10. CENOZOIC RADIOLARIANS FROM THE CENTRAL PACIFIC, DSDP LEG 33[1]

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INTRODUCTION

Radiolarians were identified in each of the five sites drilled on Leg 33. The locations of these sites are listed in Table 1.

Of these five sites, only one (Hole 317B) recovered a substantial thickness of radiolarian-bearing sediment within a continuously cored interval. The remaining sites were spot-cored within the Cenozoic portion of the section. Pre-Eocene sediments at all sites are barren of radiolarians, except for small quantities of calcified radiolarian tests within certain intervals in Holes 315A and 317A.

SCOPE OF INVESTIGATION AND PRESENTATION OF RESULTS

After preliminary shipboard analysis of all core-catcher samples, each core within which radiolarians had been identified was sampled at intervals of one or more samples per section (1 section = 150 cm). In the intervals where core-catcher examination revealed no radiolarians, only one or two additional samples per core were taken (1 core ≅ 9.5 m). Slides of coarse fraction preparations (>62 μm) were prepared according to standard techniques described by Riedel (1957) and Riedel and Sanfilippo (in press).

Preparation of samples from the pre-Eocene intervals of the cores yielded no radiolarians. Coarse fractions of many of these samples were also prepared without the final step of HCL addition, thereby leaving all material >62 μm including the calcareous component. In some of these sample preparations, small percentages of calcified radiolarian tests (principally *Dictyomitra* spp.) were observed within the foraminiferal assemblages. Because of the extensive recrystallization, however, these radiolarian specimens could be identified only at the generic level using conventional examination procedures. Consequently, the scattered occurrences of Cretaceous radiolarians at Leg 33 sites will not be considered in this report. Scanning electron microscopy would probably be required to identify these species and assign a stratigraphic age using the Cretaceous radiolarian zonations which have recently been developed (Moore, 1973; Foreman, 1973a, b; Riedel and Sanfilippo, 1974).

The Cenozoic intervals of the Leg 33 sites generally contain common and well-preserved radiolarian assemblages, except for the disappearance of radiolarians below the depths where Eocene cherts first appear, a difficulty which has been encountered at many previous sites. The principal objective of this study was to examine the Cenozoic radiolarian-bearing sediments at Leg 33 sites and identify the occurrences of all radiolarian taxa previously known to be stratigraphically useful. Because of extensive drilling in the central Pacific prior to Leg 33, a relatively precise radiolarian zonation for the region had been established previously (Riedel and Sanfilippo, 1971; Dinkelman, 1973), and no attempt was made to modify or refine this zonation on the basis of the limited additional material available in Leg 33 cores. The occurrences of Cenozoic radiolarians are discussed and summarized in tabular form in the following section. In the discussion which follows and in the tabulations, the names of most of the radiolarian taxa are abbreviated. Their full and correct form is given in the List of Species at the end of this report.

CENOZOIC RADIOLARIAN ZONATION

Investigations of sediments cored on earlier legs of the Deep Sea Drilling Project have yielded a radiolarian zonation which covers most of the Cenozoic. This zonation scheme has been followed in this report. The zonal boundaries and ranges of taxa for the upper Paleocene to lower Eocene are described by Sanfilippo and Riedel (1973) and Foreman (1973a); the zonation for the middle to upper Eocene is that of Riedel and Sanfilippo (1970), as modified by Foreman (1973b); the zonation

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TABLE 1
Site Locations

Site	Latitude	Longitude	Location	Water Depth (m)	Drilling Penetration (m)
314	15°54.76'N	168°28.07'W	Johnston Island Trough	5225	45
315	04°10.26'N	158°31.54'W	Fanning Island Fan	4164	1034
316	00°05.44'N	157°07.71'W	Line Islands, Southern End	4464	837
317	11°00.09'S	162°15.78'W	Manihiki Plateau	2622	943
318	14°49.63'S	148°51.51'W	Tuamotu Islands	2659	745

used for the Oligocene through Pliocene is that of Riedel and Sanfilippo (1971). The Quaternary zonation is that of Nigrini (1971).

The Cenozoic radiolarian zones used in this study, along with the definitions of the zonal boundaries, are listed below in order from oldest to youngest, beginning with the middle Eocene:

Eocene (Middle to Late)

Theocampe mongolfieri Zone
Base: First evolutionary appearance of *Theocampe mongolfieri* from *Theocampe amphora.*
Thyrsocyrtis triacantha Zone
Base: First evolutionary appearance of *Thyrsocyrtis triacantha* from *Thyrsocyrtis hirsuta tensa.*
Podocyrtis ampla Zone
Base: First evolutionary appearance of *Podocyrtis ampla* from *Podocyrtis phyxis.*
Podocyrtis mitra Zone
Base: First evolutionary appearance of *Podocyrtis mitra* from *Podocyrtis sinuosa.*
Podocyrtis chalara Zone
Base: First evolutionary appearance of *Podocyrtis chalara* from *Podocyrtis mitra.*
Podocyrtis goetheana Zone
Base: First evolutionary appearance of *Podocyrtis goetheana* from *Podocyrtis chalara.*
Thyrsocyrtis bromia Zone
Base: First evolutionary appearance of *Thyrsocyrtis bromia.*

Oligocene

Theocyrtis tuberosa Zone
Base: First evolutionary appearance of *Lithocyclia angustum* from *Lithocyclia aristotelis.*
Dorcadospyris ateuchus Zone
Base: First evolutionary appearance of *Dorcadospyris ateuchus* from *Dorcadospyris triceros.*
Lychnocanoma elongata Zone (synonymous with *Lychnocanium bipes* Zone)
Base: First morphotypic appearance of *Lychnocanoma elongata.*

Miocene

Calocycletta virginis Zone
Base: First evolutionary appearance of *Calocycletta virginis* from *Calocycletta robusta.*
Calocycletta costata Zone
Base: First evolutionary appearance of *Calocycletta costata* from *Calocycletta virginis.*
Dorcadospyris alata Zone
Base: First evolutionary appearance of *Dorcadospyris alata.*
Cannartus (?) *petterssoni* Zone
Base: First morphotypic appearance of *Cannartus* (?) *petterssoni.*
Ommatartus antepenultimus Zone
Base: First evolutionary appearance of *Ommatartus antepenultimus* from *Cannartus laticonus.*
Ommatartus penultimus Zone
Base: First evolutionary appearance of *Ommatartus penultimus* from *Ommatartus antepenultimus.*
Stichocorys peregrina Zone
Base: First evolutionary appearance of *Stichocorys peregrina* from *Stichocorys delmontensis.*

Pliocene

Spongaster pentas Zone
Base: First morphotypic appearance of *Pterocanium prismatium.*
Pterocanium prismatium Zone
Base: Last occurrence of *Stichocorys peregrina.*

Quaternary

Anthocyrtidium angulare Zone (=Zone 4)
Base: Last occurrence of *Pterocanium prismatium.*
Amphirhopalum ypsilon Zone (=Zone 3)
Base: Last occurrence of *Anthocyrtidium angulare.*
Collosphaera tuberosa Zone (=Zone 2)
Base: First morphotypic appearance of *Collosphaera tuberosa.*
Buccinosphaera invaginata Zone (=Zone 1)
Base: Evolutionary transition from *Collosphaera* sp. A to *Buccinosphaera invaginata* (see Knoll and Johnson, 1975).

RADIOLARIANS AT EACH SITE

In this section, the information on occurrences of Cenozoic radiolarians is tabulated in Tables 2 and 3 for those sites at which significant sequences of radiolarian-bearing sediments were cored (Sites 315 and 317); radiolarian occurrences at the remaining sites (314, 316, 318) are described in the text.

The abundance of radiolarians in each sample is indicated in the tables as "very abundant" (A), "common" (C), "few" (F), "rare" (R), or "very rare" (+). Preservation of the specimens is indicated as "excellent" (E), "good" (G), "moderate" (M), or "poor" (P).

In the columns showing occurrences of individual species, the same relative abundance terms are used to indicate the proportion that a given species constitutes of the total radiolarian assemblage. A dash (—) indicates that the species was searched for but was not found. Occurrences believed to result from the reworking of older material into younger sediments, or from downward caving resulting in introduction of younger forms into older assemblages, are marked with an asterisk (*).

Site 314

A highly diversified assemblage of moderately to well-preserved radiolarians of Eocene age was observed in several small samples of material recovered at Site 314. Small volumes (several cc) of sediment were examined from the catcher of Core 1 (depth = 9.5 m), from the outer surface of the drill collars at 10.5 meters and 12 meters above the drill bit (depth = 0 to 34 m), and from the catcher of Core 3 (depth = 45 m).

