11. UPPER OLIGOCENE TO RECENT PLANKTONIC FORAMINIFERAL REMAINS IN SEDIMENTS OF THE INNER WALL OF THE MIDDLE AMERICA TRENCH WITH SPECIAL EMPHASIS ON *GLOBOROTALIA*[1]

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ABSTRACT

This study presents a rough biostratigraphy based on the planktonic foraminifers. After a comparison with the biostratigraphy of M. Filewicz, based on nannofossils, we list the relicts of the *Globorotalia* lineages preserved.

INTRODUCTION

Species of *Neogloboquadrina* and *Globorotalia* are among the most dissolution-resistant planktonic foraminifers found in sediments of the inner wall of the Middle America Trench. Despite the dissolution and slope resedimentation that occur in this seismically active area, we recognized parts of the phyletic history of these foraminifers that are useful for biostratigraphic and sedimentary interpretation. We identified a number of morphological changes in the *Globorotalia* group and tried to use them for local Pliocene–Pleistocene stratigraphic correlations. We believe that some of these morphological changes could be useful in paleoenvironmental studies but feel that a better knowledge of morphological trends in living globorotaliids is necessary for a better understanding.

During Leg 84 of the *Glomar Challenger*, six sites were chosen in the Guatemala and Costa Rica active margins (Fig. 1, Table 1). In addition to contributing to our knowledge of the geological structure of the margin (Aubouin, von Huene, et al., 1982), the bathymetric distribution of five holes along an east–west transect off Guatemala, in water depths ranging from 1718 to 5529 m, offers an opportunity to study the modalities of the dissolution of planktonic foraminiferal tests at increasing water depths and the modalities of the sedimentation on the slope at that convergent extensive margin. The sites are localized Area 9 of Coulbourn, Parker, and Berger (1980), where "changes in relative abundance (of planktonic foraminiferal tests) are too subtle to define the lysocline."

MATERIALS AND METHODS

Approximately 700 samples were analyzed for their planktonic foraminiferal content. Of these, 358 10-cm^3 samples were collected on board, and 366 20-cm^3 samples were subsequently collected by the senior author at the DSDP core repository.

The 20-cm^3 samples were dried at 60°C for about 18 hr. and then weighed before being washed through series of sieves with mesh sizes of 500, 200, 125, and 50 μm, respectively. Each size fraction was again dried at 60°C and weighed; 10-cm^3 samples were separated into the same size fractions but were not weighed.

Quantitative analysis of the planktonic foraminifer assemblages was performed on the 20-cm^3 samples for the fraction larger than 200 μm and, in some cases, for the fraction larger than 125 μm. Counts included about 1000 individuals. If the samples contained more than this number of individuals, a split of the sample was counted. Extremely few planktonic foraminifers were found on the 50-μm sieve, possibly as a result of dissolution or winnowing. The experience of Berger and Piper (1972) shows how difficult it can be to differentiate between dissolution and transport "since sediments containing only heavy resistant foraminifera may result from dissolution of less resistant tests or from bottom currents winnowing out the lighter tests."

In the 10-cm^3 samples we made a semiquantitative estimate of the abundance of the species. The sample was poured onto a tray divided in squares. Depending on the size of the studied fraction, the side of the square is 2.5 cm for the fraction larger than 500 μm, 1 cm for the fraction between 500 and 200 μm, 0.6 cm for the fraction between 200 and 125 μm, and 0.25 cm for the fraction between 125 and 50 μm. At least 10 squares were examined. The relative abundance of species or morphotypes is: r (rare)—when only 1 specimen is present in a minimum area of three squares or more; c (common)—when a specimen is present in an area of about two squares; f (frequent)—when no more than 9 individuals occur in every square; a (abundant)—when 10 to 30 individuals occur in a square; and va (very abundant)—when more than 30 individuals occur in every square.

Biostratigraphy

In order to place our study into a regional biostratigraphic framework we compiled biostratigraphic studies in the East Pacific calibrated by various authors on the paleomagnetic time scale for the early Miocene to Recent (Figs. 2 and 3). For our geological time scale we chose the dates of the paleomagnetic anomalies calculated by Lowrie and Alvarez (1981). For the middle and early Miocene the calibration on the paleomagnetic time scale is indirect, and some discrepancies still exist, chiefly for the Langhian and Serravallian stages.

Among the biostratigraphic studies of various microfossil groups conducted-on Leg 84 material, only that of the calcareous nannofossils (Filewicz, this volume) was available to us at the time of this study; we use Filewicz's nannozonation extensively to calibrate coiling changes in *Pulleniatina* and *Globorotalia* found in our samples. Because we need to place the *Globorotalia* study in a planktonic foraminiferal framework, we examined all the planktonic foraminiferal assemblages. Results of our observations are given as range charts (Tables 2–12) and summarized (Figs. 4–8). Site by site discussion occurs after the following brief examination of dissolution effects.

Dissolution Analysis

Results of counts are summarized in Tables 2 to 12. Evidence of dissolution of the planktonic foraminiferal tests, as illustrated by Bé, Morse, and Harrison (1975), is present throughout the cores. Degree of dissolution ranges from shells that are partly abraded, to fragmented, to totally eliminated. Site 570 off Guatemala, is the shallowest site, with a water depth of about 1700 m; Cores 570-1 to -21 exhibit

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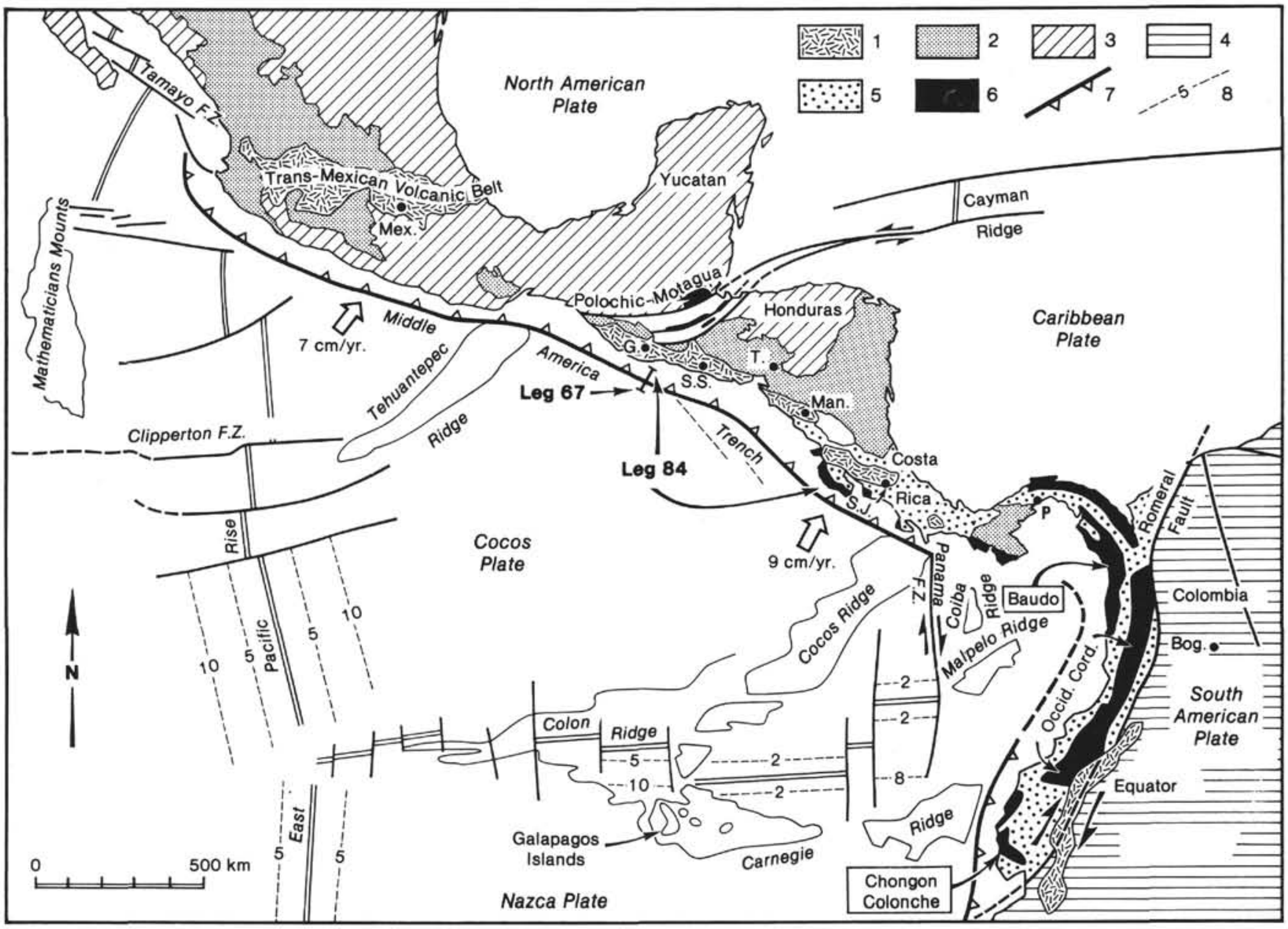

Figure 1. Location of Legs 84 and 67; present-day plate motion from Minster and Jordan (1978). 1 = Pliocene and Pleistocene volcanism, 2 = Oligocene and Miocene volcanism, 3 = North American Plate, 4 = South American Plate, 5 = Cenozoic formations, Andes and southern Central America, 6 = Mesozoic and Cenozoic ophiolitic complexes, 7 = subduction zones, 8 = magnetic anomalies.

Table 1. Locations of the sites.

Off	Site or hole	Latitude (N)	Longitude (W)	Water depth (m)
Guatemala	570	13°17.12′	90°23.57′	1718
	568	13°04.33′	90°48.00′	2031
	569	12°56.31′	90°50.35′	27997
	567A	12°42.99′	90°55.92′	5529
Costa Rica	565	9°43.69′	86°05.44′	3111

incomplete dissolution of planktonic foraminiferal shells with significant fluctuations in the number of preserved species or phenotypes—from 14 to only 1. The last species to remain in the Quaternary is usually *Neogloboquadrina eggeri* (Rhumbler) and in the Pliocene *N. humerosa* (Takayanagi and Saito). At Site 565 off Costa Rica in 3111 m water depth, by contrast, the most resistant forms in the Pliocene and Quaternary are species of *Globorotalia*.

In the middle and lower Miocene, *Globoquadrina* appears to be the most dissolution-resistant form, followed next by *Globorotalia*, and then by *Globigerinoides*. These results are summarized in Figures 4 to 8 with a column proportional in width to the number of genera present in the samples. In that scheme possible reworking of fauna is not taken into account, although reworking is probably responsible for the better preservation at some levels, as is discussed later. Seven dissolution ranks have been distinguished:

Rank 1: No planktonic foraminiferal shell remains in the sample.

Rank 2: Species of only one genus remain.

Rank 3: Species of only two genera remain, usually *Neogloboquadrina* or *Globoquadrina* and *Globorotalia*.

Rank 4: Species of three genera occur—two of those mentioned under Rank 3 together with *Pulleniatina* or, surprisingly, often *Globigerinoides* (not small-sized specimens), as might be expected in fecal pellets, but specimens larger than 200 μm).

Rank 5: More than three genera occur, but for a 20-cm^3 sample the total number of planktonic individuals is less than 500 in the fraction coarser than 200 μm;

Rank 6: More than three genera occur, and the number of specimens is between 500 and 1000 in the fraction coarser than 200 μm for a 20-cm^3 sample;

Rank 7: More than three genera and more than 1000 planktonic foraminifers occur in the fraction coarser than 200 μm for a 20-cm^3 sample.

Rank 1 is below the planktonic foraminiferal CCD (calcite compensation depth). We assume that ranks 6 and 7 could be on either side of the planktonic foraminiferal lysocline (Berger, 1970). Other dissolution indexes given in Tables 2 to 12 include (1) levels where fragmentation of planktonic foraminifers is significant; (2) the size of the largest fragments, and (3) the number of benthic foraminifers coarser than 200 μm found in a 20-cm^3 sample.

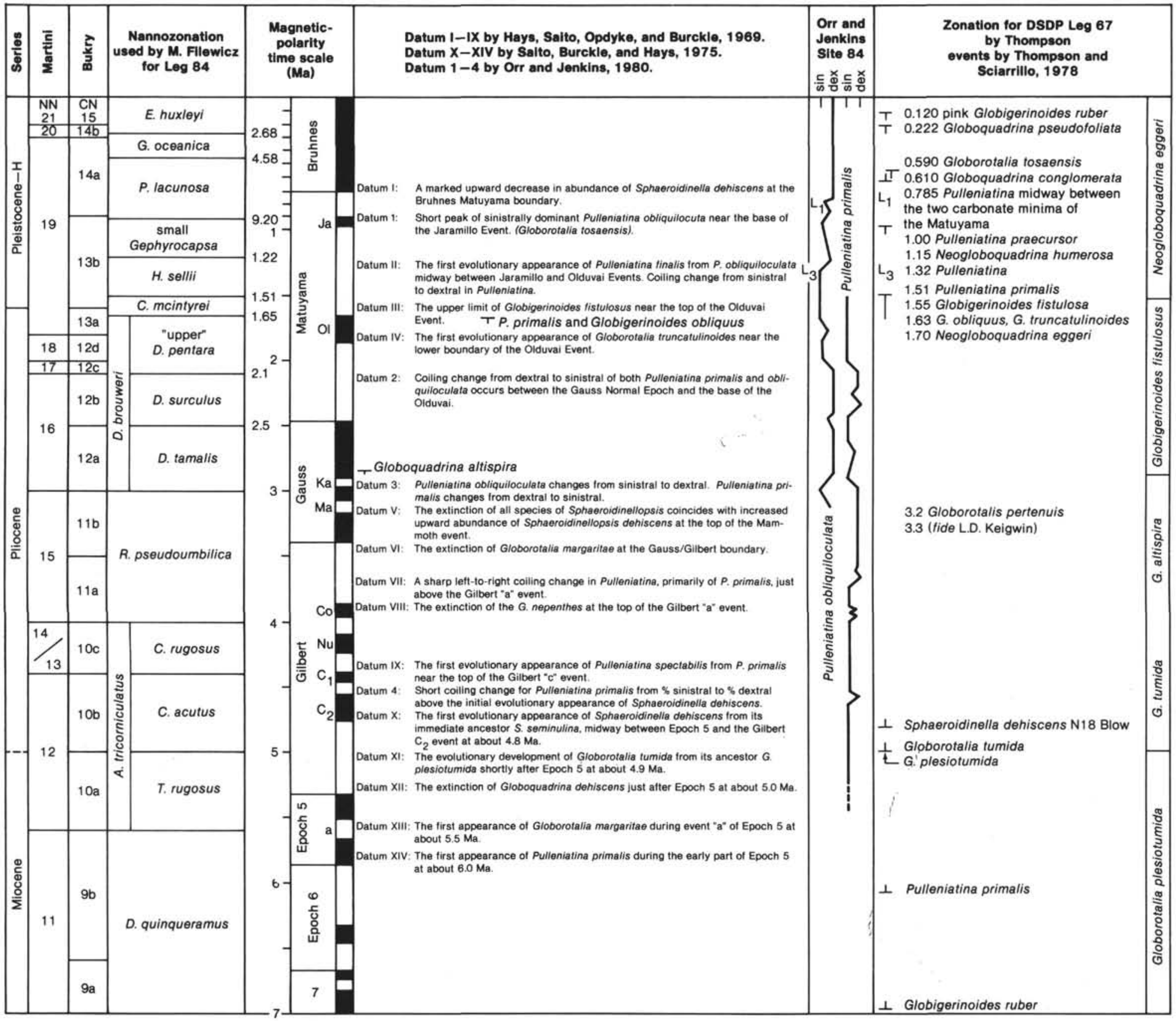

Figure 2. Correlation of nannofossil and planktonic foraminiferal biostratigraphy; sin = sinistral; dex = dextral.

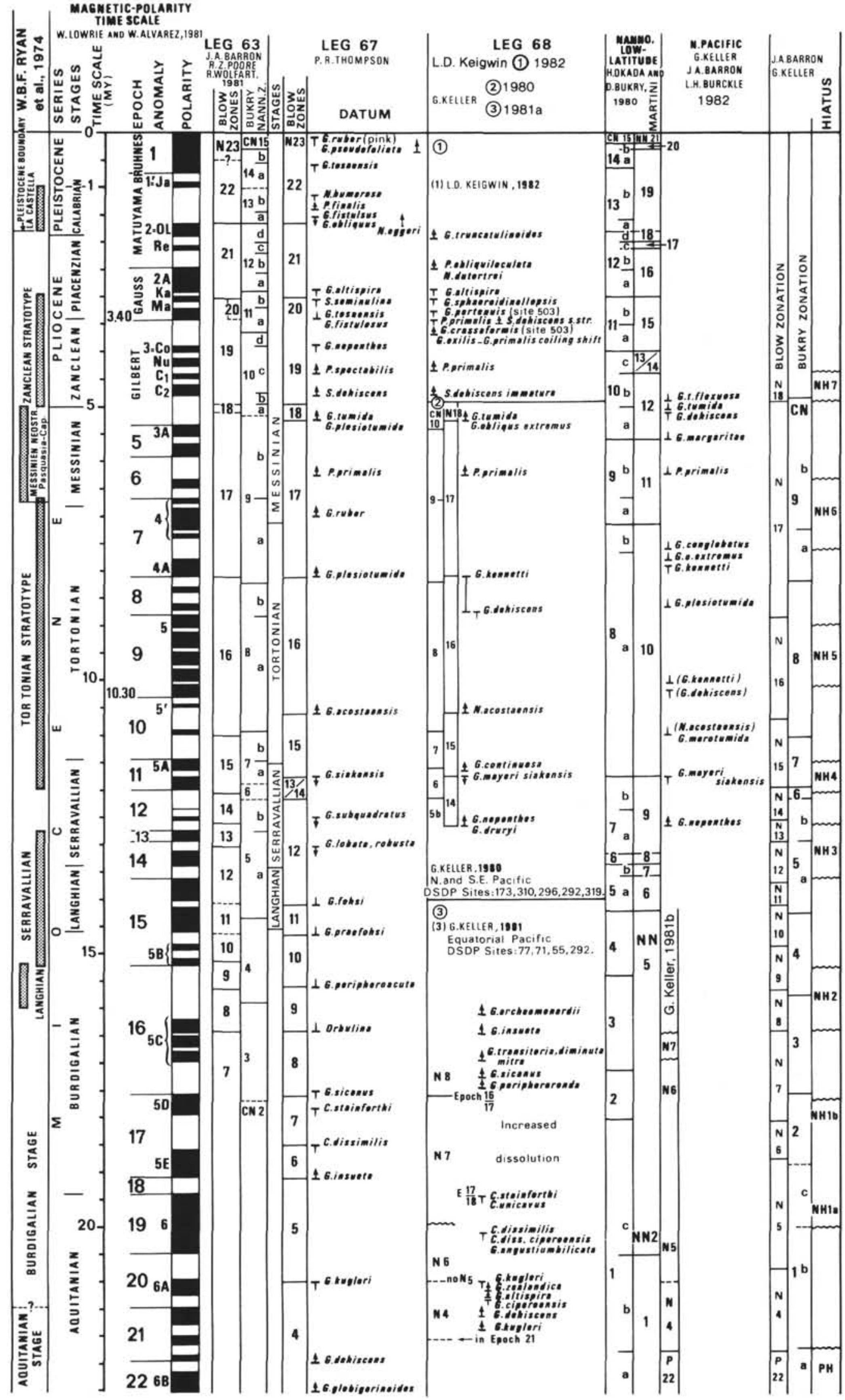

Figure 3. Comparison of post-early Miocene and younger biozonations used for East Equatorial Pacific foraminiferal ooze. Parentheses around species names in the N. Pacific column indicate boreal datum level. In the Leg 68 column, the circled numbers refer to the following citations: ① L. D. Keigwin, 1982; ② G. Keller, 1980; and ③ G. Keller, 1981a.

