Pisciotto, K. A., Ingle, J. C., Jr., von Breymann, M. T., Barron, J., et al., 1992
Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 127/128, Pt. 1

22. BENTHIC FORAMINIFERS FROM THE JAPAN SEA: LEG 128[1]

Michio Kato[2]

ABSTRACT

Five holes were drilled at two sites in the Sea of Japan during Ocean Drilling Program (ODP) Leg 128. Site 798 is located on Oki Ridge at a depth of about 900 m. Sediment age at Site 798 ranges from Pliocene to Holocene. Site 799 is located in the Kita-Yamato Trough at depth of 2000 m and below the present calcite compensation depth (CCD); the sediment ranges from Miocene to Holocene in age. Samples from all holes contain benthic foraminifers. Faunal evidence of downslope displacement is frequent in Holes 799A and 799B. The vertical frequency distribution of some dominant species shows that significant faunal changes occur in Holes 798A-C on Oki Ridge. Based on the faunal change and the thickness of sediments, it appears that the Oki Ridge was uplifted more than 1,000 m during last 4 m.y. Benthic foraminifers also demonstrate that the water depth of Site 799 rapidly changed from upper bathyal to lower bathyal during middle Miocene time. The appearance of benthic foraminifer species common to anaerobic environments suggests that the dysaerobic to anaerobic bottom conditions existed during the evolution of the Sea of Japan. Faunal distributions also suggest that the "Tertiary-type" species recognized in the Neogene strata of the Japan Sea coastal regions disappeared sequentially from the Sea of Japan during Pliocene to late Pleistocene.

INTRODUCTION

ODP Leg 128 included three drilling sites in the central and eastern Japan Sea. Site 794 is located in the northeastern Yamato Basin about 130 km west of the Oga Peninsula, Site 798 is in a small fault-bounded basin on top of Oki Ridge in the southeastern Sea of Japan and Site 799 is located in the southern Kita-Yamato Trough, a narrow topographic and structural depression that splits the larger Yamato Rise in the south central Sea of Japan (Fig. 1). This report details Neogene benthic foraminifers from Sites 798 and 799. Although Leg 128 extended basement drilling at Site 794 originally drilled during Leg 127, this report does not include analysis of benthic foraminifers from this latter site (see reports by Brunner and Nomura in this volume). One of the purposes of drilling in the Sea of Japan was to investigate the paleoceanographic and paleoenvironmental changes during evolution of the sea.

Modern foraminifers in the Sea of Japan are of special importance to understanding the Neogene faunas of this backarc basin. Study of Holocene benthic foraminifers in the Sea of Japan was initiated by Asano (1939a). He reported the foraminifer fauna from the Urashima Bank at the entrance of Wakasa Bay, southeast Sea of Japan. Ishiwada (1950, 1951) recognized four assemblages in his studies on Recent foraminifera of the area extending from Toyama Bay, Toyama Prefecture, to off Sakata, Yamagata Prefecture. He considered them to be related to the so-called Middle Water of the Tsushima Current, the Second Spring Layer, the Japan Sea Proper Water, and special parts of the latter, respectively. Matoba (1976) reported the depth distribution of the benthic foraminifers from off Noshiro, Akita Prefecture, northeast Sea of Japan. He found three major faunas in his study, and he considered them to be related to the warm Tsushima Current, including waters influenced by the coastal waters, the water of the lower thermocline, and the Japan Sea Proper Water.

In addition, many studies have been made of the taxonomy, ecology, and distribution of Holocene benthic foraminifers in the Sea of Japan that provide background for interpretation of Neogene faunas. Important papers include Asano (1956a, b; 1958a, b), Chiji and Konda (1970), Ikeya (1970), Inoue (1980, 1989), Matoba (1984), Matsuda (1957), Ujiié et al. (1983), Saidova (1961), and Troitskaya (1970, 1972, 1973).

Asano (1936–1939b, 1948–1952) studied the benthic smaller foraminifers from Neogene to Quaternary sediments distributed in the Japan Sea coastal regions. Thereafter, many studies of benthic smaller foraminifers were carried out on upper Cenozoic oil-producing formations in the Japan Sea coastal region of northeast Japan, although many were not published. Matsunaga (1963) summarized the foraminifer biostratigraphy in the oil-producing region, from Niigata to Akita prefectures, and established five zones applicable to the whole region and several zonules appropriate for each area. Some important studies of fossil benthic foraminifers of the Japan Sea coastal regions include Chiji (1960), Cushman and Ozawa (1929), Hasegawa (1979), Matoba (1990), Oinomikado (1939, 1940, 1941), and Tai (1959).

This paper analyzes the stratigraphic distribution of Miocene-to-Holocene benthic foraminifers from ODP Sites 798 and 799 in the southern Sea of Japan. Analyses of benthic foraminifers at paleodepths differing from those estimated from the benthic foraminifer assemblage were of special concern in this study. In addition, the Neogene fauna from Site 798 is compared with that from the onshore Japan Sea coastal regions.

GEOGRAPHIC AND OCEANOGRAPHIC SETTING

The Sea of Japan is one of several marginal seas of the western Pacific Ocean (Fig. 1). The Sea is about 750 km long and 180 km wide, and its maximum depth exceeds 3,700 m. The northern part of the sea is a deep flat-floored area between 3,000 and 3,700 m in depth termed the Japan Basin. The floor of the southern half of the Sea is very rugged. The Yamato Rise is situated in the central part, with the Yamato and Tsushima Basins.

The Sea of Japan is connected with the Pacific Ocean, the Sea Okhotsk, and East China Sea by four narrow and very shallow straits including the Tartar Strait (maximum water depth 12 m), Soya Strait (55 m), Tsugaru Strait (130 m), and Tsushima Strait (140 m). The warm Tsushima Current, a branch of the Kuroshio Current, flows into the Sea through the Tsushima Strait and flows out mainly through the Tsugaru Strait and partly through the Soya Strait. In most of the marginal seas of the western Pacific, such as Okhotsk, Bering, and East China seas, the sills are deep enough to allow the inflow of the Pacific Deep Water. In contrast, the sills in the Sea of Japan are so shallow than the Pacific Deep Water cannot flow into the sea. A special vertical circulation therefore occurs within the sea, and a peculiar water mass called the Japan Sea Proper Water is formed. In the Japan Sea, temperature and salinity are uniform in distribution below a depth of 300 m (Matoba, 1984). This deep water mass termed the

[1] Pisciotto, K. A., Ingle, J. C., Jr., von Breymann, M. T., Barron, J., et al., 1992. *Proc. ODP, Sci. Results,* 127/128, Pt. 1: College Station, TX (Ocean Drilling Program).
[2] Department of Geology, College of Liberal Arts, Kanazawa University, Kanazawa 920, Japan.

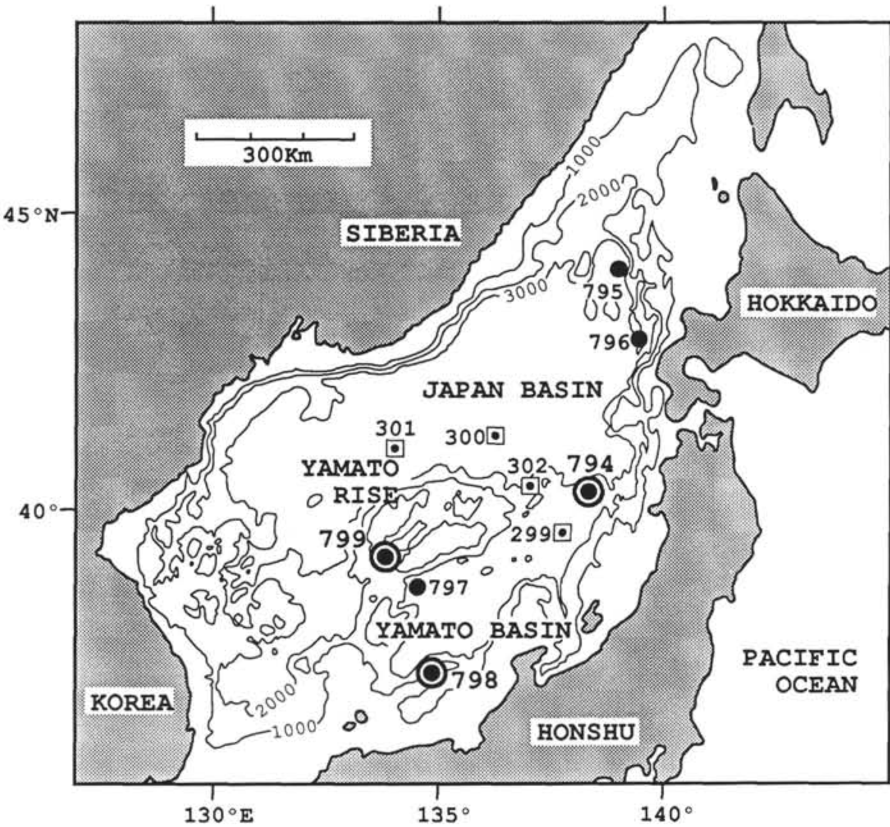

Figure 1. Location map of the Leg 128 Sites 794, 798, and 799 (circled dots), Leg 127 Sites 794 through 797 (dots), and DSDP Sites 299 through 302 (boxed dots).

Japan Sea Proper Water and has a temperature of 1° C and a salinity of 34.07 ‰. The distribution of dissolved oxygen is particularly characteristically high, exceeding 5 mL/L at almost all depths (Matoba, 1984), demonstrating that the sea is well mixed. The Japan Sea Proper Water originates in the northwestern part of the sea by excessive cooling of the surface during winter. Moreover, it originates in the central part of the sea by mixing and caballing at the front formed with the Tsushima and Liman currents. The convective circulation induced by these seasonal and constant processes maintains the low temperature, low salinity, and high dissolved oxygen water mass characterizing the present sea at all depths below 300 m. Owing to the high dissolved oxygen content, surface sediments are oxidized, and the local Calcite Compensation Depth (CCD) is situated at about 2,000 m (Ichikura and Ujiié, 1976), much shallower than in the adjacent Pacific Ocean.

METHODS

Benthic foraminifers occur in 314 of the 845 samples analyzed from Holes 798A, 798B, 798C, 799A, and 799B. Each sample consists of about 10 cm^3 of sediment. I disaggregated the samples by soaking them in hot water. Depending on the consolidation of sediment, varying amounts of hydrogen peroxide were added. I washed the disaggregated samples through a 250-mesh (0.063-mm) screen and then dried them. Before extracting the foraminifers, I sieved each sample through a 115-mesh (0.125-mm) screen; the benthic foraminifers were taken from the coarser fraction. In instances where benthic foraminifers were especially abundant, the samples were split into smaller aliquots, and 150–250 specimens were removed.

I distinguished 171 taxa of benthic foraminifers, including named and unnamed old species, subspecies, and morphotypes. Distributions of benthic foraminifers are given in Tables 1 through 4 (Tables 2, 3 back pocket) in terms of relative percentages. I did not calculate percentages for samples containing less than 10 specimens. The stratigraphic distributions of several selected species are shown in Figures 5, 6, and 7.

PRESERVATION AND ABUNDANCE

Preservation of the benthic foraminifers is shown in Tables 1 through 4 (Tables 2, 3 back pocket). Preservation of specimens from Site 798 is generally better in the stratigraphically higher samples than in the lower samples. In the samples of Site 799, the preservation is generally poor. In the deeper samples, especially samples from Hole 799B, most specimens are altered and/or the test wall changes to brown or is completely recrystallized.

Figures 2, 3, and 4 show the abundances of benthic and planktonic foraminifers, numbers of benthic foraminiferal species, components of benthic foraminiferal tests, and benthic-planktonic foraminiferal ratios from two sites. I calculated the abundance of benthic and planktonic foraminifers for each 1 g of dry weight of sediment (= foraminifer number). Abundance seems to be related to preservation.

Based on the abundance and component of tests, the sequence of Site 798 is divided stratigraphically into two parts. The upper or Quaternary part, spanning Samples 128-798C-1H-1, 41–43 cm through -798B-23X-6, 39–41 cm, is characterized by high foraminifer number and calcareous tests. Assemblages in the upper Pliocene portion of Hole 798B, below Sample 128-798B-24X-1, 39–41 cm, is characterized by low foraminifer numbers and agglutinated tests.

Benthic foraminifers are generally rare at Site 799, except in four Samples 128-799A-6H-1, 35–37 cm, -799A-8H-2, 37–39 cm, -799A-8H-7, 30–32 cm, and -799B-9R-4, 04–06 cm. In these four samples the foraminifer number reaches more than one thousand. Assemblages in the upper part of Hole 799A, above Sample 128-799A-14H-2, 37–39 cm,

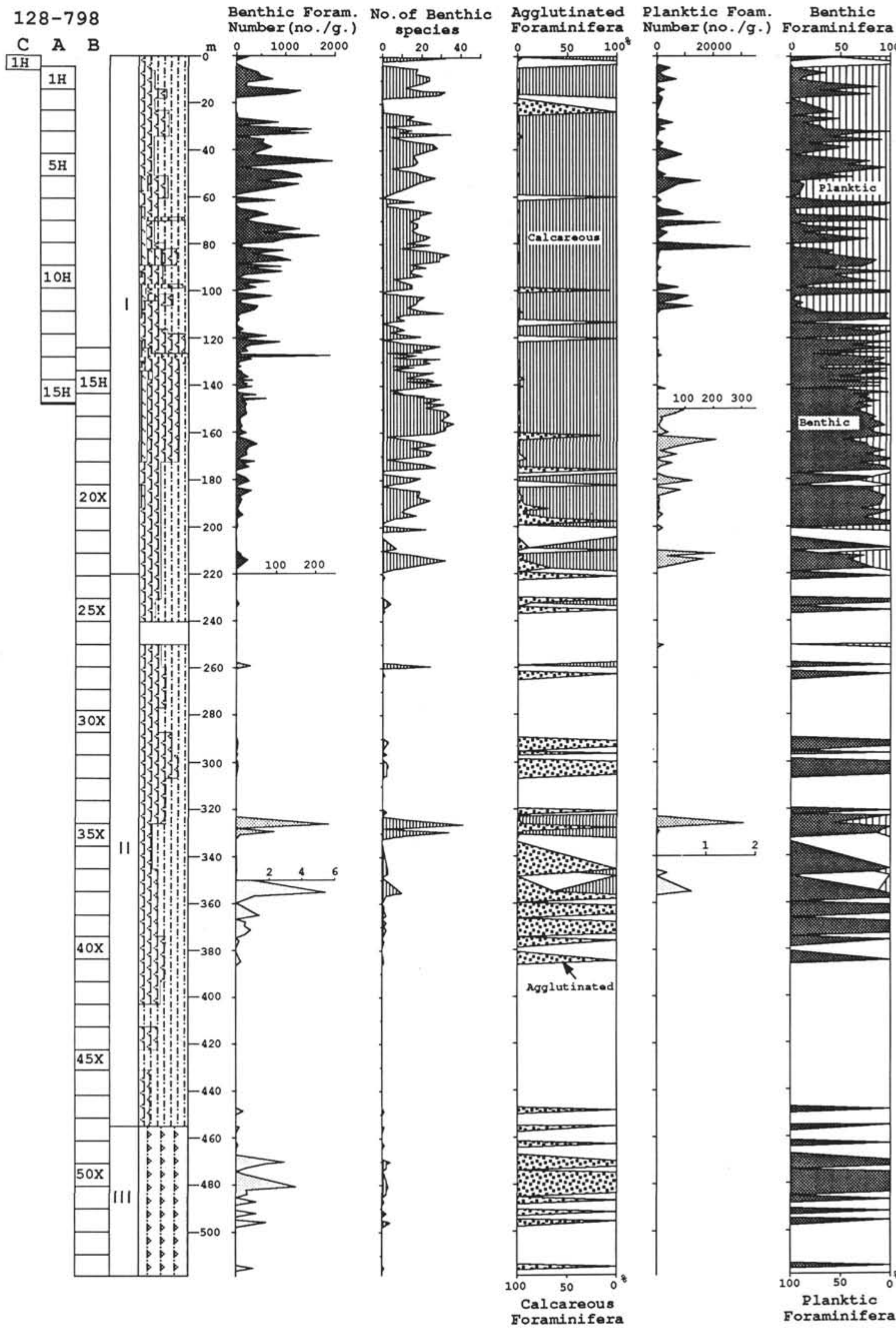

Figure 2. Abundance of benthic and planktonic foraminifers, number of benthic species, calcareous-agglutinated ratios of benthic foraminifer tests, and benthic-planktonic foraminiferal ratios of Site 798. (Abundance calculated for number of specimens per gram of sediment.)

Table 1. Abundance and occurrence of benthic foraminifers, Leg 128, Holes 798A, and 798C.

Samples	Preservation	*Miliammina echigoensis*	*Silicosigmoilina abyssalica*	*Karreriella baccata japonica*	*Quinqueloculina* sp. A	*Q.* sp. B	*Q.* spp.	*Pyrgo depressa*	*P. murrhina*	*P.* spp.	*Triloculina tricarinata*	*T.* spp.	*Sigmoilopsis schlumbergeri*	Miliolidae gen. et sp. indet.	*Dentalina communis*	*D. frobisherensis*	*D. ittai*	*D. setanaensis*	*D.* spp.	*Nodosalia* sp. A	Nodosariidae gen. et sp. indet.	*Pandaglandulina* sp. A	*Frondicularia* sp. A	*Parafrondicularia* sp. A	*Amphicoryina* sp. A	*Planularia asanoi*	*Lagena amphora*	*L. apiopleura*	*L. distoma*	*L. elongata*	*L. gracilis*	*L. gracillima*	*L. laevis*	*L. nebulosa*	*L. pliocenica*	*L. sesquistriata*
798C-1H-1,41-43	M		3	2						+																			1							
-4,42-44	M						+										+																			
798A-1H-2,33-35	G																												+							
-3,34-36	G										+			+																						
-4,33-35	G			+	2					+																							+	+		
-5,34-36	G													+																						
-6,32-34	M																																			
-CC,33-35	G			+	+					1																										
-2H-1,43-45	G			+	+								+	+																+						
-2,43-45	M			1															+								+		+							
-3H-1,36-38	P		X																																	
-2,36-38	G			1																																
-3,36-38	M			2																																
-4,36-38	G																										+			+		+				+
-5,43-45	P																																			
-6,35-37	M																																			
-CC,23-25	M																																	+		
-4H-1,42-44	G					+																					+		+							
-2,43-45	M		5																																	
-3,42-44	M																																			
-4,37-39	G			+																																
-5,45-47	G								+																											
-5H-1,42-44	G																																	+		
-3,44-46	G																																			
-4,43-45	G																																			
-5,42-44	M																																			
-6,42-44	M																+																			
-7,42-44	G			+																																
-6H-1,36-38	G					+																	+													
-2,36-38	G																																			
-3,38-40	G					+																														
-6,61-63	P																																			
-7H-1,80-82	G																																			
-2,95-97	P					X																														
-3,80-82	P																																			
-4,80-82	M																												+							
-5,80-82	M	+												+																				+		
-6,80-82	G											+																								
-7,80-82	M																		+						+											
-8,78-80	M																+																			
-8H-2,58-60	G									+																										
-3,58-60	M										+																									+
-4,58-60	M																																			
-5,58-60	G													+																						
-6,58-60	G		+																										+							+

Table 1 (continued).

-7,58-60	M																											+							
-8,58-60	M	+																																	
-9H-1,42-44	G													+		+		+				1													
-2,39-41	M																																		
-3,39-41	M													+																					
-4,36-38	M	+									+			+									+												
-5,42-44	G	2																								+									
-6,40-42	M	2		+					+																								+	+	
-7,40-42	M																									+									
-10H-1,37-39	M																						1												
-2,37-39	M																							+											
-3,52-54	M																																	+	
-4,52-54	M																																		
-5,52-54	M																																		
-6,52-54	M																																		
-7,40-42	M																																		
-8,40-42	M																																		
-11H-1,84-86	P	92																																	
-2,40-42	P																																		
-3,40-42	M																														+				
-4,40-42	M																										+							+	
-5,42-44	P																			+															
-6,40-42	P																																		
-2,43-45	P																						3	+										+	
-3,38-40	P	2																	4																
-4,19-21	P	2																																	
-6,35-37	P																																		
-7,40-42	M																																		
-8,37-39	P																																		
-13H-1,65-67	M																						+						+						
-3,67-69	M																																		
-4,42-44	P																				2		1	+											
-5,38-40	P																									+									
-6,40-42	P																																		
-7,41-43	M																																		
-14H-1,38-40	P																				+									+				+	
-2,42-44	P																												1						
-3,41-43	P	2						+																											
-4,45-47	P																																		
-5,40-42	P	3																																	
-6,38-40	P															+		+			2														+
-7,37-39	P	4																				+											+		
-8,31-33	P	3														+		+				3													
-15H-1,49-51	P									+												+													
-2,49-51	P	+																				1							+						
-3,49-51	P	+																				+									+				
-4,49-51	P																																		
-5,49-51	P																																		
-6,49-51	P																+									+									
-7,49-51	M														+																				
-8,49-51	P	2																																	

Note: Abundance is recorded as a percentage of total benthic specimens counted (+ = <1%); percentages were not calculated for samples containing less than 10 specimens (X = occurrence of the taxon in these samples).

