12. NEOGENE RADIOLARIANS FROM THE EASTERN NORTH PACIFIC (OFF ALTA AND BAJA CALIFORNIA), DEEP SEA DRILLING PROJECT LEG 63[1]

Reinhard Wolfart, Federal Institute of Geosciences and Natural Resources, Hannover, Federal Republic of Germany

INTRODUCTION

Leg 63 of the Deep Sea Drilling Project extended along the west coast of North America and northern Central America, northwest of Los Angeles to southwest of Mazatlan, Mexico. Holes were drilled at seven sites and Neogene cores recovered, exclusively (Sites 467–473). Sites 467 through 469 are situated within the California Continental Borderland, Sites 470 through 473 within the western continental margin of Baja California (Fig. 1). Leg 63 drilling was intended to study the Neogene paleooceanographical and climatological development of the northeastern Pacific and the evolution of planktonic communities.

METHODS

Light-microscope techniques were used to study the Neogene radiolarians of 429 samples. Radiolarian zonation of the samples, summarized in Fig. 2, follows mainly Hays (1970), Kling (1973), Riedel and Sanfilippo (1971, 1978), Moore (1971), Dinkelman (1973), and Foreman (1975).

The relative abundances of the various species were determined as follows. All individuals of each species were counted. After 15 individuals of one species were noted, the counting stopped, yielding the relative abundances for each species: A, abundant (more than 15 specimens on the counted part of a slide); C, common (10–14 specimens); F, few (5–9 specimens); R, rare (1–4 specimens). B, barren (no recognizable specimens).

The taxonomy, which is alphabetically arranged, references only papers in which the species mentioned are fully described.

SITE SUMMARIES

Site 467

Site 467 is located within the San Miguel Gap (Table 1), about 230 km northwest of Los Angeles. Coring was intended to provide a Miocene through Quaternary reference section that would permit biostratigraphical correlations between the California Borderland and the California province (onshore). Neogene radiolarian-bearing sediments were recovered from Cores 467-2 through 56 (Quaternary through uppermost Miocene); the radiolarian abundance is generally rare to few, the preservation poor to moderate. No datable radiolarians are known from Cores 22, 31, 37, 46, and 57 through 110. The radiolarian assemblages from Cores 2 through 56 are listed in Table 2. The biostratigraphical zonation used here follows Hays (1970) and Kling (1973) for the eastern North Pacific.

In Section 2-1 through Section 8-4, radiolarians were deposited in the early late Pleistocene (*Axoprunum angelinum* Zone), indicated by the presence of *Lamprocyrtis nigriniae* and *Lamprocyrtis neoheteroporos* and the absence of *Eucyrtidium matuyamai*. Because of the presence of *E. matuyamai* and *Lamprocyrtis heteroporos*, Section 8-5 through Sample 10,CC must be placed—at least in the upper part—in the lower Pleistocene (*E. matuyamai* Zone).

Sections 11-1 through 25-8 are in the upper Pliocene *L. heteroporos* Zone, as indicated by the occurrence of a radiolarian assemblage with *L. heteroporos* and without *E. matuyamai* and *Stichocorys peregrina*. The first typical specimens of *S. peregrina* in Section 26-2 indicate deposition in the early Pliocene. They are associated with *L. heteroporos* and some nondiagnostic Neogene radiolarians. The lower Pliocene succession comprises Section 26-2 through Sample 45,CC. *L. heteroporos* does not occur below Sample 45,CC. This and the presence of *S. peregrina* suggest that Core 47 through Core 56, Section 2 were deposited in the late late Miocene (lower part of *S. peregrina* Zone). Rare specimens of various *Cyrtocapsella* species were found in Pliocene beds; they are reworked from older layers of the Miocene.

The hard rocks of Cores 57 through 110 contain very rare (e.g., Core 58) and poorly preserved radiolarians that cannot be dated. A significant feature of the Pleistocene–Pliocene radiolarian assemblages within the range of the California Current west-northwest of Los Angeles is the absence of the stratigraphically important species of equatorial regions (*Amphirhopalum ypsilon, Anthocyrtidium angulare, Ommatartus tetrathalamus, Pterocanium praetextum, P. prismatium, Spongaster tetras, S. pentas, Theocorythium* spp.). Kling (1973) points out this same feature for the region north of Los Angeles (off Cape Mendocino). The Pleistocene–Pliocene radiolarian assemblages at Site 467 resemble those of the subarctic North Pacific. Equatorial taxa (*S. peregrina, Cyrtocapsella*) in upper Miocene sediments of Site 467, however, suggest an influence of equatorial waters at that time. These forms do not replace the normal California Current assemblage, but they appear in addition to it.

Site 468

Hole 468 was drilled on the Patton Escarpment to find clues to the late Cenozoic paleoceanographic-paleoclimatic history and the associated oscillations in the biogeographic patterns of planktonic communities.

[1] *Initial Reports of the Deep Sea Drilling Project*, Volume 63.

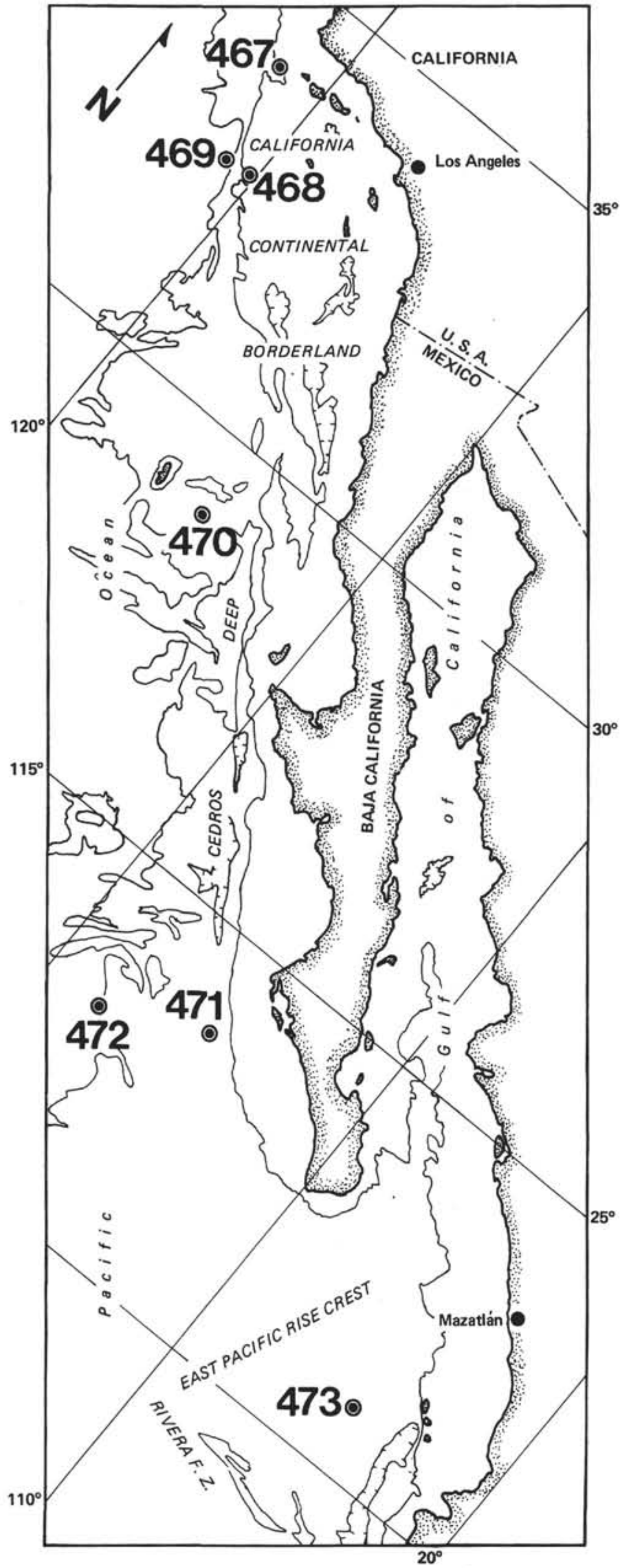

Figure 1. Locations of Leg 63 drilling sites.

Hole 468 was continuously cored to 241 meters, Hole 468A to 35.5 meters, and Hole 468B to 415.5 meters. A relatively thin cover (3.5–40 m) of upper Neogene sediment rich in calcareous microfossils and rather poor in siliceous microfossils overlies a thicker sequence of calcareous and siliceous middle Miocene sediment. This, in turn, overlies a barren sedimentary sequence that may represent either middle or lower Miocene.

The radiolarian abundance in Quaternary through middle Miocene sediments is mostly rare to few and the preservation poor to moderate. Only few cores contain common to abundant, well-preserved radiolarians—Sections 2-1 through 3-1 and Sections 4-5 through 5-1 (Hole 468), and Sections 3-2 through 9-2 (Hole 468B). Core 1 and Core 2, Section 1 (Hole 468A) contain a well-preserved, common Pleistocene radiolarian assemblage. Surface sediment in Hole 468A yields no datable radiolarians as well as Cores 14 through 16 of Hole 468 and Core 5 of Hole 468B. Below Section 468B-18-2, no remains of radiolarians occur (except in Sample 29,CC). Tables 3 and 4 list the radiolarian assemblages from the Neogene sediments of these holes.

The Quaternary sediments of Hole 468A yielded radiolarian assemblages described from the northeastern Pacific, and Kling's (1973) zonation is applicable. Sections 1 and 2 of Core 1 correlate with the upper Pleistocene *Axoprunum angelinum* Zone, as indicated by the presence of *Lamprocyrtis nigriniae* and the absence of *E. matuyamai*. The assemblages of Section 1-3 through Section 2-1, containing *E. matuyamai* and *Lamprocyrtis heteroporos* are—at least the upper part—assigned to the lower Pleistocene *E. matuyamai* Zone. Single specimens of *Amphirhopalum ypsilon* and *Theocorythium vetulum*, which are typical of equatorial regions, are included in the Quaternary assemblages. The upper Pliocene sediments of Hole 468A (Section 2-2 through Sample 2,CC) and Hole 468B (Sections 1-1 through 1-2) contain only nondiagnostic radiolarians besides *Lamprocyrtis heteroporos* and belong, therefore, to the *L. heteroporos* Zone. The upper boundary of the lower Pliocene/uppermost Miocene *Stichocorys peregrina* Zone is indicated by the extinction of *S. peregrina*. The Pliocene/Miocene boundary is marked by the first appearance of *L. heteroporos*. From the radiolarian occurrences, it follows that the Quaternary and Pliocene are only thinly represented by sediments, if at all. One or several sedimentation gaps or a very condensed sequence can be assumed between Core 1 and Sample 2,CC of Hole 468A.

Below the Quaternary–Pliocene beds, radiolarians restricted to the upper Miocene are rarely represented. Section 468-2-1 contains few specimens of *Ommatartus antepenultimus*, a species indicative of deposition in the early late Miocene. Section 468A-4-5 yielded *Stichocorys peregrina* abundantly and is assigned to the uppermost Miocene. Equivalent layers were found in Sample 468B-2,CC through Section 468B-3-4, which are again characterized by few specimens of *S. peregrina* and rare occurrences of *O. antepenultimus*. Only Section 4-1 and

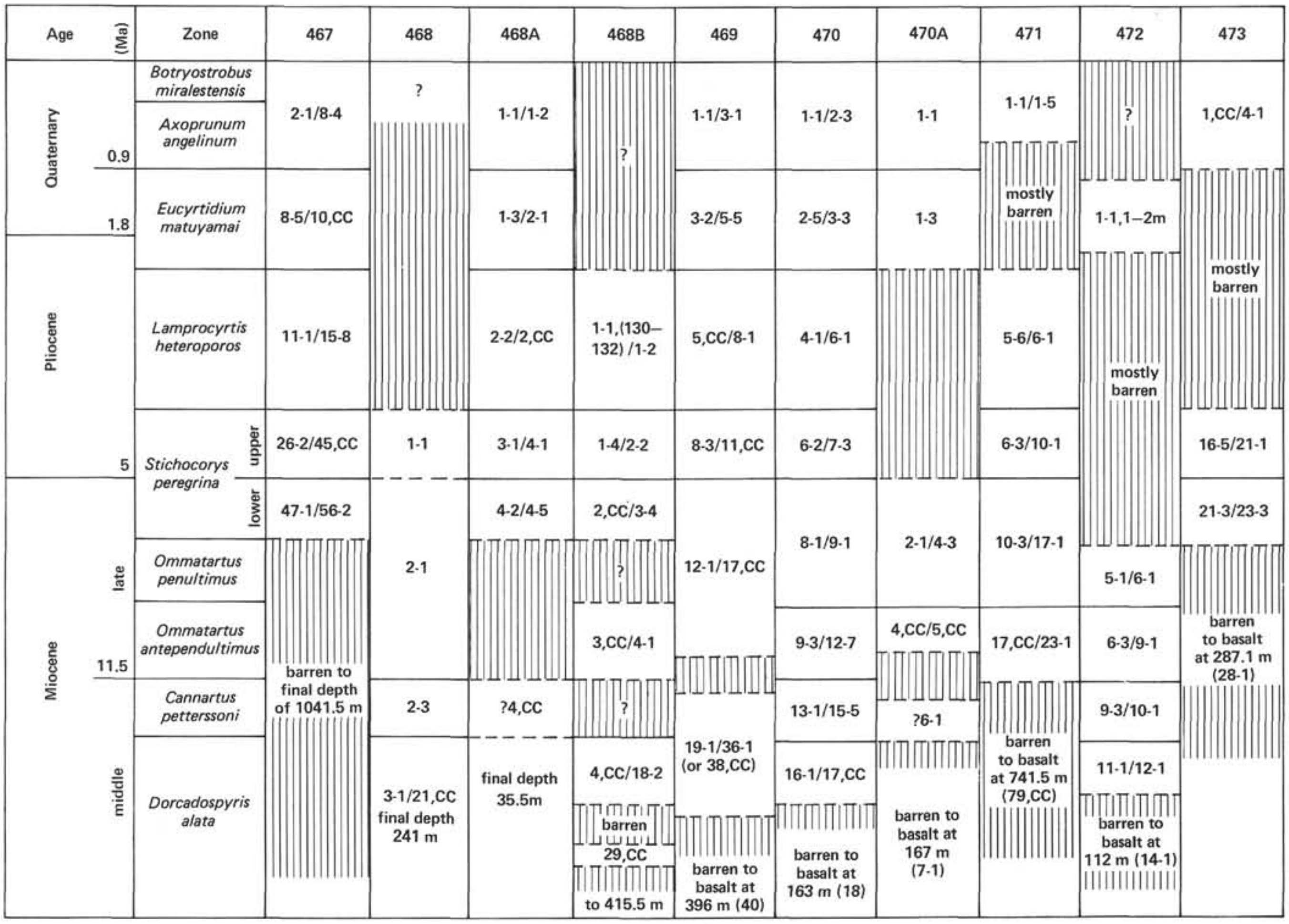

Figure 2. Radiolarian zonation of Neogene and Quaternary sedimentary depositions. After Kling (1973), the Pliocene/Quaternary boundary coincides with the base of the *Eucyrtidium matuyamai* Zone. According to the results of diatom (J. Barron, this volume) and nannofossil studies (D. Bukry, this volume), the Pliocene/Quaternary boundary presumably must be drawn within the lower part of the *E. matuyamai* Zone.

Table 1. Locations of Leg 63 Holes from which radiolarians were recovered.

Hole	Latitude	Longitude	Location	Water Depth (m)	Cored Section (m)
467	33°50.97′N	120°45.47′W	San Miguel Gap	2127.8	1041.5
468	32°37.03′N	120°07.07′W	Patton Escarpment	1849	241
468A, B	32°37.41′N	120°06.55′W	Patton Escarpment	1737	A = 35.5; B = 415.5
469	32°37.00′N	120°32.90′W	Foot of Patton Escarpment	3790	453.5
470, 470A	28°54.46′N	117°31.11′W	East of Guadalupe Island	3549	168; A = 101.5
471	23°28.93′N	112°29.78′W	Foot of continental slope of Baja California	3101	823
472	23°00.35′N	113°59.71′W	Southwest of Site 471	3831	137.5
473	20°57.92′N	107°03.81′W	Rivera plate south of Tres Marias Island	3249	287.5

Table 2. Radiolarians from the Neogene and Quaternary sediments of Hole 467.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Amphirhopalum wirchowii*	*Anthocyrtidium* sp. cf. *A. angulare*	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*B. miralestensis*	*Cannartus* sp. cf. *C. violina*	Carpocaniidae	*Clathrocyclas cabrilloensis*	*Clathrocyclas* sp.	*Cornutella profunda*	*Cyrtocapsella cornuta*	*C. japonica*	*C. tetrapera*	*Dictyophimus crisiae*	*Eucyrtidium acuminatum*	*E. calvertense*	*E. inflatum*	*E. matuyamai*	*Hymeniastrum euclidis*	*Lamprocyclas maritalis polypora*	*Lamprocyrtis hannai*	*L. nigriniae*	*L. heteroporos*	*L. neoheteroporos*	*Lipmanella dictyoceras*	*Lithomitra lineata* gr.	*Lychnocanoma* sp. cf. *L. grande*	*Ommatartus tetrathalamus*	*Peripyramis circumtexta*	*Polysolenia* spp.	*Pterocanium korotnevi*	*P. trilobum*	*Saturnalis circularis*	*Sethocorys* sp.	*Siphostichoartus* sp. cf. *S. corona*	*Sphaeropyle langii*	*Spirema* sp.	*Spirocyrtis* sp. aff. *S. scalaris*	*Spongocore puella*	*Spongotrochus glacialis*	*Stichocorys peregrina*	*S. wolffii*	*Stichopera pectinata* gr.	*Stylacontarium acquilonium*	*Stylacontarium* sp. aff. *S. bispiculum*	*Theocalyptra davisiana*	*Theoconus* sp. aff. *T. zancleus*	*Theocorys redondoensis*	*Theocorythium trachelium*	*T. vetulum*	*Xiphospira* sp. cf. *X. circularis*
				2-1, 14–16	C	G	F			R	R		A		R		C					F	R						R	C					R		R	A	R	F				C				C			R	R		F	C				F
				2-2, 14–16	C	G	F						A		R		A					R		R						F					R?			A	F	F				A				C						C	R				F
				2-3, 14–16	F	M	F				R				R		C					R	R						R								R	F	R					C				A				R		C	C				C
				2-4, 14–16	C	G	C				R	R	A		R		C					R	R	R			R		R	F		R					R	R	F					A				A				R		A	C				F
				2,CC	C	G	F			R	R	R	C				A	R				R	R				R					R			R			F	C	R				F				F				R		A	F				F
		Botryostrobus miralestensis		3-1, 120–122	C	G	C			R	R		R		R		A					R	R	R			R				R*	A							C					C				C			R	R		A	C				F
				3-2, 75–77	F	M	F				R		R		R		C					R										C					R	R	F					F				C				R		A	F				F
				3-3, 75–77	F	M	F				R		R		R		C					R	R				R		R			C	R				R	R	R			R		R				F				R		A	R				C
				3-4, 75–77	F	M	R			R	R	F	C		R		R					R					R	R			R*	C					R	F	F					R		R		F						A	F				F
				3-5, 10–12	F	M	F			R	R	R	C				C					F		F								F						F	C	R				R				C			R	R		A	F				F
				3,CC	R	P					R		F				R							R															R									F						R	R				R
				4-1, 117–119	R	P	R			R			A		R		F					R		R								C							R			R						R				R		A					F
				4-2, 15–17	R	P																													R													R						A	R				
				4-3, 60–62	F	M	R				R	R	R				R						R								R*	R								R								C						A	R				F
				4,CC	R	P	R			R			F		R		C					R		R			R					R						R	R					R				C				R		C					R
				5-1, 106–108	F	M	R	F				R	R		R		F					R	R	R			F	R	R			C							R					R				C				R		A			R	R	C
				5-3, 75–77	C	G	R					R	F		R		A					F										A	R					R	R	R								C				R		A	A		R		R
	Quaternary			5-5, 75–77	F	G	F	R		F			F		R		R					R		R			F				R*	C	R				R	R	R									C				R		A	F			R	F
		Axoprunum angelinum		5,CC	F	M	R	R		R	R	F	F		R			F						R			R	R				F						R	R					R				A				R		A	R			R	R
				6-1, 74–76	F	M				R	R		C				C					F										A					R	R	F					R				C				R		A	F				F
50				6-3, 74–76	F	M				R	R	R	C		R		F					R	R	R			R		R			C	R					R	R									A				R		A	F				F
				6-5, 74–76	R	P	R			R	R		A									R																						R				F						C	R				R
				6,CC	C	G	R	F	R	R		R	A				A	R				R	R	R			F					C					R	C	R			R		F				A				R		A	R		R		C
				7-2, 76–78	F	M	R			R	R	R	A				F							R			R					F	R					C	R									C						A	R				F
				7-4, 76–78	C	G		R			R	R	A		R		A						R	R			R		R			A					R	C	R	R								F			R	R		A	R				F
				7-5, 74–76	C	G		R			R	R	C		R		A	R				R	R									C						F	R									F				R		A	R				F
				8-1, 74–76	R	M					R	R	A				F					R	R				R					R							R					R				C				R		A	R				C
				8-3, 74–76	F	M	R		R		R	R	R				F						R				R				R*	F	R											R				F			R	R		A	R				F
			0.9	8-4, 74–76	F	M	R			R	R	R	C		R		F					R	R								R*	F					R		R	R		R						C				R		A	R		R		F
				8-5, 74–76	R	P					R	R	C														R				R*		R				R	R				R						R						F	R				
				8-6, 74–76	A	G	R			R	R	A	R		R		R				R*					F	F				A	R?					R	F	R								R	A				R		A	R			R	A
				8,CC	C	G						A	R		R			R					R			F	R				A																	A				R		A	R		R		A
		Eucyrtidium matuyamai		9-2, 53–55	C	G	R	R		C	R	F	F		R		F	R				R	R			R	F				A						R	R	R	R							R	A				R	R	A	R			R	A
				9-4, 53–55	F	G				R	R	C	R		R		F	R				R	R			R	R				C						R		R	R							R	A				R	R	A					A
				9,CC	F	G	R	R		R	R	A			R		R	R					R			C	R				C						R			R							R	A				R	R	A					A
			1.8	10-2, 55–57	F	G	F					A					R						F			R	R				C		R				R		R	R		R					R	A				R	R	A				R	C
				10-4, 55–57	F	M	R					F	R				R	R				R				R	R				F						R		R									A				R	R	A				R	F
				10-7, 55–57	F	M		R		R	R	R	C		R		R					R	R			F	R				R						R		R				R					A				F	F	A				R	F
				10,CC	F	G				R	R	R	F				R	F					R	R		R	R				R			R			R			R			R				R	A					R	A				R	A
				11-1, 54–56	F	M					R	F	R		R		R					R	F				R				F				R		R		R	R			R				R	A				F	F	A				R	F
				11-3, 54–56	C	G				R	R		C		R		A						R	R			R										R		R	F		R	R				R	A	R*			F		A				F	C
100				11-5, 54–56	C	G	R			R	R	A	R		R		C	R					R				R				A		R						R	R								C				F		A					A
				11,CC	R	P				R	R	F						R				R									F						R			R			R				R					F		F					R
				12-1, 54–56	C	M	R				R	C	R		R		F	R				R	R	R			F				C		R				R		R	R		R	R				R	C				R		A				R	F
				13-1, 53–55	C	G	F			F		A	R		R	C	C	R				R	F	R			R		R		F		F					R	F	R	R	A	R				R	A				R		A	R			R	C
				13-2, 53–55	C	G	R			C	R	A	F		R	F	F	R				R	R	R			R		R		F		R					R	R	F	R	F					R	A				R		A	R				C
				13-5, 53–55	C	G		R		F		C	F		R	F	F						R	R			F				F						R		R	R		F					R	A				R		A	R			R	F
				13,CC	F	M				R	R	F	F			F	F	R						R							F								R	R			R				R	C				R		C					F
				14-2, 54–56	C	G	R			F	R	C	C			C	C	R				R	R	R			R		R		F		R				R	R		R		R	R				R	C				R		A				R	F
				14-4, 54–56	C	G	F			C	R	F	R		R	F	F					R	R	R							A		R					R		R	R		R				R	A				R		A					F

