X-2, 42–44 cm.

Remarks: The putative derivation of this species from the fohsellids (Kennett and Srinivasan, 1983) is readily apparent in Sample 165-999A-32X-CC, 37–40 cm, where specimens of *Gr. lenguaensis* are very similar to coeval *Fohsella peripheroacuta.* That is, the apertural flap that closes the umbilicus of the descendant species is incompletely developed.

Globorotalia merotumida

Globorotalia (Globorotalia) merotumida Blow and Banner (*in* Banner and Blow, 1965), p. 1352, text fig. 1; Kennett and Srinivasan, 1983, p. 154, pl. 37, figs. 4–6.

Globorotalia merotumida Blow and Banner. Bolli and Saunders, 1985, p. 227, fig. 33.7.

Stratigraphic range: Sample 165-999A-30X-CC, 38–40 cm, to 25X-CC, 20–23 cm.

Remarks: This species may be morphologically (and phylogenetically) intermediate between *Globorotalia paralenguensis* and *Globorotalia plesiotumida.* The transition from *Gr. paralenguensis* involves loss of the apertural flap and the development of a keel. Specimens that otherwise are similar to *Gr. paralenguaensis,* but had a keel, were found in Sample 165-999A-29X-5, 41–43 cm. The transition to *Gr. plesiotumida* is achieved by the flattening of the spiral side and the elongation of the radial axis of the final chamber, which contributes to the overall more ovate *Gr. plesiotumida* test shape. Ovate *Gr. merotumida* were found as deep as Sample 165-999A-29X-4, 42–44 cm, but radial lengthening (compared to tangential width) of the final chamber is not apparent.

Globorotalia paralenguaensis

Globorotalia (Globorotalia) paralenguaensis Blow, 1969, v. 1, p. 402, pl. 46, figs. 1–6; Kennett and Srinivasan, 1983, p. 154, pl. 37, fig. 13.

Stratigraphic range: Sample 165-999A-30X-CC, 38–40 cm, to 28X-2, 42–44 cm.

Globorotalia plesiotumida

Globorotalia (Globorotalia) tumida (Brady) *plesiotumida* Blow and Banner (*in* Banner and Blow, 1965), p. 1353, figs. 2a–c.

Globorotalia (Globorotalia) plesiotumida Blow and Banner. Kennett and Srinivasan, 1983, p. 156, p. 37, figs. 7–9.

Globorotalia plesiotumida Blow and Banner. Bolli and Saunders, 1985, p. 227, fig. 33.5.

Stratigraphic range: Sample 165-999A-26X-5, 50–52 cm, to 14H-2, 42–44 cm.

Remarks: Specimens with a flat spiral side, overall ovate shape and a final chamber with a 1:1 ratio of tangential width to radial length were accepted as *Gr. pleisiotumida.* Really good specimens of this species (i.e., with a radially elongate final chamber) were found only in Samples 165-999A-25X-CC, 20–23 cm, and 24X-CC, 35–37 cm. In most samples in Hole 999A where this species was present the dimensions of the final chamber were 1:1 and the secondary criteria for identification were important to note. A final noteworthy characteristic of *Gr. plesiotumida* is a relatively "tight" umbilicus. That is, the central apices of the chambers on the umbilical side often completely obscure the umbilicus *contra* (Plate 37 of Kennett and Srinvasan, 1983).

Globorotalia tumida

Pulvinulina menardii (d'Orbigny) var. *tumida* Brady, 1877, pl. 103, figs. 4–6.

Globorotalia (Globorotalia) tumida tumida (Brady). Kennett and Srinivasan, 1983, p. 158, pl. 36, fig. 1; pl. 38, figs. 1–3.

Stratigraphic range: Sample 165-999A-18H-2, 42–44 cm, to 1H-5, 42–44 cm.

Remarks: *Gr. tumida flexuosa* was found in Sample 165-999A-6H-5, 42–44 cm.

Globorotalia ungulata

Globorotalia ungulata Bermudez, 1960, p. 1304, pl. 15, figs. 6a–b.

Globorotalia (Globorotalia) ungulata Bermudez. Kennett and Srinivasan, 1983, p. 160, pl. 36, figs. 3–4; pl. 38, figs. 7–9.

Stratigraphic range: Sample 165-999A-9H-2, 42–44 cm, to 3H-5, 42–44 cm.

GLOBOROTALOIDES

Globorotaloides hexagonus

Globigerina hexagona Natland, 1938, p. 149, pl. 7, figs. 1a–c.

Globorotaloides hexagona (Natland). Kennett and Srinivasan, 1983, p. 216, pl. 54, figs. 1, 3–5.

Stratigraphic range: Sample 165-999A-45X-2, 42–44 cm, to 1H-5, 42–44 cm.

Remarks: Maximum numbers of this species were found in Sample 165-999A-28X-2, 42–44 cm, and it was unusually common in Sample 165-999A-13H-CC, 28–31 cm. *Gd. hexagonus* normally accounts for <3% of the assemblage.

GLOBOTURBOROTALITA

Assignment of this genus name to the species listed below is dependent on the supposed phylogenetic connection between *Globoturborotalita rubescens* Hofker and a Neogene ancestor. Kennett and Srinivasan (1983) linked *Gt. rubescens* with *Globigerina (Zeaglobigerina) decoraperta,* and acknowledged the possible priority of *Globoturborotalita.* Lourens et al. (1992) proposed the derivation *Gt. rubescens* from *Globoturborotalita apertura*

Globoturborotalita apertura

Globigerina apertura Cushman, 1918, p. 57, pl. 12, figs. 8a–c.

Globigerina (Zeaglobigerina) apertura Cushman. Kennett and Srinivasan, 1983, p. 44, pl. 8, figs. 4–6.

Stratigraphic range: Sample 165-999A-33X-CC, 18–20 cm, to 9H-CC, 30–32 cm

Globoturborotalita decoraperta

Globigerina druryi Akers *decoraperta* Takayanagi and Saito, 1962, p. 85, pl. 28, figs. 10a–c.

Globigerina decoraperta Takayanagi and Saito. Kennett and Srinivasan, 1983, p. 48, pl. 9, figs. 4–6.

Stratigraphic range: Sample 165-999A-29X-CC, 37–39 cm, to 14H-2, 42–44 cm.

Globoturborotalita druryi

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

Globoturborotalita druryi (Akers). Hofker, 1977.

Globigerina (Zeaglobigerina) druryi Akers. Kennett and Srinivasan, 1983, p. 46, pl. 8, figs. 7–9.

Stratigraphic range: Sample 165-999A-32X-5, 42–44 cm, to 30X-5, 42–44 cm.

Globoturborotalita nepenthes

Globigerina nepenthes Todd, 1957, p. 301, figs. 7a–b.

Globigerina (Zeaglobigerina) nepenthes Todd. Kennett and Srinivasan, 1983, p. 48, pl. 9, figs. 1–3.

Globoturborotalita nepenthes (Todd). Hofker, 1977.

Stratigraphic range: Sample 165-999A-32X-5, 42–44 cm, to 15H-CC.

Remarks: Specimens that are intermediate between the ancestral *Globoturborotalita druryi* (Kennett and Srinivasn, 1983) and *Gt. nepenthes* are observed in Sample 165-999A-31X-CC.

Globoturborotalita rubescens

Globigerina rubescens Hofker, 1956, p. 234, pl. 32, fig. 26; pl. 35, figs. 18–21.

Globigerina (Zeaglobigerina) rubescens Hofker. Kennett and Srinivasan, 1983, p. 50, pl. 9, figs. 7–9.

Globoturborotalita rubescens (Hofker). Hofker, 1977.

Stratigraphic range: Sample 165-999A-11H-2, 42–44 cm, to 1H-2, 42–44 cm.

Remarks: In the absence of its pink coloration this species is difficult to distinguish from *Globoturborotalita woodi* from the middle Pliocene to lower Pleistocene, where their ranges overlap. A conservative definition is adopted for *Gt. rubescens* and a more inclusive one for *Gt. woodi.* This decision is made based on the large amount of morphologic variation observed in *Gt. woodi* throughout its range. Specimens are called *Gt. rubescens* if they have a relatively smooth final chamber and a relatively loose whorl, which gives the test a more tetrahedral appearance. By contrast, the chambers of *Gt. woodi* tend to be more tightly embracing. In addition, the apertural lip of *Gt. rubescens* tends to be more distinct to even flangelike, and the aperture itself tends to be round ("bullet-hole").

Globoturborotalita tenella

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

Globigerinoides tenellus Parker. Kennett and Srinivasan, 1983, p. 80, pl. 17, figs. 7–9.

Globoturborotalita tenella (Parker). This study.

Stratigraphic range: Sample 165-999A-3H-5, 42–44 cm, to 1H-CC, 25–27 cm.

Remarks: In the interest of paring *Globigerinoides* down to a monophyletic genus we interpret the close resemblance of this species to *Gt. rubescens* as evidence for phylogenetic relatedness, and reassign it to the genus *Globoturborotalita.*

Globoturborotalita woodi

Globigerina woodi Jenkins, 1960, p. 352, pl. 2, figs. 2a–c.

Globoturborotalita woodi (Jenkins). Hofker, 1977.

Globigerina (Turborotalita) woodi woodi Jenkins. Chaproniere, 1981, p. 124, pls. 1, 2.

Globigerina (Zeaglobigerina) woodi Jenkins. Kennett and Srinivasan, 1983, p. 43, pl. 7, figs. 4–6.

Stratigraphic range: Sample 165-999A-33X-CC, 18–20 cm, to 9H-CC, 30–32 cm.

HIRSUTELLA

Hirsutella challengeri

Globorotalia challengeri Srinivasan and Kennett, 1981b, pp. 499–533, pl. 1.

Globorotalia (Hirsutella) challengeri Srinivasan and Kennett. Kennett and Srinivasan, 1983, p. 142, pl. 33, figs. 7–9.

Stratigraphic range: Sample 165-999A-29X-2, 41–43 cm, to 27X-2, 42–44 cm.

Hirsutella cibaoensis

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

Globorotalia (Hirsutella) cibaoensis Bermudez. Kennett and Srinivasan, 1983, p. 136, pl. 32, figs. 1–3.

Hirsutella cibaoensis (Bermudez). Chaisson and Pearson, 1997, p. 16, pl. 2, figs. 18, 19.

Stratigraphic range: Sample 165-999A-30X-CC, 38–40 cm, to 15H-CC, 28–31 cm.

Remarks: This species is distinguished from *H. scitula* by its more pustulose test and the delicate keel on the final chamber. It also is the link between the hirsutellids and the truncorotaliids, giving rise to *Truncorotalia crassula* during the latest Miocene (Kennett and Srinivasan, 1983). Specimens that are intermediate between *H. cibaoensis* and *T. crassula* were found in Sample 165-999A-27X-5, 42–44 cm, deeper than would be expected for the FO of *T. crassula. H. cibaoensis* differs from *Hirsutella juanai* (below) by its possession of a slight keel (as per Chaisson and Leckie, 1993, but contra Kennett and Srinivasan, 1983) and a pinched edge to the final chamber. Specimens with a nearly flat spiral side and an umbate shape to the umbilical side of the chambers (i.e., grading toward *H. juanai*) were found in Samples 165-999A-25X-CC, 35–37 cm, and 21H-5, 42–44 cm.

Hirsutella hirsuta

Rotalina hirsuta d'Orbigny, 1839, p. 131, pl. 1, figs. 34–36.

Globorotalia (Hirsutella) hirsuta (D'Orbigny). Kennett and Srinivasan, 1983, p. 138, pl. 32, figs. 7–9.

Stratigraphic range: Sample 165-999A-12H-5, 42–44 cm, to 2H-CC, 11–13 cm.

Remarks: Below Sample 165-999A-10H-5, 42–44 cm, specimens are informally referred to as *H. hirsuta "praehirsuta."* These specimens serve as a morphological transition and fill the stratigraphic gap between the FO of *H. hirsuta* and the LO of its putative ancestor, *Hirsutella margaritae* (Kennett and Srinivasan, 1983). This transition has also been observed at Blake-Bahama Outer Ridge (Leg 172; Keigwin, Rio, Acton, et al., 1998) and at Site 959 (Norris, 1998). The *H. hirsuta praehirsuta* forms are distinguished from *H. margaritae* by their generally larger size and pustulose texture. In addition, the umbilically concave shape that is characteristic of *H. margaritae* gradually gives way to greater inflation on the umblical side and a flatter spiral side with earlier chambers becoming roughened by secondary calcite.

Hirsutella juanai

Globorotalia juanai Bermudez and Bolli, 1969, pp. 171–172, pl. 14, figs. 1–6; Bolli and Saunders, 1985, p. 216, figs. 30.20–21a–c, 22–24.

Globorotalia (Hirsutella) juanai Bermudez and Bolli. Kennett and Srinivasan, 1983, p. 134, pl. 31, figs. 6–8.

Hirsutella juanai (Bermudez and Bolli). Chaisson and Pearson, 1997, p. 16.

Stratigraphic range: Sample 165-999A-28X-2, 42–44 cm, to 20H-5, 42–44 cm.

Hirsutella margaritae

Globorotalia margaritae Bolli and Bermudez, 1965, p. 138, pl. 1, figs. 1–9; Bolli and Saunders, 1985, p. 216, figs. 30.1–5, 30.9–14.

Globorotalia (Hirsutella) margaritae Bolli and Bermudez. Kennett and Srinivasan, 1983, p. 136, pl. 32, figs. 4–6; Bolli and Saunders, 1985.

Hirsutella margaritae (Bolli and Bermudez). Chaisson and Pearson, 1997, p. 16, pl. 2, fig. 20.

Stratigraphic range: Sample 165-999A-17H-CC, 21–23 cm, to 14H-2, 42–44 cm.

Remarks: For succinct comparison of the three *margaritae* morphotypes of Cita (1973), see Bolli and Saunders (1985, p. 217). Most specimens in Sample 165-999A-17H-CC, 21–23 cm (the FO in this hole), were small *H. margaritae primitiva* forms. However, large, well-developed *H. margaritae evoluta* forms were found as deep as Sample 165-999A-16H-CC, 70–73 cm. At Site 999 there appeared to be a gradual morphological transformation from *H. margaritae evoluta* toward *H. hirsuta.* Morphometric work seems necessary to delimit this apparently gradual transformation, which may be a Caribbean phenomenon.

Hirsutella scitula

Pulvinulina scitula Brady, 1882, p. 27, pl. 5, fig. 5 (lectotype).

Globorotalia (Hirsutella) scitula (Brady). Kennett and Srinivasan, 1983, p. 134, pl. 31, figs. 1, 3–5.

