15. OLIGOCENE TO QUATERNARY FORAMINIFERS FROM THE PHILIPPINE SEA, DEEP SEA DRILLING PROJECT LEG 59

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INTRODUCTION

During Leg 59 of the Deep Sea Drilling Project (Okinawa to Guam, February to March 1978) the *Glomar Challenger* occupied five sites and drilled seven holes in the Philippine Sea region. Locations of the sites are shown in Figure 1. A total of 295 samples were examined for planktonic and benthic foraminifers to obtain age and paleoenvironmental information. Roughly, sediments recovered range in age from the Oligocene to the Quaternary. However, the absence of foraminifers in some samples and the poor preservation of specimens in many other samples preclude precise dating of many intervals and indicate that deposition occurred near or below the foraminiferal lysocline throughout much of the sedimentary history of these sites.

FORAMINIFERAL BIOSTRATIGRAPHY AND PALEOENVIRONMENT

The planktonic foraminiferal zonation used in this report is the letter-number system proposed by Blow (1969). A rather imprecise zonal assignment is necessitated for some of the samples, however, because of the absence of key species and the poor preservation of those species present. The zones represented in the datable core samples recovered from Leg 59 are listed in Table 1.

Because Leg 59 sites appear to have remained in very deep water throughout their sedimentary history, environmental interpretations are often limited to what can be deduced from the presence or absence of the microfossils and their state of preservation.

METHODS

With the exception of the core-catcher samples (of various volumes), 10 cm^3 samples, representing 2-cm intervals of core, were processed for foraminifers. Each sample was washed through several sieves; the residue retained on the 63-μm-mesh sieve was dried and examined.

Occurrences of selected planktonic and benthic foraminifers are recorded in Tables 2 to 7, with qualitative estimates of abundance reported as follows: A = abundant, >30 specimens; C = common, 11 to 30 specimens; F = frequent, 6 to 10 specimens; R = rare, 1 to 5 specimens; X = abundance not noted. For planktonic species, abundances are based on the examination of one slide of strewn specimens, but benthic abundances are based on the examination of the entire washed residue.

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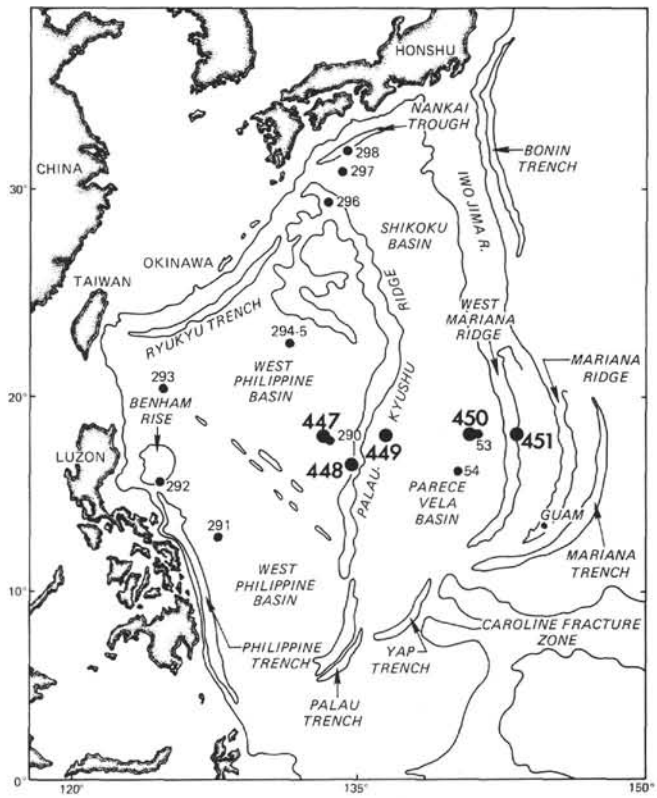

Figure 1. Location map for Leg 59 Sites.

SITE 447

Site 447 is located on the eastern side of the West Philippine Basin (18°00.88′N, 133°17.37′E) at a water depth of 6022 meters. Two holes were drilled.

Hole 447

Hole 447 was abandoned when the core-catcher of the first core became jammed with manganese nodules. Along with manganese nodules, we recovered a small amount of brown clay barren of foraminifers.

Hole 447A

Biostratigraphy. Hole 447A penetrated 113 meters of sediments before we encountered basalt. A total of 41 samples was examined for foraminifers. The uppermost 37.5 meters (Cores 1–4) consist of brown clay in which the only fossils are ichthyoliths. Poorly preserved cal-

Table 1. Foraminiferal biostratigraphy of Leg 59 cores.

Age	Zone	DSDP Holes and Core Numbers					
		447A	448	448A	449	450	451
Quaternary	N.23 N.22	Indeterminate	No zones identified	No zones identified	Indeterminate	17? 17? 17?	1 1 and 2
Late Pliocene	N.21						2 and 3
Early Pliocene	N.19 N.18						3 to 5 5?
Late Miocene	N.17 N.16						5, 7 to 10?, 25? 25?
Middle Miocene	N.15 N.14 N.13 N.12 N.11 N.10 N.9		2				
Early Miocene	N.8 N.7 N.6 N.5 N.4		3 3?, 4? 4 5 6, 7 to 10?	2? 2? 2, 3			
Oligocene	P.22 P.21 P.20		7 to 10?, 11 12 to 17 19	3?, 4? 7?	13?		

careous nannoplankton are present throughout the rest of the sedimentary section, but this entire interval is essentially barren of foraminifers. Core 7, Sections 3, 4, 5, and CC, and Core 11, Sections 1 and CC, contain rare, very poorly preserved specimens of *Globigerina* spp. Except for one specimen of *Pseudohastigerina* cf. *P. micra*? (Cole) in Section 7,CC, no other planktonic foraminifers were observed in samples from this site. One specimen of *Cassidulina subglobosa* Brady and one arenaceous tube were noted in Section 6,CC, and an additional specimen of *C. subglobosa* was found in Section 7-1. All other samples are barren of benthic foraminifers.

Because of the almost total lack of specimens, samples from Site 447 could not be assigned to planktonic foraminiferal biostratigraphic zones.

Paleoenvironment. The absence of calcareous microfossils in Cores 1 through 4 of Hole 447A indicates a depositional environment below the carbonate compensation depth (CCD), which in the Philippine Sea today appears to lie somewhere between 4000 and 4500 meters (Ujiie, 1975). Cores 5 through 12 (except for Core 10, a completely barren hydrothermally altered tuff) contain poorly preserved calcareous nannoplankton but are essentially barren of foraminifers. This evidence suggests that deposition occurred slightly above the CCD but below the foraminiferal lysocline.

SITE 448

Site 448 is located on the western edge of the Palau-Kyushu Ridge (16°20.46′N, 134°52.45′E), about 220 km southeast of Site 447 in 3483 meters of water. Two holes were drilled. The distributions of foraminifers at this site are recorded in Table 2 (planktonic species) and Table 3 (benthic species).

Hole 448

Biostratigraphy. In Hole 448, 337.5 meters of sediments were cored above the uppermost basalt flow. A total of 85 samples from this hole was examined for foraminifers; 10 of these samples are barren and therefore not included in Tables 2 and 3 (i.e., 19-5, 20,CC, 21,CC, 24,CC, 26,CC, 28,CC, 29,CC, 33,CC, 34,CC, and 35,CC). Planktonic foraminifers are abundant but not very diverse, especially in the uppermost cores (Table 2). Consequently, Section 1-1 through Section 2-1 can be dated only probably as middle Miocene, based on the overlapping ranges of *Globoquadrina dehiscens advena* Bermudez and abundant *Sphaeroidinellopsis seminulina* (Schwager)—a species which, according to Stainforth et al. (1975), is usually scarce below the middle Miocene.

