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39. RADIOLARIAN PALEOGENE BIOSTRATIGRAPHY IN THE SOUTHERN INDIAN OCEAN, LEG 120[1]

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ABSTRACT

During Ocean Drilling Program Leg 120, an almost complete Paleogene sediment section on the Kerguelen Plateau in the southern Indian Ocean was recovered. The biostratigraphy of radiolarians from these sediments at Sites 748 and 749 is studied. A biostratigraphic framework established in low and middle latitudes is not applicable because of the absence of most zonal marker species. Biogenic opal is present only in middle Eocene to Oligocene sediments, and three new zones–*Lychnocanoma conica, Axoprunum*(?) *irregularis,* and *Eucyrtidium spinosum* zones–are proposed. The Paleogene antarctic radiolarian fauna is different from that in low and middle latitudes. Three new species, *Axoprunum*(?) *irregularis, Eucyrtidium cheni,* and *Eucyrtidium spinosum,* are described.

INTRODUCTION

During Ocean Drilling Program (ODP) Leg 120, scientists drilled five sites in the Central and Southern Kerguelen plateaus of the southern Indian Ocean. Although Paleogene radiolarians were obtained from four sites (Sites 747–750), two sites have either poorly preserved shells (Site 747) or insufficient recovery (Site 750). For this study, I performed Paleogene radiolarian biostratigraphic work for Sites 748 and 749.

Paleogene radiolarians from Leg 120 range in age from the middle Eocene to the late Oligocene. Although the radiolarian zonation of this interval has already been established for low-latitude areas (Sanfilippo et al., 1985), this scheme cannot be applied to Leg 120 samples because of the absence of almost all zonal markers recognized in tropical or subtropical areas. For instance, genera *Podocyrtis* and *Thyrsocyrtis*, both of which are the most important groups for defining the middle to late Eocene zones, were not observed in Leg 120 samples at all.

Few previous studies of Paleogene radiolarians in the Antarctic Sea area exist. Petrushevskaya (1975) described many Paleogene forms from Deep Sea Drilling Project (DSDP) Leg 29. Chen (1975) treated Paleogene samples from Sites 264 and 274 of DSDP Leg 28, which have ages of Eocene and early Oligocene, respectively. He described radiolarians in these two assemblages, but no one has yet tried to zone a Paleogene interval in the Antarctic Sea. Weaver (1983) also reported on Paleogene radiolarians from the Falkland Plateau region in the southwest Atlantic. Although he studied middle Eocene to early Oligocene radiolarians and interpreted them from a paleoenvironmental perspective, he did not zone them, and no plates of Paleogene radiolarians appear in his study.

ODP has conducted several cruises in the Antarctic Sea area (Legs 113, 114, 119, and 120). During Leg 113, scientists recovered radiolarian-bearing Paleogene cores at several sites in the Weddell Sea (Barker, Kennett, et al., 1988). Abelmann (1990) studied the biostratigraphy of the late Oligocene to middle Miocene sequence from Sites 689 and 690. During Leg 114, seven sites were drilled in the subantarctic South Atlantic, and many Paleogene cores (Paleocene to Oligocene) that included radiolarians were obtained (Ciesielski, Kristoffersen, et al., 1988). During Leg 119, northernmost and southernmost Kerguelen Plateau and Prydz Bay sites were drilled (Barron, Larsen, et al., 1989). Eocene and Oligocene radiolarians were reported from Sites 738 and 744 and, particularly, from Site 738, where warmer fauna have been reported.

Until now, no Paleogene radiolarian zonation existed, except for that of Abelmann (1990). Paleogene radiolarians from Leg 120 contain many forms described by Petrushevskaya (1975) and Chen (1975). In particular, Site 748 contains a good Paleogene section for biostratigraphy composed of nannofossil oozes that include radiolarians, foraminifers, nannofossils, diatoms, and silicoflagellates. I conducted a biostratigraphic study using these samples and propose an original zonation of a Paleogene sequence.

MATERIALS AND METHODS

The samples used for this study were obtained from Holes 748B (58°26.45′S, 78°58.89′E) and 749B (58°43.03′S, 76°24.45′E). Sediments from these holes are composed mostly of calcareous sediments of Mesozoic and Cenozoic age (Schlich, Wise, et al., 1989).

At Hole 748B, Paleogene nannofossil oozes without porcellanite or chert (lithologic Subunit IIA) were drilled from Cores 120-748B-9H to -20H. Cores 120-748B-21X to -23X are composed of nannofossil chalk, chert, and porcellanite (lithologic Subunit IIB). Paleogene radiolarians are contained in Cores 120-748B-9H to -19H, and samples obtained from this interval were used for this study. Abundances and preservational states of the radiolarian shells from this interval generally became fewer and poorer with depth.

Samples of nannofossil ooze without chert were obtained from Sample 120-749B-1H-1, 24 cm, to Core 120-749B-5H (lithologic Subunit IIA), and Paleogene radiolarians were included with Cores 120-749B-1H to -3H. Because Paleogene sediments in this interval (upper[?] Eocene to upper Oligocene) are thin, I did not treat the samples from this hole in numerical order.

Almost all samples (45–47 cm) from each section of these intervals from both holes were studied (Tables 1 and 2). First, these samples were processed with HCl (about 3%), and then with H_2O_2 and sodium pyrophosphate. Residues produced by these processes were sieved through 250-mesh (63 μm). Dried

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Table 1. List of occurrences of radiolarians from Hole 748B (Cores 120-748B-9H to -19H).

Depth	Sample (Intervals: 45-47cm)	Abundance	Preservation	Age	1 Corythospyris aff. jubata Goll	2 Dendrospyris stabilis Goll	3 Zygocircus bütschli Haeckel	Other acanthodesmiids	4 Amphipyndax stocki (Campbell and Clark)	5 Dictyoprora mongolfieri (Ehrenberg)	6 Dictyoprora pirum (Ehrenberg)	7 Siphocampe acephala (Ehrenberg)	8 Siphocampe nodosaria (Haeckel)	9 Siphocampe(?) quadrata (Petrushevskaya and Kozlova)	Other artostrobiids	10 Botryopyle dictyocephalus Haeckel	Other cannobotryids	11 Carpocanistrum spp.	12 Ceratocyrtis spp.	13 Corythomelissa horrida Petrushevskaya	14 Corythomelissa(?) sp.	15 Lithomelissa challengerae Chen	16 Lithomelissa sphaerocephalis Chen	17 Lithomelissa tricornis Chen	18 Lithomelissa sp.	19 Velicucullus cf. oddgurneri Bjørklund	20 Plagoniid gen. et sp. indet.	Other plagoniids	21 Theocyrtis tuberosa Riedel	Other pterocoryids	22 Archaeodictyomitra(?) sp.	23 Artostrobus(?) cf. pretabulatus Petrushevskaya	24 Calocyclas cf. semipolita Clark and Campbell	25 Calocyclas sp. A	26 Calocyclas sp. B	27 Calocyclas sp. C	28 Clathrocyclas universa Clark and Campbell	29 Cornutella spp.	30 Cycladophora bicornis (Popofsky)	31 Cycladophora conica Lombari and Lazarus	32 Cyclampterium(?) milowi Riedel and Sanfilippo
67.05	9H-1	A	G	late Oligocene	3	1		1										3	40	0	2				3	6	1	26		5				14				1			0
68.55	9H-2	A	G	late Oligocene	8	1							0		3	1		53	78	0	0				0	3	7	32		6				6				1	0	1	
70.05	9H-3	A	G	late Oligocene	1	?		0							1	0		9	40	2	2	?		0	1	5	1	17		11				10				0	0	3	
71.55	9H-4	A	G	late Oligocene	1	0												18	56	2	1	0	?		9		3	17		1			0	9				0		3	?
73.05	9H-5	A	M	late Oligocene	0	2		0										7	14	0	2	0	0		0		0	2		0			2	3					0	2	0
74.55	9H-6	C	M	late Oligocene	1	?										1		6	11			1		0			3	1						3					0	2	0
76.05	9H-7	A	G	late Oligocene		0		1										11	12	1	0	0	1		3		3	2		0			0	1						2	0
76.55	10H-1	C	G	late Oligocene	0	0									0			7	8	1	0	0			0		5	5		0				2							0
78.03	10H-2	A	G	late Oligocene	8			45									2	52	18	1	0			2	1		1	11		0				16						10	0
79.55	10H-3	C	M	late Oligocene				0										59	5	0	1		0	1	0			8					0	6						1	0
81.05	10H-4	C	G	late Oligocene		?		0										54	27		0	0	0	0	?			11		0			1	7		?		2		1	1
82.55	10H-5	A	G	late Oligocene		0		0							0		1	92	20	0	2	0	0	0	0			18		0	1		4	1				0		4	1
84.05	10H-6	C	M	late Oligocene	5			2										32	13	0	1	1	1		3			10		0	0		5	0						10	1
86.05	11H-1	A	M	late Oligocene	0			0							0	0		23	3	0	0	0	3		1			2					3	1	?					0	2
87.55	11H-2	A	M	late Oligocene		0		0						0		0		24	12	2	1	1	1					4					7	3	?						1
89.05	11H-3	A	G	late Oligocene	0	0		0					0			0		37	25	1	1	1	3		0			10		0			6	4				0			3
90.55	11H-4	A	G	— —	70	0												117	17	2	0	0	0					16		0			1	1						0	2
92.05	11H-5	C	M	early Oligocene	68													106	20	6		0	3	0	1			10		8	0		11	2				0			2
93.55	11H-6	C	M	early Oligocene	18	1		0					2			0		168	47	4	1	0	3		1			8		0	1		6	1				0		0	1
95.05	11H-7	C	G	early Oligocene	14			0					2			0		133	11	1		0	2				0	3			0		9	0				2			3
95.55	12H-1	A	G	early Oligocene	7			0					1			0		83	5			0	1					0		0	0		5					0	?	0	2
97.05	12H-2	A	G	early Oligocene	11	0		1					0		0	1		29	30			1	4			a	0	5		0	1		6	0							3
98.55	12H-3	A	M	early Oligocene	5	1					0			0		0		9	6	1	0		4	0		a		1		2			12	1							6
100.05	12H-4	C	M	early Oligocene	42	0		1			0				0			15	5			0	2			?		1		0	0		10					0			10
101.55	12H-5	C	M	early Oligocene	21								0	0		4		16	9			0	4			?	?	3		0	0		2	?			0				1
103.05	12H-6	A	G	early Oligocene	3	0						0				8		16	10	?		0	2	0			?	5		0	1		1	?							17
104.55	12H-7	A	G	early Oligocene	4											1	1	7	3			0	1	1				3		1	0		2								24
105.05	13H-1	A	G	early Oligocene	0	?		1						0		8		8	4			0	11				?	7		2			45								14
106.55	13H-2	A	G	early Oligocene	1	1		1			?				0	15		15	14			0	31	?		??		12		3			114							0	6
108.05	13H-3	A	G	early Oligocene	2	5		2					0			14		8	9	2		2	15					11		0			193		?	?		1			8
109.55	13H-4	A	G	early Oligocene	7	13		0								21		5	47			3	31				?	21		0			103								7
111.05	13H-5	A	G	early Oligocene		1										4			5			1	64					8		2			117								11
112.55	13H-6	A	G	early Oligocene	3	1		1								1			12			0	67					25		0	0		69	?				0			14
114.05	13H-7	A	G	early Oligocene	0	2										1			15			0	95	0				17					117	?							17
114.55	14H-1	A	G	early Oligocene	0			0							0				9		0	2	79	0				16					82					0			19
116.05	14H-2	A	M	early Oligocene	11			1							0			1	1		1		44					3			0		46	?							85
117.55	14H-3	F	P	late Eocene	1			1											1				8					1		0	?		4					0			114
119.05	14H-4	C	M	late Eocene	18		0	8										8	2				50					2		15	1		17			?		0			131
120.55	14H-5	F	P	late Eocene	2			1										0	1	1			14					1			?		8								60
122.05	14H-6	C	M	late Eocene	1	?	6	4							0	0		0	2	0			8					8					28		?			0			26
124.05	15H-1	C	M	late Eocene			4	0								0		0					9					2		3			5								35
125.55	15H-2	A	M	late Eocene	0		0	0			0			0	1			6	3	0			28	0				3		1		0	13				0	0			28
127.05	15H-3	A	M	late Eocene	10	1	1	4										9	5				9	0				4		0		2	20				0				11
128.55	15H-4	C	M	late Eocene			0	1			0			0	0			2	0				12					3		7		1	1		0		1	0			39
130.05	15H-5	C	P	late Eocene	15		0	3			0							2	1				19							0			0								60
133.05	15H-7	C	M	late Eocene	5			6			0					?	0	0	0				11							0		1	1		14		0				38
133.55	16H-1	F	M	late Eocene	?		?	2								?		0					6							0			2	?	29		0		?		55
134.85	16H-2	C	P	late Eocene	3			1								?							3						0						32		3				35
136.35	16H-3	C	P	late Eocene	5	?	1	0								?			1				0										0		13		0				25
137.85	16H-4	C	M	late Eocene	12			1								?	0						5										0		6						19
139.35	16H-5	F	P	late Eocene	2	?										?	0						4										0	?	17						49
140.85	16H-6	F	P	late Eocene	2																												?		9						46
141.55	16H-7	F	P	late Eocene	1			1									0		?				1								?				2			0			63
143.05	17H-1	R	P	late Eocene	7																														15						49
144.55	17H-2	R	P	middle Eocene	0																		1												4						19
146.05	17H-3	R	P	middle Eocene	1			2																											3						43
147.55	17H-4	F	M	middle Eocene	6													3					0					1					3		8						55
152.05	17H-7	F	P	middle Eocene	3		3	6				8						2					11												10						69
157.05	18H-4	C	M	middle Eocene	?		?	5		0		3		0				5					3										?			?	0				18
161.55	18H-7	C	M	middle Eocene	10		?	7	0			1		1				2					6					0													13
166.55	19H-4	A	M	middle Eocene	8		3	21			?		0	3				5	1				1					7							0	34	4	?			3
171.05	19H-7	C	M	middle Eocene	8		1	23		1				3									1													15	1				7
Family					Acanthodesmiidae				Amphipyndacidae	Artostrobiidae						Cannobotryidae		Carpocaniidae		Plagoniidae										Pterocoryidae											

NASSELLARIA

Notes: A = abundant, C = common, F = few, R = rare, B = barren, G = good, M = moderate, and P = poor. The number 0 in the list means presence was confirmed by observation after counting.

Table 1 (continued).

