

11. PLANKTONIC FORAMINIFERS FROM OLIGOCENE TO PLEISTOCENE SEDIMENTS, DEEP SEA DRILLING PROJECT LEG 92¹

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ABSTRACT

Leg 92 of the Deep Sea Drilling Project cored sediments containing calcareous microfossils at six sites along 19°S latitude in the South Pacific Ocean. Shipboard examination of these sediments revealed planktonic foraminifers of uppermost Oligocene through Pleistocene age that were identified and assigned to biostratigraphic zones according to the tropical zonation scheme of Blow (1969).

Preservation of planktonic foraminifers in the sites from Leg 92 has been affected by the position of each site with respect to the lysocline and calcium carbonate compensation depth (CCD) at the time of deposition, depth of burial, and sediment accumulation rate (rate of burial). An additional factor may also be important, especially in the sediments deposited immediately above basement. Evidence of poor preservation in basal sediments of Holes 600C and 601, which have always been shallower than both the lysocline and the CCD, suggests that hydrothermal solutions circulating within young oceanic crust may penetrate the overlying sediments and affect the preservation of calcareous microfossils deposited there.

INTRODUCTION

Leg 92 of the Deep Sea Drilling Project left Tahiti on February 23, 1983 and arrived in Panama on April 19, 1983. Nineteen holes were drilled at six sites along a traverse at 19°S latitude in order to study evidence of ancient hydrothermal activity that occurred when the crust was newly formed and young (Table 1; Fig. 1). Sediments containing calcareous microfossils were recovered from all six sites. This report presents the results of shipboard examination and preliminary zonation of samples containing planktonic foraminifers.

The data tables in this report are not complete representations of the assemblages in each sample. They are meant to demonstrate the approximate (and subjectively determined) relative abundances of those species used to make the zonal assignments as well as the state of preservation of the samples. Core-catcher samples as well as a few samples from within selected cores were examined for this purpose.

The six sites of Leg 92 presently lie within the northernmost part of the subtropical water mass of the Southern Hemisphere. The spreading history of the crust at all sites suggests they have always been tropical-warm subtropical, and therefore the tropical zonation scheme of Blow (1969) has been utilized in this study. Modifications to this zonation scheme as proposed by Srinivasan and Kennett (1981) have been incorporated, particularly concerning the definition of the Oligocene/Miocene boundary by the first appearance of *Globoquadrina dehiscens*, which splits Blow's Zone N4 into two parts: uppermost Oligocene Zone N4A (base defined by first appearance of *Globigerinoides* species) and lowermost Miocene Zone N4B (base defined by the first appearance of *Globoquadrina dehiscens*).

Table 1. Locations and water depths of Leg 92 holes.

Hole	Latitude (S)	Longitude (W)	Water depth (corrected m)
597	18°48.38'	129°46.23'	4167
597A	18°48.43'	129°46.22'	4163
598	19°00.28'	124°40.61'	3699
599	19°27.09'	119°52.88'	3654
600C	18°55.70'	116°50.45'	3398
601	18°55.22'	116°52.11'	3433
602	18°54.41'	116°54.68'	3535

SHIPBOARD OBSERVATION

Site 597

Site 597 is the westernmost site of the transect along 19°S. The basement age at this site is calculated to be approximately 28.6 Ma (Rea, this volume). Two holes were hydraulically piston cored at this site, and both contain a record of lower Miocene to uppermost Oligocene planktonic foraminifers (Table 2).

Hole 597 was cored to basement at 54.7 m sub-bottom depth. Abundances of planktonic foraminifers vary, but the older samples are impoverished. Preservation is generally poor. In most samples there are many fragments and few specimens from the size fraction coarser than 150 μ m. The upper three cores from this hole appear to be early Miocene in age (Table 2; Fig. 2). However, the lack of *Orbulina* species in Section 597-1, CC may be due to the poor preservation of the sample (which is also indicated by the dominance of thickly calcified *Sphaeroidinellopsis* species), so it is possible that the sample may be earliest middle Miocene in age. A middle Miocene age would be in accord with the nannofossil age determination (Knüttel, this volume).

The assemblage found in the first core-catcher sample of Hole 597A is a poorly preserved and impoverished association of middle and early Miocene foraminifers and could not be assigned to a zone. Cores 597A-2

¹ Leinen, M., Rea, D. K., et al., *Init. Repts. DSDP, 92*: Washington (U.S. Govt. Printing Office).