				14-6, 54-56	F	M	F			R			R		R	R	R										R				A		R					R		R								F				R		A					F
		Lamprocyrtis heteroporos		15-1, 54-56	F	M	R			R	R	R	R			R	R						R	R		R				F						R	R		R							R	A						A					C
				16-1, 53-55	C	G	F			C	R	F	C		F	A	A						R			R				C									R								A				F		A					A
				16-3, 53-55	F	M	R			F	R	F	F		F	C	C						R	R		R				C						R			R			R					A				R		A					C
				16-5, 53-55	F/C	M	R			R	R	F	C		F	F	F						R	R		R				F		R				R	R		R							R	A				R		A					C
150				16,CC	R	P	R			R	R		R			F	F						R							R																	C						F					C
				17-1, 53-55	F	M				F		F	A		R	F	F						R			R		R		F						R			R		R	F					C				R		A				R	F
				17-3, 53-55	R	P	R			R		R	C		R	R	R					R		R			R				R																C				R		C					F
				17,CC	F	M	C	R		C		F	A		R	F	F	R					R				R				F									R			R					A						C					C
				18-2, 57-59	C	G	R	R		A	R	F	F		R	A	A					R	R				R				C		R				R	R		R	R	R	R					C				R		A					F
				18-4, 54-56	C	G	F			F	R	F	F		R	A	A					R	R				R				F		R					R		R	R		R					C				F		A					C
				18-6, 54-56	C	G	R			F	R	R	C		R	C	C					R	R				R		R		C		R					R		R			F					A				C		A					C
				18,CC	R	P				R			C		R	F	F	R						R			R				F							R					R					C				R		F					F
				19-2, 24-26	F	M	R				R	F	F			F	F					R	R	R			R		R		C		R				R	R	R	R			A					A				R		F					C
				19-4, 24-26	C	G				R		R	R			A	A					R									C						R	F	R	R			F					A				R		A					C
				19-6, 24-26	C	G	R			F	R	F	F		R	A	A	R					R	R			F		R		F								R	R			R				R	F				A		A					C
				20-1, 20-22	F	M						R	R				C					R					R				R		R			R	R	R		F								R						A					F
				20-3, 18-20	F	M	R					R	R		R		C					R		R			R				F									F								F	R*					F					C
				20,CC	F	M				R	R	R					C	R					R				R				F		R															C				R		R					C
200				21-1, 20-22	F	M	R			R		R	R			R	C														C									R			F					C				R		C					R
				23,CC	R	P							R				R	R													R			R														R						R			R		
	Pliocene			24-1, 1-2	R	P				R		R					R							R			F				F							R				R						R				R							C
				25-2, 25-27	R	P				R	R	R					F				R*			R			R				R							R										F				R		R					F
				25-4, 62-64	F	M	R			R	R	R			R		F	R			R*			R			R		R		F				R		R					C						F	R*			F		R					C
				25-6, 78-80	F	M				F	R	F	R		R		R	R						R			R		R		R		R				R		R			R	R				R	C				F		R					C
				25-8, 30-32	R	P				F	R	R			R		R												R		R		R										R					R				R							F
				26-2, 60-62	F	M				F	R	F	R		R		F	R				R		R			R		R														R				R	C	R			F						R	C
250			3	26-3, 13-15	R	P	R			F	R				R		R					R	R	R			R				F											R	R					R	R			F		R					C
				27-2, 114-116	R	P				F	F				R		R			R*				R							R								R									R	R			R	R						F
				28-1, 70-72	R	P				F	R						R	R			R*			F					R										R									R	R			C	R						F
				29-2, 54-56	F	M	F			C	R	R					C	R				R	R	F					C		R		R	R														R	F			C							R
				29-4, 64-66	R	P				C	R	R			R		F	R					R	R			R		F		R		R					R				R					R	F	F			C		R					C
				30-2, 26-28	R	P	R			F	R	R		R*										R					R		R																	R	F			F							R
				32-1, 54-56	R	P	R			F	R	R			R		R	R						R															R			R						F	F			F							C
300				32-3, 54-56	R	P	R			F	R	R	R				R	R		R*	R*			R							R											R						R	R			F		R					F
				33-2, 35-37	R	P	R			C	R	F	R				R		R*	R*	R*										R								R			R						F	F			C		R					F
				33-4, 35-37	R	P	R			C	F	F					F	R						R	R*			R			R								R				R					R	F			R		R					F
				34-3, 54-56	R	P	R			C	R	R			R		F		R*									R			F			R					R			F						F	F			R		R		R*			F
				35-1, 53-56	C	M	R			F	R	F	R		R		R		R*		R*										A		R									F						C	C									R	F
				36-2, 51-53	F/C	M	F			C	R	R		R*	R		R	R	R*	R*	R*		R						R		C											R						F	F			C		R					C
350				36-4, 51-53	C	M	R			F	R	R			R		C		R*		R*		R	R			F				C						R		R		R	R	R				R	C	C			R		R					C
		Stichocorys peregrina (upper part)		38,CC	F	M	R			F	R	F			R		F	R						R					R		C		R						R			R						A	F			F		R					C
				40-2, 26-28	C	M				C	R	R	R		R		R	R	R*	R*		R	R	R			R				C			R					R			R					R	F	C			R		R					C
				40-4, 26-28	R	P	F			F	R	R			R		R	R			R*	R	R	R					R		C																R	F	F			R		R					C
				41-2, 51-53	F	P	F			C	R	R	R					R					R	R			R				C								R									R	F			F		R		R*			C
				41-4, 51-53	C	G				A	R	R				R														A									F									A	R			R			R				A
				42-2, 55-57	R	P	R			F		R			R																C								R				R		R		R	C	R			F							C
				42-4, 55-57	F	M	R			F		R	R								R*			R			R				C												R					C	R			F							C
				42-6, 55-57	C	M	R			F	R	R	R		R			R					R	R			R				C								R				R		R		R	A	F			C		R					A
400				42-8, 55-57	C	M	R			C	R	F						R					R	R			R				A								R									A	F			F							A
				43,CC	F	M	R			C		R					R							R	R*						C																	A	R			C							C
				44-2, 45-47	C	G	R			F	R	R	F		R		R	R						R			R				A								F				R		R		R	A	C			F		R	R				A
				44-4, 45-47	C	M	F			F	R	R			R		R		R*	R*				R			R				A								F		R	R					R	A	F			R		R	R				A
				44-6, 45-47	F	M	R			C	R	R	R		R			R		R*				R			R				C		R						R								R	A	F			R		R	R	R*			C
				45-1, 62-64	F	M	R			F	R	C	R								R*			R	R*		R		R		C								R				R					C	R			C		R					C
				45-3, 62-64	F/C	M	R			F	R	F	R										R	R			R				A			R			R		R				R					A	F			F		R					C
			5	45-5, 62-64	F/C	M	R			F		A												F							C								R				R		R			A	C			F							F
				47-1, 45-48	R/F	M	R			A	R						R							R	R*				R		?			R					R				R				R	C	R			F							C
450				48-2, 46-48	R	P	F			F	R		R				R		R*		R*				R*		R		R										R			R						C	F			F							A
				49-1, 42-44	F	M	F			F	R	R			R						R*		R	R					R										R									C	F			R		R					A
				50,CC	R	P	R			F			R					R						R																			R		R			F	R			F		R					C
	late Miocene	*Stichocorys peregrina* (lower part)		51-2, 30-32	F	M	R			A	R	R			R		R	R			R*		R	R			R		R				R						R			R	R		R		R	C	F			F		R					C
				52-2, 67-69	F	M	R			F	R	C	R	R	R								R	R			R							R					R				R					C	F			F							C
500				53-1, 25-26	R	P				R		F	R		R		R	R					R	R			R		R										R		R	R	R					F	F			R							C
				54-2, 67-69	F	M	R			A	R		R	R	R									R			R																				R	C	C			F							F
				55-1, 107-109	R	P	R			C	R	R					R							R			R												R						R		R	F	F			R							C
				56-2, 75-77	R	P	R			R		R	R											R										R											R			F	R	R		R							C

Note: Preservation: P = poor, M = moderate, G = good. Abundance: B = barren, R = rare, F = few, C = common, A = abundant. * indicates reworked. The upper boundary of the Pliocene is determined on the basis of nannofossils.

Table 3. Radiolarians from the Neogene sediments of Hole 468.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*Calocycletta costata*	*C. virginis*	*Calocycletta* sp.	*Cannartus laticonus*	*Cannartus* (sp. cf. *C.*) *mammiferus*	*C. petterssoni*	*C. violina*	Carpocaniidae	*Clathrocyclas cabrilloensis*
	early Pliocene	*S. peregrina*, up. pt.	5	1-1, 90–92	R	P		R	R										
	late Miocene	*S. peregrina*, low. pt.	11.5	2-1, 123–125	C	G	A	F	R	F								R	R
		O. antepenultimus	12.5	2-3, 5–7	C	G	A	R		R				R		F			R
		C. petterssoni		3-1, 138–140	A	G	A	F	R	R			R	R					
				3-3, 140–142	F	M	C	C	R	R								R	R
				3-5, 80–82	F	M	C	C	R	F				F	R			R	
				4-1, 40–42	F	M	C	F	R	F				F				R	R
				4-3, 40–42	F	M	C	C		F				R					R
				4-5, 40–42	A	G	A	C	R	F				F	R			R	R
				5-1, 140–142	C	G	C	C	R	F				R	R		R*	R	R
				5-3, 133–135	F	M	C	C	R	F				R	R				R
				5-5, 118–120	F	M	F	C	R	F				F	R			R	R
				6-1, 18–20	F	M	F	C		R			R	F				R	R
				6-3, 18–20	F	M	C	C	R	R				F					R
50				6-5, 18–20	F	M	F	C	R	R			R	R				R	R
				7-2, 100–102	F	M	C	F	R	F				R				R	F
				7-4, 70–72	F	M	R	F	R	R			R	F				R	R
				7-6, 70–72	R	M	C	C	R	R			R	R				F	R
	middle Miocene			8-1, 38–40	F	M	C	C	R	R			R	F				R	R
		Dorcadospyris alata		8-3, 38–40	F	M	C	F					C	C				F	
				9-1, 60–62	F	M	F	R	R	R			C	F	R			F	
				9-3, 60–62	R	P	F	F		R			R	R				R	
				9-5, 60–62	F/C	M	F	F	R				A	A	R			F	
				10-1, 66–68	F	M	C	R					F	F	R			F	R
				10-3, 66–68	R	P	F	R					R	F	R			R	R
100				11-1, 90–92	F	M	F	R		R			F	R				R	
150				13-1, 75–77	R	P	F	R	R	R			R	R				R	
				17,CC	R	P		R			R	R		R	R			R	
				18-1, 56–58	F	P	R	R			F	R			R		R	F	
				18-3, 56–58	F	P	F	R			R	R			R			R	
				18-5, 51–53	F	P	F	R			C	R			R			R	
				18,CC	R	P	R	R			C	F			R		R	R	
				19,CC	R	P					R				R				
				21-1, 9–11	F	P	F	R		R	R	R			R			R	
200				21,CC	R	P					R				R			R	
212.5			16.5	23,CC	R	P													
	early Miocene	*Calocycletta costata*																	

Note: See the note in Table 2 for key to the symbols.

Sample 3,CC of Hole 468B could be placed in the lower upper Miocene *O. antepenultimus* Zone, according to the presence of rare to few specimens of *Ommatartus hughesi* and *O. antepenultimus*. It is obvious, then, that a part of the upper Miocene is not represented by sediments. At Holes 468 and 468B, radiolarian assemblages of the *O. antepenultimus* Zone could be identified; fossils of the upper upper Miocene *S. peregrina* Zone were encountered in Holes 468A and 468B. Radiolarian assemblages of the *O. penultimus* Zone could not be recognized in the Site 468 holes; radiolarians of the lower *S. peregrina* Zone are lacking in Hole 468; those of the *O. antepenultimus* Zone have not been found in Hole 468A. It is probable, therefore, that the upper Miocene sediments constitute a rather thin, condensed (or incomplete) succession.

Only part of the middle Miocene seems to be well represented by a rather thick succession of sediments at

Table 3. (Continued).

Cornutella profunda	*Cyrtocapsella cornuta*	*C. japonica*	*C. tetrapera*	*Dorcadospyris alata*	*D. simplex*	*Eucyrtidium acuminatum*	*E. calvertense*	*E. inflatum*	*Hymeniastrum euclidis*	*Lamprocyrtis hannai*	*L. heteroporos*	*Lipmanella* sp.	*Lithomitra lineata*	*Lithopera neotera*	*L. renzae*	*Lychnocanoma grande*	*Ommatartus antepenultimus*	*Peripyramis circumtexta*	*Pterocanium korotnevi*	*Saturnalis circularis*	*Sethocorys* sp.	*Siphostichoartus* sp. cf. *S. corona*	*Spirema* sp.	*Spongocore puella*	*Spongotrochus glacialis*	*Stichocorys armata*	*S. delmontensis*	*S.* sp. cf. *St. diploconus*	*S. peregrina*	*S. wolffii*	*Stichopera pectinata*	*Stylacontarium acquilonium*	*S. bispiculum*	*Theocalyptra davisiana*	*Theoconus* sp. aff. *T. zancleus*	*Theocorys redondoensis*	*Xiphospira* sp. cf. *X. circularis*
							F				C												R		R				R?	R*		F			R		R
R	F	R	C			R	R		R	C		R		R		F	F		F		F		R	R	F		F		F	R*		C		F	R	R	F
R	R		C			R	R	R*		C				R		A			R		R				A		F					F		C		R	A
R	A	R	F				F			R		R			R	C		R			C	F	R		F		C			F		R	A	F		R	F
R	C	R	R				F			R						C				R	C		R	R	C		R			R		R	F	R		R	C
R	C	R	R			R	C		R	R		R			R	C					F	R			R		R			R		R	F	R		R	C
R	C						C		R	R		R	R			C				R	C	R	R		C		C		R?	F		R	F	R		F	F
F	R	R					F		R	R		R				F					F			R	F		C			F		R	C	R		R	C
	C	R	R				F			R		R	R		R	A		R			F	R		R	A		C	R		A		F	A	R		F	F
R	C						F			F		R			R	C					C		R	R	C		C			A		R	A	F		R	C
R	C	R	R				F		R	F			R		F	F				R	F			R	F		F			C		R	C	F		R	C
R	C	R	F				F			F					R			R		R		R	R		C		R			R	R	R	C	C		R	C
R	C	R	F				F			F			R			R				R	R	R	R	R	C		F			R	R	C	C	C		R	C
R	C	R	F				R		R	R					R	R					R	R	R		C		F			F	R	F	R	R		R	C
R	C		R				F			R			R			R		R			R	R	R	R	C		F			F		C	C	F		R	C
R	C		R				C			F		R	R			R					R		R	R	C		R				R	R	F	R			C
R	C		R				R			R					R						R	R	R	R	C		R			R		F	C	R		R	C
	R	R	R				F			R		R	R						R		F		R	R	C		R			F	R	C	C	F		R	F
R	F	R	R				F		R	F		R	R		R				R				R	R	C		F			R	R	A	F	F		R	C
R	F	R	F				R		R	F											R				C		R			C	R	A	R	R			F
R	C	R	C				C	R	R	F		R	R		R						F	R		R	A		F			R		A	C	R		R	C
R	R	R					C		R	R		R			R						R				C					R		F	F	F		R	C
R	F	F	F				C	F	R	R						R?					F		R	R	F		F			F		F	R	R		R	F
	R	R	R			R	C			F		R									R				A		R			A		C	R	R		R	R
	C	R	R	R			F			R													R		C		R			F		F	C				F
R	A	R	F				F		R	R											R		R		C		R			C		R	F			R	R
							R			R													R		F					R		R					R
	R		R					R																	R		R			R							R
	R				R*																		R		C		R			F			F				C
	C						F			F													R		C					C			F				C
	C	R					R			R		R											R		C	R				C			R				F
R	R	R	R	R			R																		C	R	R	R		F		R	R				R
	R	R	R																						R					R							
	C						F																		C					C			R				C
			R																											R							R
			R																																		R

this site, because the radiolarian assemblage of the upper middle Miocene *Cannartus petterssoni* Zone, especially *C. petterssoni*, was not encountered in Holes 468A and B. In Hole 468, *C. petterssoni* is present in Section 2-3, only; the lower to middle middle Miocene *Dorcadospyris alata* Zone begins with Section 3-1 and ends possibly with Sample 18,CC. In its lower part, the middle Miocene succession is characterized by rare occurrences of *Cannartus mammiferus*, which is progressively replaced by rare to abundant individuals of *Cannartus laticonus* in the upper part. Besides mainly rare occurrences of *Eucyrtidium inflatum* and *Lithopera renzae*, which are assumed to be diagnostic for middle Miocene, various species of *Cyrtocapsella* and *Stichocorys* (except *S. peregrina*) are rare to abundant. The succession below Core 18 of Hole 468 cannot be assigned securely either to the lower middle or upper lower Miocene by means of radiolarians.

Besides rare, sporadic occurrences of *D. alata*, no radiolarians are present that precisely mark the lower

Table 4. Radiolarians from the Neogene and Quaternary sediments of Holes 468A and 468B.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*B. miralestensis*	*Calocycletta* sp.	*Cannartus laticonus*	*Cannartus* (sp. cf. *C.*) *mammiferus*	*C. tubarius/violina*	Carpocaniidae	*Clathrocyclas cabrilloensis*	*Cornutella profunda*	*Cyrtocapsella cornuta*	*C. japonica*	*C. tetrapera*	*Dictyophimus crisiae*
		Hole 468A																				
	Quaternary	*B. miralestensis/ A. angelinum*		1-1, 120–122	R	P			R		R								R*			
				1-2, 88–90	R	P	R	R	F		F											R
		Eucyrtidium matuyamai		1-3, 70–72	R	P		R	R		C								R*			
				1-4, 55–57	A	G	F	R	F	C	A					R		R		R*	R*	R
			1.8	1-5, 4–6	C	G		R	R	R	C					R						R
	Pliocene			2-1, 70–71	C	G		F	R	R	F					R						R
		L. heteroporos		2-3, 70–72	R	P		R	R		F											R
		Stichocorys peregrina (upper part)		3-1, 70–72	C	M	R	F	F	R	F					R						R
				3-3, 47–49	C	M		R	R	F						R			R*			R
			5	4-1, 58–60	R	P			R		R											
	late Miocene	*Stichocorys peregrina* (lower part)		4-2, 51–53	R	P			R			R										
				4-3, 56–58	R	P		R														
			11.5	4-5, 56–58	A	G	C	C	R	F		R					R	F			R	C
35.5	middle Miocene	*C. petterssoni*?		4,CC	C	G	R	C	R		R	R	R			R	R		R		F	
		Hole 468B																				
	Pliocene	*Lamprocyrtis heteroporos*		1-1, 130–132	F	M		F	R	R	R					R		R				F
				1-2, 130–132	R	P		R	F	R											R*	R
		S. peregrina (upper part)		1-4, 130–132	R	P	R	R	F										R*	R*	R*	
			5	2-2, 20–22	R	P		R	R													R
	late Miocene	S. peregrina (lower part)		3-2, 70–72	C	M	R	A	R	F		R				R	R	R			R*	
				3-4, 70–72	C	M	A	C	R	R		R				R	R	R			R*	
50		*O. antepenultimus*	11.5	4-1, 70–72	C	M	A	F	R	R		R				R		R		A	R	
	middle Miocene	*Dorcadospyris alata*		6-1, 60–62	A	G	C	F	R	R		R		R		R		R	A		A	
				6-3, 60–62	A	G	A	F		R						R	R	R	F		A	
				6-5, 60–62	A	G	A	F		R								R	F		A	
				7,CC	C	G	A	C		F				R		R	R	R	F	R	A	
				8-2, 70–72	C	G	A	A	R	F			R			R	F	R	R		A	
				8-4, 70–72	C	G	A	C	R	C						R	F	R	F		C	
				9-2, 54–56	C	G	A	C	R	F						F	F	R	C	R	A	
100				9-4, 54–56	F	M	C	C	R	R						R	R	R	C		C	
				10-2, 54–56	R	P	R	F		R						R	R	R	C		C	
				11,CC	R/F	P		R		R			R					R	C			
150				12-2, 70–72	R	P	F	F	R	R						R		R				
				13-1, 56–58	F	M	C	R		R		F	C			F	F	R		R		
				13-3, 56–58	F	M	F	C	R	R		R	F			R	R	R	F		R	
				13-5, 53–55	R	P		R					R				R		R			
				14-2, 82–84	C	M	F	F	R	R		C	C		R	R	R	R	C	R	R	
				14-4, 82–84	F	M	F	F		R		C	C			F	R		R	R	R	
200				15-1, 43–45	F	M	C	R		R		F	F			R	R			F		
				16-1, 36–38	F	M	F	F		R		F	F			R	R	R	C	R	F	
				17-2, 54–56	F	M	C	R		R		A	C			R			F	R		
				17-4, 54–56	F	M	C	R	R			R	C			R	R			R		
				18-2, 54–56	R	P	F	F				R	R			R	R	R	F		R	
339.5				29,CC	R	P	F	R				R	R			R	R		R		R	

Note: See Table 2 for a key to the symbols.

Table 4. (Continued).