BIOSTRATIGRAPHY AT EACH SITE

Site 570

Site 570 is located on the edge of a small bench in the upper slope of the Middle America Trench at a water depth of 1718 m (Fig. 4, Tables 2–4).

Dissolution of planktonic foraminifers is not complete in the first 21 cores retrieved and in the two first sections of Core 570-22, but strong fluctuations exist; species of only one genus remain in Sample 570-19-1, 64–66 cm and only two genera in Samples 570-1-3, 39–41 cm; and 570-2-1, 123–125 cm, and 570-10-1, 37–39 cm.

Pink *Globigerinoides ruber* appears from Sample 570-8-2, 14–18 cm to 570-2-2, 20–25 cm but is well represented by many specimens only from Samples 570-5-4, 70–77 cm to 570-3-2, 15–20 cm. Bé and Hamlin (1967) identified pheophytin as the pink pigment in *G. ruber*, and Orr (1967) wrote that the pigmenting element has an ephemeral nature, therefore "rapid sedimentation rate should preserve more pigmented specimens in a given geographic area." Perhaps stronger dissolution could explain the lack of pink *ruber* from deeper cores. In the samples we studied, the occurrence of *G. ruber* indicates an age older than 0.120 Ma.

Globigerina calida occurs in low numbers from Sample 570-3-1, 73–78 cm to the top of Core 570-1. Following Bolli and Premoli Silva (1973), the phyletic appearance of that species is dated 0.140 Ma. At Site 570, the first appearance of that species is delayed because of dissolution.

The presence of *Globoquadrina conglomerata* in Sample 570-3-6, 88–90 cm indicates an age younger than 0.610 Ma for this level (Thompson and Sciarrillo, 1978).

Filewicz (this volume) places the upper boundary of the small *Gephyrocapsa* Zone in Core 570-6, therefore the peak of left-coiled *Pulleniatina obliquiloculata* found in Sample 570-6-4, 43–46 cm appears to correspond to the second peak on the coiling curve of Orr and Jenkins (1980) "near the basis of the Jaramillo event" dated 0.97 Ma by Lowrie and Alvarez (1981). If this assumption is correct, the peak L_1 of the same curve dated 0.785 Ma is close to Sample 570-5-2, 85–90 cm, in which rare sinistral specimens of *P. obliquiloculata* appear. Dextral *Pulleniatina finalis* occur sporadically in Core 570-3; they were probably transported into the area.

Because of a gap in core recovery no interpretation is given for the next peak of the coiling curve.

The coiling change in both *P. primalis* and *P. obliquiloculata* in Sample 570-23-4, 66–70 cm is correlated to Datum 2 of Orr and Jenkins (1980) between the Gauss Normal Epoch and the Olduvai (1.87–2.47 Ma), an interpretation in agreement with Filewicz (that volume), who places the lower boundary of the *Calcidiscus mcintyrei* Zone (1.65 Ma) between Sections 570-23-4 and 570-23-6. The co-occurrence of *Sphaeroidinellopsis paenedehiscens* and *Sphaeroidinella dehiscens* in Sample 570-23-4, 66–70 cm is probably a result of reworking caused by slope sedimentation.

We suggest that the third coiling change L_3 "midway between Jaramillo and Olduvai" (part of the Datum II of Hays et al. [1969]) occurs in Sample 570-15-2, 55–56 cm. That is in agreement with the basis of the small *Gephyrocapsa* Zone (1.22 Ma) in Sample 570-8,CC (Filewicz, this volume).

We also suggest that Datum VII of Hays et al. (1969), "just above the Gilbert 'a' event," corresponds to the coiling change from left to right in *Pulleniatina primalis* in Sections 570-26-1 to 570-25-3, in agreement with Filewicz (this volume), who places Section 570-25,CC in the *Reticulofenestra pseudoumbilica* Zone.

Globigerinoides obliquus and *G. extremus* have an unique appearance in Sample 570-26-4, 14–16 cm just above a long sequence barren of planktonic foraminifers with only two exceptions: in Sample 570-34-1, 126–128 cm some *Neogloboquadrina acostaensis* and *N. humerosa* occur, and in Sample 570-32-1, 11–13 cm the first relicts of keeled *Globorotalia* of Group 3 of Tjalsma (1971) appear. Because of their tumid profile these forms are assigned to *G. merotumida* Banner and Blow. In contrast to the right-coiled holotype, the specimens here are sinistral. That species indicates a zonal interval from N16 to N18 Blow, in agreement with nannofossil data (*Discoaster quinqueramus* Zone).

Site 568

Site 568 is located on the upper slope of the Middle America Trench in 2031 m of water (Fig. 5, Tables 5–11). Compared to the previous site, there is an increase in dissolution. Almost all samples appear to have been deposited between the planktonic foraminiferal lysocline and CCD. Only four levels have more than 1000 individuals larger than 200 μm in 20 cm^3 of sediment.

Globigerina calida appears sporadically in low numbers in Samples 568-3-4, 38–42 cm and 568-2-3, 102–104 cm, dating those as younger than 0.140 Ma.

Pink *Globigerinoides ruber* occurs from Sample 568-10-4, 118–122 cm to Sample 568-6-2, 22–26 cm. The disappearance of this species seems to be related to dissolution.

L_1, the last coiling change in *Pulleniatina obliquiloculata* in the *Pseudoemiliania lacunosa* Zone, occurs in Sample 568-10-1, 53–55 cm, dated 0.785 Ma. Poor recovery doesn't permit a detailed study of coiling changes in *Pulleniatina;* peak L_2, however, could be above Sample 568-12-1, 65–67, which is in the small *Gephyrocapsa* Zone. The third peak from the top in Sample 568-20-3, 75–77 cm is correlated to L_3, between 0.97 and 1.66 Ma in age.

Sinistral *Pulleniatina primalis* occurs in Sample 568-21-1, 113–116 cm just above levels barren of planktonic foraminifers; the base of the Pleistocene should be close to that level.

Globoquadrina altispira occurs just below the zone barren of planktonic foraminifers, but *Pulleniatina* is missing, as in the lower levels. Based on nannofossil data, the Miocene–Pliocene boundary occurs in the interval between Core 568-22 and Sample 568-25-2, 14–18 cm.

From Cores 568-25 to -44, remains of various Miocene phyletic stocks occur.

***Globigerinoides* lineages.** In the lowest sample with planktonic shells preserved, (568-44-4, 62–66 cm), *G. pri-*

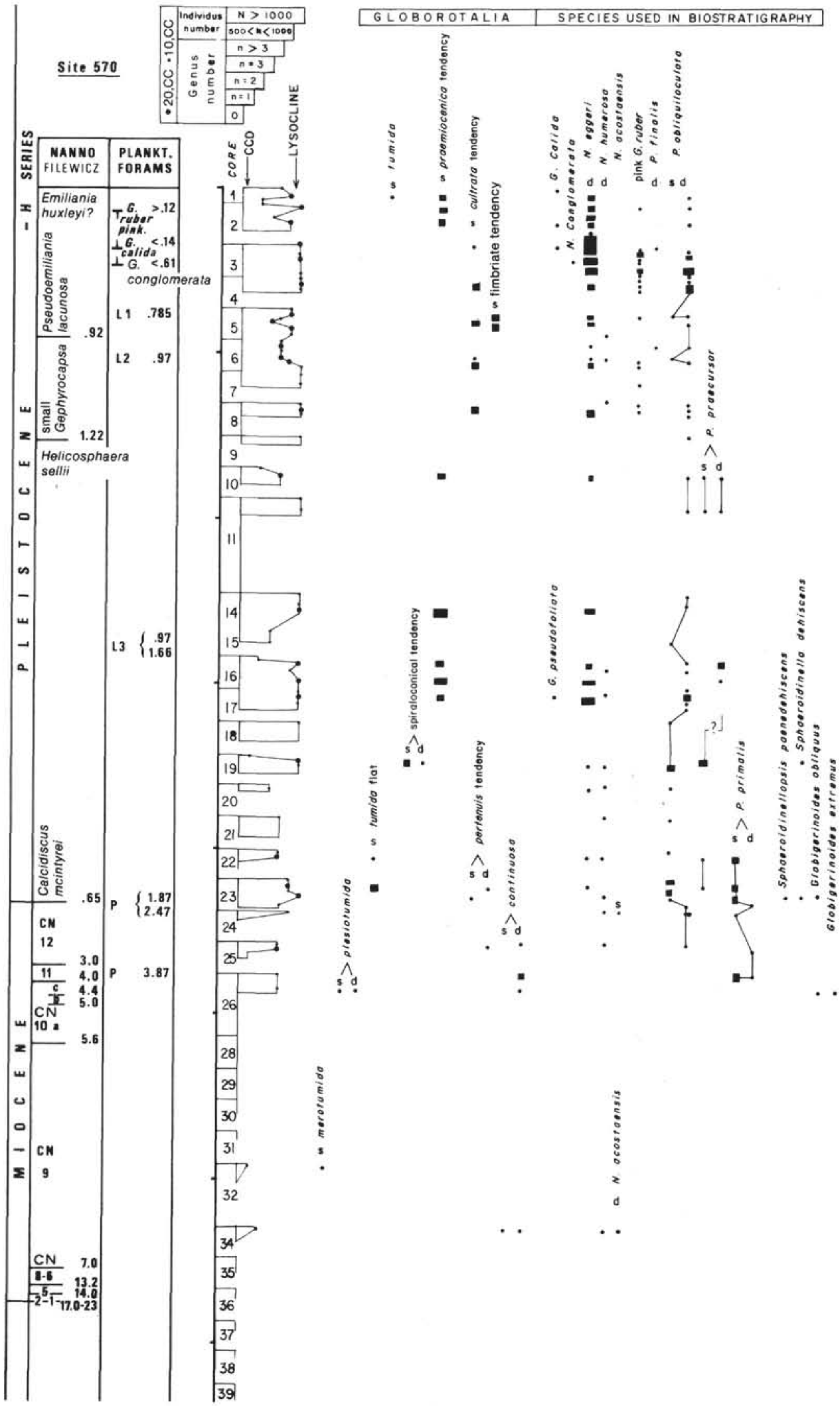

Figure 4. Biostratigraphic summary of Site 570. Solution ranking at the top of the sedimentary column has seven dissolution ranks, as discussed in the text Dissolution Analysis portion of the Materials and Methods section; s = sinistral, d = dextral.

mordius occurs together with its probable ancestor *Globigerina praebulloides*. *G. altiapertarus* first appears in Sample 568-41-4, 80–84 cm within nannofossil Zone CN3.

Globigerinoides trilobus appears in Sample 568-42-4, 91–95 cm, as *G. trilobus immaturus*, within the interval CN2–CN3. It is noteworthy that *G. trilobus*, with its smaller apertures, is more resistant to dissolution than *G. altiapertarus*, given that the presence of both species is a result of a decrease in dissolution.

A third *Globigerinoides* lineage is indicated only by *G. subquadratus*, which appears sporadically from Samples 568-41-1, 80–84 cm to 568-32-5, 52–56 cm.

***Orbulina* lineage.** No *Praeorbulina* was found. *Orbulina suturalis* appears in Sample 568-37-2, 118–122 cm within the "right" *Sphenolithus heteromorphus* Nannozone but just above levels barren of planktonic foraminifers. Therefore this first appearance may also result from a decrease in dissolution. *Orbulina universa* is well represented from Sample 568-33-5, 23–27 cm.

***Fohsella* lineage.** In Sample 568-44-4, 52–56 cm, at a level selected between mottles not greatly affected by dissolution, we found specimens of the *Fohsella kugleri* group together with *Globigerina praebulloides* and some *Globigerinoides primordius*. Above this level dissolution prevents the identification of evolutionary steps in the *F. kugleri* group, as given in Keller (1981b). No *Globoquadrina* were found. Sections 568-44-4 to 568-42-7 are assigned to Nannozones CN1–CN2 (Filewicz, this volume). Above a dissolution interval, *F. peripheroronda* first appears in Core 568-41. Populations of this species show a coiling change from dextral to sinistral in Core 568-40, then are dominantly sinistral with some dextral individuals in Core 568-37 and disappear above Core 568-28. Randomly coiled *F. peripheroacuta* appear in Core 568-29 and range up to Core 568-27, where dominantly sinistral *F. praefohsi* occur. The appearance of *F. peripheroronda* in a core not too strongly affected by dissolution is probably a real "First Appearance Datum" (FAD) (within Zone CN3) as well as those of *F. peripheroacuta* (= Zone N10 Blow) and *F. praefohsi* (= Zone N11 Blow), within Zones CN4 and CN5a, respectively.

***Globorotalia* and *Neogloboquadrina* ancestors.** *Paragloborotalia* or *Jenkinsella* are well represented by a plexus of forms in the lower samples, in which it is possible to identify randomly coiled specimens intermediate between *P. nana* and *Neogloboquadrina continuosa* and some *P. mayeri* (Cushman and Ellisor) emend. Bolli and Saunders (1982).

***Globorotalia menardii* lineage.** The following species represent parts of the lineage: sinistral "A"-type chambered *G. praescitula* (Bizon and Glaçon, 1978), in agreement with previous observations of Tjsalma (1971) and Zachariasse (1975), appears first without record of its ancestor as an invader of the middle latitudes, as was suggested in the phyletic scheme of Srinivasan and Kennett (1981). *G. praescitula* ("B"-type chambered) follows and becomes randomly coiled before its disappearance; the last individuals are dextral. Sinistral *G. praemenardii* appears slightly before sinistral *G. archeomenardii*, then becomes randomly coiled. The last *G. praemenardii* are dextral. No "C"-type chambered, wholly keeled *G. menardii* were found.

***Globorotalia tumida* ancestors.** No true *G. lenguaensis* was found. Among the "B"-type chambered *G. praemenardii* populations, some individuals with an oval equatorial outline and a relatively large last chamber resemble *G. paralenguaensis* (Sample 568-25-6, 65–67 cm). A similar observation was made by Bizon and Glaçon (1978) in the Mediterranean area, where some advanced "B"-type chambered *G. praescitula* with rounded equatorial outline closely resembling *G. lenguaensis* occur together with primitive *G. praemenardii*. We were hoping to obtain better documentation of this lineage in the present material from the Pacific Ocean for comparison with the Mediterranean fauna. The poor preservation of our material, however, makes such a comparison very difficult.

A summary of our interpretation of the nature of first and last appearances of Globorotaliids and *Neogloboquadrina* at Site 568, based mainly on calibration to the nannozonation of Filewicz (this volume), is listed as follows:

Species	FA and LA in sample (interval in cm)	Nature of event
Forms intermediate between *Paragloborotalia nana* and *Neogloboquadrina continuosa*	LA: 568-44-3, 137–139 FA: 568-44-4, 62–66	Dissolution event Dissolution event
Neogloboquadrina continuosa	LA: 568-35-2, 86–88 FA: 568-40-5, 70–74	Local event Dissolution event
Paragloborotalia acrostoma	LA: 29-5, 76–80	LA in S. Pacific, a little above the FA of *O. suturalis* (Srinivasan and Kennett, 1981)
	FA: 568-30-4, 86–90	Invader from high latitudes
Paragloborotalia mayeri	LA: 568-29-3, 90–92 FA: 568-44-4, 62–66	Local event Dissolution event
Globorotalia praescitula	LA: 568-33-4, 76–77	? No firm control by nannofossils
	FA: 568-39-4, 63–65	Local event
Globorotalia archeomenardii	LA: 568-30-4, 86–90	? No firm control
	FA: 568-35-4, 8–12	Local event
Globorotalia praemenardii	LA: 568-25-6, 65–67 FA: 568-36-5, 31–35	Dissolution event FA, but no firm control by nannofossils

Note: FA and LA = first and last appearance.

Other stratigraphically important species present in the section include: (1) *Globigerina ciperoensis*, which makes a short appearance in Samples 568-41-2, 136–140

Table 2. Distribution of foraminifers at Site 570.