In Sample 314-1, CC, poorly preserved fragments of Eocene radiolarians were observed, including *Thyrsocyrtis triacantha, T. tetracantha,* and *Theocorys* sp. cf. *T. anaclasta.* The sediment samples from the drill collars contain numerous radiolarian species of early Eocene to late Eocene age. Early Eocene specimens present include *Clathrocycloma* sp. aff. *C. capitaneum, Dorcadospyris* *confluens, Calocycloma castum, Dendrospyris fragoides,* and *Dictyospyris gigas.* Species characteristic of the middle Eocene include *Podocyrtis diamesa, Thyrsocyrtis triacantha,* and *Rhopalocanium ornatum.* Late Eocene species include *Lithapium mitra, Thyrsocyrtis tetracantha,* and *Podocyrtis chalara.* The stratigraphic ranges of these species are nonoverlapping. Moreover, scattered specimens of *Polysolenia* sp. and *Pterocanium* sp. were observed, suggesting a late Cenozoic age. The above evidence suggests that much of the material present in these samples may be reworked, indicative of substantial erosion of Eocene sediments at some time during the late Cenozoic. Alternatively, since the drill collar samples could represent virtually any interval between the sea floor and a subbottom depth of 34 meters, the mixed nature of the radiolarian assemblages may be an artifact of the drilling process.

In the clays and claystones recovered in the catcher of core 3 (depth = 45 m), moderately preserved specimens of Eocene radiolarians were identified, including: *Theocampe mongolfieri, Thyrsocyrtis triacantha, Thyrsocyrtis rhizodon, Podocyrtis papalis, Calocyclas hispida, Lithomitra docilis, Podocyrtis goetheana, Eusyringium fistuligerum,* and *Podocyrtis sinuosa.*

The presence of these species is consistent with a middle to late Eocene age for the deepest sample recovered from Site 314.

Site 315

Radiolarians are common to abundant and well preserved in the Quaternary through upper Oligocene sediments recovered at Holes 315 and 315A (Cores 315-1 through 315A-9; depth 0 to 705 m). Radiolarians exhibit decreasing abundance and poorer preservation within the lower Oligocene and upper Eocene sediments (Core 315A-10) and are absent in all samples examined below Core 10 (depth = 741 m), except for small percentages of calcified radiolarian tests in samples from 315A-22-4 and 315A-25, CC of Campanian age.

The following radiolarian zonal boundaries can be recognized within the radiolarian-bearing sediments at Site 315 (see Table 2).

The base of the *Collosphaera tuberosa* Zone lies between 1 and 2 meters (between 315-1-1 and 315-1-2). The base of the *Amphiropalum ypsilon* Zone lies between 9 and 56 meters (between 315-1, CC and 315-4-1). The *Anthocyrtidium angulare* Zone and *Pterocanium prismatium* Zone may occur in the unsampled interval between 9 and 56 meters (between Samples 315-1, CC and 315-4-1), or may be missing from this site. The base of the *Spongaster pentas* Zone occurs between 65 and 75 meters (between Samples 315-4, CC and 315A-1-1). The base of the *Stichocorys peregrina* Zone lies between 85 and 123 meters (between Samples 315A-1, CC and 315A-2-1). The *Ommatartus penultimus* Zone was not sampled. The base of the *Ommatartus antepenultimus* Zone occurs at 151 meters (between Samples 315A-36 and 314A-3, CC). The base of the *Cannartus petterssoni* Zone occurs between 151 and 256 meters (between Samples 315A-3, CC and 315A-4-1). The base of the *Dorcadospyris alata* Zone occurs at 371 meters (between Samples 315A-5-1 and 315A-5-2). The base of the *Calocycletta costata* Zone occurs at 468 meters (between Samples 315A-6-3 and 315A-6, CC). The base of the *Calocycletta virginis* Zone occurs between 522 and 588 meters (between Samples 315A-7, CC and 315A-8-1). The base of the *Lychnocanoma elongata* Zone occurs between 598 and 702 meters (between Samples 315A-8, CC and 315A-9-1). The base of the *Dorcadospyris ateuchus* Zone occurs between 712 and 730 meters (between Samples 315A-9, CC and 315A-10-1). The *Theocyrtis tuberosa* Zone may occur in the uncored interval between 712 and 730 meters, or in the upper sections of Core 315A-10 (730 to 734 m). The *Thyrsocyrtis bromia* Zone is represented in samples from the lower sections of Core 315A-10 (734 to 740 m). Samples from below 740 meters (Sample 315A-10, CC) were devoid of identifiable radiolarians.

Site 316

At Site 316 five spot cores were taken in the upper 457 meters of sediment, representing the Quaternary through lower Oligocene portion of the section. Radiolarians are common and well preserved in all samples examined from this interval. Cherts of middle Eocene age were encountered near the base of Core 316-5 (depth = 457 m), and below this point radiolarians were absent.

In Core 316-1 (depth = 0 to 9.5 m) radiolarian assemblages indicate a Quaternary age, but assignment of zonal names is difficult because of absence of many of the required taxa. *Axoprunum angelinum* is present in all samples examined from Core 1, and *Pterocanium prismatium* and *Anthocyrtidium angulare* are absent. This suggests that Core 1 may lie entirely within Nigrini's (1971) *Amphirhopalum ypsilon* Zone (= Zone 3). Rare specimens of Tertiary radiolarians occur in some assemblages examined from Core 1, indicating either erosion and redeposition of Tertiary sediments, or vertical mixing from the underlying strata.

The *Ommatartus antepenultimus* Zone is represented in Core 316-2 and the upper portion of Core 316-3 (between 153 and 268 m). The following species were identified in samples from this interval and serve to identify the *O. antepenultimus* Zone: *Stichocorys delmontensis, Phormostichoartus corona, Ommatartus antepenultimus, Artostrobium doliolum, Ommatartus hughesi, Calocycletta caepa, Stichocorys peregrina, Lithopera bacca,* and *Lithopera neotera.*

The top portion of Core 316-3, between a depth of 267 and 269 meters, represents either an erosional unconformity or an interval of very low accumulation rates. Four consecutive radiolarian zones were sampled within this 2-meter interval: *Ommatartus antepenultimus* Zone (316-3-1, 72-74 cm); *Cannartus petterssoni* Zone (316-3-1, 120-122 cm); *Dorcadospyris alata* Zone (316-3-2, 19-21 cm); and *Calocycletta costata* Zone (316-3-2, 77-79 cm). Diagnostic species indicative of the *O. antepenultimus* Zone are listed above; those for the remaining three zones are as follows:

Cannartus petterssoni Zone: *Lithopera neotera, Cannartus petterssoni, Cannartus laticonus, Stichocorys delmontensis, Phormostichoartus corona, Lithopera renzae, Artostrobium doliolum, Calocycletta caepa, Dorcadospyris alata,* and *Cyrtocapsella cornuta.*

TABLE 2
Radiolarians at Site 315

Radiolarian Zones	Sample (Interval in cm)	Abundance	Preservation	*Spongaster tetras*	*Ommatartus tetrathalamus*	*Siphocampe corbula*	*Amphirhopalum ypsilon*	*Pterocorys hertwigii*	*Collosphaera tuberosa*	*Pterocanium praetextum*	*Lithopera bacca*	*Theocorythium trachelium*	*Pterocanium prismatium*	*Stichocorys peregrina*	*Artostrobium doliolum*	*Spongaster pentas*	*Axoprunum angelinum*	*Ommatartus avitus*	*Solenosphaera omnitubus procera*	*Solenosphaera omnitubus omnitubus*	*Ommatartus penultimus*	*Phormostichoartus corona*	*Spongasterius berminghami*	*Ommatartus antepenultimus*	*Calocycletta caepa*	*Ommatartus hughesi*	*Stichocorys delmontensis*	*Acrobotrys tritubus*	*Carpocanopsis favosum*	*Cannartus laticonus*	*Cannartus petterssoni*	*Cyclampterium brachythorax*	*Lithopera neotera*
C. tuberosa	315-1-1, 105-107	C	G	C	C	C	C	F	F	R		R	-				-																
A. ypsilon	315-1-2, 24-26	C	G	F	C	F	F	F	-	R		R	-				F																
	315-1-3, 106-108	C	M	C	F	F	F	R	-	R		R	-				F										*						
	315-1-4, 54-56	C	G	C	C	C	F	R	-	F		F	-				F										*						
	315-1-5, 142-144	C	G	C	F	F	C	R	-	R	-	F	-				F																
	315-1-6, 102-104	C	G	C	C	C	F	R	-	F		R	-	-	-	-	F																
	315-1, CC	C	G	C	C	C	C	F	-	F	F	F	-	-	-	-		-															
S. pentas	315-4-1, 145-147	A	E	A	C	C	-	-		F	R	-	C	A	C	-	R	-															
	315-4-2, 90-92	A	E	-	F		-	-			R	-	R	C	F	F		R															
	315-4-3, 70-72	A	E	-	F		-	-			F	-	F	A	C	R	F	F	-	-													
	315-4-4, 70-72	C	G	-	F						F	-	F	C	F	R		F	-	-													
	315-4-5, 70-72	A	G	-	R						R	-	R	A	F	R	F	F	-	-													
	315-4-6, 70-72	A	E		F	C				R	F	-	F	A	F	F		C	+	-		-	-										
	315-4, CC	A	G		R						C	-	F	A	C	+		C	+	D	-	-	-				*			*			
S. peregrina	315A-1-1, 70-72	A	E								F		-	A	F	+		R	F	C	C	C	R										
	315A-1-2, 70-72	A	E								R		-	A	C	-		R	R	F	F	F	R										
	315A-1-3, 70-72	A	E								R		-	A	F	-		R	F	R	C	C	R										
	315A-1-4, 70-72	A	E								F		-	A	C	-			R	R	C	F	+					-					
	315A-1-5, 70-72	A	G								R		-	A	C	-			F	F	C	C	R	-		-	-	-					
	315A-1-6, 70-72	A	G								F		-	A	C				F	R	C	R	R	-		-	-	+					
	315A-1, CC	A	G			C					C		-	A	C				F	C	C	C	R	-		-	-	+					
O. antepenultimus	315A-2-1, 80-82	A	E								C			-	C				-	-	-	C		C	C	C	A	+	-				
	315A-2, CC	A	G								F			R	C				-	-	-	C		C	F	F	A	R	R				
	315A-3-1, 70-72	A	G			F					F			-	C				-	-		C		C	C	C	A	-	-	R	R		+
	315A-3-2, 70-72	C	G								F			-	C		F		-	-		F		C	F	C	C	-			R		R
	315A-3-3, 82-84	A	E								F			-	F							F		C	R	C	C					R	R
	315A-3-4, 72-74	C	G								R				F		C							C	F	F	C						R
	315A-3-5, 80-82	C	G												R									C	R	F	C		-	F	R	F	F
	315A-3-6, 70-72	C	G												F							F		C	R	C	C						F
C. petterssoni	315A-3, CC	A	G			F					R				F							F		-	F	R	A			C	C		R
D. alata	315A-4-1, 93-95	A	G												-							F		-	C	-	C		+	A	-		F
	315A-4-2, 62-64	C	G												-		C					F		-	F	-	C		-	C	-		
	315A-4-3, 70-72	C	G												-		C					F		-		-	C			C	-		
	315A-4, CC	C	G												-							F		-	C	-	C			C	-		
	315A-5-1, 26-28	C	G																			C			C		C			-			F
C. costata	315A-5-2, 125-127	C	G																			F			C		C		-	-			
	315A-5, CC	C	G																			R					C			-			
	315A-6-1, 125-127	C	G																								C						
	315A-6-2, 124-126	C	G																										-				
	315A-6-3, 115-117	C	G																			F					C						
C. virginis	315A-6, CC	C	G																			R					C		-				
	315A-7-1, 96-98	C	G																								C		+				
	315A-7-2, 125-127	C	G																								C		+				
	315A-7, CC	C	G																			F					C		F	R			