Hirsutella scitula (Brady). Chaisson and Pearson, 1997, p. 16.

Stratigraphic range: Sample 165-999A-41X-5, 40–42 cm, to 1H-2, 42–44 cm. This species shows varying amounts of chamber inflation on the umbilical side and flattening of the spiral side. In addition, the texture of the test can vary from opaque to translucent. Specimens with flat spiral sides were found in Sample 165-999A-36X-5, 35–37 cm, and 36X-3, 42–44 cm. Specimens with pronounced inflation on the umbilical side were found in Sample 165-999A-9H-5, 42–44 cm. Above Sample 165-999A-7H-2, 42–44 cm, most specimens were more translucent than those further down the section, strongly suggesting that this is a post-depositional change.

MENARDELLA

Menardella archeomenardii

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

Globorotalia (Menardella) archeomenardii Bolli. Kennett and Srinivasan, 1983, p. 122, pl. 28, figs. 3–5.

Stratigraphic range: Sample 165-999A-40X-5, 42–44 cm, to 38X-2, 42–44 cm.

Menardella exilis

Globorotalia (Globorotalia) cultrata exilis Blow, 1969.

Globorotalia (Mendardella) exilis Blow. Kennett and Srinivasan, p. 128, pl. 28, fig. 1; pl. 30, figs. 1–3.

Menardella exilis (Blow). Chaisson and Pearson, 1997, p. 15, pl. 1, figs. 6, 9.

Stratigraphic range: Sample 165-999A-15H-5, 42–44 cm, to 9H-2, 42–44 cm.

Menardella limbata

Rotalia limbata Fornasini, 1902, pp. 30–31, pl. 5, fig. 3 (lectotype).

Globorotalia (Menardella) limbata (Fornasini). Kennett and Srinivasan, 1983, p. 124, pl. 29, figs. 4–6.

Menardella limbata (Fornasini). Chaisson and Pearson, 1997, p. 15, pl. 1, fig. 3.

Stratigraphic range: Sample 165-999A-31X-CC, 37–40 cm, to 11H-5, 42–44 cm.

Remarks: *M. limbata* is distinguished from its ancestor, *Menardella menardii,* by its straight spiral sutures and inflated chambers on the umbilical side. Specimens of *M. limbata* in Sample 165-999A-29X-CC, 37–39 cm, have straight spiral sutures, but not umbilical inflation. In Sample 165-999A-22X-2, 42–44 cm, varying degrees of umbilical inflation were observed. In several samples between Sample 165-999A-20H-5, 42–44 cm, and 11H-5, 42–44 cm, finely perforate specimens were observed. These specimens resembled either *Menardella miocenica* (with umbilical side inflation) or *Menardella exilis* (with a flattened test and straight spiral sutures). Maximum numbers of *M. limbata* were found in Sample 165-999A-18H-5, 42–44 cm. In this sample morphology was also quite variable. Some specimens were slightly translucent and relatively flat with an open umbilicus, whereas others were inflated on the umbilical side with a closed umbilical area and a round periphery.

Menardella menardii

Rotalia menardii Parker, Jones, and Brady, 1865, p. 20, pl. 3, fig. 81; Bolli and Saunders, 1985, p. 220, fig. 34.1–10.

Globorotalia (Menardella) menardii Parker, Jones, and Brady. Kennett and Srinivasan, p. 124, pl. 28, fig. 2.; pl. 29, figs. 1–3.

Menardella menardii (Parker, Jones, and Brady). Chaisson and Pearson, 1997, p. 15, pl. 1, figs. 1, 2.

Stratigraphic range: Sample 165-999A-33X-3, 42–44 cm, to 1H-2, 42–44 cm.

Remarks: Some *M. menardii* specimens in Sample 165-999A-22X-4, 42–44 cm, have a "cockscomb" periphery similar to that of *Fohsella fohsi lobata.* Where their ranges overlap, specimens intermediate between *M. menardii* and *Menardella limbata* were often found (e.g., Sample 165-999A-19H-2, 42–44 cm). Similarly, in the lower parts of the *Menardella exilis* range intermediate specimens were found. For example, in Sample 165-999A-12H-2, 42–44 cm, *M. menardii* pores are visible, but are very fine and tests are biconvex. The straight spiral sutures characteristic of *M. limbata* were used to distinguish that species from *M. menardii.*

At Site 999 *M. menardii* specimens are predominantly sinistrally coiled. Both sinistral and dextral specimens co-occur in only three samples (Sample 165-999A-32X-2, 42–44 cm; 31X-CC, 37–40 cm; and 6H-5, 42–44 cm). The longest interval of dextral only *M. menardii* specimens is in the lower to middle Pliocene when the morphospecies is largely absent and dextrally coiled *M. limbata* are the most abundant menardellid.

Menardella miocenica

Globorotalia menardii (d'Orbigny) var. *miocenica* Palmer, 1945.

Globorotalia (Menardella) miocenica, Palmer. Kennett and Srinivasan, p. 128, pl. 30, figs. 4–6.

Menardella miocenica (Palmer). Chaisson and Pearson, 1997, p. 15, pl. 2, figs. 1–4.

Stratigraphic range: Sample 165-999A-11H-5, 42–44 cm, to 9H-5, 42–44 cm.

Remarks: Good specimens of *M. miocenica* were not common at Site 999. In Sample 165-999A-11H-2, 42–44 cm, specimens had significant umbilical inflation, but their peripheries were sharply oval, rather than round. In Sample 165-999A-10H-2, 42–44 cm, specimens were not very inflated on the umbilical side and were somewhat opaque, rather than translucent.

Menardella multicamerata

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

Globorotalia multicamerata Cushman and Jarvis. Bolli and Saunders, 1985, p. 220, fig. 32.5a–c.

Globorotalia (Menardella) multicamerata Cushman and Jarvis. Kennett and Srinivasan, 1983, p. 126, pl. 29, figs. 7–9.

Menardella multicamerata (Cushman and Jarvis). Chaisson and Pearson, 1997, p. 15, pl. 1, fig. 4.

Stratigraphic range: Sample 165-999A-17H-CC, 21–23 cm, to 11H-5, 42–44 cm.

Menardella pertenuis

Globorotalia pertenuis Beard, 1969, p. 552, pl. 1, figs. 1–6; pl. 2, figs. 5, 6; Bolli and Saunders, 1985, p. 220, fig. 33.3a–c.

Globorotalia (Menardella) pertenuis Beard. Kennett and Srinivasan, 1983, p. 130, pl. 30, figs. 7–9.

Menardella pertenuis (Beard). Chaisson and Pearson, 1997, p. 15, pl. 1, figs. 10, 11.

Stratigraphic range: Sample 165-999A-12H-2, 42–44 cm, to 9H-CC, 30–32 cm.

Remarks: Good specimens of this morphospecies were found only in Sample 165-999A-10H-5, 42–44 cm. This species is separated from *M. exilis* by the lowering of the apertural, which reduces the opening to a slit, and the frequent presence of a "frill"-like ornament on the apertural lip. In addition, specimens of *M. pertenuis* are less inflated than those assigned to *M. exilis* and the chambers have a more subquadrate appearance.

Menardella praemenardii

Globorotalia praemenardii Cushman and Stainforth, 1945, p. 70, pl. 13, figs. 14a–c.

Globorotalia (Menardella) praemenardii Cushman and Stainforth. Kennett and Srinivasan, 1983, p. 122, pl. 28, figs. 6–8.

Menardella praemenardii (Cushman and Stainforth). Chaisson and Pearson, p. 30, pl. 1, no. 1

Stratigraphic range: Sample 165-999A-37X-5, 40–42 cm, to 33X-3, 42–44 cm.

"Globorotalia pseudomiocenica"

Globorotalia pseudomiocenica Bolli and Bermudez, 1965, p. 140, pl. 1, figs. 13–15; Bolli and Saunders, 1985, p. 230, figs. 31.1, 35.1–3.

Stratigraphic range: Sample 165-999A-21H-2, 42–44 cm, to 10H-5, 42–44 cm.

Remarks: This morphotype is a form of *Menardella limbata* with a round, rather than an ovate, periphery and with a degree of umbilical inflation that exceeds that of ovate *M. limbata,* but is usually less pronounced than that of coeval *M. miocenica.* In addition, the spiral side of *G. pseudomiocenica* is usually slightly more convex than that of *M. miocenica.* Specimens with the flattest dorsal sides were observed in Sample 165-999A-18H-2, 42–44 cm. That is, well below the FO of *M. miocenica.*

NEOGLOBOQUADRINA

Neogloboquadrina acostaensis

Globorotalia acostaensis Blow, 1959, p. 208, pl. 17, figs. 106a–c.

Neogloboquadrina acostaensis (Blow). Kennett and Srinivasan, 1983, p. 196, pl. 47, fig. 1; pl. 48, figs. 1–3.

Stratigraphic range: Sample 165-999A-29X-5, 41–43 cm, to 12H-5, 42–44 cm.

Remarks: The FO of this species is difficult to constrain at this site because irregular specimens in Samples 165-999A-30X-CC, 38–40 cm; 30X-5, 42–44 cm; and 30X-2, 43–45 cm, resemble *Paragloborotalia mayeri.* These five-chambered specimens lack the high arched, hooked aperture of the latter species or have an apertural flap that covers that feature. However, the difference between the size of chambers in the penultimate and final whorls in these irregular specimens is greater than is usual for *N. acostaenis* and more characteristic of the paragloborotaliids. They may, however, represent five-chambered intermediate forms between the ancestral *Neogloboquadrina continuosa* and *N. acostaensis.* In the Pliocene interval of Hole 999A several samples (Samples 165-999A-10H-5, 42–44 cm; 10H-3, 32–34 cm; 10H-2, 42–44 cm; 8H-CC, 24–26 cm; 7H-CC, 23–25 cm; 7H-5, 42–44 cm; 6H-2, 42–44 cm; 5H-2, 42–44 cm; and 2H-5, 42–44 cm) include small neogloboquadrinids that resemble the "aco-pac" form described by Loubere (1988) in the Pliocene

North Atlantic. These specimens have a low trochospire, an apertural flap, four and a half to five chambers in the final whorl that gradually increase in size. In this study these specimens are classified as *N. pachyderma.*

Neogloboquadrina continuosa

Globorotalia opima Bolli subsp. *continuosa* Blow, 1959, p. 218, pl. 19, figs. 125a–c.

Neogloboquadrina continuosa (Blow). Kennett and Srinivasan, 1983, p. 192, pl. 47, figs. 3–5.

Stratigraphic range: Bottom of the section examined to Sample 165-999A-29X-CC, 37–39 cm.

Remarks: This species is distinguished from *Neogloboquadrina pachyderma* by their differing whorl geometries. Specifically, in *N. continuosa* Chamber 6 (counting backward from the final chamber) in the penultimate whorl, is on the same radial axis as Chamber 2 in the final whorl. In *N. pachyderma* Chamber 6 lines up with the suture between Chambers 1 and 2. In addition, the final chamber of an *N. continuosa* tends to be larger than the penultimate chamber. This is not often the case in an *N. pachyderma.*

Neogloboquadrina dutertrei

Globigerina dutertrei d'Orbigny, 1839, pl. 2, fig. 1 (lectotype).

Neogloboquadrina dutertrei (d'Orbigny). Kennett and Srinivasan, 1983, p. 198, pl. 48, figs. 7–9.

Stratigraphic range: Sample 165-999A-25X-CC, 20–23 cm, to 1H-2, 42–44 cm.

Remarks: Upper Miocene specimens of this species are very primitive looking with relatively lower trochospires than Pliocene specimens, little or no apertural ornamentation, and less umbilical aperture position. They are distinguished from coeval *Neogloboquadrina acostaensis* by their greater chamber inflation and less embracing chambers. See *Neogloboquadrina humerosa* below.

Neogloboquadrina humerosa

Globorotalia humerosa Takayanagi and Saito, 1962, p. 78, pl. 28, figs. 1a–2b.

Neogloboquadrina humerosa (Takayanagi and Saito). Kennett and Srinivasan, 1983, p. 196, pl. 28, figs. 1a–2b.

Stratigraphic range: Sample 165-999A-20H-CC, 41–44 cm, to 17H-CC, 21–23 cm.

Remarks: This species is distinguished from *Neogloboquadrina dutertrei* by possession of at least six chambers in the final whorl, a lower trochospire, and a more extraumbilical aperture. The aperture is also bordered by a rim. Good examples of this morphotype were found in Sample 165-999A-17H-CC, 21–23 cm.

Neogloboquadrina pachyderma

Aristopira pachyderma Ehrenberg, 1861, pp. 276, 277, 303; Banner and Blow, 1960, p. 4, pl. 3, figs. 4a–c (lectotype).

Neogloboquadrina pachyderma (Ehrenberg). Kennett and Srinivasan, p. 192, pl. 47, figs. 2, 6–8.

Stratigraphic range: Sample 165-999A-30X-5, 42–44 cm, to 2H-2, 42–44 cm.

Remarks: The LO of sinistrally coiled *N. pachyderma* is in Sample 165-999A-15H-5, 42–44 cm, in the lower Pliocene. Tropical specimens of this species retain the familiar four-square appearance of the extra-tropical representatives, but the chambers tend to be more inflated and crusting with secondary calcite not as common or as pronounced.

ORBULINA

Orbulina universa

Orbulina universa d'Orbigny, 1839, p. 3, pl. 1, fig. 1; Kennett and Srinivasan, 1983, p. 86, pl. 20, figs. 4–6.

Stratigraphic range: Sample 165-999A-37X-5, 40–42 cm, to 1H-2, 42–44 cm.

Remarks: Bilobate specimens are rarely observed at this site. However, in several samples between Sample 165-999A-33X-CC, 18–20 cm, and 22H-2, 42–44 cm, *Orbulina* specimens have the earlier trochospirally arranged chambers visibly embedded in the wall of the final spherical chamber. In Sample 165-999A-35X-2, 39–41 cm, *Orbulina* specimens that closely resemble *Praeorbulina glomerosa circularis* were found, but no *P. glomerosa* were observed at this site.

PARAGLOBOROTALIA

Spezzaferri (1991) assigned *"Globorotalia kugleri"* to the genus. According to Spezzaferri (1991) the following taxa are descended from *P. kugleri* (Spezzaferri, 1991) and therefore take the genus name. By contrast, Kennett and Srinivasan (1983) traced the ancestry of the following taxa from *Globorotalia opima* and created the subgenus *Jenkinsella* for *G. opima* and its descendants.

Paragloborotalia mayeri

Globorotalia mayeri Cushman and Ellisor, 1939, p. 11, pl. 2, figs. 4a–c.

