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15. EOCENE THROUGH PLEISTOCENE PLANKTONIC FORAMINIFERS OFF PERU, LEG 112—BIOSTRATIGRAPHY AND PALEOCEANOGRAPHY[1]

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ABSTRACT

Planktonic foraminifers were studied from 213 samples collected during Leg 112 at 10 sites located on the continental shelf and slope off Peru. Because planktonic foraminifers occur discontinuously downcore, detailed biostratigraphic zonation was not defined. However, it was possible to distinguish early and middle Eocene, early and late Miocene, Pliocene, and Pleistocene sediments on the basis of the planktonic foraminifers. The oldest sediments of Zone P6 of early Eocene age were obtained from the basal part of Hole 688E, which was penetrated to 779.0 m below seafloor (bsf). A biosiliceous facies of the area predominates above the N6-N7 zonal interval of early Miocene age.

All sites are within the present coastal upwelling area off Peru, and many of the late Pliocene and Pleistocene assemblages are similar to those that are characteristic of modern upwelling areas. The core samples differ, however, by having a predominance of cold-water elements, such as *Neogloboquadrina incompta* and *N. pachyderma*. Warm-water species are prevalent at some horizons in the cores, suggesting shifts of the coastal upwelling centers or warmer climatic events.

INTRODUCTION

From October to December 1986, 24 holes were drilled at 10 sites (Sites 679 through 688) on the continental shelf and slope off Peru during Leg 112 (Fig. 1, Table 1). Planktonic foraminifers were obtained from 213 samples of the total 665 examined.

In this study, biostratigraphic analyses of these planktonic foraminifers are presented. Detailed biostratigraphic zonation is difficult because of the discontinuous occurrence of planktonic foraminifers downcore. However, sediments of early and middle Eocene, early and late Miocene, Pliocene and Pleistocene are recognized and assigned to the P and N zones of Blow (1969). As all the sites are located within the present coastal upwelling area off Peru, the planktonic foraminiferal assemblages in the cores can be compared with those that characterize the present-day coastal upwelling waters.

Many of the late Pliocene and Pleistocene samples from the Leg 112 cores are rich in *Globigerina bulloides*, *Neogloboquadrina dutertrei*, *N. incompta* and *N. pachyderma*; the occurrence of *Globigerina quinqueloba* is sporadic, but abundant in some horizons; *Globigerinoides ruber*, *Globorotalia inflata*, and *G. menardii* are rare. These assemblages largely resemble those of the modern upwelling area off Peru, but differ from those of today by having a predominance of cold-water elements, such as *N. incompta* and *N. pachyderma*. Paleoceanographic interpretation of planktonic foraminiferal assemblages is attempted with special reference to those of the present coastal upwelling system off Peru.

METHODS

The planktonic foraminiferal biostratigraphy presented here is based on my shipboard examination of all core-catcher samples and subsequent onshore examination of additional samples from a mid-horizon of each core.

Samples of approximately 10 cm^3 were washed through a 250-mesh screen (0.062 mm) and oven dried. Planktonic foraminifers greater than 0.125 mm were selected from the washed residue, and the frequency of occurrence of each species was calculated. Quantitative analyses of species abundance are shown in Tables 2 through 11: A = abundant, greater than 10% of the total assemblage; C = common, 3% to 10%; F = few, 0.5% to 3%; R = rare, less than 0.5%; T = trace, one or two specimens in entire assemblage; and B = barren.

Sample identifiers used in Tables 2 through 11 contain the following information: (1) Leg, (2) Site, (3) Hole, (4) Core Number and Type, (5) Section, and (6) Interval in centimeters. For example, the sample identification number "112-686A-2H-3, 40–42 cm," indicates that a sample was taken between 40 and 42 cm from the top of Section 3 of APC-drilled Core 2, from the first hole (A) drilled at Site 686 during Leg 112. A sample taken from the core catcher of this core is designated "112-686A-2H-CC." The foraminiferal zonation of Blow (1969) is used here, and chronologic calibrations of Blow's zones are mainly based on those given by Berggren et al. (1985).

PLANKTONIC FORAMINIFERS FROM SITES 679 THROUGH 688

Biostratigraphy

Because of the discontinuous occurrence downcore of planktonic foraminifers, a successive biostratigraphic zonation was not possible; however, some planktonic foraminiferal zones were distinguished (Fig. 2). Holes 679 and 680 are not described because of the paucity of planktonic foraminifers, although the basal part of Hole 679E is assignable to Zones N13 through N16 of middle Miocene age. Most of the sequences recovered from Holes 681A, 681B, 686A, 686B, 687A, and 687B are assignable to Zones N22 and N23 of late Pliocene to Pleistocene age. The beginning of the Pleistocene at 1.6 Ma in the early part of Zone N22 has been adopted here at 1.6 Ma, according to Berggren et al. (1985). Holes 682A and 683B reached Zone P10 and P12 through P14 of middle Eocene age, respectively. The basal parts of Holes 684A and 684C are

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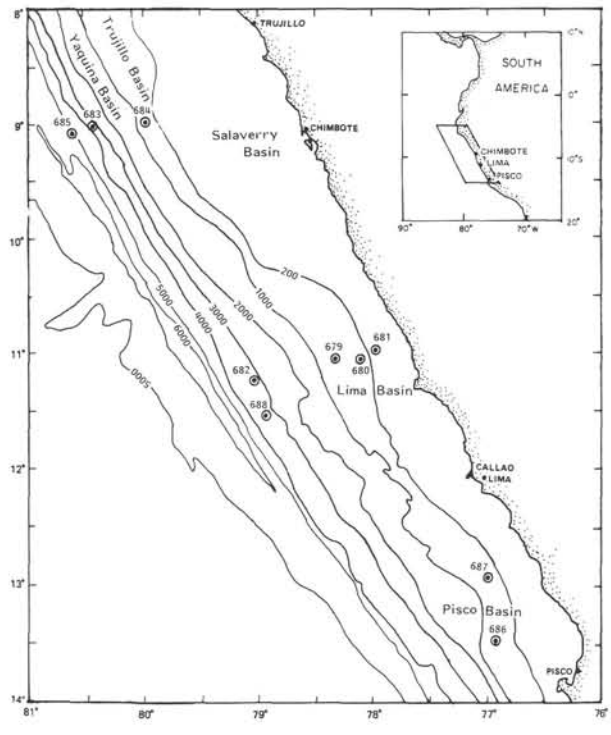

Figure 1. Location of Sites 679 through 688 off Peru.

Zones N16 and N17 and Zones N9 through N17 sequences of late Miocene and middle-late Miocene ages, respectively. Hole 685A penetrated to the P20 to N6 zonal sequence of late Oligocene to early Miocene age. Hole 688E attained the deepest penetration and the oldest sediment and drilled to Zone P6 of early Eocene age.

Site 679 and 680

Sites 679 and 680 are located in the Lima Basin. Planktonic foraminifers are not described for these sites because of their rare occurrences. However, the basal part of Hole 679E is assignable to Zones N13 through N16 of middle Miocene age (Shipboard Scientific Party, 1988; "Site 679" chapter).

Site 681

Site 681 is located in the Lima Basin, the most landward of three sites (679, 680 and 681) that form an east-west transect across the center of the coastal upwelling area at 11°S latitude off Lima. Site 681 is located on the outer shelf in water 146 m deep. Holes 681A, 681B, and 681C were drilled at this site to 187.0, 143.5, and 91.4 mbsf, respectively. Most of the sequence recovered from these holes is of late Pliocene to Pleistocene age (Fig. 3, Table 2).

Hole 681A: Planktonic foraminifers were obtained from Samples 112-681A-12H-CC and -14X-CC. The first occurrences of *Hastigerinopsis riedeli* in Sample 112-681A-10H-CC and *Globorotalia bermudezi* in Sample 112-681A-18X-CC indicate that these horizons are assignable to Zones N22 and N23 of late Pliocene to Pleistocene age (Rögl and Bolli, 1973). The latest coiling direction change in *Pulleniatina obliquiloculata* from sinistral to dextral, which is dated at about 0.75 Ma shortly before the Brunhes/Matuyama boundary (Saito, 1976; Mankinen and Dalrymple, 1979), was recognized between Samples 112-681A-7H-CC and -3H-CC. Most of the sequence recovered from Hole 681A is, therefore, of late Pliocene to Pleistocene age.

Hole 681B: Planktonic foraminifers were examined in 14 horizons from Samples 112-681B-2H-CC to -15X-CC. The first occurrence of *Hastigerinopsis riedeli* was found in Sample 112-681B-10X-CC. The section above Sample 112-681B-10X-CC is, therefore, correlated with Zones N22 to N23 of late Pliocene to Pleistocene age. The latest coiling change in *Pulleniatina obliquiloculata* from sinistral to dextral was recognized in a horizon between Samples 112-681B-8H-CC and -4H-CC and establishes a date of 0.75 Ma. *Globigerinoides obliquus*, which became extinct at 1.8 Ma (Saito et al., 1975), was found in Sample 112-681B-13X-CC. The horizon is correlative with Zones N21 to N22 of late Pliocene age. Therefore, most of the sections recovered from Hole 681B may be included in the late Pliocene to Pleistocene interval.

Site 682

Site 682 is located at 11°15.99′S, 79°03.73′W in water 3788.5 m deep on the landward lower slope of the Peru Trench. A single hole, 682A, was continuously cored to 473.7 mbsf.

Hole 682A: Planktonic foraminifers are scattered in 16 horizons of the total 81 samples examined. In Sample 112-682A-3H-4, 51–53 cm, *Hastigerinopsis riedeli* and *Globorotalia bermudezi* were found (Fig. 4, Table 3). The top part of Hole 682A above the sample is, therefore, included in Zones N22 and N23 of late Pliocene to Pleistocene age. In Sample 112-682A-35X-3, 65–67cm, *Catapsydrax stainforthi* and *Globorotalia birnageae*, indicating Zones N4 through N7 and N6 through N8, respectively (Poore, 1979), were observed. These species allow this horizon to be assigned to Zones N6 to N7 of early Miocene age. In Sample 112-682A-35X-CC, *Globigerina falconensis*, which first appears in Zone N6 (Blow, 1969), and *C. stainforthi* were found. The horizons of Samples 112-682A-35X-CC and -38X-CC thus are assignable to the N6–N7 zonal interval of early Miocene age. In Sample 112-682A-44X-CC, occurrences of *Globigerina praebulloides leroyi* and *Chilogumbelina cubensis*, ranging from Zone P17 to Zone N7 and from Zone P13 to Zone P22, respectively (Blow, 1969,; Jenkins, 1985), permit the horizon to be assigned to the P17–N22 zonal interval of late Eocene-Oligocene age. In Sample 112-682A-46X-CC, occurrences of both *Acarinina psedotopilensis* and *Truncorotaloides collactea*, ranging from Zone P6 to Zone P10 and from Zone P10 to Zone P14, respectively (Berggren, 1977; Blow, 1979), establish a correlation with Zone P10 of middle Eocene age. The most part of Hole 682A is predominated by a biosiliceous facies, and Sample 112-682A-35X-3, 65–67 cm, just below the facies, is assignable to Zones N6 and N7 of early Miocene age. This means that a biosiliceous facies of the area becomes predominant above the N6–N7 zonal interval.

Site 683

Site 683 is located at 9°01.69′S, 80°24.40′W on the lower slope off Trujillo, northwest of Lima, in water 3071.8 m deep. Two holes were drilled to 419.2 mbsf (Hole 683A) and from 402.5 to 488.0 mbsf (Hole 683B).

Hole 683A: Planktonic foraminifers occur at 33 horizons out of the total 86 samples examined (Fig. 5, Table 4). The first occurrence of *Globorotalia bermudezi* in Sample 112-683A-19X-CC, indicates the section above Sample 112-683A-19X-CC to be assignable to Zones N22 and N23 of late Pliocene to Pleistocene age. In Sample 112-683A-28X-2, 120–122cm, *Globoquadrina dehiscens*, which became extinct at 5.4 Ma (Berggren et al, 1983), was recognized. This horizon is correlated with Zone N17 of late Miocene or older age. In Sample 112-683A-30X-CC, *Globorotalia siakensis*, which became extinct in Zone N14, and *Globorotalia scitula*, which first

Table 1. Site data for Leg 112.

