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12. CENOZOIC STRATIGRAPHY AND PALEOCEANOGRAPHY OF BISERIAL PLANKTONIC FORAMINIFERS, ONTONG JAVA PLATEAU[1]

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ABSTRACT

The Ontong Java Plateau in the western equatorial Pacific contains a deposition record of biserial planktonic foraminifers concentrated in the Paleogene, in which frequencies up to 67% of the planktonic foraminifers are reported, and in the late Neogene, in which a maximum frequency of 48% is reported. Biserial planktonic foraminifers are rare or absent in the latest Oligocene and early Miocene, an interval characterized by warm bottom water and low temperature gradients. These conditions supported a surface assemblage rather than the biserial planktonic foraminifers, whose Neogene species inhabited the oxygen minimum at intermediate depths in the upper water column.

Biserial planktonic foraminifers tend to be of high frequency during high sea stands and low frequency during low sea level, presumably in response to the strengthening or weakening of the oxygen minimum. Species extinction and evolution events occur during low sea stands in the Neogene and sometimes correspond to strong reflection horizons of the plateau's seismic stratigraphy.

The biserial species are useful biostratigraphic indexes in the plateau section. The last occurrence (LO) of *Streptochilus martini* corresponds with the Eocene/Oligocene boundary; *S. subglobigerum* without *Neogloboquadrina acostaensis* indicates Zone N15; *S. latum* occurs from the middle of Zone N16 to near the top of Zone N17; *S. globigerum* ranges from near the top of Zone N17 to the middle of Zone N19/N20; and the *S. globulosum* continuous range begins just before the first left-to-right coiling change of *Pulleniatina,* but the species becomes rare in the Pleistocene section.

INTRODUCTION

Intent

This research centers on the distribution of biserial planktonic foraminifers of the genera *Streptochilus* and *Chiloguembelina* in the sedimentary section of the Ontong Java Plateau for the following reasons:

1. Evidence from stable isotopes suggests that biserial planktonic foraminifers occupied the oxygen-minimum level of the upper water column (Boersma et al., 1979, 1987; Boersma and Premoli Silva, 1983, 1989; Resig and Kroopnick, 1983; Lauritzen, 1987). They have provided useful information pertinent to the structure of the Atlantic water column during the Paleogene (Boersma et al., 1987; Boersma and Premoli Silva, 1989) but are virtually unstudied relative to Neogene paleoceanography.
2. The thick carbonate section of the Ontong Java Plateau contains a well-preserved record of varying abundances of biserial planktonic foraminifers as well as species turnovers (J. Resig, shipboard observ.), which may relate to sea-level fluctuations and accompanying changes in water mass structure (Resig, 1989).
3. Continuous coring and good stratigraphic control in the Ontong Java Plateau section (Kroenke, Berger, Janecek, et al., 1991) might further define the stratigraphic ranges of the various species and increase stratigraphic resolution within the existing zonal schemes (Blow, 1969; Berggren, 1969; Berggren and Miller, 1988).

METHODS

Samples were selected from the two shallowest locations of Ocean Drilling Program (ODP) Leg 130 (Fig. 1), Site 806 in 2521 m water depth at 0°19.11′N, 159°21.68′E, and Site 807 in 2804 m water depth at 3°36.42′N, 156°37.49′E, where foraminiferal tests are well preserved and the carbonate stratigraphy is mostly continuous. At Site 806, the interval from the Pleistocene to the base of the Miocene (~24 Ma) was sampled, and at Site 807 the interval from the Pleistocene through the upper middle Eocene (~42 Ma). In both boreholes, two 10-cm^3 samples per core, generally taken in Sections 2 and 4, plus some additional core-catcher samples of variable volume were examined, providing resolution of about 83,000 to 500,000 yr, depending upon the sedimentation rate. The sectional samples were dried and weighed before being processed so as to record actual foraminiferal abundances. Both the shipboard core-catcher samples and the sectional samples were sieved through a screen with 0.063-mm openings. The sectional sand fractions were dried in an oven at 40°C, whereas the shipboard sand fractions were dried at medium heat on a hot plate to speed the identification of stratigraphic markers.

The sand fractions were divided by means of an Otto microsplitter into aliquots containing between approximately 500 and 1000 specimens, which were tallied according to the following categories: benthic foraminifers, *Streptochilus* or *Chiloguembelina,* and other planktonic foraminifers. The percentage of benthic foraminifers was used to evaluate the extent to which selective solution affected the constituents, as benthic tests, which are the product of deep-water secretion, are generally thicker walled and less porous than planktonic tests, rendering them relatively more resistant.

The small size of the biserial planktonic foraminifers makes their species identification difficult; however, diagnostic features such as shape and chamber globosity, as well as faint impressions of surface texture, are all visible under the light microscope at magnifications of 50× or more. Thus, downcore species distributions were determined through light microscopy, but the distributions were confirmed by scanning electron microscope (SEM) photomicrographs in the Paleogene part of the section.

The stratigraphic section in the two drill holes was calibrated with the time scale of Berggren et al. (1985a, 1985b) using first and last appearance datums (FADs and LADs) of planktonic foraminifers and calcareous nannofossils (site reports in Kroenke, Berger, Janecek, et al., 1991) and extrapolating between data points by assuming uniform sedimentation rates. The Eocene/Oligocene boundary was adjusted two cores higher than that reported in the shipboard results because of the upward extent of *Hantkenina* spines and the presence of *Pseudohastigerina* in the absence of *Cassigerinella chipolensis.* The

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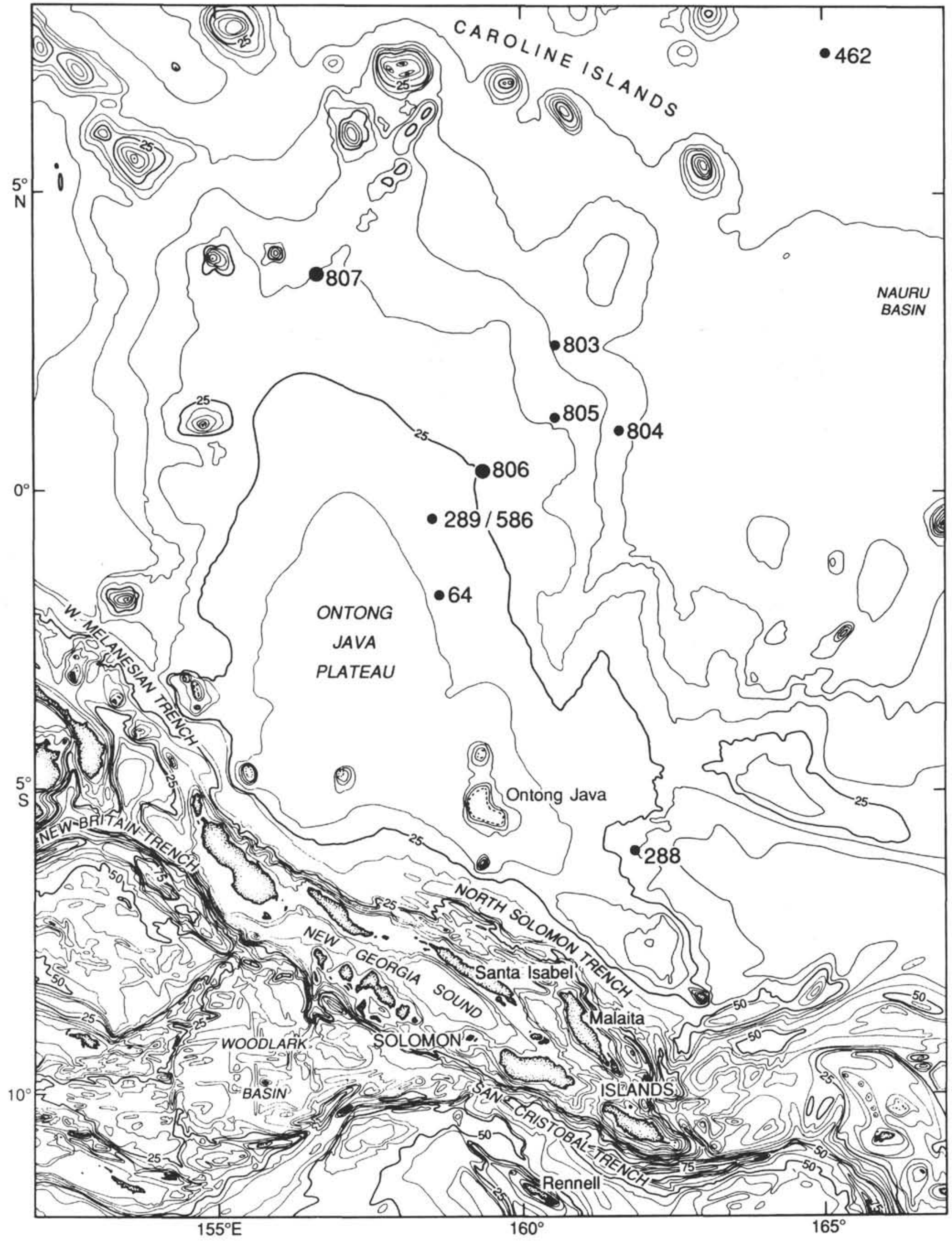

Figure 1. Location of study Sites 806 and 807 in relation to other DSDP and ODP sites on the Ontong Java Plateau.

analysis was ended in the late Eocene section at Site 807 (about 42 Ma). Below that level, the section had abundant limestone and chert, which hindered recovery and did not allow extraction of individual specimens from the matrix and accurate foraminiferal counts. Numerous unconformities were also recorded in the early Paleogene limestone. Only one unconformity encompassing the span from 28.2 to 30 Ma of the upper Oligocene at Site 807 occurred in the stratigraphic sections analyzed. This unconformity corresponds to a drop in sea level (Haq et al., 1987) and an increase in bottom water $\delta^{18}O$ (Miller et al., 1987) that may have generated increased current activity around the plateau. Tectonic activity also may have played a role in generating this unconformity (Kroenke et al., this volume).

Environmental Aspects of the Study Area

Characteristics of the Ontong Java Plateau that most affect the microfossils are its latitudinal position relative to productivity gradients, particularly the equatorial band of upwelling, and the depth of deposition relative to carbonate compensation depth and lysocline levels. Paleomagnetic evidence suggests that the 40-km-thick basalt crust forming the plateau's basement erupted at about 33°S and that the plateau moved northward with the Pacific Plate and occupied tropical latitudes throughout its Cenozoic history (Hammond et al., 1975). On the basis of the rate of Pacific Plate motion, Site 806 crossed the equator in early Pleistocene time and Site 807 in the early middle Miocene. Preliminary research on benthic foraminiferal species and frequency of total benthic specimens in the 1-km-thick carbonate deposits overlying basement suggests continuous lower bathyal environments and a pelagic depositional regime that kept pace with subsidence (Kroenke, Berger, Janecek, et al., 1991).

RESULTS

Plots of the downhole analytical data for biserial planktonic foraminifers are shown in Figure 2 relative to the sea-level curve of Haq et al. (1987) and some pertinent benthic and planktonic foraminiferal data of other researchers (Keller, 1985; Miller et al., 1987). Three basic patterns in the distribution of biserial species emerge that require explanation in terms of paleoceanography: (1) the Paleogene and Neogene clustered occurrences, (2) the fluctuating relative abundance of specimens within the two clusters, and (3) the species turnovers.