Table 4. Abundance and occurrence of benthic foraminifers, Leg 128, Hole 799B.

Sample	Preservation	*Ammodiscus* sp. A	*Cyclammina cancellata*	*Martinottiella communis*	*Haplophragmoides* spp.	Agglutinated gen. et sp. indet.	Miliolidae gen. et sp. indet.	*Lagena* spp.	*Lenticulina* spp.	*Bolivina* spp.	*Cassidulina cushmani*	*C. norcrosse*	*Stainforthia fusiformis*	*S.* spp.	*Globobulimina auriculata*	*G. subaffinis*	*G.* spp.	*Uvigerina* spp.	*Valvulineria sadonica*	*Eilohedra rotunda*	*Cibicides* spp.	*Nonionella ? fragilis*	*N. stella*	*N.* spp.	*Pullenia apertura*	*P. salisburyi*	*P.* spp.	*Chilostomella oolina*	*Quadrimorphina laevigata*	*Oridorsalis tener*	*Gyroidinoides* sp. A	Rotaliidae gen. et sp. indet.	Total number examined	Foraminiferal number (no./gr.)
128-799B-5R-1,34-36	P				44											6			6						6	11		22	6				18	2.7
6R-3,34-36	P													39		4			9		4			4		9		17	13				23	3.4
7R-3,8-10	P									X		X																					8	1.6
8R-1,34-36	P											21				4			8												17		24	9.5
9R-1,31-33	P	11														21			5								5	42			11	5	19	2.6
-2,32-34	P				100																												15	3.1
-3,23-25	P				47											24			12							12		6					17	2.5
-4,4-6	P													4					3	92						+						+	232	1186.7
11R-1,48-50	P													X			X																2	0.3
-2,48-50	P							10						10																		80	10	1.4
-4,48-50	P										16			2	11	2			7							8		33		+	10	11	134	21.6
-5,48-50	P				100																												19	4.5
12R-3,32-34	P				100																												22	7.9
-4,34-36	P				X																												7	1.4
13R-1,34-36	P				100																												46	5.8
-4,34-36	P			1	99																												86	9.2
-5,34-36	P				100																												16	2.2
14R-1,34-36	P				X																												1	0.2
-2,37-39	P				100																												98	13.6
15R-3,34-36	P		4		96																												79	10.0
-4,34-36	P		5						5					16					37			5									32		19	2.5
16R-2,32-34	P		7		93																												72	11.2
-3,39-41	P													65					3			21		2				3					66	16.1
17R-1,92-93	P		X																														5	0.6
-2,91-93	P		38	6	56																												16	1.8
-5,91-93	P			11	90																												19	2.4
-6,91-93	P				X													X															8	1.4
18R-2,33-35	P				91	9																											22	2.4
-3,33-35	P				100																												16	2.7
-4,33-35	P				83	17																											52	9.9
-6,33-35	P				18		6						12						12			6	18					29					17	3.1
19R-2,30-32	P				X																												1	0.1
-3,31-33	P				87	10																										3	39	3.1
-5,29-31	P				85	15																											13	1.6
-6,29-31	P				100																												33	3.9
20R-2,35-37	P				100																												95	12.6
-3,36-38	P				X																												1	0.1
21R-2,37-39	P				100																												19	2.5
24R-1,24-26	P		X	X	X																												9	1.2
27R-1,34-36	P				X																												8	1.2
29R-3,40-42	P			12	88																												17	2.2
54R-2,11-13	P				19		4						12	23																		39	26	7.0

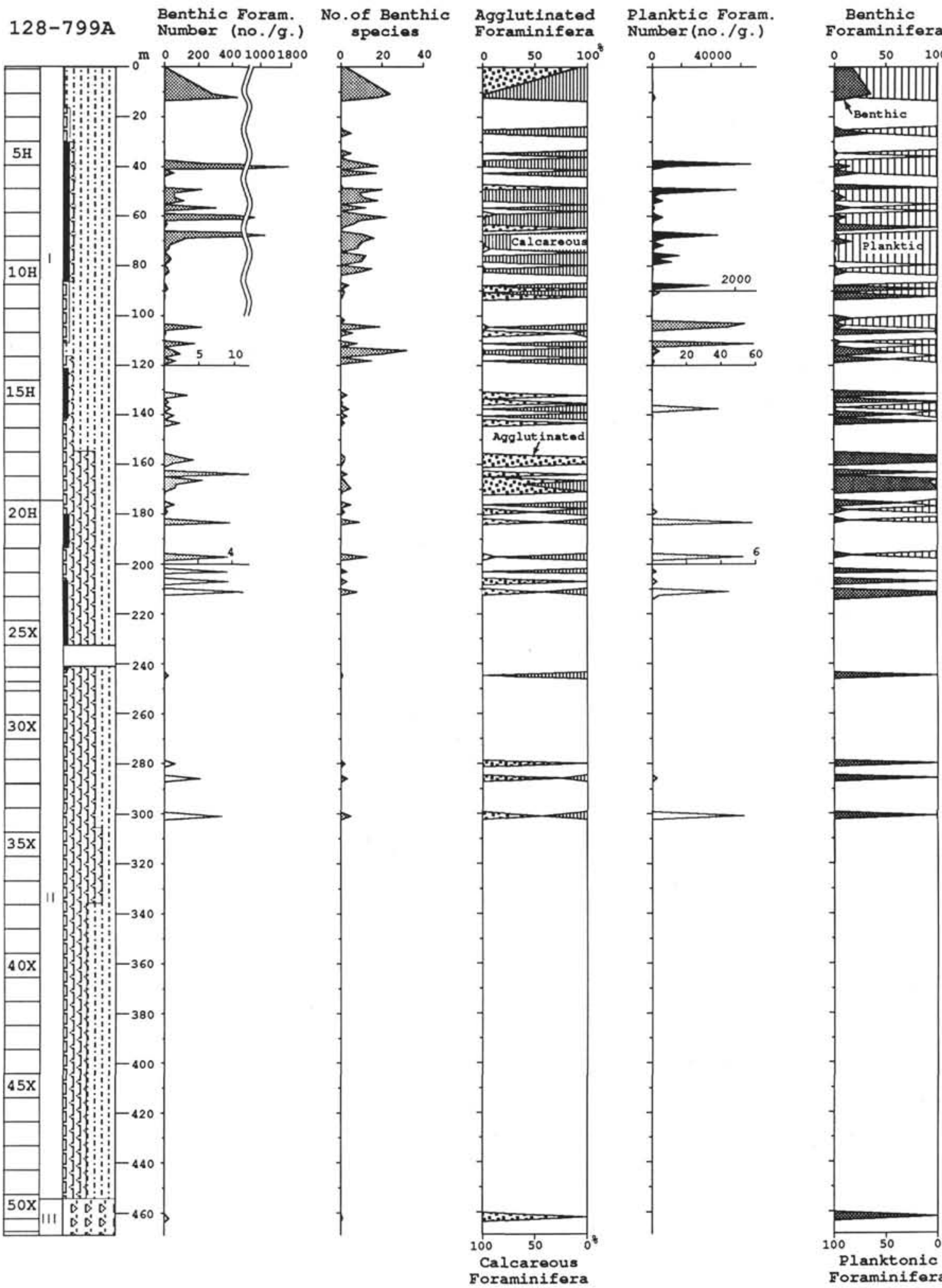

Figure 3. Abundance of benthic and planktonic foraminifers, number of benthic species, calcareous-agglutinated ratios of benthic foraminifer tests, and benthic-planktonic foraminifer ratios of Hole 799A. (Abundance calculated for number of specimens per gram of sediment.)

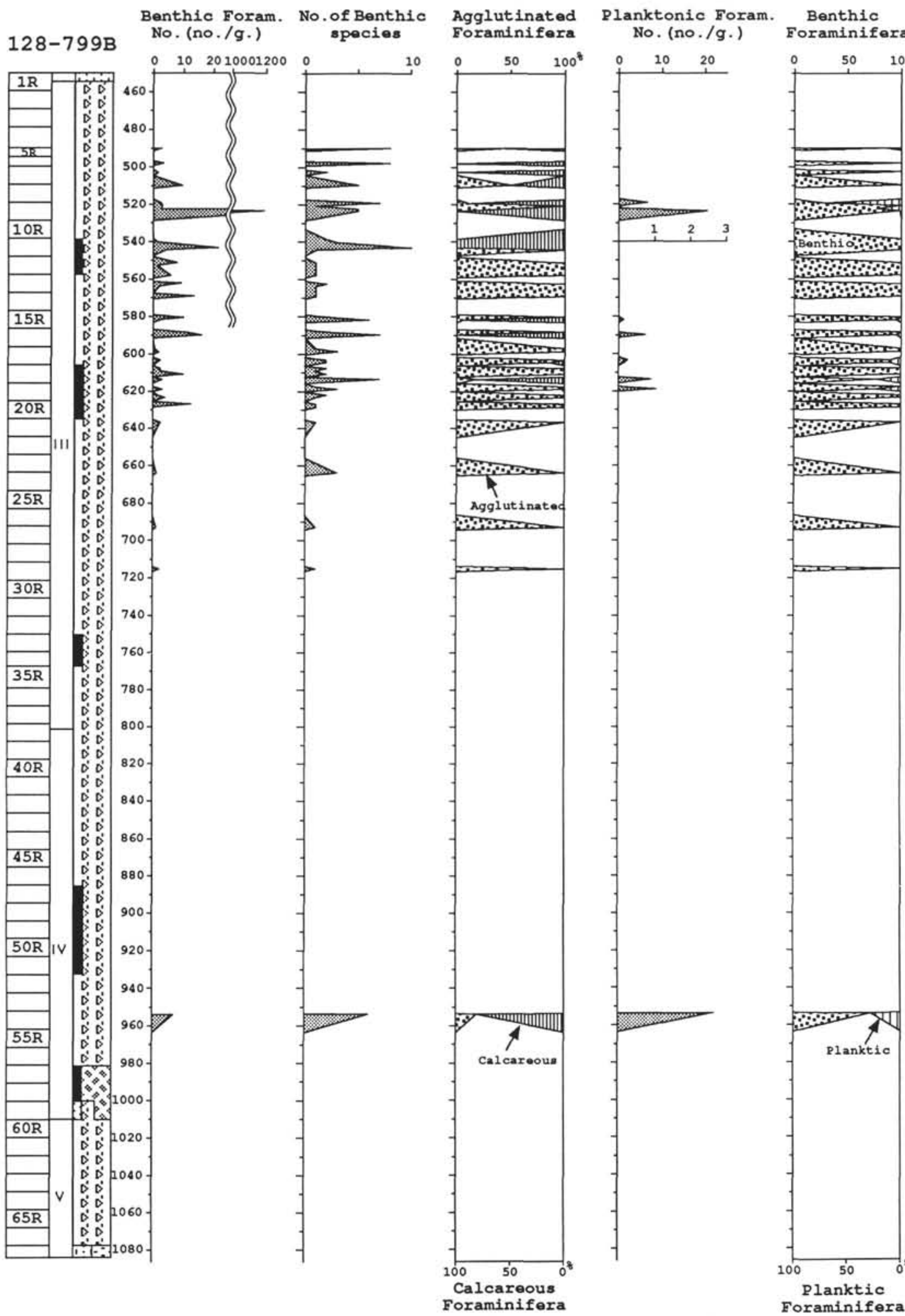

Figure 4. Abundance of benthic and planktonic foraminifers, number of benthic species, calcareous-agglutinated ratios of benthic foraminifer tests and benthic-planktonic foraminifer ratios of Hole 799B. (Abundance calculated for number of specimens per gram of sediment.)

are characterized by the dominance of calcareous tests. The faunas in the lower part of Hole 799A and in Hole 799B are characterized by agglutinated tests.

BENTHIC FORAMINIFER ASSEMBLAGES

Site 798

The occurrences of benthic foraminifers in Holes 798A, 798B, and 798C are shown in Table 1, and Table 2 (back pocket). Figure 5 shows the stratigraphic distribution of several selected species. Benthic foraminifers were found in 96, 107, and 2 samples from Holes 798A, 798B, and 798C, respectively. Assemblages in the upper part of the Site 798 sequence, above Sample 128-798B-23X-6, 39–41 cm, are characterized by the dominance of *Bolivina pacifica, Uvigerina akitaensis,* and *U. akitaensis* var., *Angulogerina kokozuraensis, Cassidulina norcrossi, C. norvangi, Pseudoparrella takayanagii, Eilohedra rotunda,* and *Epistominella pulchella.* This interval encompasses the Quaternary through late Pliocene in age. Although similar assemblages are observed in the lower portion of this sequence (Samples 128-798B-27X-7, 34–36 cm, -798B-35X-1, 38–40 cm, and -798B-35X-3, 42–44 cm) preservation is very poor.

In several samples (128-798A-1H-3, 34–36 cm; -798A-1H-5, 34–36 cm; -798A-3H-2, 36–38 cm; -798A-3H-6, 35–37 cm; -798A-9H-7, 40–42 cm; -798A-11H-4, 40–42 cm; -798A-11H-6, 40–42 cm; -798A-13H-7, 41–43 cm; and -798B-15H-1, 40–42 cm), where species diversity is low, an increase in relative abundance of *Bolivina pacifica* (> 35% of the population) was observed. All of these samples are included in the middle to late Quaternary.

Sediments from lower horizons, below Sample 128-798B-24X-1, 39–41 cm, are mostly barren of calcareous foraminifers. The agglutinated forms, *Martinottiella communis, Miliammina echigoensis, Spirosigmoilinella compressa,* and a few others, are dominant in these samples. Agglutinated species are also dominant in four samples from the upper part (128-798A-11H-1, 84–86 cm, -798B-17X-7, 41–43 cm, -798B-19X-3, 40–42 cm, and -798B-21X-5, 54–56 cm). Most of the washed residues in these samples contain many specimens of siliceous microfossils (diatoms and radiolarians) along with pumice grains and only rare specimens of *Miliammina echigoensis* and fragments of calcareous tests. Thus, calcareous tests in these samples were likely dissolved.

Site 799

Table 3 (back pocket), Table 4, and Figures 6 and 7 illustrate the occurrence of benthic foraminifers in Holes 799A and 799B. Benthic foraminifers were found in 67 samples from Hole 799A and in 42 samples from Hole 799B. The lower samples from Hole 799A, below Sample 128-799A-23X-6, 48–50 cm, are mostly barren of benthic foraminifers except following five samples, 128-799A-27X-3, 33–35 cm; -799A-32X-2, 33–35 cm; -799A-32X-6, 33–35 cm; -799A-34X-3, 33–35 cm; and -799A-51X-1, 50–52 cm. The benthic foraminifer fauna in the upper or Quaternary part of Hole 799A, ranging from Sample 128-799A-1H-1, 29–31 cm, to -799A-14H-2, 37–39 cm, is dominated by *Miliammina echigoensis, Bolivina pacifica, Uvigerina akitaensis,* and *U. akitaensis* var., *Angulogerina kokozuraensis, Cassidulina norcrossi, C. norvangi,* and *Epistominella pulchella.* Although this assemblage is almost the same as the Quaternary fauna of Site 798, the preservations of calcareous species are generally poor, and most of the specimens are broken.

Monospecific assemblages of *B. pacifica* are present in four samples including Sample 128-799A-5H-7, 31–33 cm, -799A-7H-2, 33–35 cm, -799A-9H-2, 52–54 cm, and -799A-9H-7, 30–32 cm. Only agglutinated species including *Miliammina echigoensis, Martinottiella communis, Cyclammina cancellata* were found in the lower part of Hole 799A.

Benthic foraminifers were recovered from the upper half of the Hole 799B sequence, from Sample 128-799B-5R-1, 34–36 cm, through -799B-29R-3, 40–42 cm. Rare specimens of benthic foraminifers are present in only one sample from the lower part of Hole 799B, 128-799B-54R-2, 11–12 cm. Assemblages in the uppermost part of Hole 799B, from Sample 128-799B-5R-1, 34–36 cm, through -799B-11R-4, 48–50 cm, are characterized by the dominant occurrence of *Chyrostomella oolina, Globobulimina subaffinis, Eilohedra rotunda, Cassidulina norcrossi,* and other calcareous species. This interval is late Miocene in age. Sediments from Sample 128-799B-11R-5, 48–50 cm, through -799B-29R-3, 33–35 cm, include fragments and deformed specimens of *Haplophragmoides* spp., *Martinottiella communis, M. nodulosa,* and *Cyclammina cancellata.* This interval represents a late middle Miocene in age. Assemblages in the lowest sample of Hole 799B are almost the same as the upper calcareous fauna in this hole.

The neritic species, *Quinqueloculina* spp., is included in many samples from various horizons at Site 799. Their poor preservation and habitat preference suggest that these specimens were redeposited into deeper water from shallow depths.

COMPARISON OF NEOGENE FAUNAS WITH DEPTH DISTRIBUTIONS OF HOLOCENE BENTHIC FORAMINIFERS IN THE SEA OF JAPAN: ESTIMATES OF PALEODEPTH

Site 798

Depth distributions of selected Holocene benthic foraminifer species are shown in Figure 8 as compiled from Matoba (1984) and Matoba and Honma (1990). The characteristic feature of the depth distributions in the Japan Sea is that almost all deep water species have an upper limit of their depth range of about 200 m. Exclusively deep-water species are not observed. These depth ranges are based on total (living and dead) distribution. The total distribution may include various amounts of tests displaced from a shallower- to a deeper water bottom. The depth classification of marine benthic environments used in this report follows Matoba (1984) for the Japan Sea.

At Site 798, I detected three distinct faunal associations indicative of change in water depth with time (Fig. 9). *Bolivina pacifica, Uvigerina akitaensis* and *U. akitaensis* var., *Angulogerina kokozuraensis, Cassidulina norcrossi, C. norvangi, Pseudoparrella takayanagii, Eilohedra rotunda,* and *Epistominella pulchella* are predominant in the upper part of the Site 798 sequence (Sample 128-798C-1H-1, 41–43 cm, to -798B-23X-6, 39–41 cm). This fauna suggests that water depths during latest Pliocene to Quaternary time were upper Bathyal to upper middle Bathyal, similar to the present water depth of this site. The middle part of the Site 798 sequence (Sample 128-798B-24X-1, 39–41 cm, through Sample 128-798B-49X-2, 37–39 cm) is characterized by the occurrence of *Miliammina echigoensis* and *Martinottiella communis,* and a few other agglutinated species. This fauna is representative of middle Bathyal water depths, somewhat deeper than the present water depth. In the lower portion of the Site 798 column (Sample 128-798B-49X-7, 40–42 cm, through -798B-54X-5, 115–117 cm) *Cyclammina cancellata* and *Spirosigmoilinella compressa* are present. *S. compressa* is an extinct species and its ecology is unclear, but a similar form, *Psamminopelta complanata* Saidova, is distributed in the present-day northwest Pacific in a depth range of 2700–3100 m (Saidova, 1961). The assemblage of the lower part may have inhabited depths from the lower middle Bathyal to lower Bathyal Zone. Thus, the variations in paleodepth umpired by these faunal changes together with the thickness of sediment suggest that Oki Ridge was uplifted more than 1,000 m during the last 4 m.y.

