11. FORAMINIFERS AND COARSE DETRITUS FROM FIVE DEEP-WATER SITES, DEEP SEA DRILLING PROJECT LEG 86, NORTHWEST PACIFIC[1]

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ABSTRACT

Five sites of Leg 86 of the Deep Sea Drilling Project were drilled in water greater than 5000 m deep in the northwest Pacific. The objectives of the coring program at these sites included sampling Cenozoic pelagic sediments, in an effort to define paleoceanographic patterns and boundaries, and assessing the nature of the red clay/chert boundary which is seismically mappable. The biostratigraphy of foraminifers contributes to these objectives in only four short intervals. Cenozoic pelagic sediments contained rare, small, moderately preserved assemblages of planktonic foraminifers. Calcareous sediments below 55.3 m sub-bottom at Site 576 are turbidites of Cretaceous age containing Santonian/Campanian foraminifers. A small assemblage of early Eocene age (P9–P11) was found at 163.28 m at Site 578, corroborating a similar determination based on ichthyoliths. Foraminifers in calcareous sediment immediately above the chert at 176.44 m sub-bottom at Site 578 indicate a Campanian minimum for the age of the chert horizon at that location. At Site 580, a modest assemblage of late Pleistocene (N23) age was recovered above 41.29 m sub-bottom and an early Pleistocene (N22) assemblage found in one sample at 44.89 m sub-bottom. Samples from Sites 579 and 581 were barren of foraminifers.

Examination of the washed residue for foraminifers disclosed abundant volcanic glass, Mn-oxide nodules and tubes, and eolian silt in the greenish and red pelagic clays. Biosiliceous debris and ichthyoliths are also common to abundant. Middle Miocene deposits at Site 581 contain ice-rafted basalt and andesite pebbles.

INTRODUCTION

Five deep-water sites were planned for Leg 86 (Fig. 1). The site objectives were to study the nature and rate of Cenozoic sedimentation and the chert/clay horizon. The Cenozoic sediments were expected to be predominantly biosiliceous, so the importance of calcareous fossil groups was expected to be minimal. The seismically mappable chert layer was, however, thought to be associated with calcareous deposits and foraminifers were expected to be significant in dating this horizon.

The biostratigraphic utility of foraminifers was indeed limited by rare occurrences of planktonic or benthic species in recovered Cenozoic sediments. One Cretaceous calcareous turbidite (Site 576) was penetrated above the chert, and Campanian calcareous sediment was recovered at Site 580, just above the chert. Besides foraminifers, sample examination uncovered manganese-oxide replacement of foraminifers and middle Miocene ice-rafted detritus. Results of the study of Cretaceous and Cenozoic calcareous sediment recovered from Site 577 on the Shatsky Rise will be published elsewhere.

Cored sediment is divided into lithologic units on the basis of color, smear-slide, textural, and compositional data. Three units were designated at Site 576 (see Site 576 chapter, this volume). Lithologic Unit I (0–55 m sub-bottom) consisted of yellowish brown to brown pelagic clay above 28 m sub-bottom (Subunit IA) and dark brown "slick" clay below (Subunit IB). Lithologic Unit II is an interbedded dark brown pelagic clay and pale brown nannofossil ooze. Lithologic Unit III (76 m sub-bottom) is

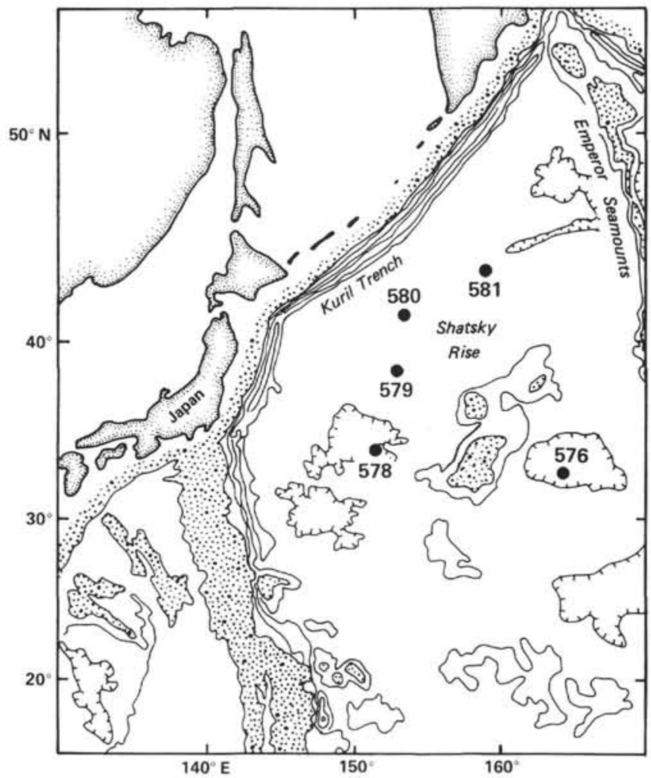

Figure 1. Map showing location of the five deep-water sites: 576, 578, 579, 580, and 581. Areas shallower than 4 km stippled, 5-km contour plain, 6-km contour hachured.

chert and porcellanite. Four units were designated at Site 578 (see Site 578 chapter, this volume). Lithologic Unit I (0–76.6 m sub-bottom) is a gray to olive gray clay and siliceous clay, Lithologic Unit II (76.6–124.5 m sub-

[1] Heath, G. R., Burckle, L. H., et al., *Init. Repts. DSDP*, 86:Washington (U.S. Govt. Printing Office).
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bottom) is a yellowish-brown to brown clay containing minor amounts of siliceous microfossils. Lithologic Unit III (124.5–176 m sub-bottom) is a dark brown pelagic clay. It contains 90% or more clay and biogenic silica is virtually absent. Lithologic Unit IV (176.0–176.8 m sub-bottom) consists of interlaminated brown, yellow, and gray clays over chert. One major unit was designated at Site 579 (see Site 579 chapter, this volume). Lithologic Unit I was subdivided into three subunits (IA, 0–60 m sub-bottom; IB, 60–102.5 m sub-bottom; IC, 102.5–149.5 m sub-bottom) based on the abundance of biogenic silica, quartz, and clay. One lithologic unit was designated at Site 580 (see Site 580 chapter, this volume). Unit I is a siliceous clay subdivided into five subunits (IA, 0–60.3 m sub-bottom; IB, 60.3–79.3 m sub-bottom; IC, 79.3–117.3 m sub-bottom; ID, 117.3–136.3 m sub-bottom; IE, 136.3–155.3 m sub-bottom) based on the content of clay, quartz, biogenic silica, and clay-sized carbonate. Four units were designated at Site 581 (see Site 581 chapter, this volume). Lithologic Unit I (0–244.8 m sub-bottom) is a gray green or yellowish brown biosiliceous clay. Unit II (244.8–276.6 m sub-bottom) is a dark brown "slick" pelagic clay. Unit III (276.7–343 m sub-bottom) is chert and porcellanite. Unit IV (343–352.5 m sub-bottom) is aphyric basalt.