33 *Cyrtocapsella robusta* Abelmann	34 *Cyrtocapsella* aff. *japonica* (Nakaseko)	35 *Dicolocapsa microcephala* Haeckel	36 *Diplocyclas* sp.	37 *Eucyrtidium cheni*, n. sp.	38 *Eucyrtidium spinosum*, n. sp.	39 *Eucyrtidium* spp.	40 *Eusyringium fistuligerum* (Ehrenberg)	41 *Lophoconus titanothericeraos* Clark and Campbell	42 *Lophocyrtis biaurita* (Ehrenberg)	43 *Lychnocanoma amphitrite* Foreman	44 *Lychnocanoma* cf. *babylonis* (Clark and Campbell)	45 *Lychnocanoma conica* (Clark and Campbell)	46 *Lychnocanoma* spp.	47 *Peripyramis* spp.	48 *Pterocanium*(?) sp.	49 *Sethocyrtis* sp.	50 Theoperid, gen. et sp. indet.	Other theoperids	Total nassellarians	1 *Amphistylus angelinus* (Clark and Campbell)	2 *Amphistylus*(?) sp.	3 *Axoprunum bispiculum* (Popofsky)	4 *Axoprunum pierinae* (Clark and Campbell)	5 *Axoprunum*(?) *irregularis*, n. sp.	6 *Lithapium anoectum* Riedel and Sanfilippo	7 *Lithapium* cf. *mitra* (Ehrenberg)	8 *Prunopyle frakesi* Chen	9 *Prunopyle haysi* Chen	10 *Prunopyle tetrapila* Hays	11 *Prunopyle* spp.	12 *Spongoplegma* aff. *antarcticum* Haeckel	13 *Stylosphaera* spp.	14 *Heliostylus* sp.	15 *Periphaena decora* Ehrenberg	16 *Periphaena heliasteriscus* (Clark and Campbell)	17 *Spongodiscus* spp.	18 *Xiphospira* spp.	Other spumellarians	Orosphaerids	Total spumellarians		Radiolarian zonation
33	22					1						30		7	2				201	4		24						59		19	2	3				74	5	621	0	811	1012	*Lychnocanoma conica* Zone
70	31											32		3				1	337	9		10						36	1	37	2	39				28	7	500	0	669	1006	
36	12									0		7		1	4			9	172	17		22						56	2	24	1	3				51	3	665	0	844	1016	
31	7											55		5				8	226	5		0		?				44	0	60	3	7				122	15	531	0	787	1013	
8	1			0						0		24		7		0		2	76	1		0						15	1	15		60			0	27	2	822	0	943	1019	
3	1									0		18		6	0			2	59	2		1						17	1	20	6	215				38	3	659	0	962	1021	
5	0			0		0		0		1		27		6	1		0	0	77	2			1	?				17	1	12	0	156				11	2	721	0	923	1000	
8	1			0			1	0		1		31		6	0			2	78	3								20		22		380				66	3	443	0	937	1015	
2	4					1		0		0		9		4		0		3	190	1		0						31		161		59				52	2	522	0	828	1018	
1	1			0				?		0		14		3	0	0		2	102	1		0						31		27	0	486				16	0	355	0	916	1018	
4	2			?				0		0		90		2	2			1	205	0		0		0				16	1	33		17			0	45	14	690	0	816	1021	
27	4			1	0	0		0	0	2		4		2		1		2	187	0		0						31	1	34		47			0	36	6	675	0	830	1017	
3	0			0	0	0		0	1	2		22		3	0		0	3	118	4		2	0	4				32	1	22		30			1	11	5	786	0	898	1016	*Axoprunum*(?) *irregularis* Zone
1	0			1	0	0		0	0	0		20		1		0	0	0	61	1		1	0	3				8	0	30		241			0	7	2	677	0	970	1031	
3	1			2	1	1				0		0		1	0			2	67	0		3		10				5	0	22		63			0	9	9	818	0	939	1006	
6	4			0	0		0	0		0				1			0	2	104	4		?		21				23	1	32		27			0	28	7	767	0	910	1014	
7	1			0	?	?		0		1		1		3	0	?		3	242	1		2		46				11	2	33		3			0	40	3	635	0	776	1018	
5	4			3		0				1		?		3	0	0	?	2	255	9		1		46				24	1	49		6			0	35	7	582	0	760	1015	
12				7	?			1		4		?		3		0		1	290	1		0	0	74				9	2	37		12			1	46	7	540	0	729	1019	
1	?			3	0	1		0	0	4		?		2		0		1	192	0		1	0	49				10		37	0	8			2	43	12	665	0	827	1019	
5	1			0				0	?	0		16		3				0	129	0		0	?	62				12	1	50		13			0	52	21	678	0	889	1018	
4	0	1		1	0			0	0	0		38		2		0		0	138	?		2	1	60				8	1	26		44			0	29	18	689	0	878	1016	
2			0	3				1		3		0		1	0	0	0	2	60	1	1	0	0	30				5	0	8		230			1	12	2	667	0	957	1017	
1	?		0	4	0			2	0	3				1		1	0	3	101	7	1	11	?	95				6		12		48			0	14	8	712		914	1015	
	?		2	17				4		0		?		1		?		2	86	3	?		0	57				8		14		23			0	23	4	797	0	929	1015	
0		0	0	10					0	1		?		4				1	79	2		3	0	21				3		10		154			5	27	3	711	0	939	1018	
		0		16				0		1		?		1		0	0	0	66	5		1	?	44				18		12		128			7	29	7	700	0	951	1017	
		1	2	35				1		1		?	3	6			0	2	151	7		8	1	17				30		32		3			16	37	7	707	0	865	1016	
		0	1	31				1	0	1			6	5			0	2	260	15		4		7				11	1	28		2			5	38	3	634	0	748	1008	
?			0	22				0		0				17			3	1	315	10		15		7			1	16		38		0			4	43	8	557	0	699	1014	
12	1			23				0		1				10	1		13	2	321	14		10	0	2			3	10		93					2	50	8	499		691	1012	
1		3	0	16	1			1		0				9			4	8	256	21		12		?				9	2	39		4			4	39	17	611	0	758	1014	
11	1	4	2	5	1					0				5		0	1	2	225	9		10		0				7		56		1			8	41	21	639		792	1017	
10		1	0	7	1			1		0				3			5	4	296	8		23	3	?			2	7	1	47	1				7	48	12	560		719	1015	
11	?	1	1	9	2			0		2				7		0	2	1	243	6		27	1	1			2	4	0	38					9	56	9	617		770	1013	
		0		0	1			0		0				4			0		198	9	1	18	19				0	2		5	2	39			7	5	2	701		810	1008	
		?						0		0				3			0		133	7	3	51	12					4		3		3			13	0		274	0	370	503	*Eucyrtidium spinosum* Zone
				?	1			?		4				5	0			2	264	3	5	43	3					8		2		19			13	7	4	641	0	748	1012	
					0			1		2				3		1		0	95	2	1	62	9					1		3		13			7		1	315	0	414	509	
1				?	2			0		0				8	3			0	97	?	1	24	4					4		2		8			1	8	4	357	0	413	510	
1			0		4	?				68	0			1		?		0	132	1	17	15	19					3		6		7			7	14	2	287	0	378	510	
?			1		7					12				3				0	106	1	5	3	11					6		7		3			3	17	3	345		404	510	
			0		10					34				6	2			0	128	2	8	3	5					5		14		1			4	29	4	307		382	510	
			0		3					26				4	1			0	101		6	8	17		?			2		3		4			5	12	1	350		408	509	
1					1			0		4				3					109	2	4	3	19							3		2			1	4	0	364		402	511	
?					1					60	1			4					142	1	5	12	19					2		15		1			6	14	5	287		367	509	
					0					3	2			0					99	2	8	17	13		0			1		2		8			6	1	0	351	0	409	508	
				?	0					1	0			2					80		5	6	11							2		3			0	1	0	403		431	511	
					0					1	0	?		1					47	2	3	6	17							1		1			4	3		425		462	509	
					0					2				1					46	2	1	17	24							2		0			1	2		415		464	510	
					0					4	3			1					80	5	7	20	21							1		0			3		3	369		429	509	
														2					59	1		7	24									0			1			418		451	510	
					0				0	3				2					73	2	1	15	31									0			1	1		385		436	509	
					0				?	1				4					76	4	15	23	56					?				2		6	4	3	3	315		431	507	
										11				1					36	?	0	2	17									3		0		0	2	145		169	205	not zoned
								0	0	65	0			3					117	?	?		31											13	1			347		392	509	
0			0		?					11				7					94	1	13	2	72							3		7	0	11	4	2	0	300		415	509	
										48			4	3	?	1			168	3	3	6	47									12	2	6		1	2	261		343	511	
								0	0	140	2	?		7	2	48			233	1	1	2	41		0			?				15	2	4	2	1		207		276	509	
										99	0		10	0		49			198	1	4	2	6					3				114		2	1	1	1	177		312	510	
							2	1	2	101	0	?	12	1	1	6		24	240	3	4	3			18	0		2				53		6	13	5	2	158		267	507	
							0	0	51	36	2		0	4		37		1	191	4	1	2	8							1		148			5	2		146		317	508	

Theoperidae — Actinomidae — Phacodiscidae — Spongodiscidae

SPUMELLARIA

Table 2. List of occurrences of radiolarians from Hole 749B.

depth	Sample (Intervals: 45-47cm)	Abundance	Preservation	Age / species	1 *Corythomelissa* cf. *jubata*	3 *Zygocircus bütchli*	6 *Dictyoprora pirum*	8 *Siphocampe nodosaria*	10 *Botryopyle dictyocephalus*	11 *Carpocanistrum* spp.	13 *Corythomelissa horrida*	15 *Lithomelissa challengerae*	16 *Lithomelissa sphaerocephalis*	18 *Lithomelissa* sp.	24 *Calocyclas* cf. *semipolita*	25 *Calocyclas* sp. A	26 *Calocyclas* sp. B	28 *Clathrocyclas universus*	30 *Cycladophora bicornis*	31 *Cycladophora conica*	32 *Cyclampterium*(?) *milowi*	33 *Cyrtocapsella robusta*	34 *Cyrtocapsella* aff. *japonica*	36 *Diplocyclas* sp.	37 *Eucyrtidium cheni*
0.45	1H-1	A	G	Oligocene										R					R	R		R-F			
1.95	1H-2	F	M							C						+			+	+		R-F	+		
3.45	1H-3	R-F	P-M							C-A						R				R		+			
4.95	1H-4	R-F	P-M							F										+					
6.25	2H-1	C	M						+	C					?	R				R		F	R		?
7.75	2H-2	C	M						+	F	+				R	F				+	+	F			+
9.25	2H-3	F-C	M		+				R	R	R	+			R	?						F			?
10.75	2H-4	F	M		+					R		+			+							R			
12.25	2H-5	C	M		C-A			+	R	C-A			R		?					+	+	F			R
13.75	2H-6	C	M		+					F		+	R		F						+	?			R
15.75	3H-1	C	M	Eocene		+				+			R		F						C				?
17.25	3H-2	B																							
18.75	3H-3	B																							
20.25	3H-4	F-C	M		F		+						R		F		F				C-A			+	
21.75	3H-5	F	P-M		F-C								F		R		F	R			C-A				
23.25	3H-6	R-F	P		R								R				F	F			C				
24.75	3H-7	F	P-M		F								F		+		R				C-A				

Note: Abbreviations are the same as those in Table 1.

residues were scattered on slides, on which thin gum tragacanth was spread and allowed to dry. After breathing lightly on each slide, radiolarian shells that did not adhere were allowed to fall off to be removed with a brush. Canada balsam and 22 × 40 mm glass covers were used to mount the specimens.

Either 500 or 1000 (rarely 200) radiolarian shells from Hole 748B were counted for each sample. The Zeiss axioscope was used as light optic, and all radiolarian shells observed by 20× objective lens were counted as moving along a transverse line. After about 1000 (or 500) specimens were counted, I observed all the radiolarian shells mounted on the slides using less magnification. Many forms still have not been described. Furthermore, I was unable to describe all the forms that were found during Leg 120 here because too many undescribed forms exist and they are too scattered. As shown in Table 1, these forms were collected into families (for instance, other theoperids).

Abundances of each radiolarian species in Hole 749B (Fig. 1) have been classified into four categories: abundant (A), common (C), few (F), and rare (R). Preservation is shown as good (G), moderate (M), or poor (P) (Tables 1 and 2).

RADIOLARIANS AT EACH SITE

Site 748

An almost continuous Paleogene sequence was obtained from Hole 748B. The Oligocene/Miocene boundary was placed near Section 120-748B-8H-CC based on planktonic foraminifers, between Samples 120-748B-8H-CC and -9H-CC using nannofossil biomarkers, and just above Sample 120-748B-8H-CC with diatoms (Schlich, Wise, et al., 1989). The first occurrence (FO) of *Cyrtocapsella tetrapera* (approximately 23 Ma) was recognized at Sample 120-748B-8H-4, 45–47 cm.

Samples from Cores 120-748B-9H and -10H commonly contain *Cyrtocapsella robusta*, *Cyrtocapsella* aff. *japonica*, *Lychnocanoma conica*, *Corythospyris* aff. *jubata*, *Calocyclas* sp. A, and *Prunopyle hayesi*. *Vellicucullus* cf. *oddgurneri* appears in Sample 120-748B-9H-3, 45–47 cm. Rare specimens of *Cyclampterium*(?) *milowi* and *Lychnocanoma amphitrite* were observed, but these may have been reworked because most are fragments. *Stylosphaera* spp. with thick walls were abundant in some samples within this interval. The last occurrence (LO) of *Lithomelissa sphaerocephalis* was found in Sample 120-748B-9H-5, 45–47 cm, and that of *Axoprunum*(?) *irregularis* in Sample 120-748B-10H-6, 45–47 cm.

In Core 120-748B-11H, *Lychnocanoma conica* occurs in most samples, whereas *Axoprunum*(?) *irregularis* was often observed. *Cyrtocapsella robusta* and *Calocyclas* sp. A are abundant, and *Corythospyris* aff. *jubata* and *Carpocanistrum* spp. are abundant in lower samples from Core 120-748B-11H. Occurrences of *Eucyrtidium cheni* and *E. spinosum* are rare to few in Cores 120-748B-10H and -11H, but the latter species may have been reworked because they usually occur as fragments.

Table 2 (continued).