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

Globorotalia (Jenkinsella) mayeri Cushman and Ellisor. Kennett and Srinivasan, 1983, p. 174, pl. 43, figs. 4–6.

Globorotalia (Jenkinsella) siakensis LeRoy. Kennett and Srinivasan, 1983, p. 172, pl. 42, figs. 1, 6–8.

Stratigraphic range: Bottom of the section examined to Sample 165-999A-30X-2, 43–45 cm.

Paragloborotalia semivera

Globigerina semivera Hornibrook, 1961, p. 149, pl. 23, figs. 455–457.

Globorotalia (Jenkinsella) semivera (Hornibrook). Kennett and Srinivasan, 1983, p. 172, pl. 42, figs. 3–5.

Stratigraphic range: Sample 165-999A-46X-5, 45–46 cm, to 42X-2, 42–44 cm.

Remarks: This species resembles *Paragloborotalia mayeri,* but its aperture lacks the "hook" characteristic of the latter species.

PRAEORBULINA

Praeorbulina sicana

Globigerinoides sicanus (De Stefani), 1950, p. 9, fig. 6; Kennett and Srinivasan, 1983, p. 62, pl. 13, figs. 4–6.

Stratigraphic range: Sample 165-999A-46X-CC, 27–32 cm, to 39X-2, 41–43 cm.

Remarks: Samples in the lower Miocene interval of Hole 999A are very clay rich, which makes it difficult to locate the tiny, third supplementary aperture that distinguishes *P. sicana* from *Globigerinodes sacculifer* of the trilobus form (see comments in Pearson and Chaisson, 1997). In the interval of transition, specimens of *Gs. sacculifer* with especially large final chambers are common. The third aperture is invariably on the suture between the ultimate and penultimate chambers.

PULLENIATINA

Pulleniatina obliquiloculata

Pullenia sphaeroides (d'Orbigny) var. *obliquiloculata* Parker and Jones, 1865, p. 368, pl. 19, figs. 4a–b.

Pulleniatina obliquiloculata (Parker and Jones), Kennett and Srinivasan, 1983, p. 202, pl. 49, fig. 2; pl. 50, figs. 6–9.

Stratigraphic range: Sample 165-999A-8H-CC, 24–26 cm, to 1H-2, 42–44 cm.

Pulleniatina primalis

Pulleniatina primalis Banner and Blow, 1967, p. 142, pl. 1, figs. 3–8; pl. 3, figs. 2a–c; Kennett and Srinivasan, 1983, p. 200, pl. 49, figs. 1, 3–5.

Stratigraphic range: Sample 165-999A-18H-2, 42–44 cm, to 12H-2, 42–44 cm.

Remarks: Dextrally coiled specimens are found in only one sample (Sample 165-999A-12H-2, 42–44 cm).

SPHAEROIDINELLA

Sphaeroidinella dehiscens

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

Sphaeroidinella dehiscens (Parker and Jones). Kennett and Srinivasan, 1983, p. 212, pl. 51, fig. 2; pl. 52, figs. 7–9.

Stratigraphic range: Sample 165-999A-17H-CC, 21–23 cm, to 1H-5, 42–44 cm.

Remarks: *S. dehiscens* with incomplete cortices were found in Sample 165-999A-17H-5, 42–44 cm, revealing the phylogenetic relationship with *Globigerinoides sacculifer*. Secondary apertures on the spiral side remain minute between the FO and Sample 165-999A-13H-5, 42–44 cm.

SPHAEROIDINELLOPSIS
Sphaeroidinellopsis disjuncta

Sphaeroidinella disjuncta Finlay, 1940, p. 467, pl. 67, figs. 224–228.

Sphaeroidinellopsis disjuncta (Finlay). Kennett and Srinivasan, 1983, p. 206, pl. 51, figs. 3–5.

Stratigraphic range: Sample 165-999A-49X-4, 42–44 cm, to 42X-5, 42–44 cm.

Sphaeroidinellopsis kochi

Globigerina kochi Caudri, 1934, text figs. 8a–b.

Synonym: *Sphaeroidinella multiloba* LeRoy, 1944, p. 91, pl. 4, figs. 7–9.

Synonym: *Sphaeroidinella dehiscens subdehiscens* Blow, 1959, p. 195, pl. 12, figs. 71a–c.

Sphaeroidinellopsis kochi (Caudri). Kennett and Srinivasan, 1983, pl. 52, figs. 1–3.

Stratigraphic range: Sample 165-999A-37X-5, 40–42 cm, to 16H-4, 42–44 cm.

Sphaeroidinellopsis paenedehiscens

Sphaeroidinellopsis paenedehiscens Blow, 1969, p. 386, pl. 30, figs. 4, 5, 9; Kennett and Srinivasan, 1983, p. 52, figs. 4–6.

Stratigraphic range: Sample 165-999A-29X-5, 41–43 cm, to 15H-2, 42–44 cm.

Remarks: *Ss. seminulina* and *Ss. kochi* with incomplete cortices were found in Sample 165-999A-37X-5, 40–42 cm, and strongly suggested a phylogenetic connection to saccate *Globigerinoides sacculifer,* although the sphaeroidinellopsids lack the supplementary apertures of *Globigerinoides* species. Similar specimens in Sample 165-999A-25X-CC, 20–23 cm, suggest non-saccate *Gs. sacculifer* may be the ancestor of *Ss. paenedehiscens.*

Sphaeroidinellopsis seminulina

Globigerina seminulina Schwager, 1866, p. 256, pl. 7, fig. 112.

Sphaeroidinellopsis seminulina seminulina (Schwager). Kennett and Srinivasan, 1983, p. 206, pl. 51, figs. 1, 6–8.

Stratigraphic range: Sample 165-999A-38X-2, 42–44 cm, to 13H-2, 42–44 cm.

TRUNCOROTALIA
Truncorotalia crassaformis

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

Globorotalia (Truncorotalia) crassaformis (Galloway and Wissler). Kennett and Srinivasan, 1983, p. 146, pl. 34, figs. 6–8.

Globorotalia crassaformis crassaformis (Galloway and Wissler). Bolli and Saunders, 1985, p. 230, fig. 36.6–7.

Truncorotalia crassaformis (Galloway and Wissler). Chaisson and Pearson, 1997, p. 16, pl. 2, figs. 6–11.

Stratigraphic range: Sample 165-999A-15H-5, 42–44 cm, to 1H-2, 42–44 cm.

Remarks: This species has distinct morphotypes that have been classified as "subspecies" by some workers (e.g., Bolli and Saunders, 1985; Arnold, 1983). Kennett and Srinivasan (1983) inferred "a possible ancestry" between *Truncorotalia crassula* and *T. crassaformis. T. crassaformis viola* is the *"crassaformis"* morphotype most similar to *T. crassula.* This form has relatively less umbilical inflation than most forms of *T. crassaformis*, more spatulate chambers, and was observed in Samples 165-999A-9H-2, 42–44 cm; 7H-5, 42–44 cm; and 5H-2, 42–44 cm. In the last sample the chambers are strongly keeled. By contrast, *T. crassaformis hessi* is a compact, nearly pyramidal form with a kummerform final chamber, the spiral base of which is on a different plane than those of the other chambers in the final whorl. Good *T. crassaformis hessi* were observed in Sample 165-999A-6H-2, 42–44 cm. Finally, specimens with very embracing chambers that are tightly coiled and very similar in form to *Truncorotalia truncatulinoides,* but have four to four and a half chambers in the final whorl, were found in Sample 165-999A-5H-5, 42–44 cm.

Truncorotalia truncatulinoides

Rotalia truncatulinoides d'Orbigny, 1839, p. 132, pl. 2, figs. 25–27.

Globorotalia truncatulinoides (d'Orbigny). Lamb and Beard, 1972, p. 56, pl. 24, figs. 1–4; pl. 25, figs. 1–7; pl. 26, figs. 1–3; Jenkins and Orr, 1972; p. 1104, pl. 33, figs. 4–6; Stainforth et al., 1975, figs. 209–211.

Globorotalia truncatulinoides truncatulinoides (d'Orbigny). Bolli and Saunders, 1985, p. 234, figs. 37.4–5.

Globorotalia (Truncorotalia) truncatulinoides (d'Orbigny). Kennett and Srinivasan, 1983, p. 148, pl. 34, fig. 2; pl. 35, figs. 4–6.

Truncorotalia truncatulinoides (d'Orbigny). Chaisson and Pearson, 1997, p. 16.

Stratigraphic range: Sample 165-999A-8H-2, 42–44 cm, to 1H-2, 42–44 cm.

Remarks: The transition from *Truncorotalia tosaensis* to *Truncorotalia truncatulinoides* is defined by the development of an imperforate peripheral keel or band. Transitional specimens were found in Sample 165-999A-4H-5, 42–44 cm; they had only a faint band on the older chambers of the final whorl.

Dextrally coiled *T. truncatulinoides* were more consistently present at Site 999. In only one sample (Sample 165-999A-7H-2, 42–44 cm) were there only sinistrally coiled specimens. In only two samples (Samples 165-999A-5H-CC, 14–16 cm, and 4H-CC, 16–20 cm) were sinistrally coiled specimens significantly more common than dextrally coiled specimens.

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Appendix A. Species' ranges, Hole 999A.

LEGEND

Occurrence

C	Common (16%-30%)
F	Few (4%-15%)
R	Rare (1%-3%)
*	Single specimen
?	Specimen of questionable identity
	Outside of published range
	Does not occur at Site 999 within published range

Preservation

Excellent (virtually no broken specimens)

Good (>90% unbroken specimens; little dissolution)

Moderate (30%-90% unbroken specimens)

Poor (<30% unbroken specimens)

Pleistocene–late Miocene

Core, section, interval (cm) 165-999A-	Age		Zone	Depth (mbsf)	Age (Ma)	*Catapsydrax dissimilis*	*Globigerina falconensis*	*bulloides*	*Globoturborotalita woodi*	*apertura*	*druryi*	*nepenthes*	*decoraperta*	*rubescens*	*tenellus*	*Globigerinoides altiapertura*	*obliquus*	*extremus*	*conglobatus*	*ruber*	*seigliei*	*subquadratus*	Preservation
1H-2, 42-44	Pleistocene	late	N22	1.92	0.05			R						R					R	C			white
1H-5, 42-44	Pleistocene	late	N22	4.92	0.14			F						R					R	C			white
1H-CC, 25-27	Pleistocene	late	N22	7.58	0.21									R	R				R	A			white
2H-2, 42-44	Pleistocene	late	N22	9.52	0.27			R						F					R	C			white
2H-5, 42-44	Pleistocene	late	N22	14.02	0.40			R						F					R	F			white
2H-CC, 11-13	Pleistocene	late	N22	17.08	0.48			R						R	R				R	C			dark gray
3H-2, 42-44	Pleistocene	late	N22	19.02	0.54		R	R						R	R					C			white
3H-5, 42-44	Pleistocene	late	N22	23.52	0.67			R						R	R				R	C			white
3H-CC, 24-26	Pleistocene	late	N22	26.58	0.75		R	R						F					R	C			light gray
4H-2, 42-44	Pleistocene	late	N22	28.52	0.81		R							F					R	C			white
4H-5, 42-44	Pleistocene	early	N22	33.02	0.96			R						F					R	C			light gray
4H-CC, 16-20	Pleistocene	early	N22	36.08	1.05									F					R	C			light gray
5H-2, 42-44	Pleistocene	early	N22	38.02	1.12			R						R					R	F			light gray
5H-5, 42-44	Pleistocene	early	N22	42.52	1.26		R	R						R					R	C			light gray
5H-CC, 14-16	Pleistocene	early	N22	45.58	1.36			R						F			R		R	F			light gray
6H-2, 42-44	Pleistocene	early	N22	47.52	1.42		R	R						R					R	C			white
6H-5, 42-44	Pleistocene	early	N22	52.02	1.56			R						R			R		R	C			white
6H-CC, 23-25	Pleistocene	early	N22	55.08	1.66			R									R		R	C			white
7H-2, 42-44	Pleistocene	early	N22	57.02	1.72		R	R						R			R		R	C			light gray
7H-5, 42-44	Pliocene	late	N22	61.52	1.87			R						F			R		R	C			light gray
7H-CC, 23-25	Pliocene	late	N22	64.58	1.96			R						R			R		R	C			light gray
8H-2, 42-44	Pliocene	late	N22	66.52	2.03		R	R						R			R		R	F			dark gray
8H-5, 42-44	Pliocene	late	N21/N20	71.02	2.17			F						F			R			C			light gray
8H-CC, 24-26	Pliocene	late	N21/N20	74.08	2.27			F	?					R					F	C			white
9H-2, 42-44	Pliocene	late	N21/N20	76.02	2.34			R						R			R		R	F			dark gray
9H-5, 42-44	Pliocene	late	N21/N20	80.52	2.49			R	?					F			R		R	F			dark gray
9H-CC, 30-32	Pliocene	middle	N21/N20	83.58	2.59				F	R				R			*		R	F			light gray
10H-2, 42-44	Pliocene	middle	N21/N20	85.52	2.65			R	R					R			R		R	C			dark gray
10H-3, 32-34	Pliocene	middle	N21/N20	86.92	2.69			R	R	R				F				?	R	C			dark gray
10H-5, 42-44	Pliocene	middle	N21/N20	90.02	2.78			R	F	F							R	R	R	F			light gray
10H-CC, 34-36	Pliocene	middle	N21/N20	93.08	2.87			R	F	R							F	R	R	F			light gray
11H-2, 42-44	Pliocene	middle	N21/N20	95.02	2.93			R	R	R				F			F	R	R	C			light gray
11H-5, 42-44	Pliocene	middle	N21/N20	99.52	3.06			R	F	R				?			F		R	F			dark gray
11H-CC, 22-25	Pliocene	middle	N19	102.58	3.15			R	F	R							F	R		F			light gray
12H-2, 42-44	Pliocene	middle	N19	104.52	3.20			R	F	R							F	R		F			dark gray
12H-5, 42-44	Pliocene	middle	N19	109.02	3.33			R	F	R							F	R	R	F			light gray
12H-CC, 36-38	Pliocene	middle	N19	112.08	3.42			R	F	R							F	R	R	F			dark gray
13H-2, 42-44	Pliocene	early	N19	114.02	3.48			R	F	F							F	R	R	F			light gray
13H-5, 42-44	Pliocene	early	N19	118.52	3.64		R	F	F	F							F	R		R			light gray
13H-CC, 28-31	Pliocene	early	N19	121.58	3.79			R	F	R							R	R	R	R			light gray
14H-2, 42-44	Pliocene	early	N19	123.52	3.89			R	F	R			*				F	F	R				dark gray
14H-5, 42-44	Pliocene	early	N19	128.05	4.13			R	F	R							F	R	R	R			light gray
14H-CC, 30-35	Pliocene	early	N19	131.08	4.29		F		F	F							F	R	R	R			dark gray
15H-2, 42-44	Pliocene	early	N19	133.02	4.39			R	F	F			*				F	R	R	R			dark gray
15H-5, 42-44	Pliocene	early	N19	137.55	4.62			F	F	F			R				F	R	R				dark gray
15H-CC, 28-31	Pliocene	early	N19	140.58	4.76		R	R	F	R		R	R				F	R	R				dark gray
16H-2, 42-44	Pliocene	early	N19	142.52	4.84			R	F	R		R	*				F	R					dark gray
16H-4, 42-44	Pliocene	early	N19	145.52	4.97			R	F	R		R	R				F	R		*			dark gray
16H-CC, 70-73	Pliocene	early	N19	150.08	5.16		R	R	F	R		R	*				F	R	*				dark gray
17H-2, 42-44	Pliocene	early	N19	152.02	5.24			R	F	R							F	R	R				dark gray
17H-5, 42-44	Miocene	late (in part)	N19	156.52	5.43			R	F				R				F	R	*				black
17H-CC, 21-23	Miocene	late (in part)	N19	159.58	5.56		R	R	F	R		R					F	F					light gray
18H-2, 42-44	Miocene	late (in part)	N18/N17	161.52	5.63			F	F			R	R				C	R					dark gray
18H-5, 42-44	Miocene	late (in part)	N18/N17	166.05	5.79			R	F			R	R				F	R					dark gray
18H-CC, 26-29	Miocene	late (in part)	N18/N17	169.08	5.90		R	R	R	R		*					F	R					light gray
19H-2, 42-44	Miocene	late (in part)	N18/N17	171.02	5.97			R	R			R					F	R					dark gray
19H-5, 42-44	Miocene	late (in part)	N18/N17	175.57	6.13		R	R	F			R					F	R					dark gray
19H-CC, 27-30	Miocene	late (in part)	N18/N17	178.58	6.23		R	R	F	R		*					F	F	*	R			light gray

Appendix A (continued).