Dorcadospyris alata	*D. simplex*	*Eucyrtidium acuminatum*	*E. calvertense*	*E. inflatum*	*E. matuyamai*	*Hymeniastrum euclidis*	*Lamprocyrtis hannai*	*L. nigriniae*	*L. heteroporos*	*L. neoheteroporos*	*Lipmanella dictyoceras*	*Lithomitra lineata*	*Lithopera neotera*	*L. renzae*	*L. thornburgi*	*Ommatartus antepenultimus*	*O. hughesi*	*Peripyramis circumtexta*	*Pterocanium korotnevi*	*P. trilobum*	*Saturnalis circularis*	*Sethocorys* sp.	*Siphostichoartus* sp. cf. *S. corona*	*Sphaeropyle langii*	*Spirema* sp.	*Spongocore puella*	*Spongotrochus glacialis*	*Stichocorys delmontensis*	*S.* sp. cf. *S. diploconus*	*S. peregrina*	*S. wolffii*	*Stichopera pectinata* gr.	*Stylacontarium bispiculum/acquilonium*	*S. acquilonium*	*Theocalyptra davisiana*	*Theocorys redondoensis*	*Theoconus* sp. aff. *T. zancleus*	*Theocorythium vetulum*	*Xiphospira* sp. cf. *X. circularis*
																			R															F					R
		R						R											R	R		R		R										C					R
					R		R												R						R		R							R	R				R
					F	R				A								R	R	R				R			A							R	A		R	F	C
			R		F	R				A	R		R*					R	R	R						R	F							F	A			R	F
			F		R?	R			A		R							R	R	R		R					A					R		R	A		R	R	F
			R			R			A										R								R							C	R				R
			C						A																R		C			R				F	R		R		C
			C						A									R		R						R	C			R				R			R		C
			R						A									R									R			R				F					R
																															A								
											R																							F					
			R			R											R	R	F	F		R			R	R	R			A		R		A	C				A
			F				R												R	R		F			R		R	F			A			A					F
		R	R			R			A										F								C							F			R	R	F
			R						C			R										R			R		R							C					R
				R*					F							R*			F						R		R			R				A					R
		R							R										R			R					R			R				C					
			R			R	R		?							R	R		F			F			R		F	A		F				A	R				F
			R				R												F	R		C					A	A		F				F	F				F
			F			R	R							R		F	R		F	R		R	?		R		F	F	R				F	F	R		R		F
			R				R										?		C			F	R		R		R	R					F	F					R
			F															R	C			C			R	R	F	R	R					R	R	R			F
			F				R					R							F			F	R		R		F	F			R		A		F				F
			F									R							C			F			R	R	R	R			R		C			R			F
			F				R										?					F	R				F	F	R		F		A		R	R			A
			F				R											R	R		R	F	F		R		F	C			C		F		F	R			F
			F				F					R										F				R	R	F					A		R	R			C
			F				F					R										F	R			R	R	F			R	R	C		F	R			F
							R																		R		R	R					C		R				
			R									R						R									R	R					R			R			F
			R				R					R					?									R	F						C		R	R			R
R	R*		F	R			F					R		F				R				F	R			R	F	F			R	R	F		F				F
			C				R					R										R	R		R		A	F			R		C		F				C
			R																								C	R			R		F		R				F
			R				R															R				R	C	R			R		A						R
	R*		C	R			R															R				R	C	F	R		F	R	C		R	R			C
			C				R					R		R	R							F			R		C	R	R		R		F			R			F
	R*		R				R															R					C	R			F		C			R			C
	R*		C	R			R					R										R			R		C	R			F		R			R			F
			C	F			R																		R		C				C		F			R			F
			F	R			R																				C	R			R		R						F
	R*		R	R			R															R			R		C	R					F						F

boundary of the middle Miocene. On the other hand, mainly lower Miocene species, such as *Calocycletta costata, C. virginis*, and *Dorcadospyris simplex*, are rare to common in Cores 17 through 21 (Hole 468). According to the results of diatom research, Sample 21,CC still contains middle Miocene species. Therefore the lower Miocene radiolarians are probably reworked.

In the region of Sites 467 and 468, the Quaternary radiolarian assemblages mainly consist of cold-water species. Site 468 differs from Site 467, however, in that some warm-water species (*Amphirhopalum ypsilon, Theocorythium vetulum*) joined the North Pacific assemblage.

Site 469

At Site 469 on the foot of Patton Escarpment, a single hole was continuously cored to a total depth of 453.5 meters, the lower 59.5 meters in the basement. It contains abundant to rare middle Miocene through Quaternary radiolarians of poor to good preservation (Cores 1-25). Very rare and poorly preserved lower middle Miocene radiolarians occur sporadically in Cores 30, 35, 36, and 38, immediately above the basement. The poor remains of siliceous microfossils in some cores of the lower middle Miocene section suggest that the absence or presence of radiolarians in that region is due to diagenesis rather than to the primary lack of siliceous skeletons. Table 5 lists radiolarians from the Neogene and Quaternary sediments of Hole 469.

The Quaternary sediments of Hole 469 yielded radiolarian assemblages containing northeastern Pacific cold-water species as well as less numerous equatorial warm-water species; Kling's (1973) zonation was applicable. Cores 1 through 3, Section 1 can be assigned to the upper Pleistocene *Axoprunum angelinum* Zone, as indicated by the rare to abundant presence of *Lamprocyrtis nigriniae* and *Lamprocyrtis neoheteroporos* and the absence of *Eucyrtidium matuyamai* and *Lamprocyrtis heteroporos*. The upper Pleistocene interval contains sporadically older radiolarians, such as different species of *Cyrtocapsella, E. matuyamai, L. heteroporos*, and *Stichocorys peregrina*, which must be considered to be reworked. Characterized by the rare to common occurrence of *E. matuyamai* and *L. neoheteroporos* in the upper part and *L. heteroporos* in the lowermost part, Section 3-2 through Section 5-5 can be placed into the lower Pleistocene/uppermost Pliocene *E. matuyamai* Zone.

Deposition in the late Pliocene (*L. heteroporos* Zone) is indicated for Sample 5,CC through Section 8-1 by the few to abundant presence of *L. heteroporos* and the absence of *E. matuyamai* and *Stichocorys peregrina*. The association of common to abundant individuals of *L. heteroporos* and rare to common occurrences of *S. peregrina* suggest that Section 8-3 through Sample 11,CC (*S. peregrina* Zone, upper part) were deposited in the early Pliocene. The boundary between Miocene and Pliocene seems to be marked by a sudden and abundant appearance of *L. heteroporos*.

Section 12-1 through Sample 17,CC are upper Miocene. The fact that this interval contains few to abundant *S. peregrina* but lacks *Ommatartus antepenultimus* and, except for Sample 17,CC, *Ommatartus penultimus* suggests that the lower part of the upper Miocene succession (*O. antepenultimus* and *O. penultimus* Zones) is partly or totally missing at Site 469.

Cannartus petterssoni has not been found below Core 17. This indicates that the upper middle Miocene *C. petterssoni* Zone is either not represented at all or represented by a condensed succession only. Cores 19 through 30 are distinguished by the presence of *Cannartus laticonus, Cannartus mammiferus*, various species of *Cyrtocapsella, Stichocorys delmontensis, Stichocorys wolffii* a.o., which suggests deposition during the early middle Miocene (*Dorcadospyris alata* Zone). The poor assemblages gained from Cores 32 through 36 were probably deposited in the early middle Miocene. A definite conclusion cannot be drawn, regarding the ages of Cores 38 through 39. Sample 38,CC yielded *Cyrtocapsella tetrapera* and *Cannartus violina*. Available evidence suggests that *C. violina* is restricted to the lower Miocene. Consequently it follows that Samples 38,CC and 39,CC are either lower middle Miocene with *C. violina* being reworked or upper lower Miocene with *C. violina* as an authochthonous fossil.

According to the radiolarian zonation, the Quaternary and Pliocene seem to be rather entirely represented at Site 469, perhaps with the exception of the upper Quaternary *Botryostrobus miralestensis* Zone. Upper and middle Miocene, however, seem to be only incompletely represented by sediments, because the assemblages with *O. penultimus, O. antepenultimus*, and *C. petterssoni* are partly or totally missing. The Pliocene and Quaternary radiolarian zones introduced by Kling (1973) are restricted to the cold-water regions of the North Pacific; they are associated with few specimens of equatorial species in Cores 1 through 8 at Site 469, such as the Pliocene-Quaternary species *Amphirhopalum ypsilon, Ommatartus tetrathalamus, Spongaster tetras*, and *Theocorythium vetulum*. The lower Pliocene and Miocene assemblages are for the most part composed of warm-water species, the number of which decreases from Miocene toward the lower Pliocene. The total lack of the equatorial lower middle Miocene *Dorcadospyris alata* may be considered an indication of cold-water influence.

Site 470

East of Guadalupe Island, 8 km south-southwest of the Experimental Mohole, Hole 470 was continuously cored to basalt at 167 meters. Hole 470A was cored from 47.5 to 95 meters and from 161.5 to 168 meters in sediment, then continuously cored in basalt to 215.5 meters. Few to abundant middle Miocene through Quaternary radiolarians of moderate to good preservation were recovered from Cores 7 through 17 in Hole 470 (lower Pliocene through middle Miocene) and from Core 1, Section 3 through Core 5 in Hole 470A (lower Quaternary and upper Miocene). Core 1, Section 3 through Core 6 of Hole 470 and Core 1, Section 1 of Hole 470A yielded rare, poorly preserved radiolarians. Sections 1-1, 4-1, 5-1, and 18-2 of Hole 470 are barren.

Tables 6 and 7 list radiolarians from the Neogene and Quaternary sediments of Holes 470 and 470A, respectively.

Except for Section 2-5, the upper layers of Hole 470 from Cores 1 through 6 are so poor in radiolarians that only incomplete zonal classification is possible. Section 2-5 must be assigned to the lower Pleistocene–upper Pliocene *Eucyrtidium matuyamai* Zone, because it contains rare to few individuals of the zone fossil and of *Lamprocyrtis neoheteroporos* and *L. heteroporos* as well as rare members of the equatorial species *Ommatartus tetrathalamus, Spongaster tetras*, and *Theocorythium vetulum*. A very thin cover of Quaternary sediments was encountered at Site 470A. Section 1 of Core 1 contains nondiagnostic radiolarians only and is tentatively assumed to have been deposited in the late Quaternary. Sediments from below this section can be assigned to the lower Quaternary *E. matuyamai* Zone, because they yielded both *Lamprocyrtis neoheteroporos* and *L. heteroporos*.

There are enough equatorial species in the Pliocene and Miocene cores of Hole 470 to permit recognition of equatorial zones. The first rare appearance of *L. heteroporos*, the last occurrences of *S. peregrina*, and the absence of the diagnostic Pleistocene and Miocene species indicate that deposition took place in the early Pliocene (upper part of *S. peregrina* Zone, Core 6, Section 2 through Core 7 of Hole 470). The Miocene/Pliocene boundary is placed between Cores 8 and 7 below the first appearance of *L. heteroporos*, which follows in that region immediately above the last presence of *Ommatartus penultimus*. In Hole 470A, the upper part of the *S. peregrina* Zone could not be recognized.

The upper Miocene lower part of the *S. peregrina* Zone cannot be separated from the underlying *Ommatartus penultimus* Zone. Both of them comprise Section 8-1 through Section 9-1 of Hole 470 and Section 2-1 through Section 4-3 of Hole 470A. They are distinguished by few to abundant occurrences of *S. peregrina* and by rare individuals of *O. penultimus*. Besides several nondiagnostic radiolarians, there are rare to abundant occurrences of *Lithopera neotera* and *Stichocorys wolffii*, which are presumably reworked, according to present knowledge. *Stichocorys delmontensis* joins the assemblage in the lower part of the uppermost Miocene section.

According to Riedel and Sanfilippo (1978) and in accordance with Kling (1973), the *O. antepenultimus* Zone is defined by the evolutionary bottom and the morphotypic top of *O. hughesi*. Consequently, the lower boundary of the lower upper Miocene *O. antepenultimus* Zone can tentatively be placed between the main occurrences of *O. hughesi* and *Cannartus petterssoni* in Hole 470 (either below Section 12-1 or below Section 12-7). Various species of *Cyrtocapsella, Lithopera, Stichocorys delmontensis*, and *S. wolffii* complete the radiolarian assemblage of the *O. antepenultimus* Zone. The succession of Hole 470A ends with Core 6 in the lower upper Miocene *O. antepenultimus* Zone, immediately above basalt.

The boundary between middle and late Miocene is thus defined by the first appearance of the typical *O. hughesi* (below Section 12-7). The transition between *C. petterssoni* and *O. hughesi*, however, cannot always be clearly recognized, and it is sometimes difficult to separate one species from the other. At Site 470, the upper middle Miocene *C. petterssoni* Zone comprises Section 13-1 through Section 15-5. Its lower boundary is defined by the first appearance of *C. petterssoni*, which is associated with *Cannartus laticonus*, various species of *Cyrtocapsella, Lithopera*, and *Stichocorys*.

The lowermost part of the succession encountered at Site 470 (Sample 15,CC through Core 17) contains few to abundant, well-preserved radiolarians of the lower middle Miocene *Dorcadospyris alata* Zone: *C. laticonus*, various species of *Cyrtocapsella, Lithopera*, and *Stichocorys* etc., without *C. petterssoni*. Core 18, immediately overlying the basalt, is barren.

The Pliocene and Miocene radiolarian assemblages of Site 470 are for the most part composed of equatorial warm-water species. Nevertheless, as at Site 469, the total lack of the equatorial middle Miocene *Dorcadospyris alata* suggests that a certain cold-water influence prevailed during that time. As far as we can conclude from the sparse evidence, the Quaternary assemblage consists of mixed cold- and warm-water species.

Site 471

Hole 471 was drilled on the distal portion of a deep-sea fan west of the foot of the continental slope off Baja California. Hole 471 was continuously cored to the top of the diabase at 741.5 meters.

The interval between Section 1-5 and Section 5-4 is barren at Site 471. Sections 3 and 5 of Core 1 contain only rare, nondiagnostic radiolarians, and Section 1 yielded with *Amphirhopalum ypsilon* and ?*Ommatartus tetrathalamus*—two species of the Quaternary–Pliocene. The latter section (5-4) does contain only rare individuals of *Stichocorys peregrina* and can be tentatively assigned to the Quaternary. The Quaternary/Pliocene boundary can be placed on top of the youngest fossiliferous layers (Section 5-6) with *Lamprocyrtis heteroporos*. It must be emphasized, however, that the true position of that boundary at Site 471 cannot be found by means of radiolarians. Table 8 lists radiolarians from the Neogene and Quaternary sediments of Hole 471.

Deposition in the late Pliocene is indicated for Section 5-6 through Section 6-1 by rare occurrences of *L. heteroporos* and the absence of *Eucyrtidium matuyamai;* otherwise there are only rare, nondiagnostic radiolarians. The extinction of *Stichocorys peregrina* marks the boundary between the upper Pliocene *L. heteroporos* Zone and the lower Pliocene *S. peregrina* Zone (upper part), which comprises the interval between Section 6-3 and Section 10-1. Mostly few to common, moderately to well-preserved radiolarians are significant for

Table 5. Radiolarians from the Neogene and Quaternary sediments of Hole 469.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Amphirhopalum wirchowii*	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*B. miralestensis*	*Calocycletta* sp.	*Cannartus laticonus*	*C.* (sp. cf. *C.*) *mammiferus*	*C. petterssoni*	*C. violina*	*Carpocaniidae*	*Clathrocyclas cabrilloensis*	*Cornutella profunda*	*Cyrtocapsella cornuta*	*C. japonica*	*C. tetrapera*	*Dictyophimus crisiae*	*Dorcadospyris forcipata*	*Eucyrtidium* sp. cf. *E. acuminatum*
		Botryostrobus miralestensis/ Axoprunum angelinum		1-1, 30–32	A	G	F		F	R	R	F						R			R*	R*		R		R
				1-2, 53–55	A	G			R	R	F	A						R		R				F		F
				1-4, 67–69	R	P		R	R	F		C											R*	R		
				2-1,120–122	R	P			R	R		C						R						R		
				2-3, 110–112	R	P	R			R		R						R								
	Quaternary	*Eucyrtidium matuyamai*		3-1, 40–42	F	M	R	R	R	R	R	A						R		R				R		R
				3-2, 95–97	F	M	R		R	R	R	A						R						R		R
				3-4, 92–94	F	M	R	R	C	R	R	C						R								R
				3-6, 92–94	R	P	R		F	F		A								R				R		
				4-1, 120–122	R	P	R		R	F		A						R					R*	R		
				4-3, 95–97	R	P			F	F	R	F						R								R
			1.8	5-1, 80–82	R/F	P			F	R		A										R*		F		
	Pliocene			5-3, 80–82	F/C	G		R	F	R	F	F						F						R		F
				5-5, 80–82	C	G	R	R	C	F	R	F						F		R				R		R
				6-1, 80–82	C	G			F	F	F	C						F						F		F
50		*Lamprocyrtis heteroporos*		6-4, 20–22	F	M	F	R	F	R	F	C						F		R				R		R
				6-6, 120–122	C	G	R	F	C	F	R	C						F		R				R		R
				7-1, 30–32	C	G	R	F	C	F	R	C						F								R
				7-2, 30–32	F	M		R	C	F	F	F						F		R						R
				7-5, 90–92	F	M	F	R	C	R	R	R						R		R				R		
		Stichocorys peregrina (upper part)		8-1, 60–62	F/C	M		F	F	F	F	C						R		R				R		R
				8-3, 60–62	C	M	R	R	C	R	F	R						R		R				R		
				9-1, 70–72	F	P	R		F	R	R	R						R						R		
				10-1, 63–65	R	P	F		F	F	R							R			R*					R
				10-3, 63–65	F/C	M	R		C	F	R	R						R		R				R		R
				11-1, 70–72	C	G	F		A	R	R	R						R		R	R*			R		R
100			5	11-3, 70–72	C	G	R		A	F	R	R						R		R						
	late Miocene	*S. peregrina* (lower part) to *Ommatartus penultimus/ antepenultimus*		12-1, 70–72	C	M	R		A	R	A							R		R						R
				12-4, 70–72	C	G	R		C	R	A	C						R		R						
				12-6, 70–72	C/A	G	R		A	R	F	F								R	R					
				13-1, 70–72	C	M	R		C	R	C	R						R		R	F					
				13-4, 70–72	C	G	R		A	R	C						R*	R	F	R	R			R		F
				14-1, 70–72	C	M	F		A	R	C								R	F	R			R		R
				15-1, 70–72	C	M	R		C	R	C	R						R	F	F	F	R		R		R
150				16,CC	F	M	R		C		F	R	R			?		R	R	F						
				17-1, 40–42	F	M	F		C	R	R		R					R	C	R	F	C		R		R
	middle Miocene	*Cannartus petterssoni* to *Dorcadospyris alata*	11.5	17,CC	C	M	R		C	R	F	R				R		R		R	R			F		
				19-1, 35–37	F	M	C		F	R	R	R	F	F				F		F	R	A				F
				20-1, 105–107	C	G	A		F	R	F		R	F				R		F	F	R	F			
				20-3, 45–47	C	M	A		C	R	F		R	C	R			R	R	R	C	R	C			
200				22-1, 90–92	F	M	A		F	R	F		R	R	R			R	R	F	R	R	R			
				23-1, 146–148	F	M	A		F	R	F		R	R	R					F	C	R	C			
				23-3, 25–27	F	M	A		C	R	F			R	F			R	F	R	C		C	R		
				24-1, 60–62	A	G	A		A	R	F							R	R	R	A	R	A	R		
				24-3, 35–37	C	G	A		C	R	R			R				R	R	R	A		A			
				24-5, 85–87	C	G	C		A	R	R		R	R				F	R	R	C		C			
				25-1, 58–60	C	G	C		C	R	R		R	C	R			R	R	R	A		A			
250				30-1, 34–36	R	P	R		R				R	R				F		R		R			R	
				32-1, 55–59	B																					
300				34,CC	R	P																	R			R
				35-1, 70–72	R	P			R									R			R		F			
350				36-1, 140–142	R	P	R		R				R					R					R			
				38,CC	R	P											R						R			
				43-2, 79–81	B		unidentifiable remains																			

Note: See Table 2 for a key to the symbols.

Table 5. (Continued).