38 *Eucyrtidium spinosum*	40 *Eusyringium fistuligerum*	41 *Lophoconus titanothericeraos*	42 *Lophocyrtis biaurita*	43 *Lychnocanoma amphitrite*	44 *Lychnocanoma* cf. *babylonis*	45 *Lychnocanoma conica*	50 Theoperid, gen. et sp. indet.	1 *Amphistylus angelinus*	2 *Amphistylus*(?) sp.	3 *Axoprunum bispiculum*	4 *Axoprunum pierinae*	5 *Axoprunum*(?) *irregularis*	9 *Prunopyle hayesi*	10 *Prunopyle tetrapila*	12 *Spongoplegma antarcticum*	16 *Periphaena heliasteriscus*	1 *Antarctissa cylindrica* Petrushevskaya	2 *Antarctissa denticulata* (Ehrenberg)	3 *Cycladophora golli* (Chen)	4 *Dendrospyris rhodospyroides* Petrushevskaya	5 *Desmospyris spongiosa* Hays	6 *Eucyrtidium calvertense* Martin	7 *Helotholus vema* Hays	8 *Prunopyle titan* Campbell and Clark	Radiolarian zonation
						F		?					F-C	+	+	+	C-A	F	R	R	C	F	F	R	*Lychnocanoma conica* Zone
						F							F				R	+							
				+		C							F												
						C							R				+								
		+		+		C		+					F				R	+				?			
				+		F-C						F	F-C			+	R				+				*Axoprunum*(?) *irregularis* Zone
						F						F-C	C				C	R			F	R	+		
						F				+		F	F-C				C	R			C-A	R	R		
						?	+	+				F	R												
+				R		R-F			+			C	F			+									
F		+	+	C-A	+		+		F	R	R		R			F									*Eucyrtidium spinosum* Zone
F			+	F				?	F	F-C	R					R									
F		+	?	F					F	F	F		+			F									
?		R	+						?	R	F					F									
R	+	+		+					R	F-C	F-C		R			R									

Core 120-748B-12H commonly contained *Axoprunum irregularis, Cyclampterium*(?) *milowi, Eucyrtidium cheni, Calocyclas* cf. *semipolita,* and *Corythospyris* aff. *jubata. Calocyclas* sp. A and *Lychnocanoma conica* first appeared in Sample 120-748B-12H-3, 45–47 cm. In Core 120-748B-13H, *Calocyclas* cf. *semipolita* and *Lithomelissa sphaerocephalis* are abundant, and *Eucyrtidium cheni, Cyclampterium*(?) *milowi,* and *Axoprunum bispiculum* are also common. Abundances of *Axoprunum*(?) *irregularis* decreased with depth. The last continuous occurrence of *Eucyrtidium spinosum* was in Sample 120-748B-13H-5, 45–47 cm.

In Core 120-748B-14H, *Cyclampterium*(?) *milowi* is sometimes abundant. *Calocyclas* cf. *semipolita, Lithomelissa sphaerocephalis, Axoprunum bispiculum,* and *Axoprunum pierinae* are common. *Eucyrtidium spinosum* was found instead of *E. cheni.* The FOs of *Axoprunum irregularis* and *Eucyrtidium cheni* were placed in Sample 120-748B-14H-1, 45–47 cm, and -14H-2, 45–47 cm, respectively. The LO of *Amphistylus*(?) sp. also was found in Sample 120-748B-14H-2, 45–47 cm.

Core 120-748B-15H contained common *Calocyclas* cf. *semipolita, Lithomelissa sphaerocephalis, Cyclampterium*(?) *milowi, Eucyrtidium spinosum, Lychnocanoma amphitrite, Amphistylus*(?) sp., *Axoprunum bispiculum,* and *A. pierinae.* The LO of *Calocyclas* sp. B was placed in Sample 120-748B-15H-7, 45–47 cm. In Core 120-748B-16H, *Calocyclas* sp. B, *Cyclampterium*(?) *milowi, Axoprunum bispiculum,* and *Axoprunum pierinae* are common.

Theocyrtis tuberosa was observed only in Sample 120-748B-16H-2, 45–47 cm. This species appeared in the *Thyrsocyrtis bromia* Zone of the late Eocene and evolved to *Theocyrtis annosa* during the late Oligocene in low and middle latitudes. Its thoracic surface is definitely tubercle in late specimens, but it is less so in early ones (Sanfilippo et al., 1985). This feature, the thoracic surface, of the specimens from Hole 748B is the same as that of these early specimens. Therefore, this horizon in Hole 748B possibly may correlate with the *T. bromia* Zone of the late Eocene.

In Core 120-748B-17H, *Cyclampterium*(?) *milowi* and *Axoprunum pierinae* are abundant, and *Lychnocanoma amphitrite* may be abundant sometimes. The FO of *Eucyrtidium spinosum* was found in Sample 120-748B-17H-1, 45–47 cm. *Calocyclas* sp. B is common in Core 120-748B-17H, and the FO of this species was placed in Sample 120-748B-17H-7, 45–47 cm. The LO of *Sethocyrtis* sp. also could be seen in Sample 120-748B-17H-7, 45–47 cm.

Cores 120-748B-18H and -19H contained *Lychnocanium amphitrite* and *Sethocyrtis* sp., usually in abundance. *Cyclampterium*(?) *milowi* and *Axoprunum pierinae* are often included. *Calocyclas* sp. C is common in the lower part of Core 120-748B-19H, and the LO of this species was placed in Sample 120-748B-19H-2, 45–47 cm.

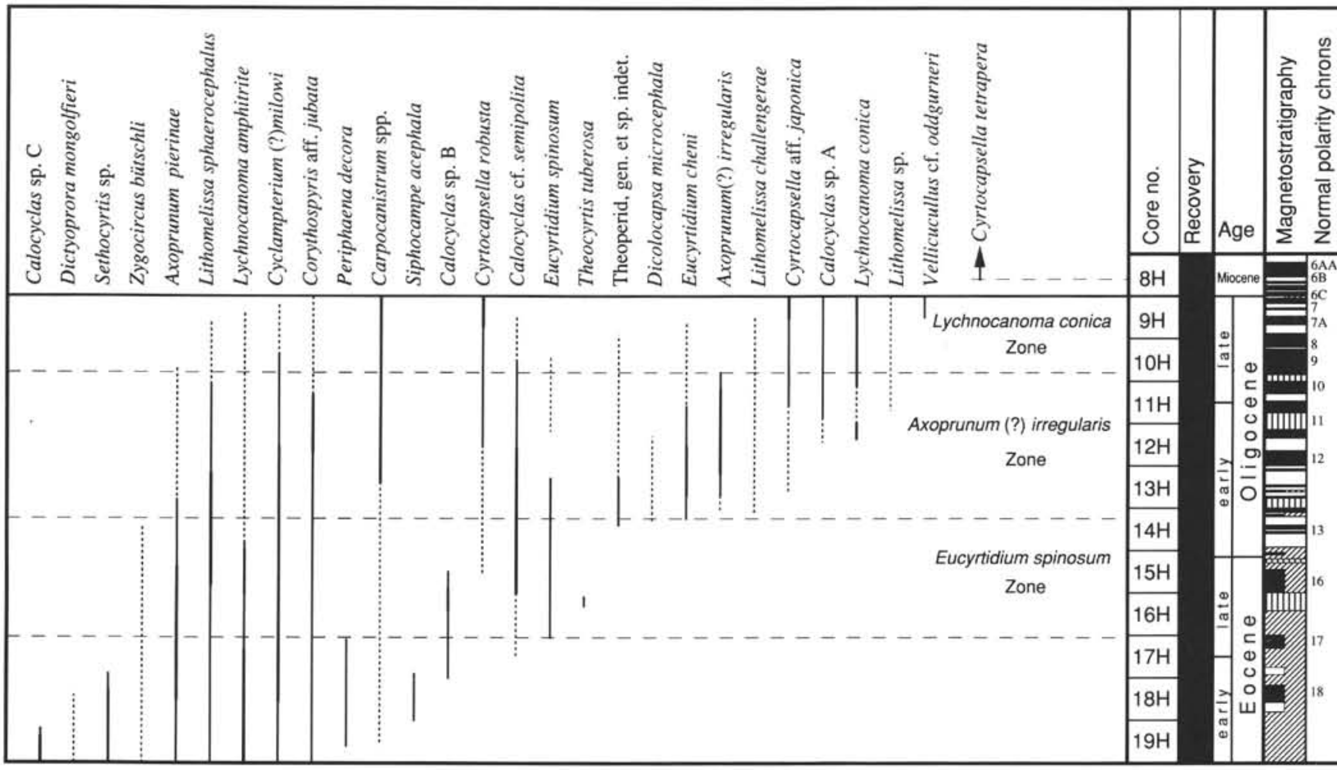

Figure 1. Ranges of Paleogene radiolarians from Hole 748B. Magnetostratigraphic data are after Schlich, Wise, et al. (1989).

Site 749

In Hole 749B, such Neogene species as *Helotholus vema, Desmospyris spongiosa,* and species of *Antarctissa* were observed in some samples of Cores 120-749B-1H and -2H (Table 2). The occurrence of these species in Core 120-749B-2H may result from downcore contamination.

Sections 120-749B-1H-1 to -2H-1 usually contained *Lychnocanoma conica, Prunopyle haysei, Carpocanistrum* spp., and *Cyrtocapsella robusta. Axoprunum*(?) *irregularis* occurred in Samples 120-749B-2H-2 to -2H-6. *Eucyrtidium cheni* also occurred in this interval. Core 120-749B-3H contained *Cyclampterium*(?) *milowi, Eucyrtidium spinosum, Amphistylus*(?) sp., *Axoprunum bispiculum,* and *A. pierinae.*

PALEOGENE RADIOLARIAN ZONES

Recently, Abelmann (1990) proposed two zones for the upper Oligocene from ODP Leg 113: the *Stylosphaera radiosa* and *Cyrtocapsella robusta* zones. Although she settled the bases of these zones at 27.2 and 27.7 Ma in the upper Oligocene sequence, respectively, the base of the occurrence of *C. robusta* was situated in the upper Eocene or lower Oligocene at Site 748. However, *Stylosphaera* has numerous forms, and I could not reasonably divide them into species here. Abelmann's (1990) occurrence data show that her lowest samples just below the *S. radiosa* Zone or the *C. robusta* Zone always have poor preservation and have rare or trace abundances. One finds it difficult to define the bases of these zones using her data.

Therefore, I propose three new zones here for the late Eocene(?) to late Oligocene sequence, described next. Other biostratigraphic and magnetostratigraphic data and the estimated absolute ages of radiolarian events are referred from those of Schlich, Wise, et al. (1989) and Berggren et al. (1985).

Lychnocanoma conica Zone

Top. FO of *Cyrtocapsella tetrapera.*
Base. LO of *Axoprunum*(?) *irregularis.*
Remarks. At Hole 748B, *Cyrtocapsella tetrapera* is a good indicator of the Oligocene/Miocene boundary and also is an important zonal marker for the early Miocene in low and middle latitudes. *Lychnocanoma conica* was adopted as a zone name because it is common and continuous within this zone.
Age. Early late Oligocene to earliest Miocene(?), 29.2–23.0 Ma.
Site 748. Top: Sample 120-748B-8H-4, 45–47 cm (62.05 mbsf); this horizon is situated within the normal paleomagnetic period, at about 60 mbsf, which correlates to Subchrons 6AA and 6B. Base: Sample 120-748B-10H-6, 45–47 cm (84.05 mbsf); the normal period between 79 and 84 mbsf correlates to Chron 9 of the late Oligocene.
Site 749. Samples 120-749B-1H-1, 45–47 cm (0.45 mbsf), to -2H-2, 45–47 cm (7.75 mbsf).
Assemblage. *Lychnocanoma conica, Cyrtocapsella robusta, Cyrtocapsella* aff. *japonica, Calocyclas* sp. A, *Carpocanistrum* spp., *Stylosphaera* spp., *Prunopyle hayesi.*
Other biohorizons. FOs include *Vellicucullus* cf. *oddgurneri* (26.1 Ma) within this zone. LOs include *Lithomelissa challengerae* and *Lithomelissa sphaerocephalis.*

Axoprunum(?) *irregularis* Zone

Top. Last continuous occurrence of *Axoprunum*(?) *irregularis.*
Base. FO of *Eucyrtidium cheni.*
Remarks. Near the base of this zone, the transition from *Eucyrtidium spinosum* to *Eucyrtidium cheni* was recognized. The FO of *Axoprunum*(?) *irregularis* is just above the base of this zone. In Site 748, few specimens of *A.*(?) *irregularis* were found in Sample 120-748B-10H-4, 45–47 cm (Table 1). This species is abundant or common in samples lower than Sample 120-748B-10H-6, 45–47 cm, and was never found in any upper samples, except in Sample 120-748B-10H-4, 45–47 cm. *A.*(?) *irregularis* in Sample 120-748B-10H-4, 45–47 cm, may be reworked and, therefore, at Site 748 the top of this zone has been settled at Sample 120-748B-10H-6, 45–47 cm, in this study.
Age. Early Oligocene to early late Oligocene, 35.0–29.2 Ma.

Site 748. Top: Sample 120-748B-10H-6, 45–47 cm (84.05 mbsf). Base: Sample 120-748B-14H-2, 45–47 cm (116.05 mbsf). This horizon may correlate to Chrons 12 or 13 in the early Oligocene.

Site 749. Samples 120-749B-2H-2, 45–47 cm (7.75 mbsf), to 120-749B-2H-6, 45–47 cm (13.75 mbsf).

Assemblage. *Axoprunum*(?) *irregularis, Lithomelissa sphaerocephalis, Calocyclas* cf. *semipolita, Cyrtocapsella robusta, Carpocanistrum* spp., *Cyclampterium*(?) *milowi, Eucyrtidium cheni,* and *Corythomelissa* aff. *jubata*.

Other biohorizons. FOs include *Calocyclas* sp. A (32.0 Ma), *Lychnocanoma conica* (32.0 Ma), *Lithomelissa challengerae* (34.8 Ma), and *Axoprunum*(?) *irregularis* (34.8 Ma). LOs include *Dicolocapsa microcephala* and the continuous sequence of *Eucyrtidium spinosum* (33.8 Ma).

Eucyrtidium spinosum Zone

Top. FO of *Axoprunum*(?) *irregularis*.

Base. FO of *Eucyrtidium spinosum*.

Age. Near the boundary between middle and late Eocene to early Oligocene, about 40–34.8 Ma.

Site 748. Top: Sample 120-748B-14H-1, 45–47 cm (114.58 mbsf). Base: Sample 120-748B-17H-1, 45–47 cm (143.05 mbsf). This horizon is situated within a less reliable normal period and correlates to Chron 17.

