10. FORAMINIFERS FROM THE NANKAI TROUGH AND THE JAPAN TRENCH, LEG 87[1]

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ABSTRACT

Leg 87 investigated two sites in the Nankai Trough, off southeastern Japan, and one in the Japan Trench, off northeastern Japan. Several holes at the Nankai Trough sites penetrated mostly Quaternary interbedded sandy turbidites and hemipelagic mud. Foraminifers are common only in certain turbidite sands because both sites are at or just below the carbonate compensation depth. The planktonic assemblages from these sandy layers consist of mixed cool-temperate and warm-water species, and include both solution-resistant and solution-prone species. The benthic assemblages from these same layers are composed of mixtures of shelf to abyssal species. The northward-flowing Kuroshio is important in producing the mixed planktonic faunas, whereas turbidity currents are the primary agents in mixing benthic faunas and in the rapid burial of both planktonic and benthic foraminifers, which protects them from solution. Interbedded hemipelagic muds are barren or contain sparse faunas. Hole 582B penetrated through the trench-fill deposits into hemipelagic sediments that originated in the Shikoku Basin. These muds contain a dissolution facies of solution-resistant planktonic species, partially dissolved tests, and deep bathyal benthic species.

Drilling at Site 584, on the landward midslope of the Japan Trench, penetrated a section of dominantly diatomaceous mudstone. This section contains a meager Pliocene calcareous fauna in its upper third and a nearly monospecific assemblage of *Martinottiella communis* in the lower two-thirds. Diatom biostratigraphy indicates that this change in assemblages occurs near the Miocene/Pliocene boundary. Similar biofacies changes are observed in neighboring sections drilled during Legs 56 and 57. The change from agglutinated to calcareous faunas is probably related to a relative drop in the carbonate compensation depth at the end of the Miocene.

INTRODUCTION

Drilling on Leg 87 was designed primarily to investigate subduction-related processes in the Nankai Trough and the Japan Trench (Fig. 1). The results from this drilling were combined with previous information from Legs 31, 56, and 57 to derive models of these processes in the two different settings (see site reports, Sites 582–584, this volume). Adjunctive to these process-related investigations was the opportunity to investigate the nature of foraminiferal faunas within the trench fill of the Nankai Trough and the Japan Trench. This chapter will focus mainly on the Nankai Trough, where most of the drilling took place and for which previous information is most lacking. The foraminifer-poor sediments at Site 584 in the Japan Trench will be briefly compared with sediments from nearby sites drilled during Legs 56 and 57.

In general, the objectives of foraminiferal studies during Leg 87 included (1) the identification of planktonic foraminiferal faunas to provide biostratigraphic ages and paleoenvironmental information about surface water masses; and (2) the identification of benthic foraminiferal faunas to provide paleoenvironmental information about deep-water mass structure and paleobathymetry.

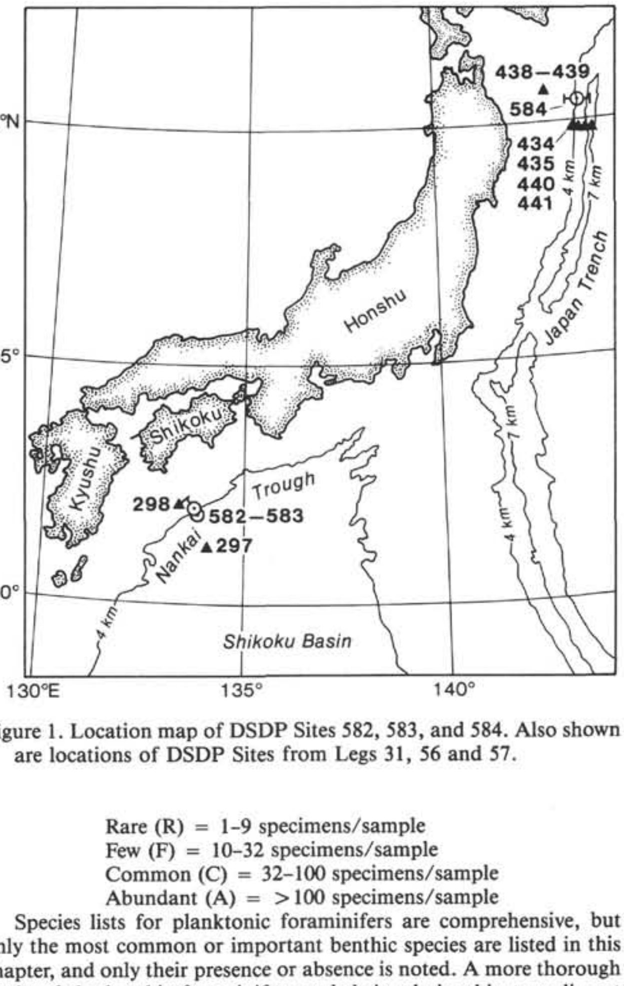

Figure 1. Location map of DSDP Sites 582, 583, and 584. Also shown are locations of DSDP Sites from Legs 31, 56 and 57.

METHODS

All samples were processed on board the *Glomar Challenger.* Approximately 10–20 cm^3 of sediment was wet-sieved; the dried residue was then sieved at 149 μm, and the foraminifers were picked. Abundances of planktonic foraminifers are reported as follows:

Rare (R) = 1–9 specimens/sample
Few (F) = 10–32 specimens/sample
Common (C) = 32–100 specimens/sample
Abundant (A) = >100 specimens/sample

Species lists for planktonic foraminifers are comprehensive, but only the most common or important benthic species are listed in this chapter, and only their presence or absence is noted. A more thorough study of the benthic foraminifers and their relationship to sediment gravity flows is currently in progress.

[1] Kagami, H., Karig, D. E., Coulbourn, W. T., et al., *Init. Repts. DSDP*, 87: Washington (U.S. Govt. Printing Office).
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The faunas examined are well illustrated in several publications (e.g., Saito et al., 1981; Thompson, 1980; Keller, 1980a, 1980b; Matoba, 1967). The taxonomy of planktonic species generally follows that given by Saito and others (1981), supplemented by that of Kennett and Srinivasan (1983). The planktonic zonation used follows Blow (1969). Paleobathymetric inferences from benthic foraminiferal faunas are based on the work of Ingle (1980), Matoba (1977), and Thompson (1980). Taxonomic notes on the species listed are given at the end of this chapter.

NANKAI TROUGH: SITES 582 AND 583

The Nankai Trough is a broad subduction zone located off southeastern Japan (Fig. 1). This rather shallow trench also forms the northern boundary of the Shikoku Basin.

Two sites were drilled in the Nankai Trough: Site 582 in the undeformed sediment filling the trench axis and Site 583 on the lowermost, landward structural terrace. Site 582 was intended to provide a reference section with respect to the more deformed sediments encountered at Site 583.

Site 582

Three holes at Site 582 penetrated a composite sediment thickness of 749.4 m. Two major lithologic units are recognized: (1) 560 m of trench fill composed of interbedded turbidite sands and hemipelagic mud overlying (2) approximately 190 m (to total depth) of Shikoku Basin-related hemipelagic deposits. The foraminifers contained within these two lithologic units exhibit important differences (Table 1; Fig. 2).

Planktonic Foraminifers

The upper 560 m of trench-fill deposits (Unit 1) contains a diverse assemblage of planktonic foraminifers, but they occur sporadically. In general, the hemipelagic mud interbeds exhibit lower abundance and diversity, whereas sandy beds often have both high abundance and diversity.

All the sediments of Unit 1 are Quaternary, Zone N22/23 (Blow, 1969). Important marker species include *Globorotalia truncatulinoides, Neogloboquadrina eggeri*, and the modern form of *Globorotalia inflata*. The faunas are usually dominated by *Globorotalia inflata*, various species of *Neogloboquadrina*, and the *Globigerina bulloides* group.

Site 582 is at 4879 m water depth. Data from piston cores within the Nankai Trough (Inoue, 1978) suggest that this depth is at or just below the carbonate compensation depth (CCD). In spite of this, several sandy layers contain significant abundances of solution-prone species (Berger, 1979), such as *Globigerinoides ruber, Globigerinoides trilobus*, and *Globigerinella siphonifera*. The assemblages combine solution-resistant and solution-prone species deposited at or below the CCD.

In addition, these assemblages represent mixtures of cool-temperate species—such as *Globorotalia inflata*, dextral *Neogloboquadrina pachyderma*, and *Turborotalia quinqueloba*, which indicate the transition between the northern boundary of Western North Pacific Central Water and Subarctic Pacific Water (Sverdrup et al., 1942; Coulbourn et al., 1980)—with species indicating warmer surface waters, such as *Globigerinoides* spp., *Globorotalia tumida, Globorotalia menardii*, and *Globigerinella siphonifera*.

The lower lithologic unit (Unit 2) is composed of hemipelagic sediments deposited within the Shikoku Basin and contains a fauna dominated by such solution-resistant species as *Globorotalia inflata, Sphaeroidinella dehiscens*, and *Neogloboquadrina* spp. Partially dissolved specimens are also common, whereas solution-prone species are rare. The sandy turbidite layers, host to diverse assemblages and so common in Unit 1, are rare in this lower unit.

The planktonic faunas within Unit 2 are not highly age-diagnostic, although they do indicate a Pliocene or younger (Zone N19 or younger) age. The Pliocene/Pleistocene boundary occurs within this unit, on the basis of calcareous nannofossil data (see Lang, this volume).