METHODS

Samples were disaggregated in distilled water and occasionally hydrogen peroxide or Calgon was used to aid in dispersal of clays. The sediment was then washed over 149- and 63-μm sieves. The dried residues then placed in separate containers for each size fraction and examined with a binocular microscope.

RESULTS

Site 576: Holes 576 and 576B

Site 576 is located east of the Shatsky Rise in 6220 m of water. The dark brown pelagic clay of Unit I (0–55 m sub-bottom) (Fig. 2) contains no planktonic foraminifers and only rare specimens of *Reophax nodulosus* and *R. difflugiformis*. Mn-oxide replacement of foraminifers was also noted in the sediments of Unit I. This phenomenon was also reported by Thompson (1980) in sediments from the Japan Trench.

Sequences of massive, cross-bedded and normally graded units exhibiting sharp and gradational contacts are common in sediments deposited by turbidity flows. The calcareous sediments of Unit II exhibit these features. The calcareous oozes are also separated by greenish pelagic clay containing Late Cretaceous ichthyoliths (see Site 576 chapter, this volume). Interbedded pelagic sediments characteristically overlie turbidity flows in a deep-sea environment. The calcareous units containing Santonian–Campanian foraminifers can be correlated between the two holes and a sequence of 23 turbidity flows can be recognized (Fig. 3). The reworked nature of the sediments is also indicated by the wide age range indicated by the foraminifers. The specimens found are typical of Late Cretaceous foraminiferal assemblages as reported in the U.S. Gulf Coast (Pessagno, 1967), New Jersey (Olsson, 1960; Petters, 1977), Shatsky Rise (Caron, 1975; Hofker, 1978), the Pacific west of the Shatsky Rise (Krasheninnikov and Hoskins, 1973), the western interior seaway of the U.S. (Frerichs and Dring, 1981), northern California (Trujillo, 1960), and Vancouver, B.C. (McGugan, 1982).

All sub-bottom depths given here and in Appendix B are adjusted according to the factors determined by Ross Heath. Details and techniques used for the adjustments are given in the Site 576 chapter (this volume). Appendix A contains lists of species found in the turbidites and clays recovered at Site 576. Appendix B contains detailed sample information for the two holes.

Site 578: Hole 578

Site 578 was the southernmost site in a northerly transect on Leg 86. It is located west of the Shatsky Rise in 6020 m of water. Foraminifers are rare in the late Pleistocene siliceous clay of Lithologic Subunit IA and in the pelagic clay of Lithologic Unit II. A small assemblage containing two species can be used to date a portion of Lithologic Unit III. A small but diverse assemblage was found just above the chert in Lithologic Unit IV. Sample 578-1-3, 80–82 cm (4.79 m sub-bottom) contained rare specimens of *Reophax difflugiformis* and *Chilostomella* sp. Sample 578-12,CC (109.29 m sub-bottom) contained two specimens of *Massilina tenuis*. Sample 578-18,CC (18–20 cm) (163.28 m sub-bottom) contained rare specimens of *Globorotalia spinulosa* and *G. broedermanni*. These indicate an early Eocene age, but the precise zonation is indeterminate. Their ranges span P9–P11 (the *Globorotalia pentacamerata* Zone to the *Globigerinatheka subconglobata* Zone; Stainforth et al., 1975). Samples 578-20-1, 64–66 cm and 578-20,CC (176.45 m, 176.8 m sub-bottom) contained abundant specimens of *Globotruncana fornicata*; common *G. tricarinata, G. lapparenti, Pseudotextularia elegans*, and *Heterohelix striata;* and rare to few *Globigerinelloides asperus, G. prairiehillensis, Hedbergella planispira, Globotruncana arca, G. stuartiformis*, and *Rugoglobigerina rugosa*. A Late Cretaceous Campanian age is indicated in the *Globotruncana fornicata-stuartiformis* Zone of Pessagno (1967).

Appendix B contains detailed information on the particles observed in these samples including Mn nodules and ichthyoliths.

Site 579: Holes 579, 579A

This site was the second in the north–south paleoceanographic transect and is located in 5746 m of water. No foraminifers were recovered. Appendix B lists observations on the detritus found in the samples examined.

Site 580: Hole 580

Site 580 is located in 5385 m of water and is the third in the series of sites in the north–south transect on Leg 86. Foraminifers were found only in the Pleistocene siliceous clay of lithologic Subunit IA (above 44.9 m sub-bottom). Planktonic and benthic species are typically rare (Table 1). Preservation is moderate to good, with no evident abrasion or breakage, and dissolution effects are light to moderate. The presence of these specimens in the