Paleogene and Neogene Clusters

A stratigraphic gap roughly 17-m.y. long exists between the LO of Paleogene biserial planktonic foraminifers and the first abundant occurrence of the Neogene species at Site 807. Beckmann (1957) reported the highest occurrence of *Chiloguembelina cubensis* in the *Globorotalia opima opima* Zone of Trinidad, and Berggren et al. (1985b) placed its LO at the top of Subzone P21a in mid-Chron 10, at 30 Ma. However, Hornibrook (1990) extended its upper range into the late Oligocene (middle Chattian) of New Zealand and the basal Miocene of Chatham Island (limestone lens occurrence). The results from Leg 130 support the New Zealand data. Leckie et al. (this volume) record its highest occurrence in Zone P22 of Hole 803D, near the Chron C7/C6C boundary, about 25.3–25.5 Ma. In Hole 807A, the species last occurs in Zone P22 at about 27.6 Ma.

C. cubensis has been placed in the genus *Streptochilus* by Poore and Gosnell (1985), who noted an internal plate connecting the foramina of all but the final one or two chambers of the test, which also tends to have an aperture that is low and fairly symmetrical (although higher apertural arches are reported elsewhere). The parallel ridges of the pustules comprising the surface sculpture of *C. cubensis* are reminiscent of the texture of some species of *Heterohelix.* The traits of three genera are combined in this species, and its taxonomic affinity needs further investigation. No intermediate forms have been found to place *C. cubensis* in the direct lineage of the Neogene species, although stratigraphic considerations suggest it is a possible ancestor. Hornibrook (1990) reported *S. pristinum* and *C. cubensis* coeval in late Oligocene (middle Chattian) strata of New Zealand, whereas they do not occur together at low-latitude Site 807. The evolution of *S. pristinum* must have occurred before the middle late Oligocene, either from *C. cubensis* (= *S. cubensis*) or from an as yet undiscovered or unrecognized ancestral link to Eocene *Streptochilus.* The early appearance of *S. pristinum* in New Zealand suggests that this evolution may have taken place in mid-latitudes rather than in the tropics.

Streptochilus pristinum, the oldest Neogene biserial planktonic, is present sporadically at Sites 806 and 807 beginning about 24 Ma, the base of the lower Miocene. The Neogene group does not become prominent until about 10 Ma (late Miocene).

The separation of these two clusters of abundant biserial planktonic foraminifers cannot be attributed to dissolution or poor preservation of tests because the interval of separation contains abundant specimens of other large and small planktonic species and, with few exceptions, benthic species compose only 3% or less of these pelagic assemblages, typical of good preservation. Kennett et al. (1985) cite additional evidence for the good preservation of lower Miocene (22 Ma) and middle Miocene (16 Ma) planktonic assemblages in the western equatorial Pacific that are comparable with the assemblages found at Sites 806 and 807 (Kroenke, Berger, Janecek, et al., 1991, "Site 806" and "Site 807" chapters).

Isotope signatures of benthic foraminifers (Miller et al., 1987) show a relationship to the clusters (Fig. 2) that suggests paleoceanographic control. The latest Oligocene to early middle Miocene section mostly lacking biserial planktonic foraminifers was deposited at a time when benthic $\delta^{18}O$ values were low, indicating relatively warm bottom waters. At this time equatorial surface water flowed sluggishly westward into the Indian Ocean, the Equatorial Undercurrent had not yet developed, and both latitudinal and vertical thermal gradients were reduced, which would tend to depress the thermocline (Kennett et al., 1985) and restrict or eliminate the habitat occupied by the Neogene biserial planktonic foraminifers. High benthic $\delta^{18}O$ beginning in the late middle Miocene, coincident with the major formation of the Antarctic ice sheet (Shackleton and Kennett, 1975), signaled increased thermal gradients accompanied by a shallower thermocline (Kennett et al., 1985) and increased habitats available for intermediate-dwelling planktonic foraminifers (Keller, 1985), including the Neogene oxygen-minimum biserial planktonic foraminifers. The late Eocene to late Oligocene cluster of biserial planktonic foraminifers also occurred during a time of increasing benthic $\delta^{18}O$ (Fig. 2), but cooler surface waters and a decreasing vertical thermal gradient (Boersma et al., 1987). In contrast to the intermediate-dwelling Neogene biserial species, various species in this interval, including *Chiloguembelina cubensis,* register near surface isotopic temperatures and relatively high $\delta^{13}C$ (Poore and Matthews, 1984; Keigwin and Corliss, 1986; Boersma et al., 1987; Boersma and Premoli Silva, 1989). According to Boersma et al. (1987) and Boersma and Premoli Silva (1989), low interplanktonic $\delta^{13}C$ gradients and relatively high $\delta^{13}C$ values in the mesopelagic habitat during this interval imply that cool, intermediate waters became ventilated, and low oxygen water shoaled to a position overlying the thermocline. These authors present isotopic and distribution evidence to support the reliability of isotopic measurements on these small biserial species, in view of the size dependence established for some other planktonic foraminifers, and their association with low oxygen water. Shallow, warm, low oxygen water had previously characterized the habitat of biserial planktonic foraminifers in Cretaceous epicontinental seas.

The geographic distribution of biserial planktonic foraminifers has changed through time. In the Cretaceous, they occurred worldwide (Masters, 1977) and were particularly well represented in epicontinental seas (e.g., Eicher and Worstell, 1970; Leckie, 1987). Their Paleogene distribution also was cosmopolitan (Loeblich and Tappan, 1987) but exhibited shifts in latitude in response to paleoceangraphic

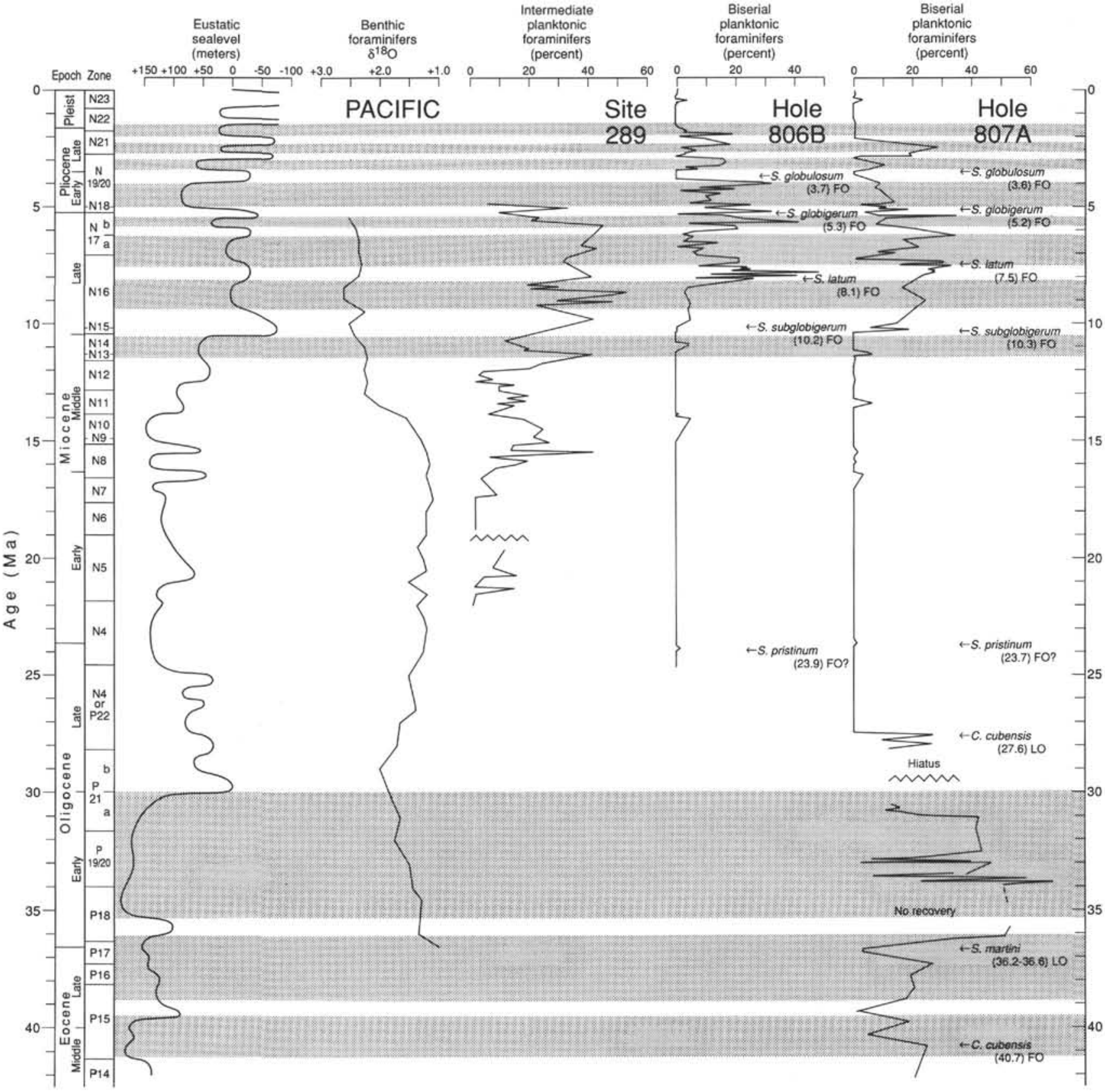

Figure 2. Stratigraphic distribution of biserial planktonic foraminifers in Holes 806B, 807A, and 807C relative to the eustatic sea-level curve (Haq et al., 1987), $\delta^{18}O$ of benthic foraminifers (Miller et al., 1987), and the distribution of intermediate-dwelling planktonic foraminifers (Keller, 1985). Time scale follows Berggren et al. (1985a, 1985b). Shading = relatively high sea levels for sections where biserials are abundant.

conditions (Boersma and Premoli Silva, 1983, 1989; Boersma et al., 1987). In contrast, their Neogene distribution is concentrated in the tropical Indo-Pacific (Resig and Kroopnick, 1983, tables 1–3), with only a few reported occurrences in the central and eastern tropical Pacific, the Caribbean, the Gulf of Mexico, and the Atlantic (Thomas, 1987; Boersma and Premoli Silva, 1989). Mid-Cenozoic biogeographic change involving closure of the Tethys between the Indian and Atlantic oceans, as well as the development of distinct latitudinal belts of planktonic assemblages (cf. Kennett, 1982), have effected this distribution. The localization of oxygen minima of the upper water column caused by increased oxygenation of oceanic waters during the Cenozoic probably played a significant role in the restricted distribution of the biserial planktonic foraminifers (Boersma and Premoli Silva, 1989).

Fluctuating Relative Abundance

Because the pelagic assemblages are generally well preserved, the relative percentages of the biserial planktonic species reflect actual abundances for the most part (Tables 1–3). The distribution plots on Figure 2 show sample groupings of high frequencies of biserial species (maximum 67% in the Paleogene and 48% in the Neogene), separated by relatively low frequencies in curves that are closely similar between the sites where data is available for the Neogene part of the section. This Neogene frequency distribution of biserial species also is similar to that of the Eauripik Rise section to the west (Resig, 1989, figs. 3 and 4), indicating a broad regional pattern of *Streptochilus* contribution to the sediments. Frequencies of lower magnitude that yield roughly similar curves are recorded for the Ninetyeast Ridge in the Indian Ocean (Resig, 1989, fig. 3), suggesting global oceanographic control such as those accompanying changes in sea level.