Site 799

Because abundance of the benthic foraminifers is rare and preservation of the specimen is very poor at Site 799, it is difficult to determine the changes in water depth based on the benthic foraminifers (Fig. 10). Based on the meager assemblages in Samples 128-799A, 1H-1, 29–31 cm, through -799A-12H-4, 39–41 cm, these sediments were deposited at upper Bathyal to middle Bathyal depths, similar to the present water depth at Site 799. Based on the occur-

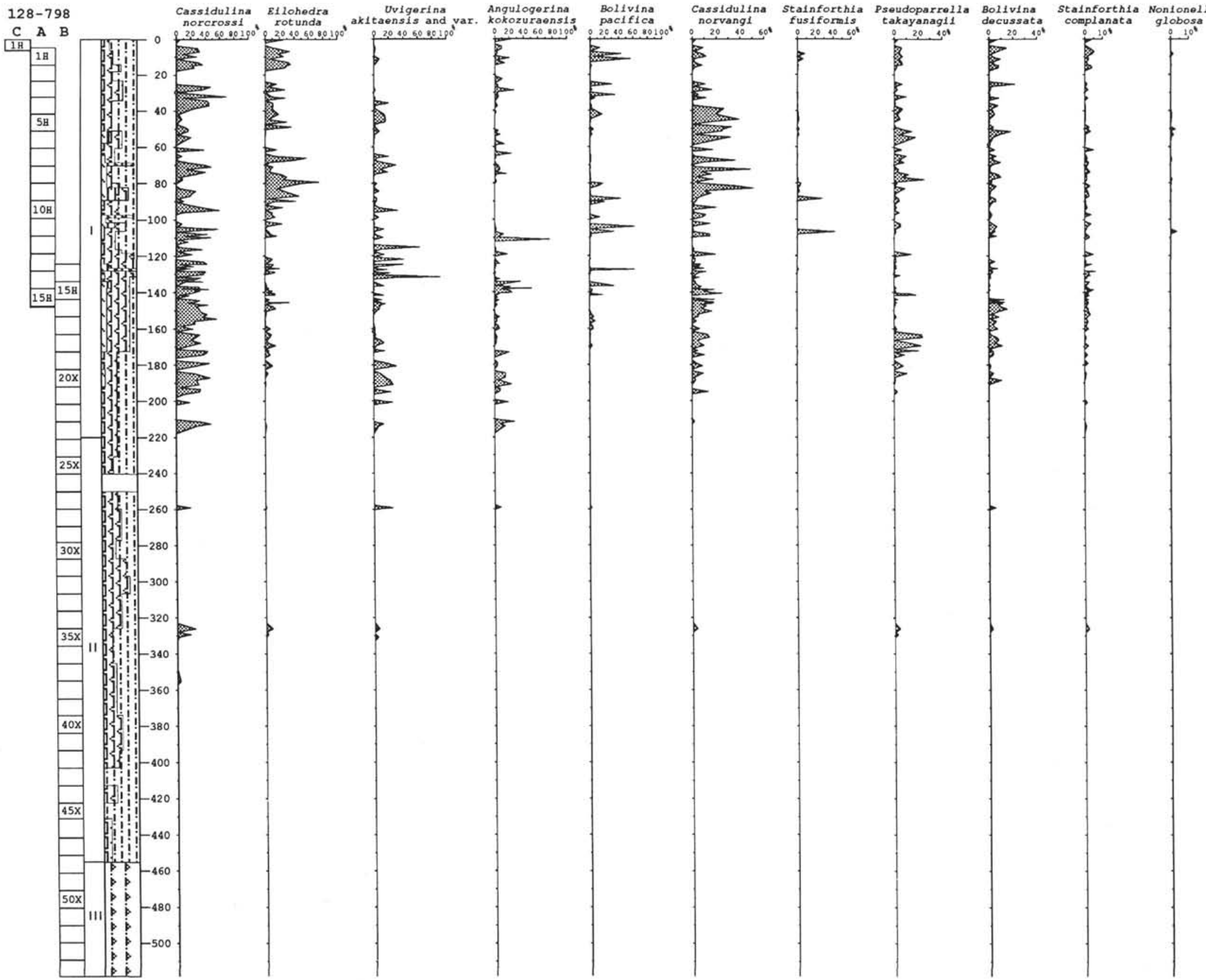

Figure 5. Stratigraphic occurrence of selected benthic foraminifers, Holes 798A, 798B, and 798C.

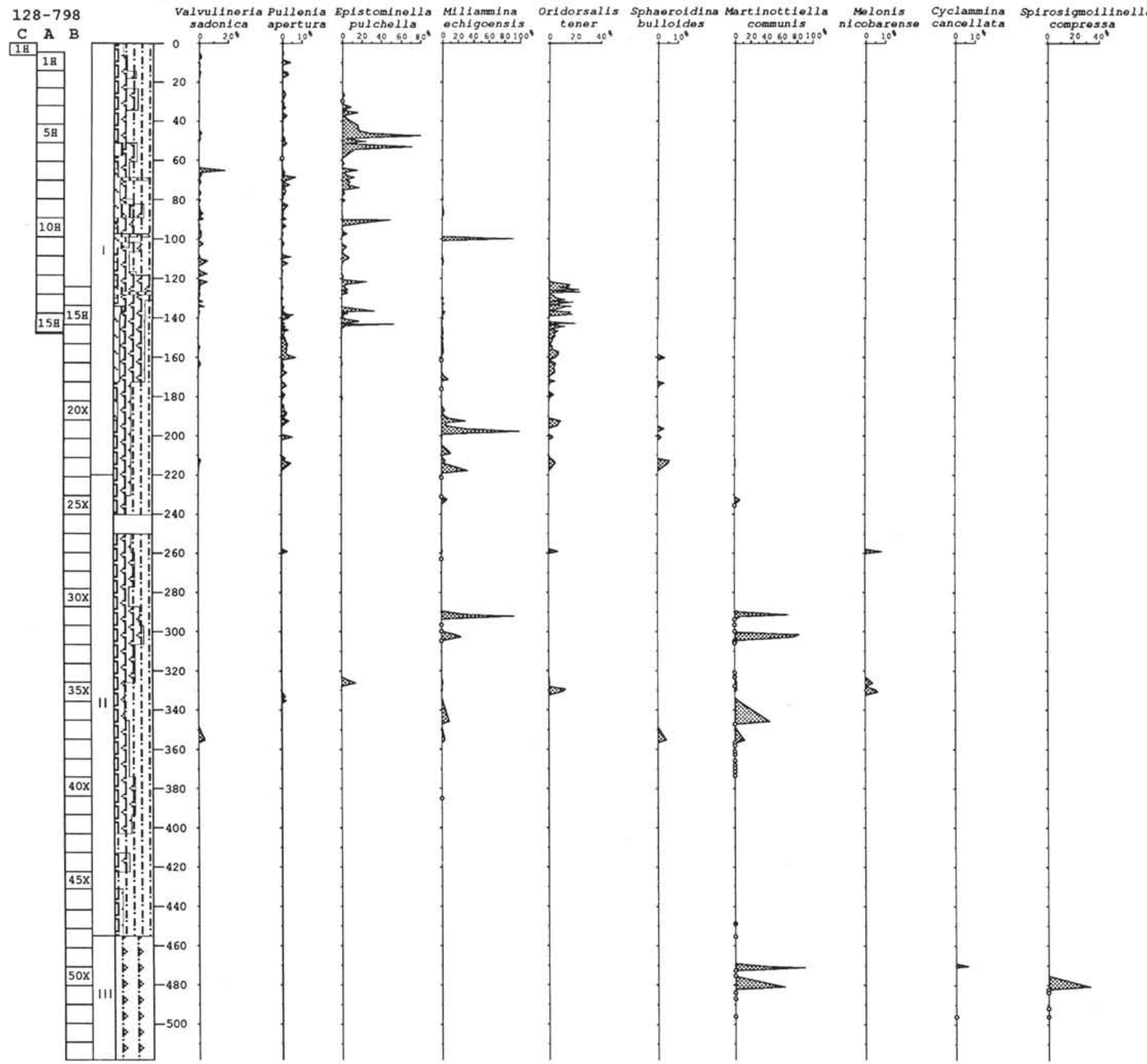

Figure 5 (continued).

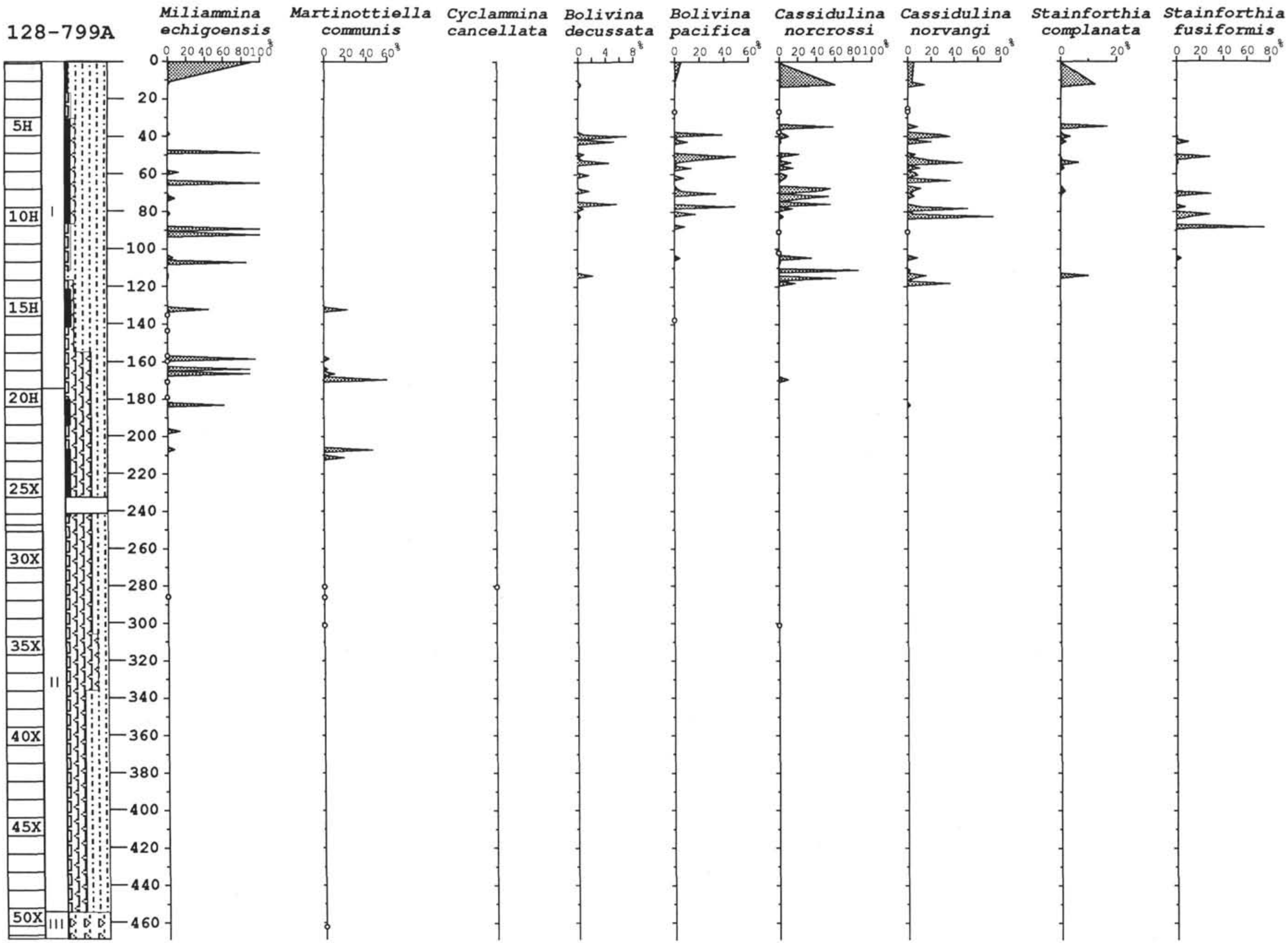

Figure 6. Stratigraphic occurrence of selected benthic foraminifers, Hole 799A.

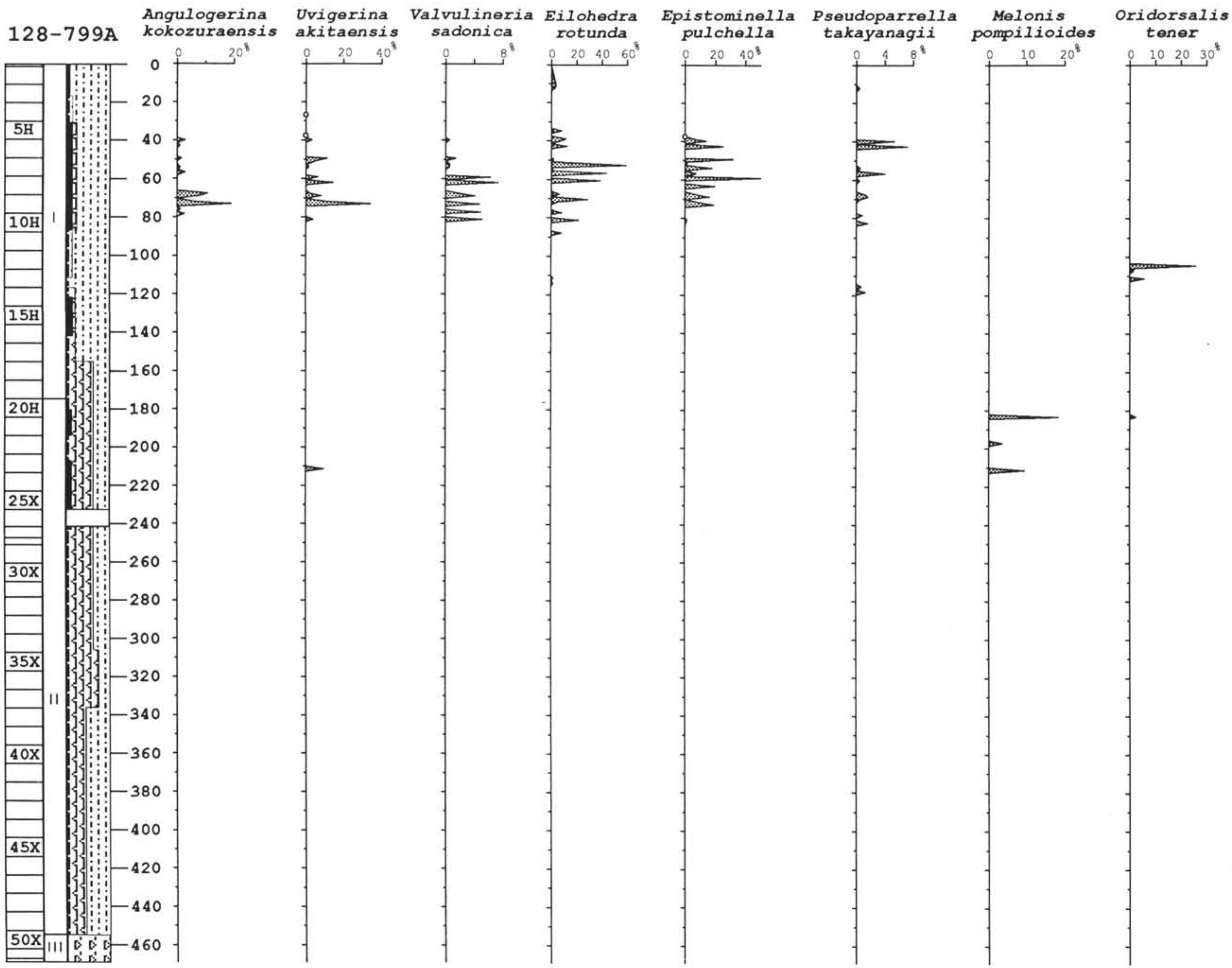

Figure 6 (continued).

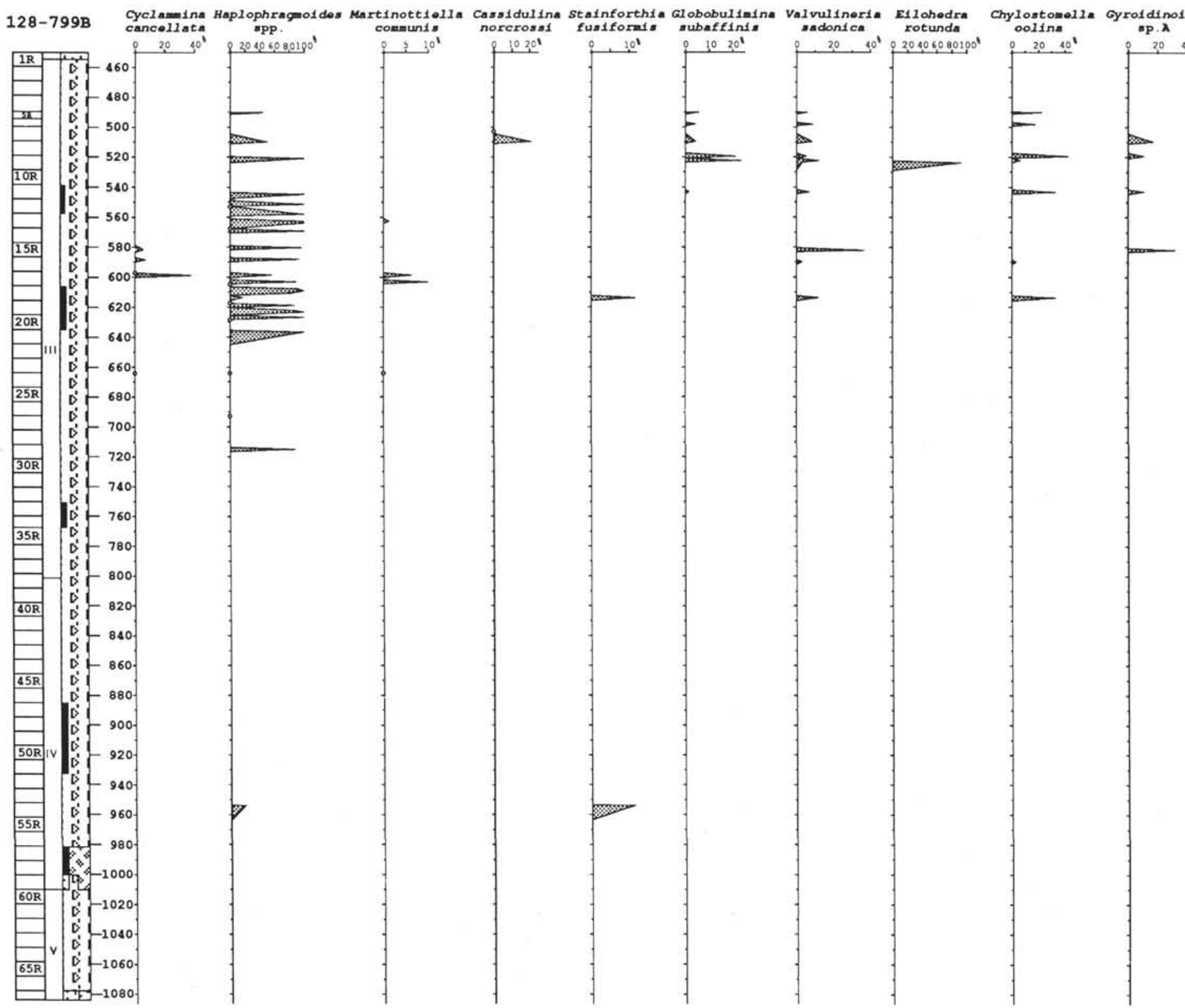

Figure 7. Stratigraphic occurrence of selected benthic foraminifers, Hole 799B.