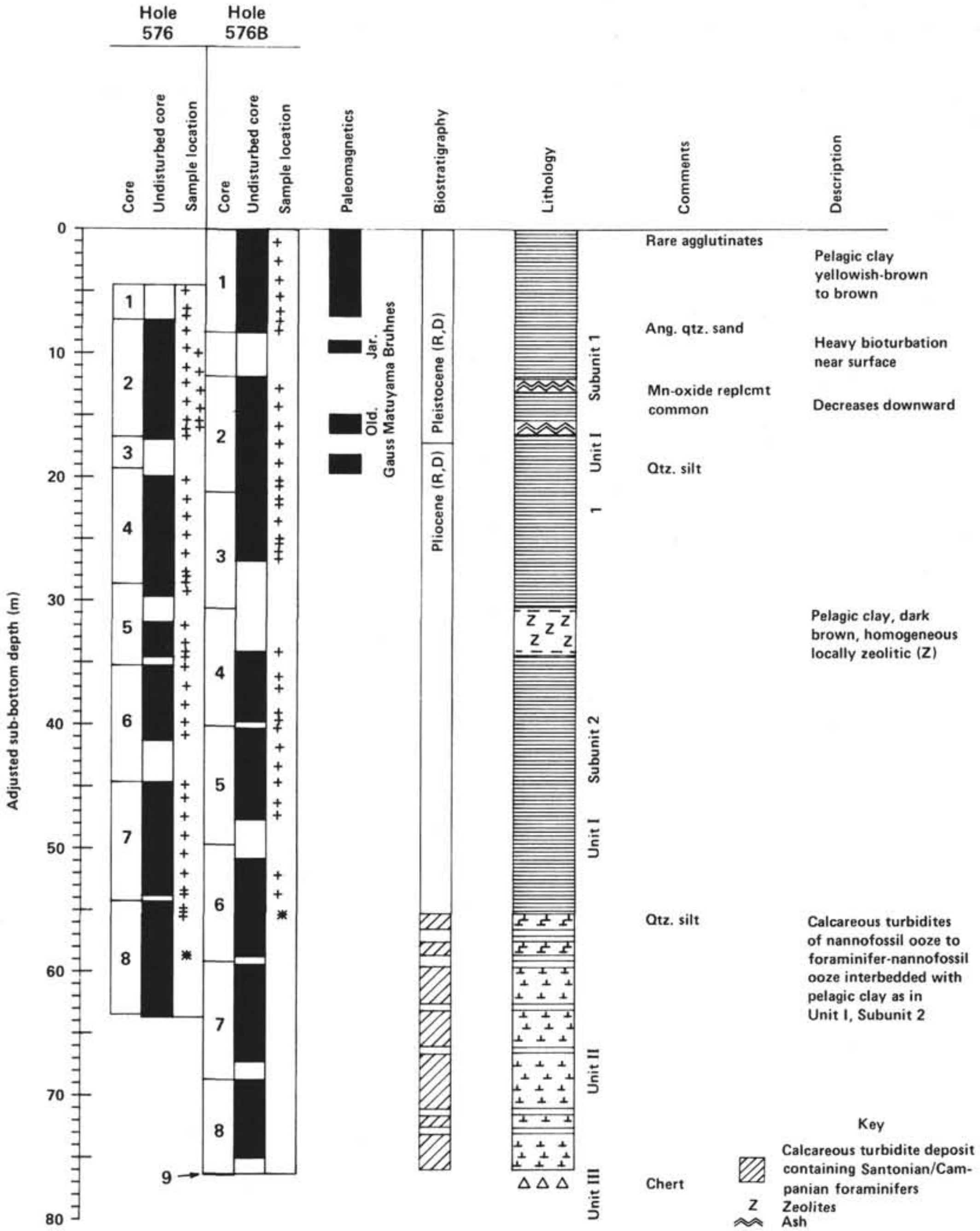

Figure 2. Sample location, paleomagnetics, biostratigraphy, and core description for Holes 576 and 576B. For information on samples below asterisks, see Figure 3.

biosiliceous clay indicates that sedimentation rate alone does not control the preservation of calcareous fossils since the rate apparently has not changed at that site since the mid-Pliocene. Appendix B contains detailed sample information for Site 580.

Site 581: Hole 581

This hole was the last and most northerly location drilled on Leg 86. The water depth of 5486 m is reflected by the total absence of foraminifers in recovered sediment. Two samples analyzed from Core 581-9 (middle Miocene, see Site 581 chapter, this volume) contain rounded basalt and andesite pebbles indicative of ice-rafted detritus deposition at this location (Duennebier, Stephen, Gettrust et al., in press).

SUMMARY

The biostratigraphic utility of foraminifers was limited at the five deep-water sites visited in the northwest Pacific during DSDP Leg 86. At Site 576, foraminifers are rare to absent except in the calcareous sediment below 55.3 m sub-bottom. Because of the turbiditic nature of the deposits, foraminifers could not be used to date them. At Sites 579, 580, and 581 foraminifers were either rare or absent and merely supplemented the detailed siliceous biostratigraphy provided by diatoms, radiolarians, and silicoflagellates. The stated objective of dating the chert/clay boundary was accomplished only at Site 578, where a minimum Campanian age can be assigned to the chert. Figure 4 summarizes the foraminiferal biostratigraphy of the deep-water sites of Leg 86.

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APPENDIX A
Listing of Species, Holes 576 and 576B

Species found in Hole 576 turbidites

Ammodiscus asperellus (d'Orbigny)
Aragonia velascoensis (Cushman)
Archaeoglobigerina blowi Pessagno
A. tradinghousensis (Pessagno)
Bolivinoides sp.
Bulimina quadrata Plummer
Dentalina colei Cushman & Dusenbury
D. peracuta (Reuss)
D. wilcoxensis Cushman
Dentalina sp.
Eponides bandyi Trujillo
E. simplex (White)
Fissurina sp.
Globigerinelloides asperus (Ehrenberg)
G. prairiehillensis Pessagno
Globotruncana angusticarinata (Gandolfi)
G. bulloides Volger
G. elevata (Brotzen)
G. lapparenti Brotzen
G. stuartiformis Dalbiez
Gyroidina tsablensis McGugan
Haplophragmoides multicameras Krasheninnikov
H. pervagatus Krasheninnikov
Hastigerinoides watersi (Cushman)
Hedbergella planispira (Tappan)
Heterohelix globulosa (Ehrenberg)
H. pulchra (Brotzen)
H. reussi (Cushman)
H. striata (Ehrenberg)
Lagena gracilis (d'Orbigny)
Melonis affinis Reuss
Nodosaria tenuicosta Reuss
Ostracod fragments
Paratrochamminoides intracatus Krasheninnikov
P. semipellucidus Krasheninnikov
P. vitreus Krasheninnikov
Praecystammina globigerinaeformis Krasheninnikov
Pseudotextularia elegans (Rzehak)
Reophax nodulosus Cushman
Reophax sp.
Schackoina multispinata (Cushman & Wickenden)
Stilostomella midwayensis (Cushman & Todd)