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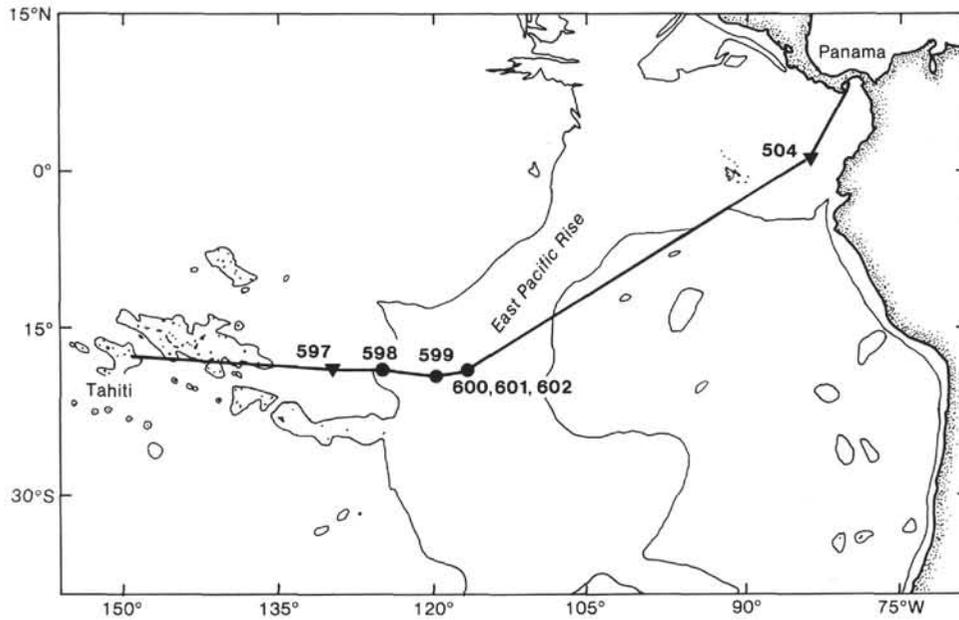


Figure 1. Location of Leg 92 sites on Tahiti-to-Panama transect of the East Pacific Rise. Inverted triangle denotes re-entry.

Table 2. Site 597 planktonic foraminifer species distribution, abundance, and preservation.

Sample (interval in cm)	Abundant Preservation	<i>Sphaeroidinellopsis disjuncta</i>	<i>Sphaeroidinellopsis seminulina seminulina</i>	<i>Globigerinoides trilobus</i>	<i>Globigerinoides primordius</i>	<i>Orbulina</i> spp.	<i>Catapsydrax dissimilis</i>	<i>Globorotalia praescitula</i>	<i>Globorotalia kugleri</i>	<i>Globorotalia nana</i>	<i>Globorotalia mayeri</i>	<i>Globorotalia siakensis</i>	<i>Globigerina brazieri</i>	<i>Globigerina angustiumblicata</i>	<i>Globigerina praebulloides</i>	<i>Globigerina angulisuturalis</i>	<i>Globigerina woodi</i>	<i>Globigerina ciperoensis</i>	<i>Globoquadrina praedeheiscens</i>	<i>Globoquadrina deheiscens</i>	<i>Globoquadrina altispira</i>	<i>Globoquadrina venezuelana</i>	<i>Neogloboquadrina continuosa</i>	Zone	Chrono- stratigraphy
597-1,CC	F P	F F R	—																					N7/N8	early Miocene
597-2,CC	A P						A R	—		+		+	+	+					C +				+	N5/N6	
597-3,CC	A P			R			F		F R	+		+	R +						C + R				+	N4B	
597-4,CC	A P			—					F R	+		+	R +	—	+		+	+	C	—			+	N4A	late Oligocene
597-6,CC	R P			—					—	+	—	+	+	+	+		+	—					+		
597-7,CC	R P			—					—	+	—	+	+	—	+		+	—	F +	F			+		
597-8,CC	R P			—			+			+	F		F		+	C	C	+	F			+			
597A-1,CC	R P	F		—																		+	R	?	early Miocene
597A-2,CC	F P		+				+	A	+	+		+	+	+		+	+					F		N4B	
597A-3-6 (148-150)	F P							+	+	+				+	+	—									
597A-4,CC	C P			R					F F	+				C	C		F	R	+					N4A	late Oligocene
597A-5,CC	F P			R					F					—	+	C	F	R	F						
597A-6,CC	C M			A			R		R	+			F	+	+	C	F	F	C						