HOLE	Latitude	Longitude	Water depth(m)	Sub-bottom depth(m)	Number of cores	Total sediment recovered(m)	Oldest sediment cored
679A	11°03.52′S	78°15.92′W	439.5	0-7.0	1	7.0	Holocene
679B	11°03.80′S	78°16.34′W	450.5	0-107.2	13	103.01	Pliocene
679C	11°03.81′S	78°16.33′W	450.5	0-75.5	8	69.78	Pliocene
679D	11°03.83′S	78°16.33′W	439.5	0-245	27	116.8	Upper Miocene
679E	11°03.78′S	78°16.34′W	450.8	245.3-356.3	13	36.3	Middle Miocene
680A	11°03.90′S	78°04.67′W	252.5	0-93.8	10	81.23	Pleistocene
680B	11°03.90′S	78°04.67′W	252.5	0-195.5	22	98.45	Lower Pliocene
680C	11°03.90′S	78°04.67′W	252.5	0-34.3	4	35.04	Pleistocene
681A	10°58.60′S	77°57.46′W	150.5	0-187.0	20	112.4	Pleistocene
681B	10°58.60′S	77°57.46′W	150.5	0-143.5	16	97.3	Pliocene-Miocene
681C	10°58.60′S	77°57.46′W	150.5	0-91.4	10	94.0	Quaternary
682	11°15.99′S	79°03.73′W	3788.5	0-436.7	48	127.04	Eocene
683A	9°01.69′S	80°24.40′W	3071.8	0-419.2	45	219.17	Middle Miocene
683B	9°01.59′S	80°24.26′W	3071.5	402.5-488.0	9	30.67	Middle Eocene
684A	8°59.59′S	79°54.35′W	426.0	0-136.1	15	72.5	Middle Miocene
684B	8°59.49′S	79°54.35′W	426.5	0-55.0	6	37.17	Pliocene
684C	8°59.49′S	79°54.35′W	426.5	0-115.0	13	56.23	Middle Miocene
685	9°06.78′S	80°35.01′W	5070.8	0-468.6	51	278.65	Lower Upper Miocene
686A	13°28.81′S	76°53.49′W	446.8	0-205.7	23	181.71	Quaternary
686B	13°28.81′S	76°53.49′W	446.8	0-303.0	32	225.53	Quaternary
687A	12°51.78′S	76°59.43′W	306.8	0-207.0	22	108.29	Quaternary/Pliocene
687B	12°51.78′S	76°59.43′W	306.8	0-195.3	22	87.43	Quaternary/Pliocene
688A	11°32.26′S	78°56.57′W	3819.8	0-350.3	37	245.29	Pliocene
688C	11°32.26′S	78°56.57′W	3819.8	350.3-359.8	1	1.19	
688E	11°32.28′S	78°56.65′W	3825.8	350.0-779.0	46	151.98	Lower Eocene

appeared in Zone N9 (Blow, 1969), were observed. Therefore, this horizon is considered to correspond to the N9–N14 zonal interval of middle Miocene age. *Globorotalia challengeri* and *Globorotalia peripheroronda*, indicating the N9–N15 and N4–N10 zonal intervals, respectively (Srinivasan and Kennett, 1981), occurred in Sample 112-683A-33X-CC. Thus, this horizon is placed within the N9–N10 zonal interval of middle Miocene age.

Hole 683B: In Sample 112-683B-5X-CC, occurrences of *Globorotalia siakensis*, *Globorotalia peripheroronda*, and *Globigerinoides immaturus*, indicating Zones P20 through N14, N6 through N10, and N6 through Holocene, respectively (Blow, 1969), were recognized (Fig. 5, Table 5). The horizon corresponds to Zones N6 through N10 of early-middle Miocene age. In Sample 112-683B-7X-CC, *Chilogumbelina cubensis* and *Catapsydrax dissimilis*, indicative of the P17–P22 and P14–N6 zonal intervals, respectively (Bolli and Sanders, 1985), were observed. This horizon is assigned to Zones P17 through N6 of Oligocene to early Miocene age. In Sample 112-683B-8X-CC, *Truncorotaloides topilensis*, *Acarinina spinuloinflata*, and *Goborotalia centralis*, indicating the P11–P14 and P12–P17 zonal intervals, respectively (Toumarkine and Luterbacher, 1985), were found. The horizon is assignable to Zones P12 through P14 of middle Eocene age.

Site 684

Site 684 is the northernmost site of Leg 112 and is the most shoreward of the three sites forming an east-west transect (685, 683, and 684) on the Peruvian margin off Trujillo. The site is located at 8°59.59′S, 79°54.35′W at a water depth of 426.0 m. Three holes (684A, 684B, and 684C) were cored at this site down to 136.1, 55.0, and 115.0 mbsf, respectively.

Hole 684A: Planktonic foraminifers were obtained from Sample 112-684A-1H-CC and several horizons from Sample 112-684A-9X-CC to -14X-CC (Table 6). In Sample 112-684A-9X-CC, *Globigerinoides obliquus,* which became extinct at 1.8 Ma (Saito et al., 1975) and *Neogloboquadrina acostaensis*, which ranges from Zone N16 to Zone N21 (Ibaraki, 1986), were found. The horizon falls within the N16–N21 zonal interval of late Miocene to Pliocene age. *Globoquadrina dehiscens*, which became extinct at the top of Zone N17, and *Globigerina apertura*, which ranges from Zone N16 to Zone N21, were present in Sample 112-684A-11X-CC. In Sample 112-684A-13X-CC, *Globoquadrina dehiscens* and *Globigerinoides obliquus extremus*, which ranges from Zone N16 to Zone N21, were found. The horizon is also assigned to Zones N16–N17 of late Miocene age.

Site 685

Site 685 is located at 9°06.78′S, 80°35.01′W on the lower slope of the Peru Trench at a water depth of 5070 m. A single hole (685A) was continuously cored to 468.6 mbsf.

Hole 685A: Planktonic foraminifers were not present in Sample 112-685A-1H-CC as the site presently lies below the carbonate compensation depth.

The first occurrence of *Hastigerinopsis riedeli* in Sample 112-685A-18X-CC attests that the sample and the upper horizons can be included in Zones N22 and N23 of late Pliocene to Pleistocene age (Fig. 6, Table 7). In Sample 112-685A-22X-CC, *Neogloboquadrina dutertrei*, which indicates Zones N21 through N23 (Parker, 1967), and *Globoquadrina altispira*, which became extinct at 2.5 Ma (Berggren et al., 1983), were found. The occurrence of these species permits the age of Sample 112-685A-22X-CC to be determined as Zone N21 of late Pliocene age. In Sample 112-685A-38X-CC, *Neogloboquadrina acostaensis* and *Globorotalia cibaoensis*, ranging from Zone N16 to Zone N21 and from Zone N17 to Zone N19, respectively (Blow, 1969), were observed, which enable one to correlate this horizon to Zones N17 through N19 of late Miocene to Pliocene age. In Sample 112-685A-44X-CC, *Catapsydrax dissimilis* and *Globigerina falconensis*, indicating the P13–N6 and N6–N23 zonal intervals, respectively (Blow, 1969), were found. Therefore, the horizon has been assigned to Zone N6 of early Miocene age. Sample, 112-685A-50X-CC yields *Catapsydrax dissimilis* and some other species indicative of an Oligocene to early Miocene age. The basal part of Hole 685A thus can be assigned to Zone N6 of early Miocene age or older.

Site 686

Site 686 is the southernmost site of Leg 112, being located at 13°28.81′S, 76°53.49′W in water 446.8 m deep in the Pisco Basin. Two holes, 686A and 686B, were continuously cored to 205.7 and 305.0 mbsf, respectively.

Table 2. Distribution of planktonic foraminifers in Holes 681A and 681B.

	Abundance	Preservation	*Globigerina bulloides*	*Globigerina calida*	*Globigerina calida praecalida*	*Globigerina decoraperta*	*Globigerina falconensis*	*Globigerina quinqueloba*	*Globigerina rubescens*	*Globigerinoides conglobatus*	*Globigerinoides cyclostomus*	*Globigerinoides elongatus*	*Globigerinoides immaturus*	*Globigerinoides obliquus obliquus*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides tenellus*	*Globigerinoides trilobus*	*Globorotaloides hexagona*	*Orbulina suturalis*	*Orbulina universa*	*Globigerinella aequilateralis*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita parkerae*	*Globigerinita uvula*	*Turborotalita humilis*	*Globorotalia anfracta*	*Globorotalia bermudezi*	*Globorotalia cultrata cultrata*	*Globorotalia cultrata menardii*	*Globorotalia obesa*	*Globorotalia scitula*	*Globorotalia theyeri*	*Globorotalia tosaensis*	*Globorotalia tumida*	*Globorotalia ungulata*	*Hastigerinopsis riedeli*	*Neogloboquadrina blowi*	*Neogloboquadrina dutertrei*	*Neogloboquadrina humerosa*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*	*Neogloboquadrina pseudopachyderma*	*Pulleniatina obliquiloculata*	*Sphaeroidinella dehiscens dehisce*
Hole 681A																																												
1, CC	R	G	A					A							T				T				R									T					R		T			A			
2, CC	R	G	A		R		A	A											T				F	T	R					T		F						F	C		C	A			
3, CC	R	G					C	A															R								T	T									A	A		T	
4, CC	B																																												
5, CC	R	G	C				F	C							T	T				R	F		F	T								C	T	T			C		F			A	A			
6, CC	R	G	A					A												T					R													F		T			A	A			
7, CC	R	G	T													T														T		T							T			R	R		T	
8, CC	R	G	A	T			F	C	T		T	T	T		C	C		T		T	T		T	T								R							T		A	C			
9, CC	R	G	A					A															T					T				T							T		T				
10, CC	R	G	A				R	A								T							C	C								T						R		T	R	F	C		T	
11, CC	B																																												
12, CC	R	G	A				T		T		T	T			A	T			T				C									T						C	T		T				
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4, CC	R	G	F				T	A				T				C		T		T			F	F						F	F					F		R		A	A		T	
5, CC	R	G	C		T		C	C												T			F	C							C							R		A	A	C		
6, CC	R	G	C				C	A					T			T		T		T			A		T												T	C		A	A			
7, CC	R	G	A	F			C													T			C	C	T						F							F		A	A			
8, CC	R	G	C	C		R	A	F	T	T			R		C	A					T		A	C						F	C	T		T	F	T		R	A	T			F	
9, CC	R	G	A				C	A	F			T	T		C	C	T			T			A					T			T			T				F	C		C			F	
10, CC	R	G	A				C	A							T					T			F														C		F		A			T	
11, CC	R	G													T																														
12, CC	R	G	T				T					T			R					T			F																					T	
13, CC	R	G		T			C		C				F	F	A	A	C	F					A				T				T							F					C	T
14, CC	R	G	A	A			A								T								C	T							A									T				
15, CC	R	G					T																																						
16, CC	B																																												

NOTE: A=abundant (>10% of assemblage); C=Common (3–10%); F=few (0.5–3%); R=rare (<0.5%); T=trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

Hole 686A: Planktonic foraminifers were recovered from Samples 112-686A-8H-CC -9X-CC -14X-CC -16X-CC, and -23X-CC (Table 8). The first occurrences of *Hastigerinopsis riedeli* and *Globorotalia bermudezi* in Samples 112-686A-20X-CC and -18X-CC, respectively, indicate that most of the cored interval is assignable to Zones N22 and N23 of late Pliocene to Pleistocene age.

Hole 686B: Planktonic foraminifers were obtained from Samples 112-686B-7X-CC, -13X-CC, -15X-CC, -20X-CC, -24X-CC, -28X-CC, and -29X-CC (Table 8). The first occurrence of *Hastigerinopsis riedeli* in Sample 112-686-29X-CC establishes that most of the cored sequence is correlative with Zones N22 and N23 of late Pliocene to Pleistocene age.

Site 687

Site 687 is located at 12°51.78′S, 76°59.43′W at a water depth of 306.8 m along the northern fringe of the Pisco Basin. Holes 687A and 687B were continuously cored to 207.0 and 195.3 mbsf, respectively.

Hole 687A: Planktonic foraminifers were obtained from Samples 112-687A-1H-CC, -3H-CC, -6H-CC, -9X-CC, -15X-CC, -17X-CC, and -21X-CC (Table 9). The first occurrence of *Hastigerinopsis riedeli* in Sample 112-687A-17X-CC indicates that most of the cored section is assignable to Zones N22 and N23 of late Pliocene to Pleistocene age. The latest coiling change in *Pulleniatina* was recognized between Samples 112-687A-6H-CC and -1H-CC, which can be correlated with the coiling direction change of the species occurring at 0.75 Ma.

Hole 687B: Planktonic foraminifers were examined in Samples 112-687B-3H-CC, -4H-CC, -8X-CC, -16X-CC, and -20X-CC (Table 9). The first occurrence of *Hastigerinopsis riedeli* in Sample 112-687B-20X-CC indicates that most of the sediments recovered from Hole 687B are assignable to Zones N22 and N23 of late Pliocene to Pleistocene age. *Globigerinoides obliquus* became extinct during the Olduvai event (Saito et al., 1975). The occurrence of this species in Sample 112-687B-9H-CC, therefore, establishes the age of this sample and the lower horizons as 1.8 to 1.9 Ma or older (Mankinen and Darlymple, 1979).

Site 688

Site 688 is located at 11°72.26′S, 78°56.57′W at a water depth of 3819.8 m on the lower slope of the Peru Trench about 30 km landward of the trench axis. Hole 688A was cored to 350.3 mbsf, and Hole 688E was penetrated farther to 779.0 mbsf and is the deepest hole of Leg 112.

Hole 688A: The basal part of Hole 688A was determined as Zone N21 of late Pliocene age by the occurrence of *Globorotalia tosaensis* and *Neogloboquadrina acostaensis* in Sample 112-688A-34X-CC (Table 10). *G. tosaensis* appeared at the base of Zone N21 (Blow, 1969) and *N. acostaensis* ranged up to the top of Zone N21 (Ibaraki, 1986). The first occurrence of *Globorotalia bermudezi* in Sample 112-688A-28X-CC and the co-occurrence of *Globigerinoides obliquus* indicate that the horizon is assignable to Zone N22 of late Pliocene age. The latest coiling direction change in *Pulleniatina obliquiloculata* from sinistral to dextral was recognized at a horizon between Samples 112-688A-9X-CC and -6X-CC, which is dated at 0.75 Ma. Therefore, most of the Hole 688A sections are included in the late Pliocene to Pleistocene interval. In the horizon of Sample 112-688A-27X-CC, most specimens were either compressed or deformed, suggesting that they derived from a fossil assemblage.

Hole 688E: Hole 688E was drilled from 350.0 to 779.0 mbsf. Planktonic foraminifers were scattered (Table 11), however, *Globoquadrina dehiscens*, ranging up to the top of Zone N17 (Berggren et al., 1983), occurred in Sample 112-688E-12X-CC. The section from Sample 112-688E-12X-CC and downward, therefore, corresponds to Zone N17 of late Miocene or older age. *Catapsydrax dissimilis*, which became extinct at the top of Zone N6 (Blow, 1969), occurred in Sample 112-688E-22R-CC. On this basis, the section from Sample 112-688E-22R-CC and downward has been assigned to Zone N6 of early Miocene or older age.