Section 2-2 contains *Praeorbulina glomerosa* (Blow), and Section 2-7 contains *Globigerinoides sicanus* de Stefani. Both of these species range from Zone N.8 to Zone N.9. Because *Orbulina universa* d'Orbigny (which does not range below Zone N.9) occurs in Section 2,CC, the entire interval from Section 2-2 through Section 2,CC is tentatively assigned to lowest middle-Miocene Zone N.9. *S. seminulina* is generally abundant in samples from Core 2.

In samples from Section 3-2 to Section 3-5, the presence of *Globigerinatella insueta* Cushman and Stainforth, *Globigerinoides diminutus* Bolli, and *G. sicanus*?, along with the virtual absence of *S. seminulina*, suggest that this interval may be assigned at the latest, to lower-Miocene Zone N.8.

G. diminutus is the only diagnostic species present in Section 3,CC and Section 4-2. Its occurrence plus the stratigraphic position indicate the lower-Miocene Zones N.7–N.8 for these samples.

Globigerinoides altiaperturus Bolli and rare specimens approaching *Globigerina venezuelana/tripartita* morphologically occur in sample from Section 4-5. This sample is dated as early Miocene, tentatively Zones N.6–N.7, based on the range of *G. altiaperturus* and on stratigraphic position.

Section 4-6 and Section 4,CC contain common to abundant *Globoquadrina altispira altispira* (Cushman and Jarvis) and common *Globigerina venezuelana/tripartita*. This is the lowest occurrence of *Globoquadrina altispira altispira* in Hole 448. According to Stainforth et al. (1975), this species does not generally occur below lower-Miocene Zone N.6; therefore this interval is placed in Zone N.6.

Section 5-1 and Section 5,CC contain abundant *Globigerina tripartita* Koch s.1. (concept includes *G. praedehiscens*) and rare to frequent *Catapsydrax dissimilis* (Cushman and Bermudez) but lack *Globoquadrina altispira altispira.* These samples are tentatively assigned to lower-Miocene Zone N.5 because they are below the range of *G. altispira altispira* and above the range of *Globorotalia (T.) kugleri* Bolli.

The stratigraphically highest occurrence of *G. (T.) kugleri* in Section 6-1 marks the top of lower-Miocene Zone N.4. Determination of the Oligocene/Miocene boundary in samples from this site is precluded by the scarcity of *Globigerinoides*. Rare specimens of this genus occur as low as Section 7,CC, but the actual boundary may be somewhat below this, because *Globigerinoides* is present only rarely and sporadically in

samples from Site 448. For this report, most of the samples containing *Globorotalia (T.) kugleri* (Section 6-2–Section 10-6) are located in the upper part of Zones P.22–N.4—equivalent to the *G. kugleri* Zone of Bolli (1966), which spans the Oligocene/Miocene boundary.

Samples from Core 11 typically contain *Globigerina angulisuturalis* Bolli and *G. ciperoensis* Bolli. These samples mark the interval between the lowest occurrence of *Globorotalia (T.) kugleri* and the highest occurrence of *G. (T.) opima opima* Bolli; therefore they were deposited during the late Oligocene in the lower portion of Zone P.22—equivalent to the *Globigerina ciperoensis ciperoensis* Zone of Bolli (1966).

Cores 12 through 17, which contain *Globorotalia (T.) opima opima* and/or *G. opima nana* Bolli, are above the highest occurrence of *Globigerina ampliapertura* Bolli. Thus they can be assigned to upper-Oligocene Zone P.21. The stratigraphically highest occurrence of *Chiloguembelina cubensis* (Palmer) in Section 13-4 may be useful in subdividing Zone P.21.

There was no recovery for Core 18. Section 19-1 contains specimens approaching *Globigerina ampliapertura* in morphology and others somewhat similar to *Globorotalia (T.) increbescens* (Bandy), in addition to two specimens of *Globigerina angulisuturalis*—such an assemblage, if in place, indicates that this sample may have been deposited near the boundary between Zones P.20 and P.21. Section 19-3 lacks *G. angulisuturalis* but contains common *Globigerina ampliapertura* and probably represents deposition within the upper-Oligocene portion of Zone P.20. The foraminiferal assemblages from samples below Section 19.3 are not particularly age-diagnostic.

Paleoenvironment. Foraminiferal, nannofossil, and radiolarian assemblages all indicate that a tropical climate persisted at Site 448 throughout the middle-Oligocene to middle-Miocene interval sampled. Preservation of calcareous microfossils is generally poor to fair in samples from this site. Although nannoplankton occur throughout the sedimentary section, the only foraminifers present in many samples are benthic species and durable planktonic species (e.g., *Sphaeroidinellopsis seminulina* or *Globigerina tripartita* s.l.), and in most samples the benthic foraminifers are much more diverse than the planktonic foraminifers. This phenomenon suggests a depositional environment near the foraminiferal lysocline.

In samples from Section 1-1 through Section 6,CC, the benthic foraminiferal assemblages are diverse and predominately calcareous (Table 3). Forms characteristic of deep bathyal to abyssal environments, including several species of *Stilostomella* and *Cibicides* aff. *C. kullenbergi* Parker, are present in most samples. Arenaceous species are quite rare.

The interval from Core 7 through Core 12 is marked by an increased diversity and abundance of arenaceous foraminifers. Large numbers of radiolarians are present in many of the washed residues. The most common calcareous foraminifers are various species of *Stilostomella; C.* aff. *C. kullenbergi* occurs throughout. This interval may represent a somewhat deeper depositional environment than do the preceeding and succeeding intervals or the CCD may have been slightly higher during this time.

Calcareous foraminifers again predominate over arenaceous specimens in Core 13 through the upper portion of Core 19, but *Stilostomella* and *C.* aff. *C. kullenbergi* (except for Section 19-3) are absent. The lack of these deep-water forms as well as the common occurrence of the typically shallow-water nannofossil *Zygrhablithus bijugatus* (Deflandre) in the lower portion of this interval indicate that these samples may have been deposited in somewhat shallower water than those from either of the overlying intervals. It should be noted, however, that the top of this interval coincides with a lithologic change from nannofossil ooze (Core 12 and above) to nannofossil chalk (Core 13 and below) and that the poor preservation and perhaps even the absence of some species of calcareous foraminifers might be due to diagenesis.

Foraminifers and nannofossils occur only sporadically below Section 19-3, because the sediment interval from Section 19-4 to the top of the basalt in Core 37 consists of volcaniclastics that accumulated very rapidly. These sediments do occasionally contain chalk layers, which are the source of the sporadic occurrences of the foraminifers and nannofossils.

Hole 448A

Spot cores were taken in the sedimentary section of Hole 448A in an attempt to recover material from poorly represented intervals of Hole 448. A total of 19 samples from Hole 448A was examined for foraminifers (see Tables 2 and 3).

Core 1 contains a foraminiferal assemblage similar to that found in Cores 1 and 2 of Hole 448 but datable only probably as the middle Miocene. The upper portion of Core 2 contains foraminifers that indicate the lower Miocene Zones N.5–N.6. In Section 2-6 the highest occurrence of *Globorotalia (T.) kugleri* is noted, marking the top of lower Miocene Zone N.4—possibly equivalent to Section 6-1 of Hole 448. All samples examined from Cores 3 and 4 contain *G. (T.) kugleri* and can, therefore, be assigned to the upper Oligocene–lower Miocene Zones P.22–N.4. The only other sample examined from Hole 448A is Section 7-5. This sample contains *Chiloguembelina cubensis*, suggesting the Oligocene or an older age (possibly Zone P.21 or older).

Discussion of Hole 448A paleoenvironments is unnecessary because of the similarities to equivalent intervals in Hole 448.

SITE 449

Site 449 is located on the western side of the Parece Vela Basin (18°01.84′N, 136°32.19′E), about 240 km northeast of Site 448 in 4712 meters of water. The distributions of both planktonic and benthic foraminifers in samples from Site 449 are recorded in Table 4. One hole was drilled, penetrating 111 meters of sediments above basaltic basement. A total of 37 samples was examined for foraminifers. Most of the sediments consist of barren brown clays, with occurrences of calcareous

Table 2. Distribution of selected planktonic foraminifers at Site 448.