Note: A = abundant; C = common; F = few; R = rare; + = present, but not subjectively quantified; — = absent, but looked for; blank = absent. G = good; M = moderate; P = poor.

and -3 contain abundant *Globorotalia kugleri* with no strictly Oligocene marker species (e.g., no specimens of *Globigerina angulisuturalis*), so has been assigned to Zone N4B (Table 2). Cores 597A-4, -5, and -6 contain both *G. angulisuturalis* and *G. ciperoensis* and have been assigned to Zone N4A. Although the Oligocene/Miocene boundary marker *Globoquadrina deheiscens* was not found in the earliest Miocene samples because of poor preserva-

tion, this boundary can be placed in Core 597A-4 above the last occurrence of *Globigerina angulisuturalis*. This placement agrees with the nannofossil determination (Knüttel, this volume).

Site 598

At Hole 598 (Table 3), 44.8 m of sediment, spanning the uppermost lower Miocene to Pleistocene, were re-

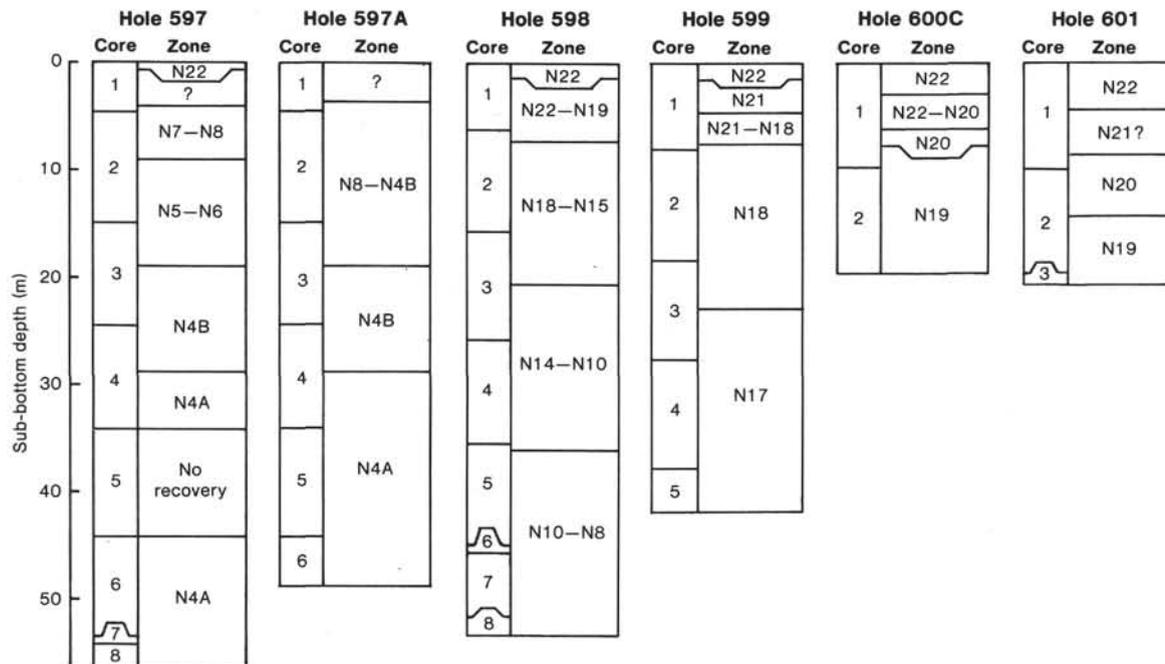


Figure 2. Foraminiferal stratigraphy of Leg 92 sites. Zones after Blow (1969).

covered from the first six cores. An additional 40 cm of nannofossil chalk and limestone recovered below the sediment unit are late early Miocene in age (nannofossil determination). Basement age below this site is approximately 16.0 Ma.

Planktonic foraminifers were rather more abundant than at Site 597 in nearly all samples examined. Preservation was poor to moderate in Hole 598. Some reworked specimens were found in Cores 598-1, -2, and -3, but a more detailed examination of more closely spaced samples is needed to determine the extent of reworking. Lithologic examination of Cores 598-4 and -5 revealed the presence of thin turbidite layers rich in foraminifers. These layers have not yet been examined but would be worthy of more detailed study to determine origin and age.