Site 749. Samples 120-749B-2H-6, 45–47 cm (13.75 mbsf), to -3H-7, 45–47 cm (24.75 mbsf).

Assemblage. *Eucyrtidium spinosum, Cyclampterium*(?) *milowi, Lychnocanoma amphitrite, Axoprunum pierinae, Axoprunum bispiculum, Amphistylus*(?) sp., and *Calocyclas* cf. *semipolita*.

Other biohorizons. FOs include *Eucyrtidium cheni* (35.0 Ma), *Dicolocapsa microcephala* (35.0 Ma), and Theoperid, gen. et sp. indet. (37.4 Ma). LOs include *Calocyclas* sp. B, *Zygocircus bütschlii*, and *Amphistylus*(?) sp. *Theocyrtis tuberosa* occurs in upper Eocene sediments between normal polarity Chrons 16 and 17 (ca. 39.4 Ma).

Cores 120-748B-17H to -19H are not zoned here (mostly middle Eocene in age). However, some biohorizons were recognized within this interval. These include the FO of *Calocyclas* sp. B, and the LOs of *Sethocyrtis* sp. and *Calocyclas* sp. C.

The radiolarian zonation of Sites 748 and 749 is different from that of radiolarians in low latitudes. The species for which ranges were determined in low latitudes (Sanfilippo et al., 1985) and that occur in Leg 120 samples are *Dictyoprora mongolfieri, Eusyringium fistuligerum, Dictyoprora pirum,* and *Theocyrtis tuberosa*. Important zonal marker species belonging to the genera *Podocyrtis,* and *Thyrsocyrtis* were not observed in Leg 120 samples. Although Riedel and Sanfilippo (1978) determined the ranges of *Cyclampterium*(?) *milowi* and *Lychnocanoma amphitrite,* the ranges of these species in Leg 120 samples seem to be different from those of low latitudes.

During Leg 119 (Barron, Larsen, et al., 1989), six sites also were drilled on the Kerguelen Plateau, and Paleogene radiolarians were reported from two sites (738 and 744) in the southernmost part. Oligocene radiolarians occurred in Site 744, but no zonal markers from low latitudes were included. Furthermore, Oligocene low-latitude fauna have not been reported from other sites in the Antarctic region (Petrushevskaya, 1975; Chen, 1975; Weaver, 1983; Barker, Kennett, et al., 1988; Ciesielski, Kristoffersen, et al., 1988; Abelmann, 1990). These data suggest that the ocean current system of the antarctic region was different in low latitudes during Oligocene time.

Barron, Larsen, et al. (1989) reported the occurrence of Eocene radiolarians from Site 738. In the upper middle Eocene sections of this site (Samples 119-738B-16X-CC to -18X-CC), many tropical forms, including *P. chalara,* were found. Although strict correlation between this interval and Core 120-748B-19H is difficult at present, both these intervals are middle Eocene; the first appearance datum of the planktonic foraminifer *G. index* was reported at Core 119-738B-19X and Sample 120-748B-20H-CC (Table 3). Thus, some transition of radiolarian fauna may have occurred during the middle Eocene.

SYSTEMATIC DESCRIPTION

The higher level (family level) taxonomy adopted for this study is after Riedel (1967, 1971). All specimens, including prototypes, have been deposited at the Geoscience Institute, Hyogo University of Teacher Education, Japan.

Subclass RADIOLARIA Müller
Order POLYCYSTINA Ehrenberg, emend. Riedel
Suborder SPUMELLARIA Ehrenberg
Family ACTINOMMIDAE Haeckel, emend. Riedel
Genus *AMPHISTYLUS* Haeckel, 1881

Amphistylus angelinus (Campbell and Clark)
(Plate 1, Figs. 8–9)

Amphistylus angelinus (Campbell and Clark) Chen, 1975, p. 453, pl. 21, figs. 3–4.

Occurrence. middle Eocene to Oligocene, rare to common.

Amphistylus(?) sp.
(Plate 5, Figs. 9–10)

Description. Cortical shell is similar to that of *A. angelinus* but usually smaller than the latter. One polar spine is rodlike, strong, and longer than the diameter of cortical shell. Other spines, when they exist, are conical, thin, and short. At least several bars connect medullary and cortical shells, but internal structures, including medullary shells, are obscure because of poor preservation.

Measurements. Diameter of cortical shell is 100–140 μm; length of long polar spine is 130–195 μm, measured in six specimens.

Remarks. Although internal structures of this species were not observed, this species is tentatively included within Genus *Amphistylus* because of the similarity of its cortical shell to *Amphistylus angelinus*.

Occurrence. middle Eocene to early Oligocene, few to common.

Genus *AXOPRUNUM* Haeckel, 1887

Axoprunum Haeckel, 1887, p. 298.
Stylacontarium Popofsky, 1912, p. 90.

Remarks. Petrushevskaya and Kozlova (1972) described this genus minutely. Sanfilippo and Riedel (1973) adopted this genus name for describing the *A. pierinae* group. Here, I follow their taxonomy and use this name for all ellipsoidal forms having one cortical and two medullary shells and two polar spines, which usually are conical or rodlike. Kling (1973) described both genera, *Axoprunum* and *Stylacontarium*, but used *Axoprunum* for *A. angelinum*, which was assigned to the genus *Amphistylus* by Chen (1975).

Axoprunum bispiculum (Popofsky) n. comb.
(Plate 1, Figs. 1–2)

Stylacontarium bispiculum Popofsky, 1912, p. 91, pl. 2, fig. 2; Chen, 1975, p. 454, pl. 21, figs. 1–2.

Remarks. Chen (1975) described this species under the genus *Stylacontarium*. However, the shell shape and structure of this species are nearly the same as those of *Axoprunum pierinae* (Clark

Table 3. Correlation between the Paleogene section of Holes 748B and 749B.

	748B	749B	radiolarian zones
top	8H-4, 45-47 cm	1H-1, 45-47 cm	*Lychnocanoma conica* Zone
base	10H-6, 45-47 cm	2H-2, 45-47 cm	
top	10H-6, 45-47 cm	2H-2, 45-47 cm	*Axoprunum*(?) *irregularis* Zone
base	14H-2, 45-47 cm	2H-6, 45-47 cm	
top	14H-2, 45-47 cm	2H-6, 45-47 cm	*Eucyrtidium spinosum* Zone
base	17H-1, 45-47 cm	3H-6, 45-47 cm	

and Campbell) group, described by Sanfilippo and Riedel (1973). Therefore, this species has been assigned to the genus *Axoprunum* here.

This species differs from *A. pierinae* (Clark and Campbell) in that it has a thinner shell and polar spines. However, differences between these two species are not clear, and these two species may be continuous in Eocene time.

Occurrence. Eocene to Oligocene, rare to common.

Axoprunum pierinae (Clark and Campbell)
(Plate 6, Figs. 3–6)

Lithatractus pierinae Clark and Campbell, 1942, p. 34, pl. 5, fig. 25.
Axoprunum pierinae (Clark and Campbell) group; Sanfilippo and Riedel, 1973 (in part), p. 488, pl. 1, figs. 6–9, pl. 23, fig. 3.
Axoprunum lithostylum (Ehrenberg) group, Petrushevskaya, 1975, p. 571, pl. 2, fig. 22.

Remarks. Here, this species has been distinguished from *A. bispiculum* by only thickness of shells and polar spines. *Lithatractus pierinae*, described by Clark and Campbell (1942), has somewhat thin polar spines. Sanfilippo and Riedel (1973) mentioned that polar spines of *Axoprunum pierinae* group are variable in size and form. Here, I use this species name for forms usually having an ellipsoidal cortical shell and double medullary shells and thick polar spines. Some specimens have thicker, more columnar spines and a thick-walled cortical shell (Plate 6, Figs. 3–4). I cannot propose this form as another species because many variations exist in the shape of its cortical shell and polar spines.

Occurrence. Eocene to early Oligocene; only fragments occur in the lower upper Oligocene part of Hole 748B (Table 1), rare to common.

Axoprunum(?) *irregularis* n. sp.
(Plate 3, Figs. 8–11)

Actinomma medusa (Ehrenberg) group, Petrushevskaya, 1975 (in part), pl. 2, figs. 6–8.
(?)*Amphisphaera* sp. Chen, 1975 (in part), p. 453, pl. 6, fig. 2.

Description. This species has a cortical shell that is irregularly shaped or nearly polygonal in section, with two polar spines. In some specimens, the cortical shell is thick with a thorny surface. The pores on the cortical shell are circular to elliptical and vary in size. Two medullary shells are nearly spherical or ellipsoidal and are joined to the cortical shell by more than six bars. The two polar spines are rodlike or conical and are not bladed without basal portion. These spines are usually not situated on a single line and often are not joined with bars that connect cortical and medullary shells. In earlier specimens, the polar spines sometimes are longer than in the later specimens, and sometimes they are joined with bars to the medullary shell.

Measurements. Diameter of cortical shell is 140–195 μm; length of shell, including two polar spines is 230–290 μm, measured in 11 specimens.

Type. Holotype: HUTE-R-4001, Sample 120-748B-11H-4, 45–47 cm (Plate 3, Figs. 8–9). Paratype: HUTE-R-4002, Sample 120-748B-12H-7, 45–47 cm (Plate 3, Figs. 10–11).

Remarks. *Axoprunum*(?) *irregularis* n. sp. differs from other species belonging to this genus in its irregularly shaped cortical shell and its two polar spines. This species was tentatively included within the genus *Axoprunum* because in earlier times (early Oligocene), some specimens were an intermediate type between this species and *A. bispiculum* and because this species might have evolved from the latter species. However, during the Eocene, a species existed that has a similar shell structure to *A.*(?) *irregularis* as well as long, three-bladed polar spines. The phylogenetic problem of this species cannot be solved here.

Occurrence. Oligocene, few to common.

Genus *LITHAPIUM* Haeckel, 1887

Lithapium anoectum Riedel and Sanfilippo
(Plate 7, Fig. 1)

Lithapium anoectum Riedel and Sanfilippo, 1970, p. 520, pl. 4, figs. 4–5.

Occurrence. middle Eocene, common.

Lithapium cf. *mitra* (Ehrenberg)
(Plate 7, Fig. 2)

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

Remarks. From Sample 120-748B-19H-4, 45–47 cm; both *L. anoectum* and *L.* cf. *mitra* were observed. Following Riedel and Sanfilippo (1978), the transition from *L. anoectum* to *L. mitra* occurred in the middle Eocene *Podocyrtis mitra* Zone in tropical areas.

Occurrence. middle Eocene, rare.

Genus *PRUNOPYLE* Dreyer, 1889

Prunopyle frakesi Chen

Prunopyle frakesi Chen, 1975, p. 454, pl. 10, figs. 1–3.

Occurrence. early Oligocene, rare; this large-sized species seems to occur usually as fragments in Leg 120 samples.

Prunopyle hayesi Chen
(Plate 1, Figs. 13–14)

Prunopyle hayesi Chen, 1975, p. 454, pl. 9, figs. 3–5.

Remarks. The hexagonally framed pores, which are regarded as a distinctive character by Chen (1975), can hardly be observed in Leg 120 specimens. For this study, many forms that have no hexagonally framed pores are included in this species.

Occurrence. Eocene to late Oligocene, few to common.

Prunopyle tetrapila Hays
(Plate 2, Figs. 1–2)

Prunopyle tetrapila Hays, 1965, p. 172, pl. II, fig. 5

Occurrence. Oligocene, rare.

Prunopyle spp.

Remarks. The small-sized ellipsoidal forms with pylome here are included under this name. These forms may correspond to *Prunopyle* sp. B group and *Prunopyle* sp. D of Abelmann (1990).

Occurrence. Eocene to Oligocene, few to common.

Genus *SPONGOPLEGMA* Haeckel, 1881

Spongoplegma aff. *antarcticum* Haeckel
(Plate 2, Figs. 9–10)

Spongoplegma antarcticum Haeckel, 1887, p. 90; Hays, 1965, pp. 165–167, pl. I, fig. 1.

Remarks. The cortical shell of this species is thin and latticed and has irregularly distributed pores. However, its medullary spongy network is the same as that of *S. antarcticum*.

Occurrence. Oligocene, rare to few.

Genus *STYLOSPHAERA* Ehrenberg, 1847

Stylosphaera spp.

Remarks. Abelmann (1990) described some species of the genus *Stylosphaera*. However, this group includes various forms, and large variations were observed within each form. I cannot reasonably divide this group into species here.

Occurrence. middle Eocene to Oligocene, few to abundant.

Family PHACODISCIDAE Haeckel
Genus *HELIOSTYLUS* Haeckel, 1881

Heliostylus Haeckel, 1881; Sanfilippo and Riedel, 1973, p. 522.

Heliostylus sp.
(Plate 6, Fig. 7)

Heliostylus sp. Sanfilippo and Riedel, 1973, p. 522, pl. 8, figs. 3–5, pl. 26, fig. 10.

Description. The cortical shell is lenticular and has two stout, long, and rodlike spines, which are unequal in length and are situated at nearly the opposite side. The cortical shell has a thick wall, with a smooth surface and hexagonally distributed, small, numerous pores. Two bars connect the cortical and medullary shells and extend to two outer spines. The medullary shell is indistinct because of poor preservation of this species.

Remarks. This species is the same as some forms reported as *Heliostylus* spp. by Sanfilippo and Riedel (1973).

Occurrence. middle Eocene, rare to few.

Genus *PERIPHAENA* Ehrenberg, 1873

Periphaena Ehrenberg, 1873; Sanfilippo and Riedel, 1973, pp. 522–523.

Periphaena decora Ehrenberg
(Plate 6, Fig. 8)

Periphaena decora Ehrenberg, 1873, p. 246; Sanfilippo and Riedel, 1973, p. 523, pl. 8, figs. 8–10, pl. 27, figs. 2–5.

Occurrence. middle Eocene, few to common.

Periphaena heliasteriscus (Clark and Campbell)
(Plate 4, Fig. 13)

Periphaena heliasteriscus (Clark and Campbell) Sanfilippo and Riedel, 1973, p. 523, pl. 9, figs. 1–6, pl. 27, figs. 8–9.

Occurrence. middle Eocene to late Oligocene, rare to common.

Family SPONGODISCIDAE Haeckel, emend. Riedel
Genus *SPONGODISCUS* Ehrenberg

Spongodiscus spp.

Occurrence. middle Eocene to Oligocene, rare to abundant.