Age	Zone	Sample (interval in cm) Hole 448	*Cassigerinella chipolensis*	*Catapsydrax dissimilis*	*C. unicavus*	*Chiloguembelina cubensis*	*Globigerina ampliapertura*	*G. angulisuturalis*	*G. binaiensis*	*G. ciperoensis*	*G. gortanii*	*G. sellii*	*G. tripartita* s.l.	*G. venezuelana*	*Globigerinatella insueta*	*Globigerinoides altiaperturus*	*G. diminutus*	*G. primativa?*	*G. sicanus*	*G. subquadratus*	*Globoquadrina altispira* s.l.	*G. altispira altispira*	*G. dehiscens* s.l.	*G. dehiscens advena*	*Globorotalia (T.) increbescens*	*G. (T.) kugleri* s.l.	*G. (T.) obesa*	*G. (T.) opima nana*	*G. (T.) opima opima*	*G. (T.) peripheroronda*	*G. (T.) siakensis*	*Orbulina universa*	*Praeorbulina glomerosa*	*Sphaeroidinellopsis seminulina*
Middle Miocene	?	448-1-1, 61-63																						F										A
		448-1-2, 9-11																						R										A
		448-1,CC																				X	?									R		A
		448-2-1, 7-9																			A			C										A
		448-2-2, 1-3																			F		R										R	A
	N.9	448-2-3, 2-4																			A		R											A
		448-2-4, 2-4																			A													A
		448-2-5, 2-4																		R	R		F											
		448-2-6, 4-6																		X	A										R			A
		448-2-7, 4-6																	R															R
		448-2,CC																														R		X
	?	448-3-1, 11-13																					R											
	N.8	448-3-2, 11-13													R		F			R	F		F							R				
		448-3-4, 5-7																	R		A		R				F			F	R			
		448-3-5, 50-52													R		R		R	R	A		R				C				X			R
Early Miocene	N.7-N.8	448-3,CC															X				X													
		448-4-2, 2-4															R				C		R											
	N.6-N.7	448-4-5, 2-4														F					A													
	N.6	448-4-6, 2-4																				A												
	?	448-4,CC																			C	C												
	N.5	448-5-1, 2-4		F						R			A	R																	R			
		448-5,CC		R									A	A												R								
	N.4	448-6-1, 7-9		F									F	R												C								
		448-6-2, 7-9		R									C	R												C								
		448-6-3, 7-9		C	R					F			R	F												A					R			
		448-6-4, 7-9		A	R								R	R												A								
		448-6-5, 5-7		A	R					R			A													A					F			
		448-6,CC		A				R		X			A	X												A					X			
		448-7-1, 18-20		R														R								A								
		448-7,CC			X								A	A				R								A	R							
Late Oligocene	P.22-N.4	448-8-1, 6-8		R								R	A	F												A								
		448-8-2, 7-9		R						R			A	F												A								
		448-8-3, 4-6											A	C												A								
		448-8,CC						R		R			F	A												A								
		448-10-1, 11-13		C				R		C		R	A													A	R				A			
		448-10-2, 13-15		F						R			A													A		R			C			
		448-10-3, 8-10		C	R								C													A					C			
		448-10-4, 9-11		F	R					R			A													C					C			
		448-10-5, 8-10						R		R			A													C		R			C			
		448-10-6, 3-5		R				R					C													C	F							
	?	448-10-7											F	X												R					R			
		448-11-1, 5-7		R	R			F		R			C													R		R						

		448-11-2, 5-7			R			R		X			A																		R		
	P.22	448-11-4, 13-15		X	X			R		X			C	X																	C		
		448-11-6, 16-18		R				A	R	F		F	A														A			A			
	?	448-11,CC			X			X		X			A	X																C			
		448-12-1, 21-23						R		R		F	A														C			C			
		448-12-4, 10-12		F						R	R	R	C														C	C		X			
		448-12-6, 10-12								R	R		C														R			X			
		448-12,CC		X									R	R													R	R					
		448-13-1, 40-42	C	R				A		R	R	F	A														A	R		R			
		448-13-4, 7-9	F			A		A		R			F															R		F			
		448-13-6, 40-42	F			C		A		A		R	F														C	R					
		59-448-13,CC						F		X			A														C	R		C			
		448-14-1, 31-33	R	F	X	R		R				R	A														X	X					
	P.21	448-14-4, 26-28	R			A							X																				
		448-14-6, 3-5	R	R		F		R			R	R	A														C						
		448-14,CC	R			F				X			A																				
		448-15-4, 2-4		R	R	F				R	R	R	A														R						
Middle to late Oligocene		448-15,CC				R		C				R	A																				
		448-16-4, 50-52				R					R	F	C																				
		448-16,CC	R			R						R	A														X						
		448-17-4, 4-6				R						R	R																				
		448-17,CC				A		C			R	X	X														X	X					
	?	448-19-1, 94-96					?	R			F	X	X																				
		448-19-3, 103-105	R			F	C				R	A																					
	P.20	448-19,CC											R																				
		448-20-2, 29-31				F				F	R	F	F																				
		448-21-1, 146-148										R	R																				
		448-23-1, 121-123										R	F																				
		448-23,CC											R																				
		448-25-1, 9-15										R	F																				
		448-31,CC				F					R		F																				
		448-32,CC									R		F																				
	P.17-P.20	448-34-1, 101-103				A	C				R	F	C											F			R						
		Hole 448A																															
		448A-1-1, 4-6																															X
		448A-1-2, 4-6																			R												A
Middle Miocene	?	448A-1-3, 4-6																				A	A	R									A
		448A-1-5, 4-6																															A
		448A-1-7, 4-6																		?		C	A	A									C
		448A-1,CC																			A		X										R
		448A-2-1, 2-4		A										X				R				R										R	
	N.5-N.6	448A-2-2, 4-6		F									A	X				R			R										R		
		448A-2-3, 4-6		R									A	C				R															
		448A-2-4, 4-6		R									F	F				R															
		448A-2-6, 4-6											C													A							
	N.4	448A-2,CC		F					R				C			?										A							
Early Miocene		448A-3-1, 4-6							R				A	C				R								A							
		448A-3-3, 4-6											C	C												X							
		448A-3-6, 4-6			R								C	C												A							
	P.22-N.4	448A-3,CC		R									X	X												A							
Oligocene		448A-4-1, 4-6							R			?	C													A							
		448A-4-4, 4-6							R				C	C												A							
		448A-4-6, 4-6		C					R	X		R	F													A							
	P.21?	448A-7-5, 130-132				C																											

Note: A = abundant, C = common, F = frequent, R = rare, X = abundance not noted.

Table 3. Distribution of selected benthic foraminifers at Site 448.

Age	Zone	Sample (intervals in cm) Hole 448	Arenaceous Benthics: *Dorothia brevis*	*Eggerella bradyi*	*Spiroplectammina spectabilis?*	*Trochammina?* sp.	*Vulvulina pennatula*	Arenaceous Tubes	Arenaceous Fragments	Calcareous Benthics: *Anomalina globulosa*	*Astrononion* spp.	*Bolivina pseudoplicata*	*B. pusilla*	*Bulimina jarvisi*
Middle Miocene		448-1-1, 61-63									R			
	?	448-1-2, 9-11								R				
		448-1,CC												
		448-2-1, 7-9	R											
		448-2-2, 1-3												
		448-2-3, 2-4	R										F	
		448-2-4, 2-4					R							R
	N.9	448-2-5, 2-4	R	R										R
		448-2-6, 4-6												
		448-2-7, 4-6	R				R							R
		448-2,CC												R
Early Miocene	?	448-3-1, 11-13												R
		448-3-2, 11-13		R			R							R
	N.8	448-3-4, 5-7					R							
		448-3-5, 50-52					R					R		
	N.7-N.8	448-3,CC												
		448-4-2, 2-4					R							
	N.6-N.7	448-4-5, 2-4												
	N.6	448-4-6, 2-4	R											
	?	448-4,CC												X
	N.5	448-5-1, 2-4		R								R		
		448-5,CC												X
	N.4	448-6-1, 7-9		X										
		448-6-2, 7-9		R										
		448-6-3, 7-9	R											
		448-6-4, 7-9												
		448-6-5, 5-7	R											R
		448-6,CC												
		448-7-1, 18-20	R	R		R	R	R						
		448-7,CC												R
Late Oligocene	P.22-N.4	448-8-1, 6-8						R	R					
		448-8-2, 7-9	R	R				R			R			
		448-8-3, 4-6	R	R				R			R			
		448-3,CC							X					
		448-10-1, 11-13	R				R							
		448-10-2, 13-15	R		R		F	R						
		448-10-3, 8-10	R	R	R		R	R	F					
		448-10-4, 9-11			R		C	R						
		448-10-5, 8-10		R	R	R	R	R						R
		448-10-6, 3-5					F			R				