Pleistocene–late Miocene

Core, section, interval (cm) 165-999A-	Age		Zone	Depth (mbsf)	Age (Ma)	*Globigerinoides sacculifer*	*Globigerinoides sacculifer* (no sac)	*Globigerinoides fistulosus*	*Praeorbulina sicana*	*Orbulina universa*	*Fohsella birnageae*	*Fohsella peripheroronda*	*Fohsella peripheroacuta*	*Fohsella praefohsi*	*Fohsella fohsi fohsi*	*Globoconella zealandica*	*Globoconella praescitula*	*Globoconella panda*	*Globoconella miozea*	*Globoconella inflata*
1H-2, 42-44	Pleistocene	late	N22	1.92	0.05	F	F			R										R
1H-5, 42-44	Pleistocene	late	N22	4.92	0.14	F	F			R										
1H-CC, 25-27	Pleistocene	late	N22	7.58	0.21	F				R										
2H-2, 42-44	Pleistocene	late	N22	9.52	0.27	R	F			R										F
2H-5, 42-44	Pleistocene	late	N22	14.02	0.40	R	F			R										R
2H-CC, 11-13	Pleistocene	late	N22	17.08	0.48	F				R										
3H-2, 42-44	Pleistocene	late	N22	19.02	0.54	R	R			R										F
3H-5, 42-44	Pleistocene	late	N22	23.52	0.67	R	F			R										F
3H-CC, 24-26	Pleistocene	late	N22	26.58	0.75	F				R										R
4H-2, 42-44	Pleistocene	late	N22	28.52	0.81	F	F			R										F
4H-5, 42-44	Pleistocene	early	N22	33.02	0.96	F	F			R										R
4H-CC, 16-20	Pleistocene	early	N22	36.08	1.05	F				R										
5H-2, 42-44	Pleistocene	early	N22	38.02	1.12	R	F			R										R
5H-5, 42-44	Pleistocene	early	N22	42.52	1.26	F	F			R										
5H-CC, 14-16	Pleistocene	early	N22	45.58	1.36	C				R										R
6H-2, 42-44	Pleistocene	early	N22	47.52	1.42	F	F			R										
6H-5, 42-44	Pleistocene	early	N22	52.02	1.56	F	C			R										R
6H-CC, 23-25	Pleistocene	early	N22	55.08	1.66	C				R										
7H-2, 42-44	Pleistocene	early	N22	57.02	1.72	F	F			R										R
7H-5, 42-44	Pliocene	late	N22	61.52	1.87	F	F			R										R
7H-CC, 23-25	Pliocene	late	N22	64.58	1.96	F				R										R
8H-2, 42-44	Pliocene	late	N22	66.52	2.03	R	F			R										R
8H-5, 42-44	Pliocene	late	N21/N20	71.02	2.17	F	F	*		F										
8H-CC, 24-26	Pliocene	late	N21/N20	74.08	2.27	C				F										
9H-2, 42-44	Pliocene	late	N21/N20	76.02	2.34	F	F			F										
9H-5, 42-44	Pliocene	late	N21/N20	80.52	2.49	F	C	R		R										
9H-CC, 30-32	Pliocene	middle	N21/N20	83.58	2.59	C		R		F										
10H-2, 42-44	Pliocene	middle	N21/N20	85.52	2.65	F	F			R										
10H-3, 32-34	Pliocene	middle	N21/N20	86.92	2.69	F	F	R		F										
10H-5, 42-44	Pliocene	middle	N21/N20	90.02	2.78	R	F			R										
10H-CC, 34-36	Pliocene	middle	N21/N20	93.08	2.87	F				R										
11H-2, 42-44	Pliocene	middle	N21/N20	95.02	2.93	R	F													
11H-5, 42-44	Pliocene	middle	N21/N20	99.52	3.06	F	C			R										
11H-CC, 22-25	Pliocene	middle	N19	102.58	3.15	F				R										
12H-2, 42-44	Pliocene	middle	N19	104.52	3.20	F	F			R										
12H-5, 42-44	Pliocene	middle	N19	109.02	3.33	F	F			R										
12H-CC, 36-38	Pliocene	middle	N19	112.08	3.42	F				R										
13H-2, 42-44	Pliocene	early	N19	114.02	3.48	F	F			R										
13H-5, 42-44	Pliocene	early	N19	118.52	3.64	F	C			R										
13H-CC, 28-31	Pliocene	early	N19	121.58	3.79	F				R										
14H-2, 42-44	Pliocene	early	N19	123.52	3.89	R	F			R										
14H-5, 42-44	Pliocene	early	N19	128.05	4.13	F	F			R										
14H-CC, 30-35	Pliocene	early	N19	131.08	4.29	C				R										
15H-2, 42-44	Pliocene	early	N19	133.02	4.39	R	F			R										
15H-5, 42-44	Pliocene	early	N19	137.55	4.62	R	C			R										
15H-CC, 28-31	Pliocene	early	N19	140.58	4.76	F				R										
16H-2, 42-44	Pliocene	early	N19	142.52	4.84	F	C			R										
16H-4, 42-44	Pliocene	early	N19	145.52	4.97	R	F			R										
16H-CC, 70-73	Pliocene	early	N19	150.08	5.16	R	C			R										
17H-2, 42-44	Pliocene	early	N19	152.02	5.24	R	F			R										
17H-5, 42-44	Miocene	late (in part)	N19	156.52	5.43	R	R			R										
17H-CC, 21-23	Miocene	late (in part)	N19	159.58	5.56	F	F			R										
18H-2, 42-44	Miocene	late (in part)	N18/N17	161.52	5.63	R	F			R										
18H-5, 42-44	Miocene	late (in part)	N18/N17	166.05	5.79	R	F			R										
18H-CC, 26-29	Miocene	late (in part)	N18/N17	169.08	5.90	R	F			R										
19H-2, 42-44	Miocene	late (in part)	N18/N17	171.02	5.97		R			R										
19H-5, 42-44	Miocene	late (in part)	N18/N17	175.57	6.13	R	F			R										
19H-CC, 27-30	Miocene	late (in part)	N18/N17	178.58	6.23	R	F			R										

Gc. puncticulata (boxed occurrences in the *inflata* column, 1H-2 to 8H-2)

Preservation

Appendix A (continued).

Pleistocene–late Miocene

Core, section, interval (cm) 165-999A-	Age	Zone	Depth (mbsf)	Age (Ma)	archeomenardii	praemenardii	menardii (d)	menardii (s)	limbata (d)	limbata (s)	multicamerata	exilis	miocenica	pertenuis	scitula	juanai	cibaoensis	margaritae	hirsuta	challengeri
1H-2, 42-44	Pleistocene late	N22	1.92	0.05				*							R					
1H-5, 42-44	Pleistocene late	N22	4.92	0.14				F							R					
1H-CC, 25-27	Pleistocene late	N22	7.58	0.21				F							R					
2H-2, 42-44	Pleistocene late	N22	9.52	0.27				R							R					
2H-5, 42-44	Pleistocene late	N22	14.02	0.40				R							R					
2H-CC, 11-13	Pleistocene late	N22	17.08	0.48				F											*	
3H-2, 42-44	Pleistocene late	N22	19.02	0.54																
3H-5, 42-44	Pleistocene late	N22	23.52	0.67				R							R					
3H-CC, 24-26	Pleistocene late	N22	26.58	0.75				F							R					
4H-2, 42-44	Pleistocene late	N22	28.52	0.81				*							R					
4H-5, 42-44	Pleistocene early	N22	33.02	0.96				*												
4H-CC, 16-20	Pleistocene early	N22	36.08	1.05				R							R					
5H-2, 42-44	Pleistocene early	N22	38.02	1.12											R					
5H-5, 42-44	Pleistocene early	N22	42.52	1.26											R					
5H-CC, 14-16	Pleistocene early	N22	45.58	1.36											R					
6H-2, 42-44	Pleistocene early	N22	47.52	1.42											R					
6H-5, 42-44	Pleistocene early	N22	52.02	1.56			R	R				?			R					
6H-CC, 23-25	Pleistocene early	N22	55.08	1.66				F												
7H-2, 42-44	Pleistocene early	N22	57.02	1.72				R							R					
7H-5, 42-44	Pliocene late	N22	61.52	1.87											R				*	
7H-CC, 23-25	Pliocene late	N22	64.58	1.96				R							R					
8H-2, 42-44	Pliocene late	N22	66.52	2.03				R											*	
8H-5, 42-44	Pliocene late	N21/N20	71.02	2.17											R					
8H-CC, 24-26	Pliocene late	N21/N20	74.08	2.27											R					
9H-2, 42-44	Pliocene late	N21/N20	76.02	2.34								R			R					
9H-5, 42-44	Pliocene late	N21/N20	80.52	2.49								R	F		R					
9H-CC, 30-32	Pliocene middle	N21/N20	83.58	2.59								R	F	R	R				R	
10H-2, 42-44	Pliocene middle	N21/N20	85.52	2.65								R	F		R					
10H-3, 32-34	Pliocene middle	N21/N20	86.92	2.69								R	R							
10H-5, 42-44	Pliocene middle	N21/N20	90.02	2.78					R			R	F	R	R				R	
10H-CC, 34-36	Pliocene middle	N21/N20	93.08	2.87								R	F	R	R					
11H-2, 42-44	Pliocene middle	N21/N20	95.02	2.93			R					R	R	*	R					
11H-5, 42-44	Pliocene middle	N21/N20	99.52	3.06					F		R	R	R						R	
11H-CC, 22-25	Pliocene middle	N19	102.58	3.15					F	R	R	R								
12H-2, 42-44	Pliocene middle	N19	104.52	3.20					R			F		R	R					
12H-5, 42-44	Pliocene middle	N19	109.02	3.33			F		F	R	R	R			R				R	
12H-CC, 36-38	Pliocene middle	N19	112.08	3.42			R		R		R	R			R					
13H-2, 42-44	Pliocene early	N19	114.02	3.48			R		R			F			R					
13H-5, 42-44	Pliocene early	N19	118.52	3.64					F		R				R					
13H-CC, 28-31	Pliocene early	N19	121.58	3.79					F		R	R			R					
14H-2, 42-44	Pliocene early	N19	123.52	3.89								F			R			R		
14H-5, 42-44	Pliocene early	N19	128.05	4.13					F			R			R					
14H-CC, 30-35	Pliocene early	N19	131.08	4.29			R		R		R				R			R		
15H-2, 42-44	Pliocene early	N19	133.02	4.39					R			R						R		
15H-5, 42-44	Pliocene early	N19	137.55	4.62					F	R	R	R			R			F		
15H-CC, 28-31	Pliocene early	N19	140.58	4.76					F	R	*				R		*	R		
16H-2, 42-44	Pliocene early	N19	142.52	4.84					F		*				*		?	R		
16H-4, 42-44	Pliocene early	N19	145.52	4.97														R		
16H-CC, 70-73	Pliocene early	N19	150.08	5.16					R		*							R		
17H-2, 42-44	Pliocene early	N19	152.02	5.24				R	R		*				R			R		
17H-5, 42-44	Pliocene early	N19	156.52	5.43					F						*			R		
17H-CC, 21-23	Pliocene early	N19	159.58	5.56			R		R		R				R			R		
18H-2, 42-44	Miocene late (in part)	N18/N17	161.52	5.63				R		F					R					
18H-5, 42-44	Miocene late (in part)	N18/N17	166.05	5.79				R		F							*			
18H-CC, 26-29	Miocene late (in part)	N18/N17	169.08	5.90				R		F					R					
19H-2, 42-44	Miocene late (in part)	N18/N17	171.02	5.97				F		F					R					
19H-5, 42-44	Miocene late (in part)	N18/N17	175.57	6.13			R		R						R					
19H-CC, 27-30	Miocene late (in part)	N18/N17	178.58	6.23				R		R					R		R			

Genus groupings: *Menardella* (archeomenardii to pertenuis); *Hirsutella* (scitula to challengeri). Preservation column shown as shaded boxes.

Appendix A (continued).