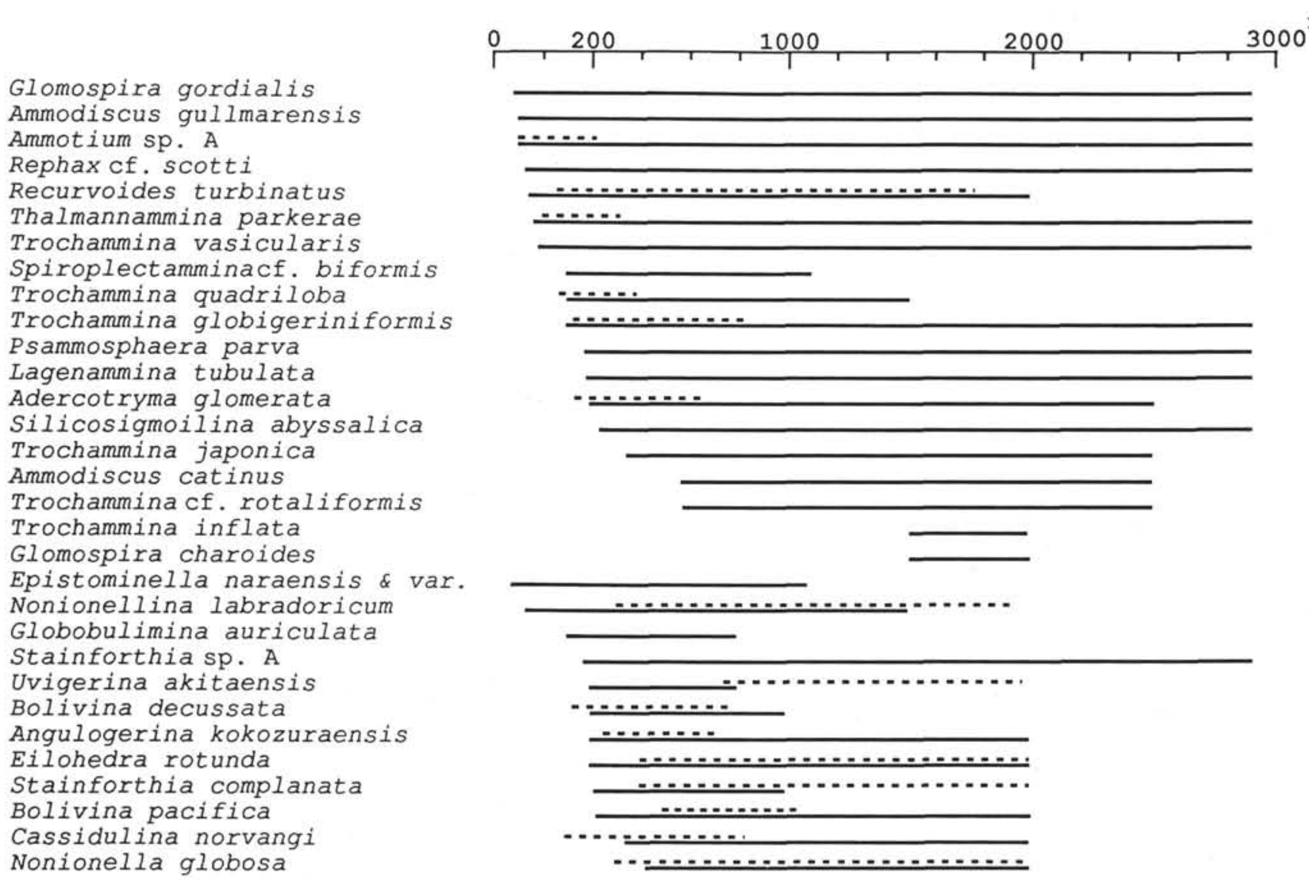

Figure 8. Depth distribution of important species of benthic foraminifers in the present Sea of Japan. The broken line shows their depth distribution in the Pacific Ocean (from Matoba, 1984; Matoba and Honma, 1989).

rences of *Melonis pompilioides* and *Cyclammina cancellata,* the intervals from Sample 128-799A-20H-7, 36–38 cm, to Sample -799A-32X-2, 33–35 cm, from Sample 128-799B-15R-3, 34–36 cm, through -799B-17R-2, 91–93 cm, and Sample -799B-24R-1, 24–26 cm, represent lower Bathyal water depths. Faunas in the five horizons from Sample 128-799A-13H-1, 33–35 cm, through -799A-20H-4, 35–37 cm, from Sample 128-799A-32X-6, 33-35 cm, through -799A-51X-1, 29–31 cm, from Sample 128-799B-11R-5,6 48–50 cm, through -799B-14R-2, 37–39 cm, from Sample 128-799B-17R-5, 91–93 cm, through -799B-21X-2, 37–39 cm, and from Sample 128-799B-27R-1, 34–36 cm, through -799B-29R-3, 40–42 cm, are representative of middle Bathyal depths. The faunas from Sample 128-799B-5R-1, 34–36 cm, through -799B-11R-4, 48–50 cm, and Sample 128-799B-54R-2, 11–12 cm, inhabited upper Bathyal to upper middle Bathyal depths. Thus, Site 799 reached middle Bathyal water depths before the middle middle Miocene and has apparently remained at this depth to the present.

BENTHIC ENVIRONMENTS

Thin-walled benthic foraminifer species including *Bolivina pacifica* and *Stainforthia fusiformis* are important for interpreting the paleoenvironment of the Japan Sea floor. Kato (1984) reported that *B. pacifica* and *S. fusiformis* are predominant in the dark-colored laminated intervals in piston core recovered on the top of Oki Ridge adjacent to Site 798. Layers containing faunas dominated by *B. pacifica* (> 40%) always correspond with laminated intervals. It is known that B. pacifica lives in the low-oxygen environment in the eastern Pacific (Phleger and Soutar, 1973). Likewise, only one species, *Fursenkoina* (= *Stainforthia*) sp., has been reported from seawater almost depleted in dissolved oxygen in the Tyro Basin in the eastern Mediterranean Sea (Jongsma et al., 1983). Figure 11 shows the faunal changes of selected species in dark-colored laminated clay and light-colored bioturbated clay layers of piston core from Oki Ridge (Kato, 1989). *B. pacifica* and *S. fusiformis* rapidly increase from massive or bioturbated clay to laminated clay layers. The high abundance of *B. pacifica* and *S. fusiformis* in piston-core sediments therefore strongly suggests periods of dysaerobic to anaerobic bottom conditions.

Samples containing high percentages of B. pacifica are recognized in the upper 133.2 mbsf of Site 798 and at Site 799 (above 77.9 mbsf). Judging from these results, modern bottom conditions in the Japan Sea were formed in late Quaternary time, about 1 m.y. ago, as a consequence of the complete isolation of the deep water in the sea from Pacific Deep Water.

CORRELATION OF ODP AND ONSHORE NEOGENE BENTHIC FORAMINIFER DISTRIBUTIONS

Matsunaga (1963) summarized the benthic foraminifer biostratigraphy in the oil-producing region of northeast Japan and established five zones applicable to the whole region and several zonules appropriate for each area. Matoba (1990) has illustrates the benthic foraminiferal zones of the Oga Peninsula, Akita Prefecture (Fig. 12). Zonal marker species of the onshore sequence are present in Sites 798 and it is possible to correlate the sequences of Site 798 with the Neogene to Quaternary strata in the Oga Peninsula (Fig. 13). However, the ages of the zone boundaries differ between Site 798 and the onshore sequence. *Spirosigmoilinella compressa,* whose range is limited in *S. compressa* Zone, is an extinct species, and its geologic range was restricted to the Miocene in Matoba (1990). However, in Site 798, *S. compressa* occurs in lower Pliocene strata. Moreover, based on their good preservation and their size range, I judge the specimens of *S. compressa* to be *in situ*. Therefore, the age of the *S. compressa/M. com-*

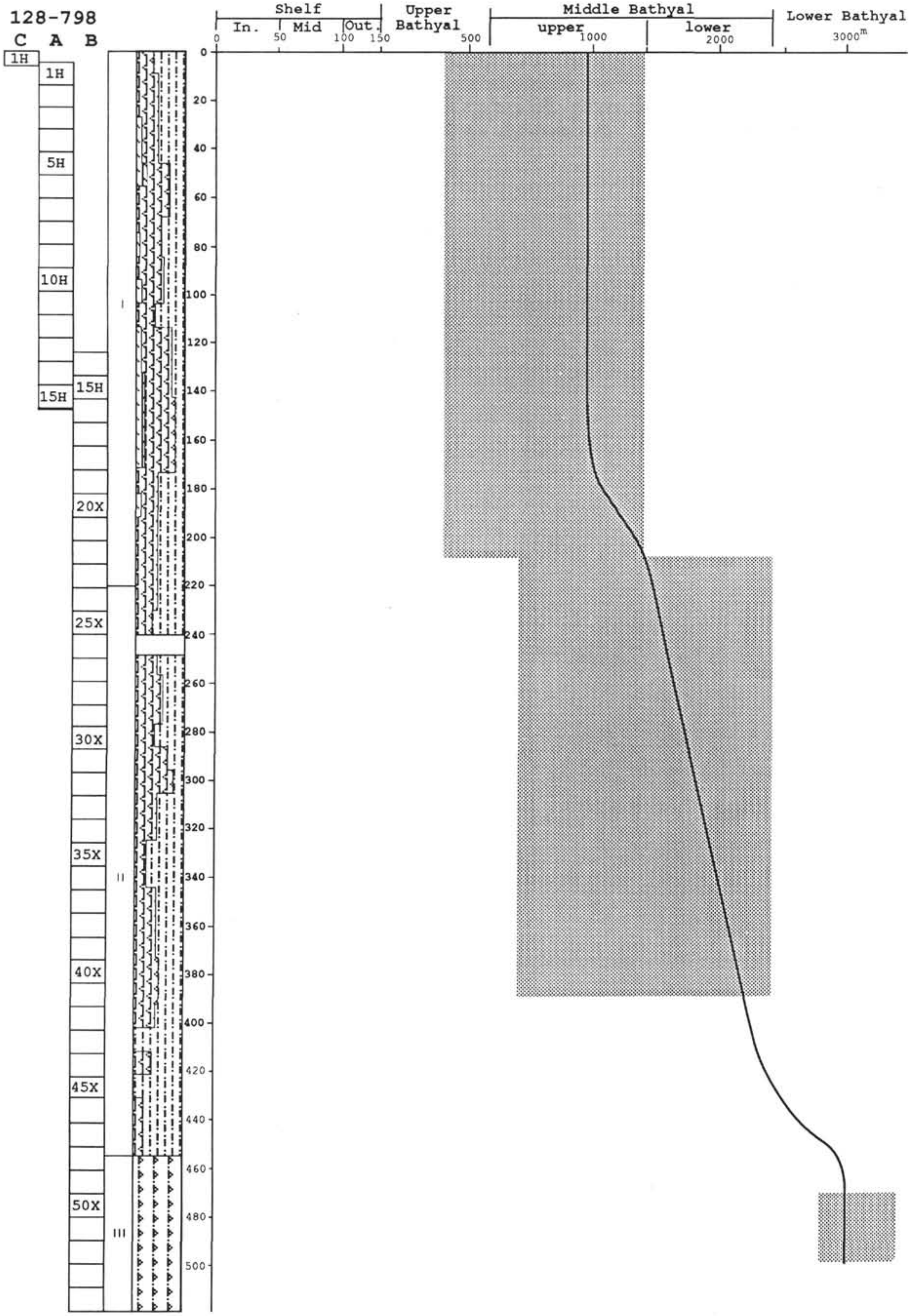

Figure 9. Paleoenvironment of Site 798, Oki Ridge (shadowed zones show the depth ranges estimated from benthic foraminifer fauna).

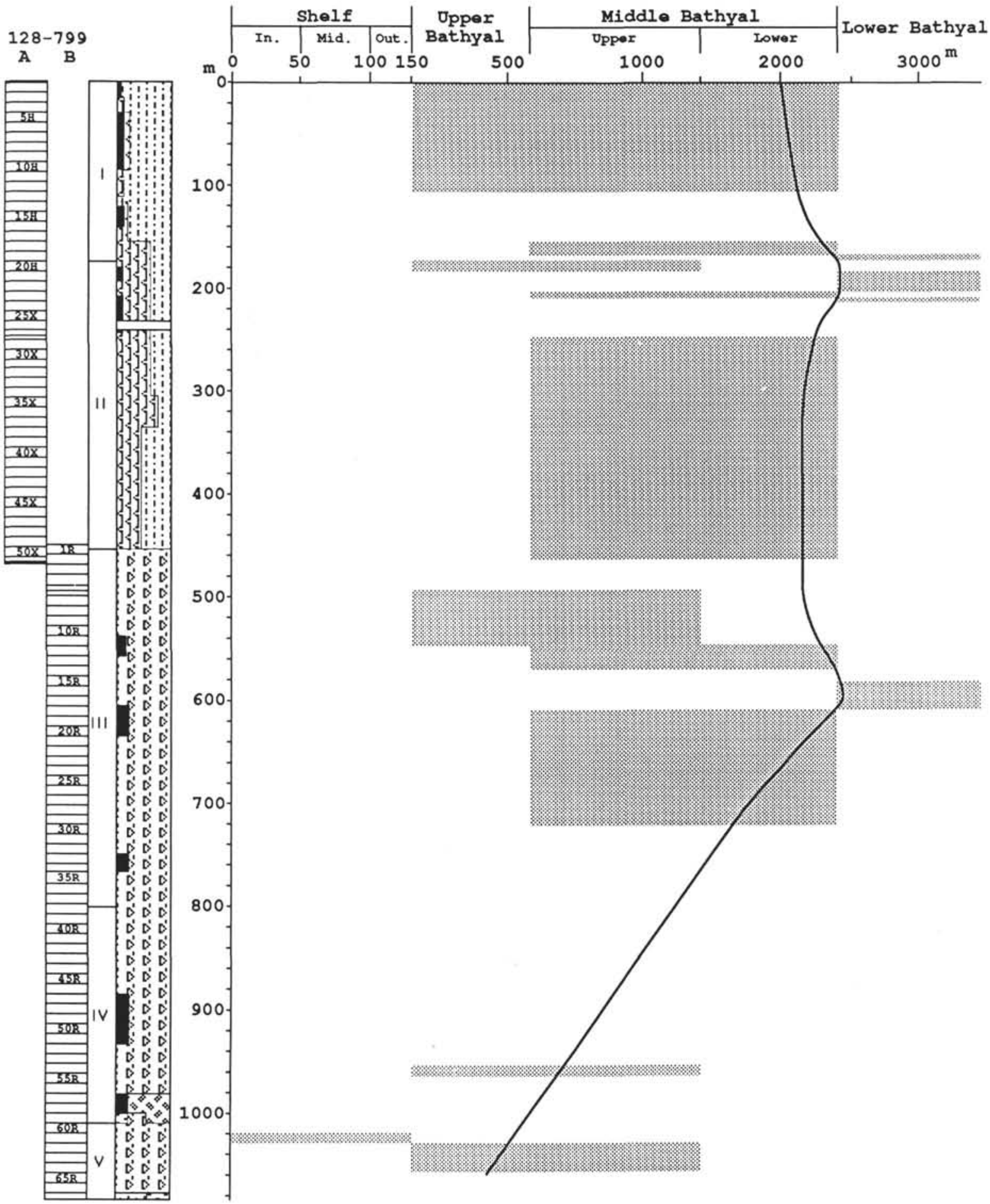

Figure 10. Paleoenvironment of Site 799, Kita-Yamato Trough (shadowed zones show the depth ranges estimated from benthic foraminifer fauna).

munis Boundary Zone and *M. echigoensis*/*M. nodulosa* Boundary Zone at the Site 798 is about 2 m.y. younger than reported in land sections. A similar time lag is noted by Sato et al. (1988) in the uppermost Cenozoic sequence of Akita Prefecture.

As a consequence of these revised correlations there is a time lag in the age of the upper limit of Uvigerina peregrina Zone in the Oga Peninsula and in the Akita oil-producing area. The age of the latter zone in the Oga Peninsula is more than 0.83 m.y. younger than in the Akita oil-producing area. The same relationship is probably present between the Sado Island and Niigata oil-producing sequences (T. Takayama, Kanazawa Univ., pers. comm., 1990). Based on these results, the range of *S. compressa* in Site 798 occurs in younger strata than in the adjacent land sections. Because the *Elphidium*/*C. sublimbata serrata* Boundary Zone is defined by the occurrence of shallow neritic species, this zone cannot be recognized in ODP sites.

As pointed out above, the modern deep-water fauna of the Sea of Japan has a peculiar depth distribution. Moreover, there are many species that are not found in the ancient Japan Sea fauna.

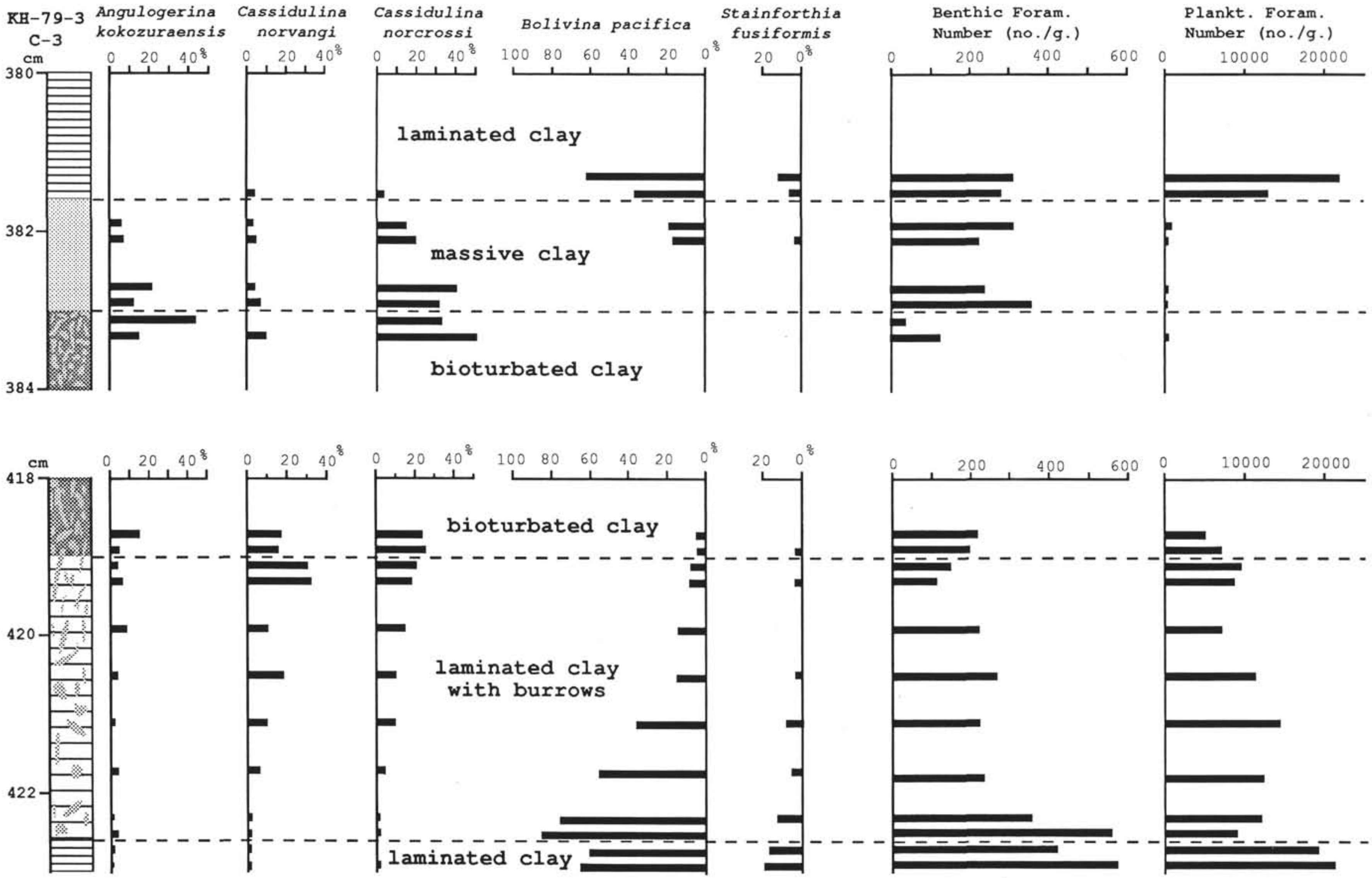

Figure 11. Stratigraphic occurrence of selected benthic foraminifers in the piston core (KH-79-3, C-3) recovered from Oki Ridge. Upper row shows the faunal change from light-colored bioturbated clay to dark-colored laminated clay layers, and lower row shows from dark laminated clay to light bioturbated clay layers.