Sample (intervals in cm) Hole 448	*B. aff. B. jarvisi*	*B.* spp.	*Cassidulina cuneata*	*C. subglobosa*	*C.* spp.	*Cibicides bradyi*	*C. aff. C. kullenbergi*	*C. mundulus*	*C. wuellerstorfi*	*Dentalina* sp.	*Ehrenbergina* sp.	*Epistominella* sp.	*Eponides* sp.	*Fissurina* sp.	*Gyroidina acuta*
448-1-1, 61-63				R					C				F		
448-1-2, 9-11	R										R				
448-1,CC				X					F						X
448-2-1, 7-9			R	R	R	R	R		X					R	R
448-2-2, 1-3		R		R		R	R				R				R
448-2-3, 2-4				R			R				R				
448-2-4, 2-4	R	R		F			C					C			R
448-2-5, 2-4	F	R		C		R	F				R				R
448-2-6, 4-6							R			R					
448-2-7, 4-6				F		R	F								R
448-2,CC	R			C	X	X	X								
448-3-1, 11-13						R	R								R
448-3-2, 11-13	R			C								R			R
448-3-4, 5-7				C			F								R
448-3-5, 50-52		R			R		R								
448-3,CC							X								
448-4-2, 2-4			X	F			F								
448-4-5, 2-4		R													
448-4-6, 2-4							R			R		R			
448-4,CC														X	X
448-5-1, 2-4														R	R
448-5,CC					X									X	X
448-6-1, 7-9				F			R							R	R
448-6-2, 7-9		R					R							R	R
448-6-3, 7-9				R										R	R
448-6-4, 7-9				F											
448-6-5, 5-7				R								R			R
448-6,CC															X
448-7-1, 18-20		R		R	R		R					C			F
448-7,CC				X	X		X		R			X			F
448-8-1, 6-8							R								R
448-8-2, 7-9		R													R
448-8-3, 4-6		R					R								R
448-3,CC				R								X		X	X
448-10-1, 11-13				R			X								R
448-10-2, 13-15						F	F								R
448-10-3, 8-10					R		F							R	R
448-10-4, 9-11			R	R	R		F							R	R
448-10-5, 8-10			R	R						R				R	R
448-10-6, 3-5						R	R		R					R	R

Sample (intervals in cm) Hole 448	*G. broeckhiana*	*G. soldanii*	*Lagena* sp.	*Lenticulina* sp.	*Melonis affinis*	*Nodosaria strigosa*	*N.* spp.	*Oridorsalis tener*	*O. umbonatus*	*Orthomorphina* spp.	*Osangularia cultur*	*O? rugosa*	*Planulina renzi*	*Pleurostomella acuminata*	*P. aff. P. subnodosa*
448-1-1, 61-63										R		R			R
448-1-2, 9-11			R				R								
448-1,CC															
448-2-1, 7-9		R			R			C							R
448-2-2, 1-3								F			R			R	
448-2-3, 2-4	R				R		R	F							R
448-2-4, 2-4					R			C							
448-2-5, 2-4					R			C			R				R
448-2-6, 4-6		R						R							R
448-2-7, 4-6		R						F							
448-2,CC		X						C							
448-3-1, 11-13					R			R							
448-3-2, 11-13		R					R	R							
448-3-4, 5-7					R		R	F							
448-3-5, 50-52					R			F							
448-3,CC								X							
448-4-2, 2-4	R	R			R			F							
448-4-5, 2-4	R							F							
448-4-6, 2-4								C							
448-4,CC								X							
448-5-1, 2-4								F	F						R
448-5,CC								X							
448-6-1, 7-9				R	X			F					X		
448-6-2, 7-9							R								
448-6-3, 7-9								R							
448-6-4, 7-9					R			F						R	
448-6-5, 5-7							R	F							
448-6,CC															
448-7-1, 18-20								C							R
448-7,CC								X					F		
448-8-1, 6-8				R											
448-8-2, 7-9						R		R							
448-8-3, 4-6								R							
448-3,CC								X							
448-10-1, 11-13								R							
448-10-2, 13-15								F							
448-10-3, 8-10								C			R				
448-10-4, 9-11								R			R				
448-10-5, 8-10								F			R				
448-10-6, 3-5						R		C							

Sample (intervals in cm) Hole 448	*Pleurostomella* spp.	*Pseudonodosaria comatula*	*Pullenia bulloides*	*P. quinqueloba*	*P. aff. P. subspherica*	*Pyrulina* sp.	*Stilostomella abyssorum*	*S. aff. S. antillea*	*S. consobrina*	*S. pomuligera?*	*S. spinea*	*S.* spp.	*Vaginulina subelegans*
448-1-1, 61-63	R		R								R		
448-1-2, 9-11			R	R	R				R	R			R
448-1,CC	X			X				R	R		C		
448-2-1, 7-9			R	R			F	R	F			R	
448-2-2, 1-3	R			R				R	F		R	R	R
448-2-3, 2-4	R	R	R		R		R	F	F				R
448-2-4, 2-4											R	F	
448-2-5, 2-4	F				F							F	
448-2-6, 4-6	R		R								R	R	
448-2-7, 4-6				R	R		R				R		
448-2,CC			X				X					X	
448-3-1, 11-13												R	
448-3-2, 11-13	R			R							R		
448-3-4, 5-7	R									R	R		
448-3-5, 50-52					R								
448-3,CC	X						X					X	
448-4-2, 2-4	R		R				R			R	F	F	
448-4-5, 2-4	R								R	R	R		
448-4-6, 2-4	R					R	R		R				
448-4,CC	X			X			F	X		X	X		
448-5-1, 2-4	R				R					F			
448-5,CC	F						X	X		X	X		
448-6-1, 7-9			R		R					F			
448-6-2, 7-9	R			R	R							R	
448-6-3, 7-9	R				R				R			R	R
448-6-4, 7-9	R		R		R							F	
448-6-5, 5-7					R							R	
448-6,CC						X		X				X	
448-7-1, 18-20	F										F	A	R
448-7,CC	X			X							A		R
448-8-1, 6-8				R					R				
448-8-2, 7-9					R							R	
448-8-3, 4-6	R				R	R						R	
448-3,CC	X			X							R	X	
448-10-1, 11-13													
448-10-2, 13-15	R								C	R		R	
448-10-3, 8-10	R							F	R	R	R	R	
448-10-4, 9-11	R			R			R	R	R	R	R		
448-10-5, 8-10	R											C	
448-10-6, 3-5	R			R					F			C	

Table 3. (Continued).