Species found in Hole 576B

Aragonia velascoensis (Cushman)
Archaeoglobigerina blowi Pessagno
A. bosquensis Pessagno
A. tradinghousensis (Pessagno)
Bulimina sp.
Dentalina colei Cushman & Dusenbury
D. peracuta (Reuss)
D. semipellucidus Krasheninnikov
Dentalina wilcoxensis Cushman
Dentalina sp.
Eponides bandyi Trujillo
E. simplex (White)
Fissurina sp.
Glandulina pygmaea Reuss
Globigerinelloides asperus (Ehrenberg)
G. prairiehillensis Pessagno
Globotruncana angusticarinata (Gandolfi)
G. bulloides Volger
G. calcarata Cushman
G. elevata (Brotzen)
G. lapparenti Brotzen
G. stuartiformis Dalbiez
Gyroidina tsablensis McGugan
Haplophragmoides biumbilicalis Krasheninnikov
H. multicamerus Krasheninnikov
H. pervagatus Krasheninnikov
Hastigerinoides watersi (Cushman)
Hedbergella planispira (Tappan)
Heterohelix globulosa (Ehrenberg)
H. pulchra (Brotzen)
H. reussi (Cushman)
H. striata (Ehrenberg)
Lagena gracilis (d'Orbigny)
Lenticulina sp.
Melonis affinis Reuss
Mn-oxide replacements
Nodosaria tenuicosta Reuss
Osangularia sp.
Paratrochamminoides intracatus Krasheninnikov
P. vitreus Krasheninnikov
Praecystammina globigerinaeformis Krasheninnikov
Pseudotextularia elegans (Rzehak)
Schackoina multispinata (Cushman & Wickendam)
Stilostomella midwayensis (Cushman & Todd)

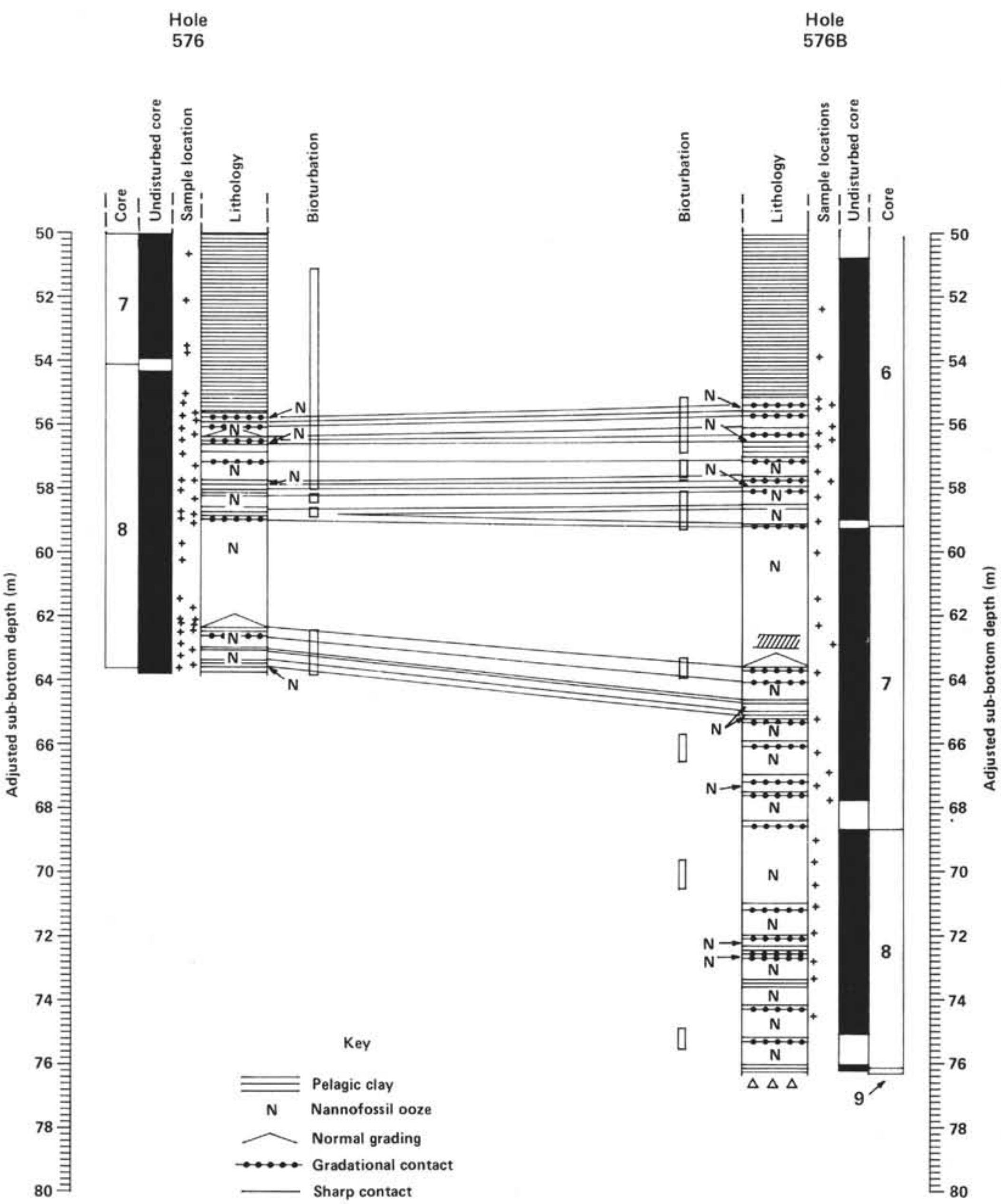

Figure 3. Sample location, lithology, bioturbation, and correlation of calcareous turbidites in Holes 576 and 576B.

Table 1. Occurrence and abundance of foraminifers in samples from Hole 580.

Core-Section (interval in cm)	Sub-bottom depth (m)	Age	*Globorotalia humerosa*	*G. inflata*	*G. ronda*	*G. tosaensis*	*G. hirsuta*	*G. praehirsuta*	*G. acostaensis*	*Neogloboquadrina pachyderma* (S)	*Globigerina linaperta*[a]	*Melonis pompiloides*	*Melonis* sp.	*Pyrgo fornasini*	*Fissurina annectens*	*Saccammina sphaerica*
1-1, 112-114	1.13	l. Pleist.										R	R			
1-2, 33-35	1.84		C	F	R					R	A					
2-4, 106-108	8.15					R	F	R			A	R	R	R		
4-3, 80-82	26.11			A	R	R					F					
5-5, 85-87	38.66			R									R			R
5,CC	41.29												R			
6-3, 58-60	44.89	e. Pleist.	A					R	A			F	R		R	

[a] Reworked.