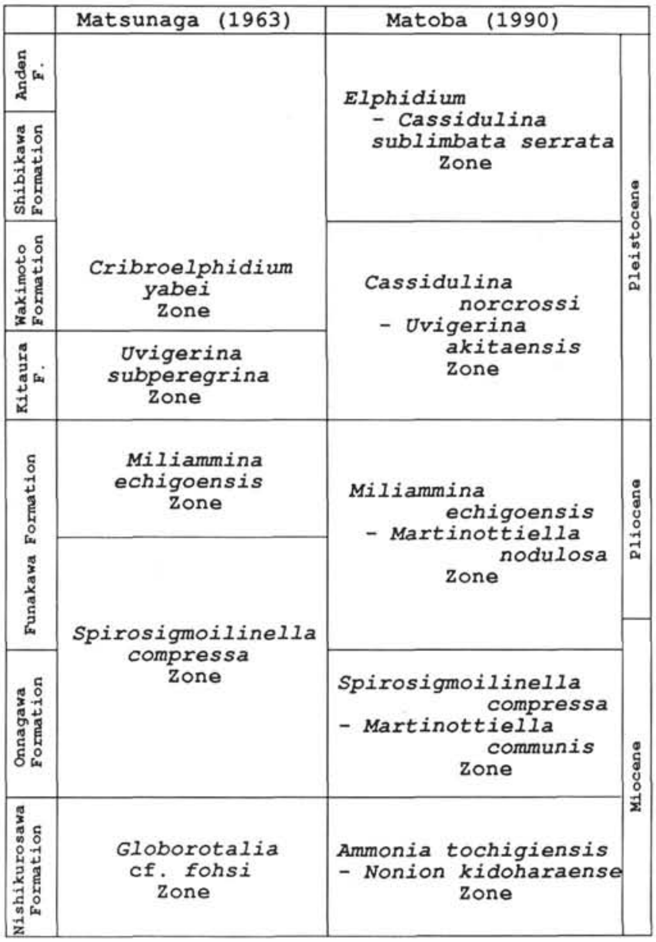

Figure 12. Late Cenozoic benthic foraminifer zones by Matsunaga (1963) in the oil-bearing strata in the Japan Sea coastal region and by Matoba (1990) in the Oga Peninsula (after Matsunaga, 1963; and Matoba, 1990).

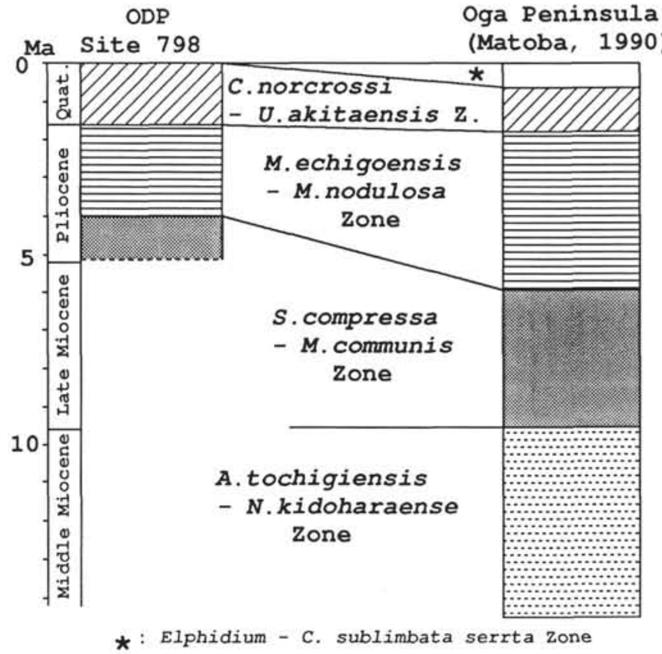

Figure 13. Correlation between Site 798 and Oga Peninsula based on the benthic foraminifer zones.

Table 5. Extinction levels of species typical of the "Tertiary-type" population, Leg 128, Site 798.

Species	Samples	Depth (mbsf)
Valvulineria sadonica	798A-1H-1, 41–43 cm	0.42
Pullenia apertura	798A-1H-4, 33–35 cm	4.93
Epistominella pulchella	798A-1H-4, 42–44 cm	9.84
Oridordalis tener	798A-13H-3, 42–44 cm	121.65
Sphaeroidina bulloides	798B-17X-6, 35–37 cm	160.07
Martinottiella communis	798B-23X-2, 38–40 cm	212.75
Martinottiella nodulosa	798B-37X-1, 54–56 cm	345.86
Cyclammina cancellata	798B-49X-7, 40–42 cm	470.21

Matoba (1975, 1984) has described these latter faunas as the "Tertiary-type" deep-water fauna of the Japan Sea and notes that they became extinct through a drastic change in the bottom environment during late Pleistocene time. Ujiié (1979), also found that the extinction of the "Tertiary-type" populations occurred in the late Pleistocene, based on analysis of piston cores taken from the Sea of Japan. Ujiié (1979) also concludes that the "Tertiary-type" species disappeared sequentially in time. The main constituents of the "Tertiary-type" population are *Cyclammina cancellata*, *Martinottiella communis*, *M. nodulosa*, *Epistominella pulchella*, *Melonis pompilioides*, *Pullenia apertula*, *Valvulineria sadonica*, *Oridorsalis tener*, and *Sphaeroidina bulloides* (Matoba, 1984; Matoba and Honma, 1986). The extinction levels of species typical of the "Tertiary-type" population, as observed in the sediments of Site 798, are shown in Table 5.

Because many reworked specimens from older horizons as well as displaced shallow sediments are present at Site 799, the extinction levels of these species are not clear at this site. However, the extinction level of *Melonis pompilioides*, which does not occur in Site 798, is recognized in Sample 128-799A-20H-7, 36–38 cm. Alternatively, the extinction levels for "Tertiary-type" species at Site 798 (Table 5) support the hypothesis of Matoba (1975) and Ujiié (1979).

Alternatively, many species representative of the modern fauna in the Sea of Japan are not found in the ancient "Tertiary-type" fauna such as *Nonionella globosa*, which makes its initial appearance in Sample 128-798B-11H-6, 40–42 cm.

ACKNOWLEDGMENTS

I thank the Ocean Drilling Program and J. C. Ingle, Jr., and K. Suyehiro, co-chief scientists on Leg 128, for the opportunity of participating in Leg 128 as a shipboard scientist. I am grateful to M. Matoba of Akita University for allowing the author to examine his collection of benthic foraminifer species, including those from the Sea of Japan and the Oga Peninsula, and for various suggestions on the depth distribution of Holocene benthic foraminifers. Thanks are due T. Takayama of Kanazawa University for his various suggestions on the geologic history of the Japan Sea coastal region, and also Prof. J. C. Ingle, Jr. of Stanford University for his various suggestions and for reading the manuscript.

REFERENCES

Asano, K., 1936. *Pseudononion*, new genus of foraminifera found in Muraoka-mura, Kamakura-gori, Kanagawa Prefecture. *Geol. Soc. Jpn., J.*, 43:347–348.

————, 1938a. Japanese fossil Nodosariidae, with notes on the Frondiculariidae. *Sci. Rep. Tohoku Univ., Ser. 2*, 19:179–220.

————, 1938b. On some Pliocene foraminifera from the Setana Beds, Hokkaido. *Jpn. J. Geol. Geogr.*, 15:86–103.

————, 1938c. On the Japanese species of *Bolivina* and its allied genera. *Geol. Soc. Japan, J.*, 45:600–609.

———, 1938d. On the Japanese species of *Nonion* and its allied genera. *Geol. Soc. Japan, J.*, 45:592–599.

———, 1938e. On the Japanese species of *Uvigerina* and its allied genera. *Geol. Soc. Japan, J.*, 45:609–618.

———, 1939a. Foraminifera from Urashima Bank, Wakasa Bay. *Shokubutsu Dobutsu*, 7:1703–1709. (in Japanese)

———, 1939b. New species of Pliocene foraminifera from Oga Peninsula, Akita Prefecture. *Geol. Soc. Japan, J.*, 46:413–427. (in Japanese with English description of new species)

———, 1948. Foraminiferal zonation of the Wakimoto and Shibikawa Formations, Oga Peninsula, Akita Prefecture, as a standard subdivision of the Japanese Pliocene of the borderland of the Japan Sea. *Geol. Soc. Jpn., J.*, 54:44–49. (in Japanese with English abstract)

———, 1949. New Miocene foraminifera from Japan. *J. Paleontol.*, 23:423–430.

———, 1950a. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 1): *Nonionidae:* Tokyo (Hosokawa), 1–12.

———, 1950b. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 2): *Buliminidae:* Tokyo (Hosokawa), 1–19.

———, 1950c. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 3): *Textulariidae:* Tokyo (Hosokawa), 1–7.

———, 1950d. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 4): *Valvulinidae:* Tokyo (Hosokawa), 1–4.

———, 1950e. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 5): *Verneuilinidae:* Tokyo (Hosokawa), 1–4.

———, 1951a. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 6): *Miliolidae:* Tokyo (Hosokawa), 1–20.

———, 1951b. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 7): *Cassidulinidae:* Tokyo (Hosokawa), 1–7.

———, 1951c. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 8): *Polymorphinidae:* Tokyo (Hosokawa), 1–14.

———, 1951d. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 9): *Ophthalminidae:* Tokyo (Hosokawa), 1–2.

———, 1951e. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 10): *Lituolidae:* Tokyo (Hosokawa), 3–7.

———, 1951f. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 11): *Trochamminidae:* Tokyo (Hosokawa), 8–9.

———, 1951g. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 12): *Chilostomellidae:* Tokyo (Hosokawa), 9–12.

———, 1951h. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 13): *Anomalinidae:* Tokyo (Hosokawa), 12–19.

———, 1951i. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 14): *Rotaliidae:* Tokyo (Hosokawa), 1–21.

———, 1951j. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Pt. 4): *Lagenidae:* Tokyo (Hosokawa), 1–39.

———, 1952. Stach, L. W. (Comp. and Ed.), *Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera* (Suppl. 1): *Eocene-Recent:* Tokyo (Hosokawa), 1–17.

———, 1956a. The foraminifera from the adjacent seas of Japan, collected by the S. S. Soyo-maru, 1922–1930, Pt. 1: Nodosariidae. *Sci. Rep. Tohoku Univ., Ser. 2*, 27:1–55.

———, 1956b. The foraminifera from the adjacent seas of Japan, collected by the S. S. Soyo-maru, 1922–1930, Pt. 2: Miliolidae. *Sci. Rep. Tohoku Univ., Ser. 2*, 27:57–83.

———, 1958a. The foraminifera from the adjacent seas of Japan, collected by the S. S. Soyo-maru, 1922–1930, Pt. 4:, Buliminidae. *Sci. Rep. Tohoku Univ., Ser. 2*, 29:1–41.

———, 1958b. The foraminifera from the adjacent seas of Japan, collected by the S. S. Soyo-maru, 1922–1930, Pt. 5: Nonionidae. *Sci. Rep. Tohoku Univ., Ser. 2*, Spec. Vol., 4:189–201.

Chiji, M., 1960. Microbiostratigraphy of the Neogene formation in the Nadaura district, Toyama Prefecture, Japan. *Osaka Mus. Nat. Hist. Bull.*, 12:63–95 (in Japanese with English abstract)

Chiji, M., and Konda, I., 1970. Depth distribution of foraminiferal assemblages in the bottom sediments around Okushiri Island, North Japan Sea. *Osaka Mus. Nat. Hist. Bull.*, 23:35–50. (in Japanese with English abstract)

Cushman, J. A., and Ozawa, Y., 1929. Some species of fossil and Recent Polymorphinidae found in Japan. *Jpn. J. Geol. Geogr.*, 6:63–77.

Hasegawa, S., 1979. Foraminifera of the Himi Group, Hokuriku Province, Central Japan. *Sci. Rep. Tohoku Univ., Ser. 2*, 49:89–163.

Ichikura, M., and Ujiié, H., 1976. Lithology and planktonic foraminifera of the Sea of Japan piston cores. *Bull. Nat. Sci. Mus., Ser. C*, 2:151–178.

Ikeya, N., 1970. Population ecology of benthonic foraminifera in Ishikari Bay, Hokkaido, Japan. *Oceanogr. Works Jpn., Rec.*, 10:173–191.

Inoue, Y., 1980. Stratigraphic and paleoenvironmental considerations of Holocene to uppermost Pleistocene Foraminifera in Nishi-Tsugaru Basin, Sea of Japan. *Prof. S. Kanno Mem. Vol.*, 241–261.

———, 1989. Northwest Pacific foraminifera as paleo-environmental indicators. *Sci. Rep. Inst. Geosci., Univ. Tsukuba, Sec. B*, 10:57–162.

Ishiwada, Y., 1950. Foraminiferal death assemblages from the mouth of Toyama Bay (Studies on Recent marine sediments—no.1). *Bull. Geol. Surv. Jpn.*, 1:182–194. (in Japanese)

———, 1951. Miscellaneous notes on the application of the fossil smaller foraminifera to the Japanese oil and gas field exploration. *Jpn. Assoc. Petrol. Tech., J.*, 16:335–348. (in Japanese)

Jongsma, D., Fortuin, A. R., Huson, W., Troelstra, S. R., Klaver, G. T., Peters, J. M., van Harten, D., de Lange, G. J., and ten Haven, L., 1983. *Nature*, 305:795–797.

Kato, M., 1984. Foraminifera—analysis of the piston core KH-79-3, C-3. *Gekkan Chikyu*, 6:529–537. (in Japanese)

———, 1989. Benthic foraminifers from the Japan Sea piston cores. *In* Takayanagi, Y., and Ishizaki, K. (Eds.), *Coll. Pap. Foram. from the Japanese Island:* Tokyo (Sendai), 111–116. (in Japanese)

Matoba, Y., 1975. Benthic foraminifera—distribution in seas around Japan. *Kaiyo-kagaku*, 7:257–262. (*in Japanese*)

———, 1976. Foraminifera from off Noshiro, Japan and postmortem destruction of tests in the Japan Sea. *In* Takayanagi, Y., and Saito, T. (Eds.), *Progress in Micropaleontology: Selected Papers in Honor of Prof. K. Asano.* Spec. Publ., Micropaleontol. Press, 169–189.

———, 1984. Paleoenvironment of the Sea of Japan. *In* Oertli, H. J. (Ed.), *Benthos '83: 2nd Int. Symp. Benthic foraminifera*, 409–414.

———, 1990. Neogene and Quaternary sedimentary sequences in the Oga Peninsula. *In Benthos '90: 4th Int. Symp. Benthic foraminifera: Guidebook for Field Trip No. 2, Oga Peninsula*, B1–B62.

Matoba, M., and Honma, N., 1985. Depth distribution of Recent benthic foraminifera off Nishitsugaru, eastern Sea of Japan. *In* Matoba, M., and Kato, M. (Eds.), *Studies on Cenozoic Benthic Foraminifera in Japan:* (Akita), 53–78. (in Japanese with English abstract)

Matsuda, T., 1957. Bathyal sediments of Toyama Bay. *Geol. Soc. Japan, J.*, 63:619–635. (in Japanese)

Matsunaga, T., 1963. Benthonic smaller Foraminifera from the oil-fields of northern Japan. *Sci. Rep. Tohoku Univ., Ser. 2*, 35:67–122.

Oinomikado, T., 1939. On the foraminiferal fauna of the Tertiary sediments along the Nobe Valley, Niigata Prefecture. *Geol. Soc. Japan, J.*, 46:455–460. (in Japanese with English abstract)

———, 1940. Tertiary foraminifera from the Amaze Oil Field. *Geol. Soc. Japan, J.*, 47:331–338. (in Japanese with English abstract)

———, 1941. Tertiary foraminifera from the Koguti Formation and the Osawa Limestone in the Niitsu Oil Field, Niigata Prefecture. *Geol. Soc. Japan, J.*, 48:85–87.

Phleger, F. B., and Soutar, A., 1973. Production of benthic foraminifera in three east Pacific oxygen minima. *Micropaleontol.*, 19:110–115.

Saidova, K. M., 1961. Ekologiya foraminifer i paleogeografiya dalinebostochnikh morei SSSR i severozapadnoi chasti Tikhogo Okeana. *Akad. Nauk SSSR, Inst. Okeanol., Moskva*, 1-232. (*in Russian*).

Sato, T., Takayama, T., Kato, M., Kudo, T., and Kameo, K., 1988. Calcareous microfossil biostratigraphy of the uppermost Cenozoic formations distributed in the coast of the Japan Sea—Pt. 4: Conclusion. *Japan. Assoc. Pet. Tech., J.* 53:475–491.

Tai, Y., 1959. Miocene Microbiostratigraphy of West Honshu, Japan. *J. Sci. Hiroshima Univ., Ser. C,* 2:265–395.

Troitskaya, T. S., 1970. Usloviya obitaniya i raspredelenie foraminifer v Yaponskom More (semeistva Elphidiidae, Cassidulinidae I Islandiellidae). *In* Fursenko, A. V. (Ed.), *Obstchie voprosy izucheniya mikrofauny Sibiri, dalinego vostoka i drugikh raionov.* Akad. Nauk SSSR, Sibirskoe Otd. Trudi Inst. Geol. Geofiz., 71:136–160. (in Russian)

————, 1972. Raspredelenie foraminifer v sovremennom basseine Yaponskogo Morya. *In Problemi izucheniya chetvertichnogo geologii.* Izd. Nauka, Moskva, 516–522. (in Russian).

————, 1973. Foraminifera of the Japan Sea West Shelf and their environments. *In* Fursenko, A. V. (Ed.), *Problems of Foraminifera's Biogeography and Ecology.* Acad. Sci. USSR, Siberian Branch, Transact. Inst. Geol. Geophys., 62:119–176. (in Russian)

Ujiié, H., 1979. Two problems on the Sea of Japan geohistory-Quaternary benthic foraminiferal faunas and age of the spreading. *Nihonkai,* 10:56–68. (in Japanese)

Ujiié, H., Ichikura, M., and Kurihara, K., 1983. Quaternary Benthonic foraminiferal changes observed in the Sea of Japan piston cores. *Bull. Nat. Sci. Mus., Ser. C,* 9:41–78.

Date of initial receipt: 25 March 1991
Date of acceptance: 23 September 1991
Ms 127/128B-142

APPENDIX

Faunal Reference List

Identified and unnamed species encountered during this study are listed alphabetically below.

Ammodiscus sp. A

Angulogerina kokozuraensis Asano

A. kokozuraensis Asano, 1949, *J. Paleontol.,* 23, p. 428, text-Fig. 1, nos. 50–53; Asano, 1938e, *Geol. Soc. Japan, J.,* 45, p. 615, Pl. 17, Fig. 17; Asano, 1950, *Ill. cat. Japan. Tert. small. foram.,* Pt. 2, p. 19, Figs. 94–96. *A. ikebei* Husejima and Maruhasii, 1944, *J. Sigenkagaku Kenkyusho,* 1, p. 396, Pl. 34, Fig. 8.

Angulogerina sp. A

Young form similar to *A. hughesi* (Galloway and Wissler). *Uvigernina hughesi* Galloway and Wissler, 1927, *J. Paleontol.,* 1, p. 76, p. 12, Fig. 5.

Angulogerina sp. B

This is a juvenile form, related to *A. angulosa* (Williamson) *Uvigerina angulosa* Williamson, 1858, *Rec. Foram. Great Brit.,* p. 67, Fig. 140.

Anomalina glablata Cushman

A. glablata Cushman, 1924, *Publ. Carnegie Instit. Washington, Dep. Mar. Biol. Pap.,* 21, p. 39, Pl. 12, Figs. 5–7; Asano, 1951h, *Ill. cat. Japan. Tert. small. foram.* Pt. 13, p. 14, Figs. 10–12.

Anomalina globulosa Chapman and Parr

A. globulosa Chapman and Parr, 1937, *Australasian Antarctic Exped., 1911–14,*
Sci. Rep., Ser. C1, p. 117; Asano, 1951h, *Ill. cat. Japan. Tert. smal. foram.,* Pt. 13, p. 14, Figs. 13–15.

Astacolus etigoensis Asano

A. etigoensis Asano, 1938a, *Tohoku Imper. Univ., Sci. Rep.,* 2nd Ser. (*Geol.*), 19, p. 207, Pl. 29, Fig. 23.

Astrononion hamadaense Asano

A. hamadaense Asano, 1950a, *Ill. cat. Japan. Tert. small. foram.,* Pt. 1, p. 6, Figs. 29–31.

Bolivina decussata Brady

B. decussata Brady, 1881, p. 28 (fide Ellis and Messina, 1949 et seq.); Cushman, 1937b, *Cushman Lab. Foram. Res., Spec. Publ.,*79, p. 125, Pl. 16, Figs. 7–9.

Bolivina pacifica Cushman and McCulloch

B. acerosa Cushman var. *pacifica* Cushman and McCulloch, 1942, *Allan Hanc. Pac. Exped.,* 6, p. 185–186, Pl. 21, Fig. 23.