	?	448-10-7		X			X							X		X		X			X		X						X		X						X									X							X	C			
		448-11-1, 5-7					R			F																			R								F			R		R						R				A	A		R	
	P.22	448-11-2, 5-7		R	R									R				R			R									R								F		R						R							R			X	
		448-11-4, 13-15												R					X											X								X																			X	X
		448-11-6, 16-18		R	R			R																						R								F																	R			
	?	448-11,CC																							X	X																															
		448-12-1, 21-23	R	R		R		F								R		R			R									R	R	R						F			R				R				R								R
		448-12-4, 10-12	R		R		R			R						R		R				R								F							F	F			R										R						R
		448-12-6, 10-12		R		R					R					R		R				F		R					R								F								R			R								R
		448-12,CC		X	R													X											X								X								R												X
		448-13-1, 40-42																F			R	R														R	F												R							
		448-13-4, 7-9	R														R																			R												R	R							
		448-13-6, 40-42							X													?																																		
		448-13,CC							X																																															
		448-14-1, 31-33		R														R				F							R								C			R									R							
	P.21	448-14-4, 26-28																R				R															X																			
		448-14-6, 3-5					R										R					R															C		R												R					
Middle to late Oligocene		448-14,CC														X	X	X																			X																			
		448-15-4, 2-4	R											R		R		R				R							R								F						R						R							
		448-15,CC		R					X									F																			R							F											
		448-16-4, 50-52					R											F											R										R																	
		448-16,CC							X									F													R						R								X											
		448-17-4, 4-6																													X																									
		448-17,CC									X					X		X				X																																	
	?	448-19-1, 94-96	R															R																					R						R											
		448-19-3, 103-105																R			F																R		R						R	R										
	P.20	448-19,CC																																		R	R																		
		448-20-2, 29-31																			R															R									X											
		448-21-1, 146-148																																																						
		448-23-1, 121-123																			X																																			
	?	448-23,CC																																																						
		448-25-1, 9-15																				R															R										R								R	
		448-31,CC																R																																						R
		448-32,CC																F	R																																				R	R
	P.17-P.20	448-34-1, 101-103																																																						
		Hole 448A																																																						
		448A-1-1, 4-6													X	X																			X																					
Middle Miocene		448A-1-2, 4-6																R																											R								F		F	C
	?	448A-1-3, 4-6		R														F																			R								R			R								F
		448A-1-5, 4-6																							R				R								F																			F
		448A-1-7, 4-6																						R													R								R										F	
		448A-1,CC												X					X												X						X							X												X
		448A-2-1, 2-4						R						R															R								R											R	R							X
	N.5-N.6	448A-2-2, 4-6												R	R			R																			F								R			R	R							F
		448A-2-3, 4-6	F											F				R			R																F															F			R	
		448A-2-4, 4-6		R														R																			F								R			R	X			F			R	
		448A-2-6, 4-6						R	R									R																															R							
Early Miocene	N.4	448A-2,CC															X														X																X									
		448A-3-1, 4-6	R			R		R						F				R						R							R																								X	
		448A-3-3, 4-6	R					R						R							R							R																	X										R	F
		448A-3-6, 4-6	R						R												R								R		R						R																			F
	P.22-N.4	448A-3,CC																											X																X											
		448A-4-1, 4-6				R		R	R					R				R																			?								R							F				
Oligocene		448A-4-4, 4-6	R	R			R	R						R																							F												R							
		448A-4-6, 4-6		R								R												R																					R				R							
	P.21?	448A-7-5, 130-132			X													X																																						

Note: A = abundant, C = common, F = frequent, R = rare, X = abundance not noted.

and siliceous microfossils restricted to only a few horizons.

Biostratigraphy. The only samples from Hole 449 that contain age-diagnostic foraminifers are from the lower portion of Core 13 (Table 4). Section 13-6 contains *Globigerina tripartita* s.1., a species which, if not too rigidly defined, ranges from the late Eocene to the early Miocene (as high as Zone N.6). Section 13,CC contains *Globorotalia (T.) opima opima*? and *G. (T.) opima nana*. The former species dates this sample as middle-to-upper Oligocene, Zones P.19–P.21. Owing to the virtual absence of planktonic foraminifers at this site no other samples could be assigned to any N or P zones.

Paleoenvironment. Aside from three manganese nodules, there was no recovery for Core 1. The upper portion of Core 2 contains a sparse assemblage of Pleistocene radiolarians and rare silicoflagellates and sponge spicules associated with a mass occurrence of the diatom *Ethmodiscus rex* (Rattray) Hendey. Several different hypotheses have been advanced in order to explain the origin of *Ethmodiscus* oozes; for a recent summary see Mikkelsen (1977). All of Core 2, and Cores 3 through 5 as well, are barren of foraminifers and nannofossils, indicating deposition below the CCD. Radiolarians are also absent from Cores 3 through 5.

Abundant and well-preserved middle-Miocene radiolarians occur in Cores 6 and 7, as do middle-Miocene nannoplankton (which consist of durable discoasters in Core 6). Only one specimen of a planktonic foraminifer is present, and the rare benthic specimens are arenaceous. These samples were deposited slightly above the CCD but below the foraminiferal lysocline. This variation from the overlying barren interval may be due to changes in ocean chemistry (e.g., circulation shifts affecting productivity) rather than tectonics, because it coincides with a pulse of siliceous organisms (the radiolarians) and with a change in the clay mineralogy (see Balshaw, this volume).

Sediments from Core 8 through the upper portion of Core 10 are again barren of radiolarians and nannofossils and essentially barren of foraminifers, indicating deposition below the CCD.

Poorly preserved lower-Miocene(?) nannoplankton and rare, poorly preserved, predominately benthic foraminifers occur in the lower portion of Core 10 and the upper portion of Core 11. Nannoplankton and foraminiferal assemblages improve in preservation, abundance, and diversity below Core 11, but planktonic foraminifers are significant only near the base of Core 13, which contains the oldest sediments (late Oligocene) above the basaltic basement. This suggests that from the initiation of sedimentation at this site (as recorded in Core 13) through the deposition of Core 10, either there was a progressive upward shift in the position of the CCD or the area around Site 449 was undergoing subsidence.

SITE 450

Site 450 is located on the eastern side of the Parece Vela Basin (18°00.02′N, 140°47.34′E), about 445 km due east of Site 449 in 4707 meters of water. One hole was drilled at this site, penetrating 333 meters of sediments above an intrusive contact with basalt. A total of 68 samples was examined for foraminifers. The distributions of both planktonic and benthic foraminifers in samples from this site are recorded in Table 5.

Biostratigraphy. The sediments in Cores 1 through 6 consist of brown clays that contain minor ash layers below Core 3. All of the samples examined from these six cores are barren or nearly barren of foraminifers and therefore cannot be dated using this fossil group. Rare and sporadic occurrences of *Orbulina suturalis* Bronnimann from the base of Core 7 and the top of Core 8 indicate that this interval is no older than the middle Miocene. From the lower portion of Core 8 through Core 11 recovery was very poor. Somewhere within this interval there is a lithologic contact, which, because of low core recovery, is placed arbitrarily in the middle of Core 10, between pelagic clay (above) and vitric tuff (below).

The interval from Section 12-2 through Core 15 contains rare and sporadic occurrences of *Globorotalia (T.) peripheroronda* Blow and Banner and various species of *Orbulina*. Their concurrent ranges restrict the age of these samples to the middle Miocene.

One specimen of *G. fohsi fohsi* Cushman and Ellisor was found in the washed residue from Section 17,CC. This species ranges through middle-Miocene Zones N.10–N.12.

Stratigraphic position as well as the sporadic occurrences of *Orbulina universa* and *O. suturalis* indicate that Core 18 through the top of Core 24 can be dated as middle Miocene.

The interval from the base of Core 24 to the contact with basalt in Core 36 is nearly barren of foraminifers. Rare specimens of *Globigerinoides subquadratus* Bronnimann are present in Core 28 and the upper portion of Core 29, indicating that samples at least as deep as Core 29 are from the early to middle Miocene. No samples below Core 29 could be dated using foraminifers.

Paleoenvironment. Cores 1 through 5 are essentially barren of calcareous foraminifers and nannoplankton, indicating deposition below the CCD. Fairly well-preserved nannoplankton assemblages are present throughout Cores 6 to 33. Relatively diverse planktonic foraminifers occur in most samples from the base of Core 6 through the base of Core 17, but they are rare and sporadic below Core 17. The preservation of calcareous microfossils in the interval from Cores 6 through 33 may be due to rapid burial (as reflected in the high ash content of these sediments) or may indicate deposition somewhat above the CCD (either because of tectonic or oceanic factors).