Benthic Foraminifers

Benthic foraminifers are, like the planktonic forms, most abundant and diverse within sandy turbidite layers of Unit 1. These species are excellent indicators of bathymetry and water-mass structure (Table 2). The assemblages found within sandy layers at Site 582 (Table 1) exhibit significant bathymetric mixing. Many layers contain species originally occurring from the shelf (e.g., *Ammonia* spp., *Elphidium* spp.) to lower bathyal/abyssal depths (e.g., *Planulina wuellerstorfi, Melonis pompilioides*). This mixing is consistent with the turbidite origin of these sandy layers. The interbedded hemipelagic muds tend to have few benthic foraminifers, and those are predominantly deep bathyal forms.

The benthic faunas within Unit 1 are roughly divided into two biofacies. The uppermost samples are dominated by very transparent specimens of *Chilostomella oolina* and *Globobulimina auriculata*, and the diversity tends to be relatively low. This group will be called the *Chilostomella oolina* biofacies, and is best developed in Hole 582, down to the base of Core 582-3. The two dominant species of this biofacies are often associated with low-oxygen conditions (Ingle, 1980), although the detailed paleoenvironmental significance of this fauna at Site 582 is still being investigated.

Below Core 582-3, the *Chilostomella oolina* biofacies is replaced by a more diverse assemblage of benthic foraminifers, which exhibits the bathymetric mixing already described. This assemblage is called the mixed biofacies, and predominates down to a barren interval in Core 582B-51.

Although the benthic foraminifers in Unit 1 are generally of little use in determining biostratigraphic ages, a rare occurrence of *Hyalinea balthica* in Core 582-29 does corroborate the Quaternary age based on planktonic foraminifers.

Unit 2 of Site 582 contains a sparse foraminiferal fauna consisting predominantly of deeper bathyal forms such as *Planulina wuellerstorfi, Pullenia bulloides*, and *Sphaeroidina bulloides* (Table 1). Mixing of shallower faunas is minimal within this unit, as expected for the hemipelagic sedimentation characteristic of the Shikoku Basin. This assemblage will be called the basin plain biofacies.

Summary

Sediments penetrated at Site 582 are characterized by two major planktonic and three benthic biofacies (Fig. 2). These biofacies are the products of diverse oceanographic and depositional processes.

The planktonic faunas of Unit 1 are mixtures of cool-temperate species and warmer-water species brought north by the Kuroshio. Coiling ratios of *Neogloboquadrina pachyderma* (Table 1), though often based on few specimens per sample, exhibit overwhelmingly dextral coiling throughout Unit 1. This preference indicates that Site 582 was not affected by the migrations of the front between the Kuroshio and Oyashio that was taking place to the north (Thompson and Shackleton, 1980).

The often excellent preservation of mixed solution-prone and solution-resistant species within sandy layers reflects their rapid burial in turbidites. In contrast, the faunas from the hemipelagic deposits of Unit 2 make up a dissolution facies dominated by solution-resistant species and partially dissolved tests, a result of slower deposition at or below the CCD.

The benthic faunas show the results of downslope mixing by sediment gravity flows and possibly the effects of low-oxygen water masses. Both shallow-water and deep-water species were redeposited in the turbidites, and the rapid burial helped preserve them. The turbidity currents certainly redeposit the planktonic foraminifers, but the extent of this process is difficult to assess. Interbedded hemipelagic muds contain a sparse, deep bathyal fauna.

Site 583

Eight holes were drilled at Site 583, on the lowermost landward terrace of the Nankai Trough (Figs. 1 and 3): four hydraulic piston core (HPC) holes—583, 583A, 583B, and 584C—and four rotary core holes—583D, 583E, 583F, and 583G. Three of the holes (583B, 583C, and 583E) were very short because of mechanical problems and are not discussed in detail. The drilling at Site 583 penetrated sediments generally equivalent to Unit 1 at Site 582. Sediments equivalent to Unit 2 (Shikoku Basin deposits) were not reached at this site.

Hole 583

The initial HPC hole at Site 583 cored a section of 152 m, consisting of interbedded sandy and silty turbidites and hemipelagic muds. The uppermost cores are either barren or contain very sparse foraminiferal faunas (Table 3). The planktonic faunas in the rest of the hole are similar to those in Unit 1 at Site 582. These assemblages indicate a Quaternary age (Zone N22/23) and contain *Globorotalia truncatulinoides, Neogloboquadrina eggeri*, and the modern form of *Globorotalia inflata*. The coiling of *Neogloboquadrina pachyderma* is overwhelmingly dextral, as it was at Site 582. The planktonic assemblages again are mixtures of solution-resistant and solution-prone species and are most abundant in sandy turbidite layers.

Benthic foraminifers are absent in the upper two cores, but Core 583-3 contains the *Chilostomella oolina* biofacies (Table 3). Below Core 583-3, the benthic faunas belong to the mixed biofacies and contain abundant examples of mixed shallow-water and deep-water species. Core 583-8 contains *Hyalinea balthica*, indicating a Quaternary age.

Hole 583A

This hole penetrated 54 m of section; core recovery was excellent. The lithology recovered is similar to that in Hole 583, but Core 583A-1 did contain a thin, brown muddy layer at its top, in contrast to the normal gray to olive gray sediments recovered elsewhere. This layer probably represents the modern surface sediment layer, which is usually lost during normal drilling operations.

The planktonic faunas in Hole 583A are Quaternary (Zone N22/23) and are similar to those in Hole 583 (Table 4). The benthic fauna from the brown muddy layer in Core 583A-1 is an agglutinated assemblage similar to assemblages found throughout the Pacific Ocean below the CCD. The upper half of Hole 583A contains a very well developed *Chilostomella oolina* biofacies, but the lower half is largely barren of benthic foraminifers.

Holes 583B and 583C

These holes penetrated 28 m (583B) and 24 m (583C) of section. The faunas are similar to those found in Holes 583 and 583A. The planktonic faunas indicate a Quaternary age (Zone N22/23).

Hole 583D

This first rotary core hole was drilled to a depth of 326.6 m but cored only below the interval sampled by the HPC holes. Recovery was poor, and the foraminiferal faunas tended to be sparse (Table 5). The planktonic faunas are Quaternary (Zone N22/23), and *Neogloboquadrina pachyderma* coiling is mostly dextral. The benthic faunas are sporadic in occurrence and all belong to the mixed biofacies (Table 5). *Hyalinea balthica* is found in Cores 4, 5, and 19 from this hole, also indicating a Quaternary age.

Hole 583E

This hole penetrated 48.3 m of section, but only 1 m of core was recovered. The samples examined were barren of foraminifers.

Hole 583F

Hole 583F was washed down to approximately 160 m and then a section of 289.3 m was cored, also with poor core recovery. The sparse planktonic faunas are Quaternary (Zone N22/23), and the benthic foraminifers belong to the mixed biofacies (Table 6).

Hole 583G

This hole was washed down to 306.6 m, and then an interval of 143.4 m was cored. As with the previous rotary-core holes, the planktonic faunas are Quaternary

Table 1. Distribution of planktonic and selected benthic foraminifers from Site 582, Nankai Trough.

Core-Section, interval (cm)	Barren samples = B	Planktonic foraminifers																					Benthic foraminifers																																
		Globigerina bulloides group	Globigerinella siphonifera	Globigerinita glutinata	Globigerinoides conglobatus	Globigerinoides cyclostomus	Globigerinoides ruber	Globigerinoides sacculifer	Globigerinoides trilobus	Globorotalia inflata	Globorotalia menardii	Globorotalia scitula	Globorotalia truncatulinoides	Globorotalia tumida	Neogloboquadrina eggeri	Neogloboquadrina pachyderma	Neogloboquadrina sp.	Orbulina universa	Pulleniatina obliquiloculata	Turborotalia quinqueloba	Sphaeroidinella dehiscens	Neogloboquadrina pachyderma coiling[a] (100% S — 50% — 100% D)	Saccammina sp.	Hyperammina sp.	Unilocular lagenids	Globobulimina auriculata	Chilostomella oolina	Cassidulina minuta	Silicosigmoilina sp.	Uvigerina spp.—costate	Ammonia sp.	Elphidium clavatum	Elphidium crispum	Melonis pompilioides	Tosaia hanzawai	Bolivinita quadrilatera	Bulimina aculeata	Melonis barleeanum	Uvigerina spp.—hispidocostate	Amphicoryna scalaris sagamiensis	Planulina wuellerstorfi	Bulimina marginata	Siphogenerina raphanus	Bulimina tenuata	"Loxostomum" karrerianum	Uvigerina spp.—hispid	"Loxostomum" bradyi	Florilus labradoricum	Pullenia bulloides	Pyrgo murrhyna	Oridorsalis tener	Sphaeroidina bulloides	Pararotalia? sp.	Hyalinea balthica	Hoeglundina elegans
Hole 583																																																							
1-1, 26-31		F	R	R		R				R					R				R				X	X	X		X																												
1-3, 36-41		R	R	R	R				R	R	R	R	R		F			R	R							X	X																												
1,CC		F		R		R	R		R	R	R		R		R	F		R	R	R		•				X	X	X	X																										
3-1, 49-54										R							R															X	X																						
3-2, 7-12															R										X																														
3-5, 75-80		R				R	R			F			R		R	R						o				X		X		X	X	X																							
3-6, 75-80		R		R		R	R			F					F	F	R		R			o			X		X							X	X																				
3,CC		C	R			C	F		F	C		R	F		C	C		R	R			•			X			X		X	X		X	X		X	X	X	X	X	X	X	X												
Hole 583A																																																							
1-3, 97-101		C	R	R	R	C	C		R	C			R		C	C	C	R	R		R	•			X					X	X	X	X	X		X	X		X		X	X	X	X	X										
1-4, 97-101		C		R		C	F	R	R	C			R		C	C	F	R	R	R		•						X		X	X	X		X		X	X				X	X	X		X	X	X	X	X						
1,CC		C	R	R		F	F		R	C	R	R	R		C	F	C	R	R			•						X		X	X		X			X	X	X		X	X	X	X					X	X	X	X	X			
2-2, 33-38		C	R	R		F	C		R	C			F	R	F	C	F	R	R	R		•			X			X		X		X	X	X		X	X	X		X	X	X	X		X	X		X							
2,CC		R							R	R					R	R	R					o												X	X			X																	
Hole 583B																																																						
1,CC		R							R	R	R				R	R						o			X									X																					
2-1, 39-41		R															R														X		X								X		X										X		
2-1, 119-123	B																																																						
2-2, 93-98	B																																																							
2-2, 119-123																																	X																						
2-3, 119-123	B																																																						
2-4, 119-123		R					R			R			R				R	R									X								X																		X			
2,CC		R		R																																																			
3,CC		F				R	R		R	R					R	R	R	R	R			o				X																													
5-2, 123-128		C				F	C	R	F	C	R	R	R		F	F	F		F			•						X		X	X	X	X	X	X	X	X	X		X	X													X		
5-2, 139-144	B																																																						
5,CC						R				R																																													
7,CC		C	R		R	F	F		R	C	R	R	R		R	C	F		F	R		•			X						X				X		X						X					X	X						
8-2, 13-18		C	R	R		F	F		R	C	R				F	F	F		F	R		•			X									X	X																	X			
8,CC										R							?								X										X																				
9-1, 40-45		F		R			R		R	R					R	R	R	R				o																																	
9-2, 40-45				R		R																			X			X																											
9,CC		R				R	R			R			R				R			R																																			
10-3, 50-54	B																																																						
10-5, 50-54	B																																																						
11,CC																																	X																						
12-1, 25-30	B																																																						
12,CC		R						R		R					R	R	R			R		o			X			X									X																		