Pseudohastigerina barbadoensis occurred in Sample 112-688E-37R-CC and this species ranges from Zone P16 of late Eocene to P19 of Oligocene age (Toumarkine and Luterbacher, 1985). In Sample 112-688E-38R-CC, *Acarinina pentacamerata* and *Acarinina esnaensis*, which indicate the P6–P8 and P4–P6 zonal intervals, respectively (Berggren, 1977), were recognized. In Sample 112-688E-45R-CC, *Acarinina pentacamerata* was found again. Thus, horizons of Samples 112-688E-44R-CC and -45R-CC are assignable to Zone P6 of early Eocene age, the oldest sediments in Leg 112.

PALEOCEANOGRAPHIC IMPLICATIONS

The distribution pattern of planktonic foraminifers in modern upwelling areas, associated occurrences of certain warm- and cold-water species, and the characteristic distribution of some indicator species sensitive to upwelling water masses seem to be features on which paleoceanographic studies of coastal upwelling can be based (Thiede, 1983). Rich occurrences of *Globigerina bulloides*, *Globigerina quinqueloba*, *Globorotalia inflata*, *Globorotalia menardii*, and *Neogloboquadrina dutertrei*, were noticed in the upwelling area of Northwest Africa (Thiede, 1975). Thiede (1983) also cited the following four species and their relation to upwelling water masses off Peru: *Globigerina bulloides*, which generally lives in temperate to subpolar surface waters (Bé, 1977), is abundant in cooler upwelled waters; *Neogloboquadrina dutertrei*, dwells in tropical to subtropical waters and is commonly found in upwelling areas; *Globigerinoides ruber*, lives in subtropical surface waters, and is rarely found in upwelling areas; *Globorotalia menardii*, usually dwells in tropical waters as deep as 100 m and occurs frequently in the upwelling area off Northwest Africa, but rarely off Peru.

All the sites drilled during Leg 112 are within the present coastal upwelling regime off Peru. Planktonic foraminiferal assemblages of some horizons contain these warm- and cold-water species discussed by Thiede (1983) as being typical of coastal upwelling specific compositions that are somewhat different from these present-day assemblages. Cold-water elements, such as *Neogloboquadrina incompta* and *N. pachyderma* are dominant in the samples through Leg 112. Warm-water species are prevalent at a few horizons in the cores, suggesting shifts of the coastal upwelling centers or incursions of warmer climatic events.

Site 681

Site 681 is located in the Lima Basin, at the center of a present coastal upwelling regime. Rich planktonic foraminiferal assemblages occur in the upper 100 m at Holes 681A and 681B. Below that depth planktonic foraminifers are scarce. About 14 to 17 species of both warm- and cold-water planktonic foraminifers occur in the upper interval of Holes 681A and 681B, which include common occurrences of *Globigerina bulloides*, *G. quinqueloba*, *Neogloboquadrina dutertrei*, *N. incompta*, and *N. pachyderma*, and sparse numbers of *Globigerinoides ruber* and *Globorotalia menardii*. The specific composition and the frequency of their occurrences resemble those of the modern upwelling area off Peru, except that dominant cold-water specimens of *N. incompta* and *N. pachyderma* are absent from modern faunas. In Samples 112-681A-8H-CC, -681B-8H-CC and -681B-9X-CC, however, the predominance of such warm-water surface dwellers as *Neogloboquadrina dutertrei* and *Globigerinoides ruber* with other warm-water species and none of the cold-water species, such as *N. pachyderma*, Globigerina bulloides, and *G. quinqueloba* suggest an incursion of warm water masses. This event was observed in both holes at almost the same depth below the seafloor (73.0–81.9 m) and again in Sample 112-681B-13X-CC (115.0 mbsf). The assemblages of other horizons consist mostly of the cold-water species *N. incompta* and *N. pachyderma*, and suggest a prevalence of cooler current in this area, perhaps during glacial intervals, than at the present interglacial time.

Site 682

Site 682 is located on the seaward slope beyond the Lima Basin in 3788 m of water. Hemipelagic sediments indirectly influenced by coastal upwelling cover this site. Late Pliocene to Pleistocene planktonic foraminiferal assemblages have some resemblance to those of Samples 112-681A-2H-CC and -681A-5H-CC in the specific combination and frequency of their occurrences. However, *Globorotalia menardii* is abun-

Table 3. Distribution of planktonic foraminifers in Hole 682A.

Hole 682A	Abundance	Preservation	*Globigerina angustiumbilicata*	*Globigerina bulbosa*	*Globigerina bulloides*	*Globigerina falconensis*	*Globigerina hagni*	*Globigerina inaequispira*	*Globigerina ouachitaensis*	*Globigerina praebulloides leroyi*	*Globigerina praebulloides praebulloides*	*Globigerina quinqueloba*	*Globigerina rubescens*	*Globigerina umbilicata*	*Globigerinoides cyclostomus*	*Globigerinoides ruber*	*Globigerinoides trilobus*	*Globoturalia hexagona*	*Globoturaloides suteri*	*Orbulina suturalis*	*Orbulina universa*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita naparimaensis*	*Globigerinita parkerae*	*Globigerinita uvula*	*Globoturalia birnageae*	*Globoturalia bermudezi*	*Globoturalia cultrata cultrata*	*Globoturalia cultrata menardii*	*Globoturalia hirsuta*	*Globoturalia obesa*	*Globoturalia pumilio*	*Globoturalia siakensis*	*Globoturalia scitula*	*Globoturalia tumida flexuosa*	*Globoturalia tumida tumida*	*Beella digitata*	*Hastigerinopsis riedeli*	*Neogloboquadrina continuosa*	*Neogloboquadrina dutertrei*	*Neogloboquadrina humerosa*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*	*Pulleniatina obliquiloculata*	*Catapsydrax stainforthi*	*Cassigerinella cipolensis*	*Chiloguembelina cubensis*	*Acarinina interposita*	*Acarinina pentacamerata*	*Acarinina pseudotopilensis*	*Truncorotaloides collactea*
1, CC	R	G			A	T						T				T		T			T									T	T						T	T	T								
2(4), 68-70	R	G			A	T								T				T			T								T				T			A	A	T	C							
2, CC	F	G			C	C						F	T		T		T	T		T	A		C				C				F	F		F		C		C		A	A	F						
3(4), 51-53	F	G		T	A	C						F						T		T	T	F						T			T	F					T		C		A	A							
3, CC	B																																																	
4(4), 68-70	B																																																	
4, CC	B																																																	
5(1), 54-56	B																																																	
5, CC	B																																																	
6, CC	B																																																	
7, CC	F	G			T	T																A																			T								
8(1), 27-29	B																																																	
8, CC	B																																																	
9(1), 44-46	B																																																	
9, CC	B																																																	
10(1), 51-53	B																																																	
10, CC	B																																																	
11(1), 34-36	B																																																	
11, CC	B																																																	
12(2), 73-77	B																																																	
12, CC	B																																																	
13(3), 53-54	B																																																	
13(4), 64-66	B																																																	
13, CC	B																																																	
14(1), 56-58	B																																																	
14, CC	B																																																	
15(1), 44-46	B																																																	
15, CC	B																																																	
16, CC	R	G																												T																				
17(1), 97-99	B																																																	
17, CC	R	G																														T																		
18(2), 75-77	R	G																				T																			T								
18, CC	B																																																	
19, CC	R	G			T																	T										T																	
20(1), 64-66	B																																																	
20, CC	B																																																	
21(1), 67-69	B																																																	
21, CC	B																																																	
22(1), 118-120	B																																																	
22, CC	B																																																	
23, CC	B																																																	
24(1), 57-59	B																																																	
24, CC	B																																																	
25(1), 34-36	B																																																	
25, CC	B																																																	
26(1), 52-54	B																																																	
26, CC	B																																																	
27(1), 49-51	B																																																	
27, CC	B																																																	
28, CC	B																																																	
29(1), 40-42	B																																																	
29, CC	B																																																	
30, CC	B																																																	
31, CC	B																																																	
32, CC	B																																																	
33, CC	B																																																	
34(4), 6-8	B																																																	

Table 3 (continued).

Hole 682A	Abundance	Preservation	*Globigerina angustiumbilicata*	*Globigerina bulbosa*	*Globigerina bulloides*	*Globigerina falconensis*	*Globigerina hagni*	*Globigerina inaequispira*	*Globigerina ouachitaensis*	*Globigerina praebulloides leroyi*	*Globigerina praebulloides praebulloides*	*Globigerina quinqueloba*	*Globigerina rubescens*	*Globigerina umbilicata*	*Globigerinoides cyclostomus*	*Globigerinoides ruber*	*Globigerinoides trilobus*	*Globorotaloides hexagona*	*Globorotaloides suteri*	*Orbulina suturalis*	*Orbulina universa*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita naparimaensis*	*Globigerinita parkerae*	*Globigerinita uvula*	*Globorotalia birnageae*	*Globorotalia bermudezi*	*Globorotalia cultrata cultrata*	*Globorotalia cultrata menardii*	*Globorotalia hirsuta*	*Globorotalia obesa*	*Globorotalia pumilio*	*Globorotalia siakensis*	*Globorotalia scitula*	*Globorotalia tumida flexuosa*	*Globorotalia tumida tumida*	*Beella digitata*	*Hastigerinopsis riedeli*	*Neogloboquadrina continuosa*	*Neogloboquadrina dutertrei*	*Neogloboquadrina humerosa*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*	*Pulleniatina obliquiloculata*	*Catapsydrax stainforthi*	*Cassigerinella cipolensis*	*Chiloguembelina cubensis*	*Acarinina interposita*	*Acarinina pentacamerata*	*Acarinina pseudotopilensis*	*Truncorotaloides collactea*
34, CC	B																																															
35(3), 65-67	R	M									A											T	T			A				T		T																
35, CC	R	M	A			T			T		A												T									T					T						T					
36(1), 71-73	B																																															
36, CC	B																																															
37(2), 59-61	B																																															
37, CC	B																																															
38(1), 88-90	R	M									T											T									T		T														
38, CC	R	M	A			T					T												T		T	A						T											T				
39(2), 49-51	B																																															
39, CC	B																																															
40(3), 106-108	B																																															
40, CC	B																																															
41, CC	B																																															
42, CC	B																																															
43, CC	B																																															
44, CC	R	M								T																																			A				
45, CC	B																																															
46(1), 57-59	B																																															
46, CC	R	P					T	T											T																											T	T	T	T
47(2), 62-64	B																																															
47, CC	B																																															
48(1), 32-34	B																																															
48, CC	R	P																	T																												T			

NOTE: A=abundant (>10% of assemblage); C=Common (3-10%); F=few (0.5-3%); R=rare (<0.5%); T=Trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

dant in the assemblage of Sample 112-681A-2H-CC as it is in the present upwelling area off Northwest Africa.

Site 683

Site 683 is located on the lower slope off Trujillo, northwest of Lima in 3072 m of water. Late Pliocene to Pleistocene planktonic foraminiferal assemblages demonstrate the character of glacial coastal upwelling, through such cold-water elements as *Neogloboquadrina incompta* and *N. pachyderma*, which are dominant. *N. dutertrei* is predominant in some upper horizons, which may suggest coastal upwelling was similar to that observed today.

Site 684

Site 684 is located on the upper slope off Trujillo, northwest of Lima in 426 m of water. Late Miocene planktonic foraminiferal assemblages consist mainly of warm-water elements, such as *Globigerinoides* and *Globoquadrina* and additionally of cold-water species, such as *Globigerina bulloides*, all of which suggest less influence on coastal upwelling during that time. The Pleistocene assemblage of Sample 112-684A-1H-CC as well as that of 112-681A-5H-CC resembles closely that of modern coastal upwelling off Peru.

Site 685

Site 685 is located on the lower slope of the Peru Trench in 5071 m of water. Late Pliocene to Pleistocene planktonic foraminiferal assemblages in the uppermost part are similar to those of Hole 681A in the specific composition and the frequency of their occurrences.