Sub-bottom depth (m)	Sample (core-section, cm interval)	Sieve mesh-size (μm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia praemiocenica* tendency s	*G. cultrata* tendency s	*G. fimbriate keel* s	*G. tumida* s	*G. scituliforms* s	*G. scituliforms* d	*Neogloboquadrina eggeri* d	*N. blowi* d	*N. pachyderma* d	*Globoquadrina conglomerata*	*Pulleniatina finalis* d
0.40	1-1, 39-41			Structureless sandy mud		f					a	r	r		
	1-2, 20-25	O.S.	15.10												
		500	0.031												
		200	0.100	Structureless sandy mud		120		1			420	r			
		125	0.202			20			1		560	r			
		50	2.032			r					r				
3.40	1-3, 39-41			Structureless sandy mud	f					r	a	r	r		
	2-2, 20-25	O.S.	16.10												
		500	0.024					1			1				
		200	0.111	Faintly laminated sandy mud				250			700				
		125	0.217					60			90		45		
		50	2.068					r			r		r		
9.04	2-3, 123-125			Sandy mud				c			a	r			
	2-4, 20-25	O.S.	16.20												
		500	0.011												
		200	0.079	Faintly laminated sandy mud				180			500		21		
		125	0.127					35	1		20		5		
		50	1.702					r			r				
	3-1, 27-32	O.S.	15.60												
		500	2.272			13					5				1
		200	5.315	Shelly sand		3000					12,000				
		125	1.619			f					f				
		50	1.166								r				
	3-1, 73-78	O.S.	15.60												
		500	0.026			4					1				
		200	0.180	Structureless mud		1050					2400				
		125	0.156			c					f				
		50	1.814								r				
	3-2, 15-20	O.S.	17.20												
		500	0.031			15					2				
		200	0.323	Structureless mud		2250			18		1800		12		
		125	0.223			1800			4		5000				
		50	2.366								c				
19.89	3-2, 88-90			Structureless mud		c				r	a		r		
21.39	3-3, 88-90					r					a				
	3-4, 23-28	O.S.	14.70												
		500	0.236			23									
		200	0.023	Structureless mud		1760					1200				
		125	0.202			a					a				
		50	1.824								c				
	3-5, 125-130	O.S.	17.10												
		500	0.030			41					1				
		200	0.210	Sandy mud between sand beds		2714			85		1100				
		125	0.383			c			f		a				
		50	3.097								r				
25.89	3-6, 88-90			Sandy mud		a					va			r	
27.81	4-1, 60-62			Structureless mud		f					a	f			
	4-2, 40-45	O.S.	16.80												
		500	0.098			7									
		200	0.167	Structureless mud		120					900	8			
		125	0.376			c					f		c		
		50	2.681			r					r				
30.81	4-3, 60-62			Sandy mud	a	f			r						
36.92	5-1, 11-13			Structureless mud	c	f									
	5-2, 85-90	O.S.	16.20												
		500	0.018				8								
		200	0.130	Structureless mud		100					400	7			
		125	0.125			50			r						
		50	1.683								c				
39.92	5-3, 11-13			Structureless mud	r	r									
	5-4, 70-75	O.S.	15.00												
		500	0.019			6									
		200	0.109	Thin laminated mud		150									
		125	0.179												
		50	1.449												
44.43	5-6, 12-14			Structureless mud		c							r		
46.83	6-1, 42-44					c							r		

Note: s = sinistral, d = dextral; "tendency" indicates resemblance to species listed; O.S. = original sediment; 10-cm^3 samples are differentiated from 20-cm^3 samples by having the sub-bottom depth given at left. Numbers indicate number of specimens counted. When no count was performed, abundance is given as: r (rare), c (common), f (frequent), a (abundant), va (very abundant), vr (very rare), and vvr (more rare than vr), following a semiquantitative scale explained in the Materials and Methods section of the chapter. In the last column (Fragments of planktonic foraminifers), abundance is given with these same symbols and sizes (in μm) as indicated; K = keel. In Samples 570-5-6, 12-14 cm and 570-6-1, 42-44 cm, reworked Camerinidae were found.

Table 2. (Continued).

P. obliquiloculata		*Globorotaloides hexagona*	*Sphaeroidinella dehiscens*	*Orbulina universa*	*Globigerinoides sacculifer*	*G. quadrilobatus*	*G. trilobus*	*G. ruber* "pink"	*G. ruber alba*	*G. conglobatus*	*Globigerinita quinqueloba*	*G. glutinata*	*Globigerina bulloides*	*Globigerinella calida*	*G. aequilateralis*	Foraminifers		Fragments of planktonic foraminifers
s	d															Planktonic	Benthic	
	f				r	r			f		r	r	c	r		<500		250
																0	25	r
	4					1			3				3			552	200	a
									11			8	11			611	10,000	a
													r			r	f	c
		r	r	f	r	r			f				r			<1000		50
																2	48	r
	2			2				1	250				4			1259	350	f
												300	45			540	700	f
												r	r			vr	r	c
	r	r							f				r			<1000		50
																0	13	0
	7	4		1					9			12		1		735	200	c
							20		2			150	30			263	650	f
																vr	r	r
				6	2				1							28	39	r
	3			12	32		35		210			35	65			15,357	396	f
							r		c			c	c			f	f	aK
													r			vr	vr	cK
				1												6	41	0
	2			5			50		140			50	100	3		3800	480	f
							r		c	r		c	f			f	f	aK
																vr	vr	ck
				1	2		2									22	47	r
	42	10			30		450	72	750			200	1500			7134	2000	r
	10						1800		1000			3600	20,000			37,814	45,000	f
							c					c	c			c	c	c
	r		r	f	r	r			f				r			≪1000		200
	r			r	r	r		r	f							<1000		200
				3												26	5	0
	47			19	4		400	14	700						3	4147	400	r
	a						a		a							va	f	c
							c									c	c	c
	2			65	1											110	26	c
	132	2		130				17	3400			160			1	7741	300	c
									c			a				f	c	c
																r	r	r
	c			f	r	r		c	f						r	<1000		
	c				r	r		r	f							<1000		
	1			1						1						10	57	r
	92	3					4	2	150						1	1280	1000	c
	r								f							f	c	f
									r							r	r	c
	f				r			r	f				r			<1000		
	r				r				f							<500		
																8	2	c
1	18			1	3		24	4	60						12	630	780	c
												100				f	1000	a
							r		r							c	r	fK
				r		r			r							r	f	50
																6	24	0
	3			2	9		80	5	21						1	271	123	c
							r									r	a	f
							r									r	r	fK
				r	f	f	f		f				r			<500	Camerinidae	
	r				r	r	r		r				r			<500	rew.	

Table 3. Distribution of foraminifers at Site 570.

Sub-bottom depth (m)	Sample (core-section, cm interval)	Sieve mesh-size (μm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia praemiocenica* tendency s	*G. cultrata* tendency s	*G.* spiraloconical tendency s	*G. tumida* s	*G.* sciteliforms s	*G.* sciteliforms d	*Neogloboquadrina humerosa* d	*N. pachyderma* d	*N. eggeri* d	*N. blowi* d	*Pulleniatina finalis* d
	6-2, 60–64	O.S.	14.90												
		500	0.013			f		13							
		200	0.072	Structureless mud									19		1
		125	0.109										r		
		50	0.954										r		
49.83	6-3, 42–44			Structureless mud		f					r			f	
	6-4, 43–46	O.S.	14.70												
		500	0.027												
		200	0.055	Structureless mud		8							12		
		125	0.093			r							c		
		50	0.607										r		
	6-5, 98–102	O.S.	14.60												
		500	0.022			150									
		200	0.150	Structureless mud									180		
		125	0.177										c		
		50	1.577										r		
54.33	6-6, 42–44					f						r	a	f	
56.71	7-1, 70–72			Structureless mud above		f					r		a	f	
59.71	7-3, 70–72			an ash horizon		f							a	f	
66.05	8-1, 34–36				c	f				r	r		a	f	
	8-2, 14–18	O.S.	16.20												
		500	0.026			28							2		
		200	0.185	Structureless mud		120							6400		
		125	0.194			c							f		
		50	1.448			r							r		
69.02	8-3, 31–33					f				r		r	a	f	
75.83	9-1, 42–44			Structureless mud									a	f	
85.48	10-1, 37–39					c		r					f		
	10-2, 18–22	O.S.	14.80												
		500	0.011												
		200	0.077	Structureless mud	300			1					140		
		125	0.204		c								c		
		50	1.388		r								r		
94.91	11-1, 20–22			Below ash horizon	f(1d)								a		
123.75	14-1, 14–16			Structureless mud	f								a		
126.75	14-3, 14–16				f								a		
	14-4, 56–60	O.S.	15.30												
		500	0.014		6										
		200	0.220	Structureless mud	1200								1000		
		125	0.143		c					1			f		
		50	1.012		r								r		
129.75	14-5, 14–16				r								a		
135.35	15-2, 54–56			Structureless mud				r					a		
138.35	15-4, 54–56			above a sand layer				r					c	r	
143.96	16-1, 95–97				r								c		
	16-2, 132–136	O.S.	18.00												
		500	0.029					1							
		200	0.347	Structureless sandy mud				700	r				200		
		125	0.906												
		50	3.129										r		
146.96	16-3, 95–97			Structureless sandy mud				f				r	f	f	
	16-5, 25–29	O.S.	18.60												
		500	0.069					3							
		200	0.678	Structureless sandy mud				2520					910	60	
		125	0.692					f					r		
		50	2.059					r					r		
151.46	16-6, 95–97			Structureless sandy mud	f								a		
153.52	17-1, 81–83							f			r		a		
	17-2, 32–36	O.S.	15.90												
		500	0.039			12									
		200	0.549	Structureless sandy mud		570			120				1650	f	
		125	0.339												
		50	1.393												
156.52	17-3, 81–83					f							a		
162.85	18-1, 44–46			Sand		f	f						a		
172.75	19-1, 64–65												r		

Note: See Table 2 for an explanation of symbols.

Table 3. (Continued).

P. obliquiloculata		P. praecursor		Globorotaloides hexagona	Sphaeroidinella dehiscens	Orbulina universa	Globigerinoides sacculifer	G. quadrilobatus	G. trilobus	G. ruber "pink"	G. ruber alba	G. conglobatus	Globigerinita glutinata	G. uvula	G. quinqueloba	Globigerina bulloides	Globigerinella calida	G. aequilateralis	Foraminifers		Fragments of planktonic foraminifers
s	d	s	d																Planktonic	Benthic	
																			0	11	0
	1																		34	210	r
																			r	f	f
																			r	r	f
	r					r					f								<500		125
														1					1	5	r
1		2									7	1	2						33	120	a
											r								c	f	f
											r								r	c	f
																			0	3	0
	3			3		4			7	5	35							1	388	300	c
																r			f	a	f
																			r	r	a
	r					r	r	f		r	f								>1000		125
						r		f			f								>1000		125
						r		r		r	f								>1000		50
				r		r		r		r	r							r	>1000		50
						18													48	22	0
	8					35	5	110			300								11,973	400	c
						c		c			c					r			f	a	a
								r			r								r	c	a
	r					f		f			f								>1000		50
	r					f		r			c								>1000		50
																			<500		50
																			0	3	r
	2	1	1						30		10								485	450	a
									r		r		r						c	a	a
																			r	c	a
	r					r	r	f			f		f						>1000		
	r					c		f			f								>1000		
	r					c	r	f			f								>1000		
						2													8	15	r
	1					40	10	1000			200								3451	380	r
				c				c					c						f	a	f
								r			r								r	r	r
						c		f											>1000		
r																			<500		
	r																		<500		
																			<500		
						1													2	14	r
	10		200			27	10	60			90								40239	5000	r
				c															c	vva	r
																			r	f	a
	r					f	r	r			r								>500		
						2													5	54	r
			9			10	70	360			90									560	r
			r								c		f						f	va	a
											r		r						r	c	va
	r							f			f								>1000		
	r					c	f	f	f										>1000		50
						120													132	11	
	120			1	350	a		30			3000	180	3		2	1	1	1	6000	510	r
				c		r													c	va	r
																				f	a
	r					f	r	c	c		c								>1000		
c						f	r	f	f		f								>1000		
																			<500		

Table 4. Distribution of foraminifers at Site 570.

Sub-bottom depth (m)	Sample (core-section, cm interval)	Sieve mesh-size (m)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia* aff. *praemiocenica* d	*G.* aff. *pertenuis* d	*G.* aff. *multicamerata* d	*G. cultrata* s	Spiraloconical tendency s	*G. flexuosa* s	*G. tumida* "flat" s	*G. tumida* "flat" d	*G. plesiotumida* s	*G. plesiotumida* d	*G. merotumida* s	*G. merotumida* d	*G. pseudomiocenica* s	*G. pseudomiocenica* d	*G. tumida* s	*G.* scituliforms d	s
	19-2, 120-124	O.S.	18.10																		
		500	0.041					53													
		200	0.293	Sandy mudstone				a													
		125	0.466					c													
		50	2.601																		
175.75	19-3, 64-66			Sandy mudstone				f	f												
182.55	20-1, 74-76							f													
192.03	21-1, 52-54			Structureless mudstone					r				aff						r		
202.43	22-2, 122-124																		f		
	22-2, 88-92	O.S.	19.80																		
		500	0;043																		
		200	0.103	Structureless mudstone					1										7		
		125	0.124																		
		50	1.214																		
205.43	22-3, 122-124			Structureless mudstone																	
211.01	23-1, 30-32								r										r		
	23-2, 94-98	O.S.	16.10																		
		500	0.024	Structureless sandy															2		
		200	0.059	mudstone					1			3							156		
		125	0.101																f		
		50	1.129																		
214.01	23-3, 30-32			Sandy mudstone						f									f		
	23-4, 66-70	O.S.	16.00																		
		500	0.050	Structureless sandy																	
		200	0.134	mudstone						2									71	1	
		125	0.325																r		
		50	1.932																		
218.51	23-6, 30-32			Sandy mudstone							r			r				f			
220.62	24-1, 41-43			laminites	f									r							
	24-2, 47-51	O.S.	14.20																		
		500	0.045																		
		200	0.204	Structureless sandy																	
		125	0.186	mudstone																	
		50	0.864																		
223.62	24-3, 41-43			Sandy mudstone																	
230.12	25-1, 41-43									r		r									
	25-2, 76-80	O.S.	16.90																		
		500	0.202	Bioturbated sandy																	
		200	0.047	mudstone		2	3										1	4			
		125	0.181																		
		50	1.578																		
233.12	25-3, 41-42			Sandy mudstone																	
239.55	26-1, 14-16													c				r			
244.05	26-4, 14-16			Structureless mud	a								r	c							
259.67	28-1, 86-88[a]																				
	29-2, 80-84	O.S.	12.90																		
		500	0.028																		
		200		Structureless mud																	
		125																			
		50																			
272.64	29-3, 123-125[b]			Structureless mud																	
297.33	32-1, 11-15			Structureless mud											r						
303.33	32-5, 11-15																				
317.67	34-1, 126-128			Mudstone																	
326.15	35-1, 14-16[c]			Shale																	
	37-1, 13-17	O.S.	15.20																		
		500	6.663																		
		200	1.054	Limestone																	
		125	0.347																		
		50	0.959																		
346.03	37-1, 22-24[d]			Limestone																	

Note: See Table 2 for explanation of symbols.
[a] Also examined: 28-3, 101-102; 28-6, 107-109; 29-1, 123-125.
[b] Also examined: 30-1, 20-22; 30-4, 20-22; 31-1, 117-119.
[c] Also examined: 35-4, 6-8 (mudstone); 36,CC (limestone).
[d] Also examined: 38-1, 77-79; 39-1, 87-89 (shale scaly fabric).

cm and 568-41-4, 82–84 cm; (2) *Catapsydrax stainforthi*, which occurs from Sample 568-40-2, 45–48 cm to 568-41-5, 132–136 cm, in sections dated CN3 by Filewicz (this volume) (we suspect that it is reworked, especially in view of the 70° dip observed at that level); (3) *Catapsydrax dissimilis*, which occurs from Sample 568-44-4, 62–66 cm to Sample 568-41-4, 82–84 cm, and *C. unicavus*, from Sample 568-40-5, 70–74 cm to 568-35-2, 86–90 cm (because Core 568-38 is assigned to Nannozone CN4, some reworking is possible here).

Table 4. (Continued).

																								Foraminifers		
Neogloboquadrina continuosa	*N. acostaensis*	*N. humerosa*	*N. eggeri*	*Pulleniatina obliquiloculata*		*P. praecursor*	*P. primalis*		*Globoquadrina conglomerata*	*Globorotaloides hexagona*	*Sphaeroidinella dehiscens*	*Sphaeroidinellopsis paenedehiscens*	*Orbulina universa*	*Globigerinoides sacculifer*	*G. quadrilobatus*	*G. trilobus*	*G. ruber alba*	*G. elongatus*	*G. obliquus*	*G. extremus*	*Globigerinita glutinata*	*Globigerina bulloides*	*Globigerinella aequilateralis*	Planktonic	Benthic	Fragments of planktonic foraminifers
d	d	d	d	s	d	s	s	d																		
																								≥ 1000		
											2		68				1							124	0	0
			f	a		a							a	f		a	a							va	c	r
			c														c							f	f	a
			c																					c	f	a
		aff		f									r				f				r			> 1000		
				c													r							< 500		
		r		c													r							< 500		
		r		c									r				c				r			< 500		
																								0	20	
		12	4			4	18			2			7				23							78	350	f
						r				r							c							c	va	c
						r																		r	f	c
																								0		
				f						r												r		> 500		
													8				2							12	37	c
				2		3	51							4		24	400				1			545	350	c
							f										f				r			a	va	c
																	c							c	c	a
		c	aff	c									r				c							> 500		
													5				1							6	7	
		9		5			75		3		13	1	15	1	5	62	700	8	2		24			994	300	c
		c							a							r	a				f	r		a	a	f
		r															c				r			c	f	f
					r			c					r											< 500		
			r		r		c								c	r	r							> 500		
																								0	8	
																								0	a	
																								0	a	
																								0	a	K
																								0		
		r						1							r	r	r							< 500		
																								0	5	
								1								18								29	1000	f
																r								r	a	f
																r								r	r	r
																1								< 500		
a							f	c								r								< 500	0	
a													r						f	c			r	< 500		
																								0		
																								0	2	
																								0	c	
																								0	r	
																								0	0	
																								0		
																								< 500		
																								0	0	
r	r	r																						< 500		
																								0		
																								0		
																								0		
																								0		
																								0		
																								0	0	

It thus appears that dissolution and sediment displacements preclude a detailed foraminiferal phyletic study at this site.

Site 569

Site 569 is located between Sites 568 and 567 on the landward side of the Middle America Trench at a water depth of 2799 m (Fig. 6, Table 12).

As expected, the section at this site is more condensed than at the other ones for the Pliocene–Quaternary, but the Oligocene–Miocene section is relatively more developed and more siliceous.