Genus *XIPHOSPIRA* Haeckel

Xiphospira Haeckel, 1887; Sanfilippo and Riedel, 1973, p. 526.

Xiphospira spp.

Occurrence. middle Eocene to Oligocene, rare to common.

Suborder NASSELLARIA Ehrenberg, 1875
Family ACANTHODESMIIDAE Haeckel, 1862
Genus *CORYTHOSPYRIS* Haeckel, 1881, emend. Goll, 1978

Corythospyris aff. *jubata* Goll
(Plate 3, Figs. 3–4)

aff. *Corythospyris jubata* Goll, 1978, pp. 177–178, pl. 4, figs. 1, 2, 4, 5, and 7–17.
Corythospyris sp. A, Abelmann, 1990, pl. 5, figs. 6A–6B.

Remarks. This species resembles *Corythospyris fiscela* Goll, as described by Abelmann (1990) in that it has sulcate basal spines. It differs from *C. jubata* Goll in not having any irregularly protruding lattice spines and in having smaller pores on its shell surface. Earlier forms of this species rarely have sulcate basal spines.

Occurrence. middle Eocene to Oligocene, common to rare.

Genus *DENDROSPYRIS* Haeckel, 1881, emend. Goll, 1968

Dendrospyris stabilis Goll
(Plate 4, Fig. 7)

Dendrospyris stabilis Goll, 1968, pp. 1422–1423, pl. 173, figs. 16–18 and 20; Chen, 1975, p. 455, pl. 7, fig. 3.

Occurrence. Oligocene, rare to few.

Genus *ZYGOCIRCUS* Bütschli, 1882, emend. Petrushevskaya, 1971

Zygocircus bütschli Haeckel
(Plate 5, Fig. 4)

Zygocircus bütschli Haeckel, 1887, p. 948; Petrushevskaya and Kozlova, 1972, p. 534, pl. 41, figs. 8–11.

Occurrence. Eocene to earliest Oligocene, rare to few.

Family AMPHIPYNDACIDAE Riedel
Genus *AMPHIPYNDAX* Foreman, 1966

Amphipyndax stocki (Campbell and Clark)
(Plate 6, Figs. 10–11)

Amphipyndax stocki (Campbell and Clark) Foreman, 1968, p. 78, pl. 8, figs. 12a–12c.

Remarks. Very rare specimens of this species occurred only in Sample 120-748B-18H-7, 45–47 cm, with an age of middle Eocene. This species has been reported mainly from the Cretaceous, but Dumitrica (1973) reported this species from a Paleocene sequence obtained during DSDP Leg 21. Although the occurrence of this species is rare (in only one sample), shell preservation is not bad (same as other Eocene radiolarians). *Amphipyndax* may have survived from the Cretaceous to the Eocene in the Antarctic Sea, but a rather large possibility of reworking exists.

Occurrence. Only in Sample 120-748B-18H-7, 45–47 cm, middle Eocene, rare.

Family ARTOSTROBIIDAE Riedel
Genus *DICTYOPRORA* Haeckel, 1881, emend. Nigrini, 1977

Dictyoprora mongolfieri (Ehrenberg)
(Plate 7, Fig. 12)

Eucyrtidium mongolfieri Ehrenberg, 1854, pl. 36, fig. 18.
Dictyoprora mongolfieri (Ehrenberg) Nigrini, 1977, pp. 250–251, pl. 4, fig. 7.

Occurrence. middle Eocene in Hole 748B, rare.

Dictyoprora pirum (Ehrenberg)
(Plate 5, Fig. 11)

Eucyrtidium pirum Ehrenberg, 1873, p. 232.
Dictyoprora pirum (Ehrenberg) Nigrini, 1977, p. 251, pl. 4, fig. 8.

Occurrence. late Eocene to Oligocene, rare.

Genus *SIPHOCAMPE* Haeckel, 1881, emend. Nigrini, 1977

Siphocampe acephala (Ehrenberg)
(Plate 6, Fig. 9)

Eucyrtidium acephalum Ehrenberg, 1875, p. 70, pl. 11, fig. 5.
Siphocampe acephala (Ehrenberg) Nigrini, 1977, pp. 254–255, pl. 3, fig. 5.

Occurrence. middle Eocene to Oligocene, few to rare.

Siphocampe nodosaria (Haeckel)
(Plate 3, Fig. 15)

Lithomitra nodosaria Haeckel, 1887, p. 1484, pl. 79, fig. 1.
Siphocampe nodosaria (Haeckel) Nigrini, 1977, pp. 256–257, pl. 3, fig. 11.

Occurrence. middle Eocene, Oligocene, rare to few.

Siphocampe(?) *quadrata* (Petrushevskaya and Kozlova)
(Plate 7, Fig. 7)

Lithamphora sacculifera (Clark and Campbell) Petrushevskaya and Kozlova, 1972, p. 539, pl. 30, figs. 4–6.
Lithamphora quadrata (Petrushevskaya and Kozlova) Petrushevskaya, 1975, p. 585, pl. 10, figs. 19–20.
Siphocampe(?) *quadrata* (Petrushevskaya and Kozlova) Nigrini, 1977, p. 257, pl. 3, fig. 12.

Occurrence. middle Eocene to Oligocene, few to rare.

Family CANNOBOTRYIDAE Haeckel, emend. Riedel
Genus *BOTRYOPYLE* Haeckel, 1881

Botryopyle dictyocephalus Haeckel group
(Plate 3, Fig. 7)

Botryopyle dictyocephalus Haeckel, 1887, p. 1113, pl. 96, fig. 6.
Botryopyle dictyocephalus Haeckel group, Riedel and Sanfilippo, 1971, p. 1602, pl. 1J, figs. 21–26, pl. 2J, figs. 16–18, pl. 3F, figs. 9–12.
Botryocella spp. aff. *B. cribrosa* (Ehrenberg) group, Petrushevskaya and Kozlova, 1972, p. 554, pl. 39, figs. 4–6.
Botryocella(?) *appeninica* Vinassa de Regny group, Petrushevskaya, 1975, p. 589, pl. 13, figs. 16 and 23.
(?)*Botryopyle*(?) sp. Petrushevskaya, 1975, pl. 13, fig. 15.

Remarks. Although Petrushevskaya and Kozlova (1972) and Petrushevskaya (1975) described several species, their taxonomy seems to be too split. Here, these forms have been assigned to *B.*

dictyocephalus Haeckel group, following Riedel and Sanfilippo (1971).

Occurrence. Oligocene, rare to common.

Family CARPOCANIIDAE Haeckel, emend. Riedel
Genus *CARPOCANISTRUM* Haeckel, 1887

Carpocanistrum spp.
(Plate 3, Figs. 5–6)

Carpocanistrum spp. Riedel and Sanfilippo, 1971, p. 1596, pl. 1G, figs. 1–6 and 8–13, pl. 2F, figs. 5–16, pl. 3D, figs. 1, 2, 6, 7, and 9; Abelmann, 1990, p. 675, pl. 5, fig. 13.
Sethocorys sp. Hays, 1965, p. 177, pl. III, fig. 8.
Cystophormis brevispina (Vinassa) Petrushevskaya, 1975, p. 588, pl. 13, figs. 3–7, pl. 44, figs. 1–2.

Occurrence. middle Eocene to Oligocene, rare to abundant.

Family PLAGONIIDAE Haeckel, emend. Riedel
Genus *CERATOCYRTIS* Bütschli, 1882

Ceratocyrtis spp.

Occurrence. late Eocene to Oligocene, few to common.

Genus *CORYTHOMELISSA* Campbell, 1951

Corythomelissa horrida Petrushevskaya
(Plate 3, Fig. 14)

Corythomelissa horrida Petrushevskaya, 1975, p. 590, pl. 11, figs. 14–15, pl. 21, fig. 9.

Occurrence. late Eocene to Oligocene, rare to few.

Corythomelissa(?) sp.
(Plate 2, Figs. 3–4)

Description. The shell is conical and has two segments. The cephalis is hemispherical and has irregularly distributed and sized pores. The surface of the cephalis often is rough or thorny. Collar stricture is distinct. The thorax is conical with irregularly distributed pores, whose sizes and shapes are irregular. Slight longitudinal grooves often exist at the upper part of the thorax. The base of the thorax is closed.

Measurements. Length of shell exclusive of feet is 80–100 μm; width of shell exclusive of feet is 75–95 μm, measured in six specimens.

Remarks. Because the cephalis of this species is smaller than that in *Corythomelissa horrida* Petrushevskaya, this species has been tentatively and questionably assigned to Genus *Corythomelissa*. The shape of the cephalis is similar to that of Genus *Ceratocyrtis* rather than *Corythomelissa*.

Occurrence. Oligocene, rare.

Genus *LITHOMELISSA* Ehrenberg, 1847

Lithomelissa challengerae Chen
(Plate 4, Figs. 11–12)

Lithomelissa challengerae Chen, 1975, p. 457, pl. 8, fig. 3.

Occurrence. Oligocene, rare.

Lithomelissa sphaerocephalis Chen
(Plate 4, Figs. 8–9)

Lithomelissa sphaerocephalis Chen, 1975, p. 457, pl. 8, figs. 1–2.

Occurrence. middle Eocene to late Oligocene, rare to common.

Lithomelissa tricornis Chen
(Plate 2, Figs. 5–6)

Lithomelissa tricornis Chen, 1975, p. 458, pl. 8, figs. 6–7.

Occurrence. late Eocene to Oligocene, rare.

Lithomelissa sp.
(Plate 2, Figs. 11–12)

Lithomelissa robusta (Chen) Abelmann, 1990, pl. 5, figs. 2A–2B.

Description. See Abelmann (1990).

Remarks. This species differs from *L. robusta* Chen in its robustness and the size of its shell, and because it has no distinct three-bladed wings and in the shape of the thorax. Abelmann's (1990) forms are similar to this species. This species is characterized by its irregularly perforated spherical cephalis that has a three-bladed apical horn, its distinct collar stricture, and its thoracic shape, of which upper part is conical and lower part is cylindrical, or becomes slightly narrower downward.

Occurrence. late Oligocene, rare to few.

Genus *VELLICUCULLUS* Riedel and Campbell, 1952

Vellicucullus cf. *oddgurneri* Bjørklund
(Plate 2, Figs. 7–8)

Vellicucullus oddgurneri Bjørklund,rklund 1976, p. 1126, pl. 19, figs. 6–9.
Vellicucullus cf. *oddgurneri* (Bjørklund)rklund Abelman, 1990, p. 698, pl. 8, fig. 6.

Occurrence. late Oligocene, few.

Plagoniid, gen. et sp. indet.
(Plate 1, Fig. 10)

Description. The shell is composed of a cephalis only and is spherical to subspherical in shape. The cephalic wall is usually smooth, with irregularly distributed elliptical pores, of various sizes. A circular or subcircular ring lies at the base of the cephalis, while cephalic skeletal elements are situated below the ring.

Measurements. Length of shell is 75–90 μm; width of shell is 65–80 μm, measured in six specimens.

Occurrence. Mainly late Oligocene, rare to few.

Family PTEROCORYIDAE Haeckel, emend. Riedel
Genus *THEOCYRTIS* Haeckel, 1887

Theocyrtis tuberosa Riedel
(Plate 6, Figs. 1–2)

Theocyrtis tuberosa Riedel, 1959, p. 298, pl. 2, figs. 10–11; Sanfilippo et al., 1985, pp. 701–702, fig. 32.

Remarks. *T. tuberosa* from Hole 748B has longitudinal plicae on its thoracic surface, but no tubercles at all. This character is the same as in the earlier forms of *T. tuberosa* in low and middle latitude areas (Sanfilippo et al., 1985). *T. tuberosa* appeared within the late Eocene *Thyrsocyrtis bromia* Zone; it might be a cosmopolitan species at the earlier stage of its phylogeny. This horizon (120-748B-16H-2) may be correlated to the *T. bromia* Zone in low-latitude areas.

Occurrence. Only in Sample 120-748B-16H-2, 45–47 cm, late Eocene, few.

Family THEOPERIDAE Haeckel, emend. Riedel

Remarks. Takemura (1986) divided Jurassic theoperids into two families (Theoperidae and Arcanicapsidae), based on their cephalic skeletal structures. Although these two cephalic structural types were observed in Cenozoic theoperids, the definition of this family proposed by Riedel (1967, 1971) was adopted for this study because of the scarcity of data on cephalic structures of Cenozoic theoperids observed with scanning electron microscopes.

Genus *ARCHAEODICTYOMITRA* Pessagno, 1976

Archaeodictyomitra(?) sp.
(Plate 3, Figs. 1–2)

Theoperid, gen. et sp. indet. Johnson, 1974, pl. 3, fig. 12.

Description. The shell is conical to spindle-shaped and somewhat curved, with five or six segments. Almost all the shell surface is covered with longitudinal costae. The cephalis is small, spherical, and poreless. The thorax is conical, with tetragonally arranged circular pores. The abdomen and post-abdominal segments are cylindrical or barrel-shaped, with longitudinally arranged pores. The pores on post-thoracic segments are usually arranged in three transverse lines. The shell becomes widest usually at the fourth segment. Sometimes, slight strictures are observed at joints of segments. The last segment becomes narrower at its base and has an open circular aperture. The costae originated at the thorax and number less than 20.

Measurements. Length of shell is 110–155 μm; width of shell is 65–75 μm, measured in five specimens.

Remarks. This species was tentatively assigned to Genus *Arachaeodictyomitra* Pessagno because Pessagno's (1976, 1977) definition of this genus is applicable to this species, although sometimes slight strictures are observed. It is unclear whether this species has a phylogenetic relationship to Mesozoic *Aracheodictyomitra* or *Dictyomitra*.

Occurrence. Oligocene, rare.

Genus *ARTOSTROBUS* Haeckel, 1887

Artostrobus(?) cf. *pretabulatus* Petrushevskaya
(Plate 5, Fig. 12)

cf. *Artostrobus*(?) *pretabulatus* Petrushevskaya, 1975, p. 580, pl. 10, figs. 2–3.

Remarks. The shape of the shell of this species for this paper is somewhat wider and more conical compared with that described by Petrushevskaya (1975).

Occurrence. late Eocene, rare.

Genus *CALOCYCLAS* Ehrenberg, 1847

Calocyclas cf. *semipolita* Clark and Campbell
(Plate 4, Figs. 5–6)

Calocyclas semipolita Clark and Campbell, 1942, p. 83, pl. 8, figs. 12, 14, 17–19, and 21–23; Blueford, 1988, p. 246, pl. 2, figs. 4–6.
Calocyclas cf. *semipolita* (Clark and Campbell) Abelmann, 1990, p. 697, pl. 7, fig. 4.