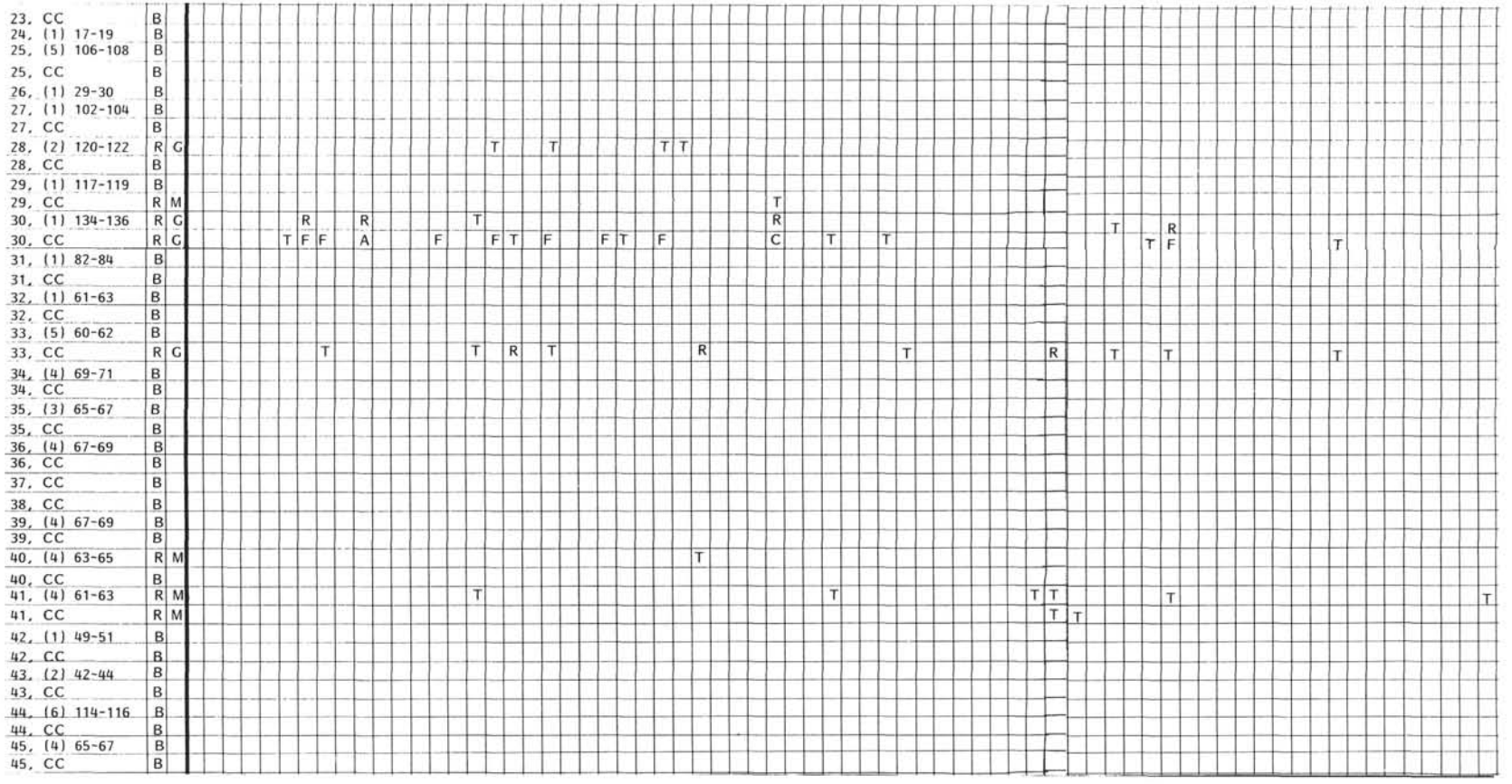
Site 686

Site 686 is located in the Pisco Basin south of Lima in 447 m of water. This site lies at the center of a present-day upwelling regime. Rich planktonic foraminiferal occurrences were noted in two correlatable depth intervals of both holes: 64.2 and 65.5 mbsf, 120.2 and 122.5 mbsf, at recover depths. In Samples 112-686A-16X-CC and 112-686A-20X-CC, *Globigerina bulloides*, *G. quinqueloba*, *Neogloboquadrina dutertrei*, *N. incompta*, and *N. pachyderma* are common, and *Globigerinoides* and *Globorotalia menardii* are absent. Similar distributions were observed at Hole 686B. The specific composition and the frequency of occurrences generally resemble that of the modern upwelling activity off Peru, except that cold-water specimens of *N. incompta* and *N. pachyderma* are dominant. This was also observed at Site 681. In other horizons, there are fewer species; *N. incompta* and *N. pachy-*

Table 4. Distribution of planktonic foraminifers in Hole 683A.

	Abundance	Preservation	*Globigerina bulbosa*	*Globigerina bulloides*	*Globigerina calida calida*	*Globigerina calida praecalida*	*Globigerina decoraperta*	*Globigerina eamesi*	*Globigerina falconensis*	*Globigerina foliata*	*Globigerina megastoma*	*Globigerina praebulloides*	*Globigerina quinqueloba*	*Globigerina rubescens*	*Globigerina umbilicata*	*Globigerina woodi*	*Globigerinoides cyclostomus*	*Globigerinoides immaturus*	*Globigerinoides parawoodi*	*Globigerinoides quadrilobatus*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides subquadratus*	*Globigerinoides trilobus*	*Globoquadrina altispira globosa*	*Globoquadrina baroemoenensis*	*Globoquadrina conglomerata*	*Glboquadrina dehiscens dehiscens*	*Globoquadrina venezuelana*	*Globorotaloides hexagona*	*Orbulina suturalis*	*Orbulina universa*	*Globigerinella aequilateralis*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita parkerae*	*Globigerinita uvula*	*Turborotalita humilis*	*Globorotalia bermudezi*	*Globorotalia birnageae*	*Globorotalia challengeri*	*Globorotalia crassaformis crassaformis*	*Globorotalia crassula*	*Globorotalia cultrata cultrata*	*Globorotalia cultrata menardii*	*Globorotalia hirsuta*	*Globorotalia inflata*	*Globorotalia minutissima*	*Globorotalia obesa*	*Globorotalia peripheroronda*	*Globorotalia praepumilio*	*Globorotalia praescitula*	*Globorotalia pumilio*	*Globorotalia scitula scitula*	*Globorotalia siakensis*	*Globorotalia theyeri*	*Globorotalia truncatulinoides*	*Globorotalia tumida*	*Beella digitata*	*Beella praedigitata*	*Hastigerinopsis riedeli*	*Neogloboquadrina acostaensis*	*Neogloboquadrina blowi*	*Neogloboquadrina continuosa*	*Neogloboquadrina dutertrei*	*Neogloboquadrina eggeri*	*Neogloboquadrina humerosa*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*	*Pulleniatina obliquiloculata*	*Sphaeroidinella dehiscens*	*Cassigerinella chipolensis*
Hole 683A																																																																							
1, (2) 18-19	C	G		A	T				A				F		F		T													T			T	F	C	T						T		R			T										T		T			F		A			C	A			
1, CC	A	A		A		F			A				F																	R	R	R	T	F	C						F	T		T		C		F					T		T					T		F		A	T	F	C	A			
2, (4) 64-66	C	G		A	T				A				C	T	F		T																	C																			T				F							A			C	A			
2, CC	C	G		A					A																					R	T	F		F									T														F							A		F	F	A	F		
3, (4) 63-65	A	G		C			F		C				F					T												R				R	F								R										T				T		T			F		F			A	A	T		
3, CC	A	G		A					A				F																	T		R		C	F									T				T					R						T	F		C		C			A	A			
4, (4) 64-66	F	G		C					C																																			F									T					F				T		A		T	A	A			
4, CC	C	G		A					A		C		C								T						T			F	T	F		F	C			T						T				R					F							R				A		R	C	C			
5, (3) 60-62	F	G		A			T		T																					T				T														F					T									C		A				A			
5, CC	F	G		C					C				F																	R	T			F			T											T					R					R		F				A			C	A			
6, (3) 58-59	C	G		A	T				A				C														T			F	R	F		C														F		T			R						T	R	F			F			A	A	T		
6, CC	A	G		C	T				C				F								T						T			F	C	C	T	F	R													R					F				R		T	F				C		R	A	A	T		
7, (4) 64-66	C	G		A	R				A				R		R							F		T			T			F	R	F	R	C											T			R					R			R	R		T			C		A			C				
7, CC	R	G			C				C				C					R				T					T			F		F	T	A	F									T									F				F					C		A		C		F	T	T	
8, (4) 63-65	F	G	F	F					T				F																	C				A											T								T											A				A			
8, CC	R	G		T					T																																																	T		T		F			C			C	A			
9, (4) 63-65	B																																																																						
9, CC	R	G		T					T																									A																											T							A	A			
10, (1) 78-80	R	G		A					C				C																	T			T	T																		C												A			T	A			
10, CC	B																																																																						
11, (1) 51-53	B																																																																						
11, CC	R	P		T																																																																T			
12, (4) 35-37	B																																																																						
12, CC	B																																																																						
13, (1) 42-44	R	G		A					T				T																	T			R	T														R																				A			
13, CC	R	G		T									T																																																						R			
14, (1) 53-55	B																																																																						
14, CC	R	G		A					F				C																	C			C	T					T								T	T						T													F	C	A			
15, (1) 56-58	B																																																																						
15, CC	B																																																																						
16, (1) 38-40	B																																																																						
16, CC	B																																																																						
17, (1) 64-67	B																																																																						
17, CC	B																																																																						
18, (2) 66-68	B																																																																						
18, CC	B																																																																						
19, (1) 30-32	B																																																																						
19, CC	R	G		A					C																					F		T	T						T									F																C		F	F				
20, (1) 28-30	B																																																																						
20, CC	B																																																																						
21, (2) 58-60	B																																																																						
21, CC	B																																																																						
22, (1) 21-23	B																																																																						
22, CC	B																																																																						
23, (1) 72-74	B																																																																						

Table 4 (continued).



23, CC	B		
24, (1) 17-19	B		
25, (5) 106-108	B		
25, CC	B		
26, (1) 29-30	B		
27, (1) 102-104	B		
27, CC	B		
28, (2) 120-122	R	G	
28, CC	B		
29, (1) 117-119	B		
29, CC	R	M	
30, (1) 134-136	R	G	
30, CC	R	G	
31, (1) 82-84	B		
31, CC	B		
32, (1) 61-63	B		
32, CC	B		
33, (5) 60-62	B		
33, CC	R	G	
34, (4) 69-71	B		
34, CC	B		
35, (3) 65-67	B		
35, CC	B		
36, (4) 67-69	B		
36, CC	B		
37, CC	B		
38, CC	B		
39, (4) 67-69	B		
39, CC	B		
40, (4) 63-65	R	M	
40, CC	B		
41, (4) 61-63	R	M	
41, CC	R	M	
42, (1) 49-51	B		
42, CC	B		
43, (2) 42-44	B		
43, CC	B		
44, (6) 114-116	B		
44, CC	B		
45, (4) 65-67	B		
45, CC	B		

NOTE: A=abundant (>10% of assemblage); C=Common (3-10%); F=few (0.5-3%); R=rare (<0.5%); T=Trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

Table 5. Distribution of planktonic foraminifers in Hole 683B.

Hole 683B	Abundance	Preservation	*Globigerina falconensis*	*Globigerina foliata*	*Globigerina praebulloides*	*Globigerinoides immaturus*	*Globigerinoides parawoodi*	*Globigerinoides subquadratus*	*Globoquadrina altispira altispira*	*Globoquadrina altispira globosa*	*Globoquadrina baroemoenensis*	*Globoquadrina dehiscens dehiscens*	*Globoquadrina venezuelana*	*Globorotaloides hexagona*	*Globorotaloides suteri*	*Globorotalia glutinata*	*Globorotalia centralis*	*Globorotalia obesa*	*Globorotalia peripheroronda*	*Globorotalia siakensis*	*Neogloboquadrina continuosa*	*Catapsydrax dissimilis*	*Cassigerinella chipolensis*	*Acarinina rotundimarginata*	*Acarinina spinuloinflata*	*Trucorotaloides collactea*	*Truncorotaloides topilensis*
1, (1) 58-60	R	G													T			F									
1, CC	R	G	R		C		T	T	T			T	T	R				R			T						
2, (1) 80-82	B																										
2, CC	B																										
3, (2) 83-85	R	G	T		C									T					T	T							
3, CC	B																										
4, (1) 20-25	B																										
4, CC	R	G											T			T			T								
5, CC 32-34	R	G		R			T												T				T				
5, CC	R	G				R			T	T		C				T		F	T	T							
6, CC 4-6	B																										
6, CC	B																										
7, CC 22-25	R	P																				T					
7, CC	B																										
6, (1) 39-40	B																										
8, CC	R	P															T							T	T	T	T

NOTE: A=abundant (>10% of assemblage); C=Common (3–10%); F=few (0.5–3%); R=rare (<0.5%); T=trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

derma predominate, and *N. dutertrei* is absent. Such occurrences suggest a prevalence of glacial conditions during the late Pliocene to Pleistocene.

Site 687

Site 687 is located in the Pisco Basin, south of Lima in 307 m of water. Planktonic foraminiferal assemblages consist largely of cold-water species including *Globigerina bulloides*, *G. quinqueloba*, *Neogloboquadrina incompta*, and *N. pachyderma* and rarely of the warm-water species *N. dutertrei*. In the uppermost sample (112-687A-1H-CC), however, many species of planktonic foraminifers, 28 in all, are found that include dominant species of *G. bulloides* and *N. dutertrei* and few *Globigerinoides ruber*, *N. incompta*, and *N. pachyderma*. This assemblage is similar to those of the modern coastal upwelling area off Peru.

Site 688

Site 688 is located on the lower slope of the Peru Trench about 30 km landward of the trench axis in 3826 m of water. Planktonic foraminiferal assemblages (Sample 112-688A-5H-CC) are similar to those of the present coastal upwelling area off Peru. Other assemblages in the cores resemble those of Sample 112-681A-5H-CC in the specific combination and the frequency of their occurrences.

TAXONOMIC NOTES

Selected age-diagnostic species and some important taxa that are dominant in this area are illustrated in Plates 1 through 3. The original references to these species are listed below. The figured specimens have been deposited in the collection of the Geoscience Institute, Faculty of Science, Shizuoka University, Shizuoka 422, Japan.

Globigerina quinqueloba Natland, 1938
(Pl. 1, Figs. 1, 2)

Globigerina quinqueloba Natland, 1938, p. 149, Pl. 6, Figs. 7a–7c.

Globigerinoides obliquus Bolli, 1957
(Pl. 1, Figs. 3, 4)

Globigerinoides obliquus Bolli, 1957, p. 113, Pl. 25, Figs. 10a–10c.