No pink *Globigerinoides ruber* nor *Globigerinella calida* occurs. The only coiling change in *Pulleniatina obliquiloculata* occurs in Core 569-5 a little below an acme of *Globoquadrina conglomerata*, suggesting that it cor-

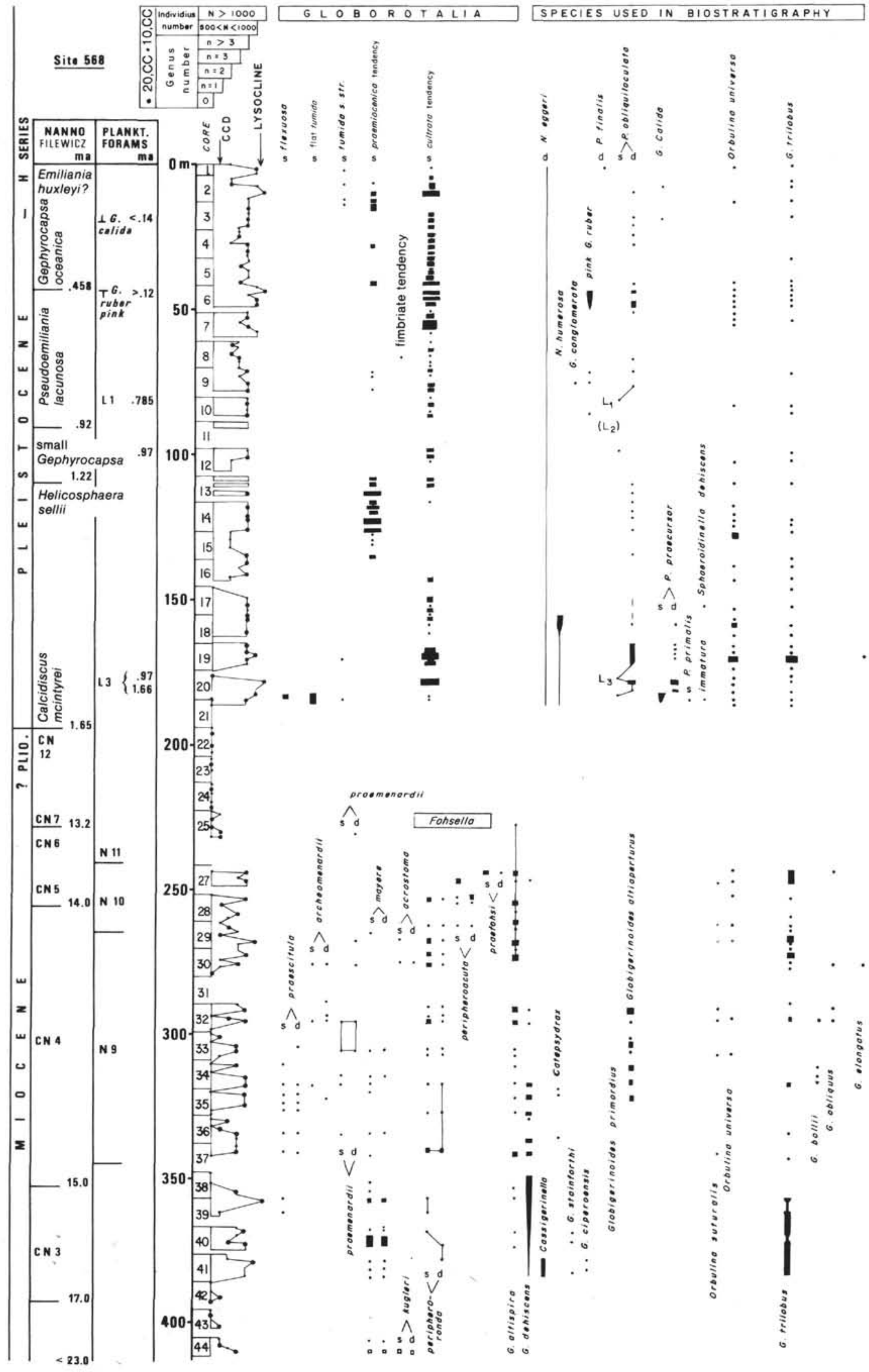

Figure 5. Biostratigraphic summary of Site 568 (see Fig. 4).

responds to the peak L_1 at about 0.785 Ma. This assumption is consistent with nannofossil data, which indicate an age of 0.458 Ma close to the boundary of Cores 569-4 and -5.

Based on nannofossil data, it appears that neither the disappearance of *Neogloboquadrina humerosa* nor that of *Pulleniatina primalis* can be used here as biostratigraphic datums but is rather a result of dissolution. That is true also of the appearance of *Orbulina suturalis*, which could be a dissolution-controlled event.

A number of Globorotaliids was found at Site 569. These forms belong to the "pitted" *Globorotalia* of McGowran (1968) or *Paragloborotalia* Cifelli (1982) or *Jenkinsella* Srinivasan and Kennett. They compare well with forms of the *mayeri* plexus *sensu* Bolli and Saunders (1982). Some are early *Neogloboquadrina continuosa* (Sample 569-27-1, 36–38 cm).

Fohsella are only represented by *F. peripheroronda* in Samples 569-13-2, 40–42 cm and 569-11-1, 40–42 cm. In the latter sample this species is associated with *Globorotalia praescitula*. In the tropics Srinivasan and Kennett (1981) found the same association dated between about 15 and 17 Ma, an age in agreement with the *Helicosphaera ampliaperta* Zone identified here between Sample 569-11-2, 71 cm and 569-12,CC.

A hiatus of about 12 m.y. occurs between Cores 569-10 and 569-8, above which *G. praemiocenica* first appears in association with left-coiling *Pulleniatina primalis* in Sample 569-8-1, 29–30 cm. Left-coiling *P. obliquiloculata* appears just slightly above in Sample 569-7-6, 30–32 cm in association with the first *Neogloboquadrina eggeri* within the *Discoaster pentaradiatus* Subzone (2–2.1 Ma).

Hole 567A

Hole 567A, located at the base of the lower slope of the Middle America Trench at a water depth of 5529 m, is the deepest hole at the west end of the Guatemala transect. The upper 176 m of Pleistocene have been washed from the top of this hole. Two samples from the first core dated early Pliocene by nannofossils are barren of planktonic foraminifers. Below these levels some dissolution-resistant planktonic foraminifers occur sporadically, always in small numbers, as follows.

Sample 567A-2-5, 5–67 cm. In this sample rare *Neogloboquadrina humerosa* with fragments of *Globigerinoides* shells occur; this level is assigned to the *Amaurolithus tricorniculatus* Zone by Filewicz (this volume).

Sample 567A-3-6, 105–107 cm. Globoquadrina praedehiscens and *G. dehiscens* with rare *Globigerinoides bispherícus* and minuscule *Paragloborotalia sp.* are present here. This association suggests a zonal assignment to the upper part of N7 Blow, in agreement with the nannofossil *Helicosphaera ampliaperta* Zone.

Sample 567A-6-2, 106–108 cm. Globoquadrina venezuelana, with *Globigerinoides bisphericus*, occur in this sample. Below this level, from Sample 567A-8-1, 56–58 cm to 567A-10-1, 74–76 cm *Globigerinoides bisphericus* still occurs. Filewicz (this volume) assigns these samples and the interval below, down to 567A-13,CC, to the *Helicosphaera ampliaperta* Zone.

Sample 567A-10-1, 74–76 cm. This is an example of downhole contamination with sinistral *Pulleniatina* and molds of *Globorotalia.*

Site 565

Site 565 is located on the lower slope of the landward side of the Middle America Trench off Costa Rica at a water depth of 3111 m (Fig. 7).

Samples at this site appear to be always located below the planktonic foraminiferal lysocline and commonly below the CCD. But it is not easy to identify *in situ* from gravity-reworked samples, for no shallower site off Costa Rica is available for comparison as was the case in the area off Guatemala. Yet we are able to recognize differences between the faunal assemblages of the two geographic areas. Here, very often, the last species to remain belongs to the genus *Globorotalia* instead of *Globoquadrina* or *Neogloboquadrina*. Strongly encrusted *Globorotalia inflata* occur in core Sample 565-1-7, 10–14 cm. Some specimens with only three chambers at the last whorl resemble *G. triangula* Theyer, although there is a slight difference in the vaulting of the umbilical face. *G. triangula* is reported from the uppermost Pliocene and middle Pleistocene of the Tasman Sea; these forms slightly resemble some three-chambered morphotypes of the *G. puncticulata* group from Mediterranean Pliocene.

The co-occurrence of pink *Globigerinoides ruber* with *Globigerinella calida* in Sample 565-1-1, 32–36 cm indicates an age of 0.12–0.14 Ma.

Planktonic foraminifers often appear to be reworked at Site 565, as shown by the occurrence of *Pulleniatina primalis* and *P. praecursor* above the stratigraphic range. Left-coiled *P. obliquiloculata* are found in the *Gephyrocapsa oceanica* Zone (0.268–0.458 Ma), whereas the last sinistral *P. obliquiloculata* is dated 0.785 Ma (see Fig. 2). Reworking could explain the stratigraphically too-high sporadic occurrence of "flat" *Globorotalia tumida* in Core 565-7 in the *Gephyrocapsa oceanica* Zone; this species is usually found in the lower Pliocene.

Upper Miocene, small-keeled "C"-type chambered, randomly coiled *Globorotalia menardii* occur with some randomly coiled *G. merotumida* in Core 565-34. Above this level, dissolution precludes a detailed study. Specimens of dextral *Globorotalia*, about twice as large as the previous ones found in Core 565-34, appear abruptly in Core 565-31. Generally biconvex, they compare well with *G. praemiocenica*. A few of them show a weak tendency toward a flattening of the spiral face, but never as pronounced as in *G. miocenica sensu stricto*. Other ones show a tendency to increase the number of chambers of the last whorl; the chambers become therefore more radially elongated, the thinner walled resemble *G. pertenuis*, but none of them is identical to the type of that species. The thicker-walled forms with strongly limbate sutures compare well with *G. multicamerata*.

In Sample 565-30-5, 102–107 cm, there are some *Globorotalia tumida* with a flat umbilical face reminiscent of *G. plesiotumida* but three times as large as the latter. Most specimens are dextral but a few, with a weak *flexuosa* tendency, are sinistral. Above this level all these

Table 5. Distribution of foraminifers at Site 568.

Sub-bottom depth (m)	Sample (core-section, cm interval)	Sieve mesh-size (μm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia praemiocenica* tendency s	*G. cultrata* tendency s	*G. tumida* s	*G. scituliforms* s	*Neogloboquadrina eggeri* d	*N. blowi* d	*N. pachyderma* d	*Pulleniatina finalis* d	*P. obliquiloculata* d
0.51	1-1, 50-52			Structureless T2 mud					r	r			
	1-2, 15-19	O.S.	10.50										
		500	0.018			3				1			
		200	0.202	Structureless T2 mud		5	2		520			1	
		125	0.239										
		50	0.660										
3.51	1-3, 50-52			Structureless T2 mud		c			a	r			
4.43	2-1, 102-104								r	r			
	2-2, 36-40	O.S.	9.20										
		500	0.025										
		200	0.140	Structureless T2 mud	1		1		8				
		125	0.276										
		50	0.764										
7.43	2-3, 102-104			Structureless T2 mud		f			a	f	r		
	2-5, 31-35	O.S.	12.40										
		500	0.018			6							2
		200	0.288	Structureless T2 mud	12	500			8000				3
		125	0.279			r			va				
		50	0.798						r				
11.93	2-6, 102-104			Structureless T2 mud	r				a	f	r		
14.17	3-1, 116-118				f				a	f			
	3-2, 12-16	O.S.	11.15	Structureless T2 mud									
		500	0.001										
		200	0.027		33		r		71	5	4		
		125	0.060		r				f		r		
		50	0.289										
17.17	3-3, 116-118			Structureless T2 mud		f	r	r	a				
	3-4, 38-42	O.S.	12.80										
		500	0.005										
		200	0.026	Structureless T2 mud		20			42	3			1
		125	0.079						r				
		50	0.347										
	3-5, 44-48	O.S.	13.60										
		500	0.003										
		200	0.040	Structureless T2 mud		32			76				1
		125	0.059						r				
		50	0.371										
21.67	3-6, 116-118			Structureless T2 mud		f			a				
24.01	4-1, 130-132			T2/SB3 mud		f			r	r			
	4-2, 40-44	O.S.	12.65										
		500	0.003										
		200	0.043	Structureless T2/SB3 mud		19							1
		125	0.065										
		50	0.307										
27.01	4-3, 130-132			Structureless T2/SB3 mud		f							
	4-4, 16-20	O.S.	12.50										
		500	0.013										
		200	0.045	Structureless T2/SB3 mud	25	25			58				1
		125	0.068										
		50	0.300										
	4-5, 34-38	O.S.	11.95										
		500	0.015										
		200	0.043	Structureless T1/SB3 mud		36			56				2
		125	0.052					f					
		50	0.353										
31.51	4-6, 130-132			Structureless T2/SB3 mud		f			r	r			
33.38	5-1, 107-109			Structureless T2 mud		f			f	a	r		r
	5-2, 14-18	O.S.	12.10										
		500	0.007										
		200	0.050	Structureless T2 mud		8			7				2
		125	0.197										
		50	0.682										
36.38	5-3, 107-109			Bedding		f			f	a			
39.38	5-5, 107-109			Structureless T2 mud		f			f	f			
	5-6, 33-37	O.S.	12.70										
		500	0.017										
		200	0.061	Structureless T2 mud	54				50				
		125	0.067		r								
		50	0.372		r				r				

Note: See Table 2 for an explanation of symbols.

Table 5. (Continued).

d Globorotaloides hexagona	Orbulina universe	Globigerinoides sacculifer	G. quadrilobatus	G. trilobus	G. tenellus	G. ruber alba	Berggrenia clarkei	Globigerinita quinqueloba	G. glutinata	G. uvula	Globigerina bulloides	Globigerinella calida	G. aequilateralis	G. obesa	Foraminifers Planktonic	Foraminifers Benthic	Fragments of planktonic foraminifers
															<500		200
															4	22	
		6	10			14			10				1		569	455	3430
									f						f	f	va
			r						r						vr	vr	va K
r				r		r		r	f				r	r	c	f	r
				r											r	f	a
															0	9	
															10	a	c
															0	c	a K
															0	r	a K
	r	r		r	r	r			c			r			a	f	r
															8	59	
	1														8516	a	
									r		r				va	a	
											r				r	r	vr
				r					r		r				r	r	50
					r	r									r	r	50
						6									119	a	f
															f	a	a
															0	0	r
			r		r	r	r			r					r	r	
																	r
															66	135	vr
															vr	vr	a
															0	r	f
															0	3	
															111	85	f
															r	r	f
															0	0	0
								r							r	c	50
								r	r						r	c	50
															0	2	
						2									22	98	
															vr	vr	a
															0	r	a K
						r									r	c	a
															0	4	
						2									111	72	r
															0	c	f
															0	0	0
									1						95	124	vr
															f	c	a
															0	0	0
								r							r	c	200
									r						r	c	200
															0	2	0
															17	900	r
															vr	vr	a
															vr	vr	r
						f									r	c	125
	r		r			f									r	c	200
															0	2	
		1	1			4									110	130	c
						r									r	r	f
															vr	vr	f

Table 6. Distribution of foraminifers at Site 568.

Sub-bottom depth (m)	Sample (core-section, interval in cm)	Sieve mesh-size (μm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia praemiocenica tendency* s	*G. cultrata tendency* s	*G. aff. fimbriata*	*G. scituliforms* s	*G. scituliforms* d	*Neogloboquadrina eggeri* d	*N. blowi* d	*N. pachyderma* d
42.28	6-1, 27–29			T2 mud		a				a	f	
	6-2, 22–26	O.S.	16.10									
		500	0.009									
		200	0.113	Stuctureless T2 mud		396		3		805		
		125	0.103			f				f		
		50	0.513			r				r		r
45.28	6-3, 27–29			T2 mud						a	f	
	6-4, 75–80	O.S.	15.95									
		500	0.020			2						
		200	0.077	Structureless T2 mud		205				368	f	
		125	0.086			f		3		f		
		50	0.301			r				r		
	6-5, 24–28	O.S.	12.70									
		500	0.014			1						
		200	0.093	Structureless T2 mud		183		8		560	23	
		125	0.077			f		r		a		r
		50	0.218									
51.99	7-1, 58–60			T2 mud		r		r		r	r	
	7-2, 15–19	O.S.	14.00									
		500	0.018									
		200	0.056	T2 mud, some lamination		58				92	r	
		125	0.055			r				r		
		50	0.289									
54.99	7-3, 58–60			T2 mud		f				a	r	
	7-4, 17–21	O.S.	13.60									
		500	0.073									
		200	0.156	T2 mud, some lamination		14				66	r	r
		125	0.039							r		
		50	0.339							r		
57.99	7-5, 58–60			T2 mud		f				a	r	
61.32	8-1, 21–23			T2/SB3 mud		r				a		
	8-2, 15–19	O.S.	11.60									
		500	0.015									
		200	0.076	Structureless T2/SB3 mud						2		
		125	0.093							r		
		50	0.169									
64.32	8-3, 21–23			Structureless mud		f				a		
	8-4, 20–24	O.S.	12.10									
		500	0.010									
		200	0.040	Structureless T2/SB3 mud		3						
		125	0.038									
		50	0.267									
	8-5, 128–132	O.S.	13.55									
		500	0.056									
		200	0.089	T2/SB3 mud above a sandy layer			1			6		
		125	0.261							r		
		50	0.523							vr		
68.82	8-6, 21–23			T2/SB3 mud		r				r		
70.65	9-1, 24–26					r				r		
	9-2, 131–135	O.S.	13.50									
		500	0.002									
		200	0.046	T2/SB3 massive mud	1	20				23		
		125	0.132									
		50	0.414									
73.65	9-3, 24–26			T2/SB3 mud	r	r				r		
	9-4, 72–76	.S.	12.45									
		500	0.023			1						
		200	0.088	T2/SB3 massive mud	2	87				127	19	5
		125	0.064			r				c	r	r
		50	0.322									
	9-5, 33–37	O.S.	14.00									
		500	0.004			2						
		200	0.046			41				150	19	3
		125	0.087			f				f		
		50	0.439			r				r		
80.64	10-1, 53–55			T2/SB3 mud		r				f		
	10-2, 30–34	O.S.	12.00									
		500	0.031			2						
		200	0.060	T2/SB3 mud above ashy mottles		41				63		
		125	0.078			f			r	r		
		50	0.284			r						

Note: See Table 2 for explanation of symbols.

Table 6. (Continued).