The Pleistocene/Pliocene boundary lies in Core 598-1 (Table 3; Fig. 2). Pleistocene Zone N22 is indicated by the presence of both *Globorotalia truncatulinoides* and *Globigerinoides fistulosus* in Sample 598-1-1 (140–150 cm). The assemblage from Section 598-1,CC indicates an early Pliocene age, Zone N19. The Pliocene/Miocene boundary appears to lie in the uppermost part of Core 2. Sample 598-2-2 (140–150 cm) has been assigned to Zones N17/N18; the presence of *Sphaeroidinellopsis paenedehiscens* suggests an age no older than N17B, and the presence of possible fragments of *Globorotalia tumida tumida* suggest an age no older than N18. Sections 598-2,CC, -3,CC, and -4,CC are middle Miocene in age. Some reworked specimens are noted. The absence of *Orbulina* species in Sections 598-5,CC and -6,CC indicates an early Miocene age. A zonal assignment to N8 has been made on the basis of the presence of both *Globigerina brazieri* and *Globigerinoides sicanius* within the same samples. However, specimens of *G. parawoodi* and *Globigerina connecta* may actually suggest a slightly older zonal designation (N7).

Site 599

Three holes were drilled at Site 599; two of these recovered sediments (Table 4). Hole 599 recovered a continuous section of late Miocene to Pleistocene sediments. Planktonic foraminifers were abundant and better preserved at this site than at either Site 597 or 598. Reworked late Miocene foraminifers were found in Sample 599-1-3 (140–150 cm), which is late Pliocene in age. Considerable reworking in the upper 20–30 m of this hole was also indicated by nannofossil distributions (Knüttel, this volume). There is large-scale lithologic “banding” of alternating color zones, which have sharp lower contacts and grade upward; these characteristics suggest turbidite deposition as well.

The uppermost sample examined in Hole 599 contained a Pleistocene assemblage with *Globorotalia truncatulinoides*, *G. tosaensis*, and *Neogloboquadrina dutertrei* (Table 4). The Pleistocene/Pliocene boundary is well constrained to a position within the first 1.5 m of the first core, since the remaining samples examined in Core 1 above the core-catcher are late Pliocene (Zone N21) in age (Table 4 and Fig. 2). Samples from core-catchers of both Cores 599-1 and -2 have been assigned to late Miocene Zone N18 because they contain *Globorotalia tumida tumida*, which marks the base of N18, and *G. merotumida*, whose range extends no younger than N18. *G. tumida tumida* was sought but not found in the remaining core-catchers (599-3,CC, -4,CC, and -5,CC). The presence of *Sphaeroidinellopsis paenedehiscens* (599-3,CC), *Pulleniatina primalis* (599-4,CC) and *Globorotalia plesiotumida* (599-5,CC) in the absence of *G. tumida* places these samples within Zone N17. This suggests that the age at the bottom of the hole is between 7.0 and 8.0 Ma, in agreement with basement age of about 8.0 Ma estimated from magnetic anomalies.

A second hole, Hole 599B, was washed to 23.6 m above basement and then cored so as to recover the sediment/basement interface. Two cores were recovered; Core 599B-2 sampled sediment and Core 599B-3 recovered basement gravel mixed with sediment. Section 599B-2,CC contained late Miocene fossils, but no distinction between Zones N17 and N18 could be made. The gravel sample contained a mixed assemblage of Pleistocene through late Miocene microfossils, probably as the result of the coring process.

Site 600

Site 600 (Table 5), the fourth site on the east-west hydrogeology transect, was to be the high-heat-flow end-member of a set of three sites drilled on East Pacific Rise crust aged approximately 4.6 Ma. Four holes were attempted at Site 600 because of thin sediment cover and locally variable heat flow. Three of these recovered sediment and were examined for biostratigraphic information.

Planktonic foraminifers were abundant in most samples, and preservation was moderate to good in the younger samples (Table 5). Two samples examined from Hole 600, a "surface" sample and the first core-catcher, contained a Pleistocene assemblage that included *Globorotalia truncatulinoides*, *Globigerinoides fistulosus*, and *Beella digitata*. Hole 600B had only one core, and its core-catcher age was also Pleistocene (Table 5). Reworked Pliocene material was evident in all samples from these holes.