Age	Zone Stainforth et al. (1975)	Zone Blow (1969)	Hole 576 Sub-bottom sample	Hole 576B Sub-bottom sample	Hole 578 Sub-bottom sample	Hole 580 Sub-bottom sample
late Pleist.	*Globorotalia truncatulinoides* Zone	N23				41.29 m 5,CC (and above)
early Pleist.		N22				44.89 m 6-3, 58–60 cm (only)
early Eocene	*Globigerinatheka subconglobata* Zone to *Globorotalia pentacamerata* Zone	P11 to P9			163.28 m 18,CC (18–20 cm) (only)	
Cretaceous	Cretaceous by ichthyolith	Maest.?	Below 8-1, 135–137 cm 55.34 m. Calcareous turbidites bearing Santonian/Campanian foraminifers	Below 6-5, 24–26 cm 55.83 m		
	Globotruncana fornicata-stuartiformis Zone	Camp.			Below 20-1, 64–66 cm 176.44 m	
	Zone (Pessagno)	Stage				

Figure 4. Summary of biostratigraphy, Sites 576, 578, and 580.

APPENDIX B
Sample Contents of All Material Examined from Sites 576, 578, 579, 580, and 581

Core-Section (interval in cm)	Depth in hole (m)	Coarse fraction (>63 μm) components[a]: Biosiliceous debris	Clay flocs	Mn nodules	Fish teeth, fish debris	Volcanic glass	Pumice fragments	Quartz silt/sand	Phillipsite	Foraminifers[b]: Preservation	Planktonic	Benthic	Comments
Hole 576[c]													
1-1, 56–58	5.06–5.08	A	A							G		R	*Rheophax* sp.
1-2, 53–55	6.53–6.55	A	A			C							
1,CC (10–13)	7.17–7.20	A	A			C				G		R	Agglutinates
2-1, 101–102	8.21–8.23	A	A										
2-2, 101–102	9.71–9.73	C	A										
2-3, 101–102	11.21–11.23	C	A										
2-4, 80–82	12.50–12.52	C	A	A	C					R		R	Mn-oxide replacement
2-5, 80–82	14.00–14.02	C	A	A									
2-6, 80–82	15.50–15.52	C	A	A	R								
2-7, 20–22	16.40–16.42	C	A	A	C								
2,CC (8–11)	16.78–16.81	C	A	A	C								
3-1, 50–52	10.10–10.12	C	A	A	C								Repeat of Core 2
3-2, 50–52	11.60–11.62	C	A	A	R								Repeat of Core 2
3-3, 50–52	13.10–13.12	C	A	A	R								Repeat of Core 2
3-4, 50–52	14.60–14.62	C	A	A	R								Repeat of Core 2
3-5, 12–14	15.72–15.74	C	A	A	R								Repeat of Core 2
3,CC (10–13)	16.02–16.05	C	A	A	R					R		P	Repeat of Core 2, Mn-oxide replacement
4-1, 120–122	20.30–20.32	P	A	A	C								
4-2, 120–122	21.80–21.82	P	A	A	R								
4-3, 120–122	23.30–23.32	P	A	A	R								
4-4, 120–122	24.80–24.82	P	A	A	C								
4-5, 120–122	26.30–26.32	P		A	F								
4-6, 120–122	27.80–27.82	P		A	F								

Appendix B. (Continued).

Core-Section (interval in cm)	Depth in hole (m)	Coarse fraction (>63 μm) components[a]: Biosiliceous debris	Clay flocs	Mn nodules	Fish teeth, fish debris	Volcanic glass	Pumice fragments	Quartz silt/sand	Phillipsite	Foraminifers[b]: Preservation	Planktonic	Benthic	Comments
Hole 576[c] (Cont.)													
4-7, 20-22	28.30-28.32	P		A									
4,CC (10-13)	28.68-28.71	P		A	A								
5-1, 120-122	29.40-29.42	R	A	A	A								
5-2, 120-122			A	A	A								Flow-in
5-3, 102-104			A	A	A								Flow-in
5-4, 102-104			A	A	A								Flow-in
5-5, 102-104	32.12-32.14	P	A	A	A								
5-6, 102-104	33.62-33.64	P	A	A	A								
5-7, 30-32	34.40-34.42	P	A	A	A								
5,CC (10-13)	34.69-34.72	P	F	A	A								
6-1, 135-136		P	R	F	A								Flow-in
6-2, 112-113		P	R	A	A			A					Flow-in
6-3, 112-113	35.52-35.53	P	R	F	A			A					
6-4, 112-113	37.02-37.03	P			A								
6-5, 112-113	38.52-38.53		F	F	A								
6-6, 112-113	40.02-40.03	P			A								
6-7, 40-42	40.80-40.82		P		A								
6,CC (10-13)	40.95-40.98		P		A								
7-1, 50-52	45.10-45.12		P		A			A					
7-2, 50-52	46.10-46.12				A								
7-3, 50-52	47.60-47.62		A	A	A								
7-4, 50-52	49.10-49.12		F	A	A								
7-5, 50-52	50.60-50.62		R	R	A	A							
7-6, 50-52	52.10-52.12	P	R	R	A								
7-7, 40-42	53.50-53.52		F	R	A								
7,CC (15-18)	53.75-53.78		F		A								
8-1, 90-92	55.00-55.02		A	A	A			A					
8-1, 135-137	55.35-55.37		A	A	A			A		M		R	
8-2, 4-6	55.64-55.66		A	A	A								
8-2, 18-20	55.78-55.80			A	A					M	A	C	Graded nannofossil ooze, tests in 63-149 μm fraction, dissolution, abrasion
8-2, 25-27	55.85-55.87		A	A						M	C	C	Bioturbated clay
8-2, 50-52	56.10-56.12		R	A	A					M	A	F	Dissolution, graded nannofossil ooze
8-2, 71-73	56.31-56.33			A	A			A		G	R	C	Tests stained brown, bioturbated clay
8-2, 88-90	56.48-56.50		R	A	A					M	A	C	Abrasion, dissolution, nannofossil ooze
8-2, 132-134	56.92-56.94			C	A					M	R	C	Brown tests, abrasion, bioturbated clay
8-3, 18-20	57.28-57.30		R	C	A					M	R	F	Bioturbated nannofossil ooze
8-3, 66-68	57.76-57.78			C	C			A					
8-3, 81-83	57.91-57.93		R	F				A					
8-3, 96-98	58.06-68.08			F	A								
8-3, 122-124	58.32-58.34			F	C					M	C	C	Nannofossil ooze
8-4, 10-12	58.78-58.72									M	R	C	Brown-stain, nannofossil ooze, bioturbation?
8-4, 20-22	58.80-58.82			A	A								
8-4, 30-32	58.90-58.92	P								P	A	F	Nannofossil ooze, dissolution, abrasion
8-4, 49-51	59.09-59.11	P		R						P	A	C	Nannofossil ooze, dissolution, abrasion
8-4, 110-112	59.70-59.72	P		R						P	A	C	Nannofossil ooze, dissolution, abrasion
8-5, 12-14	60.22-60.24			R						P	A	C	Nannofossil ooze, dissolution, abrasion
8-5, 132-134	61.42-61.44	P		C						P	A	C	Nannofossil ooze, dissolution, abrasion
8-6, 12-14	61.72-61.74	P		C						P	A	C	Nannofossil ooze, dissolution, abrasion
8-6, 42-44	62.02-62.04			C						P	A	C	Nannofossil ooze, dissolution, abrasion
8-6, 52-54	62.12-62.14	R								P	A	C	Cross-bedding, dissolution, abrasion
8-6, 62-64	62.22-62.24	R								P	A	C	Graded nannofossil ooze
8-6, 72-74	62.32-62.34	R		C	A					P	A	C	Graded nannofossil ooze, bioturbated?
8-6, 84-86	62.44-62.46	R		C	A					P	A	C	Graded nannofossil ooze, bioturbated?
8-6, 98-100	62.58-62.60	P	F	C	R					P	A	C	White tests, dissolution, abrasion, bioturbated nannofossil ooze
8-6, 125-127	62.85-62.87	P	F		A					P	A	C	White tests, dissolution, abrasion, bioturbated clay
8-6, 148-150	62.08-63.10	P		F						P	A	C	White tests, dissolution, abrasion, bioturbated nannofossil ooze
8-7, 16-18	63.26-63.28	P		C						P	A	C	White tests, dissolution, abrasion, bioturbated nannofossil ooze
8,CC (4-7)	63.57-63.59	R	C	C	A			A		P	F	F	Broken tests stained brown
8,CC (15-18)	63.68-63.70			F						P	A	C	White tests, dissolution, abrasion, nannofossil ooze
Foram-bearing													