The fluctuations in frequency of Paleogene biserial planktonic foraminifers show a direct relationship to the sea-level curve (Fig. 2). Highest frequencies occur in conjunction with the long, high sea-level stand during the early Oligocene from about 31 to 35 Ma. Boersma and Premoli Silva (1989) have reported high abundances of *Chiloguembelina* in the Atlantic during this interval, with a maximum of about 25% in the low latitudes and about 37% in the high northern latitudes. High frequencies in the mid to late Eocene section of Site 807 also correspond with high sea stands, and low frequencies conversely correspond with lower sea levels. Similar trends occur in the Atlantic distribution of biserials. This concurrence of biserial planktonic foraminifers and high sea stands reflects Fisher and Arthur's (1977) association of an expanded and intensified oxygen-minimum layer with transgressive sequences, higher temperatures, lower initial oxygen content, and diminished ocean circulation.

The hiatus in the Site 807 section, encompassing the interval from 28 to 30.5 Ma, corresponds to a drop in sea level and a decrease in bottom-water temperature that may coincide with the initial opening of the Drake Passage (Barker and Burrell, 1977), although major circulation changes brought about by the isolation of Antarctica through the development of the Circum-Antarctic Current occurred later, near the Oligocene/Miocene boundary. Keller and Barron (1983) cited these later circulation changes as the cause of hiatus PH, which they reported as occurring at Deep Sea Drilling Project (DSDP) Site 289 on the Ontong Java Plateau. No evidence of this hiatus was noted at Site 807, where planktonic foraminifers are abundant and moderately well to well-preserved in the continuous section across the boundary.

The two curves for the frequency of Neogene biserial planktonic foraminifers generally drop during the initial low sea stand and then recover during rising sea level and high sea stands (Fig. 2). This pattern is particularly well developed in the uppermost Miocene and Pliocene, where high-amplitude fluctuations in sea level occur. Late Miocene Zone N16 diverges most from the basic pattern, but the metric range between high and low sea stands is not great in that interval. The frequency of *Streptochilus* is diminished in the latest Pliocene and Pleistocene, where the numerous fluctuations of ice volume as seen in the oxygen isotopic record (Emiliani, 1955; Shackleton and Opdyke, 1973, 1976) may have disrupted the stable structure of the upper water column necessary for the proliferation of *Streptochilus*. In this regard, note that the eustatic sea-level curve reproduced in Figure 2 is based on first-, second-, and third-order onlap and offlap events, whereas fourth- and fifth-order events are probably reflected in the isotopic signatures (Vail and Haq, 1988). Higher resolution of both the eustatic sea-level curve and the biostratigraphic time scale (possibly with the addition of stable isotope data, in the absence of continuous paleomagnetic data at these low-latitude sites) is necessary to investigate the detailed relationships between peaks and valleys of the curves.

Species Turnovers

Species Ranges

The stratigraphic ranges of species in the two sections studied (Table 4 and Fig. 3) tend to overlap in the Paleogene. In the Neogene, a succession of species occurs, with each new addition replacing the older species through time. These Neogene ranges closely approximate those determined for the Eauripik Rise (Table 4) and Ninetyeast Ridge sections (Resig, 1989).

The Neogene species have been illustrated previously (Brönnimann and Resig, 1971; Resig and Kroopnick, 1983; Resig, 1989). The youngest species, *S. globulosum,* occurs in the surface sediments of the Ontong Java Plateau and has been found in plankton samples from the Indian Ocean (D. Kroon in De Klasz et al., 1988), establishing it as an extant species. It has a continuous range and is the only biserial species present from just before the first left-to-right coiling change of *Pulleniatina* in Zone N19/N20 to the present. A single occurrence of the species at about 5.3 Ma was sampled at Site 806 but not at Site 807. This range is at odds with the middle Miocene through lower Pleistocene composite range given by Fordham (1986) for occurrences at DSDP Site 208 on the Lord Howe Rise and DSDP Site 77 in the central equatorial Pacific. Fordham considers variability in *S. globulosum* to represent *S. latum* or *S. pristinum* and also the reverse, and thus the longer range he attributes to the species is a result principally of differences between us in taxonomic interpretation. However, the single latest Miocene occurrence reported in this study suggests that the species may have evolved sometime before becoming the sole species. Jenkins and Srinivasan (1986) reported *S. globulosum* only within Zone N21 at DSDP Site 586 (Ontong Java Plateau) and at Site 587 (Lord Howe Rise).

Streptochilus globigerum ranges from near the top of Subzone N17b to Zone N19/N20 below the first left-to-right coiling change of *Pulleniatina,* just before or coincident with the beginning of the continuous range of *S. globulosum.* Fordham (1986) has described *S. infirmirugosus* for specimens with weakly pustulose to weakly rugose texture and moderately globular chambers that increase moderately and regularly in size. The type level is lower Pliocene of the Lord Howe Rise, but the indicated range follows that of *S. globigerum* downward to late Miocene Zone N15. According to the distribution reported here and in previous studies of the Eauripik Rise and Ninetyeast Ridge, an interval with smooth-walled *S. latum* separates two intervals of cancellate-textured *Streptochilus.* Specimens of the upper interval are assigned to *S. globigerum* (type level Pliocene) and those of the lower interval to *S. subglobigerum* Resig (1989), a species that tends to be more finely cancellate and more rapidly expanding than *S. globigerum.* In this interpretation, the *S. infirmirugosus* morphotypes are considered within the range of variability of *S. globigerum.* The stratigraphically separate species *S. subglobigerum* is also variable and contains some moderately expanding specimens similar to the type of *S. infirmirugosus.* Fordham (1986) shows stratigraphic groupings of cancellate vs. smooth species at DSDP Site 208, Lord Howe Rise, that approximate the stratigraphic alternation of cancellate and smooth species presented here. This interpretation is therefore retained in this study.

Streptochilus latum ranges from the upper part of Zone N16, where it overlaps the LO of *S. subglobigerum,* to the upper part of Subzone 17b, just before or coincident with the appearance of *S. globigerum.* Typical specimens illustrated by Fordham (1986, plate 1, figs. 122 and 123) are from Zone N17.

Streptochilus subglobigerum first occurs in Zone N15 and can be used to recognize that zone. It ranges to upper Zone N16.

Streptochilus pristinum occurs sporadically from lower Miocene Zone N4 to late Miocene Zone N16. Its most consistent occurrences are indicated by a bar on Figure 2. Jenkins and Srinivasan (1986) reported this species in the upper Oligocene strata of DSDP Site 593 on Lord Howe Rise. Because of its relatively low abundances and sporadic distribution, the complete range is difficult to establish.

The middle Eocene (part) to Oligocene biserial planktonic species occurring in the stratigraphic section of Site 807 are illustrated in Plate 1. The specimens are presented in stratigraphic order from youngest to oldest, and examples of varying morphology both stratigraphically and in a single sample are shown.

Chiloguembelina cubensis ranges from late Eocene, lower Zone P15, to late Oligocene, lower Zone P22/N4, at Site 807. A slightly shorter range from Zones P17 to P21 was reported for it on the Manihiki Plateau (Takayanagi and Oda, 1976), whereas Toumarkine and Luterbacher (1985) show its range down to middle Eocene P11 or P12. Because of poor preservation and lithification of the strata older than middle Eocene, it is likely that the lower extent of *C. cubensis* has not yet been documented at Site 807. *C. cubensis* exhibits variability in the rate of expansion of the test (cf. Plate 1,

Table 1. Census data for Hole 806B.