14-1, 9-11|B|																																																						
14-5, 68-73										?		R																																											
14,CC																R																																						
15-1, 54-59		F			R	F	F		F	C		R	R		F	R	F		R			o			X			X		X	X		X	X		X	X			X		X	X			X			X					
16-2, 56-61	B																																																						
17,CC																																	X																						
18-1, 119-123	B																																																						
19-3, 44-49	B																																																						
19,CC										R																																													
22-2, 5-9	B																																																						
22-5, 5-9	B																																																						
22,CC										X					X				X																																					
23-1, 82-86		R								R							R								X									X								X													
23-3, 40-44	B																																																						
23-6, 106-110		R	R			R	R		R	R	R					R	R		R						X									X								X													
23,CC		F	R	R		R	R		R	F	R		R		F	R	F	R	R			o			X	X															X													
24,CC	B																																																						
25-2, 26-31	B																																																						
25-4, 38-43		C		R	R	F	F		F	C			R		R	R	F	R	R	R		o																																	
25,CC	B																																																						
26,CC	B																																																						
29-1, 54-59				R	R	F	R		F	C		R		R	F	C	F	R	R		R	•			X			X		X	X	X	X	X			X	X		X		X	X					X			X			X	X
29,CC to	B																																																						
31,CC	B																																																						
32-2, 145-150		C	R	F		F	F	R	R	C	R	R			R	F	C	R	R	R		•			X					X			X				X	X			X		X							X					
32-3, 5-10		R							R	R			R			R		R	R						X			X														X	X						X					
32,CC		R														R																																						
33-4, 110-115		R		R	R	R	R		R	R					R	F	R					•									X	X		X	X		X	X						X						X					
33,CC		C		R		F	F		R	C	R		R			F	F		R			•			X			X		X	X					X	X	X	X		X		X					X						
34,CC		R								R						R														X							X						X											
37,CC	B																																																						
38,CC	B																																																						
39,CC		R				R				R	R					R																					X																	
40,CC	B																																																						
41,CC								R	R			R			R	R					o									X	X	X					X						X											
42,CC	B																																																						
43,CC										R					R				R												X	X		X	X			X			X			X										X			
44,CC to	B																																																						
50,CC	B																																																						
51,CC		F		R		F	R			R			R			R	R					o			X			X		X	X		X	X			X	X	X		X		X											
52,CC to	B																																																						
59,CC	B																																																						
60,CC		R					R			A	R		R		F	R	F	R			R	o													X	X			X			X								X	X	X				
61,CC	B																																																						
62,CC										R						R																																							
63,CC	B																																																						
64-4, 36-38		R							R	F	R						R			R	R														X						X													
64,CC	B																																																						
65,CC		R		R						R			?																																									
68,CC		R							R	R							R																		X				X									X		X				X			
69,CC		R								R						R																															X							
70,CC	B																																																						
71,CC		R		R		R	R		R	F	R						R	R	R		R														X														X			X			
72,CC		R		R		R	R		R	F							R				R				X	X														X								X	X		X			
73,CC		R		F		R			R	F				R		R	R	R	F		R	o																X		X											X			

Note: R, F, C, A denote relative abundances of planktonic foraminifers, as explained in text. X denotes presence of benthic species.
[a] Number of specimens used for *N. pachyderma* coiling: o < 15; • ≥ 15; coiling directions: S (sinistral), D (dextral).

Table 2. Bathymetrically significant benthic foraminifers found at Nankai Trough sites, Leg 87.

Neritic species (0–150 m)	
Ammonia beccarii	*Elphidium clavatum*
Ammonia japonica	*Elphidium crispum*
Bulimina marginata	*Quinqueloculina* spp.
Species transitional from neritic to upper bathyal	
Ammonia takanabaensis	*Amphicoryna scalaris sagamiensis*
Upper bathyal species (150–500 m)	
Buliminella tenuata	*Florilus labradoricum* +
Chilostomella oolina +	*Uvigerina peregrina*
Middle bathyal species (500–2000 m)	
Bulimina aculeata +	*Melonis barleeanum* +
Bolivinita quadrilatera	*Oridorsalis tener* +
Globobulimina auriculata	*Uvigerina akitaensis*
Globocassidulina subglobosa	*Uvigerina* spp.—hispid +
Martinottiella communis +	*Uvigerina yabei*
Lower bathyal to abyssal species (>2000 m)	
Gyroidina soldanii	*Planulina wuellerstorfi*
Melonis pompilioides	*Pullenia bulloides*

Note: Species marked by a + are also important at deeper depths. Table compiled from Matoba (1977), Ingle (1980), Thompson (1980), and Keller (1980b).

(Zone N22/23) and the benthic faunas belong to the mixed biofacies (Table 7).

Summary

In Figure 3, the various HPC and rotary-core holes are combined into composite sections for the area of Site 583, so that the biofacies present can be compared with those found at Site 582. The planktonic foraminifers are very similar to those found in Unit 1 at Site 582. They are Quaternary, are dominated by cool-temperate species (e.g., *Globorotalia inflata, Neogloboquadrina* spp.) with associated warmer-water species (e.g., *Globigerinoides* spp.), and represent mixtures of solution-resistant and solution-prone species. All the holes at Site 583 are located below 4600 m water depth, so turbidity currents play an important role in the preservation of the faunas deposited below the CCD.

Two of the benthic foraminiferal biofacies recognized at Site 582 are also found at Site 583 (Fig. 3). The *Chilostomella oolina* biofacies is present at shallow levels within the cored intervals, but the majority of these sections contain the mixed biofacies, which exhibits significant bathymetric mixing of faunas by turbidity currents. In addition, the agglutinated fauna found at the top of Hole 583A probably represents another biofacies that is not well preserved downcore.

The faunas and the processes affecting them are similar at both Site 582 and Site 583. The oceanographic mixing of planktonic faunas, the depositional mixing of benthic faunas, and the rapid burial of both by turbidity currents account for these unusually diverse assemblages found below the CCD. Similar processes can be expected to be important throughout this trench system and in similar systems in the geologic record.

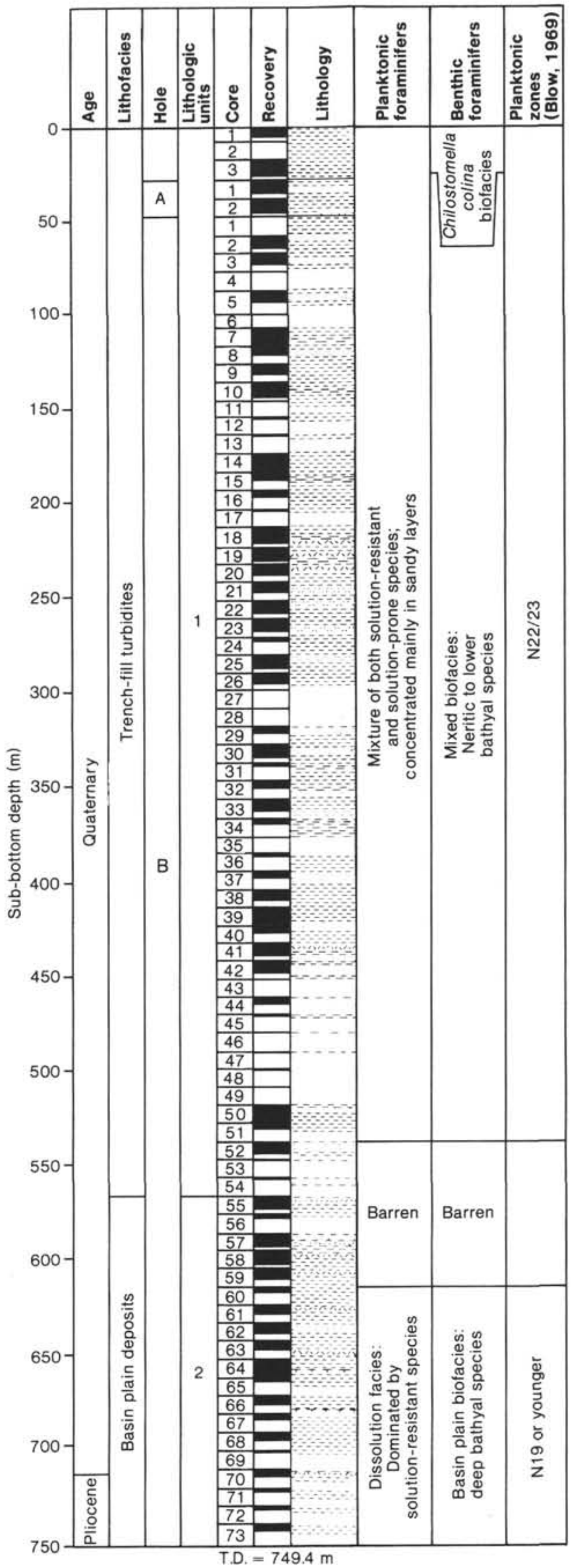

Figure 2. Summary of foraminiferal biofacies at Site 582, Nankai Trough.