N. acostaensis d	*N. humerosa* d	*Globoquadrina conglomerata*	*Pulleniatina obliquiloculata* s	*Pulleniatina obliquiloculata* d	*Globorotaloides hexagona*	*Orbulina universa*	*Globigerinoides sacculifer*	*G. quadrilobatus*	*G. trilobus*	*G. ruber* "pink"	*G. ruber alba*	*G. conglobatus*	*Globigerinita quinqueloba*	*G. glutinata*	*G. uvula*	*Globigerina bulloides*	Foraminifers: Planktonic	Foraminifers: Benthic	Fragments of planktonic foraminifers
				c		r	r	r			r			r			>500	c	r
																	0	0	
				21	1	2				10	28			r		r	1266	64	vr
				r						r	f			c		r	3000	r	a
																	r	r	a
						r					r		r				r	r	
						1				1							4	19	0
				14	2	3	2	3	2	12	84			5			700	162	r
				r					a		a			r		a	1800	f	a
											r						r	f	va
						1											5	2	
				18		4		3		3	56						858	250	vr
				r		r											f	r	va
						r											vr	vr	vva
				r		r				r	r						vr	vr	200
						1											1	14	
				3		4	1	1	3	r	7						169	245	r
								r	r		r						r	c	va
																	vr	vr	vva
										r	r			r			f	f	200
																	0	21	
				14							6						100	212	r
														r		r	r	r	a
																	vr	vr	a
								r		r	r			r			>500	f	125
											r						r	f	200
																	0	12	
											1						3	60	0
																	vr	f	f
																	vvr	vvr	f
											1						r	c	200
																	0	1	r
																	3	137	r
											2						2	142	f
																	0	vr	f
																	0	2	0
				1													8	210	f
																	vr	r	f
																	vvr	vvr	a
											r						r	f	200
											r						r	f	200
																	0	2	
	r			1			1			1	6						53	284	r
											r						vr	r	va
							r										vvr	r	vva
									r		r						r	c	200
	aff																2	5	
	2	2			1			12	9	4	33	4		3	2	2	314	116	f
											r				r	r	a	r	va
																	vr	vr	vva
																	2	10	
				2	2			7	5		18			3	1	1	252	122	f
											r				r	r	a	r	va
																	r	r	vva
			r								r						r	c	200
																	2	1	
						10			1	2	3						121	112	c
r					r						r						r	f	a
																	r	r	va

Table 7. Distribution of foraminifers at Site 568.

Sub-bottom depth (m)	Sample (core-section, interval in cm)	Sieve mesh-size (μm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia praemiocenica* tendency s	*G. cultrata* tendency s	*G. sciuliforms* s	*G. sciuliforms* d	*Neogloboquadrina eggeri* d	*N. blowi* d	*N. pseudopima*	*N. acostaensis* d
83.64	10-3, 53–55			T2/SB3 mud		r			r			
	10-4, 118–122	O.S.	12.70									
		500	0.009									
		200	0.230	T2/SB3 mud		11			18	1		
		125	0.138			4			5			
		50	0.384			r			r			
99.46	12-1, 65–67			T2/SB3 mud		f	r		a	r		aff
	12-2, 108–112	O.S.	13.70									
		500	0.014									
		200	0.089	T2/SB3 mud		28			123			
		125	0.085			r			f			
		50	0.198						r			
102.46	12-3, 65–67					r			r	r		aff
109.61	13-1, 130–132			T2/SB3 mud	f	f			a	f		aff
111.78	13-3, 47–49				f	f			a	f		
	13-5, 14–18	O.S.	17.60									
		500	0.015		1							
		200	0.098	T2/SB3 mud	393			r	460	12		
		125	0.163		c				c	r		
		50	0.536		r				r			
117.96	14-1, 15–17			T2/SB3 mud	f	r			a	f		
	14-2, 68–72	O.S.	15.05									
		500	0.002									
		200	0.033	T2/SB3 weakly stratified mud	198				18			r
		125	0.086		f				f			
		50	0.364		r				c			
120.96	14-3, 15–17			T2/SB3 mud	f				a	f		a
	14-4, 70–74	O.S.	16.60	T2/SB3 mud								
		500	0.021									
		200	0.115		296				182		3	
		125	0.120		c				c			
		50	0.425		r				r			
125.38	14-6, 7–9			T2/SB3 mud	f				a	r		r
	14-7, 35–38	O.S.	14.50									
		500	0.022									
		200	0.074	T2/SB3 weakly stratified mud	253				48		32	
		125	0.067		f							
		50	0.433		r							
127.50	15-1, 9–11			T2/SB3 mud	r				r			
130.48	15-3, 7–9			Soupy mud	r				r			
133.48	15-5, 7–9				r				f			
	15-6, 12–16	O.S.	15.30									
		500	0.035									
		200	0.130	T2/SB3 mud	56						12	
		125	0.202		r						r	
		50	0.444		r							
	16-1, 131–135	O.S.	14.90									
		500	0.052		1							
		200	0.090	T2 mud	214				112			
		125	0.223		r				r			
		50	0.635		r				r			
140.42	16-3, 21–23			T2 mud	f				r			
	16-4, 98–102	O.S.	16.10									
		500	0.087									
		200	0.081	T2 mud	63		1		24			
		125	0.168		r				r			
		50	0.375									
143.39	16-5, 18–20					f			r			
147.31	17-1, 40–42			T2 mud								
150.31	17-3, 40–42				r	f			f	r		
	17-5, 102–106	O.S.	13.05									
		500	0.035			2						
		200	0.104	T2 mud		43		1				
		125	0.099			r						
		50	0.294									
154.81	17-6, 40–42	T2	mud			r			f			r
	18-1, 123–127	O.S.	13.20									
		500	0.088			1						
		200	0.121	Structureless T2 mud		14			5			
		125	0.084									
		50	0.272									

Note: See Table 2 for an explanation of the symbols.

Table 7. (Continued).

N. humerosa	*Pulleniatina obliquiloculata*		*Globorotaloides hexagona*	*Sphaeroidinella dehiscens*	*Orbulina universa*	*Globigerinoides sacculifer*	*G. quadrilobatus*	*G. trilobus*	*G. ruber* "pink"	*G. ruber alba*	*G. elongatus*	*G. quinqueloba*	*Globigerinita glutinata*	*G. uvula*	*Globigerina bulloides*	Fora-minifers		Fragments of planktonic foraminifers
d	s	d														Planktonic	Benthic	
								r				r				r	c	
																0	3	
									2	4						36	263	r
										2			2			13	95	f
										r						r	f	a K
	r							r		r						f	c	200
																0	9	
					1			1		2						155	68	r
										r						f	f	va
																vr	vr	a
																r	f	r
																f	c	125
		r						r		r						f	c	125
					1											2	18	
			4		2					3						481	284	c
										f				r		f	c	va
										r						r	r	a
		r			r		r			r				r		f	c	125
																0	5	
r			2		5	2	12			10	3					250	117	
																f	c	va
							c			c						c	r	a
		r	r		r	r		r								f	c	125
																0	4	
2		1	1		4		18	2		4						513	254	c
			r				r									c	c	f
																r	r	a
					f			r		r			c			f	c	125
					1											1	8	
		2	2		36	1	18									392	1000	c
							r									c	f	va
																vr	vr	va
																vr	c	200
																vr	c	200
																vr	c	
																0	2	
		3					1	1		2						75	353	f
																r	r	va
																vr	vr	va
																1	14	
					4	1	9	5		3						348	276	c
																r	r	va
																vr	vr	va
								r		r						r	c	125
																0	4	
			1		8		5	4		3						109	292	f
																r	a	va
																0	vr	va
																vr	r	125
																0	r	125
		r			r	r		f								r	r	200
					2			1								5	6	
		3	2	1	6	5	12	5		79			5		4	166	191	c
										r						r	c	va
																r	r	va
a		r			r											f	r	200
					5											6	2	
		2			5	13		5		24						68	64	c
																c	r	a
																r	r	va

Table 8. Distribution of foraminifers at Site 568.

Sub-bottom depth (m)	Sample (core-section, interval in cm)	Sieve mesh-size (μm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia cultrata* tendency s	*G. flexuosa* s	*G. tumida* "flat" s	*G. tumida* s	*G. scituliforms* s	*G. scituliforms* d	*Neogloboquadrina eggeri* d	*N. blowi* d	*N. acostaensis* d
	18-2, 135–139	O.S.	12.60										
		500	0.072										
		200	0.095	Structureless T2 mud	16				9		6		r
		125	0.083		c						r		
		50	0.205		r						r		
159.66	18-3, 15–17			T2 mud	r				r		r		
	18-4, 102–106	O.S.	13.55										
		500	0.041										
		200	0.063	T2 mud faint lamination	7				6		27		
		125	0.078		r				r		r		
		50	0.134		2				r		r		
	19-1, 144–147	O.S.	12.20										
		500	0.046										
		200	0.089	T2/SB3 structureless mud	3						2	1	
		125	0.088								r		
		50	0.188								r		
	19-3, 126–130	O.S.	13.05										
		500	0.024		4								
		200	0.075	T2/SB3 structureless mud	139				1	1	72		
		125	0.088		c						c		
		50	0.250		r								
	19-4, 120–124	O.S.	12.60										
		500	0.025										
		200	0.131	Mud scaly structure	212			3		1	300		
		125	0.496		f				1	12	f		
		50	0.352		r						r		
	19-5, 80–84	O.S.	12.30										
		500	0.057										
		200	0.160	Mud scaly structure	41						14		
		125	0.122		2				1	3			
		50	0.195										
173.73 176-76	19-6, 2–4 20-1, 75–77			T2/SB3 mud	f								
	20-2, 102–106	O.S.	11.95										
		500	0.030		3								
		200	0.072	T2/SB3 mud	312								
		125	0.106		c								
		50	0.280		r								
179.76	20-3, 75–77			T2/SB3 mud									
	20-4, 104–107	O.S.	13.40										
		500	0.051										
		200	0.228	T2/SB3 mud							500	r	r
		125	0.180						1				
		50	0.503										
182.76	20-5, 75–77			T2/SB3 mottling	f						a		
	20-6, 119–123	O.S.	14.20										
		500	0.034		2	1	5						
		200	0.109	Mud mottling	5	67	67				318	2	
		125	0.163										
		50	0.342										
	21-1, 113–116	O.S.	14.40										
		500	0.053										
		200	0.111	Structureless T2/SB3 mudstone			24	1			13		
		125	0.144				1				2		
		50											
196.75	22-1, 134–136[a]			T2/SB3 mud									
	25-2, 24–28 25-4, 6–10[b] 25-5, 104–108			T2/SB3 mudstone									
232.66	25-6, 65–67[c]			T2/SB3 mudstone									
247.08	27-1, 117–119			T2/SB3 mudstone									

Note: See Table 2 for an explanation of the symbols.
[a] Also examined: 22-2, 112–116; 22-3, 134–136; 22-5, 4–8; 22-6, 134–136; 23-1, 68–70; 23-2, 60–64; 24-2, 100–104; 24-3, 89–91; 24-5, 89–91; 24-6, 30–34; 25-1, 65–67.
[b] Only one *Globoquadrina altispira*.
[c] Only one dextral *Globorotalia praemenardii*.

Table 8. (Continued).

N. humerosa d	*Pulleniatina obliquiloculata* s	*Pulleniatina obliquiloculata* d	*P. praecursor* s	*P. praecursor* d	*P. primalis* s	*Globorotaloides hexagona*	*Sphaeroidinella dehiscens immatura*	*Orbulina universa*	*Globigerinoides sacculifer*	*G. quadrilobatus*	*G. trilobus*	*G. ruber alba*	*G. elongatus*	*G. conglobatus*	*Globigerinita glutinata*	*Globigerinella aequilateralis*	Foraminifers Planktonic	Foraminifers Benthic	Fragments of planktonic foraminifers
																	0	2	
		2		4		2		18		5	7	18					87	51	c
																	c	r	a
																	r	r	va
												r					r	r	125
								3									3	2	
								1	3	9	4	12					68	43	c
						r						r					r	r	a
																	c	r	va
								2									2	0	
		15		5		1		12	3	5	1	7					55	118	r
												r					r	c	a
												r					r	r	a
								1									5	3	r
		15		4		2		17	5		16	21	3				296	72	va
				r		r						c					c	vr	va
												r					r		
		2															2	3	r
f		18				2		142	7		300						985	52	c
		r		r		4											f	r	va
																	vr	vr	va K
				1													56		
																	6		
		r						f	r		f	r			c		a	f	125
																	0	f	125
																	0	1	
																	0	147	r
																	0	r	fk
																	0	0	fK
	r																vr	r	
																	3	19	
c		21		152		8		9	25		60	80			r	r	1167	160	c
															c		c	r	va
																	r	r	va
		r		r					r		r	r			c	r	>500	f	200
8							1							1			18	10	
4	6		59	1		2					118	92		1	5		759	53	r
											r				f		a	r	a
																	r	r	vaK
																	0	5	
2			6		8	2					4	10		1			69	152	f
					2										6		11	41	a
																	vr	vr	a
																	0	0	0
																	1	vr	0
																	1	vr	500
																	0	0	0

Table 9. Distribution of foraminifers at Site 568.

Sub-bottom depth (m)	Sample (core-section, interval in cm)	Sieve mesh-size (μm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia praefoshi*		*G. peripheroacuta*		*G. peripheroronda*		*G. archeomenardii*		*G. praemenardii*		*G. acrostoma*		*G. mayeri*	*Globoquadrina dehiscens*	*G. altispira*	*G. quadraria advena*	*Orbulina suturalis*	*O. universa*	*Globigerinoides bisphericus*	*G. sacculifer*	*G. trilobus*	*G. obliquus*	*Zeaglobigerina* aff. *druryi*	*Globorotaloides hexagona*	Foraminifers: Planktonic	Foraminifers: Benthic	Fragments of planktonic foraminifers
					s	d	s	d	s	d	s	d	s	d	s	d	s														
	27-2, 132-136	O.S.	12.60																												
		500	0.042																										0	2	0
		200	0.071	T2/SB3 mudstone			10	2											7	48		3				3	1		84	35	5
		125	0.086				3													3					2				8	3	r
		50	0.661																										vr	vr	r
248.08	27-3, 117-119			Mudstone			r											r							r				r	r	500
	27-4, 36-38	O.S.	10.40																												
		500	0.024																										0	2	0
		200	0.033	Mudstone, harder layer than below	11														6	26	1			1	13				58	29	c
		125	0.060		10	1													1	4					7				23	5	a
		50	0.589																										vr	vr	r
	27-4, 38-40	O.S.	10.60																												
		500	0.030																										0	2	0
		200	0.050	T2/SB3 mudstone															5	26		1			2	22			66	24	c
		125	0.116				10												1	2								1	17	4	c
		50	0.447				13																						vr	vr	r
253.77	28-1, 36-38			T2 mudstone																									0	0	500
	28-2, 19-23	O.S.	13.95																												
		500	0.035																										0	4	
		200	0.089	T2 mudstone drilling biscuits			1	6														3			7				17	9	r
		125	0.095				1	3	3	1																			8	r	c
		50	0.645																										0	0	0
256.77	28-3, 36-38			T2 mudstone			r	r																					vr	vr	500
	28-4, 22-26	O.S.	16.80																												
		500	0.043																												
		200	0.058	T2 mudstone drilling biscuits															1										1	0	
		125	0.099																1										1	2	r
		50	0.094																										0	0	r

	28-5, 25-29	O.S.	14.50	T2 mudstone drilling biscuits																					
		500	0.021																						
		200	0.035												12	4					3		19	5	
		125	0.264		1	1	1	5							2						12		22	r	c
		50	1.219																						
261.27	28-6, 36-38			T2 mudstone		r								r		r		r					vr	vr	500
264.01	29-1, 90-92			T2 mudstone		r		r															vr	vr	500
	29-2, 136-140	O.S.	13.40	T2 mudstone below ash layer																					
		500	0.108																				0	0	
		200	0.189															2			1		3	1	
		125	0.419																		1		1	0	
		50	0.601																				0	0	
267.01	29-3, 90-92			Above ash layer			r	r						r			r		r				vr	vr	500
	29-4, 18-20	O.S.	11.30	T2 mudstone																					
		500	0.020																		1		1	0	
		200	0.359																		2		2	2	0
		125	1.073																				0	0	0
		50	1.451																				0	0	0
	29-5, 76-80	O.S.	20.20	T2 mudstone above ash layer																					
		500	0.108																				0	1	0
		200	1.160				5								104			201			203		513	r	0
		125	1.432				8	2			1	1			c			c			c		c	r	0
		50	2.180															r			r		vr	vr	0
271.48	29-6, 87-89			T2 mudstone			r										r		r				vr	vr	500
273.26	30-1, 65-67			T2 mudstone			r								r		r						vr	vr	500
	30-2, 97-103	O.S.	17.70	T2 mudstone																					
		500	0.060												2			2					4	1	0
		200	0.076				2	1							32	6					63		104	12	r
		125	0.193				16	3							f						c		f	c	c
		50	1.836												r								r	vr	r
276.26	30-3, 65-67			10° apparent dip			r	r													r		vr	vr	500
	30-4, 86-90	O.S.	15.90	T2 mudstone																					
		500	0.030												1								1	3	0
		200	0.135												8	5				1	2	1	17	15	0
		125	0.111				19	2	1	3	1	130	2										158	6	r
		50	0.669				r					r									1		1	0	r
279.26	30-5, 65-67			T2 mudstone																	1		1	0	0
	30-6, 90-93			T2 mudstone above ash																			0	0	0
282.45	31-1, 14-16			T2/CB4																			0	vr	0

Note: See Table 2 for an explanation of the symbols.

Table 10. Distribution of foraminifers at Site 568.