Pleistocene–late Miocene

Core, section, interval (cm) 165-999A-	Age	Zone	Depth (mbsf)	Age (Ma)	*Truncorotalia crassaformis*	*Truncorotalia truncatulinoides* (d)	*Truncorotalia truncatulinoides* (s)	*Globorotalia lenguaensis*	*Globorotalia paralenguaensis*	*Globorotalia merotumida*	*Globorotalia plesiotumida*	*Globorotalia tumida*	*Globorotalia ungulata*	*Paragloborotalia semivera*	*Paragloborotalia mayeri*	*Globoquadrina venezuelana*	*Globoquadrina dehiscens*	*Globoquadrina baroemoenensis*	*Dentoglobigerina altispira*	Preservation
1H-2, 42-44	Pleistocene, late	N22	1.92	0.05	R	R	R													
1H-5, 42-44			4.92	0.14	R	R	R					R								
1H-CC, 25-27			7.58	0.21	R	R						R								
2H-2, 42-44			9.52	0.27	R	R														
2H-5, 42-44			14.02	0.40	R	R						R								
2H-CC, 11-13			17.08	0.48	R	F														
3H-2, 42-44			19.02	0.54	R	*	*													
3H-5, 42-44			23.52	0.67	R	R							R							
3H-CC, 24-26			26.58	0.75	R	F	R													
4H-2, 42-44			28.52	0.81	R	R														
4H-5, 42-44	Pleistocene, early		33.02	0.96	R	R														
4H-CC, 16-20			36.08	1.05	R	R	F													
5H-2, 42-44			38.02	1.12	F	R						*								
5H-5, 42-44			42.52	1.26	F	R	R													
5H-CC, 14-16			45.58	1.36		R	F													
6H-2, 42-44			47.52	1.42	F	R	R													
6H-5, 42-44			52.02	1.56	R							R	R							
6H-CC, 23-25			55.08	1.66		R						F	R							
7H-2, 42-44			57.02	1.72	R		R					F								
7H-5, 42-44	Pliocene, late		61.52	1.87	F										*					
7H-CC, 23-25			64.58	1.96	F	R	R													
8H-2, 42-44			66.52	2.03	R	R						R	R							
8H-5, 42-44		N21 / N20	71.02	2.17	R															
8H-CC, 24-26			74.08	2.27	R															
9H-2, 42-44			76.02	2.34	R								R							
9H-5, 42-44			80.52	2.49	R															
9H-CC, 30-32	Pliocene, middle		83.58	2.59	R															
10H-2, 42-44			85.52	2.65	R															
10H-3, 32-34			86.92	2.69	R															
10H-5, 42-44			90.02	2.78	R															
10H-CC, 34-36			93.08	2.87	R															
11H-2, 42-44			95.02	2.93	R															
11H-5, 42-44			99.52	3.06	R											R			R	
11H-CC, 22-25		N19	102.58	3.15												R			R	
12H-2, 42-44			104.52	3.20	R											R			R	
12H-5, 42-44			109.02	3.33	R											*			R	
12H-CC, 36-38			112.08	3.42	R						?					R			R	
13H-2, 42-44	Pliocene, early		114.02	3.48	R											R			F	
13H-5, 42-44			118.52	3.64	F											R			F	
13H-CC, 28-31			121.58	3.79	R											R			F	
14H-2, 42-44			123.52	3.89							R					R			R	
14H-5, 42-44			128.05	4.13	R						R					R			R	
14H-CC, 30-35			131.08	4.29	R						R					R			F	
15H-2, 42-44			133.02	4.39	R											R			R	
15H-5, 42-44			137.55	4.62	R						R								R	
15H-CC, 28-31			140.58	4.76							R								R	
16H-2, 42-44			142.52	4.84							*					R			F	
16H-4, 42-44			145.52	4.97															F	
16H-CC, 70-73			150.08	5.16							R								R	
17H-2, 42-44			152.02	5.24															F	
17H-5, 42-44	Miocene, late (in part)		156.52	5.43															F	
17H-CC, 21-23			159.58	5.56							R					R			R	
18H-2, 42-44		N18 / N17	161.52	5.63								R							R	
18H-5, 42-44			166.05	5.79							R								R	
18H-CC, 26-29			169.08	5.90							R					R			R	
19H-2, 42-44			171.02	5.97							R								R	
19H-5, 42-44			175.57	6.13							R					*			R	
19H-CC, 27-30			178.58	6.23							R					R			R	

Appendix A (continued).

Pleistocene–late Miocene

Core, section, interval (cm) 165-999A-	Age		Zone	Depth (mbsf)	Age (Ma)	*Neoglobquadrina* *pachyderma* (d)	*pachyderma* (s)	*continuosa*	*acostaensis*	*humerosa*	*dutertrei*	*Pulleniatina* *primalis* (d)	*primalis* (s)	*obliquiloculata*	*Sphaeroidinellopsis* *disjuncta*	*seminulina*	*kochi*	*paenedehiscens*	*Sphaeroidinella* *dehiscens*	Preservation
1H-2, 42-44				1.92	0.05						C			R						
1H-5, 42-44				4.92	0.14						F			R					R	
1H-CC, 25-27				7.58	0.21						F			R					R	
2H-2, 42-44				9.52	0.27	R					R			R						
2H-5, 42-44				14.02	0.40						R			R						
2H-CC, 11-13		late		17.08	0.48	R					F								R	
3H-2, 42-44				19.02	0.54	R					F			R					R	
3H-5, 42-44				23.52	0.67	R					F									
3H-CC, 24-26				26.58	0.75	R					F			R					R	
4H-2, 42-44	Pleistocene			28.52	0.81	R					F			R					R	
4H-5, 42-44			N22	33.02	0.96	R					F			R					R	
4H-CC, 16-20				36.08	1.05	R					F			R					R	
5H-2, 42-44				38.02	1.12	R					C			F					R	
5H-5, 42-44		early		42.52	1.26	R					F			F					R	
5H-CC, 14-16				45.58	1.36						F			R					R	
6H-2, 42-44				47.52	1.42	R					F			R					R	
6H-5, 42-44				52.02	1.56	R					F			R					R	
6H-CC, 23-25				55.08	1.66	R					C			R					R	
7H-2, 42-44				57.02	1.72	R					F			R					F	
7H-5, 42-44				61.52	1.87	R					F			R					R	
7H-CC, 23-25				64.58	1.96	R					F			R					R	
8H-2, 42-44				66.52	2.03	R					C			R					R	
8H-5, 42-44		late		71.02	2.17	R					F								R	
8H-CC, 24-26				74.08	2.27	R					F			R					R	
9H-2, 42-44				76.02	2.34	R					F								R	
9H-5, 42-44				80.52	2.49	R					F									
9H-CC, 30-32			N21	83.58	2.59	R					F								R	
10H-2, 42-44			/	85.52	2.65	R					F								R	
10H-3, 32-34			N20	86.92	2.69						R								R	
10H-5, 42-44				90.02	2.78	R			?		F								R	
10H-CC, 34-36		middle		93.08	2.87						C								R	
11H-2, 42-44				95.02	2.93						C								R	
11H-5, 42-44				99.52	3.06						F								R	
11H-CC, 22-25				102.58	3.15	R					F								R	
12H-2, 42-44	Pliocene			104.52	3.20	R					F	R						R	R	
12H-5, 42-44				109.02	3.33				R		F									
12H-CC, 36-38				112.08	3.42	R					F									
13H-2, 42-44				114.02	3.48						F					R		R		
13H-5, 42-44				118.52	3.64				R		C					R		R	R	
13H-CC, 28-31				121.58	3.79						C					R		R		
14H-2, 42-44				123.52	3.89				R		F					R		R	R	
14H-5, 42-44				128.05	4.13				R		C							R		
14H-CC, 30-35		early	N19	131.08	4.29						F		R			R		R		
15H-2, 42-44				133.02	4.39				R		R		R			R		F	*	
15H-5, 42-44				137.55	4.62	R	R		F		F					R		R		
15H-CC, 28-31				140.58	4.76	R	R		R		F		R			R				
16H-2, 42-44				142.52	4.84	*			R		C					R		R		
16H-4, 42-44				145.52	4.97		R		R		C					R	R	R		
16H-CC, 70-73				150.08	5.16		R				F					R				
17H-2, 42-44				152.02	5.24	R			F		C						R	R		
17H-5, 42-44				156.52	5.43	R			F		C		R				R	R		
17H-CC, 21-23				159.58	5.56	R	R		F	R	C					R			R	
18H-2, 42-44				161.52	5.63		F		R		C		R			R	R			
18H-5, 42-44	Miocene		N18	166.05	5.79		R		R		F					R				
18H-CC, 26-29		late (in part)	/	169.08	5.90	R	F		R	R	F					R	R			
19H-2, 42-44			N17	171.02	5.97		R				C					R		R		
19H-5, 42-44				175.57	6.13		R		R	R	C					R	R	R		
19H-CC, 27-30				178.58	6.23	R	F		F	R	F					F		R		

Appendix A (continued).

Pleistocene–late Miocene

Core, section, interval (cm) 165-999A-	Age		Zone	Depth (mbsf)	Age (Ma)	*Beella praedigitata*	*Beella digitata*	*Berggrenia riedeli*	*Globorotaloides hexagonus*	*Globigerinita glutinata*	*Globigerinatella insueta*	*Candeina nitida*	*Globigerinella aequilateralis*	Preservation
1H-2, 42-44	Pleistocene	late	N22	1.92	0.05			R		F		*	R	
1H-5, 42-44				4.92	0.14	R		R	R	F			R	
1H-CC, 25-27				7.58	0.21	R			R	F		*	R	
2H-2, 42-44				9.52	0.27	R		R		F			R	
2H-5, 42-44				14.02	0.40	R			R	F			R	
2H-CC, 11-13				17.08	0.48	R				F			R	
3H-2, 42-44				19.02	0.54					F			R	
3H-5, 42-44				23.52	0.67					F			R	
3H-CC, 24-26				26.58	0.75					F				
4H-2, 42-44				28.52	0.81		*			C		*	R	
4H-5, 42-44		early		33.02	0.96					F			R	
4H-CC, 16-20				36.08	1.05		R		R	F		R	R	
5H-2, 42-44				38.02	1.12				R	F			R	
5H-5, 42-44				42.52	1.26					F		*	R	
5H-CC, 14-16				45.58	1.36				R	F		R	R	
6H-2, 42-44				47.52	1.42		R			C		R	F	
6H-5, 42-44				52.02	1.56					F			R	
6H-CC, 23-25				55.08	1.66		R			F				
7H-2, 42-44				57.02	1.72					C			R	
7H-5, 42-44	Pliocene	late		61.52	1.87	R				C		R	R	
7H-CC, 23-25				64.58	1.96					F		R	R	
8H-2, 42-44				66.52	2.03					F		R	R	
8H-5, 42-44			N21 / N20	71.02	2.17					F			R	
8H-CC, 24-26				74.08	2.27					R		*	R	
9H-2, 42-44				76.02	2.34					F			R	
9H-5, 42-44				80.52	2.49					F			R	
9H-CC, 30-32		middle		83.58	2.59					F			R	
10H-2, 42-44				85.52	2.65					F			R	
10H-3, 32-34				86.92	2.69					F			R	
10H-5, 42-44				90.02	2.78					F			R	
10H-CC, 34-36				93.08	2.87					R		R	R	
11H-2, 42-44				95.02	2.93					F		R	R	
11H-5, 42-44				99.52	3.06				R	R			R	
11H-CC, 22-25			N19	102.58	3.15				R	F			R	
12H-2, 42-44				104.52	3.20				R	R		R	R	
12H-5, 42-44				109.02	3.33					F		R	R	
12H-CC, 36-38				112.08	3.42				R	F		R	R	
13H-2, 42-44		early		114.02	3.48					F		R	R	
13H-5, 42-44				118.52	3.64				R	F		R	R	
13H-CC, 28-31				121.58	3.79				R	F		R	R	
14H-2, 42-44				123.52	3.89					F		R		
14H-5, 42-44				128.05	4.13				R	F			R	
14H-CC, 30-35				131.08	4.29				R	F			R	
15H-2, 42-44				133.02	4.39				R	R		R		
15H-5, 42-44				137.55	4.62				R	F			R	
15H-CC, 28-31				140.58	4.76				R	C			R	
16H-2, 42-44				142.52	4.84					F		R	R	
16H-4, 42-44				145.52	4.97					F		*	R	
16H-CC, 70-73				150.08	5.16					F		*	R	
17H-2, 42-44				152.02	5.24					F			R	
17H-5, 42-44	Miocene	late (in part)		156.52	5.43				*	F		R	R	
17H-CC, 21-23				159.58	5.56					F			R	
18H-2, 42-44			N18 / N17	161.52	5.63					F			R	
18H-5, 42-44				166.05	5.79					R			R	
18H-CC, 26-29				169.08	5.90				R	F			R	
19H-2, 42-44				171.02	5.97				R	R			R	
19H-5, 42-44				175.57	6.13					R		R	R	
19H-CC, 27-30				178.58	6.23					R		R	R	

Appendix A (continued).