Globoquadrina dehiscens (Chapman, Parr and Collins) 1934
(Pl. 1, Figs. 5, 6)

Globorotalia dehiscens Chapman, Parr, and Collins, 1934, p. 509, Pl. 11, Figs. 36a–36c.
Globoquadrina dehiscens (Chapman, Parr, and Collins). Bolli, 1957, p. 111, Pl. 24, Figs. 3a–4c.

Globorotaloides hexagona (Natland) 1938
(Pl. 1, Figs 7, 8)

Globorotaloides hexagona (Natland) 1938, p. 149, Pl. 7, Figs. 1a–1c.
Globorotaloides hexagona (Natland), Fleisher, 1974, p. 1029, Pl. 13, Fig. 6.

Globigerinita glutinata (Egger) 1893
(Pl. 2, Figs. 1, 2)

Globigerina glutinata Egger, 1893, p. 371, Pl. 13, Figs. 19–21.

Table 6. Distribution of planktonic foraminifers in Holes 684A and 684C.

	Abundance	Preservation	*Globigerina apertura*	*Globigerina bulloides*	*Globigerina calida calida*	*Globigerina decoraperta*	*Globigerina druryi*	*Globigerina falconensis*	*Globigerina foliata*	*Globigerina quinqueloba*	*Globigerina rubescens*	*Globigerina umbilicata*	*Globigerina woodi*	*Globigerinoides bollii*	*Globigerinoides elongatus*	*Globigerinoides immaturus*	*Globigerinoides obliquus extremus*	*Globigerinoides obliquus obliquus*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides trilobus*	*Globoquadrina altispira altispira*	*Globoquadrina altispira globosa*	*Globoquadrina dehiscens*	*Globorotaloides hexagona*	*Orbulina sturalis*	*Orbulina universa*	*Globigerinella aequilateralis*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita uvula*	*Globorotalia bermudezi*	*Globorotalia crassaformis oceanica*	*Globorotalia obesa*	*Globorotalia parkerae*	*Globorotalia pumilio*	*Globorotalia theyeri*	*Globorotalia ungulata*	*Neogloboquadrina acostaensis*	*Neogloboquadrina blowi*	*Neogloboquadrina dutertrei*	*Neogloboquadrina humerosa*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*
Hole 684A																																											
1, CC	R	G		A				C		F	T																	C	F		T		C	T		T				C		C	A
2, CC	B																																											
3, CC	B																																											
4, CC	B																																											
5, CC	B																																											
6, CC	B																																											
7, CC	B																																											
8, CC	B																																											
9, CC	R	G		A		A		C	R		F	F						F			T						R	T	A	R	T			F		C			F				
10, CC	R	G		A		C		C					F	F		T		F		T		F		A			R		A		F			F		A				F			
11, CC	F	G	F	A		A	T	A								C		C		A	C	F	T	C		C	T		A					C		T					F		
12, CC	F	G		A	F	C		C					F	R	C	R		C		F	F	F	T	A	R	F	R	F	A	F				C		F					R		C
13, CC	F	G		A		C		A					F				R	F			T	T		C			F	T	A		C			C		F		T		C			T
14, CC	R	G		A	R	C		A					T					C		R	T					F	C	T	A	C				C		C							
Hole 684C																																												
1, CC	R	G		A	R			A											T						F				C	C			T	F		R				F		C	A
2, CC	R	G		A				T																					T									T				T		T	A
3, CC	B																																											
4, CC	B																																											
5, CC	B																																											
6, CC	B																																											
7, CC	B																																											
8, CC	R	G		T				T								T						T		T		T			C						A						T		
9, CC	R	G		A	F	A		A					T													T	T		A	A	T				F						C	C
10, CC	R	G		A		F		C										F								T			A	C			F		C							
11, CC	R	G		A		C		A					C					C		T		C		C		T	T	T	A	T			C		T						T	
12, CC	R	G		A		F		C								T		F				T	C	A		T		T	A	C	F		C		C						C	F
13, CC	R	G		A	R	A		A		T			R	T		R				T		T			R	R	T	T	A	R			C		C						F	C

NOTE: A=abundant (>10% of assemblage); C=Common (3–10%); F=few (0.5–3%); R=rare (<0.5%); T=trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

Globigerinita glutinata (Egger), Parker, 1962, p. 246–249, Pl. 19, Figs. 1–16.

Globorotalia peripheroronda Blow and Banner, 1966
(Pl. 2, Figs. 3, 4)

Globorotalia peripheroronda Blow and Banner, 1966, p. 294, Pl. 1, Figs. 1a–1c; Pl. 2, Figs. 1–3.

Beella praedigitata (Parker) 1967
(Pl. 2, Fig. 5)

Globigerina praedigitata Parker, 1967, p. 151, Pl. 19, Figs. 5–8.
Beella praedigitata (Parker), Srinivasan and Kennett, 1975, p. 158, Pl. 2, Figs. 3, 5–9.

Hastigerinopsis riedeli (Rögl and Bolli) 1973
(Pl. 2, Figs. 6, 7)

Hastigerinella riedeli Rögl and Bolli, 1973, p. 507, Pl. 4, Figs 1–5, Pl. 14, Figs. 1–3, Text-Figs. 5a–5b.

Hastigerinopsis riedeli (Rögl and Bolli), Poore, 1979, p. 472, Pl. 19, Figs. 1–4.

Neogloboquadrina dutertrei (d'Orbigny) 1839
(Pl. 2, Figs. 8, 9)

Globigerina dutertrei d'Orbigny, 1839, p. 84, Pl. 4, Figs. 19–21.
Neogloboquadrina dutertrei (d'Orbigny), Rögl and Bolli, 1973, p. 510, Pl. 9, Figs. 1–3 and 7–10; Pl. 7, Figs. 1–6.

Neogloboquadrina incompta (Cifelli) 1961
(Pl. 2, Figs. 10, 11)

Globigerina incompta Cifelli, 1961, p. 38, Pl. 4, Figs. 1–7.
Neogloboquadrina pachyderma incompta Cifelli), Rögl and Bolli, 1973, p. 571, Pl. 10, Figs. 11–22.

Neogloboquadrina pachyderma (Ehrenberg) 1861
(Pl. 3, Figs. 1, 2)

Aristospira pachyderma Ehrenberg, 1861, p. 276, 277, and 303.

Table 7. Distribution of planktonic foraminifers in Hole 685A.

Hole 685A	Abundance	Preservation	*Globigerina bulloides*	*Globigerina calida calida*	*Globigerina calida praecalida*	*Globigerina decoraperta*	*Globigerina eamesi*	*Globigerina falconensis*	*Globigerina praebulloides*	*Globigerina quinqueloba*	*Globigerina rubescens*	*Globigerina umbilicata*	*Globigerinoides cyclostomus*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides trilobus*	*Globoquadrina altispira*	*Globorotaloides hexagona*	*Orbulina sturalis*	*Orbulina universa*	*Globigerinella aequilateralis*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita uvula*	*Globorotalia anfracta*	*Globorotalia bermudezi*	*Globorotalia cibaoensis*	*Globorotalia crassula*	*Globorotalia cultrata menardii*	*Globorotalia hirsuta*	*Globorotalia inflata*	*Globorotalia minutissima*	*Globorotalia obesa*	*Globorotalia pumilio*	*Globorotalia scitula*	*Globorotalia siakensis*	*Globorotalia theyeri*	*Globorotalia tumida tumida*	*Beella digitata*	*Hastigerinopsis riedeli*	*Neogloboquadrina acostaensis*	*Neogloboquadrina blowi*	*Neogloboquadrina dutertrei*	*Neogloboquadrina humerosa*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*	*Pulleniatina obliquiloculata*	*Catapsydrax dissimilis*	*Catapsydrax stainforthi*	*Cassigerinella chipolensis*
1, (2) 94-96	C	C	A	T				A			R							R	T	R		C	C	T					T			F	F	T				R		F			A	A				
1, CC	R	G	T																																														
2, (4) 73-75	A	G	A					A		C		F						R		T		R	C									F	F	R		T		T	R	R			A	A				
2, CC	R	G	F					T		T												T										T	T							R			T	C				
3, CC	R	G	R					R												T													T							T	F			R				
4, (1) 115-117	A	G	A					A		F			T					T		T		F	R		T					T		F	C	T		T			F	F	F	A	C				
4, CC	R	G	C					T		C								T			T	A										C		C	T								A	C				
5, (2) 87-89	B																																															
5, CC	R	G								T																																							
6, (2) 114-116	B																																															
6, CC	F	G	A			T		C		C	R							R	T	R	R	C										C	C	T		T		R		R	F		A	C	T			
7, (1) 76-78	B																																															
7, CC	R	G	F			T		T		F								R				F	T									F		T		T				T			C	A				
8, (4) 38-41	R	G																														T		T														
8, CC	B																																															
9, (4) 79-82	B																																															
9, CC	R	G	T										T	R	T	T		T				T	T									T				T				R	T	T	R				
10, (4) 82-85	R	G								C												A	F			T						C	T										C	A				
10, CC	R	P						T			T											R	R																			T	T		R	T				
11, (5) 88-91	F	G						R										T	T	T		C	F		T							C		T							F	C	A	T			
11, CC	R	G								C												A										A												A	A				
12, (4) 72-74	R	G	R															T				R	T									F										C	F		A				
12, CC	F	G	A					F		F								R	R			F	R	R								C	R	T					R	T	A	F	F	A	C				
13, CC	B																																															
14, (3) 35-37	B																																															
14, CC	R	G	A					F		C								F		T		F	C									R		T							T		A	A				
14, (4) 55-57	R	G	R																																								T			C				
15, CC	R	G	R					T																								R										T			A				
16, (3) 13-15	R	G																				T	R																					C	A				
16, CC	R	G	F							T			T					T				R										T												F	A				
17, (4) 85-87	F	G								T												F	C	T								T										T	R	C	A				
17, CC	R	M								T										T		T	T									T												R					
18, (6) 53-55	F	G	C					R		F													R	R			T			T		F	R	T										C	A				
18, CC	F	G	C					C		C												F	C	T						T		F	R						R					A	A				
19, (1) 37-39	B																																															
19, CC	R	G	C							F												C	C									C												A	A				
20, (4) 84-85	B																																															
20, CC	B																																															
21, CC 43-46	B																																															
21, CC	R	G	F																																										C	C				
22, (4) 74-77	B																																															
22, CC	F	G	A					T		F	T		T				C					F	F									F										A		A	A				
23, CC	R	G	T																																								T						
25, CC	B																																															
27, (1) 101-103																																																
27, CC	B																																															
28, (2) 25-27	B																																															
28, CC	B																																															
29, (1) 96-98	B																																															
29, CC	B																																															
30, (2) 56-59	B																																															
30, CC	B																																															
31, CC 20-23	B																																															
31, CC	B																																															
32, (4) 72-75	B																																															
32, CC	B																																															
33, (1) 14-16	B																																															
33, CC	B																																															
34, (3) 88-90	B																																															
34, CC																																																

Table 7 (continued).

Hole 685A	Abundance	Preservation	*Globigerina bulloides*	*Globigerina calida calida*	*Globigerina calida praecalida*	*Globigerina decoraperta*	*Globigerina eamesi*	*Globigerina falconensis*	*Globigerina praebulloides*	*Globigerina quinqueloba*	*Globigerina rubescens*	*Globigerina umbilicata*	*Globigerinoides cyclostomus*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides trilobus*	*Globoquadrina altispira*	*Globorotaloides hexagona*	*Orbulina sturalis*	*Orbulina universa*	*Globigerinella aequilateralis*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita uvula*	*Globorotalia anfracta*	*Globorotalia bermudezi*	*Globorotalia cibaoensis*	*Globorotalia crassula*	*Globorotalia cultrata menardii*	*Globorotalia hirsuta*	*Globorotalia inflata*	*Globorotalia minutissima*	*Globorotalia obesa*	*Globorotalia pumilio*	*Globorotalia scitula*	*Globorotalia siakensis*	*Globorotalia theyeri*	*Globorotalia tumida tumida*	*Beella digitata*	*Hastigerinopsis riedeli*	*Neogloboquadrina acostaensis*	*Neogloboquadrina blowi*	*Neogloboquadrina dutertrei*	*Neogloboquadrina humerosa*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*	*Pulleniatina obliquiloculata*	*Catapsydrax dissimilis*	*Catapsydrax stainforthi*	*Cassigerinella chipolensis*
35, (6) 90-92	B																																														
35, CC	B																																														
36, (7) 72-75	B																																														
36, CC	B																																														
37, (2) 60-62	B																																														
37, CC	B																																														
38, (1) 28-30	B																																														
38, CC	R	P					T	T										T				C				R							F						F						
39, (4) 73-76	B																																														
39, CC	B																																														
40, (3) 34-46	B																																														
40, CC	B																																														
41, CC	B																																														
42, (2) 48-50	B																																														
42, CC	B																																														
43, (1) 18-20	B																																														
43, CC	B																																														
44, CC	R	G					F	R	R															F									C												R	T	T
45, CC 10-13	B																																														
45, CC	B																																														
46, CC 15-18																																															
46, CC	B																																														
47, (1) 88-90	B																																														
47, CC	B																																														
48, (2) 39-42	B																																														
48, CC	B																																														
49, CC	B																																														
50, (1) 66-68	R	G																																												T	
50, CC	R	M					R		T													T									R	R			T								T		T

NOTE: A=abundant (>10% of assemblage); C=Common (3–10%); F=few (0.5–3%); R=rare (<0.5%); T=trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

Neogloboquadrina pachyderma (Ehrenberg), Rögl and Bolli, 1973, p. 571, Pl. 11, Figs. 2–6.

Catapsydrax dissimilis (Cushman and Bermudez) 1937
(Pl. 3, Figs. 3, 4)

Globigerina dissimilis Cushman and Bermudez, 1937, p. 25, Pl. 3, Figs. 4–6.