Core, section, interval (cm)	Depth (mbsf)	Age (Ma)	Weight (g)	Split-1	*Streptochilus*		Planktonic		Benthic		Total count	Foram/g	*Strepto*/g
					No.	%	No.	%	No.	%			
130-806B-													
1H-1, 0–2	0	0	8.3	512	2	0.2	1273	99.5	5	0.4	1280	78959	123
1H-2, 44–46	1.94	0.20	10.7	1024	4	0.6	647	96.9	17	2.5	668	63928	383
1H-4, 44–46	4.94	0.30	8.9	1024	0	0	489	98.8	6	1.2	495	56953	0
1H-CC	6.50	0.30		256	0	0	284	98.3	5	1.7	289		
2H-2, 44–46	8.44	0.40	6.3	1024	0	0	1799	99.8	3	0.2	1802	292897	0
2H-4, 44–46	11.44	0.50	8.7	512	21	3.7	540	95.2	6	1.1	567	33368	1236
2H-CC	16.00	0.60		256	1	0.2	540	99.1	4	0.7	545		
3H-2, 44–46	17.94	0.60	8.4	1024	5	0.3	1848	97.7	38	2.0	1891	230522	610
3H-4, 44–46	20.94	0.65	9.1	1024	1	0.1	836	98.8	9	1.1	846	95198	113
3H-CC	25.60	0.85		256	0	0	422	98.4	7	1.6	429		
4H-2, 44–46	27.44	0.90	19.7	1024	0	0	1128	98.9	12	1.1	1140	59257	0
4H-4, 44–46	30.44	1.00	13.0	1024	0	0	511	99.8	1	0.2	512	40330	0
4H-CC	35.00	1.65		512	0	0	330	98.8	4	1.2	334		
5H-2, 44–46	36.94	1.70	14.0	1024	5	0.8	590	97.2	17	2.8	607	44398	366
5H-4, 44–46	39.94	1.80	14.3	512	32	3.5	858	93.5	28	3.1	918	32868	1146
5H-CC	44.50	1.89		512	10	3.3	284	94.4	7	2.3	301		
6H-2, 44–46	46.44	1.89	7.5	128	55	7.5	634	86.3	46	6.3	735	26316	939
6H-4, 44–46	49.44	1.90	15.2	512	256	19.1	1106	79.7	25	1.8	1387	46720	8623
6H-CC	54.00	2.05		256	5	1.3	370	97.4	5	1.3	380		
7H-2, 44–46	55.94	2.15	21.4	1024	150	9.5	1406	89.5	15	1.0	1571	75173	7178
7H-4, 44–46	58.94	2.25	17.8	1024	153	12.8	1026	86.1	12	1.0	1191	68516	8802
7H-CC	63.50	2.45		256	73	18.2	319	79.6	9	2.2	401		
8H-2, 44–46	65.44	2.50	12.4	512	15	2.4	723	96.4	9	1.2	750	30968	743
8H-4, 44–46	68.44	2.70	11.0	512	80	6.3	1164	91.1	34	2.7	1278	59485	3724
8H-CC	73.00	2.80		256	14	3.0	443	94.3	13	2.7	470		
9H-2, 44–46	74.94	2.90	11.5	512	7	1.0	701	97.5	11	1.5	719	32011	312
9H-3, 44–46	76.44	3.00	9.4	512	150	15.7	838	82.4	19	1.9	1017	55394	8715
9H-CC	82.50	3.20		512	144	17.1	684	81.4	12	1.4	840		
10H-2, 44–46	84.44	3.30	12.2	512	168	14.6	969	84.5	10	0.9	1147	48136	7050
10H-4, 44–46	87.44	3.40	13.7	512	40	3.7	1038	95.2	12	1.1	1090	40736	1495
10H-CC	92.00	3.45		512	52	7.1	670	91.5	10	1.4	732		
11H-2, 44–46	93.94	3.50	15.2	2048	12	1.0	1163	98.1	11	0.9	1186	159798	1617
11H-4, 44–46	96.94	3.60	15.2	512	1	0.1	1026	96.8	33	3.1	1060	35705	34
11H-CC	101.60	3.75		1024	2	0.6	359	99.4	0	0	361		
12H-2, 44–46	103.44	3.75	12.3	2048	3	0.3	1087	98.9	9	0.8	1099	182988	500
12H-4, 44–46	106.44	3.80	15.3	1024	2	0.3	637	98.2	10	1.5	649	43436	134
12H-CC	111.00	3.93		512	1	0.3	332	97.1	9	2.6	342		
13H-2, 44–46	112.94	3.95	15.9	1024	376	22.9	1261	76.7	7	0.4	1644	105878	24215
13H-4, 44–46	115.94	4.00	15.8	1024	268	29.5	636	70.1	3	0.3	907	58783	17369
13H-CC	120.50	4.07		1024	193	32.4	394	66.2	8	1.3	595		
14H-2, 44–46	122.44	4.15	13.9	1024	305	22.3	1053	77.0	9	0.7	1367	100706	22469
14H-4, 44–46	125.44	4.18	15.6	1024	305	20.4	1182	79.0	9	0.6	1496	98199	20021
14H-CC	130.00	4.27		256	27	7.9	306	89.7	8	2.3	341		
15H-2, 44–46	131.94	4.30	12.5	1024	314	19.7	1271	79.9	6	0.4	1591	130335	25723
15H-4, 44–46	134.94	4.35	14.1	1024	18	2.0	886	97.7	3	0.3	907	65870	1307
15H-CC	139.50	4.43		256	21	5.0	396	94.3	3	0.7	420		
16H-2, 44–46	141.45	4.45	13.7	1024	150	9.2	1467	90.4	6	0.4	1623	121310	11212
16H-4, 44–46	144.44	4.50	16.4	1024	90	14.9	505	83.7	8	1.3	603	37651	5620
16H-CC	149.00	4.70		1024	28	10.4	238	88.1	4	1.5	270		
17H-2, 44–46	150.95	4.80	14.1	2048	88	12.1	638	87.6	2	0.3	728	105741	12782
17H-4, 44–46	153.95	4.90	16.3	1024	49	5.0	921	94.6	4	0.4	974	61189	3078
17H-CC	158.60	5.00		512	121	25.5	345	72.8	8	1.7	474		
18H-2, 44–46	160.44	5.10	14.8	2048	102	10.7	844	88.8	4	0.4	950	131459	14115
18H-4, 44–46	163.44	5.20	15.2	1024	165	20.0	659	79.8	2	0.2	826	55646	11116
18H-CC	168.00	5.25		1024	206	32.3	429	67.3	2	0.3	637		
19H-2, 44–46	169.94	5.28	12.3	1024	98	13.9	597	84.9	8	1.1	703	58526	8159
19H-2, 44–46	172.94	5.30	15.9	2048	10	1.6	602	97.9	3	0.5	615	79215	1288
19H-CC	177.50	5.37		1024	57	14.1	343	84.7	5	1.2	405		
20H-2, 45–47	179.45	5.40	14.3	512	140	16.2	706	81.5	20	2.3	866	31006	5013
20H-4, 45–47	182.46	5.45	11.7	2048	176	18.7	759	80.7	5	0.5	940	164540	30808
20H-CC	187.00	5.51		1024	1	0.3	283	98.3	4	1.4	288		
21H-2, 44–46	188.94	5.55	16.6	2048	369	22.8	1248	77.0	4	0.3	1621	199988	45525
21H-4, 44–46	191.94	5.58	16.0	2048	175	25.9	494	73.1	7	1.0	676	86528	22400
21H-CC	196.50	5.66		2048	39	2.0	409	90.5	4	0.9	452		
22H-2, 44–46	198.44	5.70	12.1	512	388	41.2	545	57.9	9	1.0	942	39860	16418
22H-4, 44–46	201.44	5.75	16.4	1024	30	4.5	631	94.0	10	1.5	671	41897	1873
22H-CC	206.00	5.80		512	57	14.7	327	84.1	5	1.3	389		
23H-3, 45–47	209.45	5.85	14.7	1024	194	19.9	769	78.9	12	1.2	975	67918	13514
24H-2, 44–46	217.44	6.00	19.0	2048	214	20.8	809	78.6	6	0.6	1029	110915	23067
24H-4, 44–46	220.44	6.10	14.9	1024	40	6.0	622	93.6	3	0.5	655	45702	2749
25H-2, 44–46	226.94	6.25	16.8	256	22	2.7	739	91.7	45	5.6	806	12282	335
25H-4, 44–46	229.94	6.35	17.3	1024	30	5.5	513	93.8	4	0.7	547	32377	1776
26H-2, 44–46	236.44	6.50	18.3	2048	30	3.0	970	95.8	12	1.2	1012	113256	3357
26H-4, 44–46	239.44	6.60	17.3	1024	143	14.2	864	85.5	3	0.3	1010	59783	8464
27H-2, 44–46	245.94	6.75	15.5	1024	8	0.9	905	98.8	3	0.3	916	60515	529
27H-4, 44–46	248.94	6.80	17.3	1024	91	9.8	813	87.9	3	0.3	925	54751	5386

Table 1 (continued).

Core, section, interval (cm)	Depth (mbsf)	Age (Ma)	Weight (g)	Split-1	*Streptochilus*		Planktonic		Benthic		Total count	Foram/g	*Strepto*/g
					No.	%	No.	%	No.	%			
28H-2, 44–46	255.44	7.00	14.7	1024	65	6.3	956	93.2	5	0.5	1026	71471	4528
28H-4, 44–46	258.44	7.10	16.0	1024	73	6.9	981	92.6	5	0.5	1059	67776	4672
29H-2, 44–46	264.94	7.25	16.9	1024	229	21.0	861	78.8	3	0.3	1093	66227	13876
29H-4, 44–46	267.94	7.40	16.6	2048	327	21.3	1199	78.1	9	0.6	1535	189378	40343
30H-2, 44–46	274.44	7.53	16.7	1024	68	8.5	730	91.0	4	0.5	802	49177	4170
30H-4, 44–46	277.44	7.56	15.8	1024	344	24.1	1073	75.3	8	0.6	1425	92354	22295
31H-2, 44–46	283.94	7.62	16.2	1024	154	23.1	511	76.7	1	0.2	666	42098	9734
31H-4, 44–46	286.94	7.65	17.4	1024	138	24.7	539	96.6	1	0.2	558	32839	8121
32H-2, 44–46	293.44	7.70	14.8	2048	164	19.0	696	80.7	2	0.2	862	77215	22694
32H-4, 44–46	296.44	7.75	16.2	512	196	39.2	302	60.6	1	0.2	498	15739	6163
33H-2, 44–46	302.94	7.83	17.1	2048	322	48.4	342	51.6	0	0	664	79525	38565
33H-4, 44–46	305.94	7.85	14.7	2048	75	11.9	555	87.9	1	0.2	631	87911	10449
34H-2, 44–46	312.44	7.93	12.3	1024	341	41.0	487	58.6	3	0.4	831	69182	28389
34H-4, 44–46	315.44	7.95	14.6	1024	327	26.0	929	73.9	1	0.1	1257	88162	22935
35X-2, 44–46	321.94	8.05	12.6	1024	58	7.2	747	92.5	3	0.4	808	65666	4714
35X-4, 44–46	324.94	8.10	13.5	1024	330	26.1	930	73.6	4	0.3	1264	95877	25031
36X-2, 44–46	331.64	8.55	9.9	1024	20	4.3	447	95.5	1	0.2	468	48407	2069
36X-4, 44–46	334.64	8.70	16.3	2048	17	3.1	522	96.7	1	0.2	540	67848	2136
37X-2, 44–46	341.34	9.20	14.4	512	47	5.1	875	94.8	1	0.1	923	32818	1671
37X-4, 44–46	344.34	9.40	13.0	1024	28	4.5	585	94.8	4	0.7	617	48601	2206
38X-2, 44–46	351.04	9.90	12.7	256	38	5.0	713	93.7	10	1.3	761	15340	766
38X-4, 44–46	354.04	10.20	19.2	1024	5	0.8	606	99.0	1	0.2	612	41229	337
39X-2, 44–46	360.74	10.35	14.4	1024	6	0.8	767	98.6	5	0.6	778	55324	427
39X-4, 44–46	363.74	10.40	10.4	1024	0	0	695	99.6	3	0.4	698	68726	0
40X-2, 44–46	370.44	10.55	11.8	512	0	0	610	99.5	3	0.5	613	26598	0
40X-4, 44–46	373.44	10.65	14.8	1024	0	0	678	99.7	2	0.3	680	47049	0
41X-2, 44–46	380.14	10.80	8.6	1024	0	0	648	99.8	1	0.2	649	77276	0
41X-4, 44–46	363.14	10.85	10.6	1024	28	4.1	658	95.9	0	0	696	66270	2705
42X-2, 44–46	389.85	10.95	10.9	1024	28	4.2	627	95.1	4	0.6	659	61910	2630
42X-4, 44–46	392.84	11.00	10.2	1024	2	0.3	690	99.0	5	0.7	697	69973	201
43X-2, 44–46	399.44	11.20	11.1	512	0	0	916	99.6	4	0.4	920	42436	0
43X-4, 44–46	402.44	11.35	12.6	1024	0	0	1014	99.6	4	0.4	1018	82733	0
44X-2, 44–46	409.14	11.40	11.5	1024	0	0	782	100.0	0	0	782	69632	0
44X-4, 44–46	412.14	11.50	15.9	2048	0	0	749	99.9	1	0.1	750	96604	0
45X-4, 44–46	421.84	12.10	17.4	2048	0	0	654	99.5	3	0.5	657	77330	0
46X-2, 44–46	428.44	12.50	11.1	2048	0	0	504	100.0	0	0	504	92990	0
46X-4, 44–46	431.48	12.70	13.3	1024	0	0	560	99.6	2	0.4	562	43270	0
47X-2, 44–46	438.04	12.95	12.4	2048	0	0	490	99.6	2	0.4	492	81259	0
47X-4, 44–46	441.04	13.00	10.0	1024	0	0	630	100.0	0	0	630	64512	0
48X-2, 44–46	447.74	13.20	12.3	1024	0	0	489	99.6	2	0.4	491	40877	0
48X-4, 44–46	450.74	13.20	12.1	1024	0	0	885	99.8	2	0.2	887	75065	0
49X-2, 44–46	457.44	13.30	12.4	1024	0	0	654	100.0	0	0	654	54008	0
49X-4, 44–46	460.44	13.35	16.4	1024	0	0	633	100.0	0	0	633	39524	0
50X-2, 44–46	465.54	13.40	7.9	512	0	0	512	99.6	2	0.4	514	33312	0
50X-4, 44–46	468.64	13.45	10.5	1024	0	0	623	99.8	1	0.2	624	60855	0
51X-2, 44–46	475.24	13.55	11.3	2048	0	0	858	99.9	1	0.1	859	155684	0
51X-4, 44–46	478.24	13.60	14.9	2048	0	0	865	99.8	2	0.2	867	119169	0
52X-2, 44–46	484.54	13.65	14.1	2048	0	0	546	100.0	0	0	546	79306	0
53X-2, 44–46	494.24	13.75	11.4	512	0	0	607	99.5	3	0.5	610	27396	0
53X-4, 44–46	497.24	13.80	10.4	1024	0	0	522	99.4	3	0.6	525	51692	0
54X-2, 44–46	503.84	13.83	8.6	1024	2	0.3	645	99.7	0	0	647	77038	0
54X-4, 44–46	506.84	13.85	14.2	1024	0	0	612	99.2	5	0.8	617	44494	0
55X-2, 44–46	513.54	13.90	11.0	1024	42	4.5	890	95.4	1	0.1	933	86854	3910
55X-4, 44–46	516.54	14.10	11.1	1024	14	2.5	552	97.5	0	0	566	52215	1292
56X-2, 44–46	523.26	14.50	12.8	1024	0	0	518	99.6	2	0.4	520	41600	0
56X-4, 44–46	526.24	15.10	13.9	256	0	0	660	99.2	5	0.8	665	12247	0
57X-2, 44–46	532.84	15.50	12.0	1024	0	0	935	100.0	0	0	935	79787	0
58X-2, 44–46	542.44	16.00	10.1	512	0	0	845	99.9	1	0.1	846	42886	0
59X-2, 44–46	552.14	16.30	9.2	512	0	0	995	99.9	1	0.1	996	55430	0
60X-2, 44–46	561.83	16.60	15.4	2048	0	0	935	99.8	2	0.2	937	124609	0
61X-2, 44–46	571.64	16.80	12.0	1024	0	0	973	100.0	0	0	973	83029	0
62X-2, 44–46	581.24	17.00	14.1	1024	0	0	941	99.4	3	0.3	947	68775	0
63X-2, 44–46	590.94	17.30	12.4	512	0	0	1080	100.0	0	0	1080	44594	0
64X-2, 44–46	600.54	17.60	10.9	2048	0	0	971	99.9	1	0.1	972	182629	0
65X-2, 44–46	610.00	19.10	12.0	2048	0	0	550	100.0	0	0	550	93867	0
66X-2, 44–46	619.84	20.50	12.1	2048	0	0	947	100.0	0	0	947	160286	0
67X-2, 44–46	629.44	21.00	11.1	2048	0	0	800	99.8	2	0.3	802	147973	0
69X-2, 44–46	648.44	21.30	13.3	1024	0	0	493	99.8	1	0.2	494	38034	0
70X-2, 44–46	658.14	21.70	9.0	1024	0	0	681	99.9	1	0.2	682	77596	0
71X-2, 44–46	667.74	22.00	11.4	256	0	0	540	100.0	0	0	540	12126	0
72X-2, 44–46	677.42	22.50	11.4	256	0	0	1416	100.0	0	0	1416	31798	0
73X-2, 44–46	687.14	23.00	18.4	1024	0	0	497	100.0	0	0	497	27659	0
74X-2, 44–46	696.74	23.50	17.1	2048	0	0	638	99.4	1	0.2	639	76531	0
75X-2, 44–46	706.45	23.80	13.0	1024	0	0	858	99.5	4	0.5	862	67899	0
75X-4, 44–46	709.44	23.90	15.4	2048	0	0	644	100.0	0	0	644	85644	0
76X-2, 44–46	716.00	24.00	10.9	1024	6	1.2	490	98.8	0	0	496	46597	564
76X-CC	718.83	24.20	13.3	1024	0	0	585	99.8	1	0.2	586	45118	0
78X-1, 44–46	733.84	24.70	14.7	2048	0	0	1040	99.9	1	0.1	1041	145032	0