Appendix B. (Continued).

Core-Section (interval in cm)	Depth in hole (m)	Coarse fraction (>63 µm) components[a]: Biosiliceous debris	Clay flocs	Mn nodules	Fish teeth, fish debris	Volcanic glass	Pumice fragments	Quartz silt/sand	Phillipsite	Foraminifers[b]: Preservation	Planktonic	Benthic	Comments
Hole 576[c]													
Shipboard CC's													
8,CC										M	A	R	
Hole 576B[c]													
1-1, 108-110	1.08-1.10	A	A										
1-2, 108-110	2.58-2.60	A	A			R							
1-3, 108-110	4.08-4.10	A	A	F									
1-4, 108-110	5.58-5.60	A	A	F									
1-5, 68-70	6.68-6.70	A	A	F	P								
1-6, 20-22	7.70-7.72	A	A	F									
1,CC (7-10)	8.14-8.16	A	A	A				P					Angular quartz sand
2-1, 130-132	12.90-12.92	A	A	A	R								
2-2, 130-132	14.40-14.42	A	A	A	R								
2-3, 130-132	15.90-15.92	A	A	A	R								
2-4, 130-132	17.40-17.42	A	A	A	R					R		P	Mn-oxide replacement
2-5, 130-132	18.90-18.92	R	A	A	R			P					Quartz silt
2-6, 130-132	20.40-20.42	R	A	A	R			P					Quartz silt
2-7, 10-12	20.70-20.72		A	A	R								
2,CC (10-13)	21.08-21.10		A	A	F			P					
3-1, 92-94	22.02-22.04	P	A	A	R			P		R		P	Mn-oxide replacement
3-2, 92-94	23.52-23.54		A	A	R								
3-3, 92-94	25.02-25.04		P	A									
3-4, 92-94			A	A	R			P					Flow-in
3-5, 92-94				A	A								Flow-in
3-6, 92-94	25.41-25.43		A	A	A								
3-7, 10-12	26.09-26.11		C	A	A								
3,CC (10-13)	26.59-26.61		C	A	A								
4-1, 138-140			A	A	A								Flow-in
4-2, 12-14			A	A	A								Flow-in
4-3, 12-14			A	A	A								Flow-in
4-4, 12-14	34.72-34.74		A	A	A								
4-5, 12-14	36.22-36.24			A	A								
4-6, 12-14	37.72-37.74			A	A								
4-7, 12-14	39.22-39.24			A	A								
4,CC (10-13)	39.72-39.74			C	A								
5-1, 130-132			R		A								Flow-in
5-2, 34-36	40.44-40.46		R	R	A								
5-3, 34-36	41.94-41.96		R	R	A								
5-4, 34-36	43.44-43.46		R	R	A								
5-5, 34-36	44.94-44.96		R		A								
5-6, 34-36	46.44-46.46		R	R	A								
5,CC (10-13)	47.43-47.45		R	A	A								
6-1, 110-112			P	C	C								Flow-in
6-2, 110-112	52.20-52.22		R	A	A								
6-3, 110-112	53.70-53.72			R	A								
6-4, 90-92	55.00-55.02			A	A								
6-4, 110-112	55.20-55.22		A	A	A								
6-4, 126-128	55.36-55.38		C	C	C			A					Quartz silt
6-5, 24-26	55.84-55.86		C	C						M	F	F	Dissolution, abrasion, white tests, nannofossil ooze
6-5, 56-58	56.16-56.18			C	R			P		P	C	F	Dissolution, abrasion, white tests, bioturbated clay
6-5, 70-72	56.30-56.32			C	R			P		P	C	F	Dissolution, abrasion, white tests, bioturbated nannofossil ooze
6-5, 96-98	56.56-56.58			A	A					P		R	Tests stained brown, bioturbated clay
6-6, 28-30	57.38-57.40			C	C					M	R	R	
6-6, 58-60	57.68-57.70			R	R	R							
6-6, 100-102	58.10-58.12			R	R					P	R	R	Dissolution, abrasion, white tests, bioturbated nannofossil ooze
6,CC (34-35)	58.86-58.88			P	R					P	A	F	Dissolution, abrasion, nannofossil ooze, white tests
7-1, 76-78	59.84-59.86		R	R						P	A	C	Dissolution, abrasion, nannofossil ooze, white tests
7-2, 76-78	61.34-61.36	P	R	R	R					P	A	C	Dissolution, abrasion, nannofossil ooze, white tests

Appendix B. (Continued).