Remarks. This species differs from *Cyrtocapsella robusta* Abelmann in the size of its shell and the length of its abdomen. The size of the thorax usually is larger than that of *C. robusta*. However, the transition from this species to *C. robusta* is gradual and continuous, and thus distinguishing these two species is sometimes difficult.

Occurrence. Mainly late Eocene to late Oligocene, rare to abundant.

Calocyclas sp. A
(Plate 1, Figs. 3–4)

Description. The shell is cylindrical with three segments. The cephalis is small, spherical, and poreless, without distinct apical horns. The thorax is large, inflated, and spherical to conical, variously shaped. Thoracic pores are large and usually are longitudinally, or sometimes irregularly, arranged. The abdomen has an open aperture that is usually not longer than the thorax and is cylindrical or barrel-shaped. Abdominal pores are similar to thoracic ones in size, usually longitudinally arranged. Collar and lumber strictures are distinct.

Measurements. Length of shell, exclusive of apical horn, is 150–200 μm; width of shell is 100–110 μm, measured in six specimens.

Remarks. This species is distinguished from *Calocyclas* cf. *semipolita* by its inflated thorax and short abdomen. It differs from *Calocyclas* sp. B of this paper in the inflated shape of its thorax and abdomen, and also differs from *Calocyclas* sp. C in having no large apical horns and in the shape of its abdomen. The cephalo-thorax of this species is similar to that of *Calocyclas asperum* (Ehrenberg), described by Petrushevskaya and Kozlova (1972). However, the abdomen of this species is larger sometimes than that of *C. asperum*.

Occurrence. Mainly late Oligocene, rare to few.

Calocyclas sp. B
(Plate 5, Fig. 13)

(?)*Theocyrtis* (*Theocorypha*) *diabloensis* (Clark and Campbell) Chen, 1975, p. 459, pl. 5, figs. 4–7.

Description. The shell is cylindrical with three segments. The cephalis is small, spherical or hemispherical, and poreless, with a short, thin apical horn. The thorax is inflated and hemispherical with irregularly or longitudinally distributed pores. The collar stricture is distinct. The abdomen is cylindrical or becomes narrower downward. The abdomen has irregularly distributed and variously sized and shaped pores, and has an aperture. The abdomen is usually shorter than the cephalo-thorax. The lumber stricture is visible.

Measurements. Length of shell, exclusive of apical horn, is 135–180 μm; width of shell is 90–100 μm, measured in seven specimens.

Remarks. The size of this species is smaller than that of *Calocyclas* sp. A. This species is similar to some forms of *Theocyrtis diabloensis*, described by Chen (1975). However, the original illustration of *T. diabloensis* (Campbell and Clark, 1942, pl. 8, fig. 13) clearly differs from this species and forms reported by Chen (1975). Moreover, this species has no pterocoryid-type cephalis. Here, this species was tentatively assigned to the Genus *Calocyclas*.

Occurrence. middle to late Oligocene, few to common.

Calocyclas sp. C
(Plate 7, Figs. 3–4)

(?)*Calocyclas semipolita semipolita* Clark and Campbell, 1942, pp. 83–84, pl. 8, figs. 12, 14, 17–19, 22, and 23; Blueford, 1988, p. 246, pl. 2, figs. 4–6.

Description. The shell is conically to cylindrically shaped with three segments. The cephalis is small, spherical, and poreless. The apical horn is stout, rodlike, and usually longer than twice the height of the cephalis. The thorax is large, inflated, and hemispherical with longitudinally and hexagonally arranged pores. The collar stricture is distinct. The abdomen is cylindrical and has nearly the same width with thorax. The abdomen has longitudinally or irregularly distributed pores and has an open aperture. In some specimens, the abdomen has a secondary growth of shell and/or small feet. The lumbar stricture is visible.

Measurements. Length of shell, exclusive of apical horn, is 185–220 μm; length of apical horn is 55–85 μm; width of shell is 110–130 μm, measured in six specimens.

Remarks. This species is easily distinguished from *Calocyclas* sp. A and sp. B by the possession of stout, long apical horns. Although this species resembles *C. semipolita* Clark and Campbell, it has a more inflated shell than the latter species.

Occurrence. middle Eocene, common.

Genus *CLATHROCYCLAS* Haeckel, 1882

Clathrocyclas universa Clark and Campbell
(Plate 7, Fig. 11)

Clathrocyclas universa Clark and Campbell, 1942, p. 86, pl. 7, figs. 8–12, 14–21, and 25; Chen, 1975, p. 459, pl. 1, figs. 2 and 3; Blueford, 1988, pp. 244 and 246, pl. 2, figs. 1–3.

Occurrence. Eocene, rare to few.

Genus *CORNUTELLA* Ehrenberg, 1838
Cornutella spp.

Occurrence. Eocene to Oligocene, rare.

Genus *CYCLADOPHORA* Ehrenberg, 1847, emend. Lombari and Lazarus, 1988

Cycladophora bicornis (Popofsky)
(Plate 2, Fig. 15)

Pterocorys bicornis Popofsky, 1908, p. 288, pl. 34, figs. 7–8.
Cycladophora bicornis (Popofsky) Lombari and Lazarus, 1988, pp. 106–114, pl. 4, figs. 1–12, pl. 5, figs. 1–12.

Occurrence. late Oligocene, rare.

Cycladophora conica Lombari and Lazarus
(Plate 2, Figs. 16–17)

Cycladophora conica Lombari and Lazarus, 1988, pp. 105-106, pl. 3, figs. 1–16.

Occurrence. Oligocene, rare to few.

Genus *CYCLAMPTERIUM* Haeckel, 1887

Cyclampterium(?) *milowi* Riedel and Sanfilippo
(Plate 5, Figs. 1–3)

Cyclampterium(?) *milowi* Riedel and Sanfilippo, 1971, p. 1953, pl. 3B, fig. 3, pl. 7, figs. 8–9; Chen, 1975, p. 460, pl. 2, figs. 4–5; Abelmann, 1990, p. 696, pl. 7, fig. 8.
Cyclampterium(?) *longiventer* Chen, 1975, pp. 459, 460, pl. 10, fig. 7.

Remarks. Chen (1975) described two species of the genus *Cyclampterium*, *C.*(?) *milowi* and *C.*(?) *longiventer*. However, it is difficult to distinguish these two species. For this study, these forms have been regarded as a single species, *C.*(?) *milowi*, following Abelmann (1990).

Occurrence. Eocene to Oligocene, rare in late Oligocene, and few to abundant in Eocene to early Oligocene.

Genus *CYRTOCAPSELLA* Haeckel, 1887

Remarks. Sanfilippo and Riedel (1970) defined the Genus *Cyrtocapsella* as three- or four-segmented theoperids having a very constricted mouth. However, here, this genus name is also used for forms with an open mouth that have a shell structure similar to other *Cyrtocapsella*.

Cyrtocapsella aff. *japonica* (Nakaseko)
(Plate 1, Figs. 11–12)

aff. *Cyrtocapsella japonica* (Nakaseko) Sanfilippo and Riedel, 1970, p. 452, pl. 1, figs. 13–15.

Description. The shell is similar to *C. robusta* Abelmann, but the abdomen is shorter than the thorax. Abdomen is variously shaped, with large aperture or aperture-fenestrated.

Remarks. This species cannot be distinguished clearly from *C. robusta* Abelmann because variation of the length of abdomen is continuous. Here, this species has been separated from *C. robusta*, based on the length of abdomen.

Occurrence. Oligocene, mainly late Oligocene, rare to common in latest Oligocene.

Cyrtocapsella robusta Abelmann
(Plate 1, Figs. 5–6)

Cyrtocapsella robusta Abelmann, 1990, p. 696, pl. 5, figs. 10–11.

Remarks. Abelmann (1990) did not describe the state of the aperture of this species. Here, forms having a large aperture also are included in this species. One finds it difficult to make a strict distinction of this species from *Cyrtocapsella* aff. *japonica* and *Calocyclas* cf. *semipolita*.

Occurrence. Oligocene, few to common.

Genus *DICOLOCAPSA* Haeckel, 1881

Dicolocapsa microcephala Haeckel
(Plate 4, Figs. 14–15)

Dicolocapsa microcephala Haeckel, 1887, p. 1312, pl. 57, fig. 1; Johnson, 1974, p. 548, pl. 6, fig. 15.

Occurrence. early Oligocene, rare.

Genus *DIPLOCYCLAS* Haeckel, 1881

Remarks. Lombari and Lazarus (1988) regarded this genus as a junior synonym of the genus *Cycladophora*. Here, this genus name has been tentatively used to describe *Diplocyclas* sp., following to Petrushevskaya and Kozlova (1972) and Chen (1975), because the taxonomic position of this species is obscure.

Diplocyclas sp.
(Plate 3, Fig. 16)

Diplocyclas sp. A, Petrushevskaya and Kozlova, 1972, p. 541, pl. 33, figs. 14–16; Petrushevskaya, 1975, p. 587, pl. 24, fig. 4; Chen, 1975, p. 460, pl. 7, figs. 4–5.

Occurrence. late Eocene to early Oligocene, rare.

Genus *EUCYRTIDIUM* Ehrenberg, 1847

Eucyrtidium cheni n. sp.
(Plate 4, Figs. 1–4)

(?)*Eucyrtidium* sp. M, Petrushevskaya, 1975, p. 581, pl. 14, fig. 20.
Eucyrtidium sp. Chen, 1975, p. 461, pl. 7, figs. 6–8.

Description. The shell, which has six to eight segments, is conical to spindle shaped, or is conical in the upper part and cylindrical in the lower. The cephalis is small, spherical to hemispherical, and poreless, with an apical horn. This apical horn is conical, three-bladed, and shorter than or nearly the same length as the cephalis. The collar stricture usually is not distinct. The thorax is conical with irregularly distributed pores. The abdomen and post-abdominal segments are usually barrel-shaped or sometimes cylindrical, and commonly has longitudinally distributed pores. Four to six pores are present along a longitudinal line of each segment. Pores on post-thoracic segments usually are uniformly sized, although sometimes distributed irregularly. When segments are barrel-shaped, the strictures are distinct between segments. The shell becomes widest in various portions, usually at the abdomen or post-abdominal segments. The post-thoracic segments commonly have nearly the same height. The last segment is usually incomplete.

Measurements. Length of shell, exclusive of apical horn, is 175–270 μm; width of shell is 90–115 μm, measured in seven specimens.

Types. Holotype: HUTE-R-4003, Sample 120-748B-12H-7, 45–47 cm (Plate 4, Figs. 1–2). Paratype: HUTE-R-4004, Sample 120-748B-13H-4, 45–47 cm (Plate 4, Figs. 3–4).

Remarks. This species is the same as the *Eucyrtidium* sp. of Chen (1975), but it contains more variations than the latter. Chen's forms have uniformly barrel-shaped post-thoracic segments. However, many variations exist in the shape of the post-thoracic segments, which are barrel-shaped to cylindrical.

One can hardly distinguish *E. cheni* from *E. spinosum* n. sp. only by the shape of the shell. I could separate these two species only by the length of its apical horn. *E. cheni* evolved from *E. spinosum* through a process of a shortening of the apical horn during early Oligocene time.

This species is named after Dr. Pei-Hsin Chen for his contribution to Antarctic radiolarian research.

Occurrence. Oligocene; common in early Oligocene and rare to few in late Oligocene.

Eucyrtidium spinosum n. sp.
(Plate 5, Figs. 5–8)

Eucyrtidium sp. A, Petrushevskaya, 1975, p. 581, pl. 14, figs. 21–22.

Description. The shell, which has five to seven segments, is conical to cylindrical, or is conical in the upper part and cylindrical in the lower part. The cephalis is small, spherical to hemispherical, and poreless, with an apical horn. The apical horn is stout, three-bladed, and usually longer than twice the height of the cephalis. The apical horn may become shorter in later specimens. The thorax is conical with irregularly distributed pores. The collar stricture is visible. The abdomen is conical or barrel-shaped, usually with irregularly distributed pores. The lumbar stricture is usually distinct. The post-abdominal segments are barrel-shaped or cylindrical, commonly with longitudinally distributed pores. When segments are barrel-shaped, strictures become distinct between segments. The shell becomes widest at various portions, at the abdomen or post-abdominal segments. The height of each segment varies. Segmentation sometimes becomes irregular.

Measurements. Length of shell, exclusive of apical horn, is 180–250 μm; length of apical horn is 30–55 μm; width of shell is 105–120 μm, measured in 11 specimens.

Types. Holotype: HUTE-R-4005, Sample 120-748B-15H-3, 45–47 cm (Plate 5, Figs. 7–8). Paratype: HUTE-R-4006, Sample 120-748B-14H-6, 45–47 cm (Plate 5, Figs. 5–6).

Remarks. *Eucyrtidium spinosum* n. sp. differs from *Eucyrtidium cheni* n. sp. in having an apical horn longer than the height of its cephalis.

Occurrence. late Eocene to early Oligocene, rare to common; rare fragments were found in the late Oligocene section, which may have been reworked from the lower horizon.

Eucyrtidium spp.

Occurrence. Oligocene, rare.

Genus *EUSYRINGIUM* Haeckel, 1881

Eusyringium fistuligerum (Ehrenberg)
(Plate 7, Figs. 5–6)

Eucyrtidium fistuligerum Ehrenberg, 1873, p. 229; 1875, p. 70, pl. 9, fig. 3.
Eusyringium fistuligerum (Ehrenberg) Riedel and Sanfilippo, 1970, p. 527, pl. 8, figs. 8–9.

Occurrence. Rare in middle Eocene and scattered to rare in late Oligocene.

Genus *LOPHOCONUS* Haeckel, 1887

Lophoconus titanothericeraos Clark and Campbell
(Plate 3, Figs. 12–13)

Lophoconus titanocthericeraos Clark and Campbell, 1942, p. 89, pl. 8, figs. 24–26, 28, and 30–37.

Occurrence. Eocene to Oligocene, rare.

Genus *LOPHOCYRTIS* Haeckel, 1887

Lophocyrtis biaurita (Ehrenberg)
(Plate 7, Fig. 8)

Eucyrtidium biauritum Ehrenberg, 1873, p. 226; 1875, p. 70, pl. 10, figs. 8–9.
Lophocyrtis biaurita (Ehrenberg) Haeckel, 1887, p. 1411; Chen, 1975, p. 461, pl. 3, fig. 2.