E. calvertense	*E. inflatum*	*E. matuyamai*	*Hymeniastrum euclidis*	*Lamprocyclas maritalis polypora*	*Lamprocyrtis hannai*	*L. nigriniae*	*L. heteroporos*	*L. neoheteroporos*	*Lipmanella dictyoceras*	*Lithomitra lineata*	*Lithopera bacca*	*L. neotera*	*L. renzae*	*L. thornburgi*	*Lychnocanoma grande*	*Ommatartus hughesi*	*O. penultimus*	*O. tetrathalamus*	*Peripyramis circumtexta*	*Pterocanium korotnevi*	*Saturnalis circularis*	*Sethocorys* sp.	*Siphostichoartus* sp. cf. *S. corona*	*Spirocyrtis* sp. aff. *S. scalaris*	*Spongaster tetras irregularis*	*Spongocore puella*	*Spongotrochus glacialis*	*Stichocorys delmontensis*	*S.* sp. cf. *S. diploconus*	*S. peregrina*	*S. wolffii*	*Stichopera pectinata*	*Stylacontarium acquilonium*	*S. bispiculum*	*Theocalyptra davisiana*	*Theoconus* sp. aff. *T. zancleus*	*Theocorys redondoensis*	*Theocorythium trachelium*	*T. vetulum*	*Xiphospira* sp. cf. *X. circularis*
R			R	R	R	F	R*	F*										R	F	F		R		R			C			R*			C		A	C			R	F
R			R	R	R	A		R*	R									?	R	F	R				R	R	A						F		A	F			R	F
R		R*	R																			R					F						C		C	R				F
R			R	R		R		R*																			F						F		C					F
				R																R		R					R						C		F					R
			R	R	R	F		R	R									R		R	R	R					F						F		C	R			R	F
		R	R		R			C											R	R		R				R	F						C		A	C				F
		F	R	R	R			C										R	R		R	R					C						R		A	F				R
		R	R	R				F										R	R								C						F		A	R				F
		R						R														R					C						C		F					R
																				R							R						C		F					F
R		F	R		R			F											R			R					C						F		A	R				F
R		F	F					C	R									R	R						R	R	A						F		A				F	F
R			F				R	A	R									R	F	R	R					R	A						F		A				R	F
F		?	R		R		A				R*					R*		R	F	R	R	R				R	A						F		A	R		R	R	A
R			F		R		F	?												R	R						A						R		A					F
F			F	R	R		C												F	F	R	R	F			R	A						F		A			R		C
F			F		F		C												R	R	R					R	A						C		A			R		F
R			F				C												R	F		R				R	C					R	F		C				R	F
R			R		R		C												R	F		R				R	C						R		C					R
R			F		R		C												R	R	R		R				C						F		C				R	F
F			F	F	R		A												R	F	R					R	A			F			C		R				R	A
							C												R	F	R	R					C						C							C
R																											R			R			C		R					R
R					R		C												R	R	R						C			R			C		R					C
R			R		R		A												R	R	R	R				R	A			C			R		F	R				A
F			R		R		A												R	R	R	R					C			F			F		R					A
R			F		R					R										R		R					C			A			F		R					F
R			R		R														R	R		R	R			R	A	R		C	R		A		R		R			A
R			R		R														R	R	R	F	R				C			C			F							A
R			R		R															R		R	R			R	C			A	R		A							C
F			F		F						R									R		C	R			R	C			A	R		C			R	R			F
R			F		F															F							C	F		A	A		A			R	R			F
R			F		F						R								R	R		R	R			R	F	R		A	A		A			R	R			C
R			R		R										R							R				R	C			C	C		A						R	C
R					F											R			R	F	R	F	R			R	C	R		F	C	R	C		R	R				C
F			R		F					R					R	F	R?		R	R		R	F			R	C			A	C		A		R	R				C
R			R		R										C				R	C	R	F	R			R	C	R	R	R	A		R		F	R	R		R	F
F	R		F		R					R		R	R		A				R			F				R	A	F			F	R	F	F	F		C			A
F			F		R				R	R		R	R		F							F	R			R	A	F			F	R	F	C	F		R			F
R	R		R							R					C							F					C	C			R	R	R	F	F		F			C
F	R				R										C						R	R	R			R	C	F			F			R	F					C
F					F				F			R	R	R	C						R	F	R			R	C	R			F			C	C		R			C
C					R				R						F						R	F				R	A	F			F	R	F	A	F		R			A
F					R				R				R		R						R	F	R			R	F	R			F		A	F	R		F			A
F	R		R		F				R			R	F		R						R	R	R			R	A	R			R	R	C	F	C		R			C
C	R		R		F				R			R			R						R	R				R	F	F			R	R	F	A	F		R			F
R			R																								F	R			F		R	R						C
																																		R						R
																																	R							
																											F				R		R	R			R			F
			R																								F				R		R	R						R
																																								R

Table 6. Radiolarians from the Neogene and Quaternary sediments of Hole 470.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*B. miralestensis*	*Calocycletta* sp.	*Cannartus laticonus*	*C.* (sp. cf. *C.*) *mammiferus*	*C. petterssoni*	Carpocaniidae	*Clathrocyclas cabrilloensis*	*Cornutella profunda*	*Cyrtocapsella cornuta*	*C. japonica*	*C. tetrapera*	*Dictyophimus crisiae*
	Quaternary	*Botryostrobus miralestensis/ Axoprunum angelinum*		1-1, 60–62	B																	
				1-3, 60–62	R	P					R											
				1-5, 71–73	R	P																
				2-1, 27–29	R	P																
			0.9	2-3, 27–29	R	P					R											
		Eucyrtidium matuyamai		2-5, 27–29	F	P	R	R	R	R	F					F	R					R
				3-1, 20–22	R	P																
			1.8	3-3, 15–17	R	P				R												
	Pliocene	*Lamprocyrtis heteroporos*		4-1, 84–86	B																	
				4-3, 84–86	R	P																
				5-1, 70–72	B				R													
				5-3, 40–42	R	P	R															
50				6-1, 70–72	R	P			R											R*		
		Stichocorys peregrina (up. pt.)		7-1, 70–72	F	P		C	F	R	R						R	F	R*		R*	
			5	7-3, 70–72	R/F	P	R	C	R	R								R				
	late Miocene	*S. peregrina* (l. pt.)		8-1, 30–32	A	M	R	A	R	C	R					R	R	C				R
		Ommatartus penultimus		8-3, 70–72	F/C	M	F	F	R	R	F					R		F				R
				9-1, 70–72	C/A	G	F	C	R	C						R	R	F				R
		Ommatartus antepenultimus		9-3, 70–72	C	G	A	C	R	F		R				R	R	R				
				10-1, 28–30	A	G	C	A	R	F						R	F	R	R*			R
				11-1, 70–72	F	M	F	F	R	F				R		R	F	R				
				11-3, 70–72	F/C	M	F	C		R						R	F	R				R
100				11-5, 70–72	F	P	F	C	R	R						R	R	R	R*			
				11-7, 45–47	C	M	F	A	R	R					R	R	R	R				
				12-1, 6–8	A	G	C	A	R	R				R		F	F	F		A		R
				12-3, 70–72	A	G	F	A	R	F				R	R	R	C	F		A		R
				12-5, 70–72	C	G	F	A	R	R				R	R	F	F	F		R		R
			11.5	12-7, 70–72	C	G	F	A	R	R				R	R	F	C	F		A		R
	middle Miocene	*Cannartus petterssoni*		13-1, 70–72	A	G	A	A	R	R					C	R	R	F		A		
				14-1, 70–72	A	G	C	A	R	R		R			C	R	R	F		A		
				15-1, 70–72	F/C	G	A	F		R		R		R	F	R	F	R		R		
				15-3, 70–72	F	G	A	C	R	R			R		C	R	R	F	C	R	R	
				15-5, 70–72	C	G	A	F	R	R		R	C		F	R	R	R	F	R	R	
		Dorcadospyris alata		16-1, 70–72	F	M	A	F	R	F						R	R	F	F		R	
150				16-3, 70–72	F/C	G	A	C	R	R		R	R	F		R		F	F			
				17-1, 60–62	F	G	A	C	R	R		R	R	F				R	F	R	R	R
				17-3, 60–62	A	G	A	A	R	F			F	R		R	R	R	C		R	
168.5				18-2, 63–65	B																	

Note: See Table 2 for a key to the symbols.

the lower Pliocene succession. Its lower limit is indicated by the first appearance of *L. heteroporos*. Besides *S. peregrina*, with rare to abundant occurrences, *Ommatartus penultimus* is another rare to common species that survived the Miocene/Pliocene boundary.

The upper Miocene cores of Hole 471 contain a radiolarian assemblage that is rather rich in species and almost exclusively composed of warm-water species. The equatorial zonation is therefore applicable. Deposition in the late late Miocene (lower part of the *S. peregrina* Zone) is suggested for Section 10-3 through Section 17-1 by the presence of *S. peregrina, S. delmontensis, S. wolffii, O. penultimus*, and *O. antepenultimus* and by the absence of *L. heteroporos*. Separating the upper upper Miocene *S. peregrina* Zone from the middle upper Miocene *O. penultimus* Zone is not possible at Site 471, because the first appearances of *S. peregrina* and *O. penultimus* nearly coincide, and because the occurrences of *S. delmontensis* and *S. peregrina* considerably overlap. There is no radiolarian

Table 6. (Continued).

Eucyrtidium acuminatum	*E. calvertense*	*E. inflatum*	*E. matuyamai*	*Hymeniastrum euclidis*	*Lamprocyrtis hannai*	*L. heteroporos*	*L. neoheteroporos*	*Lithomitra lineata*	*Lipmanella dictyoceras*	*Lithopera bacca*	*L. neotera*	*L. renzae*	*L. thornburgi*	*Lychnocanoma grande*	*Ommatartus antepenultimus*	*O. hughesi*	*O. penultimus*	*O. tetrathalamus*	*Peripyramis circumtexta*	*Pterocanium korotnevi*	*P. trilobum*	*Saturnalis circularis*	*Sethocorys* sp.	*Siphostichoartus* sp. cf. *S. corona*	*Spirema* sp.	*Spongaster tetras*	*Spongocore puella*	*Spongotrochus glacialis*	*Stichocorys delmontensis*	*S. peregrina*	*S. wolffii*	*Stichopera pectinata*	*Stylacontarium acquilonium*	*Theocalyptra davisiana*	*Theoconus* sp. aff. *T. zancleus*	*Theocorys redondoensis*	*Theocorythium vetulum*	*Xiphospira* sp. cf. *X. circularis*
																												R					F					R
																																	R					
																																	F					R
																																	R					R
R	R		R	F	R	R*	F		R									R	R	R	R		R			R		C				R	F	C	F		R	F
																												R					R					
	R			R																								R					F					R
																												R					R					
																																	R					
																									R								F					R
R	R			R	R	R												R					F		R		R	C		R			C	R	R		R	C
	R					R																						F		R			C					C
R	R			F	F						R*						R			R	R	R	F	R	R		R	C		C			A	R	R			A
F	R			F	R						R*				R		R			R	R		R	F	R		R	C		C	R		A	F	R			A
R	R			F	F				R		R*			F	R	R	R		R	R	R		F	F	R		R	A	A		C	R	A	F	F			C
F		R		F	F					R				R		C			R		R		R	R	R		R	A	A		A		C	F	F			A
	F	R		R	F				R	R					R	R			R		R	R	C	C	R		R	A	A		A		A	C	A	R		C
	F			F	F					R	R				F	F			R		R	R	R	F	R		R	A	C		C	R	F	C	R	R		C
	R				F						R			R	R	F					R		F	F				A	F		A	R	C	F	F	R		A
	F			R	R				R							R					R	R					R	A	C		C	R	F	R	R	R		F
	C			R	F				R	R	R			F		F			R		R	R	F	R	R		R	C	A		F	R	A	C	R	R		A
	F	R		R	C				R							F					R	R	C	C	R		R	A	C		C	R	A	A	R	R		A
R	R			R	C				R					R		F			R		F	R	A	F	R			A	C		F	R	A	A				A
	C	R		F	A				R					R		F			R		R	R	C	F	R		R	A	A		C		C	C	F	R		A
R	R			C	C				R					R		C			R		R	R	F	R	F		R	A	A		C	R	A	C	F	R		A
	C			F	C			R						R					R		R	R	F	R	R		R	A	C		C		A	C	R	R		A
	F			R	F			R	R					F		R			R	R	C		F	R			R	A	C		C	R	C	F	R	R		A
	C			R	C			R	R		R		R	R					R				F	R	R			A	F		C		F	C		R		A
	C			F	C			R				R		R									F	R	R		R	A	F		C	R	C	F	R	R		A
	C	R		F	F			R			F	F	R	C									C	R			R	A	F		C	R	C	A	R	R		C
	F			R				R	R			R	R	F								R	F	R	R			C			R		C	A		R		C
	C			R	F				R			F	R	C								R	R	R	R			A	F		C	R	F	F		R		A
	C			R	F				R		R	R		R									F	R	R			C	R		C		C	R		R		A
	C			C	F				R		R	R		C									C		R		R	C	R		A	R	A	C				C

species left to define the upper limit of a possible *O. penultimus* Zone. The lower boundary can be defined rather exactly, however, by the extinction of *O. hughesi* and by the first appearance of *O. penultimus*. The boundary can therefore be placed below Section 17-1, provided that the two events are not simulated by dissolution or reworking. Besides several nondiagnostic species, Sample 17,CC contains *S. delmontensis, S. wolffii*, and *O. antepenultimus*, and Section 23-1 yielded rare to few specimens of *O. antepenultimus, O. hughesi*, and *Cannartus petterssoni* (*O. antepenultimus* Zone). Samples 23,CC and 28,CC contain very rare and poorly preserved lower upper Miocene radiolarian assemblages. All of the remaining cores of Site 471 lack radiolarians or bear only indeterminable fragments, frequently with heavy crystalline overgrowths.

Site 472

Hole 472 was drilled to the west of Site 471 to obtain a pelagic upper Neogene record at this latitude away

Table 7. Radiolarians from the Neogene and Quaternary sediments of Hole 470A.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*B. miralestensis*	*Cannartus laticonus*	*C.* (sp. cf. *C.*) *mammiferus*	*Clathrocyclas cabrilloensis*	*Calocycletta* sp.	Carpocaniidae	*Cornutella profunda*	*Cyrtocapsella cornuta*
50	Quaternary	*B. miralestensis/ A. angelinum*		1-1, 30–32	R	P		R	F								C	
		E. matuyamai		1-3, 30–32	A	G		A	C	R	F						C	
	late Miocene	*Stichocorys peregrina* (lower pt.) to *Ommatartus penultimus*		2-1, 80–82	A	M	R	A	F	C	C						C	
				3-1, 30–32	A/C	M	R	A	F	R	R					R	F	
				3-3, 30–32	A	M	R	A	R	F	R					F	C	
				3-5, 30–32	F	P	R	C	R	R	C					R	C	
				4-3, 62–64	A	G	F	C	R	F	F			R	R	R	C	
		Ommatartus antepenultimus		4,CC	A	G												
				5-1, 60–62	C	G	A	A	R	F	R		R	F		R	F	
100				5,CC	A	G						R	F					
			11.5															
171.0	middle Miocene	*Cannartus petterssoni*?		6-1, 70–72	R/F	P	F	C	R	R						F		C

Note: See Table 2 for a key to the symbols.

from terrigenous influences such as those affecting Site 471. Hole 472 was continuously cored to the basaltic base at 112 meters.

The uppermost Sample 472-1-1, 1–2 cm contains a typical equatorial radiolarian assemblage deposited in the early Quaternary (? through late Pliocene), which is composed of *Amphirhopalum ypsilon, Ommatartus tetrathalamus, Pterocanium praetextum, P. prismatium, Theocorythium trachelium, T. vetulum*, etc. The usually more frequent equatorial species *Spongaster tetras* is lacking.

Rare to common, poorly preserved nondiagnostic radiolarians were recovered from Section 1-1 through Sample 1,CC. Cores 2 through 3 are barren, Cores 5 through 12 contain rare to abundant, poorly to well-preserved radiolarian assemblages deposited in the early late through middle middle Miocene. Sample 13,CC consists only of downhole contaminants. Radiolarians from the Neogene and Quaternary sediments of Hole 472 are listed in Table 9.

The Miocene radiolarian assemblages are also composed of warm-water species. Section 4-1 yielded few, nondiagnostic radiolarians; Section 5-1 through Section 6-1 contain *Ommatartus penultimus, O. antepenultimus, O. hughesi, Stichocorys peregrina, S. delmontensis*, and *S. wolffii* and can be assigned, therefore, to the *O. penultimus* Zone. Riedel and Sanfilippo (1978) placed the boundary between *O. penultimus* and *O. antepenultimus* Zones immediately above the last occurrence of *O. hughesi*. Therefore the *O. penultimus* Zone would only comprise Section 5-1 at Site 472. Alternatively, this boundary can be drawn below the first appearance of *O. penultimus*. Deposition in the early late Miocene (*O. antepenultimus* Zone) is indicated by the rare to common presence of *O. antepenultimus, O. hughesi*, rare to abundant occurrences of *S. delmontensis* and *S. wolffii* (Section 6-3 through Section 9-1), and by the absence of *O. penultimus* and *S. peregrina*. The boundary between middle and upper Miocene (i.e., the boundary between *C. petterssoni* and *O. antepenultimus* Zone) may just as well be placed immediately below the first appearances of *O. hughesi* and *O. antepenultimus* (below Section 9-1) as above the last presence of *C. petterssoni* (Section 8-1).

Deposition in the late middle Miocene (*C. petterssoni* Zone) is suggested for Section 9-3 (or Section 8-3) through Section 10-1 by the presence of *C. petterssoni* and *C. laticonus*, as well as by less diagnostic species such as *S. delmontensis, S. wolffii*, and *Cyrtocapsella japonica*.

The deepest part of the succession at Site 472, below Section 10-1, possibly belongs to the *Dorcadospyris alata* Zone, because it contains *C. laticonus* and various species of *Cyrtocapsella* and lacks *S. petterssoni*.

Site 473

Hole 473 on the Rivera Plate south of Tres Marias Islands was cored continuously to obtain an upper Neogene reference section at the mouth of the Gulf of California east of the crest of the East Pacific Rise. The hole penetrated 287.1 meters to the basaltic rocks.

Rare to common, poorly to moderately preserved upper Quaternary radiolarians were recovered from Cores 1 through 4. Cores 5 through 16 are barren or contain only very rare, mainly nondiagnostic radiolarians. Cores 17 through 21, Section 1 yielded rare to abun-

Table 7. (Continued).

C. japonica	*C. tetrapera*	*Dictyophimus crisiae*	*Eucyrtidium acuminatum*	*E. calvertense*	*Hymeniastrum euclidis*	*Lamprocyrtis hannai*	*L. heteroporos*	*L. neoheteroporos*	*Lipmanella dictyoceras*	*Lithopera bacca*	*L. neotera*	*Ommatartus antepenultimus*	*O. hughesi*	*O. penultimus*	*O. tetrathalamus*	*Peripyramis circumtexta*	*Pterocanium korotnevi*	*P. trilobum*	*Saturnalis circularis*	*Sethocorys* sp.	*Siphostichoartus* sp. cf. *S. corona*	*Spirema* sp.	?*Spongaster pentas*	*Spongocore puella*	*Spongotrochus glacialis*	*Stichocorys delmontensis*	*S. peregrina*	*S. wolffii*	*Stylacontarium acquilonium*	*Theocalyptra davisiana*	*Theoconus* sp. aff. *T. zancleus*	*Theocorys redondoensis*	*Theocorythium vetulum*	*Xiphospira* sp. cf. *X. circularis*
																									R				C					R
	R*	R	R			R	C	R	R						R	R		R		R		R			A				A	F			R	A
	R*			F	R	F										R		R		F		F		R	A		F		A	F				A
		R	R	F	F	R										R	F	R	R	R	R	R		R	A		A		A	R				A
		R	R	C	F	F				R							R	R	R	C	F			R	A		A		A	C	R			A
				R	F	R											R	R			R	R			C		C		C	F	F			F
		R		C	C				R		R	R	R	F		R		F	R	R	R	F	R	R	C	C	F	A	A	F	C			C
												R	F																					
		R	R	F	F	F				R	R	R	R					R		C	R				C	F		A	A	F		R		F
												R																						
R	F																																	
				R													R				R				R			R	C					

dant, poorly to well-preserved lower Pliocene radiolarian assemblages. The rare and poorly preserved radiolarians from Section 21-3 through Section 23-3 indicate that deposition took place in the late Miocene. Cores 24 through 28 are entirely barren. Table 10 lists radiolarians from the Neogene and Quaternary sediments of Hole 473.

Samples 1,CC through 4,CC contain a mixed radiolarian assemblage composed of the typical equatorial species *Amphirhopalum ypsilon, Anthocyrtidium angulare, Ommatartus tetrathalamus, Pterocanium praetextum, Spongaster tetras, Theocorythium trachelium*, and *T. vetulum* and of the Northeast Pacific cold-water species *Lamprocyrtis nigriniae, L. neoheteroporos*, and *L. heteroporos*. According to Dinkelman (1973), the presence of *A. angulare* and *T. vetulum* suggests deposition in the early Quaternary, because both species are assumed to be restricted to the basal Quaternary *A. angulare* Zone and because *Collosphaera tuberosa* and *Buccinosphaera invaginata*, which make their earliest appearance in late Quaternary sediments, are absent. Nannofossils, diatoms, and *L. nigriniae* indicate, however, that Cores 1 through 4 were deposited in the late Quaternary. Consequently, *A. angulare* and *T. vetulum* could not have become extinct during the early Quaternary but continued until the late Quaternary (0.45–0.7 Ma), unless they were reworked. This means that the radiolarian zonation of the equatorial Quaternary cannot be used in the region of Site 473.

Section 16-5 through Section 21-1 can be assigned to the lower Pliocene (upper part of the *Stichocorys peregrina* Zone), because this succession yielded rare to abundant individuals of *S. peregrina*, some rare specimens of *Spongaster pentas*(?), *Ommatartus tetrathalamus, O. penultimus*, and *Lamprocyrtis heteroporos*. The boundary between upper Miocene and lower Pliocene (i.e., between the lower and the upper part of the *S. peregrina* Zone) is placed beneath the first appearance of *L. heteroporos* (Section 21-1). The upper upper Miocene succession is part of the lower *S. peregrina* Zone, because it sporadically contains *S. peregrina* and *Ommatartus penultimus* (Sections 21-3 through 23-3).

NEOGENE AND QUATERNARY RADIOLARIAN ZONATION

Figure 3 shows the generalized ranges of selected Neogene and Quaternary species from Sites 467 through 473. They coincide largely with the ranges cited by Kling (1973). Hay's and Kling's zonation for the Pliocene and Quaternary of the East Pacific Coast (California Current) could be recognized in all of the Leg 63 sites. For the Miocene part of the drilled sections, the zonation of the equatorial Pacific (Riedel and Sanfilippo, 1970, 1971) has been used. According to the Leg 63 results, the Quaternary and Neogene zones are defined as follows at Sites 467 to 473.

Botryostrobus miralestensis Zone Hays, 1970

This zone could not be recognized. *Axoprunum angelinum*, which is assumed to become extinct at the base of the zone, extends to the top of the drilled sediments and is associated with *B. miralestensis*.

Axoprunum angelinum Zone Hays, 1970

The base of this zone is defined by the extinction of *Eucyrtidium matuyamai* and approximately by the first appearance of *Lamprocyrtis nigriniae*.

Table 8. Radiolarians from the Neogene and Quaternary sediments of Hole 471.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Amphirhopalum ypsilon*	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*B. miralestensis*	*Calocycletta* sp.	*Cannartus* (sp. cf. *C.*) *mammiferus*	*C. petterssoni*	Carpocaniidae	*Clathrocyclas cabrilloensis*	*Cornutella profunda*	*Cyrtocapsella cornuta*	*C. japonica*
				1-1, 75–77	R	P	R	R	F	F	R	R								
				1-3, 75–77	R	P			F	F	R	R				R				
				1-5, 75–77	R	P										R				
				3-1, 74–76	B															
	Quaternary			3-3, 74–76	B															
				4-1, 75–77	B															
				4-3, 75–77	B															
				4-5, 75–77	B															
				5-2, 75–77	B															
	— ? —	— ? —	1.8	5-4, 75–77	B															
		Lamprocyrtis heteroporos		5-6, 75–77	R	P	R		R	R								R		
				5-8, 60–62	R	P			F	F								R		
				6-1, 75–77	R	P			C	R								R		
50				6-3, 75–77	F	P			C	F	R					R		R		
				6-5, 75–77	C	M	R		A	R	F					R		F		
				6-7, 73–75	C	M			A	R	R	R				F		C		
				7-2, 75–77	C	G	R		C	F	F	R				R	R	F		
	Pliocene			7-4, 75–77	A	G	F		A		F	R				F	F	C	R*	
		Stichocorys peregrina (upper part)		7-6, 75–77	C	G			A	R	F	R				R	R	C		R*
				7-8, 44–46	F	M	R		A	R	R	R				R	R	F		
				8-1, 85–87	C	G	R		A	R	F	R				F	R	F		
				8-3, 85–87	C	M	R		A		R	R		R*		R	F	C		
				8-5, 58–60	F	M	R		A	R	R	R					C	F		
				9-1, 109–111	C	M	R		R	R	R					R	C	F		
				9-3, 77–79	C	M	R		A	R	F					R	F	R		
			5	10-1, 30–32	F	M	F		C	R	F	R					F	F		
				10-3, 30–32	R	P	R		R		R						R	R		
				10-5, 30–32	F	P	F		F	R	R						R	F		
				10-7, 30–32	F	M	R		A	R	R						R	F		
				11-1, 30–32	R	P	F		F	R	R						R	R		
100				11-3, 30–32	C	M	F		C	R	F		R				F	F		
				11-6, 30–32	R	P	R		C	R	R	R					R	F		
				12-1, 40–42	C	M	R		A	R	R	R					R	C		
				12-3, 40–42	C	M	R		A	R	F					R	R	C		
		Stichocorys peregrina (lower part) and *Ommatartus penultimus*		12-5, 40–42	F	M	R		C	R	R	R					R	F		
				12-7, 40–42	F	M	R		C	R	F	R					R	F		
				13-1, 20–22	C	M	R		A	F	F	R				R	F	C		
				13-3, 40–42	F	M	R		C	R	F						F	F		
	late Miocene			13-5, 40–42	R	M	R		C		R					R	R	R		
				13-7, 40–42	R	M	R		F	R	F					R	R	R		
				14-1, 40–42	F	M	C		C	R	R						R	R		
				15-1, 40–42	F	M	C		C		R	R				R	R	R		
				15-3, 40–42	F	M	C		C		R					R	R	R	R*	
				15-5, 40–42	R	M	F		F		R			R*		R		R		
				15-7, 40–42	R	M	F		R	R	R					R	R	R		
				16-1, 40–42	F	M	C		C	R	F					R	F	R	R*	
150				16-3, 40–42	R	M	F		F		F					R		R		
			8.5	17-1, 40–42	R	P	R		R		R						R	R		
200		*Ommatartus antepenultimus*		17,CC	F	M	R		R		R					R		R		
				23-1, 17–19	R	P									R				R	
				28,CC		B														
				33-1, 38–40		B														

Note: See Table 2 for a key to the symbols.