Catapsydrax dissimilis (Cushman and Bermudez), Bolli, 1957, p. 116, Pl. 7, Figs. 6–8.

Cassigerinella chipolensis (Cushman and Ponton) 1932
(Pl. 3, Figs. 5, 6)

Cassidulina chipolensis Cushman and Ponton, 1932, p. 98, Pl. 15, Figs. 2a–2c.

Cassigerinella chipolensis (Cushman and Ponton), Bolli, 1957, p. 108, Pl. 22, Figs. 3a–3c.

Acarinina pseudotopilensis Subbotina, 1953
(Pl. 3, Figs. 7, 8)

Acarinina pseudotopilensis Subbotina 1953, p. 294, Pl. 21, Figs. 8a–9c; Pl. 31, Figs. 1a–3c.

Acarinina interposita Subbotina, 1953
(Pl. 3, Fig. 9)

Acarinina interposita Subbotina 1953, p. 303, Pl. 23, Figs. 6a–7c.

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Table 8. Distribution of planktonic foraminifers in Holes 686A and 686B.

	Abundance	Preservation	*Globigerina bulloides*	*Globigerina calida*	*Globigerina decoraperta*	*Globigerina falconensis*	*Globigerina megastoma*	*Globigerina quinqueloba*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides tenellus*	*Globoturaloides hexagona*	*Orbulina universa*	*Globigerinella aequilateralis*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita parkerae*	*Globigerinita uvula*	*Globorotalia bermudezi*	*Globorotalia crassaformis crassaformis*	*Globorotalia cultrata menardii*	*Globorotalia inflata*	*Globorotalia obesa*	*Globorotalia praepumilio*	*Globorotalia pumilio*	*Globorotalia puncticulata*	*Globorotalia scitula*	*Globorotalia theyeri*	*Globoturalia tosaensis*	*Hastigerinopsis riedeli*	*Neogloboquadrina dutertrei*	*Neogloboquadrina eggeri*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*	*Pulleniatina obliquiloculata*
Hole 686A																																		
1, CC	B																																	
2, CC	B																																	
3, CC	B																																	
4, CC	B																																	
5, CC	B																																	
6, CC	B																																	
7, CC	B																																	
8, CC	R	G	F					T						F	F							F				T					A	A	
9, CC	R	G	T					T														T									T	T	
10, CC	B																																	
11, CC	B																																	
12, CC	B																																	
13, CC	B																																	
14, CC	R	G	F											T	T		C					C									A	A	
15, CC	B																																	
16, CC	R	G	C	T		C		C				T	R	F	F	R	T	T	T			C				T			F	F	T	A	A	
17, CC	R	G	T	T		T		T																								T	T	
18, CC	R	G	A	T				A							C				T	T			C		C					C	T	A	A	
19, CC	R	G	A	T				T						T						T		T										T		
20, CC	R	G	A			C		A						F	C	T						T	C							T	C	A	C	
21, CC	R	G	A		T	C		C	T					C						T		T										C	C	
22, CC	R	G	C			F		C						C	F								C					T	T		T		A	A	
23, CC	R	G	T					A						T									T	T									T		
Hole 686B																																		
1, CC	B																																	
2, CC	B																																	
3, CC	B																																	
4, CC	B																																	
5, CC	B																																	
6, CC	B																																	
7, CC	R	G	C	T		F		C					T	F	C	R	T						C		F					F			A	A	
8, CC	B																																	
9, CC	B																																	
10, CC	B																																	
11, CC	B																																	
12, CC	B																																	
13, CC	R	M	C			C													T		T		C									C	A	
14, CC	B																																	
15, CC	R	G	C			T		C					T		F					T			C		A					T		A	A	
16, CC	B																																	
17, CC	B																																	
18, CC	B																																	
19, CC	B																																	
20, CC	R	G	A		T	C	T	C	T			T		F	C	T			T	C		F	T		C		T			T	C	F	C	F
21, CC	R	G	C					C			T				C	C	F		T				C		C		T			F			A	A	
22, CC	R	G	C			C									C			T					A		C								C	A	
23, CC	R	G	T		T										T	T			T				T		T		T						T	T	
24, CC	R	G																					T												
25, CC	B																																	
26, CC	B																																	
27, CC	B																																	
28, CC	R	G	C			F		R	R	T					R	R				R		R	C		R		R				C		A	A	
29, CC	R	G	T			T																	T			T				T			T	A	
30, CC	B																																	
31, CC	B																																	
32, CC	B																																	

NOTE: A=abundant (>10% of assemblage); C=Common (3–10%); F=few (0.5–3%); R=rare (<0.5%); T=trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

Table 9. Distribution of planktonic foraminifers in Holes 687A and 687B.

	Abundance	Preservation	*Globigerina bulloides*	*Globigerina calida*	*Globigerina decoraperta*	*Globigerina falconensis*	*Globigerina megastoma*	*Globigerina quinqueloba*	*Globigerina rubescens*	*Globigerinoides elongatus*	*Globigerinoides immaturus*	*Globigerinoides obliquus obliquus*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides tenellus*	*Globigerinoides trilobus*	*Globoquadrina conglomerata*	*Globorotaloides hexagona*	*Orbulina sturalis*	*Orbulina universa*	*Globigerinella aequilateralis*	*Globigerinita glutinata*	*Globigerinita iota*	*Globigerinita uvula*	*Turborotalita humilis*	*Globorotalia bermudezi*	*Globorotalia crassaformis crassaformis*	*Globorotalia crassula crassula*	*Globorotalia crassula viola*	*Globorotalia cultrata menardii*	*Globorotalia hirsuta*	*Globorotalia inflata*	*Globorotalia obesa*	*Globorotalia praepumilio*	*Globorotalia pumilio*	*Globorotalia scitula*	*Globorotalia theyeri*	*Globorotalia tumida*	*Hastigerinopsis riedeli*	*Neogloboquadrina blowi*	*Neogloboquadrina dutertrei*	*Neogloboquadrina eggeri*	*Neogloboquadrina incompta*	*Neogloboquadrina pachyderma*	*Pulleniatina obliquiloculata*
Hole 687A																																											
1, CC	R	G	A	T		C		A	F	T	T		T	R	F	T		F		T	R	C	F			T					T		F	C	C	T		T	T	T	C	T			T
2, CC	B																																											
3, CC	R	G	F	T		F		A	T										T	T		F	C	T							T	C		F	T			F	C	T		A	A	
4, CC	R	G	C			F		C	T	T							F		T			T					T					F				T				F	F		C	A	
5, CC	R	G	A	T		A		A														C					T	T													T	T		A	A	
6, CC	R	G	A			C		A	T													A		T			F							T		T				T	F		A	C	T
7, CC	B																																											
8, CC	B																																											
9, CC	R	G							T																																	A	A	
10, CC	R	G	A																			T																		C			A	C	
11, CC	R	M																				A				T																	A	A	
12, CC	R	M	T			T																										T											T		
13, CC	R	G						C														C	T	C		T																	A	A	
14, CC	R	G																																										T	T	
15, CC	R	G	T			T																																							
17, CC	R	G	A																				T	T															T		T		A	A	
18, CC	B																																											
19, CC	B																																											
20, CC	B																																											
21, CC	R	G	T																			T																		T	T		T		
22, CC	B																																											
Hole 687B																																												
1, CC	B																																											
2, CC	B																																											
3, CC	R	G	C					A		T								T					C	C		T	T					C			C				F			A	A	
4, CC	R	G	C					C													T	F	F									C			C							A	A	
5, CC	B																																											
6, CC	B																																											
7, CC	B																																											
8, CC	R	G	C			T		C														T			T		T						A									A	C	
9, CC	R	G	C	T		C						T			T							C	T				C				T		A			T							A	A	
10, CC	R	G	T			T		T										T				A					T						T							T			A	A	
11, CC	R	G																															T											T	T	
12, CC	R	G	T																					T																				T	T	
13, CC	R	G																																										T	T	
14, CC	R	G																				T				T																	T		
15, CC	R	G	C		T	F		C														F	T								T	F										A	A	
16, CC	R	G	A	F		C									T							F							T			A											A	A	
19, CC	B																																											
20, CC	R	G	A	C		A	F	T	A													C									T	C						T		T		A	C	
21, CC	B																																											
22, CC	B																																											

NOTE: A=abundant (>10% of assemblage); C=Common (3–10%); F=few (0.5–3%); R=rare (<0.5%); T=trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

Table 10. Distribution of planktonic foraminifers in Hole 688A.

	Abundance	Preservation	Globigerina bulloides	Globigerina calida	Globigerina falconensis	Globigerina megastoma	Globigerina quinqueloba	Globigerina rubescens	Globigerina umbilicata	Globigerinoides cyclostomus	Globigerinoides elongatus	Globigerinoides immaturus	Globigerinoides obliquus obliquus	Globigerinoides ruber	Globigerinoides sacculifer	Globigerinoides tenellus	Globoquadrina conglomerata	Globorotaloides hexagona	Orbulina suturalis	Orbulina universa	Globigerinella aequilateralis	Globigerinita glutinata	Globigerinita iota	Globigerinita minuta	Globigerinita uvula	Globorotalia anfracta	Globorotalia bermudezi	Globorotalia crassaformis crassaformis	Globorotalia cultrata menardii	Globorotalia hirsuta	Globorotalia inflata	Globorotalia minutissima	Globorotalia neominutissima	Globorotalia obesa	Globorotalia parkerae	Globorotalia pumilio	Globorotalia puncticulata	Globorotalia ronda	Globorotalia scitula	Globorotalia theyeri	Globorotalia tosaensis	Globorotalia tumida	Globorotalia ungulata	Hastigerinopsis riedeli	Beella digitata	Beella praedigitata	Neogloboquadrina acostaensis	Neogloboquadrina blowi	Neogloboquadrina dutertrei	Neogloboquadrina eggeri	Neogloboquadrina humerosa	Neogloboquadrina incompta	Neogloboquadrina pachyderma	Pulleniatina obliquiloculata	Sphaeroidinella dehiscens
Hole 688A																																																						
1, CC	R	M	A		C		F																																T															F					T	
2, CC	C	G	A	R	A	R	T	T			T	T						T	T	T		F	F	C		T									R	T	T						T			T	T		C				C	A		
3, CC	F	G	C		F			F						T				T	T			C	F	A					F					F		R			T			T	T		T			F	A	F		A	A	T	
4, CC	R	G					T																																					T							T						T	
5, CC	F	M	F		C		T						F		T		T	T			A						T					T		F			T			C						C	A	C		F		T	
6, CC	F	M	C		C		C						R				R	T	T		C	T	R	T				T					C		F			T					T				A	C			A	A	T	T
7(2), bottom	C	G	A		A		F		R				T	T			F	R	F	T	F	R	F	T			T			F		C	F		C	R		R	R				F				A	F	T		A	C		
7, CC	R	G	C		C		T													T											A	C		C												T	T			T	C		
8, CC	A	G	C		C		C										T				R	C					T					F				T	R				F				F	T		A	A		
9, CC	F	G	A		C		C			F				F		T		T	T	R		F	F										F		R								F				C	A	F		A	A	T	
10, CC	R	G	A		C		C													T		C	C					T				C	T	C					T					T		T		T				F	A		
11, CC	R	G	C		T		C										T	T				C					T						C		F									C								C	A		
12, CC	F	G	A		C	T	C										R	R	F	T	F	F					T					F					R					R				T	T			C	A		
13, CC	F	G	C		C		C										R				F	C					T					F		F			R				F				R	R			A	A		
14, CC	R	G	T		T																																								T								T	T		
15, CC	R	G	T		T		T														T		T																										T			T	T		
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18, CC	F	G	T		T								T								T																											T			T			
19, CC	F	M	A		C		C	R		T				T				R	F	R		C	C					T			T			F		R								R					A		T	C	A		
20, CC	B																																																					
21, CC	F	G	A		C		C			T				F	F	T		F				C	T		T			F					F		T	F		T	T	T	T	T					C	A		T	C	A	R	
22, CC	R	M	A		F		C										T					F												F		C			T	T								T			C	A		
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29, CC	R	M	T				T																				T																									T	A		
30, CC	B																																																					
31, CC	B																																																					
32, CC	R	M					T																T																																
33, CC	R	M	T																				T						T										T																	T		
34, CC	R	P	C	T	T		T			T									T				T						T										T					T										T					T	A		
35, CC	B																																																					
36, CC	R	P											T																																										T	
37, CC	B																																																					

NOTE: A=abundant (>10% of assemblage); C=Common (3–10%); F=few (0.5–3%); R=rare (<0.5%); T=trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

Table 11. Distribution of planktonic foraminifers in Hole 688E.