Core-Section (interval in cm)	Depth in hole (m)	Coarse fraction (>63 μm) components[a]								Fora-minifers[b]			Comments
		Biosiliceous debris	Clay flocs	Mn nodules	Fish teeth, fish debris	Volcanic glass	Pumice fragments	Quartz silt/sand	Phillipsite	Preservation	Planktonic	Benthic	
Hole 576B[c] (Cont.)													
7-3, 115–117	62.15–62.17	P	R	R	P					P	A	C	Dissolution, abrasion, nannofossil ooze, white tests
7-4, 24–26	62.74–62.76	C	R							P	A	C	Dissolution, abrasion, nannofossil ooze, white tests
7-4, 115–117	63.65–63.67	R		R	R					P	A	C	Dissolution, abrasion, nannofossil ooze, white tests
7-5, 104–106	65.04–65.06	R	R							P	A	C	Dissolution, abraison, bioturbated nannofossil ooze, white tests
7-6, 68–70	66.18–66.20		R	R						P	R	R	Fragments only
7-6, 120–122	66.70–66.72	P		R						P	F	F	Dissolution, abrasion, nannofossil ooze, white tests
7-7, 10–12	67.10–67.12	P		R						P	A	C	Dissolution, abrasion, nannofossil ooze, white tests
7,CC (30–33)	67.64–67.66	P	R	R						P	A	C	Dissolution, abrasion, nannofossil ooze, white tests
8-1, 135–140	68.80–68.82	P		P						P	A	C	Dissolution, abrasion, nannofossil ooze, white tests
8-2, 58–60	69.53–69.55	P	R	R						P	A	C	Dissolution, abrasion, nannofossil ooze, white tests
8-2, 128–130	70.23–70.25									P	R	R	Dissolution, abrasion, 63–149 μm fraction only, graded nannofossil ooze
8-3, 50–52	70.95–70.97									P	F	R	Dissolution, abrasion, 63–149 μm fraction only
8-3, 124–126	71.69–71.71		R		R					P	F	R	Dissolution, abrasion, 63–149 μm fraction only
8-4, 66–68	72.61–72.63									P	F	R	Dissolution, abrasion, 63–149 μm fraction only
8-4, 124–126	73.19–73.21		R		P					P	F	R	Dissolution, abrasion, 63–149 μm fraction only, graded ooze
8-5, 90–92	74.35–74.37		R							P		R	Tests stained brown, dissolution, bioturbation?
Shipboard CC's													
7,CC										P		R	Agglut. benthics
6,CC										M		R	Agglut. benthics
Hole 578													
1-3, 80–82	3.80–3.82	A	A							G		R	2 calc. benthic, 1 agglut.
1,CC (18–20)	4.78–4.80	C	A		R								
2-3, 80–82	8.60–8.62	A	A										
2,CC (18–20)	14.28–14.30	A	A			A							
3-3, 90–92	18.20–18.22	A	A										
3,CC (18–20)	23.70–23.72	A	A	R									
4-3, 90–92	27.70–27.72	A	A		R								
4,CC (18–20)	33.28–33.30	A	A										
5-4, 90–92	38.70–38.72	A	A										
5,CC (18–20)	42.78–42.80	A	A			A							
6-4, 70–72	48.00–48.02	A	A			A							
6,CC (18–20)	52.58–52.30	A	A			A							
7-2, 70–72	54.50–54.52	A	A			A							
7,CC (18–20)	61.78–61.80	A	A										
8-3, 60–62	65.40–65.42	A	A			C							
8,CC (18–20)	71.28–71.30	A	A			A							Green and clear glassy particles >149 μm in size
9-3, 57–59	74.87–74.89	A	A			A							
9,CC (18–20)	80.78–80.80	A	A			A			A				
10-3, 69–71	84.49–84.51	A	A	C		A							
10,CC (18–20)	90.28–90.30	A	A	C		A	P						
11-3, 60–62	93.90–93.92	A	A						A				
11,CC (18–20)	99.78–99.90	A	A										
12-3, 50–52	103.30–103.32	A	A										
12,CC (18–20)	109.28–109.30	A	A	A					A	G		R	2 calc. benthic
13-4, 80–82	114.60–114.62	A				A							
13,CC (18–20)	118.78–118.80	A	A	A	R				A				
14-3, 90–92	122.70–122.72	A	A	C	R				A				
14,CC (18–20)	128.28–128.30			A	R								

Appendix B. (Continued).