Table 8. (Continued).

Dictyophimus crisiae	*Euchitonia* sp.	*Eucyrtidium acuminatum*	*E. calvertense*	*Hymeniastrum euclidis*	*Lamprocyrtis hannai*	*L. heteroporos*	*Lipmanella dictyoceras*	*Lithopera bacca*	*L. neotera*	*Lychnocanoma grande*	*Ommatartus antepenultimus*	*O. hughesi*	*O. penultimus*	*?O. tetrathalamus*	*Peripyramis circumtexta*	*Pterocanium korotnevi*	*P. trilobum*	*Saturnalis circularis*	*Sethocorys* sp.	*Siphostichoartus* sp. cf. *S. corona*	*Spirema* sp.	*Spongaster tetras irregularis*	*Spongocore puella*	*Spongotrochus glacialis*	*Stichocorys armata*	*S. delmontensis*	*S. peregrina*	*S. wolffii*	*Stichopera pectinata*	*Stylacontarium acquilonium*	*Theocalyptra davisiana*	*Theoconus* sp. aff. *T. zancleus*	*Theocorys redondoensis*	*Theocorythium vetulum*	*Xiphospira* sp. cf. *X. circularis*
R			R	R	R									R		R	R		R				R	R			R*			C	R				R
				R	R																R			F						C	R	R			R
																								R						R					R
				R	R	R								R						R				F						C					R
			R	R		R								R				R	R		R			F			R*			C					R
						R								?										F						C					R
			R	F	R	F								?					F		R			C			F			C	R	R			F
			F	C	F								A		R		R		C		R		R	A			A			F	F	R		C	A
R		R	F	C	F		R						C				R	R	F		R		R	A			A			A	F	R		R	C
		F	C	A	C		R						C		R	R	R		A				F	C			A		R	A	F	R		F	C
		R	C	A	C								C		R		F	R	A	R	R	R	R	A			A			C	C	R		C	A
		R	C	C	C	R							C		R		R	R	A	F		R		F			A			A	C			F	A
		F	C	C	F	R	R						F		R		R	R	A	R	R		F	A			F		R	C	C	R		F	C
		R	F	A	F	F	R						F		R		F	R	A	R	R		R	A			A			A	F			F	A
R		R	F	A	F	F	R			R					R		F	R	C	R	R		R	C		R*	F		R	A	F			F	A
		R	F	A	F	R	R						R		R		F		F	R				A			F			R	F				A
		F		C	F	F	R						F		R		C		A	R			F	C			A		R	R	F	R		R	A
		R		C	C	F	R						F		R		R		A	R	R		R	A			A		R	F	C			F	A
		R	R	C	F	R	R		R*				R		R	R	R	R	F				R	C			F		R	F	C	R			C
		R		C	R		R						R				R	R	F		R		R	F			R			R	F	R			R
		R	R	F	R		R						R		R		R		F				R	C			R		R	F	C	R		R	C
		R		C	R		F						R				R		C	R	R		R	C			F	R	R	C	C	R		?	C
		R		F	R		R						R				R		F				R	R			R		R	C	C	R		?	R
F		R	R	C	C		R			R			R		R		F		C	R			R	C		R	F	F	R	C	A	F		?	C
R		R	R	R	R		R						R		R		R		F				R	C		R	R	R	R	C	C			?	F
R		R		F	F								R				F	R	F	F	R		R	C	R*		F		R	A	A	R			C
R		R		C	C		R								R		F	F	C	R			R	C		R		R	R	C	A				C
R		R		C	F		R						R		R		F	R	C	F	R		R	C			F	R	R	C	C	R			C
		F		F	R										R		R		R	R	R		R	C				R	R	C	F	R			C
R		F	R	C	C		R			R			R		R		R		F	R	R		R	C			R		R	A	C	R	R		C
R	R	R	R	F	F		R						R		R		R		F	R	R		R	F					R	C	C	R			C
	R	R		R	R								R						R		R		R	F						F	C	R			F
	R	R		R	R								R		R		R		F				R	F		R	F	R	R	F	C	R			F
	F	R		F	R		R				R		R				R		F				R	C		R	R	F	R	C	C	R			C
		F	R	R	R		R				R		R				R	R	R	R	R			C		R	F	R		C	F	R			C
	R	F		F	R		R	R			R		R				R		F	R	R		R	C		F	R	R		C	F	R			C
	R	F	R	R	R		R						R				R		R					F		R	R		R	F	R				C
R	R	R	R	R	R		R	R									R		R	R	R		R	F		F	F	R		F	F	R	R		F
		F		R	R		R	R			R		R				R	R	F	R	R			C		C	F	R		F	F	R	R		F
	R	F	R	R	R			R			R		R						R	R			R	F		R		R		F	F	F	R		F
		R		R	R		R						R						R					R		R				R	R	F	R		R
	R	R		R			R				C										R			F	R	F		R		R	R		R		F
											R	F												R						R		R			R
																														R					

Table 9. Radiolarians from the Neogene and Quaternary sediments of Hole 472.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Amphirhopalum ypsilon*	*Anthocyrtidium angulare*	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*B. miralestensis*	*Cannartus laticonus*	*C. (sp. cf. C.) mammiferus*	*C. pettersoni*	Carpocaniidae	*Clathrocyclas cabrilloensis*	*Cornutella profunda*	*Cyrtocapsella cornuta*	*C. japonica*
	early Quaternary		1.8	1-1, 1–2	F	P		R	R												
	Pliocene?			1-1, 40–42	C	P	R			F	F		R								
				1-3, 40–42	R	P															
				2-1, 40–42	B																
				2-3, 65–67	B																
	?	?	5	2-5, 20–22	B																
	late Miocene			3-1, 20–22	B																
				3-3, 20–22	B																
				4-1, 20–22	F	P				A	R								C		
		Ommatartus penultimus		5-1, 60–62	A	G	C			C	R	R			R*		C		F		
				5,CC	A	G	R			A	R	R				R*	R		R		
				6-1, 70–72	A	M	F			F	R	R									
		Ommatartus antepenultimus		6-3, 70–72	F	M	A			F	R	F					R	R	R		
50				6-5, 30–32	A	G	F			F		R			R*	R*	F	F	R		
				7-1, 60–62	A	G	A			R		R			R*	R*	R	R	F		
				7-3, 60–62	F	M	F			R		R				R*	F	R	R		
				7-5, 60–62	F	M	F			R		R					F	R	R		
				7-7, 44–46	F	M	C			R		R					F	R	R		
				8-1, 60–62	C	M	A			F	R	R					F	R	R		
				8-3, 60–62	A	G	A			A	R				R	C	F	R	R		
			11.5	9-1, 70–72	A	G	R			F		R			R	A	C				R
	middle Miocene	*Cannartus petterssoni*		9-3, 10–12	C	P	R			A	R					A	F	R	R		C
				9-5, 68–70	C	P				A	R	R		R	R	A	R	R	R		F
				10-1, 60–62	C	P	A			A	R	C		R		C	R		R		F
		Dorcadospyris alata		11-1, 70–72	C	M	A			A	R	F		F		R	F	F	R	R	R
100				11-3, 70–72	F	M	A			C	R	R		F			F	R	R		
				12-1, 67–69	R	P				R				R							
112		downhole material		12,CC	F	P	R			C		R		F		F	F	R	R	F	F

Eucyrtidium matuyamai Zone Hays, 1970

This zone is defined by the range of *E. matuyamai*. It includes the last occurrences of *Lamprocyrtis heteroporos* and the first appearance of *Lamprocyrtis neoheteroporos*.

Lamprocyrtis heteroporos Zone Hays, 1970

The base is defined by the occurrence of *L. heteroporos* subsequent to the extinction of *Stichocorys peregrina* and *Ommatartus penultimus* and the top by the first appearance of *Eucyrtidium matuyamai*.

Stichocorys peregrina Zone Riedel and Sanfilippo, 1970

The top of the zone is approximately indicated by the last occurrence of *S. peregrina* and by the first occurrences of *Amphirhopalum ypsilon* and *A. wirchowii*. The zone includes the boundary between Miocene and Pliocene, which is tentatively identified as the earliest appearance of *Lamprocyrtis heteroporos* (Kling, 1973). Consequently, the *S. peregrina* Zone can be divided into an upper part with, and a lower part without, *L. heteroporos*. There are also several species (such as *Anthocyrtidium angulare, Ommatartus tetrathalamus, Pterocanium praetextum, Spongaster tetras*, and *Theocorythium vetulum*) that have their first occurrences as well as several species (such as *Theocorys redondoensis, Stichocorys delmontensis*, and *Ommatartus antepenultimus*) that have their last occurrences in the lower part of the *S. peregrina* Zone in the Leg 63 area.

The base of the *Stichocorys peregrina* Zone is difficult to recognize. It is approximately indicated by decreasing abundances of *T. redondoensis, S. delmontensis*, and *O. antepenultimus*. There is apparently a considerable overlap in morphotypic ranges of *Stichocorys delmontensis* and *S. peregrina* (Kling 1973), the latter of which first appears in the *O. antepenultimus* Zone.

Ommatartus penultimus Zone Riedel and Sanfilippo, 1970

The base of the zone is defined by the first appearance of *O. penultimus*, the top, by the base of the *S.*

Table 9. (Continued).

C. tetrapera	Dictyocoryne ontongensis	Dictyophimus crisiae	Euchitonia sp.	Eucyrtidium acuminatum	E. calvertense	Lamprocyrtis hannai	L. heteroporos	Lipmanella dictyoceras	Lithopera bacca	L. neotera	Lychnocanoma grande	Ommatartus antepenultimus	O. hughesi	O. penultimus	O. tetrathalamus	Peripyramis circumtexta	Pterocanium korotnevi	P. praetextum	P. prismatium	P. trilobum	Saturnalis circularis	Sethocorys sp.	Siphostichoartus sp. cf. S. corona	Spongocore puella	Spongotrochus glacialis	Stichocorys armata	S. delmontensis	S. peregrina	S. wolffii	Spirema sp.	Stichopera pectinata	Stylacontarium acquilonium	Theocalyptra davisiana	Theoconus sp. aff. T. zancleus	Theocorys redondoensis	Theocorythium trachelium	T. vetulum	Xiphospira sp. cf. X. circularis
				R					R						R			R	F						F											R	R	
					R																				R				R*			A		F				R
					R																											R						
																																R						
					R	R	R*						R*									R	R		F		R	R	R	C		C						C
	R		R	F		F			R			R		F		R				R		F	F	R	A		R	A	C	R		A	R	R	R			A
			R	R		R						F	F	F		R				R		R	R	R	A		F	F	C			A	R	R				A
	R		R	R								F	C	R						R		F		R	C		C	C	A	R		F	F	C	R			A
	C	R	R	F	R	R			R			F	C							R		C			A	R	F		A	R		F	R	R	F			A
	F		F	F	R	R		R	R		R	R	C							R		F	R	R	A	R	C		A	R		F	R	A	R			A
	F			C	R				R		R	R	C							R		C	R	R	A		C		A	R		R	R	F	R			A
	R		R	F		R		R	F			F	C							R		F	R		A		C		C	R		F	F	F	R			A
	R		R	R					R	R		F	F			R				R	R	F	R	R	A		F		A	R		F	F	F	R			A
	R	R		R	R	F		R	F	R		R	C			R				F	R	C			A		C		C	R		R	F	F	R			A
	R		R	F	R	R			R	R		F	C							R	R	F			A	R	C		A			R	F	F	R			A
	R		R	F	R	R				R		F	C							F		F			A		A		A	R	R	C	C	C				A
	R			R								R	A									R			C		R		A	R		F	R					C
	R					F							R?								R	F			A				F	F		C	C	R				C
	R					C														R		R			A		R			F		A	F	R				F
	C			R	C	R		R		R						R	R			R		F			A		F		C	R		A	A	F	F			A
R	F				C	C		R												R	R	C	R	R	A		C		C	R		A	C	R				C
	R				F	F		R	R											R	R	F	R	R	A		R		F	R		C	C	R	R			C
																									R							R						R
	R				R	R			R	R			F							R		R	R	R	A		C		F	R		C	R	R				A

peregrina Zone. The zone includes the final extinction of *Lithopera neotera, Ommatartus hughesi*, and *Stichocorys wolffii* within the Leg 63 region.

Ommatartus antepenultimus Zone Riedel and Sanfilippo, 1970

The base is defined by the first appearance of *O. antepenultimus*, the top by the base of the *O. penultimus* Zone. Numerous species have their last appearance within this zone: *Cannartus laticonus, C. mammiferus, C. petterssoni, Cyrtocapsella cornuta, C. japonica, C. tetrapera, Eucyrtidium inflatum*, and *Lithopera renzae*.

Cannartus petterssoni Zone Riedel and Sanfilippo, 1970

The base of the zone is defined by the first appearance of *C. petterssoni*, the top by the base of the *O. antepenultimus* Zone. It is also approximately indicated by the earliest occurrence of *Eucyrtidium acuminatum*. The zone includes the first occurrence of *Ommatartus hughesi*.

Dorcadospyris alata Zone Riedel and Sanfilippo, 1970, 1971

The bottom of the zone was not encountered in the Leg 63 area; the top is defined by the base of the *C. petterssoni* Zone. In the Leg 63 area, several species make their first appearance within the *D. alata* Zone, such as *Cannartus laticonus, C. mammiferus, Eucyrtidium inflatum, Lithopera bacca, L. thornburgii*, and *Theocorys redondoensis*. Some lower Miocene species (*Calocycletta costata, C. virginis*, and *Cannartus violina*) are still present in the lower part of the *D. alata* Zone, if they are not reworked.

Table 10. Radiolarians from the Neogene and Quaternary sediments of Hole 473.

Sub-bottom Depth (m)	Age	Zone	Ma	Sample (interval in cm)	Abundance	Preservation	Acanthodesmiidae	*Amphirhopalum ypsilon*	*Anthocyrtidium angulare*	*Axoprunum angelinum*	*Bathropyramis woodringi*	*Botryostrobus auritus-australis*	*B. miralestensis*	Carpocaniidae
	late Quaternary	*B. miralestensis/ Axoprunum angelinum*		1,CC	C	M	R	C	F	R		F	R	R
				2-1, 80–82	F	P		R		F	R		C	R
				2-3, 20–23	C	M		F	R	C	F	R	A	F
				2-5, 30–32	C	M		R		F	F	F	C	F
				3-1, 30–32	C	M	R	A	F	R		C	R	C
				3-3, 80–82	F	M	R	C	R	C		R		F
			0.9	4-1, 80–82	R	P	R	R	R	R	R	F	C	C
	early Quaternary	*Eucyrtidium matuyamai*		4-3, 80–82	R	P		R		C	R			R
				5-1, 80–82	B					R				
				5-3, 80–82	R	P				F	R	R	R	R
				6-1, 80–82	R	P				R			R	R
50				7-1, 80–82	R	P								
				7-3, 80–82	R	P								
				8-1, 80–82	B									
				9-1, 90–92	B						R			
			1.8	10-1, 90–92	B					R				
	Pliocene			11-1, 75–77	B									
100		*Lamprocyrtis heteroporos*		12-1, 80–82	B									
				13-1, 80–82	B									
				13-3, 80–82	B									
				14-1, 80–82	B									
				15-1, 80–82	B									
				15-4, 80–82	B									
				16-1, 80–82	B									
			3	16-3, 80–82	B									
		Stichocorys peregrina (upper part)		16-5, 80–82	R	P				F				
				17-1, 80–82	F	P	R	R		F	R	R		R
				17-3, 80–82	A	G	F		F	R		R		F
150				17-5, 80–82	A	G	F			C		F		F
				18-1, 80–82	C	M	F	R		C	R	R		
				18,CC	R	P				R		R		
				19-1, 80–82	R	P				F				
				19-3, 80–82	B									
				20-1, 80–82	C	M			R	A	R	R		R
				20-3, 80–82	C	M	R			C	R	R		R
				20-5, 80–82	F	M				A				
			5	21-1, 96–98	R	P				C	R			
	late Miocene	*Stichocorys peregrina* (lower part)		21-3, 56–58	R	P				C		R		
				21-5, 11–13	R	P				R				
				23-1, 75–77	R	P	R			C	R			
				23-3, 75–77	R	P				C	R			
200				24-1, 70–72	B									
				25-1, 60–62	B									
				26-1, 80–82	B									
				27-1, 80–82	B									
				28-1, 70–72	B									

Note: See Table 2 for a key to the symbols.

Table 10. (Continued).

Clathrocyclas cabrilloensis	*Cornutella profunda*	*Dictyophimus crisiae*	*Euchitonia furcata*	*Eucyrtidium acuminatum*	*E. calvertense*	*Lamprocyrtis hannai*	*L. nigriniae*	*L. heteroporos*	*L. neoheteroporos*	*Lipmanella dictyoceras*	*Lychnocanoma grande*	*Ommatartus penultimus*	*O. tetrathalamus*	*Peripyramis circumtexta*	*Pterocanium praetextum*	*P. trilobum*	*Saturnalis circularis*	*Sethocorys* sp.	*Siphostichoartus* sp. cf. *S. corona*	*Spirema* sp.	*Spongaster pentas*	*S. tetras*	*Spongocore puella*	*Spongotrochus glacialis*	*Stichocorys peregrina*	*Stylacontarium acquilonium*	*Theocalyptra davisiana*	*Theoconus* sp. aff. *T. zancleus*	*Theocorythium vetulum*	*Xiphospira* sp. cf. *X. circularis*
			R	C			R			R			F		R				R			F		A		F	C		R	C
				R		R							R	R	R			R	R					A		C	C		F	F
				F	R		R						R					R	R				R	A		A	C		C	A
				F	F		R						R						R					A		A	A		A	C
			R	C	R		F	R*	R	R			F	R			R		F			C	R	A		R	A		A	A
				R			R						F	R			R		F			C		C		F	C		F	C
		R	R	R	R	R	R						F	R		R			R			R	R	C		C	C		C	F
		R	R	R									R			R						R		C		R	C		F	C
																								R		R				
				R																				R		F	C			R
				R															R					F			F		R	R
																								R						R
																								R						
																								R						
																								R						
																								R						
													R					R	R					F	R	C				R
	R	R		R		R							C	R	R	R		C		R				C	C	A	R		R	F
	R		F	C	R	C							C	R	F	F		C	R					A	A	R	F			C
F	F	R	R	F	R	F				R			F	R	R			C						A	A	A	R	C	R	C
	R		R	C	R	R		R		R		A	R		R	R		A						A	A	C	R	F		C
												R							R		R			F		R				F
	R											R											R			R				
	A		R	F	R	R						C				R		A	R	R				C	C	A	C		R	A
	C		C	F		F				R	R	F		R		F	R	A						A	C	F	C	R		A
	A																			R	R			F	R	A	R			R
	C			R				R				R						R						F	R	A	R			F
	F				R														R					R		C				R
	R																			R						R				R
	F											R								R				F	R	F	R			R

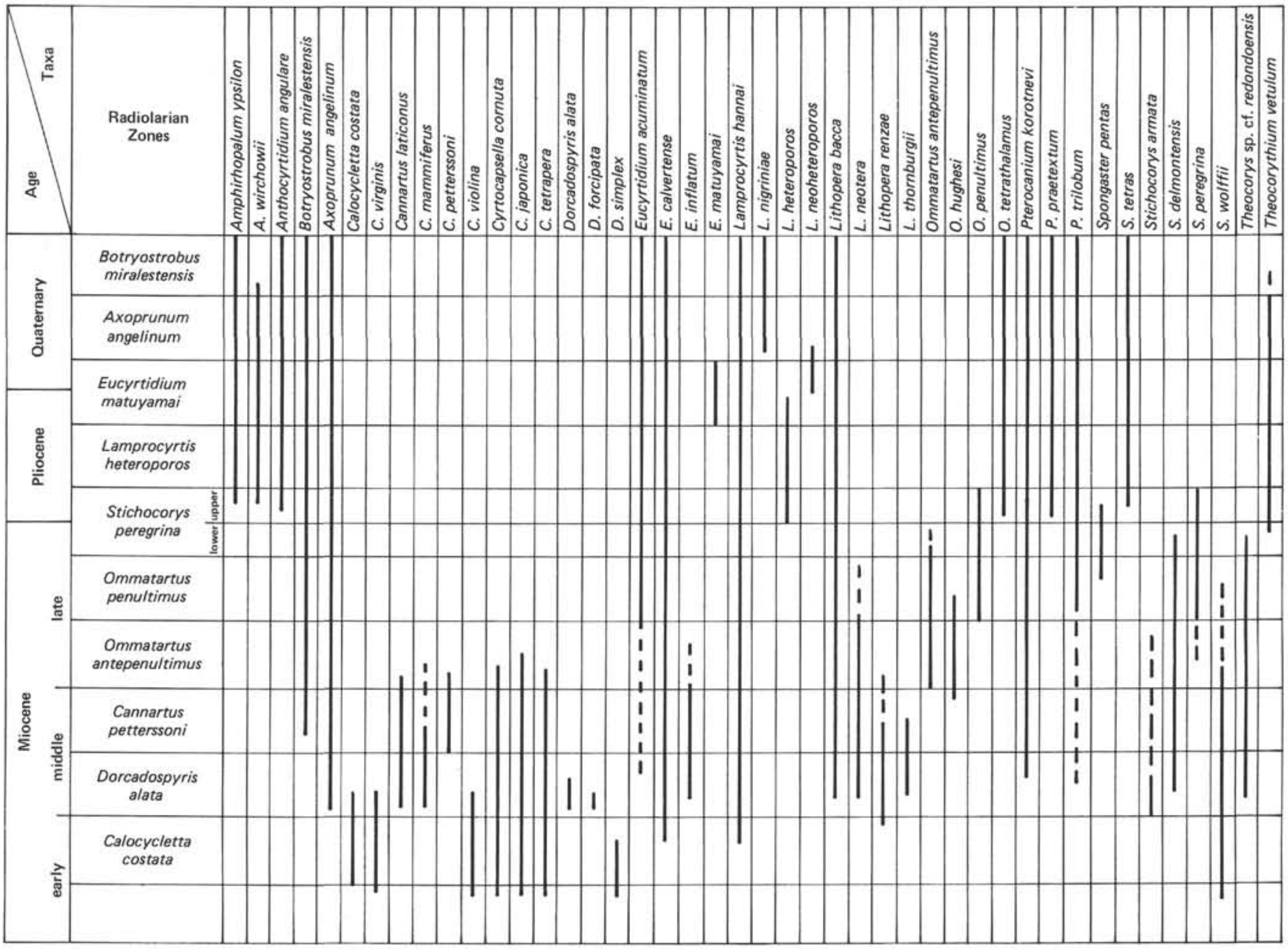

Figure 3. Generalized range chart for Neogene and Quaternary radiolarians from Sites 467 to 473.