TABLE 2 – Continued

Bekomiforma mynx	*Stichocorys wolffii*	*Dictyocoryne ontongensis*	*Lithopera thornburgi*	*Carpocanopsis cristatum*	*Cyrtocapsella cornuta*	*Lithopera baueri*	*Cyclampterium tanythorax*	*Lithopera renzae*	*Cannartus mammiferus*	*Dendrospyris bursa*	*Cyrtocapsella tetrapera*	*Calocycletta costata*	*Calocycletta virginis*	*Cannartus bassanii*	*Clathrocorona atreta*	*Carpocanopsis bramlettei*	*Dorcadospyris dentata*	*Eucyrtidium cienkowskii*	*Cannartus tubarius*	*Carpocanopsis cingulatum*	*Stichocorys armata*	*Calocycletta robusta*	*Cannartus violina*	*Dorcadospyris alata*	*Lychnocanoma elongata*	*Dorcadospyris forcipata*	*Cannartus prismaticus*	*Dorcadospyris simplex*	*Cyclampterium leptetrum*	*Theocorys spongoconum*	*Theocyrtis annosa*	*Artophormis gracilis*	*Dorcadospyris ateuchus*	*Dorcadospyris papilio*	*Cyclampterium pegetrum*	*Theocampe amphora*	*Theocampe pirum*	*Theocampe mongolfieri*	*Dorcadospyris Triceros*	*Calocyclas turris*	*Lithocyclia aristotelis*	*Thyrsocyrtis tetracantha*
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	F		C	R	R	R					-																															
	C		F	R	F	R		C			R																															
	C		F	R	R			C	R		R																															
	C			R	C		R	C	F	R	+													+																		
	F				C		R	C	C	F	C	+	F											+																		
	C			R	R		+	F	C		F	R	F	C	C	R	F							-																		
	C			F	F		F	-			R	-	C	R		R	F	F	C	C	C	F		-																		
	C				C		R				+	C	F	F		R	R			F	F		C	-																		
	C				F						F	R	C			R	+		R				C																			
	C				C						C		C			R					F				R																	
	-				F						+	-	F			R		C	F	F					C	F	R	F	R													
					C						C								F						C	F	R	F	R	R												
					F						C		F						R			R	R		C		R	R	R													
					C					F	F							C				R	R		F		F															

TABLE 2 – *Continued*

Radiolarian Zones	Sample (Interval in cm)	Abundance	Preservation	*Spongaster tetras*	*Ommatartus tetrathalamus*	*Siphocampe corbula*	*Amphirhopalum ypsilon*	*Pterocorys hertwigii*	*Collosphaera tuberosa*	*Pterocanium praetextum*	*Lithopera bacca*	*Theocorythium trachelium*	*Pterocanium prismatium*	*Stichocorys peregrina*	*Artostrobium doliolum*	*Spongaster pentas*	*Axoprunum angelinum*	*Ommatartus avitus*	*Solenosphaera omnitubus procera*	*Solenosphaera omnitubus omnitubus*	*Ommatartus penultimus*	*Phormostichoartus corona*	*Spongastericus berminghami*	*Ommatartus antepenultimus*	*Calocycletta caepa*	*Ommatartus hughesi*	*Stichocorys delmontensis*	*Acrobotrys tritubus*	*Carpocanopsis favosum*	*Cannartus laticonus*	*Cannartus petterssoni*	*Cyclampterium brachythorax*	*Lithopera neotera*
L. elongata	315A-8-1, 84-86	C	G																			F											
	315A-8-2, 40-42	C	M																										-				
	315A-8-3, 85-87	F	M																														
	315A-8, CC																																
D. ateuchus	315A-9-1, 110-112	F	M																														
	315A-9-2, 64-66	C	M																														
	315A-9, CC	F	P																														
?	315A-10-1, 29-31	+	P																														
	315A-10-2, 68-70	+	P																														
	315A-10-3, 77-79	+	P																														
	315A-10-4, 21-23	+	P																														
T. bromia	315A-10-4, 148-150	F	P																														
	315A-10-5, 124-126	R	P																														
	315A-10-6, 22-24	R	P																														
	315A-10-6, 100-102	R	P																														
	315A-10, CC	R	P																														

Dorcadospyris alata Zone: *Cyrtocapsella cornuta, Stichocorys delmontensis, Phormostichoartus corona, Cyclampterium tanythorax, Lithopera renzae, Lithopera baueri, Calocycletta caepa, Cyrtocapsella tetrapera, Dorcadospyris alata,* and *Lithopera neotera.*

Calocycletta costata Zone: *Cyrtocapsella cornuta, Calocycletta virginis, Stichocorys armata, Stichocorys delmontensis, Lithopera renzae, Cannartus tubarius, Calocycletta costata, Calocycletta caepa, Dorcadospyris dentata, Carpocanopsis bramlettei,* and *Carpocanopsis cristatum.*

The lower portion of Core 316-3, between 269 and 276 meters, lies within the *Calocycletta costata* Zone. Samples examined from this interval contain the diagnostic taxa listed above, as well as *Stichocorys wolffii, Carpocanopsis cingulatum, Cyrtocapsella tetrapera,* and *Cannartus bassanii.*

Within Core 316-4 (depth = 390 to 400 m) there is at least one erosional unconformity. Samples from 391 to 392 meters (316-4-1, 81-83 cm; 316-4-2, 35-37 cm) lie within the upper quarter of the *Calocycletta virginis* Zone, as indicated by the presence of the following taxa: *Stichocorys wolffi, Cyrtocapsella cornuta, Dorcadospyris dentata, Phormostichoartus corona, Calocycletta virginis, Cannartus tubarius, Carpocanopsis bramlettei, Carpocanopsis cristatum, Dorcadospyris forcipata,* and *Cyrtocapsella tetrapera.*

A sample from 392.5 meters (316-4-2, 83-85 cm) lies within the *Lychnocanoma elongata* Zone, on the basis of a few poorly preserved specimens of *L. elongata, Dorcadospyris ateuchus,* and *Theocorys spongoconum.* Deeper samples in Core 316-4 (393 to 400 m) lie within the *Dorcadospyris ateuchus* Zone, on the basis of the following diagnostic taxa: *Dorcadospyris ateuchus, Theocyrtis annosa, Cannartus prismaticus, Artophormis gracilis, Cyclampterium pegetrum, Centrobotrys petrushevskayae, Lithocyclia crux, Dorcadospyris circulus,* and *Dorcadospyris praeforcipata.*

Reworked Eocene radiolarians are common in Sample 316-4, CC, indicating that substantial lateral and/or vertical mixing occurred at this site during the late Oligocene. Diagnostic taxa indicative of this Eocene admixture include *Theocampe amphora, T. urceolus, Thyrsocyrtis triacantha, Amphicraspedum murrayanum,* and *Lychnocanoma babylonis.*

The upper portion of Core 316-5 (depth = 447 to 450 m) lies within the *Theocyrtis tuberosa* Zone of early Oligocene age, as indicated by the following species: *Theocyrtis tuberosa, Artophormis gracilis, Cyclampterium milowi, Dorcadospyris spinosa, Dorcadospyris quadripes, Cyclampterium pegetrum, Lithocyclia angustum, Dorcadospyris triceros, Theocampe urceolus, Lithocyclia crux,* and *Lophophaena* (?) *capito.*

No siliceous material was observed below a depth of 450 meters (Sample 316-5-2, 116-118 cm). Any siliceous microfossils deposited at this site prior to the Oligocene have evidently been remobilized and converted to chert.