Table 3. Distribution of planktonic and selected benthic foraminifers, Hole 583, Nankai Trough.

		Planktonic foraminifers																							Benthic foraminifers																													
Core-Section interval (cm)	Barren samples = B	*Globigerina bulloides* group	*Globigerinella siphonifera*	*Globigerinita glutinata*	*Globigerinoides conglobatus*	*Globigerinoides cyclostomus*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides trilobus*	*Globorotalia inflata*	*Globorotalia menardii*	*Globorotalia scitula*	*Globorotalia truncatulinoides*	*Globorotalia tumida*	*Neogloboquadrina eggeri*	*Neogloboquadrina pachyderma*	*Neogloboquadrina* sp.	*Orbulina universa*	*Pulleniatina obliquiloculata*	*Turborotalia quinqueloba*	*Sphaeroidinella dehiscens*	*Neogloboquadrina pachyderma* coiling[a] 100% S	50%	100% D	*Globobulimina auriculata*	*Chilostomella oolina*	*Uvigerina* spp.—costate	*Florilus labradoricum*	*Bolivinita quadrilatera*	*Elphidium clavatum*	Unilocular lagenids	*Uvigerina* spp.—hispid	*Uvigerina* spp.—hispidocostate	*Tosaia hanzawai*	"*Loxostomum*" *bradyi*	*Planulina wuellerstorfi*	*Siphogenerina raphanus*	*Melonis pompilioides*	*Gyroidina orbicularis planata*	*Elphidium crispum*	*Pyrgo murrhyna*	*Ammonia* spp.	*Bulimina aculeata*	*Cassidulina minuta*	*Hoeglundina elegans*	*Bulimina marginata*	*Oridorsalis tener*	*Hyalinea balthica*	*Amphicoryna scalaris sagamiensis*	"*Loxostomum*" *karrerianum*	*Melonis barleeanum*	*Pullenia bulloides*	*Gyroidina soldanii*	*Martinottiella communis*
1-1, 79-82	B																																																					
1,CC									R	?		R																																										
2-1, 51-53		?																																																				
2-3, 51-53	B																																																					
2,CC		?																																																			
3-3, 54-57		F	R			R	R			R						R	R	R						o	X	X	X	X	X	X	X	X	X	X	X																			
3-5, 50-53			R			F	F			C					C	F		R	F					o	X				X							X	X	X																
3,CC		R		R		R			R	R					R																					X	X		X															
4-2, 11-14		F		R		R	?	?	R	F			R		F	F			R					•			X		X							X	X			X	X	X	X											
4-6	B																																																					
4,CC	B																																																					
5-2, 70-73		R				R	R			R				R		R	R		R					o																														
5,CC		R	R			R				R						R	R							o																														
6,CC		C		R	R	F			R	F	R				R	R	F		R					o	X	X	X		X				X				X			X		X		X	X	X	X							
7-3, 62-65	B																																																					
7,CC	B																																																					
8-3, 130-133		C			R	F	F	R	F	C	?	R	R		C	F	F	R	F	R				•			X		X		X	X	X				X	X		X		X	X			X	X	X	X	X	X			
8,CC		C	R		R	F	F		F	C		R	R		C	C	F	R	R					•			X	X	X	X	X	X	X	X			X	X		X	X		X			X	X		X	X	X	X		
9,CC			R		?	R		R	R	C	R		R	R	F	R		F	F		R			o	X		X		X		X					X	X			X	X	X			X		X						X	X
10,CC		R					R	R	R	F			R		R	R		R	R					o			X									X	X	X				X			X						X			
11,CC		R								R					R	R			R	R				o				X			X			X											X									
12,CC		C			R	F	R		F	C	R	R	R		C	C		R	R					•			X		X	X		X			X			X		X		X	X	X		X			X					
13,CC		C	R	R	R	F	F		F	F		?	R		F	F		F	R					o			X		X	X	X										X					X					X			
14,CC							R		?	R						R																								X														X
15,CC		R	R			R	R		R	C			R		F	R		R	R					o										X		X	X			X	X	X			X								X	
17,CC						R									?	R						o									X																							
19,CC		C	R	R		C	F		F	C	R	R	R		F	C		R	R					•			X		X	X	X	X	X	X		X	X	X		X		X	X	X	X	X	X		X		X	X		
20,CC		C		F		F	F		F	F			R	R	F	F		R	R	R				•			X	X			X	X		X	X	X	X			X	X	X	X	X	X		X		X					
21,CC		F				R														R											X																							
23,CC							R		R	R	R				R															X															X									X
24,CC									R	R	R																																								?			

Note: R, F, C denote relative abundances of planktonic foraminifers, as explained in text. X denotes presence of benthic species.
[a] Number of specimens used for *N. pachyderma* coiling: o < 15; • ≥ 15; coiling directions: S (sinistral), D (dextral).

Table 4. Distribution of planktonic and selected benthic foraminifers, Hole 583A, Nankai Trough.

Core, Section	Barren samples = B	Planktonic foraminifers														Benthic foraminifers													
		Globigerina bulloides group	*Globigerinoides conglobatus*	*Globigerinoides cyclostomus*	*Globigerinoides ruber*	*Globigerinoides trilobus*	*Globigerinoides siphonifera*	*Globorotalia inflata*	*Globorotalia menardii*	*Globorotalia truncatulinoides*	*Globigerinita glutinata*	*Neogloboquadrina eggeri*	*Neogloboquadrina pachyderma*	*Orbulina universa*	*Pulleniatina obliquiloculata*	*Reophax* sp.	*Trochammina* sp.	*Haplophragmoides* sp.	*Proteonina* sp.	*Globobulimina auriculata*	*Chilostomella oolina*	*Melonis pompilioides*	*Tosaia hanzawai*	*Textularia* sp.	Unilocular lagenids	*Epistominella nipponica*	*Pyrgo murrhyna*	*Gyroidina nipponica*?	*Planulina* cf. *wuellerstorfi*
1[a]										R				R		X	X	X	X										
1,CC		C		F	R	R	R	F		R	R	C	F	R						X	X	X	X						
2,CC		R		R	R		R	F	R	R	R	R	R	R						X	X		X	X					
3,CC		F			R		R	F		R		F	R	R	R					X	X		X	X					
4,CC		R		R		R		R				R	R		R					X	X		X		X	X			
5,CC		R	R	R	R	R		R	R		R		R	R	R					X	X	X	X		X	X	X	X	
6,CC	B																			X	X								
7,CC		R	R	R		R		R		R		R																	
8,CC to	B																												
10,CC	B																												
11,CC		R		R		R		R					R																X

Note: R, F, C denote relative abundances of planktonic foraminifers, as explained in text. X denotes presence of benthic species.
[a] Sample from very top of Core 1; thought to be Recent sediment layer.

JAPAN TRENCH: SITE 584

Drilling at Site 584 (Fig. 1) sought to investigate the geologic history of a section on the middle trench slope off Honshu. This location was selected to be seaward of the postulated Oyashio landmass, delineated by drilling during DSDP Legs 56 and 57. Three holes were drilled at Site 584, but only one, Hole 584, was extensively cored. Foraminifers are sparse throughout the hole (Table 8), particularly in the lower two-thirds. Fortunately, diatoms are common throughout and form the basis for most biostratigraphic age determinations (see Akiba, this volume). The foraminifers do provide scattered biostratigraphic support, and the benthic faunas indicate some changes in the water-mass structure during the Neogene at this site.

Hole 584

Hole 584 penetrated 941 m of section, dominantly diatomaceous mudstone, and bottomed in middle Miocene sediments (Akiba, this volume). Foraminifers are sparse in the upper third of the section and very rare in the lower two-thirds (Table 8).

Planktonic Foraminifers

Planktonic foraminifers occur sporadically and in low abundance down to Core 584-42. The faunas are generally not age-diagnostic, but the occurrence of *Globorotalia* cf. *puncticulata* and the absence of *Globorotalia inflata* suggest a Pliocene age. A moderately abundant fauna in Core 584-21 contains *Pulleniatina primalis, Globorotalia* cf. *cibaoensis, Globorotalia* cf. *puncticulata*, and *Sphaeroidinellopsis*? sp., and indicates an early Pliocene age (Zone N19/20). The dominant planktonic species in most samples are *Neogloboquadrina pachyderma, Globigerina bulloides* group, and *Globorotalia* cf. *puncticulata*. This assemblage represents cool-temperate to subarctic surface-water temperature. The occurrences of planktonic foraminifers are too sporadic to reveal any climatic fluctuations.