Nannofossils are poorly preserved in Core 34 and the upper portion of Core 35, and they are absent in the lower portion of Core 35 and in Core 36. This is probably caused by the hydrothermal alteration of these sediments and does not reflect any change in depositional environment.

The scarcity of benthic foraminifers at this site precludes their being used for making precise environmental interpretations.

Table 4. Distribution of foraminifers at Site 449.

Age	Zone	Sample (intervals in cm)	Planktonics: *Catapsydrax unicavus*	*Globigerina ciperoensis*	*G. gortanii*?	*G. sellii*?	*G. tripartita*	*G. venezuelana*	*G.* spp.	*Globigerinoides diminutus*	*Globoquadrina* sp.	*Globorotalia (T.) opima nana*	*G. (T.) opima opima*	*G. (T.) siakensis*	Tiny (juvenile?) planktonics	Arenaceous Benthics: *Eggerrella bradyi*	*Haplophragmoides* sp.	*Vulvulina pennatula*	Arenaceous tubes	Arenaceous fragments	Calcareous Benthics: *Anomalina globulosa*	*Astrononion* sp.	*Bulimina jarvisi*	*Cassidulina cuneata*	*C. minuta*	*C. subglobosa*	*C.* spp.	*Cibicides aff. C. kullenbergi*	*C. mundulus*	*Dentalina* sp.	*Epistominella* sp.	*Eponides* sp.	*Fissurina* sp.	*Gyroidina acuta*	*G. broeckhiana*	*G. lamarckiana*	*G. soldanii*	*G.* spp.	*Nodosaria strigosa*	*Nodosaria* sp.	*Oridorsalis tener*	*Osangularia? rugosa*	*Pleurostomella acuminata*	*P. aff. P. subnodosa*	*P.* spp.	*Pullenia bulloides*	*P. quinqueloba*	*P.* spp.	*Sphaeroidina bulloides*	*Stilostomella abyssorum*	*S. antillea*	*S. spinea*	*S.* spp.	Barren
Indeterminate	Indeterminate	449-2-2, 120–122																																																	X
		449-2,CC																																																	X
		449-3,CC																																																	X
		449-4-1, 120–122																																																X
		449-4-3, 56–58																																																X
		449-4,CC																																																	X
		449-5-2, 62–67																																																	X
		449-5,CC																																																		X
		449-6-3, 90–92																	R																																		
		449-6-4, 90–92							R												R											R																				
		449-6,CC																																																		X
		449-7-3, 91–93																	R	R																																	
		449-7,CC																												R									R									R				
		449-8-3, 75–77																	R	R																																	
		449-8,CC																																																		X
		449-9-1, 70–72																								R																											
		449-9,CC																																																	X
		449-10-1, 8–10																																																	X
		449-10-3, 80–82																																																	X
		449-10-6, 8–10																																																	X
		449-10,CC													R												?													R	R											
		449-11-1, 6–8																								R																							R			
		449-11-2, 12–14							R		?															R																									
		449-11-3, 12–14																																																	X
		449-11-4, 8–10																		R	R											R																	R		
		449-11-6, 8–10												?												R						R									R										
		449-11,CC								?					X			R							R	F	R	C	R			R	R						F	F	X		X		R	R			R	R	
		449-12-2, 111–113													X																						R				R										
		449-12,CC													R									R				X												R							F			
		449-13-1, 10–12															R		R							F		R				R						R		R								R	R	F
		449-13-2, 10–12																								F											F				R										F
		449-13-3, 10–12													F				F			R						R				R				R		R			R		F		R					F	F
		449-13-4, 10–12													X								R		F	F							R				F													F
		449-13-5, 10–12													X											X						X							X											F	X
Oligocene–early Miocene	?	449-13-6, 10–12	R		X		F	R						R	A	R								R	F	F		R												F											F
	P.21?	449-13,CC	R	R		R	R		F		R	R	?	F					R					X		F						R							X											R
?	?	449-14,CC																								R		F	R	R					R					C	F				R						F	

Note: A = abundant, C = common, F = frequent, R = rare, X = abundance not noted.

Table 5. Distribution of foraminifers at Site 450.

Age	Zone	Sample (intervals in cm)	Planktonics: *Globigerina aff. G. druryi*	*Globigerina* spp.	*Globigerinoides conglobatus*	*G. immaturus*	*G. quadrilobatus*	*G. subquadratus*	*G. trilobus*	*Globoquadrina altispira*	*G. dehiscens*?	*Globorotalia fohsi fohsi*	*G. menardii*	*G. (T.) obesa*	*G. (T.) peripheroronda*	*Orbulina bilobata*	*O. suturalis*	*O. universa*	*Sphaeroidinellopsis seminulina*	*S. subdehiscens*	*S.* sp.	Tiny (juvenile?) planktonics	Arenaceous Benthics: *Cyclammina*? sp.	Arenaceous tubes	Arenaceous fragments	Calcareous Benthics: *Cassidulina minuta*	*C. subglobosa*	*Cibicides aff. C. kullenbergi*	*Nodosaria*? sp.	Barren
Indeterminate	Indeterminate	450-1-3, 14-16																												X
		450-1,CC																												X
		450-2-3, 17-19																												X
		450-2,CC																												X
		450-3-3, 16-18																												X
		450-3,CC																												X
		450-4-2, 10-12																					R	R						
		450-4-3, 10-12																												X
		450-4-4, 35-37																					R							
		450-4-5, 49-51																												X
		450-4,CC																											R	
		450-5-1, 61-63																												X
		450-5-2, 61-63																												X
		450-5-3, 61-63																												X
		450-5-4, 61-63																							R					
		450-5,CC																							R					
		450-6-1, 15-17																												X
		450-6,CC		R					X																				X	
		450-7,CC				C			F		R		F				R		R				R				R			
Middle Miocene or younger	?	450-8-1, 36-38																												X
		450-8-2, 36-38																						R						
		450-8,CC							R					R			R					F								
		450-11,CC																												X
		450-12-2, 81-83					R								R															
		450-12,CC							R													R								
	?	450-13-3, 13-15	R	R																										
		450-13,CC																												X
		450-14-3, 66-68																												X
		450-14,CC			R	F		?	R	R	R		R				R	R			R						R	R		
		450-15-3, 60-63	R												R							R								
		450-15,CC				R										R														
		450-16,CC																												X
	N.10-N.12	450-17-1, 49-51																												X
Middle Miocene		450-17,CC				F			R	R	R	R			R		A	F	R	R		F								
		450-18-1, 101-104																												X
		450-18,CC																												X
		450-19-3, 60-62																										R		
		450-19,CC															R	R				F								
		450-20,CC			R	R				R							R	R		R		F								
		450-21-1, 10-12																												X
	N.9-N.12	450-21,CC																				F								
		450-22-6, 10-12																												X
		450-22,CC																				F								
		450-23-1, 5-7																												X
		450-23,CC																												X
		450-24-1, 16-19		R			R							R			R	A				F								
		450-24,CC																												X
		450-25-2, 68-70																												X
		450-25,CC																												X
		450-26-2, 2-4																				R								
Early to middle Miocene	N.5-N.12	450-26,CC																												X
		450-27-1, 63-65																												X
		450-27,CC																				R								
		450-28-3, 82-84						R																						
		450-28,CC																				R								
		450-29-2, 94-96						R																						
		450-29,CC																												X
		450-30-2, 79-81																												
		450-30,CC																				F								
		450-31-1, 94-96																				R								
Indeterminate	Indeterminate	450-31,CC																												X
		450-32-3, 48-50																												X
		450-32,CC																												X
		450-33-1, 66-68																												X
		450-33,CC																				R								
		450-34-1, 19-21																												X
		450-34,CC																												X
		450-35,CC																												X

Note: A = abundant, C = common, F = frequent, R = rare, X = abundance not noted.