Site 317

Three holes were drilled at this site. The coring strategy involved (1) washing down to the Tertiary/Cretaceous boundary to minimize bit wear; (2) coring continuously to and into basement; (3) pulling

TABLE 2 – *Continued*

Bekomiforma mynx	*Stichocorys wolffii*	*Dictyocoryne ontongensis*	*Lithopera thornburgi*	*Carpocanopsis cristatum*	*Cyrtocapsella cornuta*	*Lithopera baueri*	*Cyclampterium tanythorax*	*Lithopera renzae*	*Cannartus mammiferus*	*Dendrospyris bursa*	*Cyrtocapsella tetrapera*	*Calocycletta costata*	*Calocycletta virginis*	*Cannartus bassanii*	*Clathrocorona atreta*	*Carpocanopsis bramlettei*	*Dorcadospyris dentata*	*Eucyrtidium cienkowskii*	*Cannartus tubarius*	*Carpocanopsis cingulatum*	*Stichocorys armata*	*Calocycletta robusta*	*Cannartus violina*	*Dorcadospyris alata*	*Lychnocanoma elongata*	*Dorcadospyris forcipata*	*Cannartus prismaticus*	*Dorcadospyris simplex*	*Cyclampterium leptetrum*	*Theocorys spongoconum*	*Theocyrtis annosa*	*Artophormis gracilis*	*Dorcadospyris ateuchus*	*Dorcadospyris papilio*	*Cyclampterium pegetrum*	*Theocampe amphora*	*Theocampe pirum*	*Theocampe mongolfieri*	*Dorcadospyris Triceros*	*Calocyclas turris*	*Lithocyclia aristotelis*	*Thyrsocyrtis tetracantha*
					C					R	+		+	F								F			C	R	R		R	R	F											
					C						+		-									F			C	R	F			R	C											
											-		-									R			F		R			R	F											
																		F				R			F		F			R	R	F										
																		F												F	R	R	F	R								
																															C	R	C		F							
																		F							+		R				R	F	+	+								
																																				F	R	R	R	F	R	
																																				R	R	R				
																																				R		R	R	+	R	
																																				R	+	R		R	R	
																		+												R						+	+	+	R	R		+

the drill string, respudding with a fresh bit, and continuously coring the Tertiary section. Hole 317 was terminated prematurely at a subbottom depth of 315 meters, above which three spot cores were obtained.

Hole 317A began continuously coring at 554 meters in middle Maestrichtian sediment and terminated in basalt at 943 meters. Hole 317B continuously cored the Quaternary through lower Eocene interval (0 to 424 m), and was terminated prematurely when a fragment from a broken pump got into the drill string and prevented retrieval of the core barrel. The lower Eocene to middle Maestrichtian material between the cored intervals at 317B and 317A (424 to 554 m) was not sampled.

Radiolarians are common and well preserved within only the upper Miocene through upper Oligocene section at this site (Cores 317B-7 through 317B-27; depth = 54-254 m). Poorly preserved and nondiagnostic radiolarian debris is present in the Quaternary and Pliocene intervals. Radiolarians are absent below the upper Oligocene sediments, except for some calcified and poorly preserved radiolarians in the Upper Cretaceous material of Cores 317A-8 through 317A-11 (601-604 m). These specimens were insufficiently preserved for reliable identification by optical microscopy.

The following radiolarian zonal boundaries can be identified in the Cenozoic material examined from Site 317 (see Table 2). The base of the Quaternary was identified by the extinction of discoasters, and lies between 16 and 25.5 meters (between 317B-2, CC and 317B-3, CC). The *Pterocanium prismatium* Zone and *Spongaster pentas* Zone were not sufficiently represented to be identified. The base of the *Stichocorys peregrina* Zone lies between 77 and 78.5 meters (between 317B-9-3, 78-80 cm and 371B-9-4, 70-72 cm). The base of the *Ommatartus penultimus* Zone lies between 89.5 and 91 meters (between 317B-10-5, 70-72 cm and 317B-10-6, 70-72 cm). The base of the *Ommatartus antepenultimus* Zone lies between 107 and 108.5 meters (between 317B-12-4, 70-72 cm and 317B-12-5, 70-72 cm). The base of the *Cannartus petterssoni* Zone lies between 130 and 139.5 meters (between 317B-14, CC and 317B-15, CC). The base of the *Dorcadospyris alata* Zone lies between 168 and 169 meters (between 317B-18, CC and 317B-19-1, 70-72 cm). The base of the *Calocycletta costata* Zone lies between 173 and 174.5 meters (between 317B-19-4, 70-72 cm and 317B-19-5, 70-72 cm). The base of the *Calocycletta virginis* Zone lies between 219 and 220.5 meters (between 317B-24-3, 70-74 cm and 317B-24-4, 82-86 cm). The base of the *Lychnocanoma elongata* Zone lies between 234.5 and 237 meters (between 317B-25, CC and 317B-26-2, 60-64 cm). The *Dorcadospyris ateuchus* Zone extends below 257 meters (Sample 317B-28-3, 70-74 cm), the deepest sample in which identifiable radiolarians were observed.

Site 318

Site 318 was cored intermittently between the sea floor and the deepest penetration at 745 meters, except for a portion of the middle Eocene section (596 to 653 m) which was cored continuously. Radiolarians of sufficient abundance and preservation for age determination are present in only two intervals of the sedimentary column cored at this site. The upper Miocene through