The section below Core 584-42 is barren of planktonic foraminifers.

Benthic Foraminifers

The benthic faunas in Hole 584 also exhibit dramatic changes within the section (Table 8). Above Core 584-43, the assemblages are generally calcareous and indicative of lower bathyal to abyssal depths (greater than 2000 m). Key species include *Martinottiella communis, Melonis pompilioides, Melonis barleeanum, Planulina wuellerstorfi*, and hispid uvigerinids. Some downslope mixing from middle bathyal depths is apparent, but not to the extent observed in the Nankai Trough sites.

Below Core 584-42 the benthic foraminifers consist largely of *Martinottiella communis* and little else. This dramatic change in biofacies may be related to the level of the CCD; the agglutinated assemblages below Core 584-42 would result from deposition beneath it. Whether this change in the CCD is due to uplift of the section above that level or a drop in the level itself is presently unclear.

Summary

Most of the Pleistocene is missing at Site 584 (see Akiba, this volume). The Pliocene section below the basal Pleistocene unconformity is characterized by sparse, generally calcareous foraminiferal faunas. The planktonic foraminifers indicate a Pliocene age and cool-tem-

Table 5. Distribution of planktonic and selected benthic foraminifers, Hole 583D, Nankai Trough.

		Planktonic foraminifers																				Neogloboquadrina pachyderma coiling[a]		
Core-Section, interval (cm)	Barren samples = B	Globigerina bulloides group	Globigerinella siphonifera	Globigerinita glutinata	Globigerinoides conglobatus	Globigerinoides cyclostomus	Globigerinoides ruber	Globigerinoides sacculifer	Globigerinoides trilobus	Globorotalia inflata	Globorotalia menardii	Globorotalia scitula	Globorotalia tosaensis	Globorotalia truncatulinoides	Globorotalia tumida	Neogloboquadrina eggeri	Neogloboquadrina pachyderma	Neogloboquadrina sp.	Orbulina universa	Pulleniatina obliquiloculata	Turborotalia quinqueloba	100% S	50%	100% D
1,CC										R														
2,CC	B																							
3,CC						R				R			?				R			R				o
4,CC		F			R	F	R		F	C		R		R		F	F		R	F				•
5,CC		R				R			R	F							R							o
6-1, 96–100	B																							
6,CC	B																							
7-1, 25–30						R				R														
7,CC										R						R								
8-1, 25–30 to	B																							
9-3, 110–112	B																							
9,CC				R		R			R								R							o
10-1, 23–25 to	B																							
12,CC	B																							
13-1, 55–56		R		R		R				R														
13,CC	B																							
14-2, 86–91		R								R								?						
14,CC to	B																							
15,CC	B																							
16-3, 95–100		R		R		R	R		R	F		?		R		F	R			R				o
16,CC										R		?												
17,CC	B																							
18,CC	B																							
19-3, 54–58		F				F	R		R	C					?	F	F		R	R				•
19,CC		R																						
20-1, 24–29	B																							
20,CC		R					?			R				R		R	R							
21,CC to	B																							
22-3, 102–105	B																							
22-5, 102–105		R							R	F						R	R							o
22-6, 102–105				R				?		R									R					
22,CC						R				R						R	R							o
23,CC										R							R							o
24-2, 77–82										R														
24,CC	B																							
25-1, 77–82	B																							
25,CC		F	?	R		R															R			
26,CC	B																							
28,CC	B																							
29-1, 85–90		R				R			R								R	R		R				o
29-2, 85–90				R												?	R						o	
29,CC	B																							

	Benthic foraminifers																									
Core-Section, interval (cm)	Uvigerina spp.—hispid	Pullenia bulloides	Bulimina aculeata	Amphicoryna scalaris sagamiensis	Siphogenerina raphanus	Planulina wuellerstorfi	Hyalinea balthica	Karreriella? sp.	Bulimina marginata	Unilocular lagenids	Tosaia hanzawai	Elphidium crispum	Globocassidulina subglobosa	Cassidulina depressa	Melonis barleeanum	Uvigerina spp.—costate	Globobulimina spp.	Melonis pompilioides	"Loxostomum" bradyi	"Loxostomum" karreriana	Bolivinita quadrilatera	Pyrgo murrhyna	Martinottiella communis	Ammonia spp.	Florilus labradoricum	Bolivina subangularis osagaensis
1,CC																										
2,CC																										
3,CC																										
4,CC	X	X	X	X	X	X	X	X	X	X		X														
5,CC					X		X																			
6-1, 96–100																										
6,CC																										
7-1, 25–30																										
7,CC																										
8-1, 25–30 to																										
9-3, 110–112																										
9,CC						X				X	X															
10-1, 23–25 to																										
12,CC																										
13-1, 55–56																										
13,CC																										
14-2, 86–91										X																
14,CC to																										
15,CC																										
16-3, 95–100			X								X	X	X	X	X											
16,CC																										
17,CC																										
18,CC																										
19-3, 54–58	X	X	X	X	X		X			X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	
19,CC																										
20-1, 24–29																										
20,CC																										
21,CC to																										
22-3, 102–105																										
22-5, 102–105		X																								
22-6, 102–105											X															
22,CC																										
23,CC																										X
24-2, 77–82																										
24,CC																										
25-1, 77–82																										
25,CC										X				X												
26,CC																										
28,CC																								X		
29-1, 85–90										X																
29-2, 85–90										X								X								
29,CC																										

Note: R, F, C denote relative abundances of planktonic foraminifers, as explained in text. X denotes presence of benthic species.
[a] Number of specimens used for *N. pachyderma* coiling: o <15; • ≥15; coiling directions: S (sinistral), D (dextral).

Table 6. Distribution of planktonic and selected benthic foraminifers, Hole 583F, Nankai Trough.

		Planktonic foraminifers																		Benthic foraminifers																					
Core-Section, interval (cm)	Barren samples = B	*Globigerina bulloides* group	*Globigerinella siphonifera*	*Globigerinita glutinata*	*Globigerinoides cyclostomus*	*Globigerinoides ruber*	*Globigerinoides sacculifer*	*Globigerinoides trilobus*	*Globorotalia inflata*	*Globorotalia menardii*	*Globorotalia tosaensis*	*Globorotalia truncatulinoides*	*Neogloboquadrina eggeri*	*Neogloboquadrina pachyderma*	*Pulleniatina obliquiloculata*	*Turborotalia quinqueloba*	*Neogloboquadrina pachyderma* coiling[a] 100% S	50%	100% D	*Oridorsalis tener*	Unilocular lagenids	*Bulimina aculeata*	*Bulimina marginata*	*Pyrgo murrhyna*	*Siphogenerina raphanus*	*Elphidium crispum*	*Planulina wuellerstorfi*	*Melonis pompilioides*	*Globocassidulina subglobosa*	*Uvigerina* spp.—hispid	*Uvigerina* spp.—costate	*Ammonia* spp.	*Hoelundina elegans*	*Tosaia hanzawai*	*Sphaeroidina bulloides*	*Uvigerina* spp.—striate	*Uvigerina auberiana*	*Cassidulina depressa*	*Melonis barleeanum*	*Uvigerina* spp.—hispidocostate	*Pullenia bulloides*
2,CC	B																																								
3,CC		R							R					R					o	X	X																				
6-2, 44-49		R		R	R	R			R		R	R	R	R					o	X		X	X	X	X	X	X	X	X	X	X	X									
6,CC to	B																																								
8,CC	B																																								
11-1, 100-105							R								?																	X	X	X							
11,CC			R						R																X							X									
12-1, 71-75									R	R		R																													
12,CC	B																																								
13,CC												R																													
14-2, 52-55	B																																								
14,CC		R			R							R	R		R							X																			
15-1, 55-60	B																																								
15,CC									R																																
16-1, 55-60	B																																								
16,CC	B																																								
17-2, 26-31		R			R			R	F	R		R		R		R			o	X	X	X						X	X	X	X				X	X	X	X	X		
17,CC to	B																																								
19,CC	B																																								
20-1, 21-26		R			R			R	R	R		R		R	R				o	X			X	X	X		X		X	X		X			X						
20,CC to	B																																								
23,CC	B																																								
24-4, 64-66		R			R	R			R			R	R	R					o																						
24,CC to	B																																								
29-1, 41-44	B																																								
29,CC		R																			X									X	X						X			X	X

Note: R = rare; see text for details. X denotes presence of benthic species.
[a] Number of specimens used for *N. pachyderma* coiling: o <15; coiling directions: S (sinistral), D (dextral).

perate to subarctic surface-water temperatures. The benthic foraminifers indicate lower bathyal to abyssal deposition. There is a marked reduction in calcareous fauna below Core 584-42. This change in benthic foraminifers occurs just above the Miocene/Pliocene boundary as based on diatoms (Akiba, this volume). Miocene sediments contain nearly monospecific assemblages of *Martinottiella communis*, suggesting deposition below the CCD.

A comparison of broad faunal patterns with those of surrounding DSDP sites, drilled during Legs 56 and 57, shows that the basic patterns present at Site 584 are widespread (Fig. 4). The thickness of the Pleistocene sediments varies considerably; major unconformities occur at Sites 584 and 434. Pliocene sediments generally contain both planktonic and calcareous benthic faunas, though they are very sparse at Site 434 (Thompson, 1980).