SITE 451

Site 451 is located on the eastern edge of the West Mariana Ridge (18°00.88'N, 143°16.57'E), about 240 km due east of Site 450 in 2060 meters of water. The distributions of foraminifers at this site are recorded in Table 6 (planktonic species) and Table 7 (benthic species).

One hole was drilled at this site, continuously coring 930.5 meters of sediments. Igneous basement was not reached. A total of 45 samples was examined for foraminifers. The interval from Core 1 through the upper portion of Core 5 contains foraminiferal and nannofossil ooze with minor volcaniclastic constituents (Table 6). Below Core 5, vitric ash and tuff predominate and the sediment becomes increasingly lithified. Moderately well-preserved foraminifers are diverse and abundant in Cores 1 through 14, but they occur only rarely and sporadically below Core 14. Considerable mixing of different age faunas as well as anomalous assemblages (especially in core-catcher samples) that are apparently displaced downhole signficantly complicate biostratigraphic interpretations for samples from Site 451. Because of such complications, in dating these samples more emphasis is placed on the use of "tops" (highest stratigraphic occurences) of key species than on the total or concurrent ranges of species.

Biostratigraphy. Quaternary planktonic foraminiferal assemblages are present from the top of Core 1 through Section 2-1. The occurrence of *Sphaeroidinella dehiscens excavata* Banner and Blow above the highest occurrences of *Globorotalia tumida flexuosa* (Koch) and *G. (T.) tosaensis* Takayanagi and Saito suggests that the upper portion of Core 1 may possibly be from the Holocene (Zone N.23).

Section 1,CC through Section 2-1 is dated as Pleistocene Zone N.22 by the presence of *G. tosaensis* above the highest occurrence of *Globigerinoides fistulosus* (Schubert).

Section 2-3 contains the highest stratigraphic occurrence of *G. fistulosus*, which in this report is used to mark the top of Zone N.21. No other tops of age-diagnostic species were noted above Section 3-7. Samples from this section through Section 4-3 are below the range of *G. tosaensis*, above the range of *Globigerina nepenthes* Todd, and contain abundant *Sphaeroidinellopsis seminulina kochi* (Caudri). They were deposited in lower-Pliocene Zone N.19. *G. nepenthes*, which occurs in mid-Zone N.19 and lower, has its abundant top in Section 4-5. Section 5-1 contains one specimen of *Sphaeroidinella dehiscens* (Parker and Jones) and rare *Globigerinoides fistulosus*; if in place, these specimens suggest a deposition no later than that of Zone N.19.

Zone N.18 could not be recognized and may be missing. Aside from two anomalous core-catcher samples (Section 6,CC and Section 8,CC), *Globorotalia tumida tumida* (Brady) is not noted below Section 5-1. Rare questionable specimens of *G. plesiotumida* Blow and Banner are found in Section 5-3, but good specimens of this species are not found above Core 6. Samples from Core 5 below Section 1 do not contain any particularly age-diagnostic species and thus are grouped into Zones N.17–N.19, which span the late Miocene/early Pliocene boundary.

The interval from Section 6-1 through Section 8-6 contains relatively consistent occurrences of *G. plesiotumida*, *G. merotumida* Blow and Banner, and *Candeina nitida* d'Orbigny s.s. but lacks *G. tumida tumida*, probably indicating the upper-Miocene Zone N.17. Section 10-1 contains a similar assemblage.

The presence of *Orbulina* in samples at least as low as Section 52,CC indicates a middle Miocene or younger age, but the key species necessary for zonal assignment are generally absent. The deepest sample that can be dated by foraminifers with reasonable precision is from Section 25-1, where the occurrence of *C. nitida praenitida*? Blow and *G. plesiotumida/merotumida* probably suggest the upper-Miocene Zones N.16–N.17.

Paleoenvironment. Most samples from Cores 1 through 14 (with the exception of Cores 11, 12, and 13, which had no recovery) contain common to abundant moderately well-preserved calcareous nannofossils and planktonic and benthic foraminifers, indicating deposition above the CCD. Cores 6 through 14 do not contain assemblages as rich as those of the uppermost five cores because of the dilution effect of increased amounts of volcanogenic sediments in the lower cores. Benthic foraminiferal assemblages from Cores 1 through 14 typically contain deep bathyal to abyssal forms including *Cibicides wuellerstorfi* (Schwager) and several species of *Stilostomella*; *Bulimina alazanensis* Cushman occurs sporadically throughout this interval (Table 7).

Cores 15 through 19 had very low recovery, and the few samples available from this interval are barren or essentially barren of microfossils. In Core 20 and below, calcareous layers are rare, typically contain poorly preserved nannofossils, and occasionally contain *Orbulina* spp. The larger foraminifers (shallow-water inhabitants) that occur sporadically from Core 31 downward are reworked; these are discussed elsewhere (see Site 451 report, this volume).

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Table 6. Distribution of selected planktonic foraminifers at Site 451.

Age	Zone	Sample (intervals in cm)	*Candeina nitida*	*C. nitida praenitida?*	*Globigerina nepenthes*	*G. venezuelana?*	*Globigerinoides conglobatus*	*G. elongatus*	*G. fistulosus*	*G. obliquus extremus*	*G. quadrilobatus*	*G. ruber*	*G. sacculifer*	*G. trilobus*	*Globoquadrina altispira*	*G. dehiscens*	*Globorotalia (T.) crassiformis*	*G. (T.) crassiformis ronda*	*G. cultrata* s.l.	*G. hirsuta*	*G. margaritae*	*G. menardii*	*G. merotumida*	*G. aff. G. miocenica*	*G. aff. G. multicamerata*	*G. plesiotumida*	*G. (T.) tosaensis*	*G. truncatulinoides*	*G. tumida flexuosa*	*G. tumida tumida*	*Hastigerina siphonifera*	*Neogloboquadrina dutertrei*	*Orbulina bilobata*	*O. universa*	*Pulleniatina obliquiloculata*	*Sphaeroidinella dehiscens dehiscens*	*S. dehiscens excavata*	*Sphaeroidinellopsis seminulina* s.l.	*S. seminulina kochi*	*S. subdehiscens*
Quaternary	N.22–N.23	451-1-2, 5–7	C				A					A	A					C	A	C		X				?	A			A	C		A	C			A		
		451-1-3, 5–7	A				A					A	A			F			A								A	R	A	A	C		A	C	F	F			
	N.22	451-1,CC	X				X					X		X								X				F	R		C	X									
		451-2-1, 45–47	C									A	A			R	A	A	C							C	F		A	A	R	R	A	C	C	A			
	N.21	451-2-3, 27–29	C				C		F			A	C				A	A	C						R	F	A		A	R	R		C	C	C	C			
		451-2-5, 9–11	A				C		F			A	C				F	C	C				R	C		F	?	R	A		R		C	C	A	C			
Late Pliocene	?	451-2,CC	X				X															X					X		X	X			X	X	X				
	N.21	451-3-1, 12–14					C		R			A	A				C		C							C	R		A	C	R		C	C	A	F			
		451-3-3, 12–14	F				A		A	?		X	A			F	C		F						A				A	F		F	A	R	A	F			
		451-3-5, 12–14	R				F		A	X		F	A				C					F			A	F			F	R			F		F	R			
	?	451-3-6, 12–14					F			F		R	A		C	R									A				F	R		R	A		F		R		
	N.19	451-3-7, 12–14	R				A			A		C	A		C	R	R								F				A	R			A			R	A	A	A
	?	451-3,CC							X																		X			X							X		
Early Pliocene	N.19	451-4-3, 12–14				C	X			X		R	A		R						F		?		R	?		C	R	R			A				C	A	C
		451-4-5, 12–14			A	R	A	R		A					F						R				A				F				A				C	A	A
		451-4,CC			C										R							X			X				X								A	A	C
		451-5-1, 12–14			C	R	C		R	X				C	F	R		F		R					F				R	R			C			R	C	A	C
		451-5-2, 12–14			C	R	A						C		F						F				X								A				C	C	C
	N.17–N.19	451-5-3, 12–14			C					F					R											R								A			A		C
		451-5-4, 12–14			C					R			R	F	R															R				C			C		C
		451-5,CC			F					X					F							X												X			C		F
	N.17	451-6-1, 12–14	F		F					A	X				R								R		F								A			C		F
		451-6-3, 12–14	F							X			A		R	R							R		F					R		R	A		R			
		451-6-5, 12–14	F							R			A		R	R									R					R			F					
	?	451-6,CC			X					X														X				F	R			X		R	C			
	N.17	451-7-1, 60–62	R							X			A		F	R							R		F					R		F	A			C		F
		451-7,CC	F		X								C	C	F								R	R						R			X			C		C
		451-8-1, 12–14			R		R			X			A		R	R							R		F								A			C	R	C	
		451-8-6, 12–14	F		X					X			A	X									R		F								A						
	?	451-8,CC			R					X				R								R											R				R		
	N.17	451-9-1, 28–30			R		F							F														C				F	R			F			
		451-10-1, 63–65	R		A					X			A		X	R					R									R			A				C		
Late Miocene		451-10,CC	X		F					X			X	X	F							F								R			A				A		F
		451-14-1, 12–14								X			F	C																			X				R		
		451-14,CC			F								X	A	R																		X	A			R		R
		451-15,CC			R																													X			R		
	?	451-20,CC	R											R								R											R	F			R		R
		451-21,CC			R																													F					R
		451-22,CC												R																				R					
		451-23,CC													?																			R					
		451-24,CC	R		R								R	R	R																			R			R		
	N.16–N.17	451-25-1, 36–38		R									F	R	?								?			R								R			R		
		451-25,CC												R																R				R					R
	?	451-33,CC												R	?																			R					
		451-52,CC																																R					?