Hole 688E	Abundance	Preservation	*Globigerina eamesi*	*Globigerina foliata*	*Globigerina linaperta*	*Globigerina praebulloides*	*Globigerina quinqueloba*	*Globigerinoides sacculifer*	*Globoquadrina altispira altispira*	*Globoquadrina altispira globosa*	*Globoquadrina dehiscens dehiscens*	*Globigerinita glutinata*	*Globigerinita uvula*	*Globorotalia obesa*	*Catapsydrax dissimilis*	*Catapsydrax unicavus*	*Acarinina esnaensis*	*Acarinina pentacamerata*	*Acarinina pseudotopilensis*	*Acarinina punctocarinata*	*Acarinina soldadoensis*	*Morozovella lensiformis*	*Pseudohastigerina barbadoensis*
1, CC	B																						
2, CC	B																						
3, CC	B																						
4, CC	B																						
5, CC	B																						
6, CC	B																						
7, CC	B																						
8, CC	B																						
9, CC	B																						
10, CC	B																						
11, CC	B																						
12, CC	R	M	T	T		T		T		T	T	T		T									
13, CC	B																						
14, CC	B																						
15, CC	B																						
16, CC	B																						
17, CC	R	G										T											
18, CC	R	G				T			T				T										
19, CC	B																						
20, CC	B																						
21, CC	B																						
22, CC	R	G													T								
23, CC	B																						
24, CC	B																						
25, CC	B																						
26, CC	B																						
27, CC	B																						
28, CC	B																						
29, CC	B																						
30, CC	B																						
31, CC	B																						
32, CC	B																						
33, CC	B																						
34, CC	B																						
35, CC	B																						
36, CC	B																						
37, CC	R	P																					T
38, CC	R	P																T					
39, CC	B																						
40, CC	B																						
41, CC	B																						
42, CC	B																						
43, CC	B																						
44, CC	R	P															T	T	T	T	T	T	
45, CC	R	P																T					

NOTE: A=abundant (>10% of assemblage); C=Common (3–10%); F=few (0.5–3%); R=rare (<0.5%); T=trace (only one or two specimens in entire assemblage); B=barren. G=good; M=moderate; P=poor.

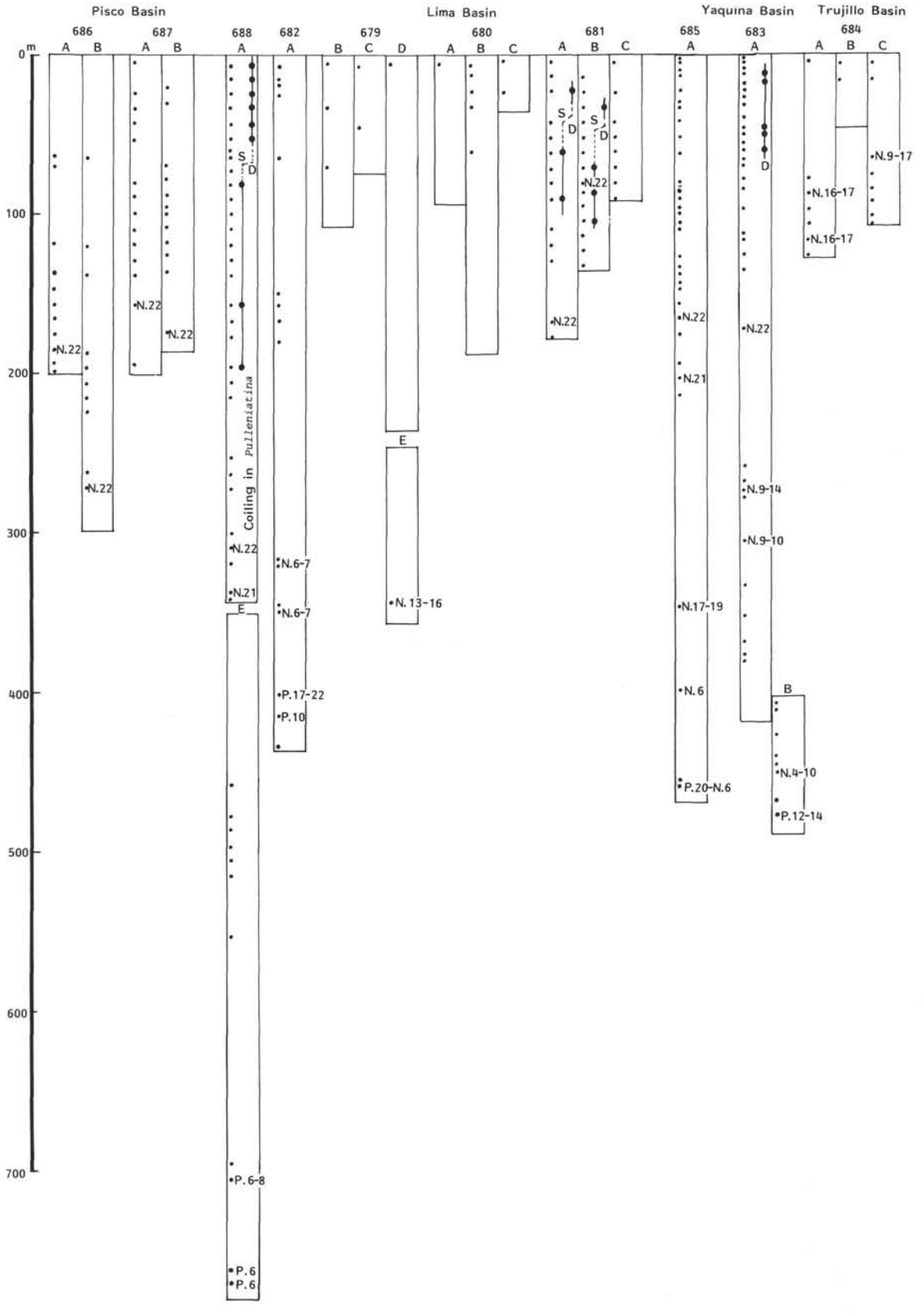

Figure 2. Occurrences of planktonic foraminifers in cores obtained during Leg 112 off Peru. Dots are sample horizons that include planktonic foraminifers. Ages are indicated by the planktonic foraminiferal zones of Blow (1969). D and S represent dextral and sinistral coiling of *Pulleniatina* spp., respectively.

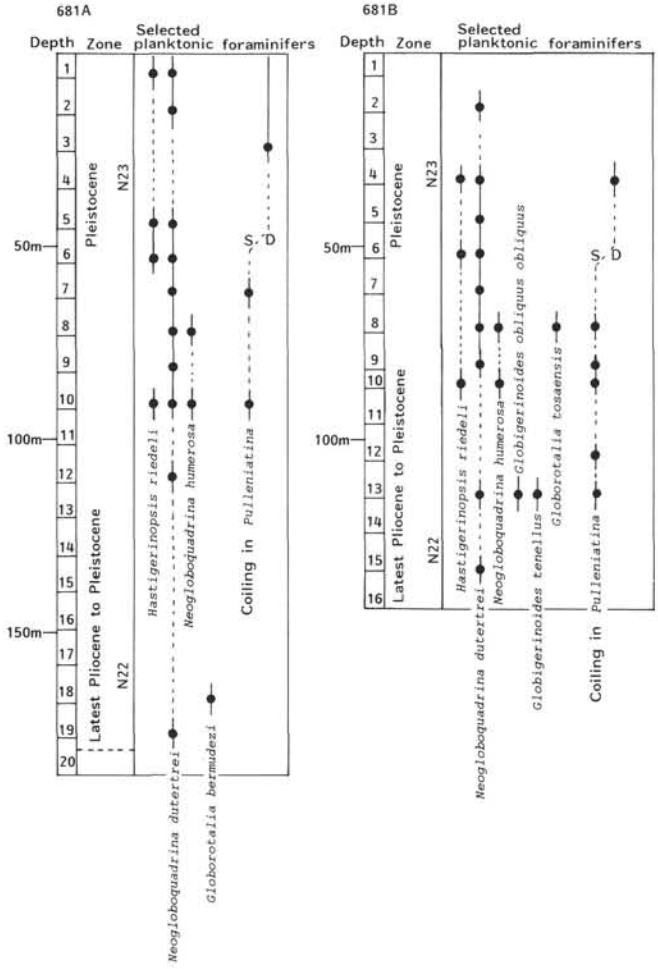

Figure 3. Range chart for selected taxa from Holes 681A and 681B. Planktonic foraminiferal zones after Blow (1969).

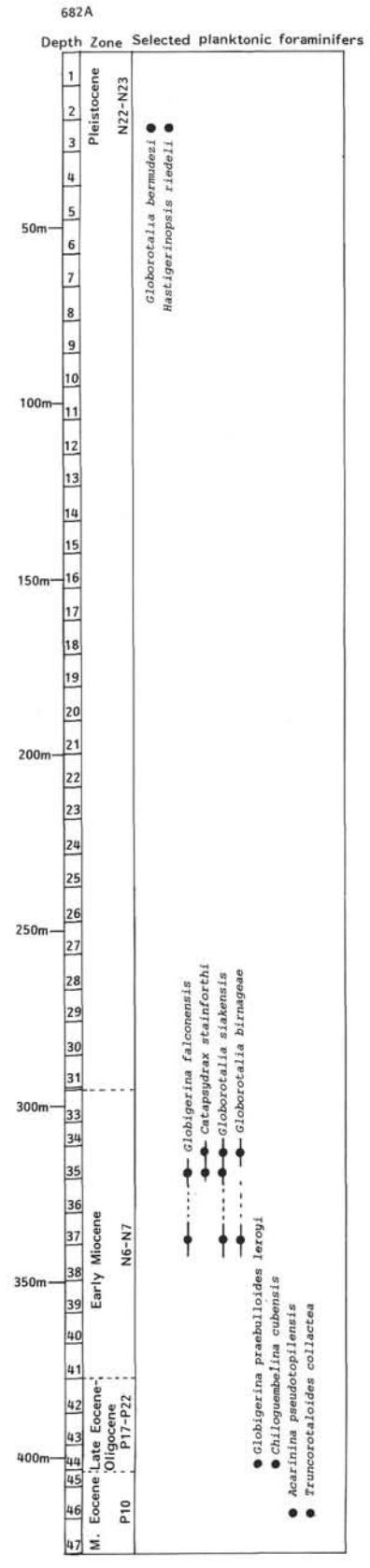

Figure 4. Range chart for selected taxa from Hole 682A.

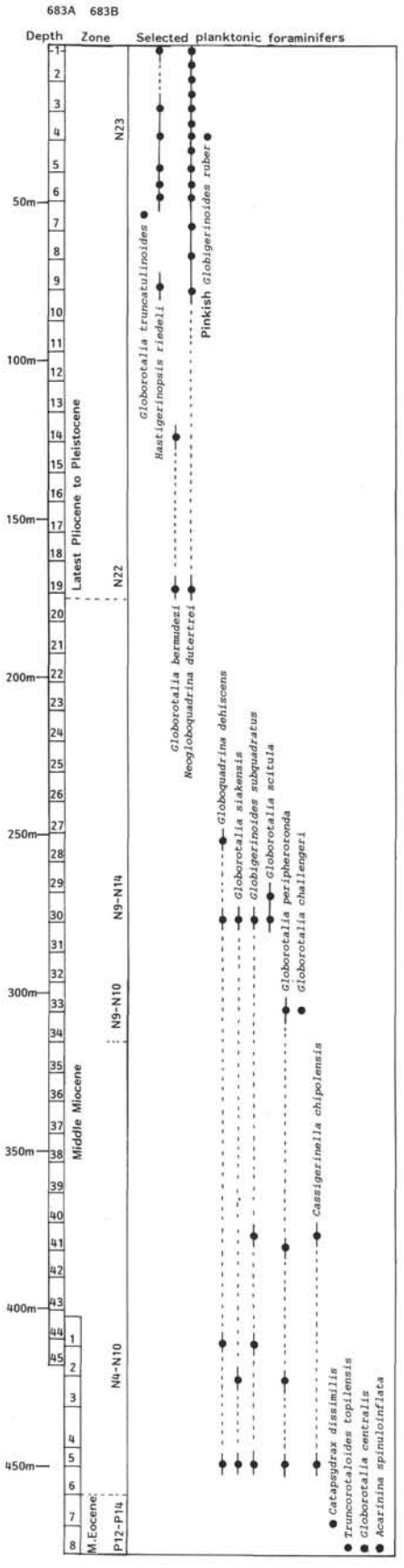

Figure 5. Range chart for selected taxa from Holes 683A and 683B.

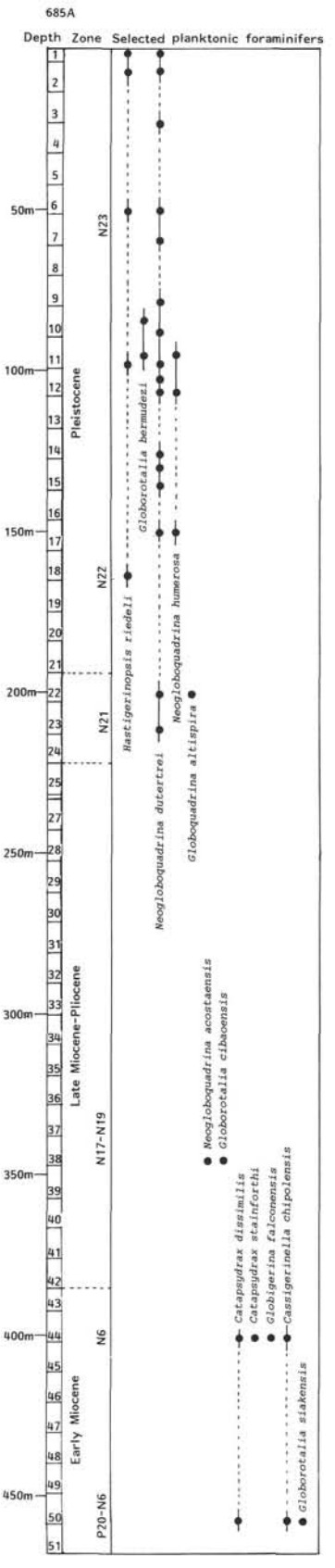

Figure 6. Range chart for selected taxa from Hole 685A.