TABLE 3
Radiolarians in Hole 317B

Radiolarian Zones	Sample (Interval in cm)	Abundance	Preservation	*Solenosphaera omnitubus omnitubus*	*Stichocorys peregrina*	*Spongastericus berminghami*	*Acrobotrys tritubus*	*Ommatartus penultimus*	*Ommatartus hughesi*	*Lithopera bacca*	*Ommatartus antepenultimus*	*Cannartus petterssoni*	*Phormostichoartus corona*	*Artostrobium doliolum*	*Lithopera neotera*	*Cannartus laticonus*	*Cannartus mammiferus*	*Dorcadospyris alata*	*Dorcadospyris dentata*	*Carpocanopsis cristatum*	*Calocycletta costata*	*Stichocorys wolffii*	*Stichocorys delmontensis*	*Cyrtocapsella elongata*	*Carpocanopsis bramlettei*	*Carpocanopsis favosum*	*Cyrtocapsella tetrapera*	*Cyrtocapsella cornuta*	*Dorcadospyris simplex*	*Calocycletta virginis*	*Lychnocanoma elongata*	*Calocycletta robusta*	*Theocorys spongoconum*	*Dorcadospyris ateuchus*	*Cannartus prismaticus*	*Dorcadospyris circulus*	*Lithocyclia angustum*	*Dorcadospyris forcipata*	*Cannartus tubarius*	*Cyclampterium leptetrum*	*Cyclampterium pegetrum*	*Calocycletta serrata*	*Dorcadospyris papilio*
S. peregrina	317B-7-1, 70-72	F	P	R	F	+	+	R																																			
	317B-7-2, 70-72	C	P	R	C	+		F																																			
	317B-7-3, 70-72	R	M	R	C	+		+													*		*																				
	317B-7-4, 70-72	F	M	+	F	+		R															*																				
	317B-7-5, 70-72	R	M	+	C	+		R																																			
	317B-7, CC	R	M	R	R			R		+																																	
	317B-8-1, 105-107	R	M		R		+	+																												*									
	317B-8-2, 70-72	+	P		+																																								
	317B-8-3, 70-74	+	P																																										
	317B-8-4, 70-72	+	P																																										
	317B-8-5, 70-72	+	P																																										
	317B-8-6, 20-22	+	P		R																																								
	317B-8, CC	R	M	R	R									R									-																				
	317B-9-1, 80-82	F	M	+	F		+	+		R				R									+																				
	317B-9-2, 70-72	F	M	+	F		+	+						R									R																				
	317B-9-3, 78-80	C	M		F		+	+					R	F									R																				
O. penultimus	317B-9-4, 70-72	A	G		F		+	R		R				R									C																				
	317B-9-5, 70-72	C	G		F			R		+				R									C																				
	317B-9-6, 70-72	C	G		R			R		F				F									C																				
	317B-9, CC	C	G		R			R		F			F	R									C																				
	317B-10-1, 80-82	C	M		R			R		+			F	F									C																				
	317B-10-2, 70-72	F	M		R			R		+			R	F									C																				
	317B-10-3, 81-82	F	M					F		+			R	R									F																				
	317B-10-4, 70-72	F	M					R		R			R	R									R																				
	317B-10-5, 70-72	C	G					R	+	+	+		F	F									C																				
O. antepenultimus	317B-10-6, 70-72	C	M				+		R	R		+	F	C									C																				
	317B-10, CC	C	M						R	F	+		R	F									C																				
	317B-11-1, 110-112	C	M						F	R	R	+	R	R		R							C																				
	317B-11-2, 70-72	C	M						R	F	R	+	R	R									R																				
	317B-11-3, 70-72	F	M						R	R	R		R	+									F																				
	317B-11, CC	F	M						R	R	F	+	R	R																													
	317B-12-1, 70-72	F	M						+	+	R	R	R	R									C														R								
	317B-12-2, 70-72	F	M								R	+	R	+	+	+							C														+								
	317B-12-3, 70-72	C	M							+	R	+	R	R	+	R							F																				
	317B-12-4, 70-72	C	M								+	C	R	R	+	+							R																				
C. petterssoni	317B-12-5, 70-72	C	G							+		R	F	R	R	+							R																				
	317B-12-6, 70-72	C	M									R	R	F	+	R							F																				
	317B-12, CC	F	M									R	R	R	+	F							F																				
	317B-13-1, 70-72	C	M								R	F	F	+	R	+							+																				
	317B-13-2, 70-74	F	M									F	R	R	R	F								+																	+				
	317B-13-3, 70-74	C	M								+	C	R	+	+	R							R																				
	317B-13-4, 70-74	C	M									R	F	R	R	F						R	F	F	+																		
	317B-13-5, 52-58	F	P									R	+	R	R	F								R																					
	317B-13-6, 60-64	F	M									F		R	R	F							R	+																					
	317B-13, CC	F	M									R		R	R	F																													
	317B-14-1, 80-84	C	G									F		+	F	R		-		+			+																						
	317B-14-2, 80-84	C	G									F		F	R	F		-					R	+																					
	317B-14, CC	F	M									R		R	R	F		-																											
	317B-15, CC	F	M												R	F		R										F																	
D. alata	317B-16-1, 70-74	C	M										R		F	R		F										F																	
	317B-16-2, 70-72	C	M										+		+	F	R	F		R		+	+		R			F																	
	317B-16-3, 70-74	C	P										+		R	+	+	F		F									R																
	317B-16-4, 70-74	C	P										+		R	R	+	F		+	F	+			F		+	F																	
	317B-16-5, 70-74	C	M											+		R	R	C	+	F					C	R		F														+			
	317B-16-6, 70-74	C	M												+		R	C	+	F					C		R	R																	
	317B-16, CC	F	M												-		R	F							R			R																	
	317B-17-1, 90-94	C	M														R	C	R	+	C	R	C		C			F																	
	317B-17, CC	C	G														F	R	R	R	C		C					C																	
	317B-18-1, 101-105	C	M														R	C	F	R	C	R	C		R			F																	
	317B-18-2, 110-114	C	P														R	F	+	R	C	R	A		R			F																	

TABLE 3 – Continued

Radiolarian Zones	Sample (Interval in cm)	Abundance	Preservation	*Solenosphaera omnitubus omnitubus*	*Stichocorys peregrina*	*Spongasterius berminghami*	*Acrobotrys tritubus*	*Ommatartus penultimus*	*Ommatartus hugheri*	*Lithopera bacca*	*Ommatartus antepenultimus*	*Cannartus petterssoni*	*Phormostichoartus corona*	*Artostrobium doliolum*	*Lithopera neotera*	*Canna rtus laticonus*	*Cannartus mammiferus*	*Dorcadospyris alata*	*Dorcadospyris dentata*	*Carpocanopsis cristatum*	*Calocycletta costata*	*Stichocorys wolffii*	*Stichocorys delmontensis*	*Cyrtocapsella elongata*	*Carpocanopsis bramlettei*	*Carpocanopsis favosum*	*Cyrtocapsella tetrapera*	*Cyrtocapsella cornuta*	*Dorcadospyris simplex*	*Calocycletta virginis*	*Lychnocanoma elongata*	*Calocycletta robusta*	*Theocorys spongoconum*	*Dorcadospyris ateuchus*	*Cannartus prismaticus*	*Dorcadospyris circulus*	*Lithocyclia angustum*	*Dorcadospyris forcipata*	*Cannartus tubarius*	*Cyclampterium leptetrum*	*Cyclampterium pegetrum*	*Calocycletta serrata*	*Dorcadospyris papilio*
D. alata	317B-18-3, 70-74	F	M													R	F	R		C	R	A		R																				
	317B-18-4, 70-74	C	M													R	R	R	R	C	R	C		R			F																
	317B-18-5, 70-72	C	M													R	R	R	R	F	R	A		F															R					
	317B-18-6, 70-72	C	M														+	F	F	F	F	C		F			F																
	317B-18, CC	C	G														F	R	R	C	F	C		F			C																
C. costata	317B-19-1, 70-72	C	M														-	C		C	R	A	R	+			F												R					
	317B-19-2, 75-77	C	M														-	C		-	R	C		+				+	C					+							
	317B-19-3, 70-72	C	M														-	F		-	C	C		+			R		C								+	R				
	317B-19-4, 70-72	C	M														-	F			A	C	F	R			R	R	C					R				R				
C. virginis	317B-19-5, 70-72	C	M															R			A	C	F	R			F	R	F					R			R	+				
	317B-19-6, 74-76	C	G															R			C	F	R	+	R		C	R	F	+				R			F					
	317B-19, CC	C	G															-			C	F		+	R		F	C	F								F					
	317B-20-1, 70-72	C	M															R			R	F	R	+	R		R	C	R				F	F						+			
	317B-20-2, 70-72	C	M															-			R	F	R	R	R		R	C	R	R			C	F						R			
	317B-20-3, 70-72	C	M																			-	R		R	F		F	C	R	R			C	F						+			
	317B-20-4, 70-72	C	M																			-	F		-	F	-	F	F	R				+	F			F		F			
	317B-20-5, 70-72	C	M																			-		F	-	R	-	F	F	R			+	R	F			F		F			
	317B-20-6, 70-72	C	M																			-	F		-	R	R	F	F	F	F				F			R		+			
	317B-20, CC	F	M																						R	-	R	F	F	F	R			F	R								
	317B-21, CC	F	P																						+	R	R	R	F	R	R				R								
	317B-22-1, 70-72	C	M																					R	F	R	F	-	F	F	R		+		F			F	+	F			
	317B-22-2, 70-72	C	M																			F	F	F	-	F	-	F	F	R		+	R	F				+				
	317B-22-3, 70-74	F	M																						+	-	+	-	C	F			R	R	F				R	+		R	
	317B-22-4, 70-72	C	M																			F		-	R	+		C	F			F		F			+	R	+		R	
	317B-22-5, 68-70	F	M																						-	-	+		C	F	F		F		F			F	R	+		R	
	317B-22-6, 70-72	C	M																							R			F	F	R		F	R	R			C	F	+		F	
	317B-22, CC	F	M																										C	C	R									+		R	
	317B-23-1, 70-72	C	M																										F	F	R	C	F		R			R	F	+		R	
	317B-23-2, 70-72	C	M																									R	F	R	R	C	F	F	R			R		+		R	
	317B-23-3, 70-74	C	M																							+	F	R	R	R	R	C		R	F			+	R	+	+	R	
	317B-23-4, 70-72	C	M																								F		F	R	R	C	+	F	F			R	+		+	R	
	317B-23-5, 70-74	C	M																								F	F	F	R	R	C	R	+	F			R	R		+	F	
	317B-23-6, 70-74	C	M																								F	F	F	+	R	C		R	R			+			+	F	
	317B-23, CC	C	M																					F			C	F	R	+	R	C			C			R			+	C	
	317B-24-1, 70-74	C	M																								R	C	F	+	F	C	R		R			F			+	C	
	317B-24-2, 70-74	C	M																									F	F	+	R	C	R		R			R			+	C	
	317B-24-3, 70-74	C	M																									F	F	+	R	C	R		F			R			+	F	
L. elongata	317B-24-4, 82-86	C	M																									R	F		+	C	R	+	F					+	F	
	317B-24-5, 70-74	C	M																									R	F		+	C			+					+		
	317B-24-6, 70-74	C	M																									+	C		R	C	R	R							R		
	317B-24, CC	C	M																									-			R	F		C	R					+		
	317B-25-1, 70-74	C	P																									-	R		+	R	F	F	F								
	317B-25-2, 86-90	C	M																									-	C		R	C	F	F	R								
	317B-25-3, 70-74	C	M																									-	C		+	-	F	F	-					R		
	317B-25-4, 76-80	C	M																										F		+	-	F	C	-					R		
	317B-25-5, 70-74	F	M																												+	-	F	C	+					+		
	317B-25-6, 70-74	F	M																										R		+	-	F	F	+					+		
	317B-25, CC	+	P																																								
D. ateuchus	317B-26-2, 60-64	F	M																												-			C	-					R		R
	317B-26-5, 70-74	F	M																												-			C	-	F					+		R
	317B-26, CC	C	M																												-			C	-					R		C
	317B-27-1, 76-80	F	M																															F	-								R
	317B-27-2, 70-74	F	M																															+	-								+
	317B-27-3, 76-80	C	M																														C	C	-		R						R
	317B-27-4, 70-74	C	M																														C	C	-		R						F
	317B-27-5, 70-74	C	M																														C	F			R						F
	317B-27-6, 70-74	R	P																															R									+
	317B-27, CC	C	M																															C			+						+
	317B-28-1, 90-94	F	M																														F	R			+						F
	317B-28-2, 70-74	F	M																														F	R		R	+						F
	317B-28-3, 70-74	F	M																														R	F		F	+						R

upper Oligocene (Cores 5 through 13; depth 131 to 359 m) has a siliceous assemblage dominated by sponge spicules, but with a sufficient number of diagnostic radiolarians for reliable age control. The middle Eocene *Thyrsocyrtis triacantha* Zone is represented in a moderately to poorly preserved radiolarian assemblage in Cores 22 through 25 (depth 606 to 635 m). The remainder of the cored intervals are barren of radiolarians.