Table 2. Census data for Hole 807A.

Core, section, interval (cm)	Depth (mbsf)	Age (Ma)	Weight (g)	Split-1	*Streptochilus* No.	*Streptochilus* %	Planktonic No.	Planktonic %	Benthic No.	Benthic %	Total count	Foram/g	*Strepto*/g
130-807A-													
1H-1, 4–6	0	0.10	8.20	256	1	0.1	1015	98.4	16	1.6	1032	32219	31
1H-2, 44–46	1.9	0.20	8.80	512	1	0.2	661	99	6	0.9	668	38865	58
1H-4, 44–46	4.9	0.40	11.70	256	0	0	734	98.1	14	1.9	748	16366	0
2H-2, 44–46	8.9	0.50	9.20	128	20	2.5	750	95.4	17	2.1	795	11061	278
2H-4, 44–46	12.3	0.70	9.90	256	0	0	1303	99.4	8	0.6	1311	33901	0
3H-2, 44–46	18.8	1.25	12.30	256	0	0	800	99	8	1.0	808	16817	0
3H-4, 44–46	21.8	1.50	13.00	512	4	0.5	761	98.2	10	1.3	775	30523	158
4H-2, 44–46	28.3	2.00	13.10	512	4	0.4	1108	98.5	13	1.2	1125	43969	156
4H-4, 44–46	31.3	2.10	11.70	512	6	0.9	666	96.8	16	2.3	688	30107	263
5H-2, 44–46	37.8	2.50	6.20	512	423	28.1	1072	71.2	10	0.7	1505	12484	34932
5H-4, 44–46	40.8	2.70	12.90	1024	158	20.9	590	78.2	7	0.9	755	59932	12542
6H-2, 44–46	47.3	2.75	11.60	1024	185	19.1	777	80.4	5	0.5	967	85363	16331
6H-4, 44–46	50.3	2.85	12.10	1024	181	19.6	739	80.1	3	0.3	923	78112	15318
7H-2, 44–46	56.8	2.90	11.20	1024	27	3.0	857	96	9	1.0	893	81646	2469
7H-4, 44–46	59.8	2.95	11.40	1024	2	0.4	537	99.3	2	0.4	541	48595	180
8H-2, 44–46	66.3	3.30	11.50	1024	81	10.3	700	89.1	5	0.6	786	69988	7213
8H-4, 44–46	69.3	3.45	11.60	1024	32	5.9	499	92.6	8	1.5	539	47581	2825
9H-2, 44–46	75.4	3.48	9.00	512	3	0.4	746	98.6	8	1.1	757	43065	171
9H-4, 44–46	78.4	3.60	13.10	512	2	0.1	1420	99.2	9	0.6	1431	55929	78
11H-2, 44–46	94.8	4.15	13.30	1024	51	9.1	511	90.8	1	0.2	563	43347	3927
11H-4, 44–48	97.8	4.24	13.00	512	75	7.7	890	91.9	4	0.4	969	38164	2954
12H-4, 44–46	107.3	4.53	11.30	1024	62	9.3	606	90.6	1	0.2	669	60624	5618
13H-2, 44–46	113.8	4.85	11.30	512	215	14.4	1268	85.2	6	0.4	1489	67466	9742
13H-4, 44–46	116.8	4.90	12.20	1024	113	9.1	1127	90.5	6	0.5	1246	104582	9485
14H-2, 44–46	123.3	4.95	12.90	512	18	2.6	665	95.5	13	1.9	696	27624	714
14H-4, 44–46	126.3	5.05	8.00	512	95	11.4	736	88.1	4	0.5	835	53440	6080
15H-2, 44–46	132.8	5.10	11.50	256	125	9.1	1239	90.1	11	0.8	1375	30609	2783
15H-4, 44–46	135.8	5.20	11.70	1024	250	18.5	1099	81.3	3	0.2	1352	118329	21800
16H-2, 44–46	142.3	5.30	13.10	256	21	4.1	478	94.3	8	1.6	507	9908	410
16H-4, 44–46	145.3	5.40	12.60	256	70	8.8	717	90	10	1.3	797	16193	1422
17H-2, 45–47	151.8	5.45	12.20	1024	480	34.9	893	65	1	0.1	1374	115326	40289
17H-4, 44–48	154.8	5.50	12.40	512	152	13.7	950	85.7	7	0.6	1109	45791	6276
18H-2, 44–46	161.3	5.80	11.90	512	42	7.5	516	91.8	4	0.7	562	24180	1807
18H-4, 44–46	164.3	6.00	13.60	512	218	21.5	793	78.1	5	0.5	1016	38249	8207
19H-2, 44–46	170.8	6.30	12.10	1024	263	34.7	488	64.4	7	0.9	758	64148	22257
19H-4, 44–48	173.8	6.45	12.20	512	172	16.6	859	82.8	6	0.6	1037	43520	7218
20H-2, 44–46	180.3	6.80	11.40	512	347	22	1226	77.6	6	0.4	1579	70916	15585
20H-4, 43–45	183.3	6.90	12.00	512	120	9.5	1136	90.0	6	0.5	1262	53845	5120
21H-2, 44–46	189.8	7.00	12.10	1024	122	14	746	85.6	4	0.5	872	73796	10325
22H-4, 44–46	202.3	7.25	14.10	512	14	1.6	846	97.6	7	0.8	867	31483	508
23H-2, 44–46	208.8	7.30	12.40	512	8	0.8	1046	99.0	3	0.3	1057	43644	330
23H-4, 44–48	211.8	7.30	13.50	512	7	0.9	745	98.5	4	0.5	756	28672	265
24H-2, 44–46	218.3	7.35	12.50	512	312	29.9	727	69.7	4	0.4	1043	42721	12780
24H-4, 44–46	221.3	7.35	14.30	512	350	31	776	68.6	5	0.4	1131	40495	12531
25H-2, 44–46	227.8	7.40	12.80	512	264	30.1	609	69.5	3	0.3	876	35040	10580
25H-4, 44–46	230.8	7.45	11.20	256	268	18.5	1172	81.1	6	0.4	1446	33051	6126
26H-2, 44–46	237.3	7.50	7.50	128	105	16.2	536	82.8	6	0.9	647	11042	1792
26H-4, 44–48	240.3	7.50	6.40	256	322	32.9	657	67.0	1	0.1	980	29867	9813
27H-2, 44–46	246.8	7.70	11.30	512	184	26	520	73.6	3	0.4	707	32034	8337
27H-4, 44–46	249.8	7.75	8.60	256	374	27.3	993	72.5	2	0.2	1369	40752	11133
28X-2, 44–46	256.3	7.80	11.90	256	193	27.1	515	72.2	5	0.7	713	15338	4152
28X-4, 44–46	259.3	7.90	12.30	512	164	23.9	520	75.8	2	0.3	686	28555	6827
29X-2, 44–46	266.0	8.50	13.40	512	96	16.8	475	83.0	1	0.2	572	21856	3668
29X-4, 44–46	269.0	9.00	13.50	256	440	24.6	1342	74.9	10	0.6	1792	33982	8344
30X-2, 44–46	275.7	10.00	11.80	256	124	14.8	703	83.7	13	1.6	840	18224	2690
30X-4, 44–46	278.7	10.20	10.70	126	54	6.3	796	92.9	7	0.8	857	10252	646
31X-2, 44–46	285.4	10.30	12.60	256	221	18.2	990	81.5	4	0.3	1215	24686	4490
31X-4, 44–46	288.4	10.35	14.10	256	5	0.7	704	98.5	8	0.8	715	12982	91
32X-2, 44–46	294.6	10.38	10.40	256	0	0	800	99.8	2	0.3	802	19742	0
32X-4, 44–46	297.6	10.40	9.10	256	0	0	607	99.2	5	0.8	612	17217	0
33X-2, 44–46	304.2	11.05	11.20	256	0	0	965	99.4	6	0.6	971	22194	0
33X-4, 44–46	307.2	11.10	9.20	256	0	0	693	99.7	2	0.3	695	19339	0
34X-2, 44–46	313.9	11.25	13.80	512	36	5	677	94.4	4	0.6	717	26602	1336
34X-4, 44–46	316.9	11.35	11.40	256	53	6.2	796	93.5	2	0.2	851	19110	1190
35X-2, 44–46	323.1	11.40	8.60	256	0	0	728	99.7	2	0.3	730	21730	0
35X-4, 44–46	326.1	11.50	9.90	256	1	0.1	809	99.6	2	0.3	812	20997	26
36X-2, 44–46	332.8	11.75	9.30	256	0	0	1095	99.8	2	0.2	1097	30197	0
36X-4, 44–46	335.8	11.80	7.70	512	0	0	631	99.8	1	0.2	632	42024	0
37X-2, 44–46	342.5	12.20	8.20	512	0	0	643	99.8	1	0.2	644	40211	0
37X-4, 44–46	345.5	12.40	8.30	512	1	0.2	615	99.5	2	0.3	618	38122	62
38X-2, 45–47	352.1	12.70	10.60	512	0	0	822	99.8	2	0.2	824	39801	0
38X-4, 44–46	355.1	12.90	12.40	256	0	0	693	99.7	2	0.3	695	14348	0
39X-2, 46–48	361.8	13.10	8.20	256	0	0	990	99.6	4	0.4	994	31032	0
39X-4, 44–46	364.8	13.20	7.20	256	0	0	809	99.8	2	0.3	811	28836	0
40X-2, 44–46	371.6	13.40	10.30	512	37	6	577	93.8	1	0.2	615	30571	1839