TAXONOMY

ACANTHODESMIIDAE Haeckel, 1862, emend. Riedel, 1967b.

Acanthodesmiidae, gen. et spp. indet., Kling, 1973, p. 635, pl. 2, figs. 8–14; pl. 8, figs. 1–26.

***Amphirhopalum wirchowii* (Haeckel)**
(Plate 3, Figs. 1-3)

Euchitonia wirchowii Haeckel, 1862, p. 503, pl. 30, figs. 1–4.
Amphirhopalum wirchowii (Haeckel), Dumitrică, 1973, p. 835, pl. 9, figs. 2 and 4; pl. 11, fig. 6; pl. 21, figs. 2–13.

***Amphirhopalum ypsilon* Haeckel**

Amphirhopalum ypsilon Haeckel, 1867, p. 522; Nigrini, 1967, p. 35, pl. 3, figs. 3a–d; 1970, pl. 2, fig. 2; Dinkelman, 1973, p. 768, pl. 10, fig. 10.

***Anthocyrtidium* sp. cf. *A. angulare* Nigrini**

Anthocyrtidium angulare Nigrini, 1971, p. 445, pl. 34.1, figs. 3a, b; Dinkelman, 1973, p. 788, pl. 10, fig. 5.

***Axoprunum angelinum* (Campbell and Clark)**

Stylosphaera angelina Campbell and Clark, 1944, p. 12, pl. 1, figs. 14–20.
Axoprunum angelinum (Campbell and Clark), Kling, 1973, p. 634, pl. 1, figs. 13–16, pl. 6, figs. 14–18.

***Bathropyramis woodringi* Campbell and Clark**
(Plate 4, Fig. 2)

Bathropyramis woodringi Campbell and Clark, 1944, p. 39, pl. 5, figs. 21, 22.
Bathropyramis woodringi Campbell and Clark, Kling, 1973, pl. 2, figs. 20–23; pl. 9, figs. 5, 7.

***Botryostrobus auritus-australis* (Ehrenberg) group**

Lithocampe aurita Ehrenberg, 1844, p. 84; 1854, pl. 22, fig. 25.
Artostrobium auritum (Ehrenberg) group, Riedel and Sanfilippo, 1971, p. 1599, pl. 1H, figs. 5–8.
Artostrobium auritum (Ehrenberg), Kling, 1973, p. 639, pl. 5, figs. 27–30; pl. 12, figs. 24–27.
Botryostrobus auritus-australis (Ehrenberg) group, Nigrini, 1977, p. 246, pl. 1, figs. 2–5.

***Botryostrobus miralestensis* (Campbell and Clark)**
(Plate 2, Figs. 8–10)

Dictyocephalus miralestensis Campbell and Clark, 1944, p. 45, pl. 6, figs. 12–14.
Artostrobium miralestense (Campbell and Clark), Riedel and Sanfilippo, 1971, p. 1599, pl. 1H, figs. 9–17; pl. 2J, figs. 9, 10; pl. 3E, fig. 12.
Artostrobium miralestense (Campbell and Clark), Kling, 1973, p. 639, pl. 5, figs. 31–35; pl. 12, figs. 28–31.
Botryostrobus miralestensis (Campbell and Clark), Nigrini, 1977, p. 449, pl. 1, fig. 9.

Calocycletta costata **(Riedel)**
(Plate 4, Fig. 6)

Calocyclas costata Riedel, 1959, p. 296, pl. 2, fig. 9.
Calocycletta costata (Riedel), Riedel and Sanfilippo, 1971, p. 1598, pl. 2H, figs. 12-14.

Calocycletta virginis **(Haeckel)**

Calocyclas (Calocycletta) virginis Haeckel, 1887, pl. 74, fig. 4.
Calocycletta virginis (Haeckel), Riedel and Sanfilippo, 1971, pl. 2H, figs. 5-11.

Cannartus laticonus **Riedel**
(Plate 5, Figs. 6-7)

Cannartus laticonus Riedel, 1959, pl. 291, pl. 1, fig. 5.
Cannartus laticonus Riedel, Riedel and Sanfilippo, 1971, p. 1587, pl. 1C, figs. 13, 14.
Cannartus laticonus Riedel, Moore, 1971, p. 736, pl. 12, fig. 6.
Cannartus laticonus Riedel, Kling, 1973, p. 634, pl. 7, fig. 7.

Cannartus **sp. cf.** *C. mammiferus* **(Haeckel)**
(Plate 5, Figs. 11-12)

Cannartidium mammiferum Haeckel, 1887, p. 375, pl. 39, fig. 16.
Cannartus mammiferum (Haeckel), Riedel, 1959, p. 291, pl. 1, fig. 4.
Cannartus mammiferum (Haeckel), Moore, 1971, p. 736, pl. 12, fig. 5.
Cannartus mammiferus (Haeckel), Riedel and Sanfilippo, 1971, p. 1587, pl. 2C, figs. 1-3.

Cannartus petterssoni **Riedel and Sanfilippo**
(Plate 5, Figures 11-12)

Cannartus? *petterssoni* Riedel and Sanfilippo, 1970, p. 520, pl. 14, fig. 3.
Cannartus? *petterssoni* Riedel and Sanfilippo, 1971, p. 1587, pl. 1C, figs. 19-20.
Cannartus? *petterssoni* Riedel and Sanfilippo, Moore, 1971, p. 737, pl. 12, fig. 7.
Cannartus? *petterssoni* Riedel and Sanfilippo, Kling, 1973, p. 634, pl. 7, fig. 8.
Cannartus? *petterssoni* Riedel and Sanfilippo, Dinkelman, 1973, p. 766, pl. 8, figs. 5, 9-11.

Cannartus violina **Haeckel**

Cannartus violina Haeckel, 1887, p. 538, pl. 39, fig. 10.
Cannartus violina Haeckel, Riedel, 1959, p. 290, pl. 1, fig. 3.
Cannartus violina Haeckel, Moore, 1971, p. 736, pl. 12, fig. 4.
Cannartus violina Haeckel, Riedel and Sanfilippo, 1971, p. 1588, pl. 2C, figs. 4-7.

Cannartus? **sp.**
(Plate 4, Fig. 9)

Ommatartus sp. B, Foreman, 1975, p. 618, pl. 8, figs. 24-25.

CARPOCANIIDAE Haeckel 1881, emend. Riedel 1967b.

Members of this family are illustrated but not further identified.

Clathrocyclas cabrilloensis **Campbell and Clark**

Clathrocyclas cabrilloensis Campbell and Clark, 1944, p. 48, pl. 7, figs. 1-3.
Clathrocyclas cabrilloensis Campbell and Clark, Kling, 1973, p. 635, pl. 9, figs. 23-25.

Clathrocyclas **sp.**

Clathrocyclas spp., Kling, 1973, p. 635, pl. 3, figs. 17-22; pl. 9, figs. 26-31.

Cornutella profunda **Ehrenberg**

Cornutella clathrata profunda Ehrenberg, 1854, pl. 35B, fig. 21.
Cornutella profunda Ehrenberg, Nigrini, 1967, p. 60, pl. 6, figs. 5a-c.
Cornutella profunda Ehrenberg, Kling, 1973, p. 635, pl. 3, figs. 1-4; pl. 9, figs. 8-17.
Cornutella profunda Ehrenberg, Riedel and Sanfilippo, 1978, p. 114, pl. 4, fig. 8.

Cyrtocapsella cornuta **Haeckel**

Cyrtocapsa (Cyrtocapsella) cornuta Haeckel, 1887, p. 1513, pl. 78, fig. 9.
Cyrtocapsella cornuta Haeckel, Riedel and Sanfilippo, 1971, p. 1593, pl. 2E, figs. 1-4.
Cyrtocapsella cornuta Haeckel, Kling, 1973, p. 636, pl. 11, figs. 16-18.

Cyrtocapsella japonica **(Nakaseko)**
(Plate 3, Figs. 5-6)

Eusyringium japonicum Nakaseko, 1963, p. 193, pl. 4, figs. 1-3.
Cyrtocapsella japonica (Nakaseko), Sanfilippo and Riedel, 1970, p. 452, pl. 1, figs. 13-15.

Cyrtocapsella tetrapera **Haeckel**
(Plate 3, Fig. 4)

Cyrtocapsa (Cyrtocapsella) tetrapera Haeckel, 1887, p. 1512, pl. 78, fig. 5.
Cyrtocapsella tetrapera Haeckel, Riedel and Sanfilippo, 1971, p. 1594,, pl. 2E, figs. 5-7.
Cyrtocapsella tetrapera Haeckel, Kling, 1973, p. 636, pl. 11, figs. 12-15.

Dictyocoryne ontongensis **Riedel and Sanfilippo**

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

Dictyophimus crisiae **Ehrenberg**

Dictyophimus crisiae Ehrenberg, 1854, p. 241.
Dictyophimus crisiae Ehrenberg, Nigrini, 1967, p. 66, pl. 6, figs. 7a, 7b.
Dictyophimus crisiae Ehrenberg, Kling, 1973, p. 636, pl. 4, figs. 11-15; pl. 10, figs. 18-20.

Dorcadospyris alata **(Riedel)**

Brachiospyris alata Riedel, 1959, p. 293, pl. 1, figs. 11, 12.
Dorcadospyris alata (Riedel), Riedel and Sanfilippo, 1971, p. 1590, pl. 2D, fig. 1.
Dorcadospyris alata (Riedel), Moore, 1971, p. 740, pl. 11, figs. 3, 4.

Dorcadospyris forcipata **(Haeckel)**

Dipospyris forcipata Haeckel, 1887, p. 1037, pl. 85, fig. 1.
Dorcadospyris forcipata (Haeckel), Riedel and Sanfilippo, 1971, p. 1590, pl. 2C, figs. 20-23; pl. 3A, fig. 8.
Dorcadospyris forcipata (Haeckel), Moore, 1971, p. 740, pl. 10, figs. 1, 2.

Dorcadospyris simplex **(Riedel)**

Brachiospyris simplex Riedel, 1959, p. 293, pl. 1, fig. 10.
Dorcadospyris simplex (Riedel) Moore, 1971, p. 740, pl. 10, figs. 3, 4.

Euchitonia **sp. aff.** *E. furcata* **Ehrenberg**

Euchitonia furcata Ehrenberg, 1860, p. 823.
Euchitonia furcata Ehrenberg, Ling and Anicouchine, 1967, p. 1484, pl. 189, figs. 5-7; pl. 190, figs. 5-7.
Euchitonia furcata Ehrenberg, Nigrini, 1970, p. 169, pl. 2, fig. 5.

Eucyrtidium acuminatum **(Ehrenberg)**
(Plate 3, Fig. 7)

Lithocampe acuminatum Ehrenberg, 1844, p. 84.
Eucyrtidium acuminatum (Ehrenberg), 1847, p. 43.
Eucyrtidium acuminatum (Ehrenberg), Nigrini, 1967, p. 83, pl. 8, figs. 4a, b.

Eucyrtidium acuminatum (Ehrenberg), Kling, 1973, p. 636, pl. 4, figs. 20–23.

***Eucyrtidium calvertense* Martin**
(Plate 2, Figs. 12–14)

Eucyrtidium calvertense Martin, 1904, p. 450, pl. 130, fig. 5.
Eucyrtidium calvertense Martin, Kling, 1973, p. 636, pl. 4, figs. 16, 18, 19; pl. 11, figs. 1–5.

***Eucyrtidium inflatum* Kling**
(Plate 2, Fig. 15)

Eucyrtidium inflatum Kling, 1973, p. 636, pl. 11, fig. 7; pl. 15, figs. 7–10.

***Eucyrtidium matuyamai* Hays**
(Plate 3, Figs. 8–9, 10?)

Eucyrtidium matuyamai Hays, 1970, p. 213, pl. 1, figs. 7–9.
Eucyrtidium matuyamai Hays, Kling, 1973, p. 636, pl. 4, fig. 17.

***Hymeniastrum euclidis* Haeckel**

Hymeniastrum euclidis Haeckel, 1887, p. 531, fig. 13.
Hymeniastrum euclidis Haeckel, Ling and Anicouchine, 1967, p. 1488, pls. 191/192, fig. 3.
Hymeniastrum euclidis Haeckel, Nigrini, 1970, p. 168, pl. 2, fig. 4.

***Lamprocyclas maritalis maritalis* Haeckel**
(Plate 2, Fig. 11)

Lamprocyclas maritalis Haeckel, 1887.
Lamprocyclas maritalis maritalis Haeckel, Nigrini, 1970, p. 171, pl. 4, fig. 8.

***Lamprocyclas maritalis polypora* Nigrini**

Lamprocyclas maritalis polypora Nigrini, 1967, p. 76, pl. 7, fig. 6.
Lamprocyclas maritalis polypora Nigrini, 1970, p. 171, pl. 4, fig. 9.
Lamprocyclas maritalis polypora Nigrini, Kling, 1973, pl. 5, fig. 7.

***Lamprocyrtis hannai* (Campbell and Clark)**
(Plate 1, Fig. 4)

Calocyclas hannai Campbell and Clark, 1944, p. 48, pl. 69, figs. 21, 22.
Lamprocyrtis? *hannai* (Campbell and Clark), Kling, 1973, p. 638, pl. 5, figs. 12–14; pl. 12, figs. 10–14.

***Lamprocyrtis nigriniae* (Caulet)**
(Plate 2, Figs. 1–2)

Conarachnium nigriniae Caulet, 1971, p. 3, pl. 3, figs. 1–4; pl. 4, figs. 1–4.
Lamprocyrtis haysi Kling, 1973, p. 639, pl. 5, figs. 15, 16; pl. 15, figs. 1–3.
Lamprocyrtis nigriniae (Caulet), Kling, 1979, p. 309, pl. 2, fig. 26.

***Lamprocyrtis heteroporos* (Hays)**
(Plate 2, Figs. 4, 6, 7)

Lamprocyclas heteroporos Hays, 1965, p. 179, pl. 3, fig. 1.
Lamprocyrtis heteroporos (Hays), Kling, 1973, p. 639, pl. 5, figs. 19–21; pl. 15, fig. 6.

***Lamprocyrtis neoheteroporos* Kling**
(Plate 2, Figs. 3 and ?5)

Lamprocyrtis neoheteroporos Kling, 1973, p. 639, pl. 5, figs. 17, 18; pl. 15, figs. 4, 5.

***Lipmanella dictyoceras* (Haeckel)**

Lithornithium dictyoceras Haeckel, 1860, p. 840.
Lipmanella wirchowii (Haeckel), Petrushevskaya, 1971, p. 220, fig. 198.
Lipmanella dictyoceras (Haeckel), Kling, 1973, p. 636, pl. 4, figs. 24–26.

***Lithomitra lineata* (Ehrenberg) group**

Lithocampe lineata Ehrenberg, 1838, p. 130 (partim); 1858, pl. 22, fig. 26; pl. 36, fig. 16.
Lithomitra lineata (Ehrenberg) group, Riedel and Sanfilippo, 1971, p. 1600, pl. 1J, figs. 1–11; pl. 2J, figs. 14–16; pl. 3E, fig. 14.
Lithomitra lineata (Ehrenberg), Kling, 1973, p. 639, pl. 12, figs. 19, 20.

***Lithopera bacca* Ehrenberg**

Lithopera bacca Ehrenberg, 1872a, p. 314; 1872b, pl. 8, fig. 1.
Lithopera bacca Ehrenberg, Riedel and Sanfilippo, 1971, p. 1594, pl. 1F, figs. 10–13.
Lithopera bacca Ehrenberg, Kling, 1973, p. 636, pl. 11, figs. 21, 22.

***Lithopera neotera* Sanfilippo and Riedel**

Lithopera neotera Sanfilippo and Riedel, 1970, p. 454, pl. 1, figs. 24–26, 28.
Lithopera neotera Sanfilippo and Riedel, Kling, 1973, p. 636, pl. 11, fig. 23.

***Lithopera renzae* Sanfilippo and Riedel**
(Plate 1, Fig. 13)

Lithopera renzae Sanfilippo and Riedel, 1970, p. 454, pl. 1, figs. 21–23, 27.
Lithopera renzae Sanfilippo and Riedel, Kling, 1973, p. 636, pl. 11, fig. 25.

***Lithopera thornburgi* Sanfilippo and Riedel**

Lithopera thornburgi Sanfilippo and Riedel, 1970, p. 455, pl. 2, figs. 4–6.
Lithopera thornburgi Sanfilippo and Riedel, Kling, 1973, p. 636, pl. 11, fig. 24.

***Lychnocanoma grande* (Campbell and Clark)**

Lychnocanium grande Campbell and Clark, 1944, p. 42, pl. 6, figs. 3–6.
Lychnocanoma grande (Campbell and Clark), Kling 1973, p. 637, pl. 10, figs. 10–14.

***Ommatartus antepenultimus* Riedel and Sanfilippo**
(Plate 5, Figs. 3–5)

Ommatartus antepenultimus Riedel and Sanfilippo, 1970, p. 521, pl. 14, fig. 4.
Ommatartus antepenultimus Riedel and Sanfilippo, Moore, 1971, p. 737, pl. 12, figs. 9, 10.
Ommatartus antepenultimus Riedel and Sanfilippo, 1971, p. 1588, pl. 1C, figs. 11, 12.

***Ommatartus hughesi* (Campbell and Clark)**
(Plate 5, Fig. 8)

Ommatocampe hughesi Campbell and Clark, 1944, p. 23, pl. 3, fig. 12.
Ommatartus hughesi (Campbell and Clark), Riedel and Sanfilippo, 1970, p. 521; 1971, p. 1588, pl. 1C, figs. 17, 18.
Ommatartus hughesi (Campbell and Clark), Moore, 1971, p. 737, pl. 12, fig. 8.

***Ommatartus penultimus* (Riedel)**
(Plate 5, Figs. 1–2)

Panarium penultimum Riedel, 1957, p. 76, pl. 1, fig. 1.
Ommatartus penultimus (Riedel), Riedel and Sanfilippo, 1971, p. 1588, pl. 1C, figs. 8–10.
Ommatartus penultimus (Riedel), Moore, 1971, p. 737, pl. 12, fig. 11.

***Ommatartus tetrathalamus* (Haeckel)**
(Plate 4, Fig. 7)

Panartus tetrathalamus Haeckel, 1887, p. 378, pl. 40, fig. 3.
Ommatartus tetrathalamus (Haeckel), Moore, 1971, p. 737, pl. 12, fig. 12.

Ommatartus tetrathalamus (Haeckel), Riedel and Sanfilippo, 1971, p. 1588, pl. 1C, figs. 5-7.

***Ommatartus* sp. cf. *Cannartus bassanii* (Carnevale)**
(Plate 4, Fig. 4)

Ommatartus sp. cf. *Cannartus bassanii* (Carnevale), cf. Foreman, 1975, p. 619, pl. 8, figs. 11-12.

***Peripyramis circumtexta* Haeckel**
(Plate 3, Fig. 11)

Peripyramis circumtexta Haeckel, 1887, p. 1162, pl. 54, fig. 5.
Peripyramis circumtexta Haeckel, Kling, 1973, p. 637, pl. 2, figs. 15, 16; pl. 9, figs. 1-3.

***Phormostichoartus doliolum* (Riedel and Sanfilippo)**

Artostrobium doliolum Riedel and Sanfilippo, 1971, p. 1599, pl. 1H, figs. 1-3; pl. 8, figs. 14, 15.
Phormostichoartus doliolum (Riedel and Sanfilippo), Nigrini, 1977, p. 252, pl. 1, fig. 14.

***Pterocanium korotnevi* (Dogiel and Reshetnyak)**
(Plate 4, Fig. 3)

Pterocorys korotnevi Dogiel and Reshetnyak, 1952, p. 17, fig. 11.
Pterocanium korotnevi (Dogiel and Reshetnyak), Nigrini, 1970, p. 170, pl. 3, figs. 10, 11.
Pterocanium korotnevi (Dogiel and Reshetnyak), Kling, 1973, p. 638, pl. 4, figs. 1-4.

***Pterocanium praetextum* (Ehrenberg)**

Lychocanium praetextum (Ehrenberg), 1872a, p. 316.
Pterocanium praetextum (Ehrenberg), Haeckel, 1887, p. 1330.
Pterocanium praetextum (Ehrenberg), Nigrini, 1970, pl. 3, fig. 7.
Pterocanium praetextum (Ehrenberg), Moore, 1971, pl. 13, fig. 3.

***Pterocanium prismatium* Riedel**

Pterocanium prismatium Riedel, 1957, p. 87, pl. 3, figs. 4-5.
Pterocanium prismatium Riedel, Riedel and Sanfilippo, 1971, p. 1595, pl. 8, fig. 1.
Pterocanium prismatium Riedel, Moore, 1971, pl. 13, figs. 1, 2.

***Pterocanium trilobum* (Haeckel)**

Dictyopodium trilobum Haeckel, 1860, p. 839; 1862, p. 340, pl. 8, figs. 6-10.
Pterocanium trilobum (Haeckel), Nigrini, 1970, p. 170, pl. 3, fig. 9.
Pterocanium trilobum (Haeckel), Kling, 1973, pl. 4, figs. 5-8.

***Saturnalis circularis* Haeckel**

Saturnalis circularis Haeckel, 1887, p. 131.
Saturnalis circularis Haeckel, Nigrini, 1967, p. 25, pl. 1, fig. 9.
Saturnalis circularis Haeckel, Kling, 1973, p. 635, pl. 1, figs. 21-25; pl. 7.

***Sethocorys* sp.**
(Plate 1, Fig. 3)

Sethocorys Haeckel, 1881, p. 430.
Sethocorys spp., Kling, 1973, p. 639, pl. 12, figs. 15-18.

***Siphostichoartus* sp. cf. *S. corona* (Haeckel)**
(Plate 1, Fig. 15)

Cyrtophormis (Acanthocyrtis) cornona Haeckel, 1887, p. 1462, pl. 77, fig. 15.
Phormostichoartus corona (Haeckel), Riedel and Sanfilippo, 1971, p. 1600, pl. 1J, figs. 13-15; pl. 2J, figs. 1-5.
Siphostichoartus corona (Haeckel), Nigrini, 1977, p. 257, pl. 2, figs. 5, 6.