Samples were prepared and examined from each section of the cored sediment. Because of the poor preservation of radiolarians in many of the cores, and because the radiolarian-bearing intervals were not cored continuously, the occurrences of radiolarians at Site 318 will be listed in the text, rather than in tabular form.

Core 1 (0-7.5 m): A few moderately to poorly preserved radiolarians, mostly Eocene in age. Species observed include *Thyrsocyrtis triacantha, Podocyrtis papalis, Theocampe amphora, Theocampe mongolfieri, Dorcadospyris triceros,* and *Thyrsocyrtis rhizodon.* Actual age of deposition is late Neogene, based on calcareous microfossils, indicating substantial reworking.

Core 2 (26.5-36 m): No radiolarians.

Core 3 (64.5-74 m): A few radiolarian spines and fragments; no identifiable species.

Core 4 (93-102.5 m): Abundant sponge spicules, a few radiolarian spines; no identifiable species.

Core 5 (121.5-131 m): A few moderately to poorly preserved radiolarians. Neogene forms include *Stichocorys peregrina* and *Siphocampe corbula.* Admixed Eocene specimens of *Lychnocanoma babylonis, Theocampe amphora, T. urceolus,* and *Podocyrtis papalis.* Age of this core is upper Miocene (*S. peregrina* Zone) or younger.

Core 6 (150-157.5 m): A few well-preserved specimens of *Stichocorys delmontensis, S. peregrina, Phormostichoartus corona, Artostrobium doliolum, Ommatartus penultimus,* and *Lithopera bacca.* Age: *Ommatartus penultimus* Zone.

Core 7 (178.5-188 m): A few moderately to poorly preserved specimens of *O. hughesi, S. delmontensis, A. doliolum, L. bacca,* and *L. neotera.* Age: *Ommatartus antepenultimus* Zone, based on the co-occurrence of the morphotypes of *L. bacca* and *L. neotera.*

Core 8 (207-216.5 m): A few moderately preserved specimens of *S. delmontensis, A. doliolum, Cannartus laticonus,* and *Calocycletta caepa.* Abundant orosphaerids. Age: *Cannartus petterssoni* Zone, based on the absence of *O. antepenultimus* and *O. hughesi.*

Core 9 (235.5-245 m): A diverse radiolarian assemblage, dominated by reworked Eocene material, with middle Miocene specimens of *Cyrtocapsella japonica, Calocycletta costata, Cyrtocapsella tetrapera,* and *Stichocorys delmontensis.* Age: *Calocycletta costata* Zone.

Core 10 (264-273.5 m): A few moderately preserved specimens of *Dorcadospyris simplex, Carpocanopsis bramlettei, Cyrtocapsella japonica, C. cornuta,* and *Theocorys spongoconum.* Age: *Calocycletta virginis* Zone.

Core 11 (292.5-302 m): A few well-preserved specimens of *C. virginis, C. serrata, Cyrtocapsella tetrapera, Dorcadospyris simplex,* and *D. ateuchus.* Age: *Calocycletta virginis* Zone.

Core 12 (321-330.5 m): Rare specimens of *Cannartus prismaticus, D. ateuchus, Calocycletta robusta,* and *D. papilio.* Age: *L. elongata* Zone.

Core 13 (349.5-359 m): Rare specimens of *D. ateuchus, D. papilio, L. elongata,* and *Cyclampterium milowi.* Age: *Dorcadospyris ateuchus* Zone.

Cores 14 through 21 are barren of radiolarians or contain only unidentifiable fragments.

Cores 22 through 25 (596.5-634.5 m): A few well-preserved specimens of Eocene radiolarians, including: *Theocampe amphora, Phormocyrtis striata striata, Thyrsocyrtis triacantha, Eusyringium lagena, Theocampe mongolfieri, Calocyclas hispida, Lychnocanoma babylonis, Podocyrtis sinuosa, Theocotyle ficus, Thyrsocyrtis rhizodon,* and *Podocyrtis diamesa.* Age: *Thyrsocyrtis triacantha* Zone. Radiolarians are absent below Core 25.

The physiographic setting of this site is favorable for the accumulation of erosional products from the nearly Tuamotu Ridge; consequently, the extensive reworking of radiolarian debris within certain cored intervals is not surprising.

DISCUSSION OF RESULTS

Preservation of Radiolarian Assemblages

Three principal factors are responsible for low abundance or poor preservation of radiolarian assemblages: (1) low silica production in surface waters; (2) chemical dissolution at the benthonic boundary layer; and (3) post-depositional diagenesis leading to chert formation. Each of these mechanisms should be considered as a possible factor in the varying degree of preservation of radiolarians at the Leg 33 sites.

At the two equatorial sites (315 and 316), radiolarians are common and well preserved within all intervals cored between the Quaternary and upper Eocene; below this level radiolarians are absent, and chert horizons are interbedded with the calcareous material. This evidence suggests that biogenic silica deposition may have occurred through much of the sedimentary history at each of these two sites, but that chert formation has resulted from the remobilization of most of the silica of pre-Oligocene age.

In the two sites from subtropical southern latitudes (317 and 318), radiolarians are common and well preserved within only the upper Oligocene through upper Miocene intervals of the cored material. Silica accumulation is not occurring in these latitudes today, and evidently did not occur prior to the late Oligocene. The Pacific plate underlying Sites 317 and 318 has migrated on the order of one or two degrees northward since the late Miocene, so that these sites were located in slightly higher southern latitudes during the times of increased silica production and accumulation. This small amount of northward plate motion is probably inadequate to explain the varying silica accumulation, because of the similarity in the silica accumulation record at these two widely separated sites. The most plausible explanation is a change in the physical oceanographic setting of the south-central Pacific during the late Oligocene to late Miocene, such that a zone of divergence and high productivity existed in subtropical latitudes (10°-15°S) during this time interval.

Unconformities

The existence of unconformities at the Leg 33 sites can be reliably documented within only certain portions of the sites, since only a relatively few intervals were cored continuously. At Site 316 three significant unconformities were cored; these unconformities correspond approximately to the depth of prominent acoustic reflectors. These unconformities are of the following age: middle Miocene (Core 3, 267-276 m); lower Miocene/lower Oligocene (Core 4, 391-400 m); and lower Oligocene/middle Eocene (Core 5, 447-456 m). These unconformities may be indicative of episodic erosional events associated with turbidite deposition from the nearby Line Islands Ridge; alternatively they may be a result of episodic flow of Antarctic Bottom Water eastward through passages in the Line Islands Ridge.

LIST OF SPECIES

The purpose of this list is to provide bibliographic references to the taxa mentioned in this report. When the published literature contains several different concepts of the limits of a species, the reference cited conforms to the concept as applied here.

Acrobotrys tritubus Riedel, 1957, p. 80, pl. 1, fig. 5; Riedel and Sanfilippo, 1971, pl. 1J, fig. 19, 20.

Amphicraspedum murrayanum Haeckel, 1887, p. 523, pl. 44, fig. 10; Sanfilippo and Riedel, 1973, p. 524, pl. 10, fig. 3-6; pl. 28, fig. 1.

Amphirhopalum ypsilon Haeckel, 1887, p. 522; Nigrini, 1967, p. 35, pl. 3, fig. 3a-d.

Anthocyrtidium angulare Nigrini, 1971, p. 445, pl. 34.1, fig. 3a, b.

Artophormis gracilis Riedel, 1959, p. 300, pl. 2, fig. 12, 13; Riedel and Sanfilippo, 1970, p. 532, pl. 13, fig. 6, 7.

Artostrobium doliolum Riedel and Sanfilippo, 1971, p. 1599, pl. 1H, fig. 1-3; pl. 8, fig. 14, 15.

Axoprunum angelinum (Campbell and Clark), Kling, 1973, p. 634, pl. 1, fig. 13-16; pl. 6, fig. 14-18.