In Hole 600C, sediments were successfully recovered down to basement. The distribution of nannofossils (Knüttel, this volume) indicates that the Pleistocene/Pliocene boundary is within Core 600C-1, probably in Section 3 (3.0 to 4.5 m sub-bottom depth). Sections 600C-1-1

and -2 contain Pleistocene fossils, with some reworked Pliocene specimens like the samples examined in Holes 600 and 600B. Sample 600C-1-4 (145-150 cm) contains early Pliocene fossils but no evidence of *Globigerina ne-penthes*; thus, it has been assigned to Zone N20. *G. ne-penthes* is found in all the remaining samples in company with *Globorotalia tumida*, *G. tumida flexuosa*, *G. margaritae*, and *Sphaeroidinellopsis seminulina kochi*. The presence of *G. margaritae* in Sections 600C-1,CC and 600C-2,CC and the presence of *Pulleniatina praecursor* in Section 600C-1,CC constrains these samples to Zone N19.

Site 601

Site 601 was planned as the intermediate-heat-flow site of the three drilled on 4.6-Ma crust. Three holes were cored, one for heat-flow measurements and two for sediment recovery. Hole 601 recovered approximately 20 m of early Pliocene to Pleistocene sediments. At Hole 601B, the lower part of the sediment section and the sediment/basalt contact was cored. An early Pliocene age was determined from the biostratigraphy, which agrees well with the estimated crustal age of 4.6 Ma.

Preservation and abundance of foraminifers in Hole 601 are similar to those of Hole 600C (Tables 5 and 6), the foraminifers being best preserved and most abundant in younger sediments and less well preserved and fewer in the oldest material. The stratigraphy is similar to that of Hole 600C, and reworked early Pliocene fossils are found in most of the younger samples. Most of Core 601-1 contains a Pleistocene assemblage dominated by *Globorotalia truncatulinoides*, *G. tosaensis*, and *Globigerinoides fistulosus*. However, because of the greater abundances of Pliocene species in Sections 601-1-4 and 601-1-5, the Pleistocene/Pliocene boundary has been

Table 5. Site 600 planktonic foraminifer species distribution, abundance, and preservation.

Sample (interval in cm)	Abundance	Preservation	<i>Beella praedigitata</i>	<i>Sphaeroidinella dehiscens</i>	<i>Sphaeroidinellopsis paenedehiscens</i>	<i>Sphaeroidinellopsis seminulina seminulina</i>	<i>Sphaeroidinellopsis kochi</i>	<i>Globorotalia truncatulinoides</i>	<i>Globorotalia tosaensis</i>	<i>Globorotalia crassaformis</i>	<i>Globorotalia cibaoensis</i>	<i>Globorotalia hirsuta</i>	<i>Globorotalia margaritae</i>	<i>Globorotalia menardii</i>	<i>Globorotalia merotumida</i>	<i>Globorotalia pleiotumida</i>	<i>Globorotalia scitula</i>	<i>Globorotalia tumida tumida</i>	<i>Globorotalia tumida flexuosa</i>	<i>Globorotalia unguolata</i>	<i>Globigerinoides sacculifer</i>	<i>Globigerinoides fistulosus</i>	<i>Globigerina ne-penthes</i>	<i>Globigerina aequilateralis</i>	<i>Neoglobobulimina dutertrei</i>	<i>Pulleniatina obliquiloculata</i>	<i>Pulleniatina primalis</i>	<i>Pulleniatina praecursor</i>	<i>Pulleniatina spectabilis</i>	Zone	Chrono-stratigraphy			
600 top	A	G-M	C					F	R	+	r			+				C	r	?	C		C							N22	Pleistocene			
600-1,CC	A	M	+			r		R	R	+	r			+				+	r			C									N22	Pleistocene		
600B-1,CC	C	P	+			r							r		r			C				F									N22	Pleistocene		
600C-1-1 (145-150)	A	G-M	r	C				C		F			C					C		F	C	F										N22	Pleistocene	
600C-1-2 (145-150)	A	G-M	+					C	F		F		+					+		F	C	F			F	+						N22	Pleistocene	
600C-1-4 (145-150)	A	M		F	F	r			C				F					C	F				-				F					N20	early Pliocene	
600C-1-5 (145-150)	A	M		F	+	+				+			F					C	F			C		C		F								
600C-1,CC	A	M-P		C	C	C							F					C	C		C		C						R	F				N19
600C-2,CC	C	M-P		R	C	C							C					C	C			F	F											

Note: See Table 3 for key.