late Miocene–early Miocene

Core, section, interval (cm) 165-999A-	Age	Zone	Depth (mbsf)	Age (Ma)	*Catapsydrax* *dissimilis*	*Globigerina* *falconensis*	*Globigerina* *bulloides*	*Globoturborotalita* *woodi*	*Globoturborotalita* *apertura*	*Globoturborotalita* *druryi*	*Globoturborotalita* *nepenthes*	*Globoturborotalita* *decoraperta*	*Globigerinoides* *altiapertura*	*Globigerinoides* *obliquus*	*Globigerinoides* *extremus*	*Globigerinoides* *conglobatus*	*Globigerinoides* *ruber*	*Globigerinoides* *seigliei*	*Globigerinoides* *subquadratus*	*Globigerinoides* *sacculifer*	*Globigerinoides* *sacculifer* (no sac)	Preservation
20H-2, 42-44	Miocene, late (in part)	N18/N17	180.52	6.30				F	R		R	R		F	R					R	R	
20H-5, 42-44	Miocene, late (in part)	N18/N17	185.02	6.46				F			R			F	R					F	F	
20H-CC, 41-44	Miocene, late (in part)	N18/N17	188.08	6.57			R	R			R			F	R		R			R	R	
21H-2, 42-44	Miocene, late (in part)	N18/N17	190.02	6.63			R	F			R			F	R					R	F	
21H-5, 42-44	Miocene, late (in part)	N18/N17	194.52	6.79				R			R			C	R					R	F	
21H-CC, 27-31	Miocene, late (in part)	N18/N17	197.58	6.90				F	R		F			C	R					R	F	
22X-2, 42-44	Miocene, late (in part)	N18/N17	199.52	6.97				F			R	R		F	R					R	F	
22X-4, 42-44	Miocene, late (in part)	N18/N17	202.52	7.07			R	R			F			R						R	F	
22X-CC, 10-12	Miocene, late (in part)	N18/N17	200.58	7.00				R			R			F	R					R	R	
23X-2, 42-44	Miocene, late (in part)	N18/N17	202.52	7.07			R	R			F			F						R	R	
23X-5, 42-44	Miocene, late (in part)	N18/N17	207.02	7.23			R	F			R			F	R					R	F	
23X-CC, 33-35	Miocene, late (in part)	N18/N17	210.28	7.34				R			R			R	R					R	R	
24X-2, 41-43	Miocene, late (in part)	N18/N17	212.21	7.41			R	F			R			C	F		R			F	F	
24X-5, 42-44	Miocene, late (in part)	N18/N17	216.72	7.57			R	R			R			C	R					R	F	
24X-CC, 35-37	Miocene, late (in part)	N18/N17	219.88	7.68				R			R			C	F		R	R		R	R	
25X-2, 40-42	Miocene, late (in part)	N18/N17	221.80	7.75				R			F	*		R	R					R	F	
25X-5, 42-44	Miocene, late (in part)	N18/N17	226.32	7.91			R	F			R			C			*			R	F	
25X-CC, 20-23	Miocene, late (in part)	N18/N17	229.48	8.02							F	*		F	R			R		R	R	
26X-2, 40-42	Miocene, late (in part)	N18/N17	231.40	8.08				R						C	R					R	R	
26X-5, 50-52	Miocene, late (in part)	N18/N17	236.00	8.25				R			R			F	F					R	F	
26X-CC, 17-20	Miocene, late (in part)	N16	239.08	8.41							R			F	R		*			R	F	
27X-2, 42-44	Miocene, late (in part)	N16	241.02	8.54				F			R			F						R	F	
27X-5, 42-44	Miocene, late (in part)	N16	245.52	8.86			R	F			R	R		C						R	F	
27X-CC, 25-27	Miocene, late (in part)	N16	248.68	9.08			R	F			R			C	R			*		R	F	
28X-2, 42-44	Miocene, late (in part)	N16	250.62	9.21		R	R	F	*		R	R		F	?					R	F	
28X-5, 42-44	Miocene, late (in part)	N16	255.12	9.53		R	R	F	R		F	R		C				R		R	F	
28X-CC, 38-40	Miocene, late (in part)	N16	258.38	9.75				R	R		F			C	R		R			R	F	
29X-2, 41-43	Miocene, late (in part)	N16	260.31	9.89			R	F	R			R		C						F	F	
29X-5, 41-43	Miocene, late (in part)	N16	264.81	10.20				R			R			F	*		*			R	F	
29X-CC, 37-39	Miocene, late (in part)	N15	267.98	10.42			R	F			R	*		C	R		R			R	F	
30X-2, 43-45	Miocene, late (in part)	N14	269.93	10.52			R	R			R			F			R			R	F	
30X-5, 42-44	Miocene, late (in part)	N14	274.42	10.64				R		R				F				?		R	C	
30X-CC, 38-40	Miocene, late (in part)	N14	277.58	10.73		R		R			R			F						R	C	
31X-2, 42-44	Miocene, late (in part)	N14	279.52	10.78				R			R			F						R	C	
31X-5, 42-44	Miocene, middle (in part)	N14	284.02	10.90		R		F			R			C					R		C	
31X-CC, 37-40	Miocene, middle (in part)	N14	287.18	10.99			R			R	R			R						R	F	
32X-2, 42-44	Miocene, middle (in part)	N14	289.12	11.04						R	R			R					F	R	F	
32X-5, 42-44	Miocene, middle (in part)	N14	293.62	11.16				R		R	R			R					F	R	C	
32X-CC, 37-40	Miocene, middle (in part)	N13	296.68	11.48				R						R					F	*	F	
33X-3, 42-44	Miocene, middle (in part)	N12	300.12	12.10			*	R						R					R	R	F	
33X-6, 42-44	Miocene, middle (in part)	N12	304.62	12.92			R	R						F					F	R	C	
33X-CC, 18-20	Miocene, middle (in part)	N12	306.28	13.22			R	F						F					R	R	F	
34X-2, 41-43	Miocene, middle (in part)	N11	308.21	13.42										F					F	R	F	
34X-5, 39-41	Miocene, middle (in part)	N11	312.69	13.53										R					F	R	F	
34X-CC, 33-37	Miocene, middle (in part)	N11	315.98	13.60										F					R	R	F	
35X-2, 39-41	Miocene, middle (in part)	N11	317.91	13.65										F					F	R	F	
35X-5, 42-44	Miocene, middle (in part)	N11	322.42	13.75										F					R	R	F	
35X-CC, 16-20	Miocene, middle (in part)	N11	325.58	13.82										F					R	R	F	
36X-3, 42-44	Miocene, middle (in part)	N11	329.02	13.90										R					R	R	F	
36X-5, 35-37	Miocene, middle (in part)	N11	331.45	13.96										R					R	R	F	
36X-CC, 35-37	Miocene, middle (in part)	N10	335.18	14.10										R						R	R	
37X-2, 60-62	Miocene, middle (in part)	N10	337.30	14.22										F					R	R	F	
37X-5, 40-42	Miocene, middle (in part)	N10	341.60	14.47										F					R	R	F	
37X-CC, 25-27	Miocene, middle (in part)	N10	344.78	14.65										R					R	R	F	
38X-2, 42-44	Miocene, middle (in part)	N9/N8	346.72	14.72										R					R	R	F	
38X-5, 42-44	Miocene, middle (in part)	N9/N8	351.22	14.83										F					R		F	
38X-CC, 34-36	Miocene, middle (in part)	N9/N8	354.38	14.91										R					F		F	

Appendix A (continued).

late Miocene–early Miocene

Core, section, interval (cm) 165-999A-	Age		Zone	Depth (mbsf)	Age (Ma)	*Praeorbulina sicana*	*Orbulina universa*	*Fohsella birnageae*	*Fohsella peripheroronda*	*Fohsella peripheroacuta*	*Fohsella praefohsi*	*Fohsella fohsi fohsi*	*Globoconella zealandica*	*Globoconella praescitula*	*Globoconella panda*	*Globoconella miozea*	*Menardella archeomenardii*	*Menardella praemenardii*	*Menardella menardii* (d)	*Menardella menardii* (s)	*Menardella limbata* (d)	*Menardella limbata* (s)	Preservation
20H-2, 42-44	Miocene	late (in part)	N18 / N17	180.52	6.30		R														R		
20H-5, 42-44				185.02	6.46		R														R		
20H-CC, 41-44				188.08	6.57		R													R	R	R	
21H-2, 42-44				190.02	6.63		R															R	
21H-5, 42-44				194.52	6.79		R														F		
21H-CC, 27-31				197.58	6.90		R													R		R	
22X-2, 42-44				199.52	6.97		R													R		R	
22X-4, 42-44				202.52	7.07		R													R			
22X-CC, 10-12				200.58	7.00		R													F			
23X-2, 42-44				202.52	7.07		R													R		R	
23X-5, 42-44				207.02	7.23		F													R			
23X-CC, 33-35				210.28	7.34		R														R		
24X-2, 41-43				212.21	7.41		R															R	
24X-5, 42-44				216.72	7.57		F												R				
24X-CC, 35-37				219.88	7.68		R																
25X-2, 40-42				221.80	7.75		R													R			
25X-5, 42-44				226.32	7.91		R															R	
25X-CC, 20-23				229.48	8.02		R													R			
26X-2, 40-42				231.40	8.08		R													R		R	
26X-5, 50-52				236.00	8.25		R															R	
26X-CC, 17-20			N16	239.08	8.41		R													R			
27X-2, 42-44				241.02	8.54		R													R			
27X-5, 42-44				245.52	8.86		R													R		R	
27X-CC, 25-27				248.68	9.08		R															R	
28X-2, 42-44				250.62	9.21		R													R		*	
28X-5, 42-44				255.12	9.53		R																
28X-CC, 38-40				258.38	9.75		R													R			
29X-2, 41-43				260.31	9.89		R													R			
29X-5, 41-43				264.81	10.20		R												R				
29X-CC, 37-39			N15	267.98	10.42															R		R	
30X-2, 43-45			N14	269.93	10.52		F												*	F		R	
30X-5, 42-44				274.42	10.64		R													F			
30X-CC, 38-40				277.58	10.73		R													F			
31X-2, 42-44				279.52	10.78		F								*	R				F			
31X-5, 42-44		middle (in part)		284.02	10.90		F								R	R				R			
31X-CC, 37-40				287.18	10.99		*							*	*	R			R	R		*	
32X-2, 42-44				289.12	11.04		R							R	R	F			R	R			
32X-5, 42-44				293.62	11.16		R							R	F	F				R			
32X-CC, 37-40			N13	296.68	11.48		R							R		R							
33X-3, 42-44			N12	300.12	12.10		R					R		F	R	R		R		R			
33X-6, 42-44				304.62	12.92		R			R	R	R		R	R	R		R					
33X-CC, 18-20				306.28	13.22		R			R		*				R							
34X-2, 41-43			N11	308.21	13.42		R			R	R	R				R							
34X-5, 39-41				312.69	13.53		R			R	R			*		R		R					
34X-CC, 33-37				315.98	13.60		R			R	R							R					
35X-2, 39-41				317.91	13.65		R			F	R					R		R					
35X-5, 42-44				322.42	13.75		R			F	R							R					
35X-CC, 16-20				325.58	13.82		R			F	R					*							
36X-3, 42-44				329.02	13.90		R			F	R					*							
36X-5, 35-37				331.45	13.96		R			R	R												
36X-CC, 35-37			N10	335.18	14.10					F													
37X-2, 60-62				337.30	14.22		R		R	R						R		R					
37X-5, 40-42				341.60	14.47		R		R	R				*				R					
37X-CC, 25-27				344.78	14.65				R	R													
38X-2, 42-44			N9/ N8	346.72	14.72				R								R						
38X-5, 42-44				351.22	14.83				R							R	R						
38X-CC, 34-36				354.38	14.91				R								R						

Appendix A (continued).

late Miocene–early Miocene

					Hirsutella				*Globorotalia*				*Paragloborotalia*		*Globoquadrina*			*Dentoglobigerina*
Core, section, interval (cm) 165-999A-	Age	Zone	Depth (mbsf)	Age (Ma)	*scitula*	*juanai*	*cibaoensis*	*challengeri*	*lenguaensis*	*paralenguaensis*	*merotumida*	*plesiotumida*	*semivera*	*mayeri*	*venezuelana*	*dehiscens*	*baroemoenensis*	*altispira*
20H-2, 42-44	Miocene, late (in part)	N18 / N17	180.52	6.30	R		*					R			*			R
20H-5, 42-44			185.02	6.46	R	*									R			F
20H-CC, 41-44			188.08	6.57	R	R	R					R			R			F
21H-2, 42-44			190.02	6.63	R	F	?					R				*		R
21H-5, 42-44			194.52	6.79		R	R								R			R
21H-CC, 27-31			197.58	6.90	R		R					R			R			R
22X-2, 42-44			199.52	6.97		R	R					R						R
22X-4, 42-44			202.52	7.07	R	R	R					R			R			R
22X-CC, 10-12			200.58	7.00	R													
23X-2, 42-44			202.52	7.07											R			R
23X-5, 42-44			207.02	7.23								R			R			R
23X-CC, 33-35			210.28	7.34	R		R					R			R			R
24X-2, 41-43			212.21	7.41	R	R						F			R			F
24X-5, 42-44			216.72	7.57		R	*					R			R			R
24X-CC, 35-37			219.88	7.68	R		R					R			R			R
25X-2, 40-42			221.80	7.75	R	R						F			R		R	F
25X-5, 42-44			226.32	7.91	R							R			R			R
25X-CC, 20-23			229.48	8.02	R	R	R				R	F			R			R
26X-2, 40-42			231.40	8.08		R						F			R			R
26X-5, 50-52			236.00	8.25								R			R			R
26X-CC, 17-20		N16	239.08	8.41	R										R			R
27X-2, 42-44			241.02	8.54	R	*		**R**			*				R			R
27X-5, 42-44			245.52	8.86	R	R					R				R	R		F
27X-CC, 25-27			248.68	9.08	*			**R**			R				R			F
28X-2, 42-44			250.62	9.21	R	R			R	R	R				F	R		F
28X-5, 42-44			255.12	9.53	R				R	R					F			F
28X-CC, 38-40			258.38	9.75	R				R	F	R				R		*	R
29X-2, 41-43			260.31	9.89	R			**R**	R	R	R				R			F
29X-5, 41-43			264.81	10.20	R				R	F	*				F	R	R	F
29X-CC, 37-39		N15	267.98	10.42	R				R	R	**R**				R			R
30X-2, 43-45		N14	269.93	10.52	R				F	**F**	**R**			F	R	*	R	R
30X-5, 42-44			274.42	10.64	R				R		**R**			C		R	R	R
30X-CC, 38-40			277.58	10.73	R		**R**			**R**	**R**			F	R		*	R
31X-2, 42-44			279.52	10.78	R				*					F	R		R	R
31X-5, 42-44	middle (in part)		284.02	10.90	R									C	R		R	R
31X-CC, 37-40			287.18	10.99	R				F					C	R		R	R
32X-2, 42-44			289.12	11.04	R				R					C	R		R	F
32X-5, 42-44			293.62	11.16	R				R					C	F		R	F
32X-CC, 37-40		N13	296.68	11.48	*				R					F	R		R	R
33X-3, 42-44		N12	300.12	12.10	R				R					C	R	R	R	F
33X-6, 42-44			304.62	12.92	*				R					C	R	R	R	F
33X-CC, 18-20			306.28	13.22										F	R		*	F
34X-2, 41-43		N11	308.21	13.42					*					F	R		R	R
34X-5, 39-41			312.69	13.53					R					C	R		R	R
34X-CC, 33-37			315.98	13.60	*									F	R		R	R
35X-2, 39-41			317.91	13.65	*									F	R		R	C
35X-5, 42-44			322.42	13.75										F	F		R	F
35X-CC, 16-20			325.58	13.82	R									F	R			F
36X-3, 42-44			329.02	13.90	*									C	R			F
36X-5, 35-37			331.45	13.96	*									C	F		R	F
36X-CC, 35-37		N10	335.18	14.10										C	F		R	F
37X-2, 60-62			337.30	14.22	R									C	F		R	R
37X-5, 40-42			341.60	14.47	R									F	R			C
37X-CC, 25-27			344.78	14.65										C	F			F
38X-2, 42-44		N9/ N8	346.72	14.72										C	F			F
38X-5, 42-44			351.22	14.83	*									C	F		R	F
38X-CC, 34-36			354.38	14.91										C	F	R	R	F

Preservation

Appendix A (continued).