Bekomiforma mynx Sanfilippo and Riedel, 1974, p. 1020, pl. 2, fig. 3-5.

Buccinosphaera invaginata Haeckel, 1887, p. 99, pl. 5, fig. 11; Nigrini, 1971, p. 445, pl. 34.1, fig. 2.

Calocyclas hispida (Ehrenberg); Foreman, 1973, p. 434, pl. 1, fig. 12-15.

Calocyclas turris Ehrenberg; Foreman, 1973, p. 434.

Calocycletta caepa Moore, 1972, p. 150, pl. 2, fig. 4-7.

Calocycletta costata (Riedel), Riedel and Sanfilippo, 1970, p. 535, pl. 14, fig. 12; Moore, 1972, p. 147, pl. 1, fig. 8.

Calocycletta robusta Moore, 1971, p. 743, pl. 10, fig. 5, 6; 1972, pl. 48, pl. 1, fig. 6.

Calocycletta serrata Moore, 1972, p. 148, pl. 2, fig. 1-3.

Calocycletta virginis (Haeckel), Riedel and Sanfilippo, 1970, p. 535, pl. 14, fig. 10; Moore, 1972, p. 147, pl. 1, fig. 7.

Calocycloma castum (Haeckel), Foreman, 1973, p. 434, pl. 1, fig. 7, 9, 10.

Cannartus bassanii (Carnevale), Sanfilippo et al., 1973, p. 216, pl. 1, fig. 1-3.

Cannartus laticonus Riedel, 1959, p. 291, pl. 1, fig. 5; Riedel and Sanfilippo, 1971, pl. 1C, fig. 13, 14.

Cannartus mammiferus (Haeckel), Riedel, 1959, p. 291, pl. 1, fig. 4.

Cannartus (?) *petterssoni* Riedel and Sanfilippo, 1970, p. 520, pl. 14, fig. 3; 1971, pl. 1C, fig. 19, 20.

Cannartus prismaticus (Haeckel), Riedel and Sanfilippo, 1970, p. 520, pl. 15, fig. 1; 1971, p. 1588, pl. 2C, fig. 11-13.

Cannartus tubarius (Haeckel), Riedel and Sanfilippo, 1970, p. 520, pl. 15, fig. 2; Kling, 1971, pl. 3, fig. 3.

Cannartus violina Haeckel, 1887, p. 358; Riedel, 1959, p. 290, pl. 1,fig. 3; Moore, 1971, pl. 12, fig. 4.

Carpocanopsis bramlettei Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, fig. 8-14; pl. 8, fig. 7.

Carpocanopsis cingulatum Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, fig. 17-21; pl. 8, fig. 8.

Carpocanopsis cristatum (Carnevale) ?, Riedel and Sanfilippo, 1971, p. 1597, pl. 1G, fig. 16; pl. 2G, fig. 1-7.

Carpocanopsis favosum (Haeckel), Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, fig. 15, 16; pl. 8, fig. 9-11.

Centrobotrys petrushevskayae Sanfilippo and Riedel, 1973, p. 532, pl. 36, fig. 12, 13.

Clathrocorona atreta Sanfilippo and Riedel, Sanfilippo et al., 1973, p. 219, pl. 4, fig. 5-8.

Clathrocycloma capitaneum Foreman, 1973, p. 434, pl. 2, fig. 15; pl. 11, fig. 11.

Collosphaera sp. A, Knoll and Johnson, 1975, pl. 2, fig. 4-6.

Collosphaera tuberosa Haeckel, 1887, p. 97; Nigrini, 1971, p. 445, pl. 34.1, fig. 1.

Cyclampterium (?) *brachythorax* Sanfilippo and Riedel, 1970, p. 457, pl. 2, fig. 15, 16; Riedel and Sanfilippo, 1971, pl. 1E, fig. 7.

Cyclampterium (?) *leptetrum* Sanfilippo and Riedel, 1970, p. 456, pl. 2, fig. 11, 12; Riedel and Sanfilippo, 1971, pl. 2D, fig. 9-12.

Cyclampterium (?) *milowi* Riedel and Sanfilippo, 1971, p. 1593, pl. 3B, fig. 3; pl. 7, fig. 8, 9; Sanfilippo et al., 1973, pl. 220, pl. 4, fig. 12-14.

Cyclampterium (?) *pegetrum* Sanfilippo and Riedel, 1970, p. 456, pl. 2, fig. 8-10; Riedel and Sanfilippo, 1971, pl. 2D, fig. 13, 14; pl. 3B, fig. 1, 2.

Cyclampterium (?) *tanythorax* Sanfilippo and Riedel, 1970, p. 457, pl. 2, fig. 13, 14; Riedel and Sanfilippo, 1971, pl. 1E, fig. 8-10; pl. 2D, fig. 7, 8.

Cyrtocapsella cornuta Haeckel, Sanfilippo and Riedel, 1970, p. 453, pl. 1, fig. 19, 20; Sanfilippo et al., 1973, pl. 5, fig. 1, 2.

Cyrtocapsella elongata (Nakaseko), Sanfilippo and Riedel, 1970, p. 452, pl. 1, fig. 11, 12.

Cyrtocapsella japonica (Nakaseko), Sanfilippo and Riedel, 1970, p. 452, pl. 1, fig. 13-15; Sanfilippo et al., 1973, pl. 5, fig. 3.

Cyrtocapsella tetrapera Haeckel; Sanfilippo and Riedel, 1970, p. 453, pl. 1, fig. 16-18; Sanfilippo et al., 1973, pl. 5, fig. 4-6.

Dendrospyris bursa Sanfilippo and Riedel, Sanfilippo et al., 1973, p. 217, pl. 2, fig. 9-13.

Dendrospyris fragoides Sanfilippo and Riedel, 1973, p. 526, pl. 15, fig. 8-13; pl. 31, fig. 13, 14.

Dictyocoryne ontongensis Riedel and Sanfilippo, 1971, p. 1588, pl. 1E, fig. 1, 2; pl. 4, fig. 9-11.

Dictyospyris gigas Ehrenberg, Sanfilippo and Riedel, 1973, p. 527, pl. 16, fig. 9, 10; pl. 32, fig. 10, 11.

Dorcadospyris alata (Riedel), Riedel and Sanfilippo, 1970, pl. 14, fig. 5; 1971, pl. 2D, fig. 1; Moore, 1971, pl. 11, fig. 3, 4.

Dorcadospyris ateuchus (Ehrenberg), Riedel and Sanfilippo, 1970, pl. 15, fig. 4; 1971, p. 1590, pl. 2D, fig. 6, pl. 3A, fig. 9, 10.

Dorcadospyris circulus (Haeckel), Moore, 1971, p. 739, pl. 8, fig. 3-5.

Dorcadospyris confluens (Ehrenberg), Goll, 1969, p. 337; Sanfilippo and Riedel, 1973, p. 528, pl. 17, fig. 6-10; pl. 33, fig. 1.

Dorcadospyris dentata (Haeckel), 1887, p. 1037; Riedel, 1957, p. 79, pl. 1, fig. 3.

Dorcadospyris forcipata (Haeckel), Moore, 1971, p. 740, pl. 10, fig. 1, 2.

Dorcadospyris papilio (Riedel), Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 5; Moore, 1971, p. 739, pl. 8, fig. 6, 7.

Dorcadospyris quadripes Moore, 1971, p. 738, pl. 7, fig. 3-5.

Dorcadospyris simplex (Riedel); Riedel and Sanfilippo, 1970, pl. 15, fig. 6.

Dorcadospyris spinosa Moore, 1971, p. 739, pl. 7, fig. 1, 2.

Dorcadospyris triceros (Ehrenberg); Moore, 1971, p. 739, pl. 6, fig. 1-3.

Eucyrtidium cienkowskii Haeckel, 1887, p. 1493; Sanfilippo et al., 1973, p. 221, pl. 5, fig. 7-11.

Eusyringium fistuligerum (Ehrenberg), Riedel, 1957, p. 94, pl. 4, fig. 8; Riedel and Sanfilippo, 1970, p. 527, pl. 8, fig. 8, 9; Foreman, 1973, p. 435, pl. 11, fig. 6.

Eusyringium lagena (Ehrenberg) (?); Riedel and Sanfilippo, 1970, p. 527, pl. 8, fig. 5-7; Foreman, 1973, p. 435, pl. 11, fig. 4, 5.

Lithapium mitra (Ehrenberg), Riedel and Sanfilippo, 1970, p. 520, pl. 4, fig. 6, 7.

Lithocyclia angustum (Riedel), Riedel and Sanfilippo, 1970, p. 522, pl. 13, fig. 1, 2; 1971, pl. 3A, fig. 1, 3.

Lithocyclia aristotelis (Ehrenberg) group, Riedel and Sanfilippo, 1970, p. 522; 1971, pl. 3A, fig. 4, 5.

Lithocyclia crux Moore, 1971, p. 737, pl. 6, fig. 4.

Lithomitra docilis Foreman, 1973, p. 431, pl. 8, fig. 20-22; pl. 9, fig. 3-5.

Lithopera bacca Ehrenberg, 1872, p. 314; Nigrini, 1967, p. 54, pl. 6, fig. 2; Sanfilippo and Riedel, 1970, p. 455, pl. 1, fig. 29.