Sub-bottom depth (m)	Sample (core-section, interval in cm)	Sieve mesh-size (µm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia peripheroacuta*		*G. peripheroronda*		*G. praescitula*		*G. archeomenardii*		*G. praemenardii*		*G. mayeri*		*G. continuosa*		*Globoquadrina dehiscens*	*G. altispira*	*G. langhiana*	*G. quadraria*	*G. venezuelana*	*Catapsydrax unicavus*	*Orbulina suturalis*	*O. universa*	*Globigerinoides bisphericus*	*G. sacculifer irregularis*	*G. trilobus*	*G. altiaperturus*	*G. obliquus*	*G. subquadratus*	*G. bollii*	*Zeglobigerina druryi*	*Globorotaloides hexagona*	*Clavatorella bermudezi*	Foraminifers: Planktonic	Foraminifers: Benthic	Fragments of planktonic foraminifers
					s	d	s	d	s	d	s	d	s	d	s	d	s	d																					
292.29	32-1, 28–30			T2 mudstone								1														2			1								vr	vr	0
	32-2, 64–67	O.S.	15.50																																				
		500	0.019																																		0	4	0
		200	0.048	T2 mudstone			5	5											1	34		7								27	1			1	1	1	83	57	r
		125	0.085				r	r																						r							c	r	c
		50	0.285				vr	vr																													vr	vr	vr
295.39	32-3, 38–40																																				0	0	0
	32-4, 117–121	O.S.	15.00																																				
		500	0.030																																		0	0	0
		200	0.029	T2 mudstone															2																		2	5	r
		125	0.079				1	1				1																									3	vr	r
		50	0.455																																		vr	vr	vr
	32-5, 52–56	O.S.	12.85																																				
		500	0.005																																		0	1	r
		200	0.057	T2 mudstone			3	2			11	2	1	2						15		3			4	5					1			1		2	52	54	c
		125	0.054				16	5												f												r					r	vr	r
		50	0.318																	r																	vr	vr	vr
299.96	32-6, 45–47[a]			T2 mudstone																																	0	0	0
	33-2, 64–68	O.S.	16.60																																				
		500	0.068																																		0	4	0
		200	0.127	T2 mudstone																		1								3							4	22	0
		125	0.170																																		0	vr	0
		50	0.572																																		0	0	0
305.10	33-3, 49–51			Breccia																																	0	0	0
	33-4, 73–77	O.S.	12.00																																				
		500	0.042																																		0	1	0
		200	0.064	T2 mudstone			1													2		9			9												21	52	r
		125	0.119				1	1		1			3	1																							7	vr	vr
		50	0.332																																		0	vr	vr
	33-5, 23–27	O.S.	16.35																																				
		500	0.046																																		0	0	0
		200	0.075	T2 mudstone																2		5					1			3							11	35	0
		125	0.091				2	1							1	1																					5	vr	vr
		50	0.370																																		vr	vr	vr

309.93	33-6, 82–84			T2 scaley fabric mudstone																				r										r	r	0
312.51	34-1, 120–122																																	0	0	0
	34-2, 63–67	O.S.	13.80	T2 mudstone, drilling disturbance																																
		500	0.013																															0	0	
		200	0.095																	5	5				2	1		14		2				29	13	0
		125	0.056						3					1														2				1		7	vr	0
		50	0.177																															vr	vr	vr
315.51	34-3, 120–122			T2 mudstone																														0	0	0
	34-5, 22–26	O.S.	13.80	T2 mudstone, drilling biscuits																																
		500	0.036																															0	2	vr
		200	0.043							2			1	1	5	2			2	6	5					2		24		1		2	2	55	69	vr
		125	0.082		1		2	2	2		1		1		3	2																		14	r	c
		50	0.361																															0	0	0
	34-6, 70–74	O.S.	14.90	T2 mudstone, drilling biscuits																																
		500	0.005																															0	1	
		200	0.037												11				12	8						3		12						46	27	c
		125	0.055		1				2	2			1																					6	r	r
		50	0.247						r	r																								vr	vr	r
322.07	35-1, 86–88			T2 mudstone																														0	0	0
	35-2, 86–90	O.S.	13.70	T2 mudstone, drilling disturbance																																
		500	0.047																															0	5	
		200	0.089			3				1							1		4	24		11		1				11	3			2	1	63	184	c
		125	0.135						2	3										4												2		11	vr	f
		50	0.595																															0	0	c
325.07	35-3, 86–88			T2 mudstone			r		r	r		1						1		c														r	c	200
	35-4, 8–12	O.S.	14.25	T2 mudstone, drilling disturbance																																
		500	0.015																															0	3	
		200	0.052								8									8		1						7						24	59	
		125	0.108						1	1	3																							r	r	
		50	0.496																															0	0	
328.07	35-5, 86–88[b]			T2 mudstone																														0	0	0
	36-2, 123–126						r																					r						r	r	0
334.91	36-3, 90–92																																	0	0	0
	36-4, 47–51	O.S.	14.40	T2 mudstone, drilling disturbance																																
		500	0.002																															0	0	0
		200	0.065																									2						2	3	0
		125	0.120																															0	vr	0
		50	0.320																															0	0	0
	36-5, 31–35	O.S.	16.20	T2 mudstone, drilling disturbance																																
		500	0.031																															0	0	
		200	0.069				1								3	1			12						1		4		6					28	24	r
		125	0.101				5	4	4	4			1		8	1													5					32	31	c
		50	0.196																															vr	vr	vr

Note: See Table 2 for an explanation of the symbols.
[a] Also examined: 33-1, 47–49.
[b] Also examined: 35-6, 17–20; 36-1, 90–92

Table 11. Distribution of foraminifers at Site 568.

Sub-bottom depth (m)	Sample (core-section, interval in cm)	Sieve mesh-size (μm)	Weight (g) of O.S. and each sieve residue	Description	*Globorotalia kugleri* s	*Globorotalia kugleri* d	*G. peripheroronda* s	*G. peripheroronda* d	*G. praescitula* s	*G. praescitula* d	*G. mayeri* s	*G. mayeri* d	*G. continuosa* s	*G. continuosa* d	*G. nana*	*Globoquadrina dehiscens*
339.43	36-6, 92–94			T2 mudstone			r	r								
341.72	37-1, 101–103						r	r								
	37-2, 118–122	O.S.	20.00													
		500	0.005	T2 mudstone, drilling disturbance												
		200	0.074				5	4								12
		125	0.032				12	13	4	4	2					
		50	0.109													
344.72	37-3, 101–103			T2 mudstone												
	38-4, 124–128	O.S.	15.00													
		500	0.139	T2 mudstone, drilling disturbance												
		200	0.087								2	1				11
		125	0.159									1				3
		50	0.204													
	38-5, 98–102	O.S.	17.50													
		500	0.049	T2 mudstone, drilling disturbance												
		200	0.121				1									4
		125	0.070								1					
		50	0.314													
358.79	38-6, 108–110			T2 mudstone					r		r					
	39-1, 50–53	O.S.	16.90													
		500	0.582													
		200	0.106	T2 mudstone					r		14	1				a
		125	0.128								f	f				a
		50	0.442													c
365.04	39-4, 63–65			T2 mudstone			r		r							
370.83	40-1, 122–124											r				f
	40-2, 45–48	O.S.	13.60													
		500	0.540													
		200	0.253	T2 mudstone												a
		125	0.247				r				f	f				a
		50	0.479								f	f				
373.83	40-3, 122–124			Dip 35° T2 mudstone								f				
	40-4, 112–115		12.70													
			0.037													
			0.077	T2 mudstone												
			0.046								a	a				
			0.203								r	r				
	40-5, 70–74	O.S.	12.40													
		500	0.436													
		200	0.149	T2 mudstone				1			7	7	1	1		33
		125	0.119								f	f	f	f		r
		50	0.244								c	c	c	c		
380.57	41-1, 126–128			T2 mudstone								f				
	41-2, 136–140	O.S.	15.60													
		500	0.139	T2 mudstone, dip 60°												
		200	0.093								vr	vr				
		125	0.145					vr			vr	vr				
		50	0.563								vr	vr				
382.67	41-3, 36–38			T2 mudstone												f
	41-4, 80–84	O.S.	13.00													
		500	0.351													
		200	0.076	T2 mudstone												39
		125	0.077								r	r				
		50	0.449													
	41-5, 132–136	O.S.	6.90													
		500	0.062													
		200	0.053	T2 mudstone							1	1				15
		125	0.023								3	2				
		50	0.212								f	f				
387.37	41-6, 56–58			T2 mudstone, dip 70°												f
389.45	42-1, 44–46[a]															
	42-4, 91–95	O.S.	20.70													
		500	0.700	T2 mudstone, abundant burrowing, dip 70°												
		200	0.209													
		125	0.120													
		50	0.589													
	42-5, 26–28[b]															
	43-4, 101–104			Dip 70°,												
409.80	44-1, 139–141			T2 mudstone,							r	r				
	44-2, 89–93			bedding subvertical												
412.78	44-3, 137–139														r	
	44-4, 62–66	O.S.	15.80													
		500	0.065	Piece of apparent homogeneous mudstone												
		200	0.124								12	15			5	
		125	0.482		16	17					8	12				
		50	1.264													
414.45	44-5, 4–6			Bedding vertical												

Note: See Table 2 for an explanation of the symbols.
[a] Also examined 42-3, 53–55.
[b] Also examined 43-1, 49–51; 43-2, 75–80; 49-3, 49–51.

Table 11. (Continued).

G. altispira	G. globularis	G. rohri	G. gortanii	G. venezuelana	Catapsydrax unicavus	C. dissimilis	C. stainforthi	Orbulina suturalis	Globigerinoides subquadratus	G. bisphericus	G. sacculifer	G. trilobus	G. immaturus	G. altiaperturas	G. primordius	Globigerina praebulloides	G. ciperoensis	Cassigerinella sp.	Globigerinita uvula	Foraminifers: Planktonic	Foraminifers: Benthic	Fragments of planktonic foraminifers
r					1				r											vr	vr	vr
r									r											vr	vr	vr
																				0	2	
9								2	2			8								42	48	r
									2			3								40	12	r
																				vr	vr	r
																				0	r	500
																				0	0	0
2									3	1		9								29	23	r
																				4	vr	0
																				vr	vr	r
																				0	1	0
1												7								13	12	0
																				1	3	0
																				vr	vr	0
				r								r			r					vr	r	500
																				0	14	
					2										a					>1000	c	r
					r										a					a	a	r
																				c	c	r
																				r	r	
										r		r								f	r	
																				0	2	
c										r		a		r						a	r	
r							r					a								a	r	c
												r								f	r	f
													f		r	c				f	r	
																				0	0	
												2								2	6	
							r													a	r	
																				r	r	
																				0	0	
2					5					5	1	62								125	9	vr
												r								f	r	r
																				c	r	r
										r		f						f		f	r	
																				0	16	
r	r		r							r	r		c		a					a	f	r
r															c		r			c	r	r
																				vr	vr	
r															c					f	r	
																				0	12	
2			6			1			1	3	2	12	5	53	1					125	59	r
												r	r	c			r		f	f	r	r
												r						r		r	r	r
																				0	0	
		2				2				2		32			6					61	3	
								1												c	r	a
																		r		f	r	r
																	f	f	f	f	r	0
																				0	0	
																				0	0	0
																				0	0	0
													1							1	0	0
																				0	0	0
																				0	0	0
															2					2	c	0
																				vr	vr	0
															r	r				vr	vr	0
						2														vr	vr	0
																				0	0	0
															34	12				78	4	0
						2														55	2	0
																				c	r	r
																				0	0	0

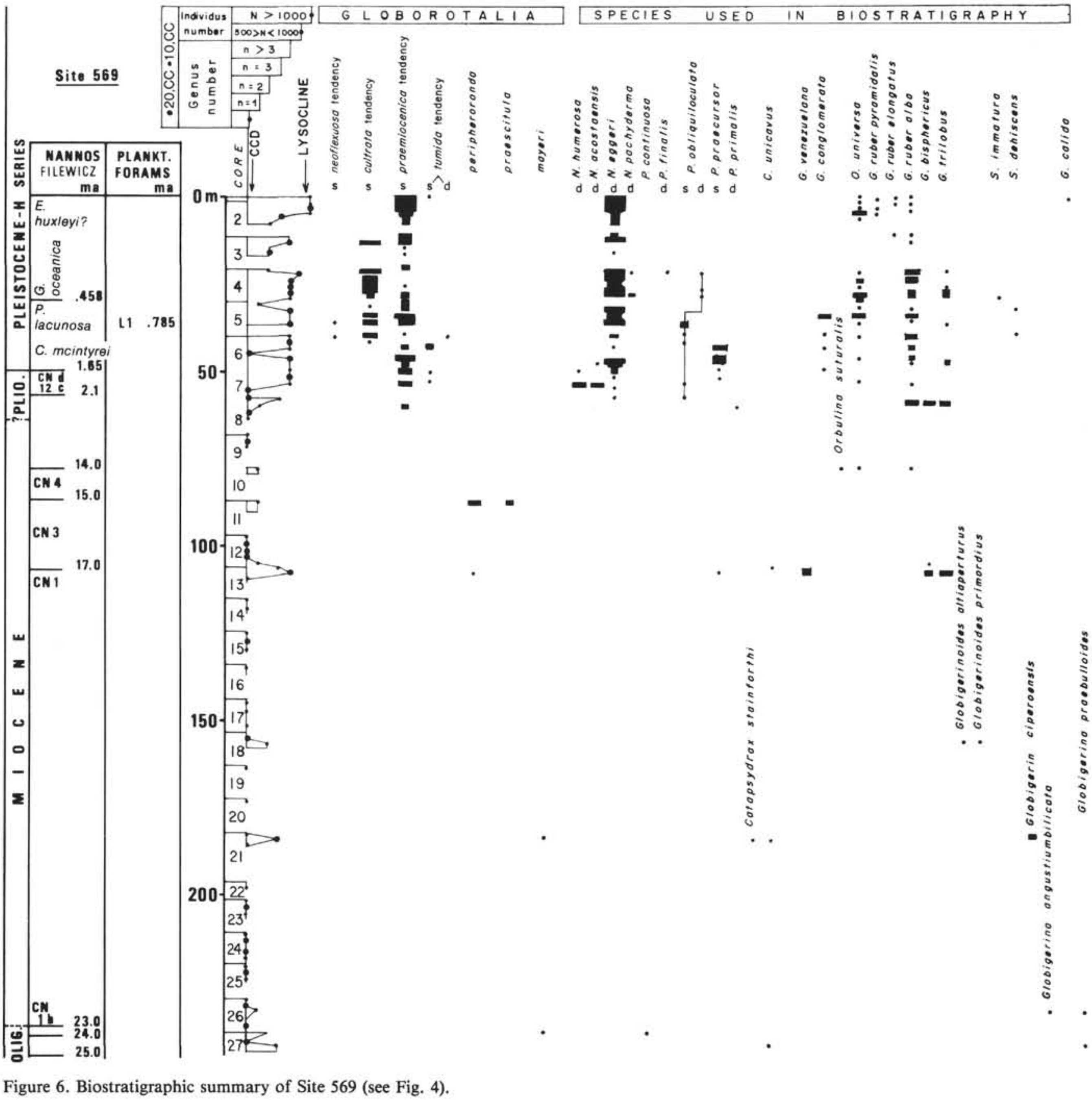

Figure 6. Biostratigraphic summary of Site 569 (see Fig. 4).

globorotaliids co-occur and change their coiling mode from dextral to sinistral at different levels: the "flat" *G. tumida* become sinistral in Sample 565-26-2, 138–141 cm, whereas *G. praemiocenica* and *G.* aff. *pertenuis-multicamerata* change simultaneously from left to right just above a level with strong dissolution in Sample 565-18-2, 120–130 cm. The level of disappearance of the *G.* aff. *pertenuis* group is in Core 565-16, and that of the "flat" *G. tumida* and *G. flexuosa* in Core 565-7.

Summary of Biostratigraphic Results

Planktonic foraminiferal biostratigraphic events are in good agreement with the nannofossil biozonation given by Filewicz (this volume). Peaks of the coiling curves of *Pulleniatina* are good correlative tools, provided they are calibrated to another stratigraphic scale. We used here the nannofossil zonation for comparison (Fig. 8). Left-coiling peaks of *Pulleniatina* (see Figs. 2–8) allow correlations to be made between the various sites. They are identified as follows:

During the Pleistocene: L_1 (0.758 Ma) at Site 570 (570-5-2, 85–90 cm, Site 568 (568-10-1, 53–55 cm), and Site 569 (upper part of Core 569-5); L_2 (0.97 Ma) at Site 570 (570-6-4, 43–46 cm); L_3 (between 0.97 and 1.66 Ma, following Hays et al. [1969], but here, taking in account the nannofossil zonation, the age should be between

Table 12. Distribution of foraminifers at Site 569.

Sub-bottom depth (m)	Sample (core-section, interval in cm)	Description	Globorotalia neoflexuosa	G. cultrata tendency	G. cultrata tendency	G. praemiocenica tendency	G. praemiocenica tendency	G. tumida tendency	G. tumida tendency	G. scituliforms	G. scituliforms	G. peripheroronda	G. praescitula	G. mayeri	Globoquadrina humerosa	G. acostaensis	G. eggeri	G. blowi	G. pachyderma	G. continuosa	Pulleniatina finalis	P. obliquiloculata	P. obliquiloculata	P. praecursor	P. primalis	Catapsydrax stainforthi	C. unicavus	Globoquadrina venezuelana	G. conglomerata	Globorotaloides hexagona	Orbulina suturalis	O. universa	Globigerinoides tenellus	G. ruber pyramidalis	G. ruber elongatus	G. ruber alba	G. trilobus	G. bisphericus	G. sacculifer	G. quadrilobatus	G. altiaperturus	G. primordius	Sphaeroidinella immatura	S. dehiscens	Globigerina praebulloides	G. rubescens	G. ciperoensis	G. angustiumbilicata	Globigerinella calida	G. aequilateralis	Globigerinita glutinata	G. quinqueloba	Planktonic (number of individuals in 20 cm of sediment)	Fragments of planktonic foraminifers
			s	s	d	s	d	s	d	s	d				d	d	d	d	d		d	s	d	s	d																													
0.27	1-1, 26-28	T2 mud				a		r			r						a	f												r		r		r	r	r			r	r									r		r	r	>1000	
1.91	2-1, 70-72	T2/SB3 mud				a											a	r												r		r			r	r				r											r	r	>1000	
	2-2, 72-76					a											a	r												r		r		r		r				r													>1000	a 200
4.91	2-3, 70-72					a											c	r												r		f	r	r		r			r	r													>1000	c 200
	2-4, 70-74					f											c	r														r																					<500	c 200
7.91	2-5, 70-72					c											r	r																																			<500	a 125
11.45	3-1, 34-37					f											c	r												r					r	r				r													<500	a 125
	3-2, 46-50			a		f											c	r																		r			r	r													<500	a 125
14.45	3-3, 34-37					r												r																																			<500	a 125
	3-4, 50-54					r											r																																				<500	a 125
21.01	4-1, 40-42	T2/SB1 mud				c											a																																				<500	a 125
	4-2, 90-94			a						r							a				r		r									r				f	r			r											r		<1000	a 125
24.01	4-3, 40-42			f													a	c	r											r		c				f																	<500	c 200
	4-4, 110-114			f		r				c							f	r														r					r																<500	a 125
	4-5, 73-77			f		c				c							a	c					r									f				c	c		r														<500	a 125
28.51	4-6, 40-42			c						f							a	c	c				r							r		c				c																	<500	f 200
30.41	5-1, 10-12					c																																															<500	a 200
	5-2, 120-124			r		c											a															r				r	r							r									<500	a 125
33.41	5-3, 10-12			f		a											f												f	r		f				f			r	c										r	r	r	<500	f 200
	5-4, 18-22		r	f		r											a					c										r				r																	<500	f 200
40.60	6-1, 59-61		r	f		a											c					r							r			r				f								r									<500	f 200
	6-2, 6-10			r		r			r													r																	r														<500	f 200
43.60	6-3, 59-61					c		c									r							f					r							c			r	c						r							<500	a 200
	6-4, 80-84	CCD																																																				0	0
	6-5, 40-44					c											a							f												c	c			r													<500	a 125
48.10	6-6, 59-61					c										r	f	r						f												r				r													<500	f 200
50.01	7-1, 30-32					f									r		c	r						r					r																								<500	f 200
	7-2, 70-74					r		r									r							r																													<500	a 125
53.01	7-3, 30-32					f		r							f	f						r										r				r			r	r											r		<500	a 125
	7-4, 88-92																																																					0	0
	7-5, 90-94																																																					0	0
57.51	7-6, 30-32					r											r					r																															<500	0
59.19	8-1, 29-30					c																			f											f	f	f														<500	0
	8-2, 110-114[a]																																																					0	0
78.31	10-1, 40-42																															r	r				r																	<500	0
87.81	11-1, 40-42												f	c																																								<500	0
97.51	12-1, 40-42[b]																																																					0	0
105.01	12-6, 40-42																												r																								<500	0
107.06	13-1, 35-37																											r	c									r														<500	0
	13-2, 40-42												r											r				c								f	c														<500	0
110.06	13-3, 35-37[c]																																																					0	0
		30° dip																																																					
154.72	18-1, 31-33																																																					0	0
157.72	18-3, 31-33																																									r	r											<500	0
164.36	19-1, 25-27[d]																																																					0	0
	21-2, 63-67	Below ash													r												r																			r		c						<500	0
	21-2, 127-131																																															r						<500	0
186.64	21-3, 23-25[e]																																																					0	0
234.59	26-3, 18-20	T2 mudstone																																												r								<500	0
	26-4, 103-107[f]																																																					<500	0
241.37	27-1, 36-38														r						r																																	<500	0
	27-2, 120-124																																																					0	0
244.37	27-3, 36-38	T2 mudstone																										r																		r								0	0