Table 2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Age (Ma)	Weight (g)	Split-1	*Streptochilus*		Planktonic		Benthic		Total count	Foram/g	*Strepto*/g
					No.	%	No.	%	No.	%			
40X-4, 44–46	374.6	13.60	11.86	512	0	0	695	100.0	0	0	695	30006	0
41X-2, 44–48	381.4	13.75	13.46	512	0	0	606	100.0	0	0	606	23057	0
41X-4, 44–48	384.4	13.80	13.30	512	0	0	661	100.0	0	0	661	25438	0
42X-2, 44–46	391.1	14.00	10.74	512	0	0	509	99.6	2	0.4	511	24354	0
42X-4, 44–46	394.1	14.50	11.30	256	0	0	735	99.6	3	0.4	738	16724	0
43X-2, 44–46	400.8	14.80	12.56	126	0	0	998	99.8	2	0.2	1000	10192	0
43X-4, 44–46	403.8	14.90	13.44	256	0	0	884	99.4	5	0.6	889	16936	0
44X-2, 44–46	410.5	15.40	11.96	256	1	0.2	485	99.6	1	0.2	487	10427	21
44X-4, 44–46	413.5	15.50	14.58	256	19	1.7	1114	98.2	2	0.2	1135	19931	334
45X-2, 43–45	420.2	15.70	10.03	512	0	0	593	99.8	1	0.2	594	30313	0
45X-4, 44–46	423.2	15.80	16.05	64	0	0	698	99.3	5	0.7	703	2804	0
45X-5, 60–62	424.9	—	12.11	512	0	0	855	99.8	2	0.2	857	36242	0
45X-6, 62–64	426.4	—	16.62	512	0	0	696	99.6	3	0.4	699	21531	0
46X-2, 44–46	429.7	15.95	11.18	512	1	0.2	536	99.4	2	0.4	539	24684	46
46X-4, 44–46	432.7	16.00	10.57	512	0	0	592	99.2	5	0.8	597	28910	0
47X-2, 44–46	439.4	16.40	10.24	32	0	0	954	99.4	6	0.6	960	2999	0
47X-4, 44–46	442.4	16.50	15.64	64	28	3	892	96.0	9	1.0	929	3801	115
48X-2, 44–46	449.0	17.00	12.91	256	2	0.2	959	99.4	4	0.4	965	19136	40
48X-4, 44–46	452.0	17.50	14.53	256	1	0.1	909	99.7	2	0.2	912	16072	18
49X-2, 44–46	458.7	18.50	11.47	1024	0	0	679	99.3	5	0.7	684	61044	0
49X-4, 44–46	461.7	18.70	11.03	512	0	0	813	99.8	2	0.3	815	37828	0
50X-2, 44–46	468.3	19.30	11.62	512	0	0	904	99.8	2	0.2	906	39930	0
50X-4, 44–46	471.3	19.40	12.76	512	0	0	564	99.7	2	0.4	566	22711	0
51X-2, 44–46	478.0	19.90	13.53	512	0	0	495	99.4	3	0.6	498	18841	0
51X-4, 44–46	481.0	20.05	12.09	512	0	0	627	99.5	3	0.5	630	26675	0
52X-2, 44–46	487.7	20.50	17.59	1024	0	0	694	99.9	1	0.1	695	40452	0
52X-4, 44–46	491.7	20.80	9.13	256	0	0	685	99.6	3	0.4	688	19295	0
53X-2, 44–46	497.3	21.20	10.64	256	0	0	834	99.8	2	0.2	836	20122	0
53X-4, 44–46	500.3	21.40	17.05	512	0	0	1413	99.7	4	0.3	1417	42542	0
54X-2, 44–46	507.0	21.70	11.71	512	0	0	699	99.7	2	0.3	701	30658	0
54X-4, 44–46	510.0	21.80	12.15	512	0	0	743	100.0	0	0	743	31300	0
55X-2, 44–46	516.7	22.10	9.94	512	0	0	687	99.7	2	0.3	689	35490	0
55X-4, 44–46	519.7	22.20	12.52	1024	0	0	708	99.7	2	0.3	710	58061	0
56X-2, 44–46	525.9	22.40	13.03	512	0	0	1025	99.9	1	0.1	1026	40328	0
56X-4, 44–46	528.9	22.50	11.19	512	0	0	826	99.8	2	0.2	828	37892	0
57X-2, 44–46	535.6	22.80	11.13	1024	0	0	771	99.7	2	0.3	773	71100	0
57X-4, 44–46	538.6	22.90	12.80	1024	0	0	497	100.0	0	0	497	39760	0
58X-2, 40–42	545.3	23.10	11.10	1024	0	0	499	99.6	2	0.4	501	46218	0
58X-4, 44–46	548.3	23.20	10.80	512	0	0	587	99.7	2	0.3	589	27923	0
59X-2, 44–46	554.9	23.40	11.60	512	0	0	539	99.5	3	0.6	542	23923	0
59X-4, 44–46	557.9	23.50	12.80	512	0	0	764	99.6	3	0.4	787	31187	0
60X-2, 44–46	564.5	23.61	11.40	1024	0	0	906	99.7	3	0.3	909	81651	0
60X-4, 44–48	567.5	23.02	14.30	512	0	0	910	99.7	3	0.3	913	32689	0
61X-2, 44–46	574.2	23.63	11.40	1024	0	0	986	99.9	1	0.1	987	88657	0
61X-4, 44–48	577.2	23.64	12.50	1024	0	0	1209	99.9	1	0.1	1210	99123	0
62X-2, 44–46	583.8	23.65	11.70	1024	0	0	842	99.8	2	0.2	844	73M	0
62X-4, 44–46	586.8	23.66	12.60	2048	1	0.1	753	99.5	3	0.4	757	123043	163
63X-2, 44–46	593.5	23.80	11.70	512	0	0	712	99.9	1	0.1	713	31201	0
63X-4, 44–46	598.5	24.00	9.00	512	0	0	640	99.7	2	0.3	642	36523	0
64X-2, 44–48	603.2	24.50	11.90	512	0	0	1057	99.5	5	0.5	1062	45693	0
64X-4, 44–46	606.2	24.60	13.20	512	0	0	1032	99.9	1	0.1	1033	40068	0
65X-2, 44–46	612.9	25.00	14.30	512	0	0	735	100.0	0	0	735	36316	0
65X-4, 44–46	615.9	25.10	17.10	2048	0	0	534	99.8	1	0.2	535	64075	0
66X-2, 44–48	622.5	25.30	9.40	512	0	0	1131	99.7	3	0.3	1134	61767	0
66X-4, 44–46	625.6	25.40	11.50	256	0	0	719	99.9	1	0.1	720	16028	0
67X-2, 44–46	632.2	26.00	12.70	512	0	0	750	100.0	0	0	750	30236	0
68X-2, 44–46	641.8	26.20	12.10	512	0	0	801	100.0	0	0	801	33894	0
68X-4, 44–46	644.8	26.30	19.80	512	0	0	694	99.9	1	0.1	695	17972	0
69X-1, 44–46	650.0	26.40	13.30	256	0	0	1311	99.9	1	0.1	1312	25254	0
70X-2, 44–46	661.1	26.60	12.10	512	0	0	845	99.7	3	0.4	848	35882	0
70X-4, 44–46	664.1	26.80	12.40	1024	0	0	677	99.7	2	0.3	679	56072	0
71X-2, 44–46	670.8	26.90	10.80	512	0	0	873	99.5	4	0.5	877	41576	0
71X-4, 44–46	673.8	27.00	18.70	2048	0	0	994	99.8	2	0.2	996	109081	0
72X-2, 44–46	680.1	27.30	16.20	512	0	0	880	100.0	0	0	880	27812	0
72X-4, 44–46	663.1	27.40	22.10	2048	0	0	724	99.9	1	0.1	725	67186	0
73X-2, 44–46	689.7	27.60	10.20	512	*311	*26.7	855	73.3	0	0	1166	58529	*15611
73X-4, 44–46	692.7	27.70	13.00	256	61	10	548	90.0	0	0	609	11993	1201
74X-2, 44–46	699.4	27.90	19.40	1024	224	26.1	631	73.4	5	0.6	860	45394	11824
74X-4, 44–46	702.4	28.20	18.60	512	129	12.1	935	87.9	0	0	1064	29289	3551
76X-2, 44–46	718.8	30.50	16.00	512	95	13.4	610	85.9	5	0.7	710	22720	3040
76X-4, 44–46	721.0	30.60	29.00	2048	128	15.6	689	83.8	5	0.6	822	58050	9039
77X-2, 44–46	728.4	30.75	21.20	512	147	11.2	1154	88.2	8	0.6	1309	31614	3550
77X-4, 44–46	731.4	30.80	22.10	512	157	16.7	781	82.9	4	0.4	942	21824	3637
78X-2, 44–46	738.1	30.90	9.90	128	186	23.6	597	75.8	5	0.6	788	10188	2405
78X-4, 44–46	741.1	31.00	11.50	256	356	42.2	485	57.6	2	0.2	843	18766	7925
80X-2, 46–48	757.1	31.50	17.40	258	212	41.8	295	58.2	0	0	507	7459	3119

Table 2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Age (Ma)	Weight (g)	Split-1	*Streptochilus*		Planktonic		Benthic		Total count	Foram/g	*Strepto*/g
					No.	%	No.	%	No.	%			
82X-2, 44–46	776.4	32.50	9.30	128	305	43.7	393	56.3	0	0	698	9607	4198
82X-4, 44–46	779.4	32.60	1.40	256	280	35.2	513	64.4	3	0.4	796	14555	5120
83X-2, 44–46	786.1	32.72	1.20	128	148	24.8	446	74.7	3	0.5	597	6368	1579
83X-4, 44–46	789.1	32.74	9.80	512	105	17.6	488	81.9	3	0.5	596	31138	5486
84X-2, 44–46	795.8	32.76	15.80	64	35	6.9	458	90.3	14	2.8	507	2054	142
84X-4, 44–46	798.8	32.80	12.40	512	377	40	559	59.2	8	0.8	944	39978	15566
85X-2, 44–46	805.5	32.85	12.20	258	16	2.6	602	96.3	7	1.1	625	13115	336
85X-CC	813.0	32.90	—	512	658	46.7	745	52.9	6	0.4	1409	—	—
86X-CC	823.0	33.45	—	2048	233	36	377	61.5	3	0.5	613	—	—

**Chiloguembelina* and *Streptochilus* from Samples 130-807A-73X-2 to -86X-CC.

Table 3. Census data for Hole 807C.