Bolivina spissa Cushman

B. subadvena Cushman var. *spissa* Cushman, 1926b, *Contr. Cushman Lab. Foram. Res.,* 2, p. 45, Pl. 6, Figs. 8a, b.

Bolivina sp. A, aff. *B. difformis* (Williamson)

aff. *Textularia variabilis* Williamson var. *difformis* Williamson, 1858, *Rec. Foram. Great Brit.* p. 77, Figs. 166, 167; Cushman, 1937b, *Cushman Lab. Foram. Res., Spec. Publ.,* 9, p. 164, 165, Pl. 15, Figs. 13–17.

Bolivina sp. B, aff. B. *peirsonae* Uchio

aff. *B. peirsonae* Uchio, 1960, *Cushman Found. Foram. Res., Spec. Publ.,* 5, p. 63, 64, Pl. 7, Figs. 3, 4.

Bolivinita quadrilatera (Schwager)

Textularia quadrilatera Schwager, 1866, *Novara Exped., Geol. Theil,* 2, p. 253, Pl. 7, Fig. 10.
B. quadrilatera, Srinivasan and Sharma, 1980, *Schwager's Car Nicobar Foram. Rep. Novara Exped. A Revision,* p. 42, 43, Pl. 6, Figs. 22, 23.

Brizalina sp. A, aff. *B. bradyi* Asano

aff. *B. bradyi* Asano, 1938c, *Geol. Soc. Japan, J.,* 45, p. 603, Pl. 16, Fig. 2.

Buccella inusitata Andersen

B. inusitata Andersen, 1952, *J. Wash. Acad. Sci.,* 42, p. 148, Figs. 10, 11.

Buccella nipponica (Husezima and Maruhasi)

Discorbis nipponica Husezima and Maruhasi, 1944, *J. Sigenkagaku Kenkyusho,* 1, p. 397, Pl. 34, Figs. 9a–c.
Eponides nipponicus, Asano, 1951, *Ill. cat. Tert. small. Foram,* Pt. 14, p. 10, Figs. 74–76.

Bulimina aculeata d'Orbigny

B. aculeata d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 269, no. 7; Cushman and Parker, 1947, *U. S. Geol. Surv. Prof. Pap.,* 210-D, p. 120, 121, Pl. 28, Figs. 8–11.

Bulimina marginata d'Orbigny

B. marginata d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 269, Pl. 12, Figs. 10–12.

Bulimina striata d'Orbigny

B. striata d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 269, no.2; Cushman and Parker, 1947, *U. S. Geol. Surv. Prof. Pap.,* 210-D, p. 119, Pl. 28, Figs. 1–3.

Bulimina sp. A

Buliminella tenuata Cushman

B. subfusiformis Cushman var. *tenata* Cushman, 1927a, *Bull. Scripps Inst. Oceanogr.,* 21, p. 149, Pl. 2, Fig. 9.

Cassidulina cushmani Stewart and Stewart

C. cushmani, Troitskaya, 1970, Akad. Nauk SSSR, Sibirsk Otd., Trud. Inst. Geol. i Geofiz., 71, p. 147, Pl. 3, Figs. 4, 5.

Cassidulina japonica Asano and Nakamura

C. japonica Asano and Nakamura,1937, *Japan. J. Geol. Geogr.,* 14, p. 144, Pl. 13, Figs. 1, 2, text-Figs. 2a, b.

Cassidulina cf. *japonica* Asano and Nakamura

Cassidulina norcrossi Cushman

C. norcrossi Cushman, 1933b, *Smith. Misc. Coll.,* 89, p. 7, Pl. 2, Figs. 7a–c.

Cassidulina norvangi Thalmann

C. islandica Norvang var. *norvangi* Thalmann, 1950, *Contr. Cushman Found. Foram. Res.,* 1, pt. 3–4, p. 41, footnote 1.

Cassidulina cf. *sublimbata* Asano and Nakamura

cf. *C. sablimbata* Asano and Nakamura, 1937, *Japan. J. Geol. Geogr.,* 14, nos. 2–3, p. 146, Pl. 14, Figs. 3, 4.

Cassidulina sp. A

Cassidulinoides tenuis Phleger and Parker

C. tenuis Phleger and Parker, 1951, *Philos. Trans. Roy. Soc. London,* 155, p. 27, Pl. 14, Figs. 14a–17.

Chilostomella oolina Schwager

C. oolina Schwager, 1878, *Italy, Uff., Geol.,* 9, p. 527, Pl. 1, Fig. 16 (fide Ellis and Messina, 1940 et seq.); Cushman, 1926a, *Contr. Cushman Lab. Foram. Res.,* 1, pt. 4, p. 74, Pl. 11, Figs. 3–10.

Chilostomella ovoidea Reuss

C. ovoidea Reuss, 1850, *Kaiser. Akad. Wissenschaft Wien, Math.-Nat., Class, Denkschrift,* 1, p. 380, Pl. 48, Figs. 12a–e (fide Ellis and Messina, 1940 et seq.); Cushman, 1914, *U. S. Nat. Mus. Bull.,* 71, pt. 4, p. 2, 3. Pl. 1, Figs. 1–5.

Chilostomellina fimbriata Cushman

C. fimbriata Cushman, 1926a, *Contr. Cushman Lab. Foram. Res.,* 1, pt. 4, p. 78, Pl. 11, Fig. 22; Loeblich and Tappan, 1953, *Smiths. Misc. Coll.,* 121, 7, p. 93, 94, Pl. 17, Fig. 3.

Cibicides asanoi Matsunaga

C. asanoi Matsunaga, 1963, *Tohoku Univ., Sci. Rep.,* 2nd Ser. (*Geol.*), 35, p. 116, Pl. 51, Figs. 4a–c.

Cibicides sp. A
Cibicidoides wuellerstorfi (Schwager)
Anomalina wuellerstorfi Shwager, 1866, *Novara Exped., Geol. Theil,* 2, p. 58, Pl. 7, Figs. 105, 107 (fide Ellis and Messina et seq.).
Cyclammina cancellata Brady
C. cancellata Brady, 1879, p. 62 (fide Ellis and Messina et seq.).
Dentalina communis d'Orbigny
Nodosalia (*Dentalina*) *communis* d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 254, no. 35.
Dentalina frobisherensis Loeblich and Tappan
D. frobisherensis Loeblich and Tappan, 1953, *Smiths. Misc. Coll.,* 121, no. 7, p. 55, 56, Pl. 10, Figs. 1–9.
Dentalina ittai Loeblich and Tappan
D. ittai Loeblich and Tappan, 1953, *Smiths. Misc. Coll.,* 121, no. 7, p. 56, 57, Pl. 10, Figs. 10–12.
Dentalina setanaensis Asano
D. setanaensis Asano, 1938a, *Tohoku Imper. Univ., Sci. Rep.,* 2nd Ser. (*Geol.*), 19, p. 215, Pl. 30, Figs. 9–12, 30–32.
Discorbinella sp. A
Echigoina hataii Matsunaga
E. hataii Matsunaga, 1963, *Tokoku Univ., Sci. Rep.,* 2nd Ser. (*Geol.*), 35, p. 115, Pl. 50, Figs. 4a, b.
Eilohedra rotunda (Husezima and Maruhasi)
Eponides rotundus Husezima and Maruhasi, 1944, *J. Sigenkagaku Kenkyusho,* 1, p. 399, Pl. 36, Figs. 12a–c.
Elphidium clavatum Cushman
E. incertam (Williamson) var. *clavatum* Cushman, 1930, *U. S. Nat. Mus. Bull.,* 104, pt. 7, p. 20, Pl. 7, Fig. 10.
Elphidium schmitti Cushman and Wickenden
E. schmitti, Cushman, 1939, *U. S. Geol. Surv. Prof. Pap.,* 191, p. 58, Pl. 16, Figs. 18a–c.
Elphidium subarcticum Cushman
E. subarcticum Cusman, 1944, *Cushman Found. Foram. Res., Spec. Publ.,* 12, p. 27, Pl. 3, Figs. 34, 35.
Elphidium subgranulosum Asano
E. subgranulosum Asano, 1938, *Geol. Soc. Japan, J.,* 45, p. 586, Pl. 14, Figs. 4a, b.
Elphidium sp. A
Epistominella pulchella Husezima and Maruhasi
E. pulchella Husezima and Maruhasi, 1944, *J. Sigenkagaku Kenkyusho,* 1, p. 398, Pl. 34, Figs. 10a–c.
Epistominella sp. A
Eponides sp. A
Fissurina annectens (Burrows and Holland)
Lagena annectens Burrows and Holland, 1895, *A monograph of the Foraminifera of the Crag,* pt. 2, p. 203, Pl. 7, Figs. 11a, b.
Fissurina biconica Silvestri
F. biconica Silvestri, 1902, *Mem. Roma Italia,* v. 19, p. 141, text-Figs. 6–8 (fide Ellis and Messina, 1940 et seq.).
Entosolenia biconica, Asano, 1952, *Ill. cat. Japan. Tert. small. foram., Suppl.,* 1., p. 7, text-Figs. 33, 34.
Fissurina cucurbitasema Loeblich and Tappan
F. cucurbitasema Loeblich and Tappan, 1953, *Smiths. Misc. Coll.,* 121, no. 7, p. 76, Pl. 14, Figs. 10, 11.
Fissurina echigoensis (Asano and Inomata)
Entosolenia echigoensis Asano and Inomata, *In* Asano, 1952, *Ill. cat. Japan. Tert. small. foram., Suppl.,* 1., p. 7, text-Figs. 35, 36.
Fissurina fimbriata (Brady)
Lagena fimbriata Brady, 1881 (fide Ellis and Messina, 1940 et seq.); Brady, 1884 (part), *Rep. Voy. Challenger, Zool.,* 9, Pl. 60, Fig. 26 (not Figs. 27, 28).
Fissurina lagenoides (Williamson)
Entosolenia lagenoides Williamson, 1848, *Ann. Mag. Nat. Hist.,* Ser. 2, 1, (fide Ellis and Messina, 1940 et seq.); Williamson, 1858, *Rec. Foram. Great Britain,* p. 11, Pl. 1, Figs. 25, 26.
Fissurina lucida (Williamson)
Entosolenia marginata (Montagu) var. *lucida* Williamson, 1848 *Ann. Mag. Nat. Hist.,* Ser. 24, 1, (fide Ellis and Messina, 1940 et seq.). *F. lucida,* Loeblich and Tappan, 1953, *Smiths. Misc. Coll.,* 121, 7, p. 76, 77, Pl. 14, Fig. 4.
Fissurina marginata (Montagu)
Vermiculum marginatum Montagu, 1803, *Testacea Britannica,* p. 524 (fide Ellis and Messina et seq.).
L. marginata, Cushman, 1913, *U. S. Nat. Mus. Bull.,* 71, pt. 3, p. 37, Pl. 22, Figs. 1–7.
Fissurina multicostulata McCulloch
F. multicostulata McCulloch, 1977, *Qualit. observ. Recent foram. tests, eastern Pacific.* p. 117, Pl. 57, Fig. 14.
Fissurina orbignyana Seguenza
F. orbignyana Seguenza, 1862, *Dei ter. Terz. Messina,* Pt. II, p. 66, Pl. 2, Figs. 24, 26 (fide Ellis and Messina, 1940 et seq.). *Entosolenia orbignyana,* Asano, 1951j, *Ill. cat. Japan. Tert. small. foram.,* Pt. 15, p. 36, Fig. 156.
Fissurina sublagenoides (Cushman)
Lagena sublagenoides Cushman, 1913, *U. S. Nat. Mus. Bull.,* 71, pt. 3, Pl. 3, p. 40, Pl. 16, Fig. 4.
Fissurina ventricosa (Wiesner)
Lagena (*Entosolenia*) *marginata* Montagu var. *ventricosa* Wiesner, 1931, *Deutsche Sudpolar-Exped.,* 20, p. 120, Pl. 19, Fig. 222.
Fissurina cf. *walleriana* (Wright)
cf. *Lagena orbignyana* (Segenza) var. *walleriana* Wright, 1886, p. 481, Pl. 20, Fig. 8 (fide Ellis and Messina, 1940 et seq.). *F. walleriana,* Boltovskoy and Kahn, 1983, *Micropaleontol.,* 29, p. 301, Pl. 2, Figs. 14, 15.
Frondicularia sp. A
Gavelinopsis hatakeyamai (Iwasa and Kikuchi)
Eponides hatakeyamai Iwasa and Kikuchi, 1954, *Paleontol. Soc. Japan, Trans. Proc., N. S.,* 16, p. 192, text-Figs. 6a–c.
Glandulina laevigata d'Orbigny
Nodosalia (*Glandulina*) *laevigata* d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 252, Pl. 10, Figs. 1–3.
Globobulimina auriculata (Bailey)
Bulimina auriculata Bailey, 1851, *Smiths. Contr.,* 2, p. 12, Figs. 25–27 (fide Ellis and Messina, 1940 et seq.).
G. auriculata, Cushman and Parker, 1947, *U. S. Geol. Surv. Prof. Pap.,* 210-D, p. 129, Pl. 29, Figs. 22–24.
Globobulimina pacifica Cushman
G. pacifica Cushman, 1927b, *Contr. Cushman Lab. Foram. Res.,* 3, p. 27, Pl. 14, Fig. 12.
Globobulimina spinescens Brady
Bulimina pyrula d'Orbigny var. *spinescens* Brady, 1884, *Rep. Voy. Challenger, Zool.,* 9, p. 400, Pl. 50, Figs. 11, 12; Cushman and Parker, 1947, *U. S. Geol. Surv. Prof. Pap.,* 210-D, p. 124, Pl. 28, Figs. 30, 31.
Globobulimina subaffinis (Cushman)
Bulimina subaffinis Cushman, 1921, *U. S. Nat. Mus. Bull.,* 71, pt. 4, p. 166, text-Figs. 7a, b; Cushman and Parker, 1947, *U. S. Geol. Surv. Prof. Pap.,* 210-D, p. 126, Pl. 29, Fig. 7.
Gyroidina sp. A
Gyroidinoides sp. A
Heronallenia cf. *parva* Parr
cf. *H. parva* Parr, 1950, *Rep. B. A. N. Z. Antarctic Res. Exped., Ser. B* (*Zool., Botany*), 5, p. 358, Pl. 14, Fig. 10.
Karreriella baccata japonica Asano
K. baccata japonica Asano, 1938b, *Japan. J. Geol. Geogr.,* 15, p. 90, Pl. 10, Fig. 1.
Lagena amphora Reuss
L. amphora, Cushman and McCulloch, 1950, *Allan Hanc. Pac. Expd.,* 6, p. 329, 334, Pl. 43, Figs. 11–14.
Lagena apiopleura Loeblich and Tappan
L. apiopleura Loeblich and Tappan, 1953, *Smiths. Misc. Coll.,* 121, no. 7, p. 59, Pl. 10, Figs. 14, 15.
Lagena distoma Parker and Jones
L. distoma Parker and Jones, 1864, *Trans. Linn. Soc. London,* 24, p. 467, Pl. 48, Fig. 6 (fide Ellis and Messina, 1940 et seq.); Cushman and McCulloch, 1950, *Allan Hanc. Pac. Exped.,* 6, p. 337, Pl. 44, Fig 12.
Lagena elongata (Ehrenberg)
Miliola elongata Ehrenberg, 1844, *K. Preuss. Akad. Wiss. Berlin, Monatsber.,* p. 274 (fide Ellis and Messina, 1940 et seq.).
Lagena elongata, Cushman, 1923, *U. S. Nat. Mus. Bull.,* 104, pt. 4, p. 15, 16, Pl. 3, Fig. 4.
Lagena flatulenta Loeblich and Tappan
L. flatulenta Loeblich and Tappan, 1953, *Smiths. Misc. Coll.,* 121, no. 7, p. 60, Pl. 11, Figs. 9, 10.
Lagena gracillima (Seguenza)
Amphorina gracilimma Seguenza, 1862, *Descrizione foram. monotalamici Marne Mioceniche, Messina,* Pt. II, p. 51, Pl. 1, Fig. 37 (fide Ellis and Messina, 1940 et seq.); Loeblich and Tappan, 1953, *Smiths. Misc. Coll.,* 121, no. 7, p. 60, 61, Pl. 11, Figs. 1–4.
Lagea gracilis Williamson

L. gracilis Williamson, 1848, *Ann. Mag. Nat. Hist.*, Ser. 2, 1, p. 13, Pl. 1, Figs. 3, 4 (fide Ellis and Messina, 1940 et seq.); Brady, 1884, *Rep. Voy. Challenger, Zool.*, 9, p. 464, Pl. 58, Fig. 22.

Lagena laevis (Montagu)
Vermiculum laeve Montagu, 1803, *Testacea Britannica*, p. 524. *L. laevis*, Loeblich and Tappan, 1953, *Smiths. Misc. Coll.*, 121, no. 7, p. 61, 62, Pl. 11, Figs. 5–8.

Lagena nebulosa Cushman
L. laevis (Montagu) var. *nebulosa* Cushman, 1923, *U. S. Nat. Mus. Bull.*, 104, pt. 4, p. 29, 30, Pl. 5, Figs. 4, 5.

Lagena pliocenica Cushman and Gray
L. pliocenica Cushman and Gray, 1946, *Contr. Cushman Lab. Foram. Res.*, 22, p. 68, Pl. 12, Figs. 22–25.

Lagena semilineata Wright
L. semilineata Wright, 1886, p. 320, Pl. 26, Fig. 7 (fide Ellis and Messina, 1940 et seq.); Loeblich and Tappan, 1953, *Smiths. Misc. Coll.*, 121, no. 7, p. 65, 66, Pl. 11, Figs. 14–22.

Lagena sesquistriata Bagg
L. sesquistriata Bagg, 1912, *U. S. Geol. Surv. Bull.*, 513, p. 50, Pl. 13, Figs. 12–14; Cushman and McCulloch, 1950, *Allan Hanc. Pac. Exped.*, 6, p. 350, Pl. 46, Figs. 12–15.

Lagena setigera Millett
L. clavata d'Orbigny var. *setigera* Millett, 1901, *J. Royal Microscop. Soc.*, p. 122, Pl. 8, Fig. 9.

Lagena striata (d'Orbigny)
Oolina striata d'Orbigny, 1839, *Voy. l'Amér. méridionale-Foram.*, 5, p. 21, Pl. 5, Fig. 12. *L. striata*, Cushman, 1913, *U. S. Nat. Mus. Bull.*, 71, pt. 3, p. 19, Pl. 7, Figs. 4, 5.

Lagena substriata Williamson
L. vulgaris Williamson var. *substriata* Williamson, 1958, *Rec. Foram. Great Britain*, p. 7, Pl. 1, Fig. 14.
Lagena sulcata (Walker and Jacob)
Serpula (*Lagena*) *sulcata* Walker and Jacob, 1798, *Adams' Essays microscope*. 2nd ed., p. 634, Pl. 14, Fig. 5 (fide Ellis and Messina, 1940 et seq.).
L. sulcata, Cushman, 1913, *U. S. Nat. Mus. Bull.*, v. 71, pt. 3, p. 22, Pl. 9, Fig. 2.

Lagena sulcata spicata Cushman and McCulloch
L. sulcata Cushman var. *spicata* Cushman and McCulloch, 1950, *Allan Hanc. Pac. Exped.*, 6, p. 360, 361, Pl. 48, Figs. 3–7.

Lagena tricaritortuosa Ujiié, Ichikura and Kurihara
L. tricaritortuosa Ujiié, Ichikura, and Kurihara, 1983, *Bul. Nat. Sci. Mus.*, Ser. C (*Geol. Paleontol.*), 9, p. 54, Pl. 2, Figs. 7–9.

Lagena sp. A

Lagena sp. B

Lenticulina sagamiensis (Asano)
Robulus sagamiensis Asano, 1938a, *Tohoku Imper. Univ., Sci. Rep.*, 2nd Ser. (*Geol.*), 19, p. 201, Pl. 24, Fig. 6, Pl. 26, Figs. 11–13, Pl. 28, Fig. 12, Pl. 29, Fig. 16.

Martinottiella communis (d'Orbigny)
Clavulina communis d'Orbigny, 1826, *Ann. Sci. Nat. Paris*, Ser. 1, 7, p. 268, no. 4. *Listerella communis*, Cushman, 1937a, *Cushman Lab. Foram. Res., Spec. Publ.*, 8, p. 148, 149, Pl. 17, Figs. 4–7.

Martinottiella gracillima (Cushman and Bermudez)
Listerella gracillima Cushman and Bermudez, 1937, *Contr. Cushman Lab. Foram. Res.*, 13, p. 6, Pl. 1, Figs. 27, 28.