late Miocene–early Miocene

Core, section, interval (cm) 165-999A-	Age	Zone	Depth (mbsf)	Age (Ma)	*Neoglobquadrina*						*Sphaeroidinellopsis*				*Globorotaloides*	*Globigerinita*	*Globigerinatella*	*Candeina*	*Globigerinella*	
					pachyderma (d)	*pachyderma* (s)	*continuosa*	*acostaensis*	*humerosa*	*dutertrei*	*disjuncta*	*seminulina*	*kochi*	*paenedehiscens*	*hexagonus*	*glutinata*	*insueta*	*nitida*	*aequilateralis*	Preservation
20H-2, 42-44	Miocene, late (in part)	N18 / N17	180.52	6.30		F		F		C				R		R			R	
20H-5, 42-44			185.02	6.46		R		F	R	C		F		R		R				
20H-CC, 41-44			188.08	6.57		F		F	R	R		R	*	R	*	R		*	R	
21H-2, 42-44			190.02	6.63	R			F		F		R		R	R	R		R	R	
21H-5, 42-44			194.52	6.79				F		R		F		R	R	R		R	R	
21H-CC, 27-31			197.58	6.90		R		R				R		R	R	R		R	R	
22X-2, 42-44			199.52	6.97		R		C		R		R		R	*	R			R	
22X-4, 42-44			202.52	7.07		R		F		R		R		R		R		R	R	
22X-CC, 10-12			200.58	7.00	R	R		R		R		F		F		R		*	R	
23X-2, 42-44			202.52	7.07		R		R		R		F		F		R			R	
23X-5, 42-44			207.02	7.23		R		R		R		F				R				
23X-CC, 33-35			210.28	7.34		C		F		R		F		F		R				
24X-2, 41-43			212.21	7.41				F		R				R		F		*	R	
24X-5, 42-44			216.72	7.57		R		F		R		R		R		F		R		
24X-CC, 35-37			219.88	7.68				R		R		F	R	R		F			R	
25X-2, 40-42			221.80	7.75				R		R		F		R		F			R	
25X-5, 42-44			226.32	7.91		R		R		R		R				F				
25X-CC, 20-23			229.48	8.02		R		R		R		F		R		F			R	
26X-2, 40-42			231.40	8.08				F								F				
26X-5, 50-52			236.00	8.25		R		F		?		R			R	R				
26X-CC, 17-20		N16	239.08	8.41		R		F				R							*	
27X-2, 42-44			241.02	8.54		R	?	F		?		R				F			R	
27X-5, 42-44			245.52	8.86		R		F		?		R				F		R		
27X-CC, 25-27			248.68	9.08	*	R		F		?		R		R		F			R	
28X-2, 42-44			250.62	9.21				F		?		R			R	F			R	
28X-5, 42-44			255.12	9.53		R		R		?		R			R	F			R	
28X-CC, 38-40			258.38	9.75		R		R				R				F		R	R	
29X-2, 41-43			260.31	9.89				R				R		R	R	F		R	R	
29X-5, 41-43			264.81	10.20		R		R				R	R	R	R	F			R	
29X-CC, 37-39		N15	267.98	10.42	R		*					R	R		R	F			R	
30X-2, 43-45		N14	269.93	10.52			*					R			R	F			R	
30X-5, 42-44			274.42	10.64		R		?				R	R			R			R	
30X-CC, 38-40			277.58	10.73			*	?				R	R			F			R	
31X-2, 42-44			279.52	10.78								R				R			R	
31X-5, 42-44	middle (in part)		284.02	10.90								R	R			F			R	
31X-CC, 37-40			287.18	10.99								R			*	F			R	
32X-2, 42-44			289.12	11.04								R	*		R	F			R	
32X-5, 42-44			293.62	11.16								R	R			F			R	
32X-CC, 37-40		N13	296.68	11.48			R					R				R			*	
33X-3, 42-44		N12	300.12	12.10								R				F			R	
33X-6, 42-44			304.62	12.92								R	R		R	F			R	
33X-CC, 18-20			306.28	13.22			*									R				
34X-2, 41-43		N11	308.21	13.42			R									R				
34X-5, 39-41			312.69	13.53											*	R			R	
34X-CC, 33-37			315.98	13.60			*					*				R				
35X-2, 39-41			317.91	13.65								R	R		R	R			*	
35X-5, 42-44			322.42	13.75								R	R		*	R			R	
35X-CC, 16-20			325.58	13.82												R				
36X-3, 42-44			329.02	13.90			*					R				R			R	
36X-5, 35-37			331.45	13.96			R					R	R			F			R	
36X-CC, 35-37		N10	335.18	14.10								R	R			R				
37X-2, 60-62			337.30	14.22			*					R	R		*	R			R	
37X-5, 40-42			341.60	14.47			R					F	R		R	R			R	
37X-CC, 25-27			344.78	14.65			R													
38X-2, 42-44		N9/ N8	346.72	14.72			*					R			*	R				
38X-5, 42-44			351.22	14.83			R									R			R	
38X-CC, 34-36			354.38	14.91			R													

Appendix A (continued).

early Miocene

Core, section, interval (cm) 165-999A-	Age		Zone	Depth (mbsf)	Age (Ma)	*Catapsydrax dissimilis*	*Globigerinoides altiapertura*	*Globigerinoides obliquus*	*Globigerinoides subquadratus*	*Globigerinoides sacculifer*	*Globigerinoides sacculifer* (no sac)	*Praeorbulina sicana*	*Fohsella birnageae*	*Fohsella peripheroronda*	*Globoconella zealandica*	*Globoconella praescitula*	*Globoconella miozea*	*Menardella archeomenardii*	*Hirsutella scitula*
39X-2, 41-43	Miocene	middle (in part)	N9 / N8	356.31	14.95			R	F	R	R	R		F		R	R	R	
39X-5, 41-43				360.81	15.06			*	F	R	F	R		F				R	
39X-CC, 40-42				363.98	15.14			R	F	R	F	R		F				R	*
40X-2, 41-43				365.91	15.19			R	F	R	F			F	*			R	*
40X-5, 42-44				370.42	15.29			R	F	R	F	R		F				R	
40X-CC, 28-30				373.68	15.37				F		F			R					
41X-2, 42-44				375.62	15.42			R	F	R	C	R		R					
41X-5, 40-42				380.10	15.53			F	F	R	C	R		R					R
41X-CC, 32-35				383.38	15.61			R	F	R	F			R					
42X-2, 42-44				385.32	15.65			R	C		F	R		R	*				
42X-5, 42-44				389.82	15.76			R	C	R	C	R		R					
42X-CC, 30-33				392.98	15.84			R	F		C			R	*				
43X-2, 42-44				394.92	15.89			R	F	R	C	R		R					
43X-4, 42-44				397.92	15.96				C		C	R		*					
43X-CC, 34-37				402.48	16.07			R	C		F	R							
44X-CC, 38-40				412.08	16.30		R		F		F			F	R	R			
45X-2, 42-44				414.02	16.35		F	R	F	R	C	R		R					
45X-5, 38-40		early (in part)	N7	418.48	16.45		R		R		C			R					
45X-CC, 34-36				421.78	16.53						C			F					
46X-2, 42-44				423.72	16.58		F	R	F		C			R		R			
46X-5, 45-46				428.25	16.69		F		R	R	C			R					
46X-CC, 27-32				431.38	16.76		R	R	R		C	*		R					
47X-2, 40-42				433.80	16.82		F		F	R	C		R	R					
47X-5, 41-43				437.81	16.91		F	R	F	R	C								
47X-CC, 32-34				441.08	16.99														
48X-2, 41-43				443.01	17.04		F		R	R	C		R	R					
48X-5, 41-43				447.51	17.14		F	F	R	R	C		R	F					
48X-CC, 36-38				450.68	17.22		R	R	R	R	C		F	R					
49X-2, 46-48				452.66	17.26			R	R		C								
49X-4, 42-44			N6	455.62	17.33	R	R		R		F								
49X-5,115-117				460.28	17.42	R	R				R			R					
50X-2, 42-44				462.22	17.45	R			R		F								
50X-5, 58-60				466.88	17.54	R			R		C			R					
50X-CC, 37-39				469.88	17.60	F	*	*	R		R			R					

Preservation

Appendix A (continued).

early Miocene

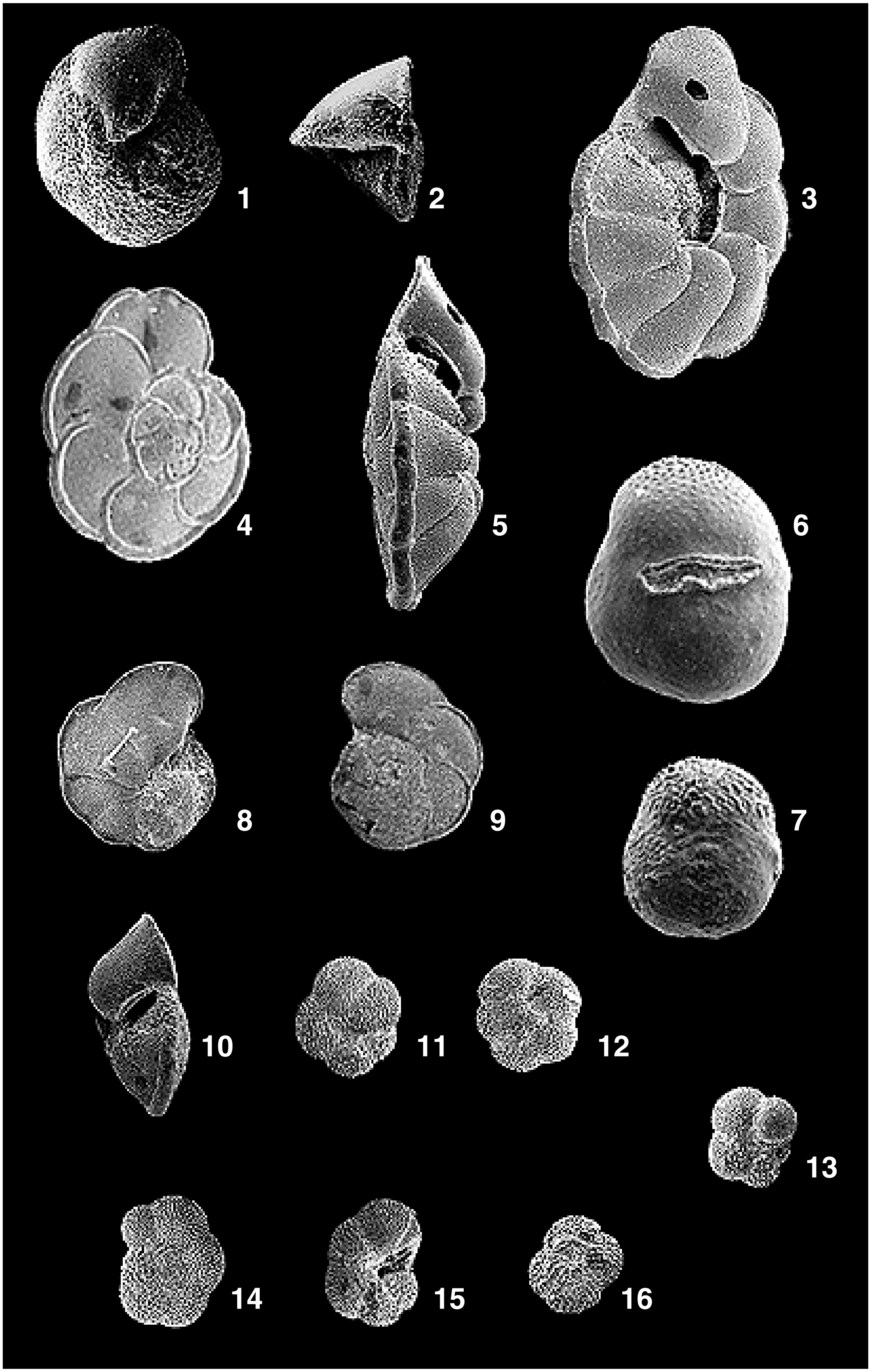
Core, section, interval (cm) 165-999A-	Age	Zone	Depth (mbsf)	Age (Ma)	semivera	*Paragloborotalia* mayeri	*Globoquadrina* venezuelana	*Globoquadrina* dehiscens	*Globoquadrina* baroemoenensis	*Dentoglobigerina* altispira	*Neoglobquadrina* continuosa	*Sphaeroidinellopsis* disjuncta	*Globorotaloides* hexagonus	*Globigerinita* glutinata	*Globigerinatella* insueta	*Globigerinella* aequilateralis	*Cassigerinella* chipolensis	Preservation
39X-2, 41-43	Miocene, middle (in part)	N9 / N8	356.31	14.95		C	F	R	R	F	R			R	R			
39X-5, 41-43			360.81	15.06		C	F	R	R	R				R	R			
39X-CC, 40-42			363.98	15.14		F	F	R	R	R					R			
40X-2, 41-43			365.91	15.19		F	F	R	R	R	R		*	R	R	*		
40X-5, 42-44			370.42	15.29		F	F		R	F	R		R	R				
40X-CC, 28-30			373.68	15.37		F	F			F	R		R		R			
41X-2, 42-44			375.62	15.42		F	F	R	R	F			*	R	*			
41X-5, 40-42			380.10	15.53		F	R	R		C	R		*					
41X-CC, 32-35			383.38	15.61		C	R	F		F	R				R			
42X-2, 42-44			385.32	15.65	R	F	R	R	R	C					*			
42X-5, 42-44			389.82	15.76		C	F	R		F	R	R	R					
42X-CC, 30-33			392.98	15.84		C	F	R		R	R			R	*			
43X-2, 42-44			394.92	15.89	R	C	F	F	R	F		R	*	R	R			
43X-4, 42-44			397.92	15.96	F	C	F	F		F	R	R		R	R			
43X-CC, 34-37			402.48	16.07	R	C	R	R	R	R				R	R			
44X-CC, 38-40			412.08	16.30		R	F	F		F	R							
45X-2, 42-44			414.02	16.35	R	C	R	R	R	F		R	R	R	R	R		
45X-5, 38-40	Miocene, early (in part)	N7	418.48	16.45	R	F	R		R	F	R	*		R	R			
45X-CC, 34-36			421.78	16.53		C	R	R		R	R							
46X-2, 42-44			423.72	16.58		F	F	R	R	F								
46X-5, 45-46			428.25	16.69	R	C	F	R	R	F								
46X-CC, 27-32			431.38	16.76		C	F			F								
47X-2, 40-42			433.80	16.82		F	F			F				*	R	R		
47X-5, 41-43			437.81	16.91		F	F		R	F		R			R	R		
47X-CC, 32-34			441.08	16.99		*	*		*									
48X-2, 41-43			443.01	17.04		F	F		R	C								
48X-5, 41-43			447.51	17.14		F	R	R		F					*	R	R	
48X-CC, 36-38			450.68	17.22		F	F			F				R	R		R	
49X-2, 46-48			452.66	17.26		R	F		R	F	R	R				R		
49X-4, 42-44		N6	455.62	17.33		F	F		R	C	R	R		R		R	R	
49X-5,115-117			460.28	17.42		C	F				R			R	R		R	
50X-2, 42-44			462.22	17.45		R	C		R	F	R			R		R		
50X-5, 58-60			466.88	17.54		F	F	*		F	R			R		R		
50X-CC, 37-39			469.88	17.60		R	F		R	R	R			R	R			

Appendix A (continued).