Within the Pliocene at all Japan Trench sites, the agglutinated species *Martinottiella communis* makes its final appearance, although it ranges up into the Pleistocene at the Nankai Trough sites and into the Recent elsewhere. Miocene sediments at both Site 584 and Site 434 contain the nearly monospecific assemblages of this species. It is apparent that a major water-mass change occurred near the Miocene/Pliocene boundary, depressing the CCD. Higher on the trench slope, at Sites 438 and 439 (not shown on Fig. 4 but drilled in 1552–1656 m water depth), the Miocene sediments contain both planktonic and calcareous benthic foraminifers (Keller, 1980a, b). These sites were shallow enough during the late Miocene and Pliocene to be relatively unaffected by fluctuations in the CCD.

CONCLUSIONS

The foraminifers recovered from the Nankai Trough and the Japan Trench during Leg 87 occur in assemblages reflecting various oceanographic and depositional processes, of which the following have particular interest:

1. The effects of major ocean currents in mixing cool-temperate and warm-water faunas in Quaternary sediments at Sites 582 and 583 in the Nankai Trough.

2. The effect of turbidity currents in producing bathymetrically mixed benthic foraminiferal assemblages in these same deposits.

3. The influence of these same turbidity currents in preserving calcareous foraminiferal faunas below the CCD by rapid burial. In contrast, hemipelagic, basin plain deposits, originating in the Shikoku Basin, are significantly affected by carbonate dissolution.

4. The effects of major water-mass changes along the middle and lower Japan Trench slope. An apparent lowering of the CCD near the Miocene/Pliocene bound-

Table 7. Distribution of planktonic and selected benthic foraminifers, Hole 583G, Nankai Trough.

Core-Section interval (cm)	Barren samples = B	Planktonic foraminifers: *Globigerina bulloides* group	*Globigerinoides cyclostomus*	*Globigerinoides ruber*	*Globigerinoides trilobus*	*Globorotalia inflata*	*Globorotalia menardii*	*Globorotalia truncatulinoides*	*Neogloboquadrina pachyderma*	*Orbulina universa*	*Pulleniatina obliquiloculata*	*Turborotalia quinqueloba*	*Neogloboquadrina pachyderma* coiling[a]: 100% S	50%	100% D	Benthic foraminifers: *Oridorsalis tener*	*Melonis pompilioides*	*Planulina wuellerstorfi*	*Ammonia* spp.	*Elphidium crispum*	*Cassidulina depressa*	Unilocular lagenids	*Siphogenerina raphanus*	*Uvigerina auberiana*	*Uvigerina* spp.—costate	*Uvigerina* spp.—hispid	*Uvigerina* spp.—hispidocostate	*Bulimina aculeata*	*Globocassidulina subglobosa*	*Bulimina marginata*	*Gyroidina soldanii*	*Pyrgo murrhyna*	*Amphicoryna scalaris sagamiensis*
1-3, 49-54	B																																
1,CC	B																																
2-4, 64-69		R				R																											
2,CC		R								R		R																					
3,CC	B																																
4-3, 62-64		F	R	R		R		R	F		R				o	X	X	X	X	X	X	X	X	X	X								
4,CC	B																																
5,CC	B																																
6,CC					R	R																		X		X	X						
7,CC	B																																
8-2, 5-10		R	F	R	R	F		R	F	R	R				o		X			X	X		X		X	X	X	X	X				
8,CC						R		R	?															X	X	X							
9,CC			R		R	R			R						o											X	X						
10,CC	B																																
11,CC			R			R		R	R						o		X	X					X		X	X		X	X	X	X		
12,CC	B																																
13,CC	B																																
15,CC		R	R	?	R	F	R	F	R		R			o			X	X	X	X			X		X		X	X	X	X	X	X	X

Note: R, F denote relative abundances of planktonic foraminifers, as explained in text. X denotes presence of benthic species.
[a] Number of specimens used for *N. pachyderma* coiling: o <15; coiling directions: S (sinistral), D (dextral).

ary replaces very sparse agglutinated faunas in the Miocene with more diverse planktonic and calcareous benthic assemblages in the Pliocene.

TAXONOMIC NOTES

Original references for species listed in the tables are given below. Also included are comments on selected taxa and references to recent illustrations for several taxa.

Planktonic Foraminifers

Globigerina bulloides group

Within this group I have included *Globigerina bulloides* d'Orbigny, 1826, p. 277; *Globigerina falconensis* Blow, 1959, p. 177, pl. 9, figs. 40, 41; and *Globigerina umbilicata* Orr and Zaitzeff, 1971, p. 18, pl. 1, figs. 1-3.

Remarks. All three species are present in the assemblages studied, but for the purposes of this study no attempt was made to list them separately.

Globigerinella siphonifera (d'Orbigny)

Globigerina siphonifera d'Orbigny, 1839a, p. 83, pl. 4, figs. 15-18.
Globigerinella aequilateralis (Brady), Saito and others, 1981, p. 26, pl. 2, fig. 2.

Globigerinita glutinata (Egger)

Globigerina glutinata Egger, 1893, p. 371, pl. 13, figs. 19-21.
Globigerinita glutinata (Egger), Saito and others, 1981, p. 77, pl. 22, figs. 1-7.

Globigerinoides conglobatus (Brady)

Globigerina conglobata Brady, 1879, p. 286.
Globigerinoides conglobatus (Brady), Saito and others, 1981, p. 56, pl. 14, fig. 1.

Globigerinoides cyclostomus (Galloway and Wissler)

Globigerina cyclostoma Galloway and Wissler, 1927, p. 42, pl. 7, figs. 8-9.
Globigerinoides cyclostomus (Galloway and Wissler), Saito and others, 1981, p. 60, pl. 15, fig. 2.

Globigerinoides ruber (d'Orbigny)

Globigerina rubra d'Orbigny, 1839a, p. 82, pl. 4, figs. 12-14.
Globigerinoides ruber (d'Orbigny), Saito and others, 1981, p. 59, pl. 15, fig. 1.

Globigerinoides sacculifer (Brady)

Globigerina sacculifera Brady, 1877, p. 535.
Globigerinoides sacculifer (Brady), Saito and others, 1981, p. 65, pl. 17, fig. 2.

Globigerinoides trilobus (Reuss)

Globigerina triloba Reuss, 1850, p. 374, pl. 447, fig. 11.
Globigerinoides sacculifer (Brady), Saito and others, 1981, p. 65, pl. 17, fig. 1.

Remarks. Saito and others (1981) put *G. trilobus* in synonymy with *G. sacculifer*. Their pl. 17, fig. 1 illustrates the *trilobus* form; fig. 2 of their pl. 15 illustrates the *sacculifer* form.

Globorotalia inflata (d'Orbigny)

Globigerina inflata d'Orbigny, 1839b, *in* Barker-Webb and Berthelot, 1839, p. 134, pl. 2, figs. 7-9.
Globorotalia inflata (d'Orbigny), Saito and others, 1981, p. 124, pl. 41, fig. 1.

Globorotalia menardii (Parker, Jones, and Brady)

Rotalia menardii Parker, Jones, and Brady, 1865, p. 20, pl. 3, fig. 81.
Globorotalia menardii (Parker, Jones, and Brady), Saito and others, 1981, p. 147, pl. 50, fig. 1.