Martinottiella nodulosa (Cushman)
Clavulina communis d'Orbigny var. *nodulosa* Cushman, 1922b, *U. S. Nat. Mus. Bull.*, 104, pt. 3, p. 85, Pl. 18, Figs. 1–3.

Melonis nicobarense (Cushman)
Nonion nicobarense Cushman, 1936, *Contr. Cushman Lab. Foram. Res.*, 12, p. 67, Pl. 12, Figs. 9a, b.

Melonis pompilioides (Fichtel and Moll)
Nautilus pompolioides Fichtel and Moll, 1798, *Testacea microscopica*, p. 31, Pl. 2, Figs. a–c (fide Ellis and Messina, 1940 et seq.); Rogl and Hansen, 1984, *A revision of Testacea Microscopia*, p. 30, Pl. 2, Figs. 1, 2, Pl. 3, Fig. 1.

Miliammina echigoensis Asano and Inomata
M. echigoensis Asano and Inomata, *In* Asano, 1952, *Ill. cat. Japan. Tert. small. foram., Suppl.*, 1, p. 5, text-Figs. 21–25.

Miliolinella oblonga (Montagu)
Vermiculina oblongum Montagu, 1803, *Testacea Britannica*, p. 522, Pl. 14, Fig. 9 (fide Ellis and Messina, 1940 et seq.). *M. oblonga*, Asano, 1951a, *Ill. cat. Japan. Tert. small. foram.*, Pt. 6, p. 10, text-Figs. 68, 69.

Nodosalia sp. A

Nonion japonicum Asano
N. japonicum Asano, 1938, *Geol. Soc. Japan, J.*, 45, p. 593, Pl. 15, Figs. 1,2. *Nonionella* (?) *fragilis* Uchio
N. (?) *fragilis* Uchio, 1960, *Cushman Found. Foram. Res., Spec. Publ.*, 5, p. 62, Pl. 4, Figs. 19–21.

Nonionella globosa Ishiwada
N. globosa Ishiwada, 1950, *Geol. Surv. Japan, Bull.*, 1, p. 191, Figs. 3a–c.

Nonionella stella Cushman and Moyer
N. miocenica Cushman var. *stella* Cushman and Moyer, 1930, *Contr. Cushman Lab. Foram. Res.*, 6, p. 56, Pl. 7, Figs. 17a–c.

Nonionella turgida (Williamson)
Rotalina turgida Williamson, 1958, *Rec. Foram. Great Britain*, p. 50, 51, Figs. 95–97.

Nonionellina labradoricum (Dawson)
Nonion labradoricum Dawson, 1860, *Canad. Natur.*, 5, p. 191, Fig. 4 (fide Ellis and Messina, 1940 et seq.).
Nonion labradoricum, Cushman, 1939, *U. S. Geol. Surv. Prof. Pap.*, 191, p. 23, Pl. 6, Figs. 13–16.

Oolina globosa (Montagu)
Vermiculum globosum Montagu, 1803, *Testacea Britannica*, p. 523. (fide Ellis and Messina, 1940 et seq.). *Lagena globosa*, Brady, 1884, *Rep. Voy. Challenger, Zool.*, 9, p. 452, Pl. 56, Fig. 1. *O. globosa*, Parr, 1950, *Rep. B. A. N. Z. Antarctic Res. Exped., Ser. B* (*Zool., Botany*), 5, p. 30.

Oolina lineata (Williamson)
Entosolenia lineata Williamson, 1848, *Ann. Mag. Nat. Hist.*, Ser. 2, 1, p. 18, Pl. 2, Fig. 18 (fide Ellis and Messina, 1940 et seq.). *O. lineata*, Loeblich and Tappan, 1953, *Smiths. Misc. Coll.*, 121, no. 7, p. 70, Pl. 13, Figs. 11–13.

Oolina melo d'Orbigny
O. melo d'Orbigny, 1839, *Voy. l'Amérique méridionale-Foram.*, 5, p. 20, Pl. 5, Fig. 9; Loeblich and Tappan, 1953, *Smiths. Misc. Coll.*, v. 121, 7, p. 71, 72, Pl. 12, Figs. 8–15.

Oolina striatopunctata (Parker and Jones)
Lagena sulcata (Walker and Jacob) var. *striatopunctata* Parker and Jones, 1865, *Philos. Trans. Roy. Soc. London*, 155, Pl. 13, Figs. 25–27 (fide Ellis and Messina, 1940 et seq.).
O. striatopunctata, Loeblich and Tappan, 1953, *Smiths. Misc. Coll.*, 121, no. 7, p. 74, 75, Pl. 12, Figs. 2–5.

Oolina sp. A

Oridorsalis tener (Brady)
Truncatulina tenera Brady, 1884, *Rep. Voy. Challenger, Zool.*, 9, p. 665, Pl. 95, Figs. 11a–c.

Oridorsalis umbonatus (Reuss)
Rotalia umbonata Reuss, 1851, *Natur. Abhandlungen, Wien*, 4, p. 75, Pl. 5, Figs. 35a–c (fide Ellis and Messina, 1940 et seq.). *Eponides umbonatus*, Cushman, 1931, *U. S. Nat. Mus. Bull.*, 104, pt. 8, p. 52, Pl. 11, Figs. 1–3.

Pandaglandulina sp. A

Parafissurina costata Ujiié, Ichikura and Kurihara
P. costata Ujiié, Ichikura and Kurihara, 1983, *Bull. Nat. Sci. Mus.*, Ser. C (*Geol. Paleontol.*), 9, p. 56, Pl. 3, Figs. 19, 20.

Parafissurina fersinea (Fornasini)
Lagena emaciata Reuss var. *felsinea* Fornasini, 1902, *R. Accad. Sci. 1st Bologna, Mem. Sci. nat.*, Ser. 5, 9, p. 47, Fig. 1 (fide Ellis and Messina, 1940 et seq.); Cushman, 1913, *U. S. Nat. Mus. Bull.*, 71, pt. 3, p. 10, Pl. 4, Figs. 1a–c.

Parafissurina lateralis crassa Boltovskoy and Watanabe
P. lateralis (Cushman) forma *crassa* Boltovskoy and Watanabe, 1977, *Mus. Argentino Cienc. Nat., Rev., Hydobiol.*, 5, p. 60, Pl. 6, Figs. 8, 9.

Parafissurina tectulostoma Loeblich and Tappan
P. tectulostoma Loeblich and Tappan, 1953, *Smiths. Misc. Coll.*, 121, no. 7, p. 81, Pl. 14, Figs. 17a–c.

Parafissurina sp. A

Parafissurina sp. B

Parafrondicularia sp. A

Pararotalia sp. A

Planularia asanoi Ujiié, Ichikura and Kurihara
P. tricarinella, Asano (not *Cristellaria tricarinella* Reuss, 1862), 1938e, *Tohoku Imper. Univ., Sci. Rep.*, 2nd Ser. (*Geol.*), 19, p. 207, Pl. 30, Figs. 2, 3. *P. asanoi* Ujiié, Ichikura and Kurihara, 1983, *Bull. Nat. Sci. Mus.*, Ser. C (*Geol., Paleontol.*), 9, p. 54, 55, Pl. 2, Figs. 13, 14.

Planulina sp. A

Pleurostomella sp. A

Pseudoeponides japonicus Uchio

P. japonicus Uchio, *In* Kawai, Uchio, Ueno and Hozumi, 1950, *Assoc. Petrol. Technol., J.,* 15, p. 190, Fig. 16.

Pseudonodosalia appressa (Loeblich and Tappan)

Rectoglandulina appressa Loeblich and Tappan, 1955, *Smiths. Misc. Coll.,* 126, no. 3, p. 4, 5, Pl. 1, Figs. 1–4.

Pseudononion grateloupi (d'Orbigny)

Nonionina grateloupi d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 294, no. 19. *Nonion grateloupi,* Cushman, 1939, *U. S. Geol. Surv. Prof. Pap.,* 191, p. 21, 22, Pl. 6, Figs. 1–7.

Pseudononion japonicum Asano

P. japonicum Asano, 1936, *Geol. Soc. Japan, J.,* 43, p. 347, text-Figs. A–C.

Pseudoparrella naraensis Kuwano

P. naraensis Kuwano, 1950, *Geol. Soc. Japan, J.,* 56, p. 317, Figs. 6a–c.

Pseudoparrella suttuensis (Shirai)

Epistominella suttsuensis Shirai, 1960, *Hokkaido Univ., Fac. Sci., J.,* Ser. 4, Geol. & Mineral., 10, p. 541–542, Pl. 2, Figs. 3a–c.

Pseudoparrella takayanagii (Iwasa)

Epistominella takayanagii Iwasa, 1955, *Geol. Soc. Japan J.,* 61, p. 17, text-Figs. 4a–c.

Pseudoparrella tamana Kuwano

P. tamana Kuwano, 1950, *Geol. Soc. Japan J.,* 56, p. 317, Figs. 5a–c.

Pullenia apertura Cushman

P. apertura Cushman, 1927a, *Bull. Scripps Inst. Oceanog.,* 1, p. 171, Pl. 6, Fig. 10. *Pullenia salisburyi* Stewart and Stewart *P. salisburyi* Stewart and Stewart, 1930, *J. Paleontol.,* 4, p. 72, Pl. 8, Fig. 2.

Pyrgo depressa (d'Orbigny)

Biloculina depressa d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 298, no. 7. *P. depressa,* Cushman, 1929, *U. S. Nat. Mus. Bull.,* 104, pt. 6, p. 71, Pl. 19, Figs. 4, 5.

Pyrgo murrhina (Schwager)

Biloculina murrhina Schwager, 1866, *Novara Exped., Geol. Theil,* 2, p. 203, Pl. 4, Figs. 15a–c. *P. murrhina,* Cushman, 1929, *U. S. Nat. Mus. Bull.,* 104, pt. 6, p. 71, 72, Pl. 19, Figs. 6, 7.

Quadrimorphina laevigata (Phleger and Parker)

Valvulineria laevigata Phleger and Parker, 1951, *Geol. Soc. Am. Mem.,* 46 (pt. 2), p. 25, Pl. 13, Figs. 11, 12.

Quinqueloculina cf. *lamarckiana* d'Orbigny

cf. *Q. lamarckiana* d'Orbigny, 1839, *Foraminiferes,* p. 189, Pl. 11, Figs. 14, 15.

Quinqueloculina vulgaris d'Orbigny

Q. vulgaris d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 302, no. 33; Cushman, 1929, *U. S. Nat. Mus. Bull.,* 104, pt. 6, p. 25, Pl. 2, Figs. 3a–c.

Quinqueloculina sp. A

Quinqueloculina sp. B

Rosalina globularis d'Orbigny

R. globularis d'Orbigny, 1826, *Ann. Sci. Nat.,* 7, p. 271, no. 1, Pl. 13, Figs. 1–4.

Rutherfordioides cf. *rotundiformis* McCulloch

cf. *R. rotundiformis* McCulloch, 1977, *Qualit. observ. Rec. foram. eastern Pacific,* p. 249.

Sigmoilopsis schlumbergeri Silvestri

Sigmoilina schlumbergeri Silvestri, 1904, *Mem. Pontificia Accad. Romana, Nuovi Lincei.,* 22, p. 267 (fide Ellis and Messina, 1940 et seq.); Cushman, 1921, *U. S. Nat. Mus. Bull.,* 71, pt. 4, p. 449.

Silicosigmoilina abyssalica Inoue

S. abyssalica Inoue, 1980, *Prof. S. Kanno Memorial Vol.,* p. 257, 258, Pl. 26, Figs. 7, 11, 12, 14, 16, 19, 20.

Siphonodosalia hyugaensis (Ishizaki)

Ellipsonodosaria hyugaensis Ishizaki, 1943, *Trans. Nat. Hist. Soc. Taiwan,* 33, p. 686, Figs. 12, 13.

S. hyugaensis, Kohl, 1985, *Bull. Am. Paleontol.,* 88, no. 322, p. 64, Pl. 19, Fig. 1.

Sphaeroidina bulloides d'Orbigny

S. bulloides d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 267, no. 1; Brady, 1884, *Rep. Voy. Challenger, Zool.,* 9, p. 620, Pl. 84, Figs. 1–7; Cushman, 1913, *U. S. Nat. Mus. Bull.,* 71, pt. 3, p. 18, Pl. 10, Fig. 7, Pl. 12, Fig. 1.

Spirosigmoilinella compressa Matsunaga

S. compressa Matsunaga, 1955, *Paleontol. Soc. Japan, Trans. Proc., N. S.,* 15, p. 50, text-Figs. 1, 2.

Stainforthia complanata (Egger)

Vigulina schreibersiana Czjzek var. *complanata* Egger, 1893, *K. Bayer, Akad. Wiss., Munchen, Math.-Phys. Cl.,* Abhandle 18, p. 292, Pl. 8, Figs. 91, 92 (fide Ellis and Messina, 1940 et seq.). *V. complanata,* Uchio, 1960, *Cushman Found. Foram. Res., Spec. Publ.,* 5, p. 63, Pl. 6, Fig. 13. *V. loeblichi* Feyling-Hanssen, 1954, *Norsk Geol. Tidsskr.,* 33, p. 191, Pl. 1, Figs. 14–18.

Stainforthia fusiformis (Williamson)

Bulimina pupoides d'Orbigny var. *fusiformis* Williamson, 1858, *Rec. Foram. Great Britain,* p. 63, Pl. 5, Figs. 129, 130.

Stainforthia rotundata, Ujiié, Ichikura and Kurihara, (not *B. rotundata* Parr), 1983, *Bul. Nat. Sci. Mus.,* Ser. C (*Geol., Paleontol.*), 9, p. 58, Pl. 4, Figs. 17–19.

Stainforthia sandiegoensis (Uchio)

Virgulina sandiegoensis Uchio, 1960, *Cushman Found. Foram. Res., Spec. Publ.,* 5, p. 63, Pl. 6, Figs. 17, 18.

Stainforthia spinosa (Heron-Allen and Earland)

Virgulina schreibersiana Czjzek *spinosa* Heron-Allen and Earland, 1932, *Disc. Rep.,* 4, p. 352, Pl. 9, Figs. 3, 4.

Stainforthia sp. A

Stilostomella japonica (Ishizaki)

Ellipsonodosaria japonica Ishizaki, 1943, *Trans. Nat. Hist. Soc. Taiwan,* 33, nos. 242–243, p. 682, Figs. 14, 15.

Stilostomella ketienziensis (Ishizaki)

Ellipsonodosaria ketienziensis Ishizaki, 1943, *Trans. Nat. Hist. Soc. Taiwan,* 33, nos. 242–243, p. 684, Figs. 1, 6, 11.

Stilostomella lepidula (Schwager)

Nodosaria lepidula Schwager, 1866, *Novara Exped., Geol. Theil,* 2, p. 210, Pl. 5, Figs. 27, 28 (fide Ellis and Messina et seq.). *Stilostomella lepidula,* Kohl, 1985, *Bull. Am. Paleontol.,* 88, p. 64, 65, Pl. 19, Fig. 4.

Textularia sp. A

Triloculina tricarinata d'Orbigny

T. tricarinata d'Orbigny, 1826, *Ann. Sci. Nat. Paris,* Ser. 1, 7, p. 299, no. 7; Cushman, 1917, *U. S. Nat. Mus. Bull.,* 71, pt. 6, p. 66, 67, Pl. 25, Figs. 1, 2, text-Fig. 32.

Uvigerina akitaensis Asano

U. akitaensis Asano, 1950b, *Ill. cat. Japan. Terti. small. foram.,* Pt. 2, p. 14, Figs. 60–62.

Uvigerina hispida Schwager

U. hispida Schwager, 1866, *Novara Exped., Geol. Theil,* 2, p. 249, Pl. 7, Fig. 95 (fide Ellis and Messina, 1940 et seq.); Kohl, 1985, *Bull. Am. Paleontol.,* 88, p. 72, 73, Pl. 24, Fig. 3, Pl. 37, Fig. 4.

Uvigerina lobulata (Jung)

Euuvigerina lobulata Jung, 1988, *Tohoku Univ., Sci. Rep.,* 2nd Ser. (*Geol.*), 59, no. 2, p. 158, 159, Pl. 29, Figs. 1, 4, 5, Pl. 35, Figs. 8, 9, Pl. 43, Figs. 1–9.

Uvigerina wakimotoensis Asano

U. wakimotoensis Asano, 1950b, *Ill. cat. Japan. Tert. small. foram.,* Pt. 2, p. 19, Figs. 89, 90.

Uvigerina yabei Asano

U. yabei Asano, 1938e, *Geol. Soc. Japan, J.,* 45, Pl. 17, Figs. 1, 2.

Uvigerinella sp. A

Valvulineria sadonica Asano

V. sadonica Asano, 1951i, *Ill. cat. Japan. Tert.. small. foram.,* Pt. 14, p. 8, Figs. 55–57.

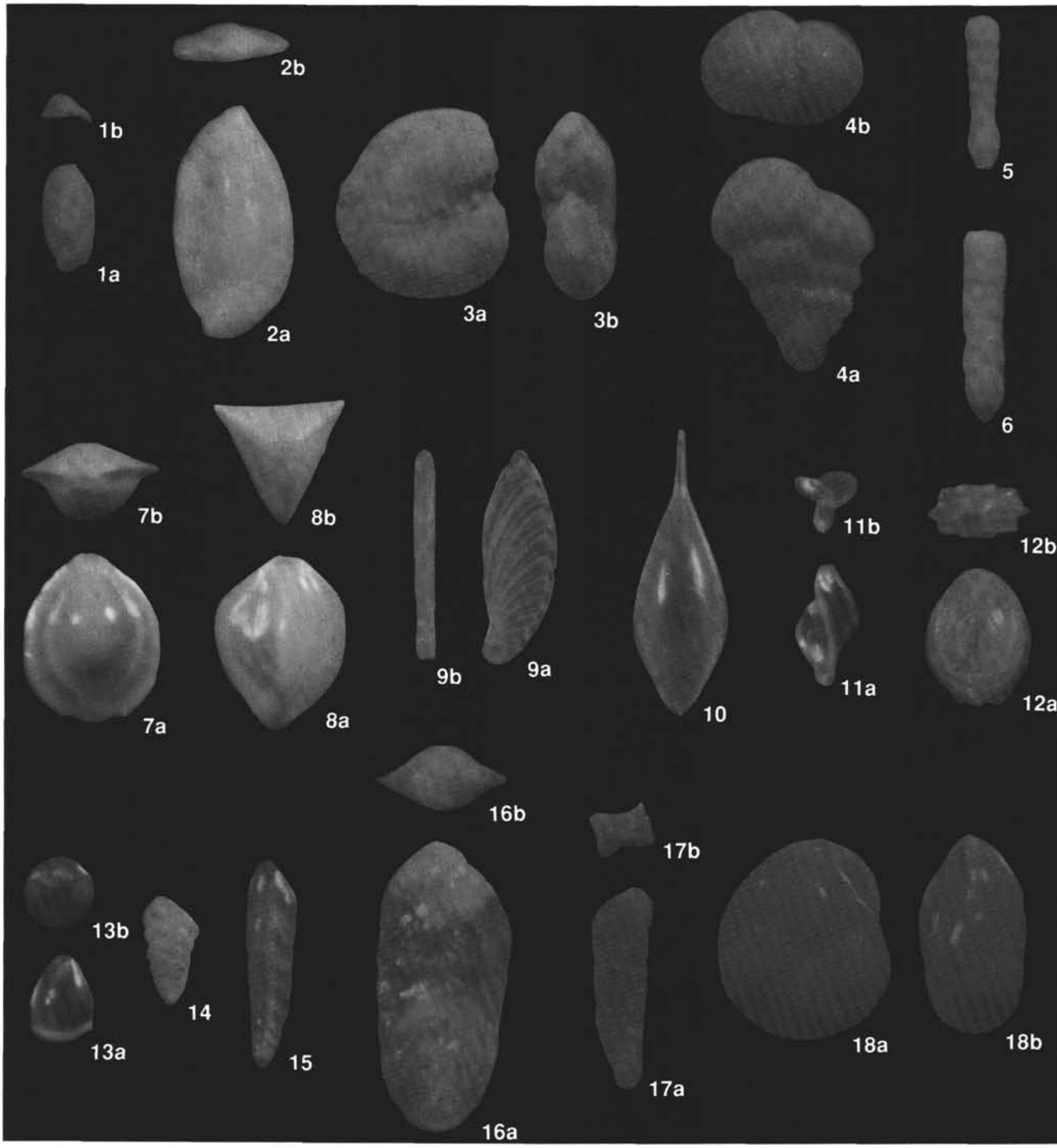

Plate 1. Miocene to Pliocene benthic foraminifers. **1A, B.** *Miliammina echigoensis* Asano and Inomata. ×65. KZGF 90001. Sample 128-798A-8H-6, 56–58 cm. **2A, B.** *Spilosigmoilinella compressa* Matsunaga. ×150. KZGF 90002. Sample 128-798B-51X-1, 50–52 cm. **3A, B.** *Cyclammina cancellata* Brady. ×45. KZGF 90003. Sample 128-799B-15R-3, 34–36 cm. **4A, B.** *Karreriella baccata japonica* Asano. ×45. KZGF 90004. Sample 128-798A-4H-1, 42–44 cm. **5.** *Martinottiella communis* (d'Orbigny). ×65. KZGF 90005. Sample 128-798B-38X-6, 33–35 cm. **6.** *Martinottiella nodulosa* (Cushman). ×45. KZGF 90006. Sample 128-798B-39X-1, 47–49 cm. **7A, B.** *Pyrgo murrhina* (Schwager). ×150. KZGF 90007. Sample 128-798A-1H-4, 33–35 cm. **8A, B.** *Triloculina tricarinata* d'Orbigny. ×150. KZGF 90008. Sample 128-798A-1H-3, 34–36 cm. **9A, B.** *Planularia asanoi* Ujiié, Ichikura and Kurihara. ×45. KZGF 90009. Sample 128-798A-8H-6, 58–60 cm. **10.** *Lagena laevis* (Montagu). ×150. KZGF 90010. Sample 128-798A-8H-6, 58–60 cm. **11A, B.** *Lagena tricaritortuosa* Ujiié, Ichikura and Kurihara. ×150. Sample 128-798A-4H-1, 42–44 cm. **12A, B.** *Fissurina biconica*. ×150. KZGF 90012. Sample 128-798A-8H-6, 58–60 cm. **13A, B.** *Fissurina echigoensis* (Asano and Inomata). ×150. KZGF 90013. Sample 128-798A-2H-1, 43–45 cm. **14.** *Bolivina decussata* Brady. ×150. KZGF 90014. Sample 128-798A-1H-4, 33–35 cm. **15.** *Bolivina pacifica* Cushman and McCulloch. ×150. KZGF 90015. Sample 128-798A-1H-3, 34–36 cm. **16A, B.** *Bolivina spissa* Cushman. ×150. KZGF 90016. Sample 128-798A-13H-4, 42–44 cm. **17A, B.** *Bolivinita quadrilatera* (Schwager). ×45. KZGF 90017. Sample 128-799A-7H-4, 34–36 cm. **18A, B.** *Cassidulina japonica* Asano and Nakamura. ×65. KZGF 90018. Sample 128-798A-2H-1, 43–45 cm.