Occurrence. Eocene to Oligocene, common to rare.

Genus *LYCHNOCANOMA* Haeckel, 1887

Remarks. Foreman (1973) used the generic name, *Lychnocanoma*, for "two-segmented theoperids with three feet, without accompanying ribs in the thorax, and without a large cephalis as *Bekoma*" (Foreman, 1973, p. 437). Although her definition may be too broad and her selection of this genus name is questionable, the genus *Lychnocanoma* has been tentatively used for this study.

Lychnocanoma amphitrite Foreman
(Plate 7, Figs. 9–10)

Lychnocanoma amphitrite Foreman, 1973, p. 437, pl. 11, fig. 10.

Occurrence. Few to abundant in the Eocene, and few to rare in the Oligocene; usually, fragments are found in later samples.

Lychnocanoma cf. *babylonis* (Clark and Campbell)
(Plate 7, Fig. 13)

Dictyophimus babylonis Clark and Campbell, 1942, p. 67, pl. 9, figs. 32 and 36.
Sethochyrtis babylonis (Clark and Campbell) group, Riedel and Sanfilippo, 1970, p. 528, pl. 9, figs. 1–3.
Lychnocanoma babylonis (Clark and Campbell) group, Foreman, 1973, p. 437, pl. 1, fig. 17, pl. 11, fig. 9; Chen, 1975, p. 462, pl. 2, fig. 8.

Remarks. The aperture of this species apparently is larger than that of *L. babylonis*.
Occurrence. Eocene, rare.

Lychnocanoma conica (Clark and Campbell)
(Plate 2, Figs. 13–14)

Lychnocanium conicum Clark and Campbell, 1942, p. 71, pl. 9, fig. 38.
Lychnocanella conica (Clark and Campbell) Petrushevskaya, 1975, p. 583, pl. 12, figs. 2 and 11–15.
Lychnocanoma sphaerothorax Weaver, 1976, p. 581, pl. 5, figs. 4–5.
Lychnocanoma conica (Clark and Campbell) Abelmann, 1990, p. 697, pl. 6, fig. 8, pl. 7, figs. 1A–1B.

Remarks. The shape of the thorax of *L. conica* varies from subspherical to truncate-conical. This species is characterized by its relatively large-sized thorax, short apical horn, and in particular, its straight, three-bladed, and short (usually shorter than the thorax) feet, which originate just outside the aperture. Sometimes, this species has a tube (abdomen?) below the thorax, and three feet are never attached to this tube.

Occurrence. late early Oligocene to late Oligocene, few to common.

Lychnocanoma spp.

Occurrence. Eocene and Oligocene, few.

Genus *PERIPYRAMIS* Haeckel, 1881

Peripyramis spp.

Occurrence. Eocene to Oligocene, few.

Genus *PTEROCANIUM* Ehrenberg, 1847

Pterocanium(?) sp.
(Plate 1, Fig. 7)

Pterocanium sp. (Benson) Chen, 1975, pl. 13, fig. 9.

Occurrence. Eocene to Oligocene, rare to few.

Genus *SETHOCYRTIS* Haeckel, 1887

Remarks. Riedel (1971) assigned this genus to the Family Pterocoryidae. Chen (1975) described *Sethocyrtis* sp. (see below) under the Family Pterocoryidae. However, the cephalic structure of Pterocoryidae, lobed cephalis by arches AL, was not observed in *Sethocyrtis* sp. For this study, *Sethocyrtis* sp. have been tentatively included within the Family Theoperidae.

Sethocyrtis sp.
(Plate 7, Figs. 14–15)

Sethocyrtis sp. Chen, 1975, p. 459, pl. 1, figs. 4–5.

Remarks. The cephalis of this species is spherical, small, poreless, and similar to those of the Family Theoperidae. This species has a stout shell with a distinct shape. It should be an important species in the Antarctic middle Eocene assemblage.
Occurrence. Common in the middle Eocene and scattered or rare in the Oligocene; Oligocene specimens usually occur as fragments and thus may be reworked.

Theoperid gen. et sp. indet.
(Plate 4, Fig. 10)

Description. The shell has three segments and is conical in its upper part and cylindrical in the lower part. The cephalis is small, subspherical, and usually poreless, with a small, thin apical horn. The thorax is conical and divided into two parts. The upper part of the thorax is subcylindrical or conical, with irregularly distributed pores. Collar stricture is usually indistinct. The lower part of the thorax is inflated and barrel-shaped, with hexagonally and longitudinally arranged, subcircular and relatively large pores. The lumbar stricture is distinct. The abdomen is cylindrical and has irregularly distributed subcircular pores, which are slightly larger than the pores of the lower part of its thorax. Commonly, the upper part of the abdomen is somewhat inflated. The aperture is large.
Measurements. Length of shell is 95–145 μm; width of shell is 65–80 μm, measured in five specimens.
Remarks. This species differs from the species of Genus *Calocyclas* in the shape of its thorax.
Occurrence. Oligocene, rare to common.

A species list in alphabetical order is shown in Table 4.

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Table 4. List of species in alphabetical order.

Species Name	species	No.	Plate	Figure	page
Amphipyndax stocki (Campbell and Clark)	N	4	6	10,11	x
Amphistylus angelinus (Clark and Campbell)	S	1	1	8,9	x
Amphistylus(?) sp.	S	2	5	9,10	x
Archaeodictyomitra(?) sp.	N	22	3	1,2	x
Artostrobus(?) cf. *pretabulatus* Petrushevskaya	N	23	5	12	x
Axoprunum bispiculum (Popofsky)	S	3	1	1,2	x
Axoprunum pierinae (Clark and Campbell)	S	4	6	3~6	x
Axoprunum(?) *irregularis*, n. sp.	S	5	3	8~11	x
Botryopyle dictyocephalus Haeckel	N	10	3	7	x
Calocyclas cf. *semipolita* Clark and Campbell	N	24	4	5,6	x
Calocyclas sp. A	N	25	1	3,4	x
Calocyclas sp. B	N	26	5	13	x
Calocyclas sp. C	N	27	7	3,4	x
Carpocanistrum spp.	N	11	3	5,6	x
Clathrocyclas universa Clark and Campbell	N	28	7	11	x
Corythomelissa horrida Petrushevskaya	N	13	3	14	x
Corythomelissa(?) sp.	N	14	2	3,4	x
Corythospyris aff. *jubata* Goll	N	1	3	3,4	x
Cycladophora bicornis (Popofsky)	N	30	2	15	x
Cycladophora conica Lombari and Lazarus	N	31	2	16,17	x
Cyclampterium(?) *milowi* Riedel and Sanfilippo	N	32	5	1~3	x
Cyrtocapsella aff. *japonica* (Nakaseko)	N	34	1	11,12	x
Cyrtocapsella robusta Abelmann	N	33	1	5,6	x
Dendrospyris stabilis Goll	N	2	4	7	x
Dicolocapsa microcephala Haeckel	N	35	4	14,15	x
Dictyoprora mongolfieri (Ehrenberg)	N	5	7	12	x
Dictyoprora pirum (Ehrenberg)	N	6	5	11	x
Diplocyclas sp.	N	36	3	16	x
Eucyrtidium cheni, n. sp.	N	37	4	1~4	x
Eucyrtidium spinosum, n. sp.	N	38	5	5~8	x
Eusyringium fistuligerum (Ehrenberg)	N	40	7	5,6	x
Heliostylus sp.	S	14	6	7	x
Lithapium anoectum Riedel and Sanfilippo	S	6	7	1	x
Lithapium cf. *mitra* (Ehrenberg)	S	7	7	2	x
Lithomelissa challengerae Chen	N	15	4	11,12	x
Lithomelissa sp.	N	18	2	11,12	x
Lithomelissa sphaerocephalus Chen	N	16	4	8,9	x
Lithomelissa tricornis Chen	N	17	2	5,6	x
Lophoconus titanothericeraos Clark and Campbell	N	41	3	12,13	x
Lophocyrtis biaurita (Ehrenberg)	N	42	7	8	x
Lychnocanoma amphitrite Foreman	N	43	7	9,10	x
Lychnocanoma cf. *babylonis* (Clark and Campbell)	N	44	7	13	x
Lychnocanoma conica (Clark and Campbell)	N	45	2	13,14	x
Periphaena decora Ehrenberg	S	15	6	8	x
Periphaena heliasteriscus (Clark and Campbell)	S	16	4	13	x
Plagoniid gen. et sp. indet.	N	20	1	10	x
Prunopyle haysi Chen	S	9	1	13,14	x
Prunopyle tetrapila Hays	S	10	2	1,2	x
Pterocanium(?) sp.	N	48	1	7	x
Sethocyrtis sp.	N	49	7	14,15	x
Siphocampe acephala (Ehrenberg)	N	7	6	9	x
Siphocampe nodosaria (Haeckel)	N	8	3	15	x
Siphocampe(?) *quadrata* (Petrushevskaya and Kozlova)	N	9	7	7	x
Spongoplegma aff. *antarcticum* Haeckel	S	12	2	9,10	x
Theocyrtis tuberosa Riedel	N	21	6	1,2	x
Theoperid, gen. et sp. indet.	N	50	4	10	x
Vellicucullus cf. *oddgurneri* Bjørklund	N	19	2	7,8	x
Zygocircus bütchli Haeckel	N	3	5	4	x

Note: Species no. indicates the number in Tables 1 and 2.

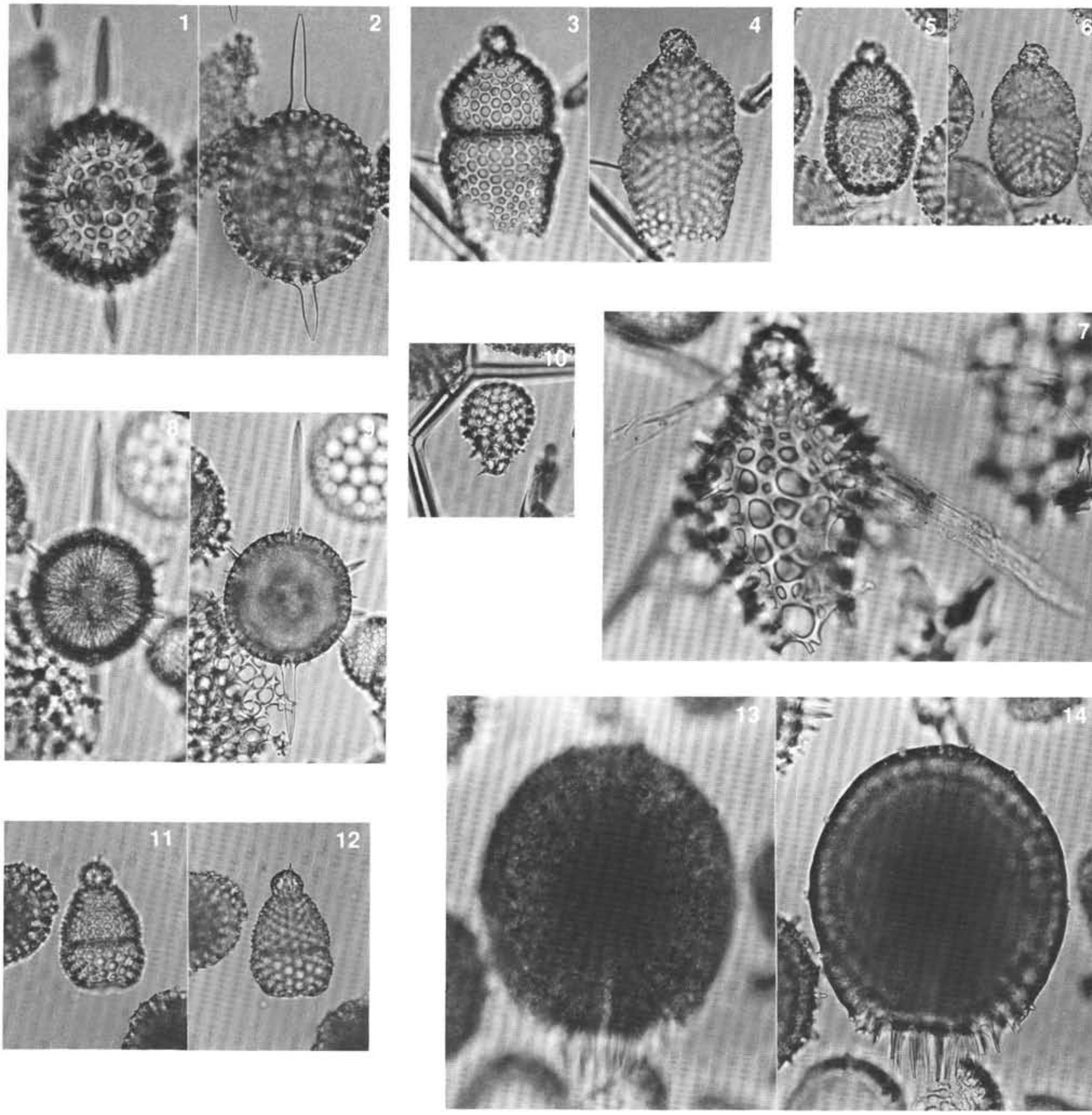

Plate 1. **1, 2.** *Axoprunum bispiculum* (Popofsky), Sample 120-748B-9H-1, 45–47 cm. **3, 4.** *Calocyclas* sp. A, Sample 120-748B-9H-1, 45–47 cm. **5, 6.** *Cyrtocapsella robusta* Abelmann, Sample 120-748B-9H-1, 45–47 cm. **7.** *Pterocanium*(?) sp., Sample 120-748B-9H-1, 45–47 cm. **8, 9.** *Amphistylus angelinus* (Clark and Campbell), Sample 120-748B-9H-2, 45–47 cm. **10.** Plagoniid gen. et sp. indet., Sample 120-748B-9H-2, 45–47 cm. **11, 12.** *Cyrtocapsella* aff. *japonica* (Nakaseko), Sample 120-748B-9H-2, 45–47 cm. **13, 14.** *Prunopyle haysi* Chen, Sample 120-748B-9H-3, 45–47 cm. Magnification of all figures is 175×.