Core, section, interval (cm)	Depth (mbsf)	Age (Ma)	Weight (g)	Split-1	*Streptochilus**		Planktonic		Benthic		Total count	Foram/g	*Strepto**/g
					No.	%	No.	%	No.	%			
130-807C-													
1R-CC, 11–13	789.7	33.45	11.6	512	226	33.5	447	66.3	1	0.2	674	29749	9975
2R-2, 44–46	791.6	33.50	11.5	64	40	6.8	549	93.1	1	0.2	590	3283	223
3R-CC	809.0	33.59		1024	633	37.2	1064	62.6	3	0.2	1700		
4R-2, 44–46	810.9	33.60	21.7	1024	293	58.7	204	40.9	2	0.4	499	23547	13826
4R-CC	818.6	33.64		256	348	37.7	568	61.6	6	0.7	922		
5R-CC	828.3	33.67		512	123	23.8	391	75.8	3	0.6	517		
6R-2, 44–46	830.2	33.68	22.2	1024	543	67.0	266	32.8	2	0.3	811	37408	25046
7R-CC	847.7	33.75		2048	939	64.4	519	35.6	1	0.7	1459		
8R-CC	857.4	33.79		512	358	55.8	283	44.1	1	0.2	642		
12R-1, 42–44	877.0	33.90	17.7	2048	492	51.2	466	48.5	3	0.3	981	111194	56927
13R-CC	888.9	35.70		512	764	53.1	673	48.8	1	0.7	1438		
14R-CC	893.9	36.16		2048	294	51.1	280	48.7	1	0.2	575		
15R-1, 42–44	894.3	36.20	9.3	256	209	33.2	540	66.7	1	0.1	810	22297	7405
16R-CC	903.9	36.62		512	4	2.6	147	94.2	5	3.2	156		
17R-CC	908.9	36.74		256	15	3.0	475	96.2	4	0.8	494		
18R-CC, 0–2	913.9	37.25	9.7	256	70	27.2	186	72.4	1	0.4	257	6783	1847
19R-CC	918.9	37.70		512	108	19.0	462	81.1	0	0	570		
20R-CC	923.9	38.25		512	183	20.3	716	79.3	4	0.4	903		
21R-CC	933.7	38.70		256	72	18.1	321	80.7	5	1.3	3M		
22R-CC	938.7	39.25		64	6	1.6	324	90.5	28	7.8	358		
23R-CC	943.7	39.70		64	82	18.6	350	79.5	8	1.8	440		
24R-CC	948.4	40.25		16	16	4.8	248	75.6	64	19.5	328		
25R-CC	958.1	40.70		64	104	24.8	312	74.5	3	0.7	419		

**Streptochilus* and *Chiloguembelina.*

Table 4. First and last occurrences of biserial planktonic species at ODP Sites 806 and 807 and DSDP Site 62.

	Last occurrence			First occurrence			
Species	Sample	Zone	Age (Ma)	Sample	Zone	Age (Ma)	Events
S. globulosum	135-806B-1H-1, 0–2	N23	0.00	135-806B-12H-2, 44–46	N19/20	3.75	Low sea stand
	135-807A-1H-2, 44–46	N22/23	0.10	135-807A-9H-4, 44–46	N19/20	3.60	3.6 Ma—First L/R coiling
	7-62-4-5, 109–111	N22	1.20	7-62-12-1, 109–111	N19/20	3.70	change in *Pulleniatina*
S. globigerum	135-806B-13H-2, 44–46	N19/20	3.95	135-806B-19H-4, 44–46	N17b	5.30	5.2–4.7 Ma—Hiatus NH7
	135-807A-10H-CC	N19/20	4.09	135-807A-15H-4, 44-46	N17b	5.20	5.2–6.5 Ma—Seismic reflector
	7-62-12-1, 109–111	N19/20	3.70	7-62-17-6, 109–111	N17b	5.45	5.5 Ma—Mediterranean salinity crisis
S. latum	135-806B-20H-2, 45–47	N17b	5.40	135-806B-35X-4, 44-46	N16	8.10	
	135-807A-16H-2, 44–46	N17b	5.30	135-807A-25H-4, 44-46	N16	7.45	8.1 Ma—Low sea stand
	7-62-17-1, 106–108	N17b	5.40	7-62-25-6, 101	N16	8.00	
S. subglobigerum	135-806B-31H-4, 44–46	N16	7.65	135-806B-38X-4, 44–46	N15	10.20	Low sea stand
	135-807A-25H-2, 44–46	N16	7.40	135-807A-31X-4, 44–46	N15	10.35	10.4 Ma—Seismic reflector
	7-62-26-1, 109–111	N16	7.90	7-62-31-6, 109–111	N15	10.40	16.0–15.0 Ma—Hiatus NH2; 16.5 Ma—Reflector
S. pristinum	135-806B-36X-4, 44–46	N16	8.70	135-806B-76X-2, 44–46	N4	23.90	Low sea stand
	135-807A-31X-4, 44–46	N15	10.35	135-807A-62X-4, 44–46	N4/P22	23.66	23.0–22.5 Ma—Hiatus PH,
C. cubensis	135-807A-73X-2, 44–46	P22	27.60	135-807C-25R-1, 48–50	P15	40.70	Circum-Antarctic Current
C. ototara	135-807C-12R-1, 42–44	P18	33.90	135-807C-15R-1, 42–44	P18	35.60	35.9 Ma / Growth East
S. martini	135-807C-16R-1, 44–46	P17	35.61 36.62	Before late Eocene			Antarctic ice sheet

Note: DSDP Site 62 data from Resig (1989).

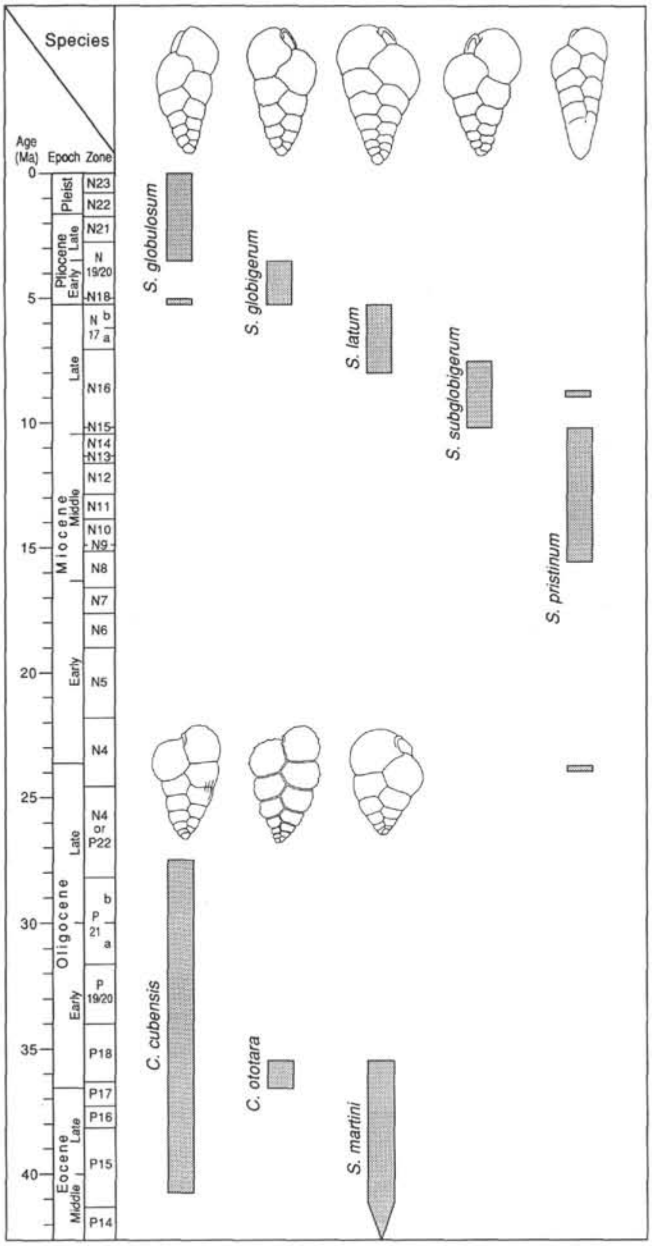

Figure 3. Stratigraphic ranges of Paleogene and Neogene species of biserial planktonic foraminifers at Sites 806 and 807.

Figs. 1 and 3) and in the proportion of costate to pustulose chambers (cf. Plate 1, Figs. 1, 4, and 7). On the oldest specimens, which exhibit poor preservation, the costae are reduced to short bars visible near the sutures (Plate 1, Fig. 17). Rare specimens exhibit multiple chambers in the final series (Plate 1, Fig. 6). The specimens have low arched apertures with a rim and are symmetrical to slightly asymmetrical in the later chambers. In chambers before the last one or two, the rim bends inward on one side to touch the rim of the preceding foramen (Plate 1, Fig. 8), in the manner described by Poore and Gosnell (1985).

Chiloguembelina ototara (Plate 1, Fig. 9) occurs in two samples just above the Eocene/Oligocene boundary. The chambers of this species are pustulose and the sutures are incised. Hornibrook (1990) indicates its range in New Zealand as middle Eocene (Bartonian) to lower Oligocene (lower Whaingaroan). Therefore, the occurrence at Site 807 represents a minor part of its total range.

Streptochilus martini (Plate 1, Fig. 11) last occurs at the Eocene/Oligocene boundary at Site 807 and extends downward at least into the middle Eocene, where preservation of foraminiferal tests deteriorates. Beckmann (1957) gives its range as lower Eocene to the Eocene/Oligocene boundary. Some of the specimens are comparatively large and have roughened lower surfaces (Plate 1, Figs. 15 and 16), which may result from corrosion or, alternatively, represent another species. The specimens have an internal plate connecting foramina (Plate 1, Fig. 12), as described by Poore and Gosnell (1985).