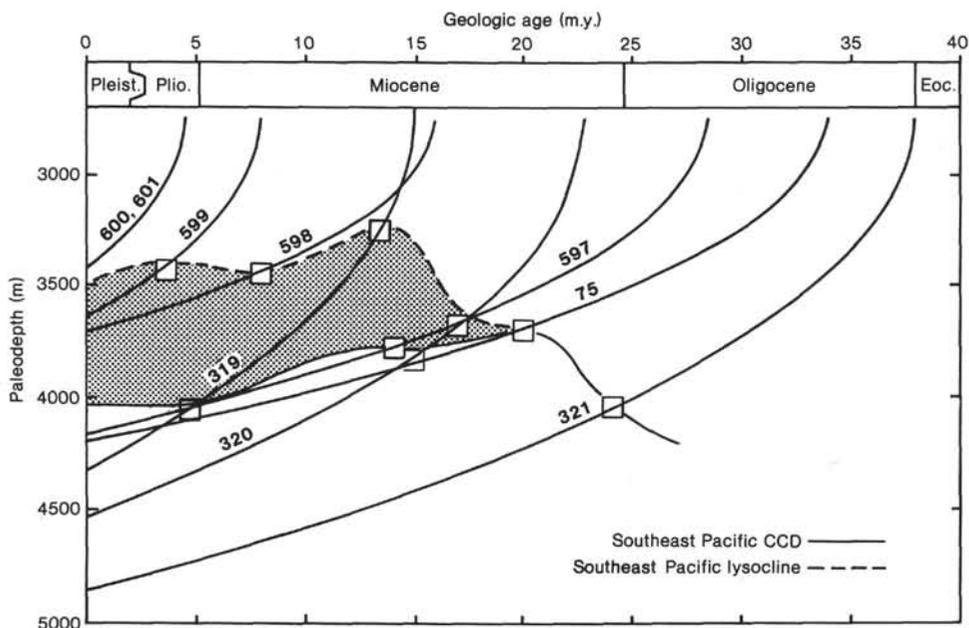


Figure 4. Subsidence curves and the history of the calcite compensation depth for Leg 92 sites (from Rea and Leinen, this volume). Squares are 1 m.y. \times 100 m and provide an indication of the accuracy of the age/depth data.

preservation are complex and will require further study. However, one observation is worthy of note here. Two of the sites examined, 600 and 601, have been shallower than both the lysocline CCD throughout their history and should have very well preserved calcareous microfossils. Foraminiferal preservation is good in all except the oldest sediments, which were deposited at the shallowest crustal depth (i.e., far above the CCD). Neither depth relative to the lysocline or CCD, nor the depth of burial (approximately 20 m of sediment make up the column), appears to be a control on dissolution in those sediments, so some other factor must be involved. These sites are located on relatively young crust which has been hydrothermally active in its past (Lyle et al., this volume). Penetration of hydrothermal solutions into the sediment column may have resulted in increased dissolution of the foraminifers deposited there. More research will be necessary to better determine the effects of hydrothermal solution on the preservation of carbonate in sediments.

SUMMARY

Leg 92 recovered sediments of uppermost Oligocene through Pleistocene age in a region which heretofore had very poor site coverage. The material recovered was zonal using Blow's tropical zonation scheme. More detailed study of the assemblages found in these sites has potential for use in the determination of the paleoceanographic history of the subtropics of the Southern Hemisphere.

Carbonate dissolution is evident in the cores obtained on Leg 92. It is clear that the history of the lysocline

and calcite compensation depth alone does not account for the preservational character of calcareous microfossils at all sites. In most sites the younger samples appear to be the best preserved, while older samples, which presumably were deposited above the lysocline and CCD, seem to be relatively less well preserved. The reason for this phenomenon may be tied to the nature of the crust the oldest sediments were originally deposited on, that is, a crust where active hydrothermal systems existed. The extent of penetration of hydrothermal solutions into these overlying sediments is not well known, nor is the length of time they may have persisted. However, their chemical influence may well have induced or encouraged dissolution of carbonate sediments in contact with the solutions.

ACKNOWLEDGMENTS

I would like to thank M. Leinen, D. K. Rea, and J. P. Kennett for encouraging me to participate on Leg 92. I would also like to thank the crew and captain of the *Challenger* and the other members of the scientific party for a most rewarding experience.

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Date of Initial Receipt: 6 July 1984

Date of Acceptance: 5 February 1985