Note: See Table 2 for an explanation of the symbols.
[a] Also examined: 8-3, 28-30; 9-1, 30-32; 9-2, 115-119.
[b] Also examined: 12-2, 14-18, 12-3, 40-42, 12-4, 14-18; 12-5, 125-129.
[c] Also examined: 14-1, 35-37; 14-3, 35-37; 15-1, 84-86; 15-2, 67-70; 15-3, 84-86; 16-1, 46-50; 16-1, 86-88; 17-1, 53-55; 17-6, 53-55; 18-2, 50-54.
[d] Also examined: 20-1, 84-86; 21-8, 45-57.
[e] Also examined: 22-1, 139-141; 23-1, 22-24; 23-2, 28-32; 23-3, 29-31; 24-2, 72-74; 24-2, 19-23, 24-5, 32-36, 24-6, 13-15; 25-1, 14-16; 25-2, 56-60; 25-3, 14-16; 26-1, 10-12; 26-2, 14-18; 26-2, 49-53.
[f] Also examined: 26-5, 56-60.

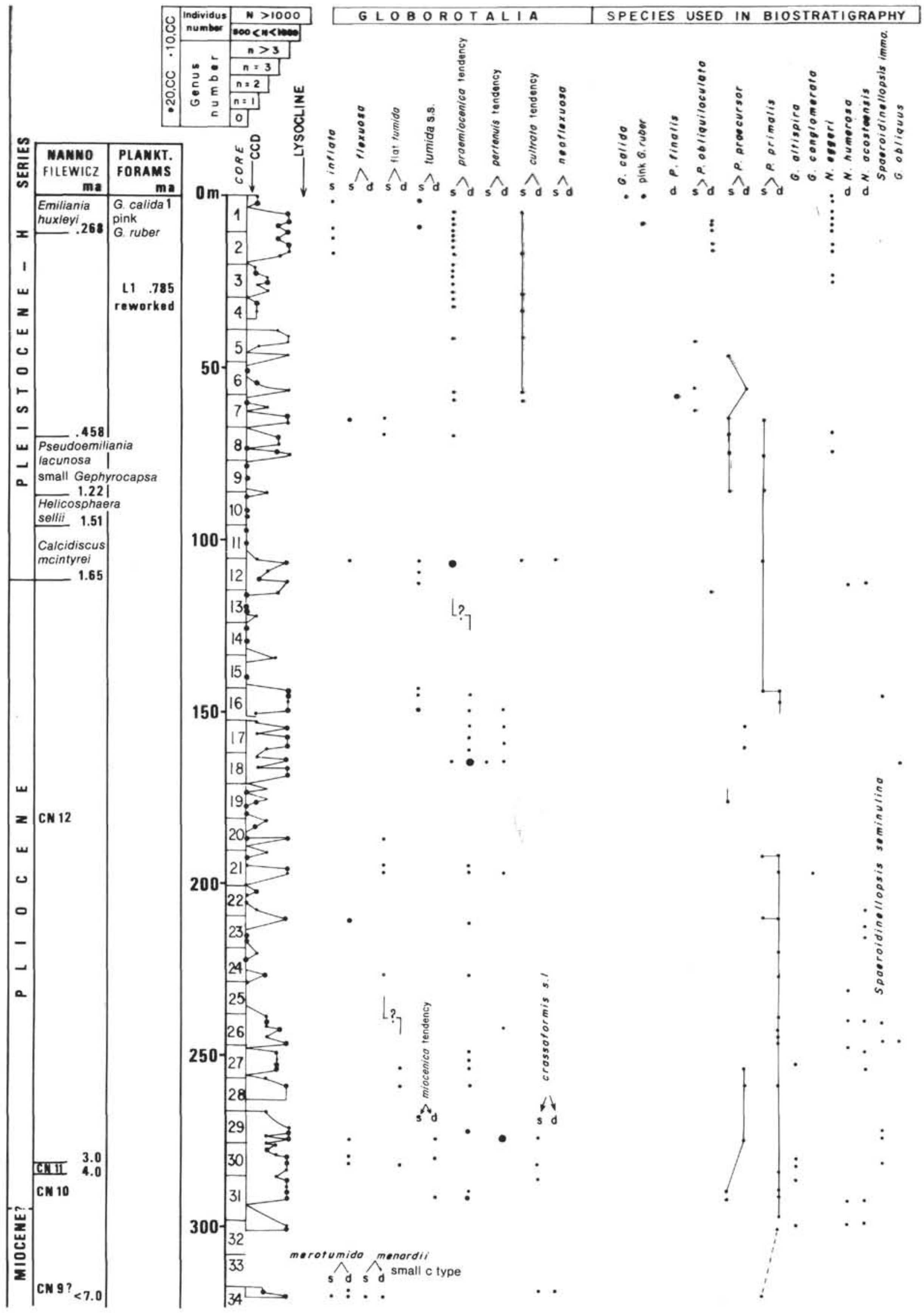

Figure 7. Biostratigraphic summary of Site 565 (see Fig. 4).

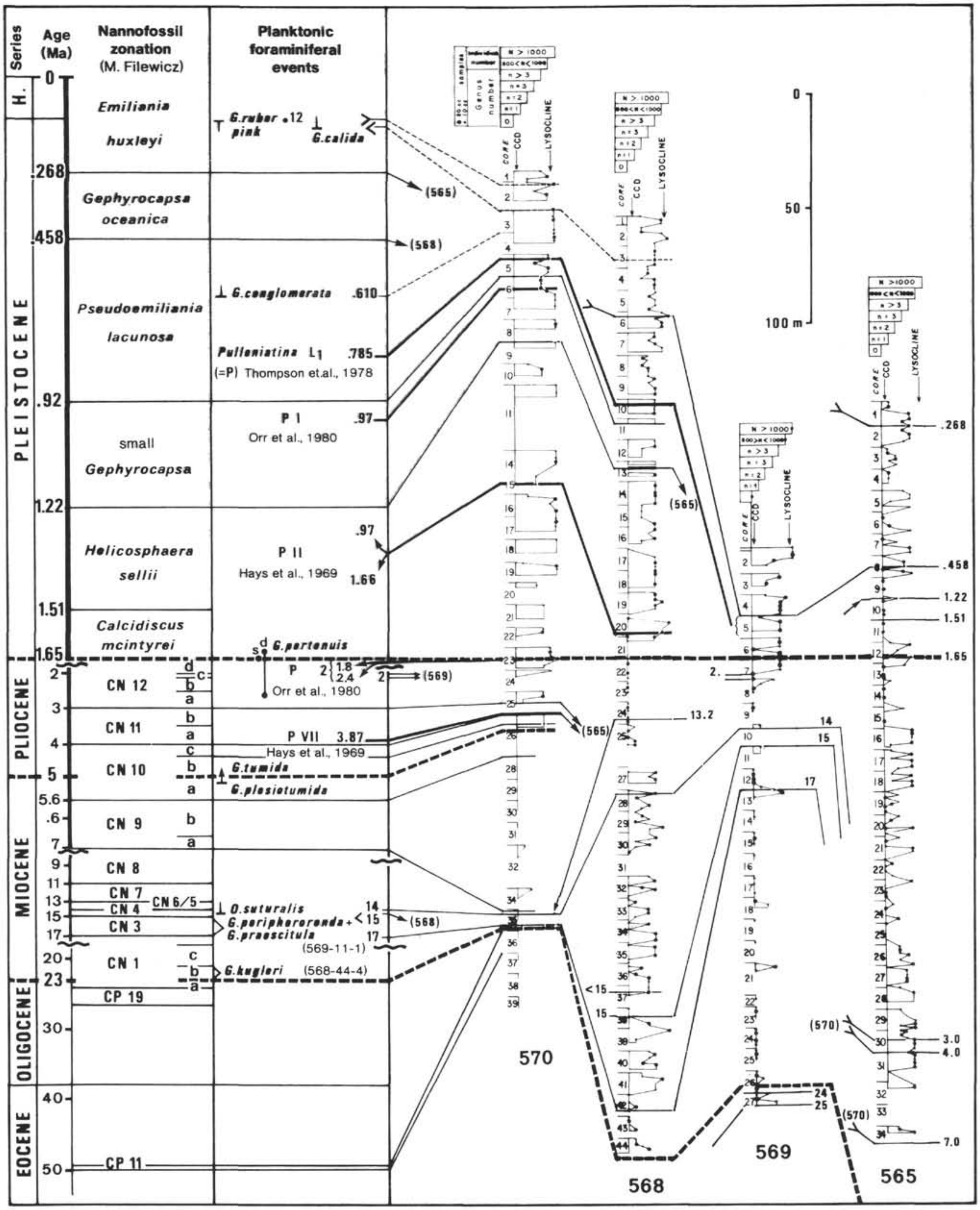

Figure 8. Biostratigraphic correlations of Sites 570, 568, 569, and 565. In the planktonic foraminiferal events column, PI, PII, and PVII, and P2 refer to *Pulleniatina* coiling changes (see Fig. 2 for references).

1.22 and 1.65 Ma) at Site 570 (570-15-2, 55-56 cm) and Site 568 (568-20-3, 75-77 cm).

The coiling change in both *Pulleniatina primalis*, and *P. obliquiloculata* dated between 1.87 and 2.47 Ma at Site 570 (570-23-4, 66-70 cm) supports the position of the Pliocene/Pleistocene boundary between Sections 570-23-4 and 570-23-6, on the basis of nannofossil data (Filewicz, this volume). The coiling change of *Pulleniatina primalis* just above the Gilbert "a" event (3.87 Ma) is at Site 570 between Cores 570-26-1 and 570-25-3.

In the Miocene only the first appearance of two *Fohsella* species can be used at Site 568: *F. peripheroacuta* Fa in Core 568-29 (about 15 Ma) and *F. praefohsi* FA in Core 568-27 (about 14 Ma).

The biostratigraphic correlations (Fig. 8) show how the sedimentation rate varies from site to site. In order to evaluate better gaps in the record, we made a graphic representation (Fig. 9) of the sedimentation rates and of planktonic shell preservation at all sites. In Figure 9 the Leg 84 sites are positioned according to their water depths. From an examination of this figure it can be seen that it is not possible to obtain from these poor sequences a complete record of *Globorotalia* phyletic history except for the Pleistocene. The presence of preserved species and morphotypes of the *Globorotalia* group in these sections, however, provides useful information on their geographic distribution.

GLOBOROTALIA REMAINS FROM LEG 84

A number of steps in *Globorotalia* phyletic history are documented in our samples, but because of stratigraphic gaps and strong dissolution (Figs. 4-7), a detailed phyletic study is not possible.

Species of the *Fohsella* and the *G. menardii* lineages are well represented at Site 568 in the lower and middle Miocene (Plate 1, Figs. 16-20). After a gap, equivalent to about 7 Ma, *G. merotumida* is found in association with forms of the *G. menardii* plexus in the upper Miocene at Sites 565 and 570. A second gap of information precludes the identification of the evolutionary appearance of *G. plesiotumida*. This species occurred only at Site 570 about 4.4 Ma.

Pliocene *Globorotalia* are preserved at Site 565 (Plate 2), but their stratigraphic ordering is probably disturbed. Coiling changes occurred first in the "flat" *G. tumida* at about 2.7 Ma, followed shortly by a change in the *G. praemiocenica* and the *G.* aff. *pertenuis multicamerata* forms at about 2 Ma. From dextral all those forms become sinistral. Malmgren et al. (1983) described the evolution of *G. tumida* on the Ninetyeast Ridge in the southern Indian Ocean using eigenshape analysis. They give a listing of the various coiling changes of that species: dextral forms occur at 3.8, 5.3, and between 6.4 and 10.4 Ma. The dextral "flat" *G. tumida* seen in core 565-30 are from the middle Pliocene and fit well with the datum of 3.8 Ma given by Malmgrem et al. (1983). But in Cores 565-28 and 565-27, *G. tumida* are still dextral and probably reworked. At Site 570, randomly coiled *G. tumida*, dated 3.87 Ma, occur in Core 570-26, which shows that this core is stratigraphically slightly lower than Core 30 at Site 565, in agreement with the nannofossil zonation. According to Filewicz (this volume), Core 570-26 dates from CN10 and Core 565-30 is from CN11.

At Site 570 globorotaliids showing an affinity with *G. pertenuis* occurred in an interval between approximately 3 and 3.87 Ma. This occurrence may support the suggestion that the Panama isthmus was still open at that time (Keigwin, 1982c). The identification of *G. pertenuis*, however, presents some ambiguities. Our own observations on living globorotaliid populations in an upwelling area in the Arabic Sea (8°21′5N, 75°58′E, during a cruise on the *Marion Dufresne*, 1977) show homeomorphs from both *G. pertenuis* and "flat" *G. tumida* with a weak *flexuosa* tendency. In a sediment trap located in the East Equatorial Pacific, in the loop of the North Equatorial Counter Current (12°50′N, 103°58′W) at 2560 m water depth, we collected a globorotaliid assemblage with a large variety of morphotypes. Some of those show many common characters with the Pliocene *G. pertenuis*. We believe therefore that in a particular environment, chiefly perhaps in an upwelling area, the globorotaliids are able to develop variable morphologies. Unfortunately, no sample of living planktonic assemblages from this area of study was available to us for comparison.

Quaternary globorotaliids from leg 84 (Plates 3 and 4) show cyclical changes in morphologies. Two basic morphotypes with opposite tendencies can be distinguished (Plate 4): the *cultrata* group and the *tumida* group with many intermediate forms resembling members of the *G. limbata-G. praemiocenica* lineage. We use here the names *cultrata* and *tumida* according to their etymological meanings of edged (*tonsorus culter* = razor) and swollen (*uva tumida*, like a grape) and not as species names, as we do not know how many species are distinguishable in the group. In the sedimentary record available here (incomplete because of dissolution), we found a *tumida plexus* with a flattening tendency at various levels. We do not know if these tendencies are the result of a run-over of invaders of different morphologies or if globorotaliids are able to change their morphology as (in a crude comparison) oysters do. We believe that it is useful to identify these morphological changes to see if they are of biostratigraphic or ecological value. Therefore in Figures 4 to 7 we distinguished the main morphological tendencies recognized at every level. Comparing the sites it can be seen that true *G. tumida* occur only in the lower Pleistocene, then disappear to reappear in the upper Quaternary. Dissolution is not the cause of the disappearance, because in many levels barren of *G. tumida, G. cultrata* are preserved. Often *G.* aff. *praemiocenica* replace *G. cultrata*. Some "fimbriate" forms occur at Site 570 and 568 slightly below and slightly above the *Pulleniatina* L_1 datum (0.785 Ma).