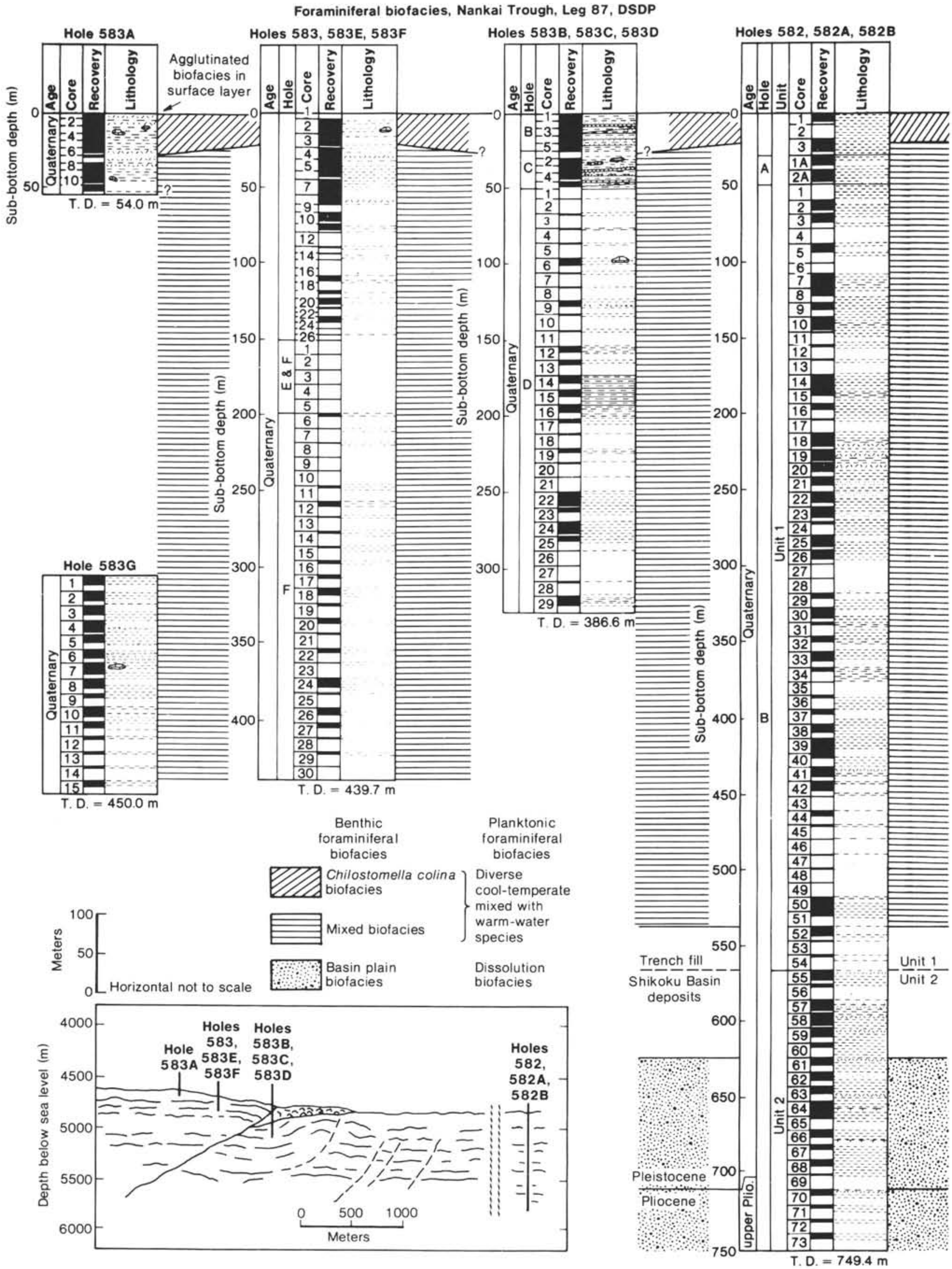

Figure 3. Summary of foraminiferal biofacies at Site 583, including comparison with those at Site 582, Nankai Trough.

Table 8. Distribution of planktonic and selected benthic foraminifers, Hole 584, Japan Trench.

	Planktonic foraminifers															Benthic foraminifers																			
Core, Section	*Globigerina bulloides* group	*Globigerina* sp.	*Globigerina* cf. *decoraperta*	*Globigerinita glutinata*	*Globigerinoides ruber*	*Globigerinoides trilobus*	*Globorotalia* cf. *ciboaensis*	*Globorotalia* cf. *puncticulata*	*Globorotalia tumida*	*Globorotalia* sp.	*Neogloboquadrina pachyderma*	*Neogloboquadrina* sp.	*Orbulina universa*	*Pulleniatina primalis*	*Sphaeroidinella* sp.	Unilocular lagenids	*Globobulimina* sp.	*Pyrgo* sp.	*Dentalina* spp.	*Martinottiella communis*	*Plectofrondicularia* sp.	*Eponides* cf. *tumidulus*	*Lenticulina* sp.	*Melonis pompilioides*	*Hoeglundina elegans*	*Pullenia* sp.	*Planulina wuellerstorfi*	*Melonis barleeanum*	Calcareous tubes	*Uvigerina* sp.—smooth	*Gyroidina* sp.	*Uvigerina* sp.—hispid	*Tosaia?* sp.	*Sphaeroidina bulloides*	*Stilostomella* spp.
7,CC	R	R									R					X	X	X																	
8,CC																			X																
10,CC																X	X			X	X														
11,CC																X		X	X			X							X						
12,CC	R			R							R		R		R		X						X												
16,CC																	X		X					X											
17,CC	F							R					R			X	X	X	X			X			X	X	X	X							
18,CC	R									R		R						X	X		X	X				X									
20,CC																	X		X							X									
21,CC	F		R		F	R	F		R		R		R	R	R	X		X	X				X	X	X	X	X							X	X
22,CC																									X										
23,CC																X		X							X					X					X
24,CC																X		X	X		X					X				X	X				
25,CC	R							R			R							X	X		X				X	X		X			X	X	X	X	
28,CC	R					R		R			R		R					X	X					X		X		X			X				
29,CC	R							R					R			X	X		X					X		X	X	X							X
32,CC	F		R					F			R							X	X	X						X		X	X		X		X	X	
34,CC																	X	X		X			X	X		X					X				
35,CC																		X		X															
37,CC	R		R																X	X								X	X	X					
38,CC																X				X									X						
39,CC																				X															
41,CC																X				X						X									
42,CC	F		R												R	X			X	X															
46,CC																				X															
49,CC																				X															
55,CC																			X	X													X		
56,CC																				X															
57,CC																				X															
58,CC																				X															
60,CC																				X															
61,CC																			?	X															
63,CC																				X															
69,CC																				X															
75,CC																				X											X				
76,CC																				X															
77,CC																				X															
81,CC																				X															
82,CC																				X															
83,CC																				X															
89,CC																				X															
93,CC																				X															

The following samples were barren of foraminifers: 1,CC; 3,CC; 4,CC; 5,CC; 6,CC; 9,CC; 13,CC; 14,CC; 15,CC; 19,CC; 26,CC; 27,CC; 30,CC; 31,CC; 33,CC; 36,CC; 40,CC; 43,CC; 44,CC; 45,CC; 47,CC; 48,CC; 50,CC; 51,CC; 52,CC; 53,CC; 54,CC; 59,CC; 62,CC; 64,CC; 65,CC; 66,CC; 67,CC; 68,CC; 70,CC; 71,CC; 72,CC; 73,CC; 74,CC; 78,CC; 79,CC; 80,CC; 84,CC; 85,CC; 86,CC; 87,CC; 88,CC; 90,CC; 91,CC; 92,CC; 94,CC; 95,CC; 96,CC; 97,CC; 98,CC.

Note: R, F denote relative abundances of planktonic foraminifers, as explained in text. X denotes presence of benthic species.

Globorotalia scitula (Brady)

Pulvinulina scitula Brady, 1882, p. 716.
Globorotalia scitula (Brady), Saito and others, 1981, pp. 137–138, pl. 46, fig. 2.

Globorotalia truncatulinoides (d'Orbigny)

Rotalina truncatulinoides d'Orbigny, 1839b, *in* Barker-Webb and Bertholet, 1839, p. 132, pl. 2, figs. 25–27.
Globorotalia truncatulinoides (d'Orbigny), Saito and others, 1981, p. 158, pl. 54, fig. 1.

Globorotalia tumida (Brady)

Pulvinulina menardii var. *tumida* Brady, 1877, p. 535.
Globorotalia tumida (Brady), Saito and others, 1981, p. 148, pl. 50, fig. 2.

Neogloboquadrina eggeri (Rhumbler)

Globigerina eggeri Rhumbler, 1901, pp. 12–20, text fig. 20.
Neogloboquadrina eggeri (Rhumbler), Saito and others, 1981, pp. 111–112, pl. 36, figs. 3–4.

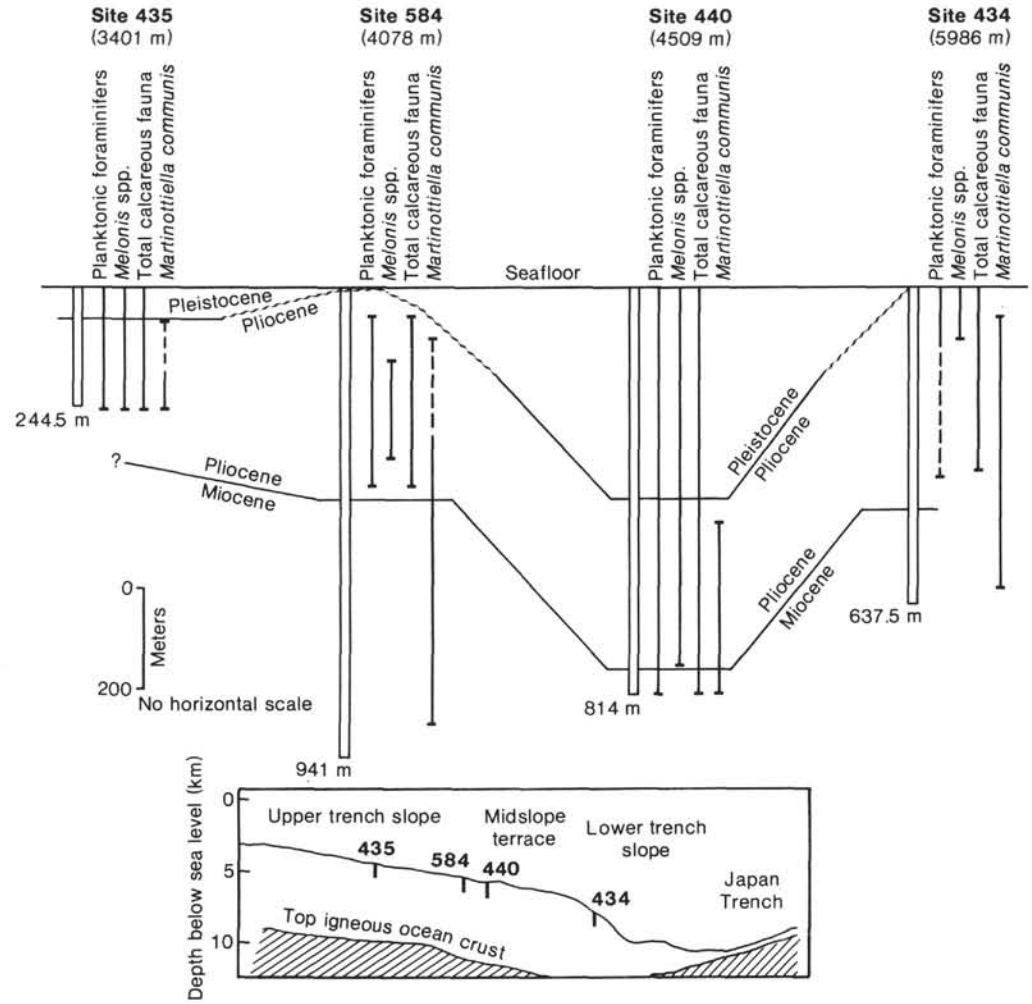

Figure 4. Comparison of distribution of foraminiferal biofacies and selected species at Japan Trench DSDP sites. Depths in parentheses are water depths. Data for Sites 434 and 435 from Thompson (1980), for Site 440 from Keller (1980a, 1980b).