***Sphaeropyle langii* Dreyer**

Sphaeropyle langii Dreyer, 1889, p. 13, pl. 4, fig. 54.
Sphaeropyle langii Dreyer, Kling, 1973, p. 634, pl. 1, figs. 5-10; pl. 13, figs. 6-8.

***Spirema* sp.**

Spirema Haeckel, 1881, p. 464.
Spirema sp., Kling, 1973, p. 635,pl. 7, figs. 23-25.

***Spirocyrtis* sp. cf. *S. scalaris* Haeckel**

Spirocyrtis scalaris Haeckel, 1887, p. 1509, pl. 76, fig. 14.
Spirocyrtis sp. aff. *Spirocyrtis scalaris* Haeckel, Riedel and Sanfilippo, 1971, pl. 1G, figs. 19-24; pl. 2H, figs. 3, 15-18.

***Spongaster pentas* Riedel and Sanfilippo**

Spongaster pentas Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 3.
Spongaster pentas Riedel and Sanfilippo, 1971, p. 1589, pl. 1D, figs. 5-7.

***Spongaster tetras* Ehrenberg**

Spongaster tetras Ehrenberg, 1860, p. 833; 1872(b), pl. 6, fig. 8.
Spongaster tetras Ehrenberg, Riedel and Sanfilippo, 1971, p. 1589, pl. 1D, figs. 2-4.

***Spongaster tetras irregularis* Nigrini**
(Plate 4, Fig. 1)

Spongaster tetras irregularis Nigrini, 1967, p. 43, pl. 5, fig.2.
Spongaster tetras irregularis Nigrini, Foreman, 1975, p. 619, pl. 9, fig. 27.

***Spongocore puella* Haeckel**

Spongocore puella Haeckel, 1887, p. 347, pl. 48, fig. 6.
Spongocore lata Campbell and Clark, 1944, p. 22, pl. 3, figs. 7-9.
Spongocore puella Haeckel, Kling, 1973, p. 635, pl. 7, figs. 18-22.

***Spongotrochus? glacialis* Popofsky**

Spongotrochus glacialis Popofsky, 1908, p. 228, pl. 26, fig. 8; pl. 27, fig. 1; pl. 28, fig. 2.
Spongotrochus? glacialis Popofsky, Riedel, 1958, p. 227, pl. 2, figs. 1, 2.
Spongotrochus? glacialis Popofsky, Kling, 1973, p. 635, pl. 2, figs. 4-6.

***Stichocorys armata* (Haeckel)**
(Plate 1, Fig. 9)

Cyrtophormis armata Haeckel, 1887, p. 1460, pl. 78, fig. 17.
Stichocorys armata (Haeckel), Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, figs. 13-15.
Stichocorys armata (Haeckel), Kling, 1973, p. 638, pl. 13, fig. 11.

***Stichocorys delmontensis* (Campbell and Clark)**
(Plate 1, Figs. 10-11)

Eucyrtidium delmontensa Campbell and Clark, 1944, p. 56, pl. 7, figs. 19, 20.
Stichocorys delmontensis (Campbell and Clark), Riedel and Sanfilippo, 1971, p. 1595, pl. 1F, figs. 5-7; pl. 2E, figs. 10, 11.
Stichocorys delmontensis (Campbell and Clark), Dinkelman, 1973, p. 783, pl. 9, fig. 1.
Stichocorys delmontensis (Campbell and Clark), Kling, 1973, p. 638, pl. 11, figs. 8-10.

***Stichocorys diploconus* (Haeckel)**

Cyrtocapsa diploconus Haeckel, 1887, p. 1513, pl. 78, fig. 6.
Stichocorys diploconus (Haeckel), Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, fig. 16.
Stichocorys diploconus (Haeckel), Kling, 1973, p. 638, pl. 11, fig. 11; pl. 13, fig. 12.

***Stichocorys peregrina* (Riedel)**
(Plate 1, Figs. 6-8)

Eucyrtidium elongatum peregrinum Riedel, 1953, p. 812, pl. 85, fig. 2.
Stichocorys peregrina (Riedel), Riedel and Sanfilippo, 1971, p. 1595, pl. 1F, figs. 2-4; pl. 8, fig. 5.
Stichocorys peregrina (Riedel), Riedel and Sanfilippo, 1971, p. 1595, pl. 1F, figs. 2-4; pl. 8, fig. 5.

Stichocorys peregrina (Riedel), Kling, 1973, p. 638, pl. 4, fig. 27; pl. 11, fig. 29; pl. 13, figs. 9, 10.

Stichocorys wolffii **Haeckel**
(Plate 1, Figs. 1-2)

Stichocorys wolffii Haeckel, 1887, p. 1497, pl. 80, fig. 10.
Stichocorys wolffii Haeckel, Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, figs. 8, 9.
Stichocorys wolffii Haeckel, Moore, 1971, p. 742, pl. 13, fig. 8.

Stichopera pectinata **Haeckel group**
(Plate 4, Fig. 5)

Stichopera pectinata Haeckel, 1887, p. 1449, pl. 75, fig. 11.
Stichopera pectinata Haeckel, Kling, 1973, p. 638, pl. 3, figs. 25-27; pl. 10, figs. 1-5.

Stylacontarium acquilonium **(Hays)**

Druppatractus acquilonius Hays, 1970, p. 214, pl. 1, figs. 4, 5.
Stylacontarium acquilonium (Hays), Kling, 1973, p. 634, pl. 1, figs. 17-20; pl. 14, figs. 1-4.

Stylacontarium **sp. aff.** *S. bispiculum* **Popofsky**

Stylacontarium bispiculum Popofsky, 1912, p. 91, pl. 2, fig. 2.
Stylacontarium sp. aff. *S. bispiculum* Popofsky, Kling, 1973, p. 634, pl. 6, figs. 19-23; pl. 14, figs. 5-8.

Theocalyptra davisiana **(Ehrenberg)**

Cycladophora? *davisiana* Ehrenberg, 1861, p. 297; 1873, pl. 2, fig. 11.
Theocalyptra davisiana (Ehrenberg), Riedel, 1958, p. 239, pl. 4, figs. 2, 3.
Theocalyptra davisiana (Ehrenberg), Kling, 1973, p. 638, pl. 3, figs. 9-12, 28.

Theoconus **sp. cf.** *T. zancleus* **(Müller)**
(Plate 1, Fig. 5)

Eucyrtidium zancleum Müller, 1855, p. 672; 1858, pl. 6, figs. 1-3.
Theoconus zancleus (Müller), Haeckel, 1877, p. 1399.
Theoconus zancleus (Müller), Kling, 1973, p. 639, pl. 5, figs. 9-11.

Theocorys **sp. cf.** *T. redondoensis* **(Campbell and Clark)**
(Plate 1, Fig. 14)

Theocyrtis redondoensis Campbell and Clark, 1944, p. 49, pl. 7, fig. 4.
Theocorys redondoensis (Campbell and Clark), Kling, 1973, p. 638, pl. 11, figs. 26-28.

Theocorythium trachelium trachelium **(Ehrenberg)**

Eucyrtidium trachelius Ehrenberg, 1872(b), p. 293, pl. 7, fig. 8.
Calocyclas amicae Haeckel, 1887, p. 1382, pl. 74, fig. 2.
Theocorythium trachelium trachelium (Ehrenberg), Nigrini, 1967, p. 79, pl. 8, fig. 2; pl. 9, fig. 2.
Theocorythium trachelium trachelium (Ehrenberg), Dinkelman, 1973, p. 788, pl. 10, figs. 8, 9; Foreman, 1975, pl. 9, fig. 12.

Theocorythium vetulum **Nigrini**

Theocorythium vetulum Nigrini, 1971, p. 447, pl. 34.1, figs. 6a, b.
Theocorythium vetulum Nigrini, Dinkelman, 1973, p. 788, pl. 10, figs. 11, 12; 1975, p. 620, pl. 9, fig. 11.

Xiphospira **sp. cf.** *X. circularis* **(Clark and Campbell)**

Porodiscus circularis Clark and Campbell, 1942, p. 42, pl. 2, figs. 2, 6, 10.
Xiphospira circularis (Clark and Campbell), Sanfilippo and Riedel, 1973, p. 526, pl. 14, figs. 5-12; pl. 31, figs. 4-7.
Xiphospira cf. *circularis* (Clark and Campbell), Kling, 1973, p. 635, pl. 2, figs. 1-3; pl. 7, figs. 11-17.

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REFERENCES

Campbell, A. S., and Clark, B. L., 1944. Miocene radiolarian faunas from southern California. *Geol. Soc. Am. Spec. Pap.*, 51:1-76.

Caulet, J., 1971. Contribution à l'étude de quelques Radiolaires Nasselaires des boues de la Méditerranée et du Pacifique. *Arch. Orig. Documentation CNRS, Cah. Micropaleontol.*, 2, 10, 498:1-10.

Clark, B. L., and Campbell, A. S., 1942. Eocene radiolarian faunas from the Mt. Diablo Area, California. *Geol. Soc. Am. Spec. Pap.*, 39:1-112.

Dinkelman, M. G., 1973. Radiolarian Stratigraphy: Leg 16, Deep Sea Drilling Project. *In* van Andel,. Tj. H., Heath, G. R., et al., *Init. Repts. DSDP*, 16: Washington (U.S. Govt. Printing Office), 747-813.

Dogiel, V. A., and Reshetnyak, V. V., 1952. Materialy po radiolyariyam severi-zapadnoi chasti Tikhogo okeana. *Issled. Dal'nevost. Morei SSSR*, 3:5-36.

Dreyer, F., 1889. Die Pylombildungen in vergleichend-anatomischer und entwicklungsgeschichtlicher Beziehung bei Radiolarien und bei Protisten überhaupt. Jena, *Z. Naturwiss.*, 23(N.F. 16):77.

Dumitrică, P., 1973. Cretaceous and Quaternary radiolaria in deep sea sediments from the Northwest Atlantic Ocean and Mediterranean Sea. *In* Ryan, W. B. F., Hsü, K. J., et al., *Init. Repts. DSDP*, 13: Washington (U.S. Govt. Printing Office), 829-901.

Ehrenberg, C. G., 1838. Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *K. Acad. Wiss. Berlin, Abh.*, für 1838:59-147.

________, 1844. Über 2 neue Lager von Gebirgsmassen aus Infusorien als Meeres-Absatz in Nord-Amerika und eine Vergleichung derselben mit den organischen Kreide-Gebilden in Europa und Afrika. *K. Preuss. Acad. Wiss. Berlin, Ber.*, für 1844:57-97.

________, 1847. Über die mikroskopischen kieselschaligen Polycystinen als mächtige Gebirgsmasse von Barbados und über das Verhältnis der aus mehr als 300 neuen Arten bestehenden ganz eigenthümlichen Formengruppe jener Felsmasse zu den jetzt lebenden Thieren und zur Kreidebildung. Eine neue Anregung zur Erforschung des Erdlebens. *K. Preuss. Acad. Wiss. Berlin, Ber.*, für 1847:40-60.

________, 1854. *Mikrogeologie*, Atlas, Fortsetzung (1856): Leipzig (Voss).

________, 1858. Kurze Charakteristik der 9 neuen Genera und der 105 neuen Species des ägäischen Meeres und des Tiefgrundes des Mittelmeeres. *K. Preuss. Acad. Wiss., Monatsber.*, f. 1858:10.

________, 1860. Über den Tiefgrund des Stillen Oceans zwischen Californien und den Sandwich-Inseln aus bis 15 600′ Tiefe nach Lieut. Brooke. *K. Preuss. Acad. Wiss. Berlin, Monatsber.*, für 1860:819-833.

________, 1861. Über die Tiefgrund-Verhältnisse des Oceans am Eingange der Davisstraße und bei Island. *K. Preuss. Acad. Wiss. Berlin, Monatsber.*, für. 1861:275-315.

________, 1872a. Mikrogeologische Studien als Zusammenfassung der Beobachtungen des kleinsten Lebens der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluß. *K. Preuss. Acad. Wiss. Berlin, Monatsber.*, für 1872:265-322.

________, 1872b. Mikrogeologische Studien über das kleinste Leben der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluß. *K. Acad. Wiss. Berlin, Abhandl.*, für 1872:131-399.

Foreman, H. P., 1975. Radiolaria from the North Pacific, Deep Sea Drilling Project, Leg 32. *In* Larson, R. L., Moberly, R., et al., *Init. Repts. DSDP*, 32: Washington (U.S. Govt. Printing Office), 579-676.

Haeckel, E., 1860. Abbildungen und Diagnosen neuer Gattungen und Arten von lebenden Radiolarien des Mittelmeeres. *K. Preuss. Acad. Wiss. Berlin, Monatsber.*, für 1860:835-845.

________, 1862. *Die Radiolarien. (Rhizopoda, Radiaria):* Berlin (Reimer).

________, 1881. Entwurf eines Radiolarien-Systems auf Grund von Studien der Challenger-Radiolarien. Jena. *Z. Med. Naturwiss.*, 15:418-472.

________, 1887. Report on the Radiolaria collected by H.M.S. Challenger during the years 1873-76. *Rept. Voyage Challenger, Zool.*, 18:1-1803.

Hays, J. D., 1965. Radiolaria and late Tertiary and Quaternary history of Antarctic Seas. Biology of Antarctic Seas II. *Antarct. Res. Ser.*, 5:124-184.

_______, 1970. Stratigraphy and evolutionary trends of Radiolaria in North Pacific Deep-Sea sediments. *In* Hays, J. D. (Ed.), *Geological investigations of the North Pacific: Geol. Soc. Am. Mem.* 126:185-218.

Kling, S. A., 1973. Radiolaria from the Eastern North Pacific, Deep Sea Drilling Project, Leg 18. *In* Kulm, L. D., von Huene, R., et al., *Init. Repts. DSDP*, 18: Washington (U.S. Govt. Printing Office), 617-671.

_______, 1979. Vertical distribution of Polycystine radiolarians in the central North Pacific. *Mar. Micropaleontol.*, 4:295-318.

Ling, H.-Y., and Anikouchine, W. A., 1967. Some Spumellarian Radiolaria from the Java, Philippine, and Mariana trenches. *J. Paleontol.*, 6:1481-1491.

Martin, G. C., 1904. Radiolaria. *Maryland Geol. Surv. (Miocene):*, Baltimore (John Hopkins Press), pp. 447-459.

Moore, T. C., 1971. Radiolaria. *In* Tracey, J. I., Jr., Sutton, G. H., et al., *Init. Repts. DSDP*, Washington (U.S. Govt. Printing Office), 8:727-775.

Müller, J., 1855. Über die im Hafen von Messina beobachteten Polycystinen. *K. Preuss. Acad. Wiss. Berlin, Ber.*, f. 1855:671-674.

Nakaseko, K., 1963. Neogene Cyrtoidea (Radiolaria) from the Isozaki Formation in Ibaraki Prefecture, Japan. *Sci. Rep. Osaka Univ.*, 12, 2:165-198.

Nigrini, C., 1967. Radiolaria in pelagic sediments from the Indian and Atlantic Oceans. *Bull. Scripps Inst. Oceanogr.*, 11:1-125.

_______, 1970. Radiolarian assemblages in the North Pacific and their application to a study of Quaternary sediments in Core V 20-130. *In* Hays, J. D. (Ed.), *Geological Investigations of the North Pacific: Geol. Soc. Am. Mem.*, 126:139-183.

_______, 1971. Radiolarian zones for the Quaternary of the equatorial Pacific Ocean. *In* Funnell, B. M., and Riedel, W. R. (Eds.), *The Micropaleontology of Oceans:* Cambridge (Cambridge Univ. Press), pp. 443-461.

_______, 1977. Tropical Cenozoic Artostrobiidae (Radiolaria). *Micropaleontology*, 23, 3:241-269.

Petrushevskaya, M. G., 1971. Radiolyarii Nassellaria v planktone mirovogo okeana. (Radiolaria Nassellaria of the world ocean). *Akad. Nauk SSSR, Zool. Inst. Issled. Fauny Morei*, 9(17):3-295.

Popofsky, A., 1908. Die Radiolarien der Antarktis (mit Ausnahme der Tripyleen). *Deutsche Sudpolar-Expedition 1901-1903*, 10(3): 1-305.

_______, 1912. Die Sphaerellarien des Warmwassergebietes. *Deutsche Südpolar-Expedition 1901-1903*, 13(Zool. 5), 2:73.

Riedel, W. R., 1953. Mesozoic and Late Tertiary Radiolaria of Rotti. *J. Paleontol.*, 27, 6:805-813.

_______, 1957. Radiolaria: a preliminary stratigraphy. *Rep. Swed. Deep-Sea Exped.*, 6, 3:59-96.

_______, 1958. Radiolaria in Antarctic sediments. *Rep. B.A.N.Z. Antarct. Res. Exped.*, B6, 10:217-255.

_______, 1959. Oligocene and lower Miocene Radiolaria in tropical Pacific sediments. *Micropaleontology*, 5, 3:285-302.

_______, 1967a. Subclass Radiolaria. *In* Harland, W. B., et al. (Eds.), *The Fossil Record:* London (Geol. Soc. London), pp. 291-298.

_______, 1967b. Some new families of Radiolaria. *Proc. Geol. Soc. London*, 1640:148-149.

Riedel, W. R., and Sanfilippo, A., 1970. Radiolaria, Leg 4, Deep Sea Drilling Project. *In* Bader, R. G., Gerard, R. D., et al., *Init. Repts. DSDP*, 4: Washington (U.S. Govt. Printing Office), 503-575.

_______, 1971. Cenozoic Radiolaria from the western tropical Pacific, Leg 7. *In* Winterer, E. L., Riedel, W. R., et al., *Init. Repts. DSDP*, 7, Pt. 2: Washington (U.S. Govt. Printing Office), 1529-1672.

_______, 1978. Stratigraphy and evolution of tropical Cenozoic radiolarians. *Micropaleontology*, 24, 1:61-96.

Sanfilippo, A., and Riedel, W. R., 1970. Post-Eocene "closed" theoperid radiolarians. *Micropaleontology*, 16, 4:446-462.

_______, 1973. Cenozoic Radiolaria (exclusive of the theoperids, artostrobiids, and amphipyndacids) from the Gulf of Mexico. *In* Worzel, J. L., Bryant, W., et al., *Init. Repts. DSDP*, 10: Washington (U.S. Govt. Printing Office), 475-611.

Theyer, F., and Hammond, S. R., 1974. Cenozoic magnetic time scale in deep-sea sediments: completion of the Neogene. *Geology*, 2: 487-492.

Theyer, F., Mato, C. Y., and Hammond, S. R., 1978. Paleomagnetic and geochronologic calibration of latest Oligocene to Pliocene radiolarian events, equatorial Pacific. *Mar. Micropaleontol.*, 3:377-395.

Westberg, M. J., and Riedel, W. R., 1978. Accuracy of radiolarian correlations in the Pacific Miocene. *Micropaleontology*, 24, 1: 1-23.

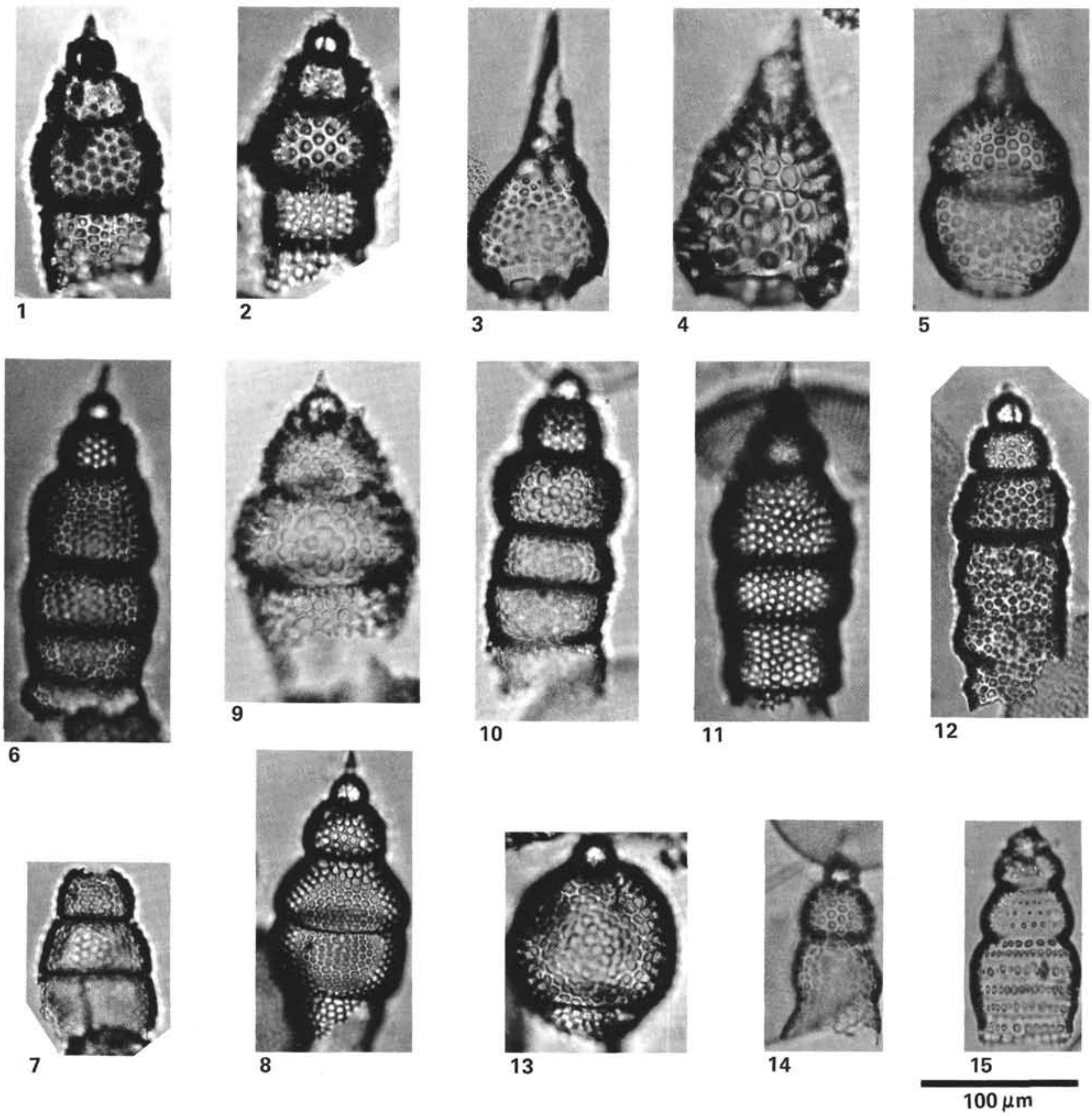

Plate 1. (The figures on Plates 1 through 5 cover the 11 different horizons of the Pleistocene through middle Miocene. Magnifications are ×240. The samples used for the illustrations are noted for each figure. All slides have BGR numbers; they are deposited in the Bundesanstalt für Geowissenschaften und Rohstoffe, BGR (Federal Institute for Geosciences and Natural Resources), Postfach 510153, D-3000 Hannover, 51, Federal Republic of Germany.) 1-2. *Stichocorys wolffii* Haeckel, (1) Sample 469-30-1, 34-36 cm. *D. alata* Zone, BGR-R 1149, (2) Sample 468B-17-4, 54-56 cm. *D. alata* Zone, BGR-R 1060. 3. *Sethocorys* sp. Sample 469-20-1, 105-107 cm. *C. petterssoni* Zone, BGR-R 1134. 4. *Lamprocyrtis hannai* (Campbell and Clark). Sample 469-17-1, 40-42 cm. *O. penultimus/O. antepenultimus* Zone, BGR-R 1132. 5. *Theoconus* sp. cf. *T. zancleus* (Müller). Sample 467-2-1, 14-16 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 795. 6-8. *Stichocorys peregrina* (Riedel), (6, 7) Sample 471-12-5, 40-42 cm. BGR-R 1351, (8) Sample 471-13-7, 40-42 cm. BGR-R 1360; both samples are from the lower *S. peregrina* Zone. 9. *Stichocorys armata* (Haeckel). Sample 468-18-5, 51-53 cm. *D. alata* Zone, BGR-R 995. 10-11. *Stichocorys delmontensis* (Campbell and Clark), (10) Sample 472-7-1, 60-62 cm. *O. antepenultimus* Zone, BGR-R 1431, (11) Sample 471-15-3, 40-42 cm. *O. penultimus* Zone, BGR-R 1366. 12. *Stichocorys* sp. Sample 472-10-1, 60-62 cm. *C. petterssoni* Zone, BGR-R 1446. 13. *Lithopera renzae* Sanfilippo and Riedel. Sample 468-5-3, 133-135 cm. *D. alata* Zone, BGR-R 1178. 14. *Theocorys* sp. cf. *T. redondoensis* (Campbell and Clark). Sample 469-20-1, 105-107 cm. *C. petterssoni* Zone, BGR-R 1173. 15. *Siphostichoartus* sp. cf. *S. corona* (Haeckel). Sample 469-20-1, 105-107 cm, *C. petterssoni/D. alata* Zone, BGR-R 1134.