We need the results of an integrated biostratigraphy for careful selection of levels to compare from site to site and we also need to know the distribution of living morphotypes in the various water masses in the studied area to check our hypothesis: a better knowledge of the morphological variations in the globorotaliids should permit

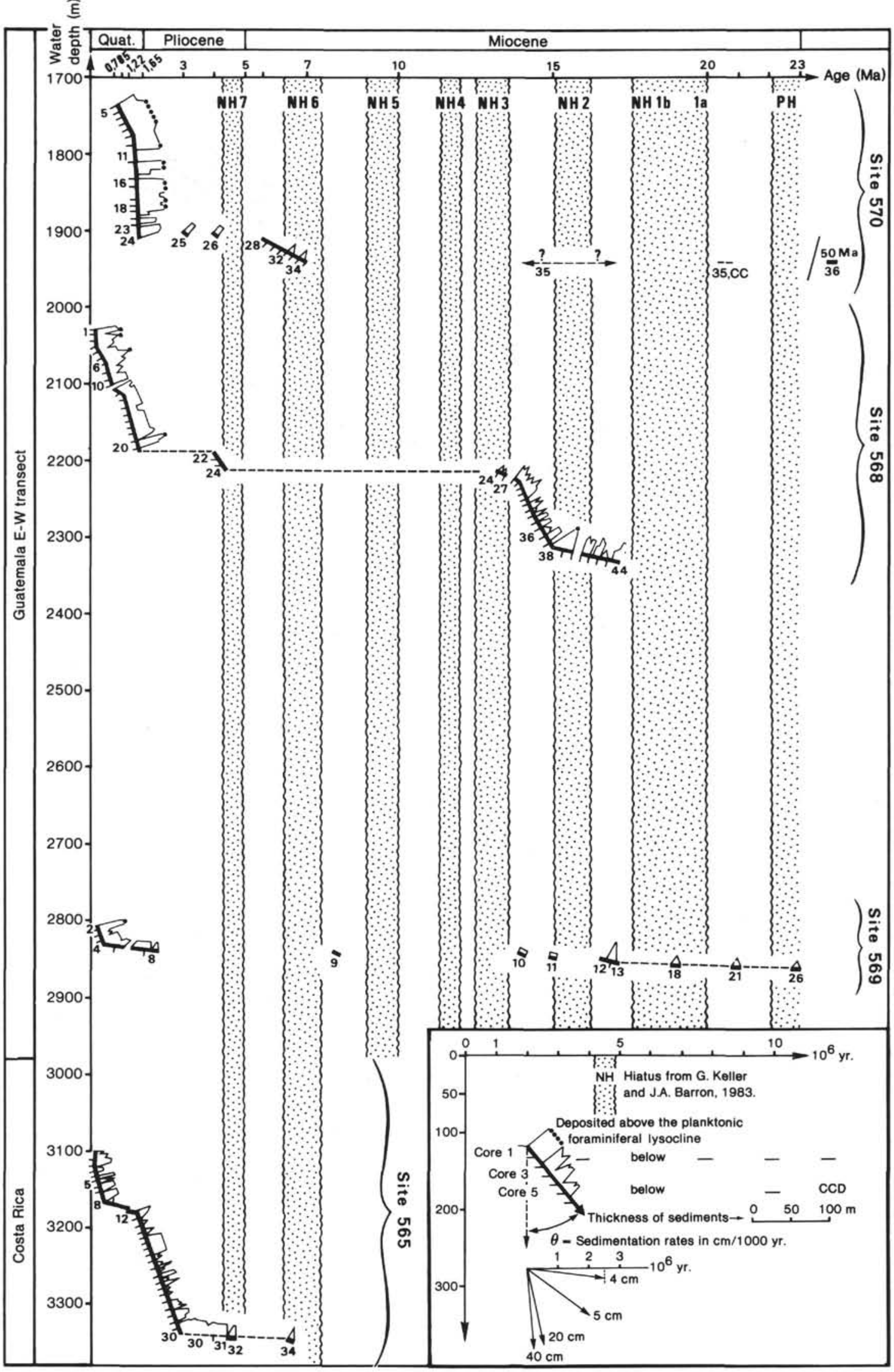

Figure 9. Sedimentation rates and intensity of dissolution at Sites 570, 568, 569, and 565.

detailed biostratigraphic correlations and an understanding of the evolution of the water masses and oceanic circulation with time (Romine, 1983).

ADDENDUM

The phylogenetic atlas by J. P. Kennett and M. S. Srinivasan (1983), *Neogene Planktonic Foraminifera*, became available to us after we had finalized this chapter. In many instances the taxonomy used in this paper is in agreement with that of Kennett and Srinivasan, however, the following comments are relevant to this study.

Following Bolli and Saunders (1982), in this chapter we grouped together *G. siakensis* and *G. mayeri*. However, forms with radial sutures at the spiral and umbilical faces can be distinguished (as *siakensis*) from the true *mayeri*, with curved sutures at the spiral face. For example, the specimen illustrated in Plate 1, Figures 7–9 appears as an intermediate form between *P. semivera* and *P. siakensis* sensu Kennett and Srinivasan.

We did not find in Kennett and Srinivasan (1983) a figuration of Pleistocene *Globorotalia* showing a *praemiocenica* "tendency" nor a Pliocene "flat" *tumida*.

Kennett and Srinivasan use *Menardella menardii* as a form ranging from the Miocene to the Recent. However, as discussed in this study, we can distinguish steps in the morphological evolution of this form. There is a tendency for the spiral to increase more quickly and the umbilica area to open. That can be seen when we compared the diameters of the last and penultimate whorl in spiral view. If we are able to distinguish *G. limbata* we would like to give a special name to the Quaternary *Menardella: cultrata* seems appropriate.

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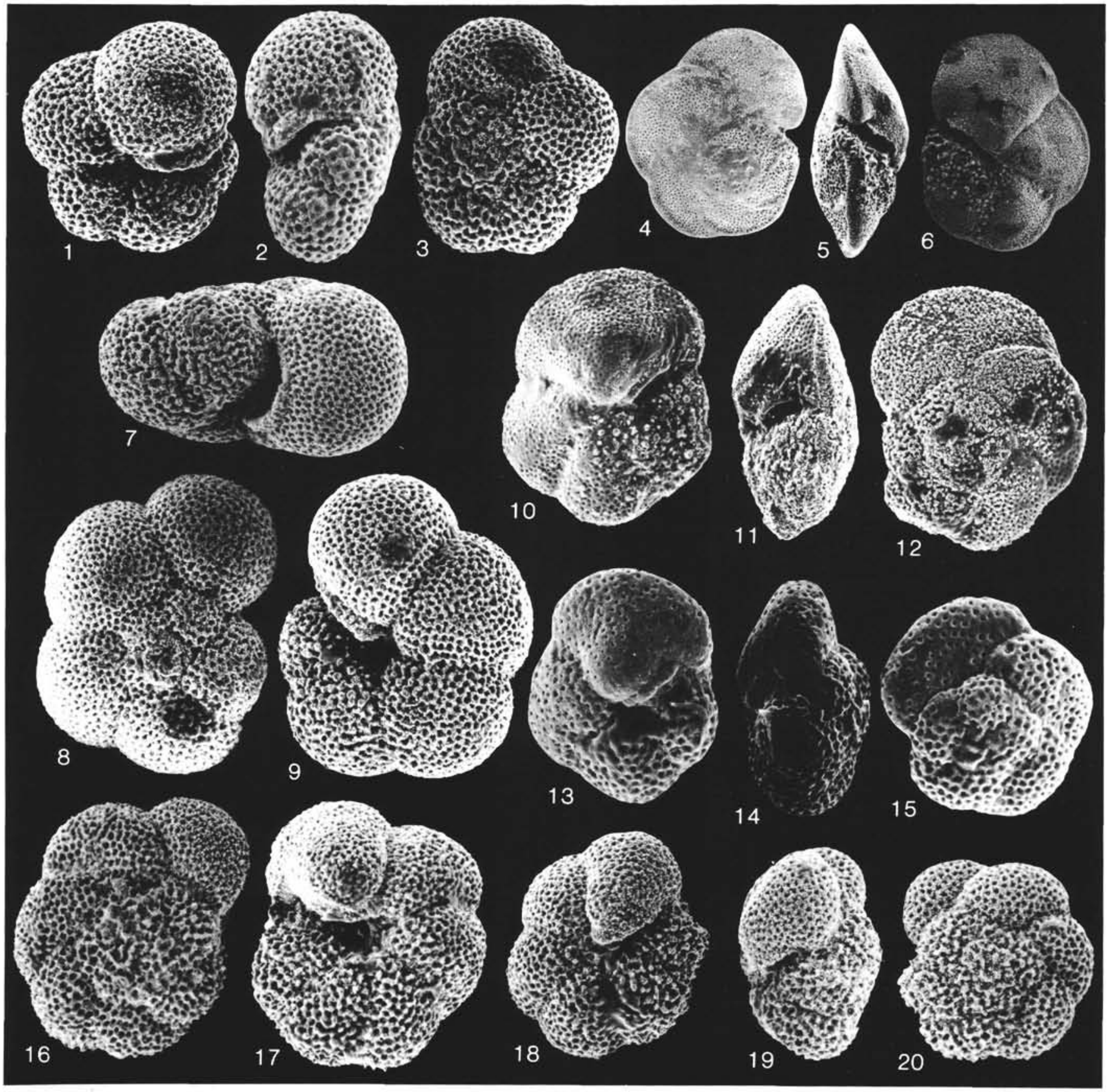

Plate 1. Globorotaliids of the early Miocene at Site 568. **1-3.** *Paragloborotalia nana* (Bolli)-*Neogloboquadrina continuosa* (Blow) intermediate. Sample 568-44-4, 62-66 cm, × 190. **4-6.** *Globorotalia praemenardii* Cushman and Stainforth. Sample 568-32-1, 28-30 cm, × 125. **7-9.** *Paragloborotalia mayeri* Cushman and Ellisor emend. Bolli and Saunders (1982). Sample 568-44-4, 62-66 cm, × 190. **10-12.** *Globorotalia praescitula* Blow. Sample 568-36-1, 90-92 cm, × 190. **13-15.** Sinistral coiled "A"-type chambered primitive *Globorotalia praescitula* Blow. Sample 568-38-6, 108-110 cm, × 300. **16-17** and **18-20.** Dextral and sinistral coiled *Fohsella kugleri* (Bolli). Sample 568-44-4, 62-66 cm, × 190.

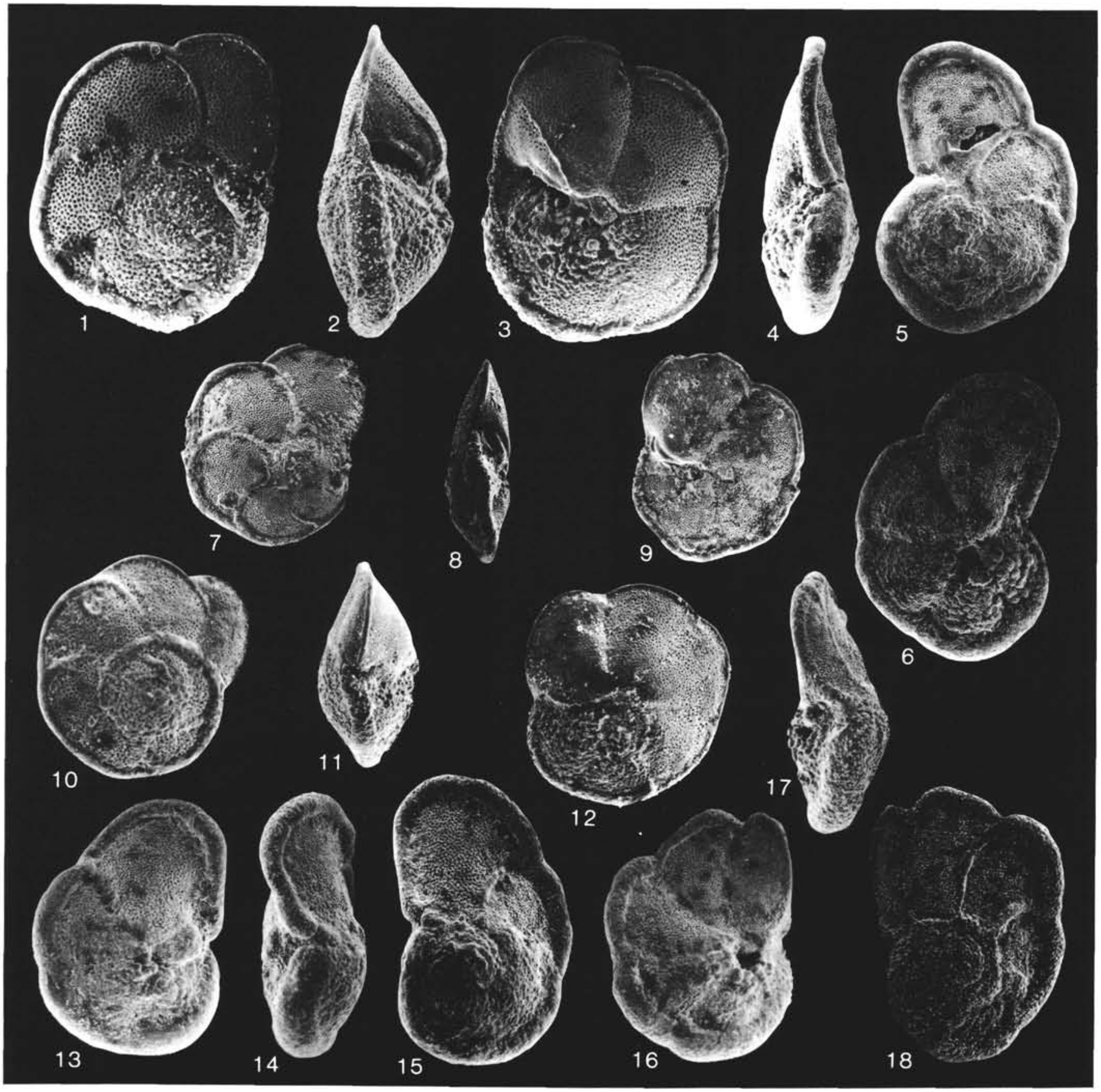

Plate 2. Globorotaliids of the early Pliocene at Site 565. **1–3.** Dextral "*G. miocenica*" tendency. Sample 565-31-4, 88–91 cm, ×125. **4–6.** Sinistral "flat *G. tumida*," Sample 565-31-3, 73–75 cm, ×60. **7–9.** Dextral *G. limbata* (Fornasini). Sample 565-31-3, 73–75 cm, ×60. **10–12.** Dextral *G. praemiocenica* Lamb and Beard. Sample 565-33-2, 16–20 cm, ×90. **13–15.** Intermediate between "flat *G. tumida*" and *G. flexuosa* (Koch). Sample 565-33-2, 16–20 cm, ×90. **16–18.** Sinistral *G. flexuosa* (Koch). Sample 565-33-2, 16–20 cm, ×60.

Plate 3. Quaternary *Globorotalia*. **1-3.** *G. tumida* (Brady). Sample 569-1-1, 26–28 cm, ×60. **4-6, 7-9, 10-12,** and **13-15.** Four specimens showing the "*G. praemiocenica*" tendency in the *G. tumida* plexus. (4-6 and 10-12) Sample 568-14-1, 15–17 cm, ×60; (7-9) Sample 569-1-1, 26–28 cm, ×90; (13-15) Sample 570-14-1, 14–16 cm, ×60. **16, 17.** The "fimbriate" tendency in Sample 568-6-1, 28–29 cm, ×60.

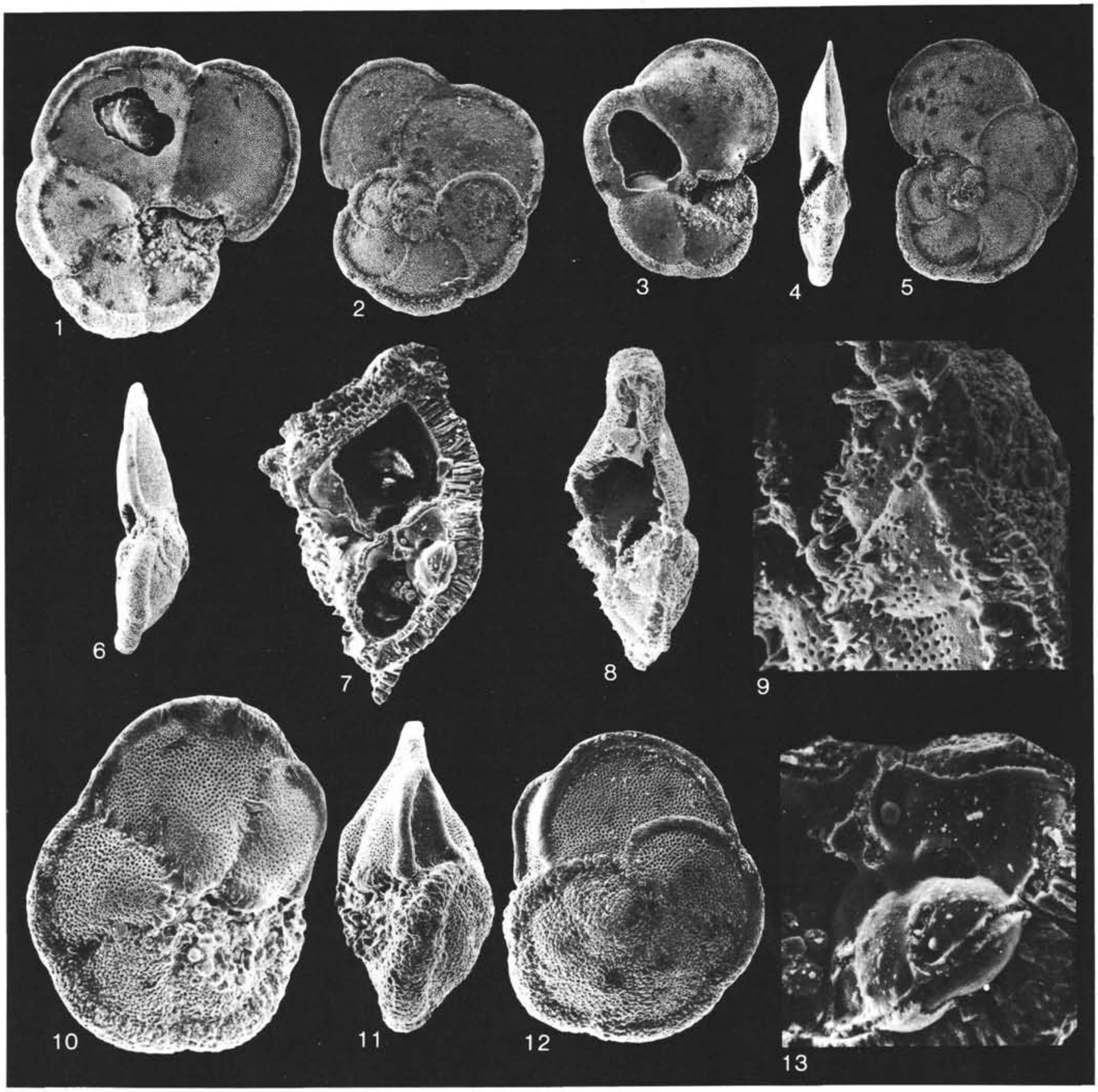

Plate 4. Some *Globorotalia* of the late Quaternary from Sample 568-1-1, 50–52 cm. **1, 2,** and **6; 3–5,** and **8–9.** Two specimens illustrating the "*G. cultrata*" tendency, (1, 2, 6) sinistrally coiled specimen, ×45, (3–5, 8–9) sinistrally coiled very flat biconvex specimen, ×42, (8–9) the same specimen with the three last chambers removed to show the imperforated band along the keel on the umbilical face of the chambers of the penultimate whorl, (8) ×125, (9) ×420. **7, 10–13.** Illustration of the "*G. tumida*" tendency: 1a–12a sinistral specimen, (10–12) ×90, (7, 13) an approximately axial section of the same specimen, which allows us to compare the wall of the last whorl with that of Figure 8 and to study the imperforate juvenile stage, (7) ×190, (13) ×600.