Evolution and Extinction Events

Two Paleogene last occurrence events, those of *Streptochilus martini* (between 35.6 and 36.6 Ma) and *Chiloguembelina cubensis* (27.6 Ma), are supported by reported ranges in other geographic areas, suggesting global rather than regional oceanographic causes. *S. martini* becomes extinct at the time when sea level is falling (Fig. 2), resulting from a major growth of the East Antarctic ice sheet at 35.9 Ma (Barron et al., 1990). This event does not, however, result in the extinction of *C. cubensis,* which continues on to the late Oligocene Zone P22/N4, where its LO at about 27.6 Ma also corresponds with a sea-level fall.

Among the Neogene species, the first occurrence (FO) of *Streptochilus pristinum* is uncertain because it is rare and discontinuous in its distribution; however, it appeared by at least 23.9 Ma at Site 807. It is slightly more frequent and more continuous in distribution beginning about 16.5 Ma, a time of low sea stand. A prominent seismic reflector is positioned at this stratigraphic level (Mosher and Mayer, this volume), which also corresponds to the Zone N7/N8 boundary as defined by faunal changes that accompanied changing environmental conditions.

The top of the continuous range of *S. pristinum* corresponds with the FO of *S. subglobigerum* at 10.2 or 10.3 Ma. Again, this level corresponds with a low sea stand and a prominent seismic reflector determined at about 10.4 Ma (Mosher and Mayer, this volume). The faunal turnover from *S. subglobigerum* to *S. latum* occurs at 8.1 Ma in Hole 806B, corresponding with a low sea stand. This event at Site 807 is determined to be at 7.5 Ma, a time of rising sea level. On the Eauripik Rise, the event was determined at 8.0 Ma (Resig, 1989), confirming the date at Site 806 and suggesting that the age determined from the sedimentation rate for that part of the Site 807 section is too young.

The faunal turnover from *S. latum* to *S. globigerum* at about 5.2 or 5.3 Ma corresponds with a low sea stand, which abetted the Mediterranean salinity crisis, and a prominent seismic reflector placed at 5.2–5.5 Ma (Mosher and Mayer, this volume). The extinction of *S. globigerum,* and perhaps a faunal turnover to *S. globulosum* (if the single occurrence at the top of Zone N17 is in error), occurs at about 3.7 Ma, just before the first left-to-right coiling change of *Pulleniatina.* This horizon lies at the beginning of a low sea stand.

In summary, evolution and extinction events of the biserial planktonic foraminifers studied occur in times of low sea level and, presumably, restructuring of the oxygen-minimum habitat in which they lived. At least three of these turnover events correspond with prominent reflectors in the stratigraphic section of the Ontong Java Plateau.

CONCLUSIONS

Correlations of paleoceanographic events, such as are represented by sea-level curves, with the planktonic response to those events is only as accurate as the scale against which both are measured. The sections studied here were correlated with the time scales of Berggren et al. (1985a, 1985b) using nannofossil and foraminiferal first and last occurrence datums, as determined in shipboard analyses. The resolution of these correlations may be improved in the future through more detailed faunal analysis and through calibrations with the strontium time scale as well as the $\delta^{18}O$ scale, which denotes more clearly variable ice volumes productive of fourth- and fifth-order sea-level changes that might relate to variations on the biserial planktonic foraminifer frequency curve. Nevertheless, the data at hand support the conclusions that follow.

Paleogene and Neogene clustered occurrences of biserial planktonic foraminifers are separated by an interval in the latest Oligocene and early Miocene when low surface-to-bottom thermal gradients existed and amiable climates prevailed. These conditions generally reduced the habitat of the Neogene biserial planktonic foraminifers and other intermediate-dwelling planktonic species that live low in the thermocline in the oxygen-minimum layer.

High frequencies of biserial planktonic foraminifers mostly correspond with high sea stands. High frequencies within low sea stands may reflect fourth- or fifth-order sea-level changes not apparent on the scale employed here. The high frequencies reflect reduced water circulation and better development of the oxygen minimum during periods of high sea level.

Species evolution and extinction events coincide with low sea stands in the Neogene, but they are less well defined in the Paleogene. Presumably, vigorous water circulation resulting in oxygenation leads to species turnover during low sea levels. The increase in continuity of occurrence of *S. pristinum* about 16.5 Ma as well as the FO of *S. subglobigerum* about 10.4 Ma and the turnover of *S. latum* to *S. globigerum* about 5.3 Ma all correspond to prominent seismic reflectors in the Ontong Java Plateau section. At about these levels, the absolute abundance of foraminifers is decreased by an order of magnitude over that in the stratigraphically older or younger section, indicating a reduction in grain size.

The Indo-Pacific ranges of some of the species are well defined and provide useful means of recognizing parts of established biostratigraphic zones. The LO of *Streptochilus martini* marks the Eocene/Oligocene boundary at 36.6 Ma within Zone P17. The FO of *Streptochilus subglobigerum* at 10.2–10.4 Ma can aid in the recognition of Zone N15, where it occurs before the FO of *Neogloboquadrina acostaensis*. The *Streptochilus latum* FO and *S. subglobigerum* LO at 7.5–8.1 Ma enable recognition of the upper half of Zone N16. The *Streptochilus globigerum* FO and *S. latum* LO at 5.2–5.4 Ma enable recognition of the uppermost part of Subzone N17b, coincident with the Mediterranean salinity crisis. Finally, *S. globigerum* LO and *S. globulosum* FO (continuous occurrence) at 3.6 or 3.7 Ma occurs just before the first left-to-right coiling change of *Pulleniatina* in the middle of Zone N19/N20.

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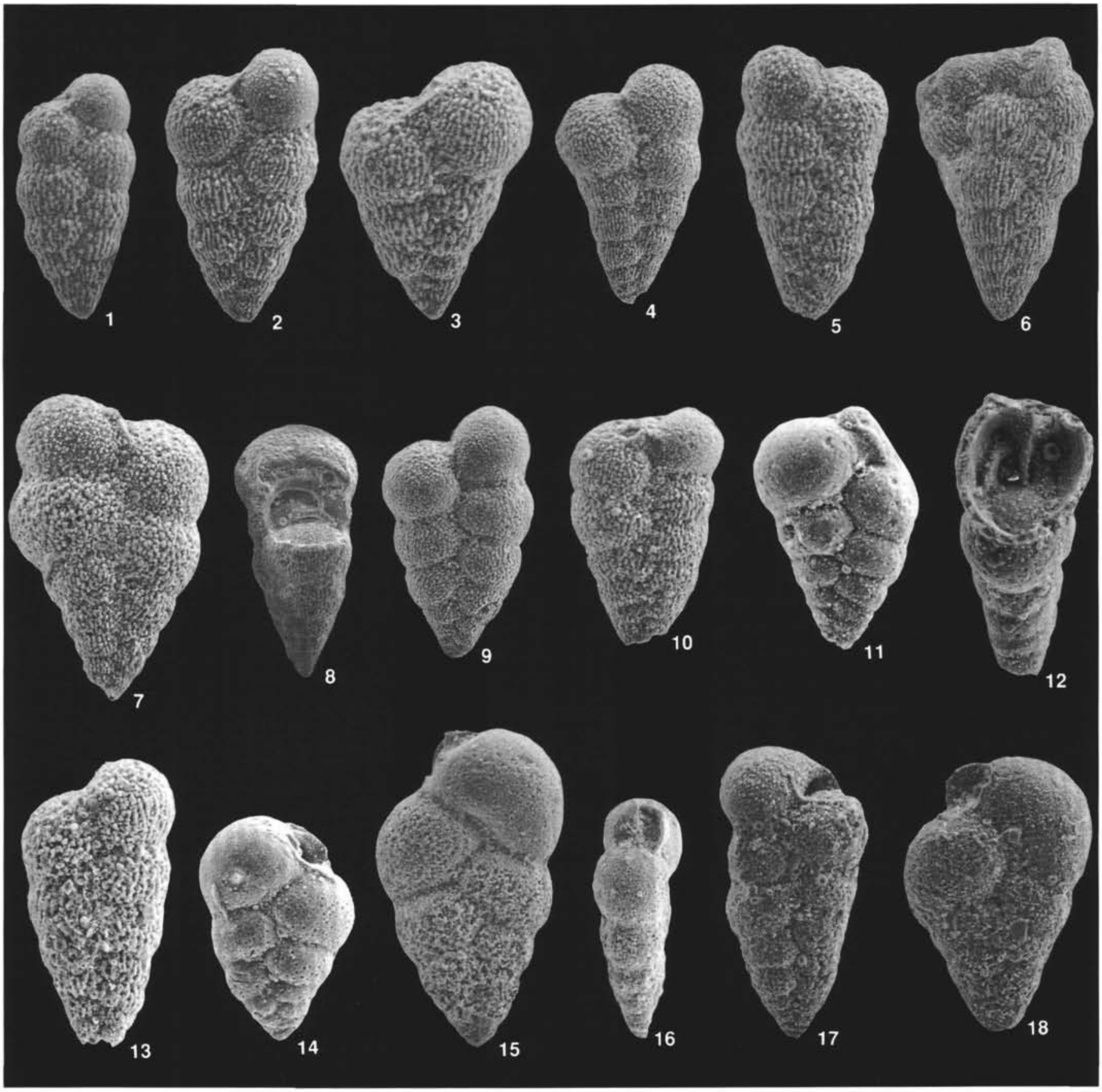

Plate 1. Stratigraphic sequence of Paleogene biserial planktonic foraminifers. **1–8.** Lower Oligocene *Chiloguembelina cubensis;* (1) Sample 130-807A-76X-2, 44–46 cm, 225×, Subzone P21a; (2) Sample 130-807A-78X-4, 44–46 cm, 180×, Subzone P21a; (3) Sample 130-807A-78X-4, 44–46 cm, 225×, Subzone P21a; (4) Sample 130-807C-4R-2, 44–46 cm, 135×, Zone P19; (5) Sample 130-807C-4R-2, 44–46 cm, 225×, Zone P19; (6) Sample 130-807C-4R-2, 44–46 cm, 180×, Zone P19; (7) Sample 130-807C-6R-4, 44–46 cm, 180×, Zone P19; (8) Sample 130-807C-6R-4, 44–46 cm, 135×, Zone P19. **9.** *Chiloguembelina ototara,* 125×, Sample 130-807C-12R-1, 42–44 cm, lower Oligocene, Zone P18. **10.** *Chiloguembelina cubensis,* 180×, Sample 130-807C-12R-1, 42–44 cm, lower Oligocene, Zone P18. **11.** *Streptochilus martini,* 270×, Sample 130-807C-16R-1, 44–46 cm, upper Eocene, Zone P17. **12.** *Streptochilus martini,* 270×, Sample 130-807C-16R-1, 44–46 cm, upper Eocene, Zone P17. **13.** *Chiloguembelina cubensis,* 225×, Sample 130-807C-16R-1, 44–46 cm, upper Eocene, Zone P17. **14.** *Streptochilus martini,* 180×, Sample 130-807C-19R-1, 42–44 cm, upper Eocene, Zone P17. **15.** *Streptochilus martini,* Sample 130-807C-19R-1, 42–44 cm, upper Eocene, Zone P17. **16.** *Streptochilus martini,* 135×, Sample 130-807C-19R-1, 42–44 cm, upper Eocene, Zone P17. **17.** *Chiloguembelina cubensis,* 180×, Sample 130-807C-19R-1, 42–44 cm, upper Eocene, Zone P17. **18.** *Streptochilus martini,* 180×, Sample 130-807C-26R-1, 35–37 cm, upper Eocene.