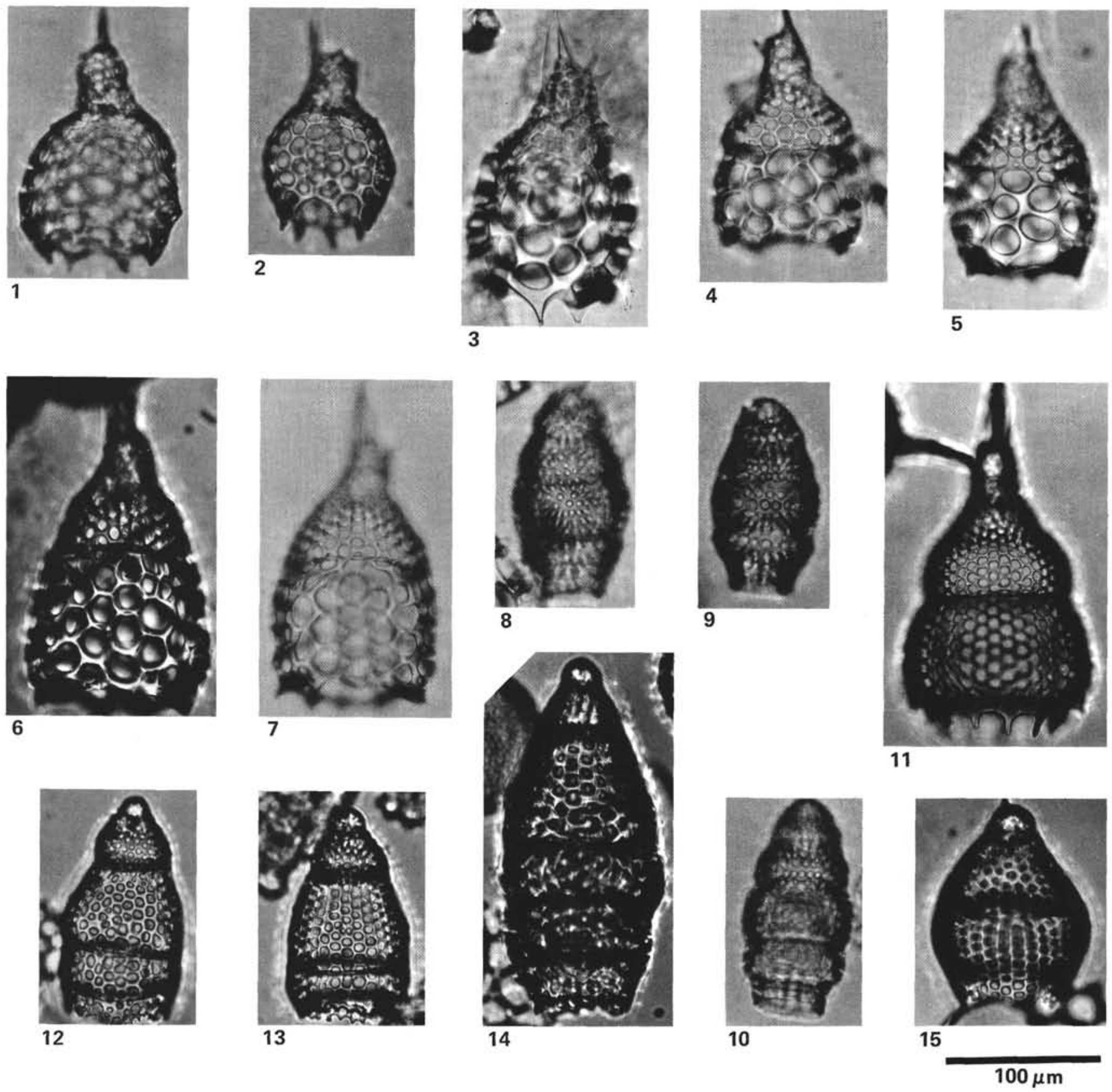

Plate 2. 1-2. *Lamprocyrtis nigriniae* (Caulet). Sample 467-2-1, 14-16 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 795. 3 and 5(?). *Lamprocyrtis neoheteroporos* Kling. Sample 468A-1-4, 55-57 cm. *E. matuyamai* Zone, BGR-R 1000. 4, 6, 7. *Lamprocyrtis heteroporos* (Hays), (6, 7) Sample 469-7-2, 30-32 cm. *L. heteroporos* Zone, BGR-R1100, (4) Sample 467-35-1, 53-56 cm. Upper *S. peregrina* Zone, BGR-R 920. 8-10. *Botryostrobus miralestensis* (Campbell and Clark); (8, 10) Sample 468A-1-4, 55-57 cm. *E. matuyamai* Zone, BGR-R 1000, (9) Sample 467-2-1, 14-16 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 795. 11. *Lamprocyclas maritalis maritalis* Haeckel. Sample 471-7-2, 75-77 cm. Upper *S. peregrina* Zone, BGR-R 1318. 12-14. *Eucyrtidium calvertense* Martin, (12) Sample 467-25-6, 78-80 cm. *L. heteroporos* Zone, BGR-R 892, (13) Sample 467-26-2, 60-62 cm. Upper *S. peregrina* Zone, BGR-R 896, (14) Sample 467-19-6, 24-26 cm. *L. heteroporos* Zone, BGR-R 875. 15. *Eucyrtidium inflatum* Kling. Sample 468B-17-2, 54-56 cm. *D. alata* Zone, BGR-R 1058.

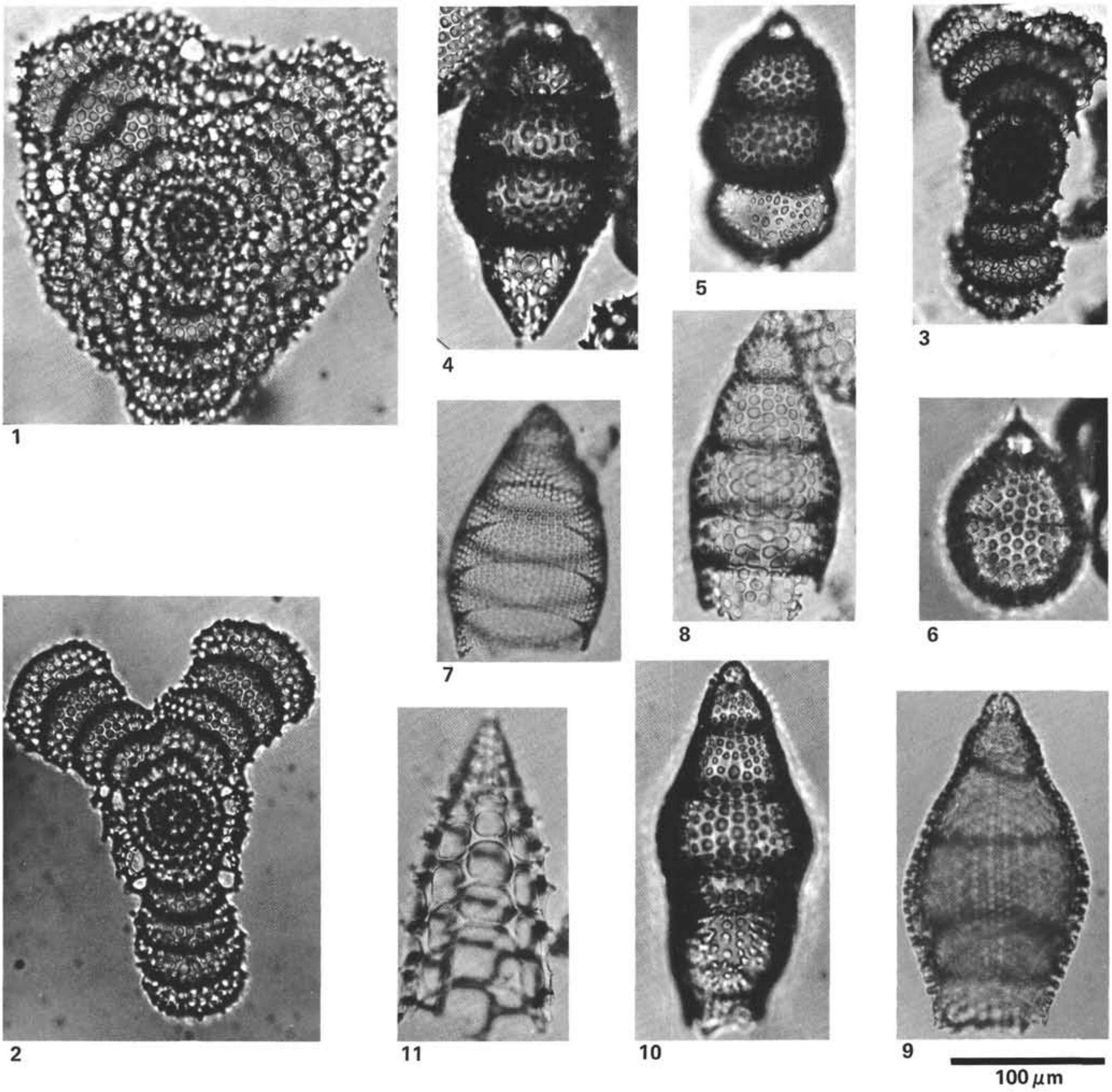

Plate 3. 1-3. *Amphirhopalum wirchowii* (Haeckel), (1) Sample 469-5-3, 80-82 cm. *E. matuyamai* Zone, BGR-R 1090, (2) Sample 469-3-1, 40-42 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 1077, (3) Sample 467-6,CC. *B. miralestensis/A. angelinum* Zone, BGR-R 818a. 4. *Cyrtocapsella tetrapera* Haeckel. Sample 468B-6-5, 60-62 cm. *D. alata* Zone, BGR-R 1032. 5-6. *Cyrtocapsella japonica* (Nakaseko), (5) Sample 470-12-1, 6-8 cm. *O. antepenultimus* Zone, BGR-R 1251, (6) Sample 469-30-1, 34-36 cm. *D. alata* Zone, BGR-R 1149. 7. *Eucyrtidium acuminatum* (Ehrenberg). Sample 467-2-1, 14-16 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 795. 8-9. *Eucyrtidium matuyamai* Hays. Sample 468A-1-4, 55-57 cm. *E. matuyamai* Zone, BGR-R 1000. 10. *Eucyrtidium* sp. cf. *E. matuyamai* Hays. Sample 469-5-3, 80-82 cm. *E. matuyamai* Zone, BGR-R 1090. 11. *Peripyramis circumtexta* Haeckel. Sample 468A-1-4, 55-57 cm. *E. matuyamai* Zone, BGR-R 1000.

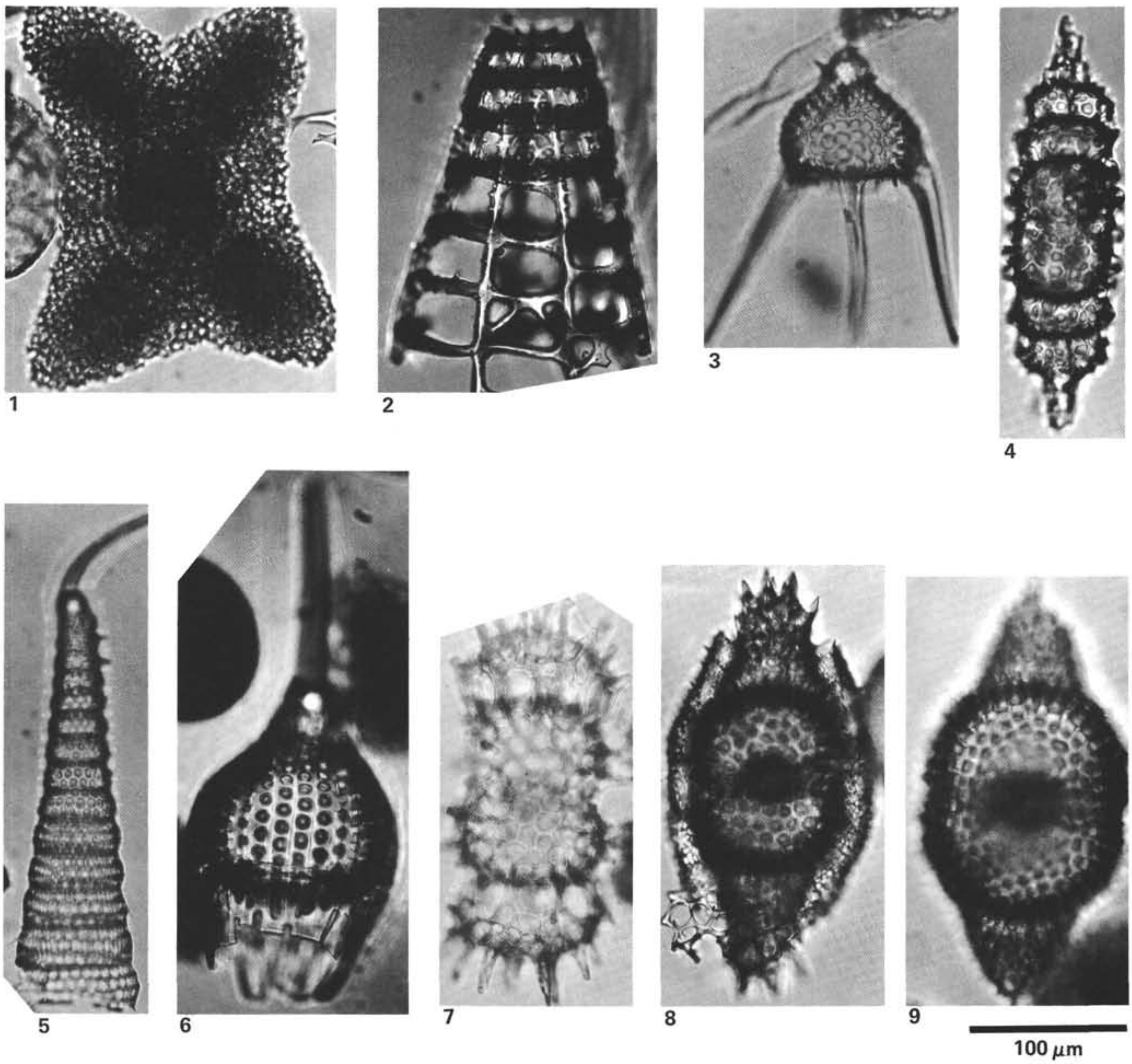

Plate 4. 1. *Spongaster tetras irregularis* Nigrini. Sample 469-1-2, 53–55 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 1070. 2. *Bathropyramis woodringi* Campbell and Clark. Sample 467-33-4, 35–37 cm. Upper *S. peregrina* Zone, BGR-R 916. 3. *Pterocanium korotnevi* (Dogiel and Reshetnyak). Sample 467-2-1, 14–16 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 795. 4. *Ommatartus* sp. cf. *Cannartus bassanii* (Carnevale), cf. sensu Foreman, 1975, pl. 8, figs. 11–12. Sample 471-6-7, 73–75 cm. Upper *S. peregrina* Zone, BGR-R 1317. 5. *Stichopera pectinata* Haeckel group. Sample 467-2-1, 14–16 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 795. 6. *Calocycletta costata* (Riedel). Sample 468-18-5, 51–53 cm. *D. alata* Zone, BGR-R 995. 7. *Ommatartus tetrathalamus* (Haeckel). Sample 473-2-1, 80–82 cm. *B. miralestensis/A. angelinum* Zone, BGR-R 1454. 8. *Ommatartus* sp. Sample 472-7-5, 60–62 cm. *O. antepenultimus* Zone, BGR-R 1435. 9. *Cannartus* ?sp. Sample 470-12-1, 6–8 cm. *O. antepenultimus* Zone, BGR-R 1251.

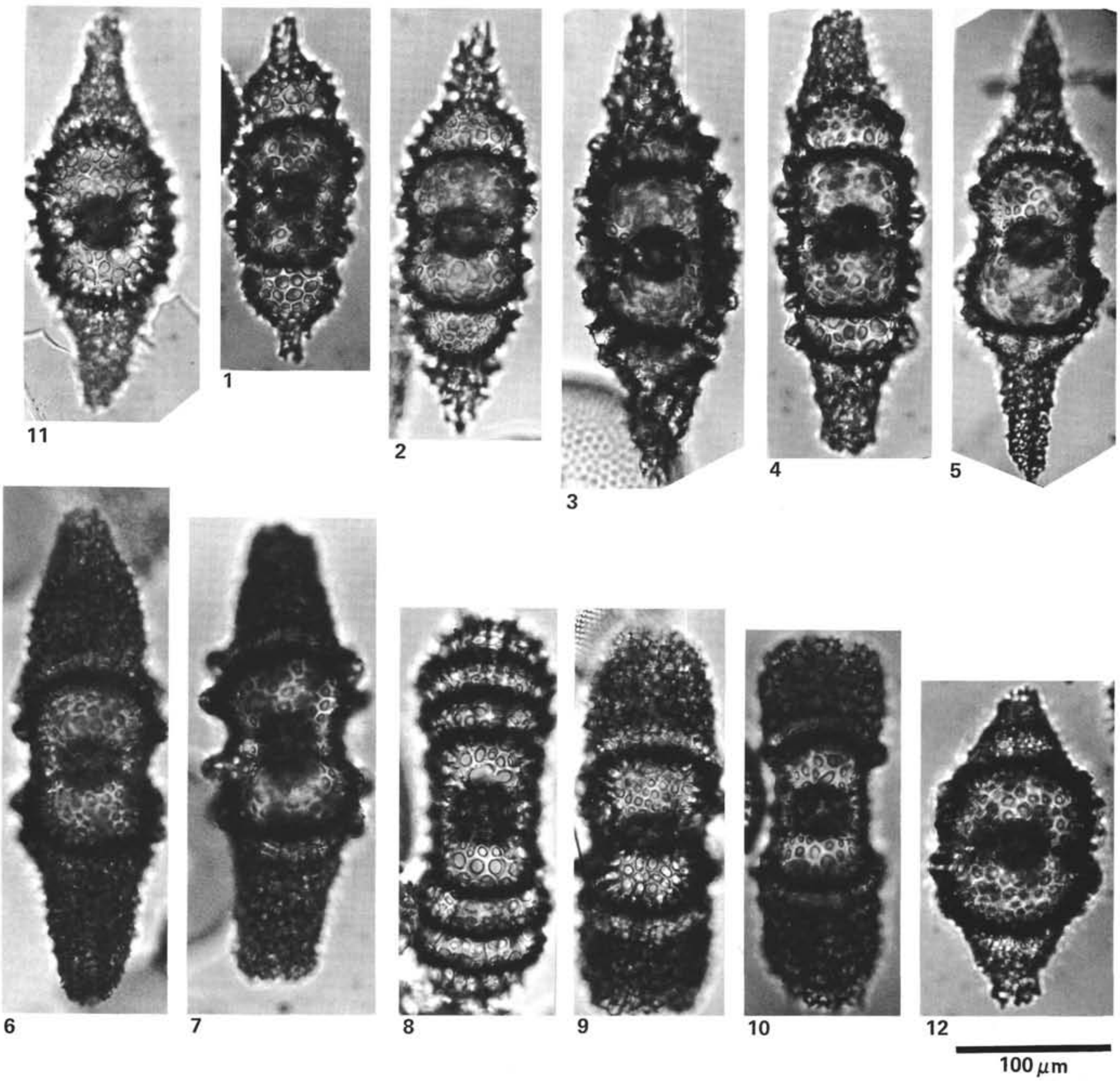

Plate 5. 1–2. *Ommatartus penultimus* (Riedel), (1) Sample 471-7-2, 75–77 cm. Upper *S. peregrina* Zone, BGR-R 1318, (2) Sample 470A-4-3, 62–64 cm. *O. penultimus* Zone, BGR-R 1284. 3–5. *Ommatartus antepenultimus* Riedel and Sanfilippo, (3) Sample 470-8-3, 70–72 cm. *O. penultimus/ lower S. peregrina* Zone, BGR-R 1238, (4) Sample 471-14-1, 40–42 cm. *O. penultimus* Zone, BGR-R 1362, (5) Sample 470-11-1, 70–72 cm. *O. antepenultimus* Zone, BGR-R 1244. 6–7. *Cannartus laticonus* Riedel, (6) Sample 470-15-3, 70–72 cm. BGR-R 1264, (7) Sample 470-15-5, 70–72 cm. BGR-R 1266, both samples belong to the *C. petterssoni* Zone. 8. *Ommatartus hughesi* (Campbell and Clark). Sample 470-9-1, 70–72 cm. *O. penultimus* Zone, BGR-R 1239. 9–10. *Cannartus petterssoni* Riedel and Sanfilippo, (9) Sample 470-12-5, 70–72 cm. *O. antepenultimus* Zone, BGR-R 1255, (10) Sample 468-2-3, 5–7 cm. *C. petterssoni* Zone, BGR-R 1163. 11–12. *Cannartus* sp. cf. *C. mammiferus* (Haeckel). Sample 469-23-3, 25–27 cm. *C. petterssoni/D. alata* Zone, BGR-R 1142.