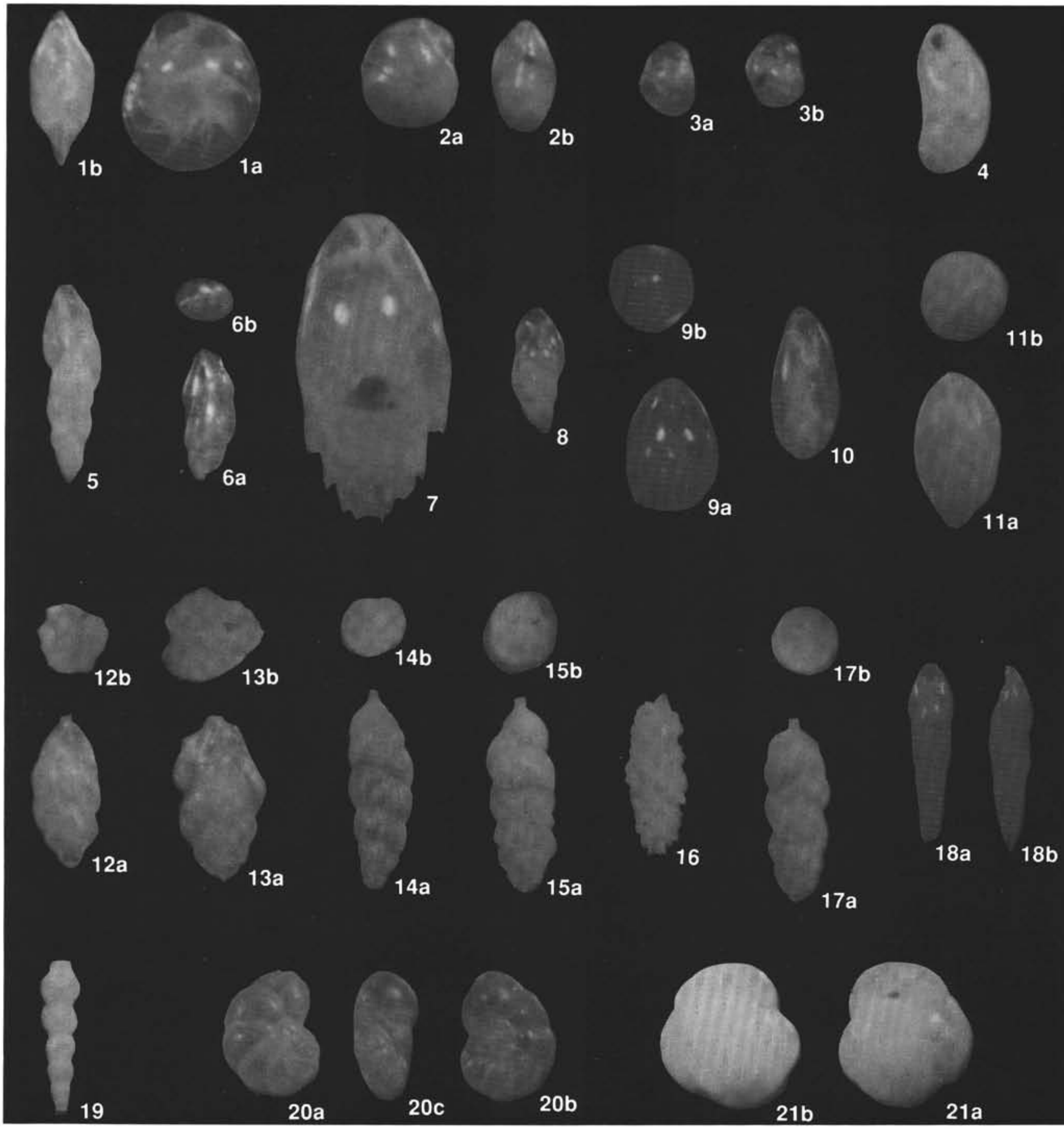

Plate 2. Miocene to Holocene benthic foraminifers. **1A, B.** *Cassidulina norcrossi* Cushman. ×150. KZGF 90019. Sample 128-798A-1H-4, 33–35 cm. **2A, B.** *Cassidulina norvangi* Thalmann. ×150. KZGF 90020. Sample 128-798A-5H-6, 42–44 cm. **3A, B.** *Cassidulina* sp. A. ×150. KZGF 90021. Sample 128-798A-2H-1, 43–45 cm. **4.** *Cassidulinoides tenuis* Phleger and Parker. ×150. KZGF 90022. Sample 128-799A-7H-4, 34–36 cm. **5.** *Stainforthia complanata* (Egger). ×150. KZGF 90023. Sample 128-798A-1H-3, 34–36 cm. **6A, B.** *Stainforthia fusiformis* (Williamson). ×150. KZGF 90024. Sample 128-798A-11H-6, 40–42 cm. **7.** *Bulimina striata* d'Orbigny. ×150. KZGF 90025. Sample 128-798B-23X-3, 41–43 cm. **8.** *Buliminella tenuata* Cushman. ×150. KZGF 90026. Sample 128-798A-11H-4, 40–42 cm. **9A, B.** *Globobulimina auriculata* (Bailey). ×65. KZGF 90027. Sample 128-798A-11H-6, 40–42 cm. **10.** *Globobulimina pacifica* Cushman. ×150. KZGF 90028. Sample 128-798B-19X-1, 40–42 cm. **11A, B.** *Globobulimina subaffinis* (Cushman). ×65. KZGF 90029. Sample 128-798B-23X-3, 41–43 cm. **12A–13B.** *Angulogerina kokozuraensis* Asano. ×150. (12) KZGF 90030. Sample 128-798A-1H-3, 34–36 cm, (13) KZGF 90031. Sample 128-798A-2H-1, 43–45 cm. **14A, B.** *Uvigerina akitaensis* Asano. ×65. KZGF 90032. Sample 128-798A-8H-3, 58–60 cm. **15A, B.** *Uvingerina akitaensis* Asano, var., ×65. KZGF 90033. Sample 128-798A-13H-4, 42–44 cm. **16.** *Uvigerina lobatula* (Jung). ×65. KZGF 90034. Sample 128-798A-11H-4, 40–42 cm. **17A, B.** *Uvigerina yabei* Asano. ×65. KZGF 90035. Sample 128-798A-4H-3, 42–44 cm. **18A, B.** *Pleurostomella* sp. A. ×65. KZGF 90036. Sample 128-799A-13H-7, 33–35 cm. **19.** *Stilostomella lepidula* (Schwager). ×150. KZGF 90037. Sample 128-798B-17X-4, 40–42 cm. **20A–C.** *Valvulineria sadonica* Asano. ×65. KZGF 90038. Sample 128-798A-13H-7, 41–43 cm. **21A, B.** *Sphaeroidina bulloides* d'Orbigny. ×150. KZGF 90039. Sample 128-798B-19X-1, 40–42 cm.

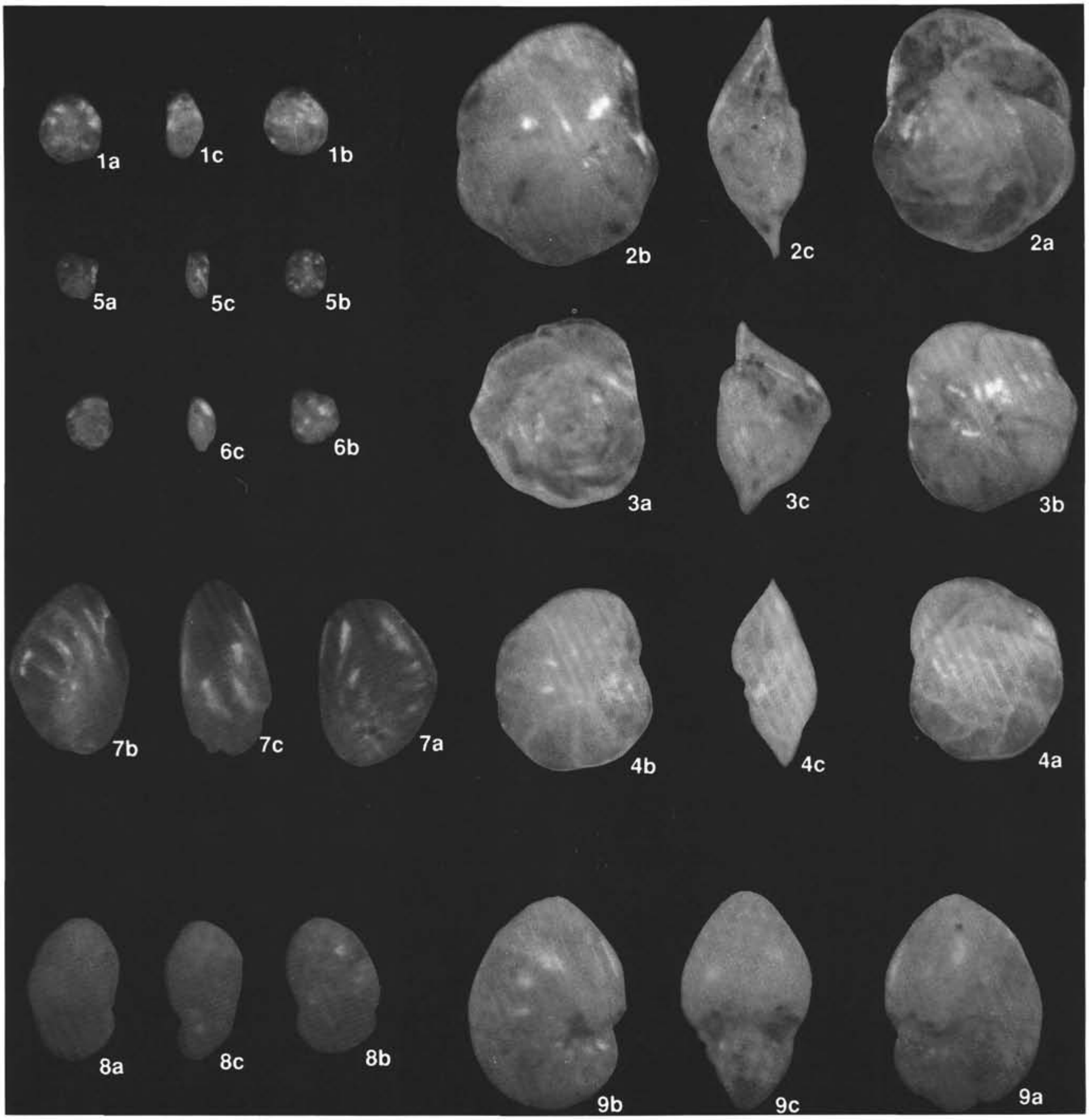

Plate 3. Miocene to Holocene benthic foraminifers. **1A–C.** *Eilohedra rotunda* (Husezima and Maruhasi). ×150. KZGF 90040. Sample 128-798A-5H-6. 42–44 cm. **2A–4C.** *Epistominella pulchella* Husezima and Maruhasi. ×150. **(2)** KZGF 90041. Sample 128-798A-8H-4, 58–60 cm, **(3)** KZGF 90042. Sample 128-798A-6H-3, 38–40 cm, **(4)** KZGF 90043. Sample 128-798A-13H-7, 41–43 cm. **5A–C.** *Pseudoparrella naraensis* Kuwano. ×150, KZGF 90044. Sample 128-798A-2H-1, 43–45 cm. **6A–C.** *Pseudoparrella takayanagii* (Iwasa). ×150, KZGF 90045. Sample 128-798A-1H-3, 34–36 cm. **7A–C.** *Nonionella globosa* Ishiwada. 148150. KZGF 90046. Sample 128-798A-1H-3, 34–36 cm. **8A–C.** *Nonionella stella* Cushman and Moyer. ×150. KZGF 90047. Sample 128-799B-18R-6, 33–35 cm. **9A–C.** *Nonionellina labradoricum* (Dawson). ×150. KZGF 90048. Sample 128-798B-16X-3, 40–42 cm.

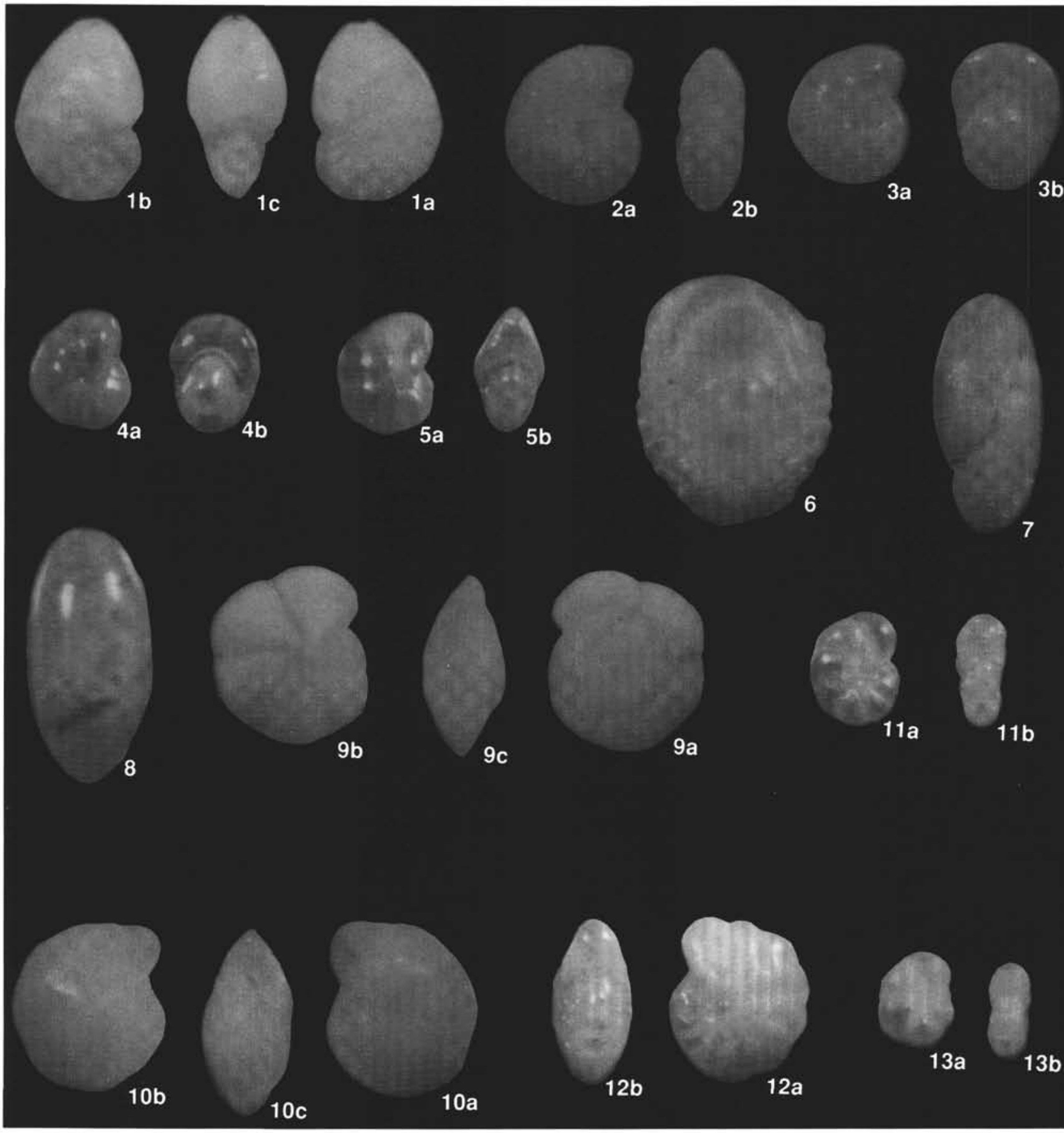

Plate 4. Miocene to Holocene benthic foraminifers. **1A–C.** *Psudononion grateloupi* (d'Orbigny). ×150. KZGF 90049. Sample 128-798B-17X-4, 40–42 cm. **2A, B.** *Melonis nicobarense* (Cushman). ×150. KZGF 90050. Sample 798B-35X-1, 38–40 cm. **3A, B.** *Melonis pompilioides* (Fichtel and Moll). ×150. KZGF 90051. Sample 128-799A-20H-7, 36–38 cm. **4A, B.** *Pullenia apertura* Cushman. ×150. KZGF 90052. Sample 128-798A-3H-4, 36–38 cm. **5A, B.** *Pullenia salisburyi* Stewart and Stewart. ×150. KZGF 90053. Sample 128-798A-8H-6, 58–60 cm. **6.** *Chilostomellina fimbriata* Cushman. ×150. KZGF 90054. Sample 128-798A-6H-3, 38–40 cm. **7.** *Chilostomella oolina* Schwager. ×150. KZGF 90055. Sample 128-799B-11R-4, 48–50 cm. **8.** *Chilostomella ovoidea* Reuss. ×150. KZGF 90056. Sample 128-798A-13H-4, 42–44 cm. **9A–C.** *Ordorsalis tener* (Brady). ×150. KZGF 90057. Sample 128-798B-14H-2, 50–52 cm. **10A–C.** *Oridorsalis umbonatus* (Reuss). ×150. KZGF 90058. Sample 128-798B-35X-1, 38–40 cm. **11A, B.** *Echigoina hataii* Matsunaga. ×150. KZGF 90059. Sample 128-798A-1H-4, 33–35 cm. **12A, B.** *Elphidium clavatum* Cushman. ×150. KZGF 90060. Sample 128-798A-6H-3, 38–40 cm. **13A, B.** *Elphidium subarcticum* Cushman. ×150. KZGF 90061. Sample 128-798B-16X-3, 40–42 cm.