Appendix B. Sample Ages, Hole 999A.

Core, section, interval (cm)	Depth (mbsf)	Age (Ma)
165-999A-		
1H-2, 42-44	1.92	0.05
1H-5, 42-44	4.92	0.14
1H-CC, 25-27	7.58	0.21
2H-2, 42-44	9.52	0.27
2H-5, 42-44	14.02	0.40
2H-CC, 11-13	17.08	0.48
3H-2, 42-44	19.02	0.54
3H-5, 42-44	23.52	0.67
3H-CC, 24-26	26.58	0.75
4H-2, 42-44	28.52	0.81
4H-5, 42-44	33.02	0.96
4H-CC, 16-20	36.08	1.05
5H-2, 42-44	38.02	1.12
5H-5, 42-44	42.52	1.26
5H-CC, 14-16	45.58	1.36
6H-2, 42-44	47.52	1.42
6H-5, 42-44	52.02	1.56
6H-CC, 23-25	55.08	1.66
7H-2, 42-44	57.02	1.72
7H-5, 42-44	61.52	1.87
7H-CC, 23-25	64.58	1.96
8H-2, 42-44	66.52	2.03
8H-5, 42-44	71.02	2.17
8H-CC, 24-26	74.08	2.27
9H-2, 42-44	76.02	2.34
9H-5, 42-44	80.52	2.49
9H-CC, 30-32	83.58	2.59
10H-2, 42-44	85.52	2.65
10H-3, 32-34	86.92	2.69
10H-5, 42-44	90.02	2.78
10H-CC, 34-36	93.08	2.87
11H-2, 42-44	95.02	2.93
11H-5, 42-44	99.52	3.06
11H-CC, 22-25	102.58	3.15
12H-2, 42-44	104.52	3.20
12H-5, 42-44	109.02	3.33
12H-CC, 36-38	112.08	3.42
13H-2, 42-44	114.02	3.48
13H-5, 42-44	118.52	3.64
13H-CC, 28-31	121.58	3.79
14H-2, 42-44	123.52	3.89
14H-5, 42-44	128.05	4.13
14H-CC, 30-35	131.08	4.29
15H-2, 42-44	133.02	4.39
15H-5, 42-44	137.55	4.62
15H-CC, 28-31	140.58	4.76
16H-2, 42-44	142.52	4.84
16H-4, 42-44	145.52	4.97
16H-CC, 70-73	150.08	5.16
17H-2, 42-44	152.02	5.24
17H-5, 42-44	156.52	5.43
17H-CC, 21-23	159.58	5.56
18H-2, 42-44	161.52	5.63
18H-5, 42-44	166.05	5.79
18H-CC, 26-29	169.08	5.90
19H-2, 42-44	171.02	5.97
19H-5, 42-44	175.57	6.13
19H-CC, 27-30	178.58	6.23
20H-2, 42-44	180.52	6.30
20H-5, 42-44	185.02	6.46
20H-CC, 41-44	188.08	6.57
21H-2, 42-44	190.02	6.63
21H-5, 42-44	194.52	6.79
21H-CC, 27-31	197.58	6.90
22X-2, 42-44	199.52	6.97
22X-4, 42-44	202.52	7.07
22X-CC, 10-12	200.58	7.00
23X-2, 42-44	202.52	7.07
23X-5, 42-44	207.02	7.23
23X-CC, 33-35	210.28	7.34
24X-2, 41-43	212.21	7.41
24X-5, 42-44	216.72	7.57
24X-CC, 35-37	219.88	7.68
25X-2, 40-42	221.80	7.75
25X-5, 42-44	226.32	7.91
25X-CC, 20-23	229.48	8.02
26X-2, 40-42	231.40	8.08
26X-5, 50-52	236.00	8.25
26X-CC, 17-20	239.08	8.41
27X-2, 42-44	241.02	8.54
27X-5, 42-44	245.52	8.86
27X-CC, 25-27	248.68	9.08
28X-2, 42-44	250.62	9.21
28X-5,42-44	255.12	9.53
28X-CC, 38-40	258.38	9.75
29X-2, 41-43	260.31	9.89
29X-5, 41-43	264.81	10.20
29X-CC, 37-39	267.98	10.42
30X-2, 43-45	269.93	10.52
30X-5, 42-44	274.42	10.64
30X-CC, 38-40	277.58	10.73
31X-2, 42-44	279.52	10.78
31X-5, 42-44	284.02	10.90
31X-CC, 37-40	287.18	10.99
32X-2, 42-44	289.12	11.04
32X-5, 42-44	293.62	11.16
32X-CC, 37-40	296.68	11.48
33X-3, 42-44	300.12	12.10
33X-6, 42-44	304.62	12.92
33X-CC, 18-20	306.28	13.22
34X-2, 41-43	308.21	13.42
34X-5, 39-41	312.69	13.53
34X-CC, 33-37	315.98	13.60
35X-2, 39-41	317.91	13.65
35X-5, 42-44	322.42	13.75
35X-CC, 16-20	325.58	13.82
36X-3, 42-44	329.02	13.90
36X-5, 35-37	331.45	13.96
36X-CC, 35-37	335.18	14.10
37X-2, 60-62	337.30	14.22
37X-5, 40-42	341.60	14.47
37X-CC, 25-27	344.78	14.65
38X-2, 42-44	346.72	14.72
38X-5, 42-44	351.22	14.83
38X-CC, 34-36	354.38	14.91
39X-2, 41-43	356.31	14.95
39X-5, 41-43	360.81	15.06
39X-CC, 40-42	363.98	15.14
40X-2, 41-43	365.91	15.19
40X-5, 42-44	370.42	15.29
40X-CC, 28-30	373.68	15.37
41X-2, 42-44	375.62	15.42
41X-5, 40-42	380.10	15.53
41X-CC, 32-35	383.38	15.61
42X-2, 42-44	385.32	15.65
42X-5, 42-44	389.82	15.76
42X-CC, 30-33	392.98	15.84
43X-2, 42-44	394.92	15.89
43X-4, 42-44	397.92	15.96
43X-CC, 34-37	402.48	16.07
44X-CC, 38-40	412.08	16.30
45X-2, 42-44	414.02	16.35
45X-5, 38-40	418.48	16.45
45X-CC, 34-36	421.78	16.53
46X-2, 42-44	423.72	16.58
46X-5, 45-46	428.25	16.69
46X-CC, 27-32	431.38	16.76
47X-2, 40-42	433.80	16.82
47X-5, 41-43	437.81	16.91
47X-CC, 32-34	441.08	16.99
48X-2, 41-43	443.01	17.04
48X-5, 41-43	447.51	17.14
48X-CC, 36-38	450.68	17.22
49X-2, 46-48	452.66	17.26
49X-4, 42-44	455.62	17.33
49X-5, 115-117	460.28	17.42
50X-2, 42-44	462.22	17.45
50X-5, 58-60	466.88	17.54
50X-CC, 37-39	469.88	17.60

Plate 1. All specimens are magnified 70×. **1.** *Truncorotalia truncatulinoides* (Sample 165-999A-5H-CC, 14–16 cm), umbilical view. **2.** *Truncorotalia truncatulinoides* (Sample 165-999A-5H-CC, 14–16 cm), edge view. **3.** *Menardella miocenica* (Sample 165-999A-10H-CC, 34–36 cm), umbilical view. **4.** *Menardella miocenica* (Sample 165-999A-10H-CC, 34–36 cm), spiral view. **5.** *Menardella miocenica* (Sample 165-999A-10H-CC, 34–36 cm), edge view. **6.** *Sphaeroidinella dehiscens* (Sample 165-999A-15H-2, 42–44 cm), umbilical view. **7.** *Sphaeroidinella dehiscens* (Sample 165-999A-15H-2, 42–44 cm), spiral view. **8.** *Globorotalia plesiotumida* (Sample 165-999A-26X-2, 40–42 cm), umbilical view. **9.** *Globorotalia plesiotumida* (Sample 165-999A-26X-2, 40–42 cm), spiral view. **10.** *Globorotalia plesiotumida* (Sample 165-999A-26X-2, 40–42 cm), edge view. **11.** *Neogloboquadrina acostaensis* (Sample 165-999A-38X-2, 42–44 cm), umbilical view. **12.** *Neogloboquadrina acostaensis* (Sample 165-999A-38X-2, 42–44 cm), spiral view. **13.** *Neogloboquadrina pachyderma* sinistral (Sample 165-999A-28X-2, 42–44 cm), umbilical view. **14.** *Paragloborotalia mayeri* (Sample 165-999A-30X-2, 43–45 cm), spiral view. **15.** *Paragloborotalia mayeri* (Sample 165-999A-30X-2, 43–45 cm), umbilical view. **16.** *Globoturborotalita nepenthes* (Sample 165-999A-30X-2, 43–45 cm), umbilical view.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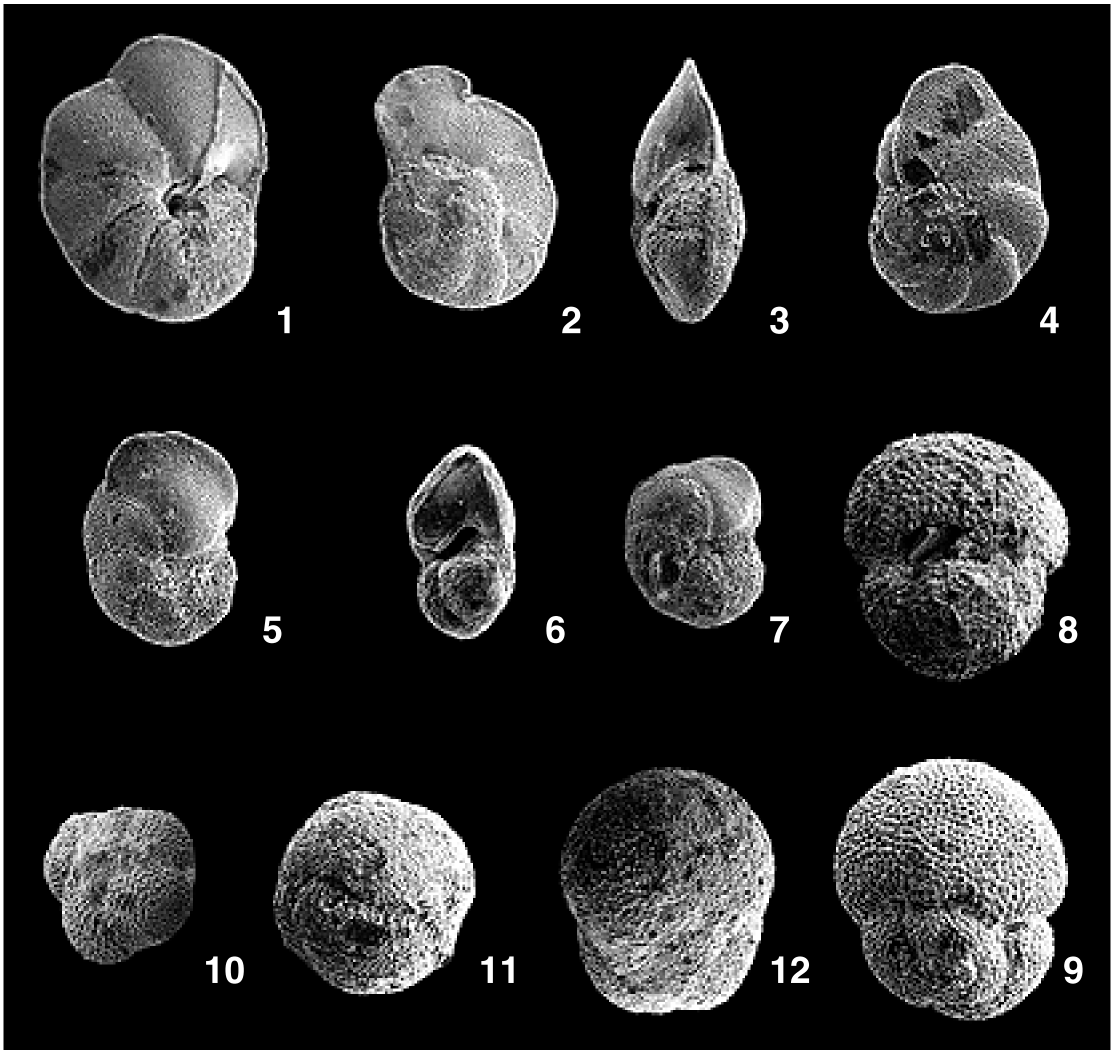

Plate 2. All specimens are magnified 70×. **1.** *Fohsella fohsi* (Sample 165-999A-33X-6, 42–44 cm), umbilical view. **2.** *Fohsella fohsi* (Sample 165-999A-33X-6, 42–44 cm), spiral view. **3.** *Fohsella fohsi* (Sample 165-999A-33X-6, 42–44 cm), edge view. **4.** *Fohsella praefohsi* (Sample 165-999A-33X-6, 42–44 cm), spiral view. **5.** *Fohsella praefohsi* (Sample 165-999A-33X-6, 42–44 cm), umbilical view. **6.** *Fohsella peripheroacuta* (Sample 165-999A-36X-3, 42–44 cm), edge view. **7.** *Fohsella peripheroacuta* (Sample 165-999A-36X-3, 42–44 cm), umbilical view. **8.** *Praeorbulina sicana* (Sample 165-999A-45X-2, 42–44 cm), umbilical view. **9.** *Praeorbulina sicana* (Sample 165-999A-45X-2, 42–44 cm), spiral view. **10.** *Catapsydrax dissimils* (Sample 165-999A-49X-5, 115–117 cm), spiral view. **11.** *Globigerinatella insueta* (Sample 165-999A-45X-5, 38–40 cm), without areal apertures. **12.** *Globigerinatella insueta* (Sample 165-999A-39X-5, 41–43 cm), with areal apertures.