Note: A = abundant, C = common, F = frequent, R = rare, X = abundance not noted.

Table 7. Distribution of benthic foraminifers at Site 451.

			Arenaceous									Calcareous									
Age	Zone	Sample (intervals in cm)	*Cyclammina?* sp.	*Eggerella bradyi*	*Karreriella bradyi*	*Siphotextularia?* sp.	*Spiroplectammina spectabilis*	*Trochammina?* sp.	*Vulvulina pennatula*	Arenaceous Tubes	Arenaceous Fragments	*Anomalina globulosa*	*Bolivina? translucens*	*Bulimina alazanensis*	*Cassidulina minuta*	*C. subglobosa*	*C.* spp.	*Cibicides cicatricosus*	*C. aff. C. kullenbergi*	*C. robertsonianus*	*C. rugosus*
	N.22-N.23	451-1-2, 5-7														F					
Quaternary		451-1-3, 5-7														F					
	N.22	451-2-1, 45-47								R				R		C					
		451-2-3, 27-29														C					
		451-2-5, 9-11			R			R	R	R						F			R		
Late Pliocene	N.21	451-3-1, 12-14									R	R		R		C	R		R		
		451-3-3, 12-14	R	R					R	R						C			R	R	
		451-3-5, 12-14								R						F					
	?	451-3-6, 12-14								R	R					F					
		451-3-7, 12-14								R				R		F		R			
Early Pliocene	N.19	451-4-3, 12-14		R		R			R		R			R	R	R		R		R	
		451-4-5, 12-14		R	R										F	F					
		451-4,CC									X				X	X	X				
		451-5-1, 12-14		R											A	A				R	
		451-5-2, 12-14													F	A				R	
	N.17-N.19	451-5-3, 12-14												R							
		451-5-4, 12-14														R					
		451-6-1, 12-14		R												R					
		451-6-3, 12-14											R			R					
		451-6-5, 12-14			R											R					
	N.17	451-7-1, 60-62																			R
Late Miocene		451-7,CC												X							
		451-8-1, 12-14														R					
		451-8-6, 12-14														F					
	?	451-9-1, 28-30														C					
	N.17	451-10-1, 63-65					R														
		451-10,CC		R												R					
	?	451-14-1, 12-14									R					R					
		451-14,CC														R					

	Calcareous																			
Sample (intervals in cm)	*C. wuellerstorfi*	*Ehrenbergina* sp.	*Favocassidulina australis*	*Fissurina comata*	*Gavelinopsis praegeri*	*Gyroidina acuta*	*G. broeckhiana*	*G. lamarckiana?*	*G. soldanii*	*Hoeglundina elegans*	*Islandiella?* sp.	*Laticarinina pauperata*	*Lenticulina* sp.	*Melonis affinis*	*M. pompilioides*	*Nodosaria* spp.	*Oridorsalis tener*	*Orthomorphina challengeriana*	*Orthomorphina?* sp.	*Osangularia culter*
451-1-2, 5-7	R											R			?					
451-1-3, 5-7	F				R															
451-2-1, 45-47	C	R				R						R								
451-2-3, 27-29	R					R	R									R	F	R		
451-2-5, 9-11	R			R					R			R		R			R			R
451-3-1, 12-14	R				R						R					R	R			R
451-3-3, 12-14		R											R						R	
451-3-5, 12-14				R	F		R					R								
451-3-6, 12-14	R	R														R				
451-3-7, 12-14				R	R															
451-4-3, 12-14	R		R					R	R			R	R			R	R			
451-4-5, 12-14				R																
451-4,CC	X	X																		
451-5-1, 12-14		R	R			R											R			
451-5-2, 12-14	R	F		R												R	R		R	
451-5-3, 12-14																				
451-5-4, 12-14	R																			
451-6-1, 12-14	R																R			
451-6-3, 12-14	R								R											
451-6-5, 12-14																				
451-7-1, 60-62	R																R			
451-7,CC	X						X	R									R			
451-8-1, 12-14																				R
451-8-6, 12-14																	R			
451-9-1, 28-30									F	R	R						R			F
451-10-1, 63-65	R														R					
451-10,CC	R	R				X										X	X			
451-14-1, 12-14																	R			
451-14,CC	R							R									R			

	Calcareous																
Sample (intervals in cm)	*Pleurostomella sapperi*	*P. aff. P. subnodosa*	*P.* spp.	*Pullenia bulloides*	*P. aff. P. subspherica*	*P.* sp.	*Pyrgo murrhina*	*Pyrgo* sp.	*Quinqueloculina* sp.	*Rectuvigerina* sp.	*Sphaeroidina bulloides*	*Stilostomella aff. S. antillea*	*S? consobrina*	*S. spinea*	*S.* spp.	*Uvigerina aff. U. ampullacea*	*U. senticosa*
451-1-2, 5-7					R		R		R								
451-1-3, 5-7							R	R									
451-2-1, 45-47						R	F										
451-2-3, 27-29	R		R				R					F	R			R	
451-2-5, 9-11			R	R			F					R	R	R			
451-3-1, 12-14			R	R			R						F		R		
451-3-3, 12-14					R		R								R		
451-3-5, 12-14			R			R	R		R				R		R		
451-3-6, 12-14			R									R			R		
451-3-7, 12-14		R	R	R			R										R
451-4-3, 12-14		R					R			R	R		R		R		
451-4-5, 12-14			R						R		R				R		
451-4,CC															X		
451-5-1, 12-14			R						R				R		R		
451-5-2, 12-14			F				F					R	R	R			
451-5-3, 12-14					R			R									
451-5-4, 12-14												R					
451-6-1, 12-14												R			R		
451-6-3, 12-14								R				R			R		
451-6-5, 12-14																	
451-7-1, 60-62											R				R		
451-7,CC											R				R		
451-8-1, 12-14											R				R		
451-8-6, 12-14															R		
451-9-1, 28-30								R							R		
451-10-1, 63-65															R		
451-10,CC								R			R						
451-14-1, 12-14																	
451-14,CC								R		R	R						

Note: A = abundant, C = common, F = frequent, R = rare, X = abundance not noted.