Neogloboquadrina pachyderma (Ehrenberg)

Aristerospira pachyderma Ehrenberg, 1861, pp. 276–277, 303.
Neogloboquadrina pachyderma (Ehrenberg), Saito and others, 1981, p. 106, pl. 34, fig. 1.

Neogloboquadrina sp.

Included in this group are forms transitional to *N. eggeri* s.s. but not assignable to *N. himiensis* (Maiya, Saito, and Sato).

Orbulina universa d'Orbigny

Orbulina universa d'Orbigny, 1839a, *in* Sagra, 1839, p. 3, pl. 1, fig. 1.

Pulleniatina obliquiloculata (Parker and Jones)

Pullenia sphaeroides var. *obliquiloculata* Parker and Jones, 1865, p. 354, pl. 19, fig. 4.
Pulleniatina obliquiloculata (Parker and Jones), Saito and others, 1981, p. 98, pl. 31, fig. 3.

Sphaeroidinella dehiscens (Parker and Jones)

Sphaeroidina bulloides var. *dehiscens* Parker and Jones, 1865, p. 369, pl. 19, fig. 5.
Sphaeroidinella dehiscens (Parker and Jones), Saito and others, 1981, p. 72, pl. 20, fig. 21.

Turborotalia quinqueloba (Natland)

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

Benthic Foraminifers

Ammonia spp.

Included in this group are such species as *Ammonia japonica* (Hada), *Ammonia takanabaensis* (Ishizaki), and *Ammonia beccarii* (Linnaeus).

Amphicoryna scalaris sagamiensis (Asano)

Lagenonodosaria scalaris sagamiensis Asano, 1936a, p. 613, pl. 30, figs. 6–7.
Amphicoryna scalaris sagamiensis (Asano), Matoba, 1967, p. 261, pl. 25, fig. 4.

Bolivina subangularis osagaensis Asano

Bolivina subangularis osagaensis Asano, 1936b, p. 331, pl. 37, fig. 8.

Bolivinita quadrilatera (Schwager)

Textularia quadrilatera Schwager, 1866, p. 253, pl. 7, fig. 10.
Bolivinita quadrilatera (Schwager), Matoba, 1967, p. 252, pl. 25, fig. 19.

Bulimina aculeata d'Orbigny

Bulimina aculeata d'Orbigny, 1826, p. 269.
Bulimina aculeata d'Orbigny, Matoba, 1967, p. 252, pl. 25, figs. 30–32.

Bulimina marginata d'Orbigny

Bulimina marginata d'Orbigny, 1826, p. 269, pl. 12, figs. 10–12.
Bulimina marginata d'Orbigny, Matoba, 1967, p. 252, pl. 25, fig. 37.

Bulimina tenuata (Cushman)

Buliminella subfusiformis var. *tenuata* Cushman, 1927, p. 149, pl. 2, fig. 9.
Bulimina tenuata (Cushman), Matoba, 1967, p. 252, pl. 25, figs. 28–29.

Cassidulina depressa Asano and Nakamura

Cassidulina subglobosa depressa Asano and Nakamura, 1937, p. 148, pl. 13, fig. 8.
Cassidulina depressa Asano and Nakamura, Matoba, 1967, p. 252, pl. 28, fig. 19.

Cassidulina minuta

Cassidulina minuta Cushman, 1933, p. 92, pl. 10, fig. 3.

Chilostomella oolina Reuss

Chilostomella oolina Reuss, 1850, p. 380, pl. 48, fig. 12.
Chilostomella oolina Reuss, Matoba, 1967, p. 253, pl. 29, fig. 4.

Elphidium clavatum Cushman

Elphidium incertum var. *clavatum* Cushman, 1930, p. 20, pl. 7, fig. 10.
Elphidium clavatum Cushman, Matoba, 1967, p. 254, pl. 27, fig. 8.

Elphidium crispum (Linnaeus)

Nautilus crispus Linnaeus, 1758, p. 709.
Elphidium crispum (Linnaeus), Matoba, 1967, p. 254, pl. 27, fig. 7.

Epistominella nipponica (Kuwano)

Epistominella nipponica Kuwano, 1962, pl. 17, fig. 7.
Epistominella nipponica Kuwano, Matoba, 1967, p. 254, pl. 26, fig. 13.

Florilus labradoricum (Dawson)

Nonionina labradorica Dawson, 1860, p. 191, text-fig. 4.
Nonion labradoricum (Dawson), Matoba, 1967, p. 256, pl. 29, fig. 7.

Globobulimina spp.

Included in this group are a few species of *Globobulimina* (generally rare) other than *G. auriculata*. For the purposes of this study these have not been differentiated.

Globulimina auriculata (Bailey)

Bulimina auriculata Bailey, 1851, p. 12, figs. 25–27.
Globobulimina auriculata (Bailey), Matoba, 1967, p. 255, pl. 26, fig. 1.

Globocassidulina subglobosa (Brady)

Cassidulina subglobosa Brady, 1881, p. 60.
Cassidulina subglobosa Brady, Matoba, 1967, p. 253, pl. 28, figs. 15–18.

Gyroidina orbicularis planata Cushman

Gyroidina orbicularis planata Cushman, 1935, p. 45, pl. 18, fig. 3.

Gyroidina soldanii d'Orbigny

Gyroidina soldanii d'Orbigny, 1826, p. 278.

Haplophragmoides spp.

Hoeglundina elegans (d'Orbigny)

Rotalia (Turbinulina) elegans d'Orbigny, 1826, p. 276.
Hoeglundina elegans (d'Orbigny), Matoba, 1967, p. 255, pl. 29, fig. 17.

Hyalinea balthica (Schröter)

Nautilus balthicus Schröter, 1783, p. 20, pl. 1, fig. 2.
Hyalinea balthica (Schröter), Matoba, 1967, p. 256, pl. 28, fig. 2.

Hyperammina? sp.

Rare occurrences of slender agglutinated tubes are questionably assigned to this genus.

Lagenids—unilocular

Included in this group are all species of the genera *Lagena, Oolina, Fissurina*, and *Parafissurina*.

"Loxostomum" bradyi (Asano)

Bolivina bradyi Asano, 1938, p. 603, pl. 16, fig. 2.
"Loxostomum" bradyi (Asano), Matoba, 1967, p. 256, pl. 25, fig. 20.

"Loxostomum" karrerianum (Brady)

Bolivina karreriana Brady, 1881, p. 28.
"Loxostomum" karrerianum (Brady), Matoba, 1967, p. 256, pl. 25, fig. 21.

Martinottiella communis (d'Orbigny)

Clavulina communis d'Orbigny, 1826, p. 268.
Martinottiella communis (d'Orbigny), Matoba, 1967, p. 256, pl. 25, figs. 1–3.

Melonis barleeanum (Williamson)

Nonionina barleeana Williamson, 1858, p. 32, pl. 3, figs. 68–69.
Melonis barleeanum (Williamson), Ingle and others, 1980, p. 142, pl. 7, figs. 14–15.

Melonis pompilioides (Fichtel and Moll)

Nautilus pompilioides Fichtel and Moll, 1798, p. 32, pl. 2, figs. a–c.
Melonis pompilioides (Fichtel and Moll), Matoba, 1967, p. 256, pl. 29, fig. 16.

Oridorsalis tener

Truncatulina tenera Brady, 1884, p. 665, pl. 95, fig. 11.

Planulina wuellerstorfi (Schwager)

Anomalina wuellerstorfi Schwager, 1866, p. 258, pl. 7, figs. 105, 107.
Planulina wuellerstorfi (Schwager), Matoba, 1967, p. 256, pl. 28, fig. 1.

Pullenia bulloides (d'Orbigny)

Nonionina bulloides d'Orbigny, 1846, p. 107, pl. 5, figs. 9–10.
Pullenia bulloides (d'Orbigny), Matoba, 1967, p. 257, pl. 29, fig. 5.

Pyrgo murrhyna (Schwager)

Biloculina murrhyna Schwager, 1866, p. 203, pl. 4, fig. 15.

Reophax spp.

Saccammina sp.

Silicosigmoilina sp.

Siphogenerina raphanus (Parker and Jones)

Uvigerina (Sagrina) raphanus Parker and Jones, 1865, p. 364, pl. 18, figs. 16–17.

Sphaeroidina bulloides d'Orbigny

Sphaeroidina bulloides d'Orbigny, 1826, p. 267.
Sphaeroidina bulloides (d'Orbigny), Matoba, 1967, p. 257, pl. 25, fig. 6.

***Textularia* sp.**

***Tosaia hanzawai* Takayanagi**

Tosaia hanzawai Takayanagi, 1953, p. 30, pl. 4, fig. 7.

***Trochammina* sp.**

***Uvigerina* spp.—costate**

Included in this group are species such as *U. akitaensis* Asano, *U. peregrina* Cushman, *U. yabei* Asano, and *U. cushmani* Todd.

***Uvigerina* spp.—hispidocostate**

Species such as *U. peregrina dirupta* Todd and *U. wakimotoensis* Asano are included here.

***Uvigerina* spp.—hispid**

This group includes such species as *U. proboscidea* Schwager and *U. hispida* Schwager.

***Uvigerina auberiana* d'Orbigny**

Uvigerina auberiana d'Orbigny, 1839a, *in* Sagra, 1839, p. 106, pl. 2, figs. 23-24.

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