Lithopera baueri Sanfilippo and Riedel, 1970, p. 455, pl. 2, fig. 1, 2.

Lithopera neotera Sanfilippo and Riedel, 1970, p. 454, pl. 1, fig. 24-26, 28.

Lithopera renzae Sanfilippo and Riedel, 1970, p. 454, pl. 1, fig. 21-23, 27.
Lithopera thornburgi Sanfilippo and Riedel, 1970, p. 455, pl. 2, fig. 4-6.
Lophophaena (?) *capito* Ehrenberg group, Petrushevskaya and Kozlova, 1972, p. 535, pl. 33, fig. 20-23.
Lychnocanoma babylonis (Clark and Campbell) group, Foreman, 1973, p. 437, pl. 2, fig. 1.
Lychnocanoma elongata (Vinassa), Sanfilippo et al., 1973, p. 221, pl. 5, fig. 19, 20.
Ommatartus antepenultimus Riedel and Sanfilippo, 1970, p. 521, pl. 14; 1971, pl. 1C, fig. 11, 12.
Ommatartus avitus (Riedel), Riedel and Sanfilippo, 1971, p. 1588, pl. 4, fig. 6.
Ommatartus hughesi (Campbell and Clark), Riedel and Sanfilippo, 1970, p. 521; 1971, pl. 1C, fig. 17, 18.
Ommatartus penultimus (Riedel), Riedel and Sanfilippo, 1970, p. 521; 1971, pl. 1C, fig. 8-10.
Ommatartus tetrathalamus (Haeckel), Riedel and Sanfilippo, 1971, p. 1588, pl. 1C, fig. 5-7.
Phormocyrtis striata striata Brandt, Foreman, 1973, p. 438, pl. 7, fig. 5, 6, 9.
Phormostichoartus corona (Haeckel), Riedel and Sanfilippo, 1971, p. 1600, pl. 11, fig. 12; pl. 21, fig. 17; pl. 3E, fig. 15-19.
Podocyrtis (Lampterium) chalara Riedel and Sanfilippo, 1970, p. 535, pl. 12, fig. 2, 3.
Podocyrtis (Lampterium) goetheana (Haeckel), Riedel and Sanfilippo, 1970, p. 535; 1971, pl. 8, fig. 13.
Podocyrtis (Lampterium) mitra (Ehrenberg), Riedel and Sanfilippo, 1970, p. 534, pl. 11, fig. 5, 6.
Podocyrtis (Lampterium) sinuosa Ehrenberg (?), Riedel and Sanfilippo, 1970, pl. 11, fig. 3, 4.
Podocyrtis (Podocyrtis) ampla Ehrenberg, Riedel and Sanfilippo, 1970, p. 533, pl. 12, fig. 7, 8.
Podocyrtis (Podocyrtis) diamesa Riedel and Sanfilippo, 1970, p. 53, pl. 12, fig. 4; Sanfilippo and Riedel, 1973, p. 531, pl. 20, fig. 9, 10; pl. 35, fig. 10, 11.
Podocyrtis papalis Ehrenberg, 1847, fig. 2; 1874, p. 251; Riedel and Sanfilippo, 1970, p. 533, pl. 11, fig. 1; Sanfilippo and Riedel, 1973, pl. 20, fig. 11-14; pl. 36, fig. 2, 3.
Podocyrtis (Podocyrtis) phyxis Sanfilippo and Riedel, 1973, p. 531; Riedel and Sanfilippo, 1970, pl. 12, fig. 6.
Pterocanium praetextum (Ehrenberg), Riedel, 1957, p. 86, pl. 3, fig. 1-3; Moore, 1971, pl. 13, fig. 3.
Pterocanium prismatium Riedel, 1957, p. 87, pl. 3, fig. 4, 5; Riedel and Sanfilippo, 1971, pl. 8, fig. 1.
Pterocorys hertwigii (Haeckel), Sanfilippo and Riedel, 1974, pl. 3, fig. 12-14.
Rhopalocanium ornatum Ehrenberg, 1847, fig. 3; 1854, pl. 36, fig. 9; 1874, p. 256; 1876, p. 82, pl. 17, fig. 8; Foreman, 1973, p. 439, pl. 2, fig. 8-10; pl. 12, fig. 3.
Siphocampe corbula (Harting), Riedel and Sanfilippo, 1971, p. 1601, pl. 1H, fig. 18-25.
Solenosphaera omnitubus omnitubus Riedel and Sanfilippo, 1971; p. 1586, pl. 1A, fig. 24; pl. 4, fig. 1, 2; Sanfilippo and Riedel, 1974, p. 1024, pl. 1, fig. 1.
Solenosphaera omnitubus procera Sanfilippo and Riedel, 1974, p. 1024, pl. 1, fig. 2-5.
Spongaster klingi Riedel and Sanfilippo, 1971, p. 1589, pl. 4, fig. 7, 8.
Remarks: Sanfilippo and Riedel (1973, p. 524) state that *Spongaster klingi* Riedel and Sanfilippo is probably a junior synonym of *Spongastericus berminghami* Campbell and Clark (1944).
Spongaster pentas Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 3.
Spongaster tetras Ehrenberg, 1860, p. 833; Nigrini, 1967, p. 41, pl. 5, fig. 1 a-b, 2.
Stichocorys armata (Haeckel), Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, fig. 13-15; Sanfilippo et al., 1973, p. 222, pl. 6, fig. 1, 2.
Stichocorys delmontensis (Campbell and Clark), Sanfilippo and Riedel, 1970, p. 451, pl. 1, fig. 9; Riedel and Sanfilippo, 1971, pl. 1F, fig. 5-7; pl. 2E, fig. 10, 11.
Stichocorys peregrina (Riedel), Riedel and Sanfilippo, 1970, p. 530; 1971, pl. 8, fig. 5.
Stichocorys wolffii Haeckel, 1887, p. 1479; Riedel, 1954, p. 173, pl. 1, fig. 4; Riedel, 1957, p. 92, pl. 4, fig. 6, 7; Riedel and Sanfilippo, 1971, pl. 2E, fig. 8, 9.
Theocampe amphora (Haeckel) group, Foreman, 1973, p. 431, pl. 8, fig. 7, 9-13; pl. 9, fig. 8, 9.
Theocampe armadillo (Ehrenberg) group, Riedel and Sanfilippo, 1971, p. 1601, pl. 3E, fig. 3-6.
Theocampe mongolfieri (Ehrenberg), Burma, 1959, p. 239; Riedel and Sanfilippo, 1970, p. 536, pl. 12, fig. 9; Foreman, 1973, p. 432, pl. 8, fig. 1; pl. 9, fig. 17.
Theocampe pirum (Ehrenberg), Riedel and Sanfilippo, 1971, p. 1601, pl. 3E, fig. 10, 11; Foreman, 1973, pl. 9, fig. 11, 12.
Theocampe urceolus (Haeckel), Foreman, 1973, p. 432, pl. 8, fig. 14-17; pl. 9, fig. 6, 7.
Theocorys anaclasta Riedel and Sanfilippo, 1970, p. 530, pl. 10, fig. 2, 3; Sanfilippo and Riedel, 1973, p. 440, pl. 5, fig. 14, 15.
Theocorys spongoconum Kling, 1971, p. 1087, pl. 5, fig. 6; Riedel and Sanfilippo, 1971, pl. 2F, fig. 4; pl. 3C, fig. 3.
Theocorythium trachelium (Ehrenberg), Nigrini, 1967, p. 79, pl. 8, fig. 2.
Theocotyle (Theocotylissa) ficus (Ehrenberg), Foreman, 1973, p. 441, pl. 4, fig. 16-20.
Theocyrtis annosa (Riedel), Riedel and Sanfilippo, 1970, p. 535, pl. 15, fig. 9.
Theocyrtis tuberosa Riedel, 1959, p. 258, pl. 2, fig. 10, 11; Moore, 1971, p. 743, pl. 5, fig. 5, 6.
Thyrsocyrtis bromia Ehrenberg, 1874, p. 260; 1876, p. 84, pl. 12, fig. 2; Riedel and Sanfilippo, 1970, p. 526; 1971, pl. 8, fig. 6; Moore 1971, pl. 5, fig. 1-3.
Thyrsocyrtis hirsuta tensa Foreman, 1973, p. 442, pl. 3, fig. 13-16; pl. 12, fig. 8.
Thyrosocyrtis rhizodon Ehrenberg, 1874, p. 262; 1876, p. 94, pl. 12, fig. 1; Riedel and Sanfilippo, 1970, p. 525, pl. 7, fig. 6, 7; Foreman, 1973, p. 442, pl. 3, fig. 1, 2.
Thyrsocyrtis tetracantha (Ehrenberg), Riedel and Sanfilippo, 1970, p. 527; Moore, 1971, pl. 4, fig. 3.
Thyrsocyrtis triacantha (Ehrenberg), Riedel and Sanfilippo, 1970, p. 526, pl. 8, fig. 2, 3; Foreman, 1973, p. 442, pl. 12, fig. 9-11.

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