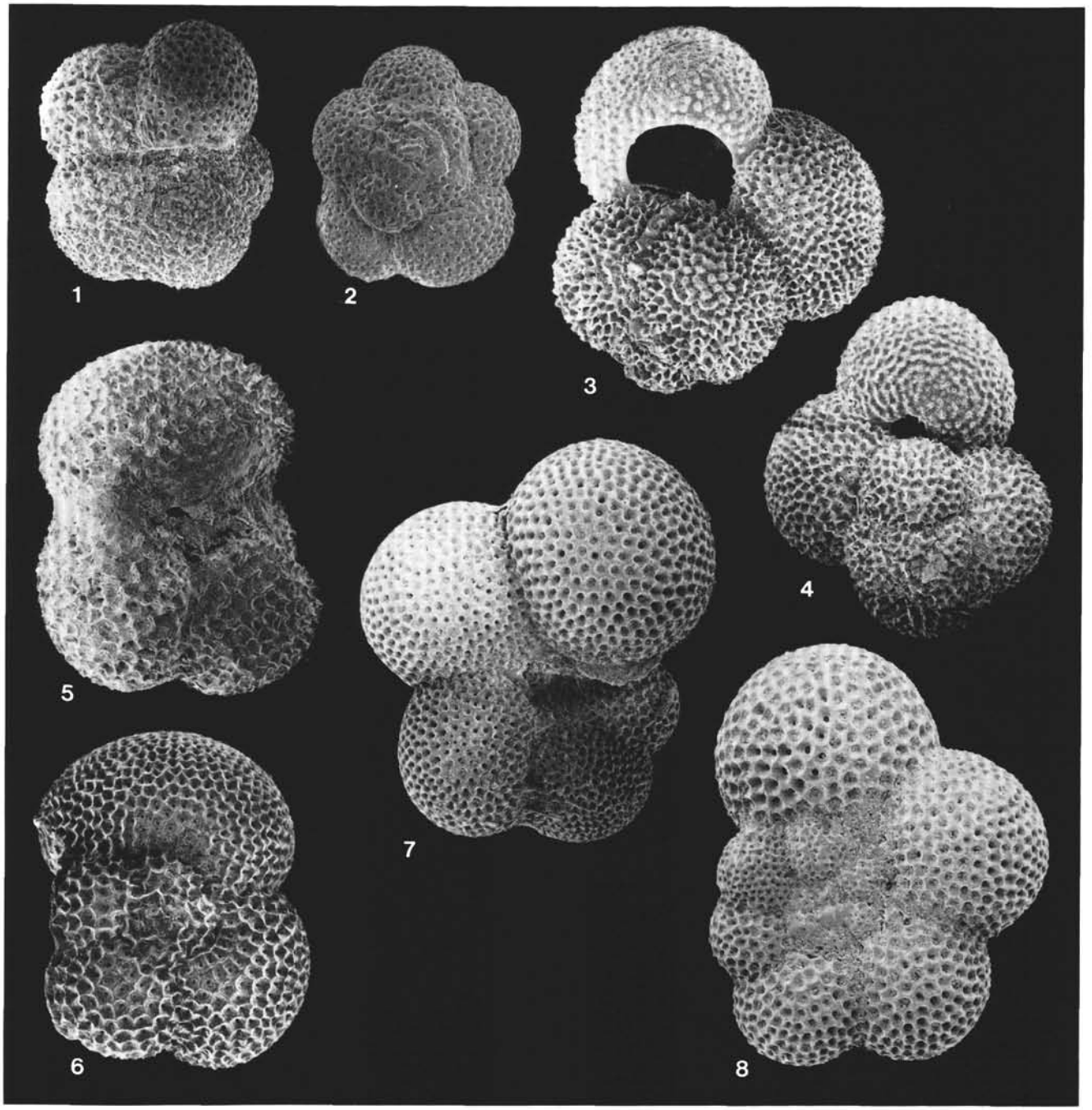

Plate 1. **1–2.** *Globigerina quinqueloba* Natland, umbilical and spiral side views, 160×; Sample 112-685A-6H, CC; Pleistocene. **3–4.** *Globigerinoides obliquus obliquus* Bolli, umbilical and spiral side views, 160×; Sample 112-684A-12H, CC; late Miocene. **5–6.** *Globoquadrina dehiscens* (Chapman, Parr, and Collins), umbilical and spiral side views, 160×; Sample 112-684A-12H, CC; late Miocene. **7–8.** *Globorotalia hexagona* (Natland), umbilical and spiral side views, 160×, Sample 112-688A-7H-2 to bottom; Pleistocene.

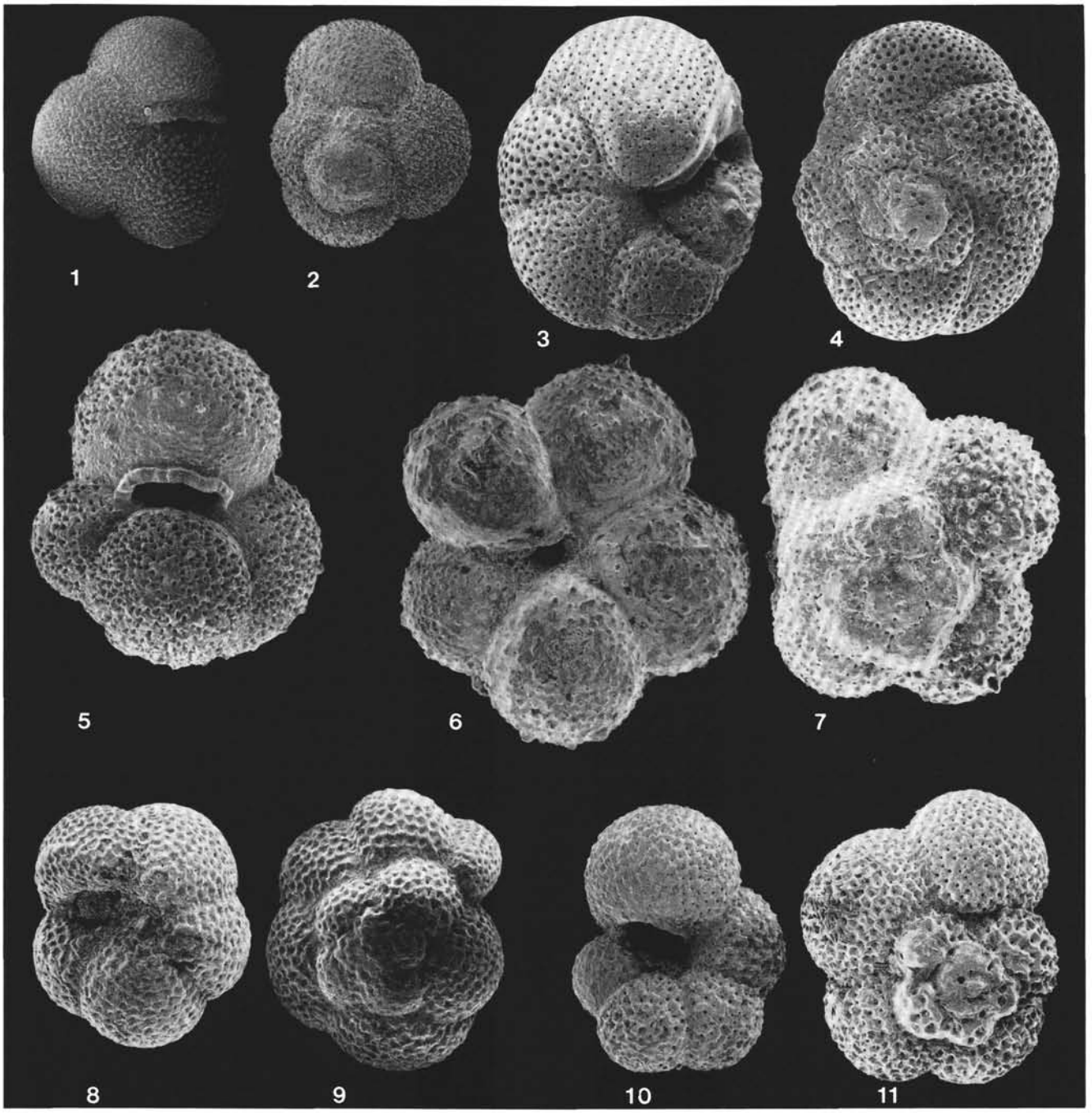

Plate 2. **1–2.** *Globigerinita glutinata* (Egger), umbilical and spiral side views, 160×, Sample 112-683A-7H, CC; Pleistocene. **3–4.** *Globorotalia peripheroronda* Blow and Banner, umbilical and spiral side views, 160×; Sample 112-683B-3H-3, 83–85 cm; early Miocene. **5.** *Beella praedigitata* (Parker), umbilical and side views, 160×; Sample 112-683A-6H-3, 58–59 cm; Pleistocene. **6–7.** *Hastigerinopsis riedeli* (Rögl and Bolli), unbilical and spiral side views, 320×; Sample 112-685A-6, CC; Pleistocene. **8–9.** *Neogloboquadrina dutertrei* (d'Orbigny), umbilical and spiral side views, 80×; Sample 112-685A-22, CC; Pliocene. **10–11.** *Neogloboquadrina incompta* (Cifelli), umbilical and spiral side views, 160×; Sample 112-688A-2H to bottom; Pleistocene.

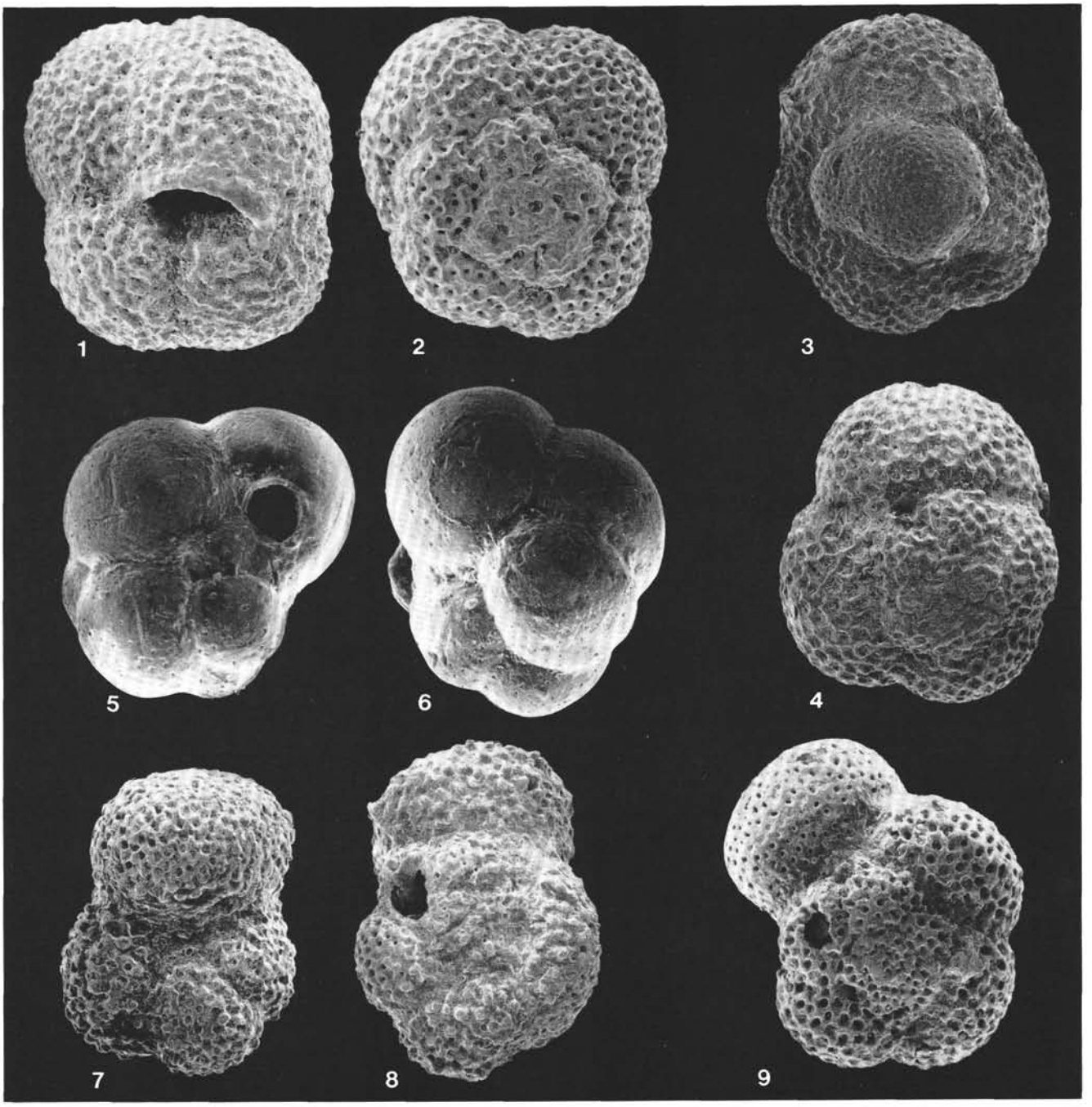

Plate 3. **1–2.** *Neogloboquadrina pachyderma* (Ehrenberg), umbilical and spiral side views, 320×; Sample 112-685A-22 CC; Pliocene **3–4.** *Catapsydrax dissimilis* (Cushman and Bermudez), umbilical and spiral side views, 160×; Sample 112–688E-22, CC; early Miocene. **5–6.** *Cassigerinella chipolensis* (Cushman and Ponton), umbilical and spiral side views, 400×; Sample 112-683B-5, CC; early Miocene. **7–8.** *Acaninina pseudotopilensis* Subbotina, umbilical and spiral side views, 160×; Sample 112-682A-46, CC; middle Eocene. **9.** *Acarinina interposita* Subbotina, spiral view, 160×; Sample 112-682A-46, CC; middle Eocene.