Core-Section (interval in cm)	Depth in hole (m)	Coarse fraction (>63 μm) components[a]								Foraminifers[b]			Comments
		Biosiliceous debris	Clay flocs	Mn nodules	Fish teeth, fish debris	Volcanic glass	Pumice fragments	Quartz silt/sand	Phillipsite	Preservation	Planktonic	Benthic	
Hole 578 (Cont.)													
15-3, 33-35	131.63-131.65	A	A	A	R								
15,CC (18-20)	137.78-137.80		A	A	R								
16-1, 20-22	138.00-138.02		A	A	R								
16-2, 28-30	139.58-139.60		A	A	R								
16-2, 138-139	140.68-140.69		A	A	R								
16-3, 130-131	142.09-142.11		A	A	R								
16-5, 138-139	145.17-145.19					A							Blocky, varicolored glass
16,CC (18-20)	147.28-147.30		A	A	A	C							
17,CC (18-20)	155.28-155.30		R	A	A								
18-3, 50-52	160.30-160.32			C	A								
18,CC (18-20)	163.28-163.30			A	A					M	C	R	late early to early middle Eocene
19-2, 70-72	168.50-168.52			A	A								
20-1, 64-66	176.44-176.46									R	A	C	Silica replacement, Campanian
20,CC	176.78-176.80									R	A	C	Silica replacement, Campanian
Hole 579													
1-4, 41-43	4.91-4.93		A					P					
1,CC (18-20)	8.38-8.40		A					A					
2-3, 95-97	12.35-12.37		A					P					
2,CC (18-20)	17.88-17.99	A	A					R					
Hole 579A													
1-5, 95-97	20.95-20.97	A	A					C					
1,CC (18-20)	23.48-23.50	A	A					C					
2-5, 100-102	30.50-30.52	A	A					C					
2,CC (18-20)	32.98-33.00	A						C					
3-3, 68-70	36.68-36.70	A						C					
3,CC (18-20)	42.48-42.50	C	A					C					
4-3, 118-120	46.68-46.70	A	A			C							
4,CC (18-20)	51.98-51.20	A				A							
5-3, 53-55	55.53-55.55	A	A			C							
5,CC (18-20)	61.48-61.50	A	A			A							
6-3, 50-52	65.00-65.02	A	A										
6,CC (18-20)	70.98-71.00	A	A										
7-3, 94-96	74.94-74.96	A	A			C							
7,CC (18-20)	80.48-80.50	A	A										
8-5, 100-102	87.50-87.52	A	A										
8,CC (18-20)	89.98-90.00	A	A										
9-3, 70-72	93.70-93.72	A	A										
9,CC (18-20)	99.48-99.50	A	A										
10-4, 100-102	105.00-105.02	A	A										
10,CC (18-20)	108.98-109.00	C	A										
11,CC (18-20)	118.48-118.50	A											
12-3, 28-30	121.78-121.80	A				A							
12,CC (18-20)	127.98-128.00	A				A							
13-3, 70-72	131.70-131.72	A	A			C							
13,CC (18-20)	137.48-137.50	A	A										
14-3, 30-32	140.80-140.82	A	A										
14,CC (18-20)	146.98-147.00	A	A										
15-1, 110-112	148.10-148.12	A	A										
15,CC (18-20)	149.48-149.50	A	A										
Hole 580													
1-1, 27-29	0.27-0.29	A				C							
1-1, 112-114	1.12-1.14	A				A	C			G		P	2 calc. benthics, 1 rounded basalt pebble
1-2, 33-35	1.83-1.85	A				A				G	A	A	Rounded basalt pebbles
1-2, 142-144	2.92-2.94	A	A			C							
1-3, 3-5	3.03-3.05	A				C							2 rounded basalt pebbles
1,CC (18-20)	3.28-3.30	A				C							
2-1, 76-80	4.06-4.08	A				A							
2-2, 124-126	6.04-6.06	A				A							
2-3, 108-110	7.38-7.40	A				C							
2-3, 124-126	7.54-7.56	A				C							

Appendix B. (Continued).

Core-Section (interval in cm)	Depth in hole (m)	Coarse fraction (>63 μm) components[a]								Foraminifers[b]			Comments
		Biosiliceous debris	Clay flocs	Mn nodules	Fish teeth, fish debris	Volcanic glass	Pumice fragments	Quartz silt/sand	Phillipsite	Preservation	Planktonic	Benthic	
Hole 580 (Cont.)													
2-4, 34-36	8.14-8.16	A	A			C							
2-4, 106-108	8.86-8.88	A				A				G	A	C	
2-5, 72-74	10.02-10.04	A				A							
2,CC (18-20)	12.78-12.80	A				A							
3-4, 45-47	17.75-17.77	A	A										
3,CC (18-20)	22.28-22.30	A	C			C							Varicolored glassy grains
4-3, 80-82	26.10-26.12	A	A							G	A	R	
4,CC (18-20)	31.78-31.80	A				A							
5-5, 85-87	38.65-38.67	A	A							G	R	R	
5,CC (18-20)	41.28-41.30	A	A							M	R	R	
6-3, 58-60	44.88-44.90	A	A							M	A	C	
6,CC (18-20)	50.78-50.80	A	A										
7-3, 62-64	54.42-54.44	A	A			A							
7,CC (18-20)	60.28-60.30	A	A										
8-3, 43-45	63.73-63.75	A	A										
8,CC (18-20)	69.78-69.80	A				A							
9-3, 32-34	73.12-73.14	A	A			A							
9,CC (18-20)	79.28-79.30	A											
10-3, 60-62	82.90-82.92	A				A							
10,CC (18-20)	88.78-88.80	A	A			A							
11-3, 105-107	92.85-92.87	A	A										
11,CC (18-20)	98.28-98.30	A	A			A							
12-4, 20-22	103.00-103.02	A	A										
12,CC (18-20)	107.78-107.80	A											
13-4, 60-62	112.90-112.92	A											
13,CC (18-20)	117.28-117.30	A											
14-3, 30-32	120.60-120.62	A	A										
14,CC (18-20)	126.78-126.80	A	C										
15-2, 101-103	129.31-129.33	A											
15,CC (18-20)	136.28-136.30	A				A							
16-3, 26-28	139.56-139.58	A	A										
16,CC (18-20)	145.78-145.80	A	A										
17-3, 21-23	149.01-149.03	A	A										
17,CC (18-20)	155.28-155.30	A											
Hole 581													
1-1, 40-42	0.40-0.42	A	C			A	C						Glassy grains of various colors
1,CC (18-20)	0.98-1.00	A	C			A	C						Glassy grains of various colors
2-2, 20-22	183.20-183.22	A											
2,CC (18-20)	190.98-191.00	A	C										
3-4, 33-35	195.83-195.85	A											
3,CC (18-20)	200.48-200.50	A											
4-4, 50-52	205.50-205.52	A	A										
4,CC (18-20)	209.98-210.00	A				C							
5-3, 34-36	213.34-213.36	A	A										
5,CC (18-20)	219.48-219.50	A							A				
6-3, 28-30	222.78-222.80	A	A										
6,CC (18-20)	228.98-229.00	A	A										
7-3, 80-82	232.80-232.82	A							A				
7,CC (18-20)	238.48-238.50	A	A						A				
8-3, 60-62	242.10-242.12	A	A										
8,CC (18-20)	247.98-248.00	A	A										One large, rounded, basalt pebble
9-2, 60-62	250.10-250.12	C	F										
9,CC (18-20)	257.48-257.50	C	F										2 rounded basalt, 1 angular andesite pebble
10-2, 90-92	259.90-259.92		F		P								
10,CC (18-20)	266.98-267.00		F		P								
11-1, 26-28	267.26-267.28		C		R								

[a] Abundance: P = present, R = rare, F = few, C = common, A = abundant.
[b] Preservation: G = good, M = moderate, P = poor, R = replaced.
[c] Adjusted sub-bottom depth.