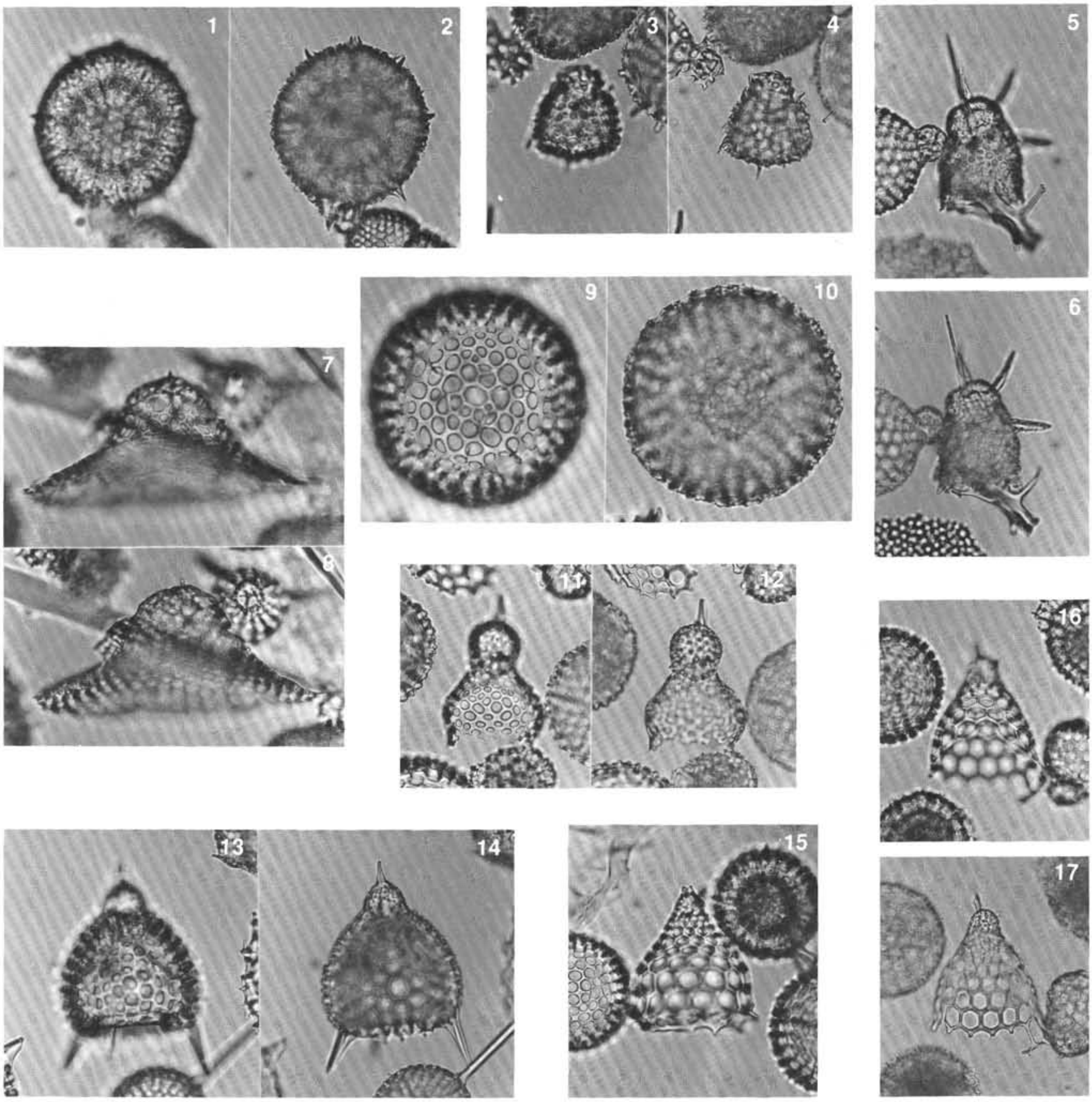

Plate 2. **1, 2.** *Prunopyle tetrapila* Hays, Sample 120-748B-9H-3, 45–47 cm. **3, 4.** *Corythomelissa*(?) sp., Sample 120-748B-9H-3, 45–47 cm. **5, 6.** *Lithomelissa tricornis* Chen, Sample 120-748B-9H-3, 45–47 cm. **7, 8.** *Vellicucullus* cf. *oddgurneri* Bjørklund,rklund Sample 120-748B-9H-3, 45–47 cm. **9, 10.** *Spongoplegma* aff. *antarcticum* Haeckel, Sample 120-748B-9H-4, 45–47 cm. **11, 12.** *Lithomelissa* sp., Sample 120-748B-9H-4, 45–47 cm. **13, 14.** *Lychnocanoma conica* (Clark and Campbell), Sample 120-748B-9H-4, 45–47 cm. **15.** *Cycladophora bicornis* (Popofsky), Sample 120-748B-10H-2, 45–47 cm. **16, 17.** *Cycladophora conica* Lombari and Lazarus, Sample 120-748B-10H-2, 45–47 cm. Magnification of all figures is 175×.

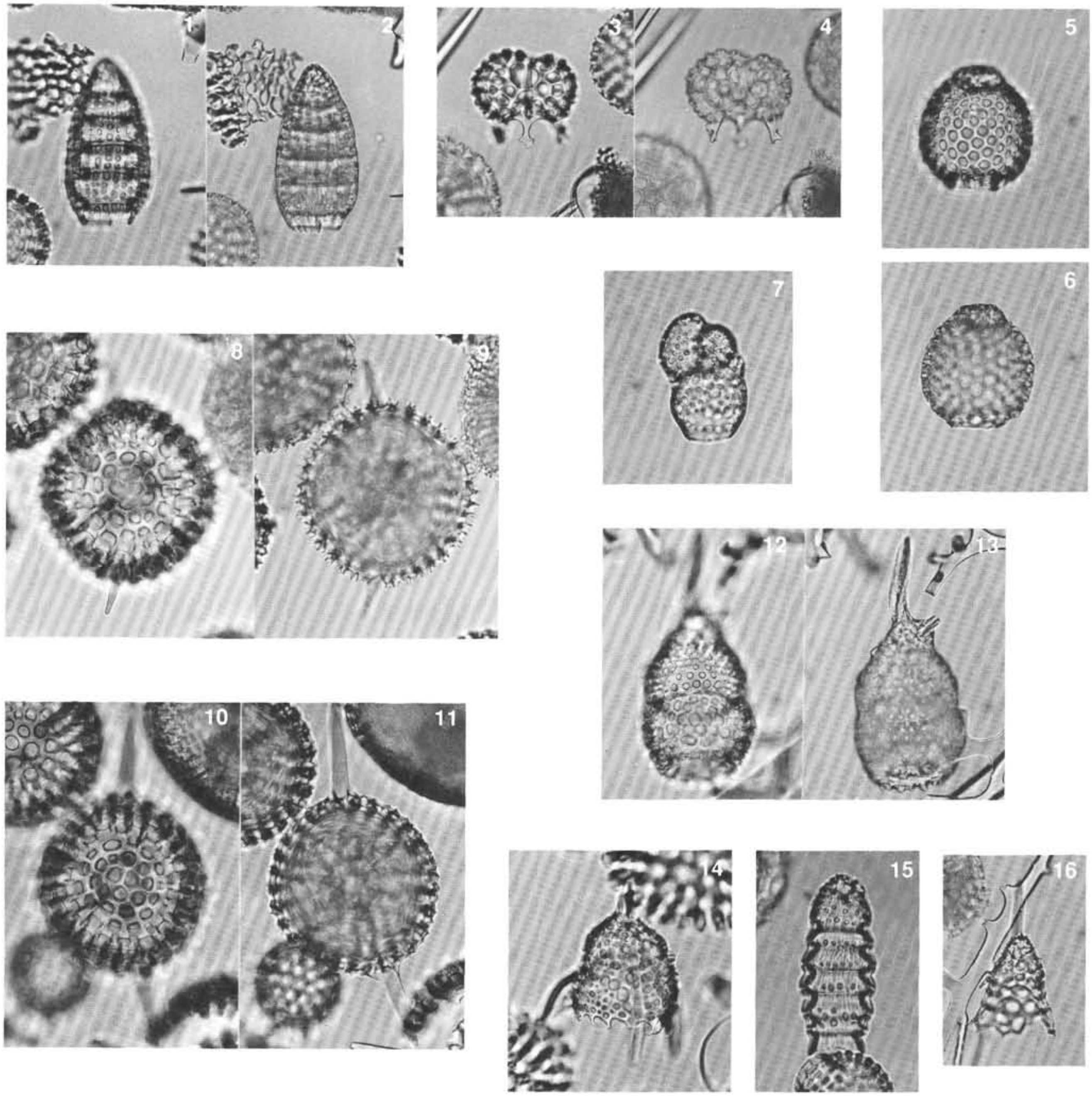

Plate 3. **1, 2.** *Archaeodictyomitra*(?) sp., Sample 120-748B-10H-5, 45–47 cm. **3, 4.** *Corythospyris* aff. *jubata* Goll, Sample 120-748B-11H-4, 45–47 cm. **5, 6.** *Carpocanistrum* spp., Sample 120-748B-11H-4, 45–47 cm. **7.** *Botryopyle dictyocephalus* Haeckel, Sample 120-748B-11H-4, 45–47 cm. **8–11.** *Axoprunum*(?) *irregularis* n. sp.; (8, 9) holotype, HUTE-R-4001, Sample 120-748B-11H-4, 45–47 cm; (10, 11) paratype, HUTE-R-4002, Sample 120-748B-12H-7, 45–47 cm. **12, 13.** *Lophoconus titanothericeraos* Clark and Campbell, Sample 120-748B-11H-4, 45–47 cm. **14.** *Corythomelissa horrida* Petrushevskaya, Sample 120-748B-11H-6, 45–47 cm. **15.** *Siphocampe nodosaria* (Haeckel), Sample 120-748B-11H-7, 45–47 cm. **16.** *Diplocyclas* sp., Sample 120-748B-12H-5, 45–47 cm. Magnification of all figures is 175×.

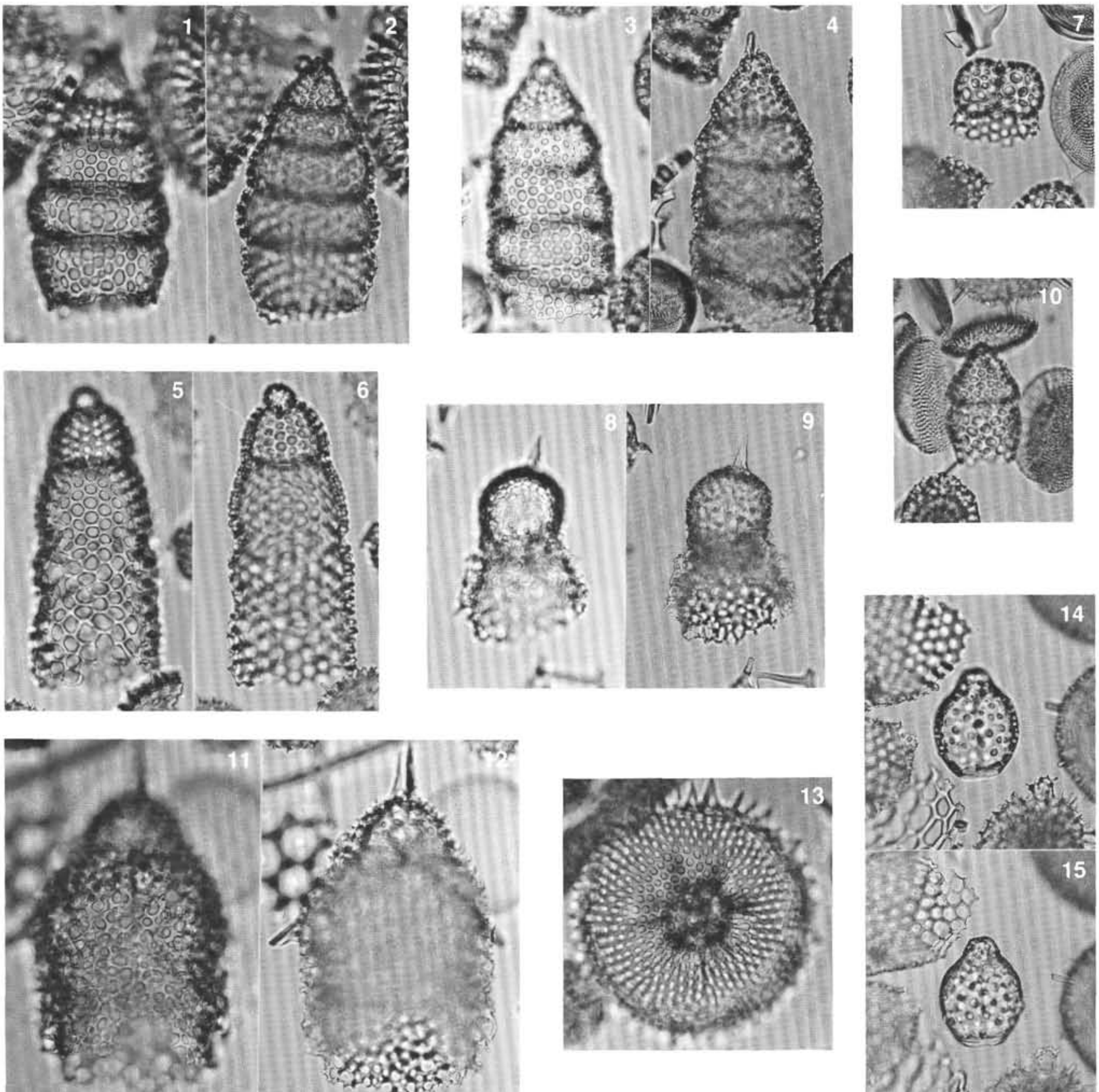

Plate 4. **1–4.** *Eucyrtidium cheni* n. sp.; (1, 2) holotype, HUTE-R-4003, Sample 120-748B-12H-7, 45–47 cm; (3, 4) paratype, HUTE-R-4004, Sample 120-748B-13H-4, 45–47 cm. **5, 6.** *Calocyclas* cf. *semipolita* Clark and Campbell, Sample 120-748B-13H-3, 45–47 cm. **7.** *Dendrospyris stabilis* Goll, Sample 120-748B-13H-4, 45–47 cm. **8, 9.** *Lithomelissa sphaerocephalis* Chen, Sample 120-748B-13H-4, 45–47 cm. **10.** Theoperid gen. et sp. indet., Sample 120-748B-13H-4, 45–47 cm. **11, 12.** *Lithomelissa challengerae* Chen, Sample 120-748B-14H-1, 45–47 cm. **13.** *Periphaena heliasteriscus* (Clark and Campbell), Sample 120-748B-14H-1, 45–47 cm. **14, 15.** *Dicolocapsa microcephala* Haeckel, Sample 120-748B-13H-6, 45–47 cm. Magnification of all figures is 175×.

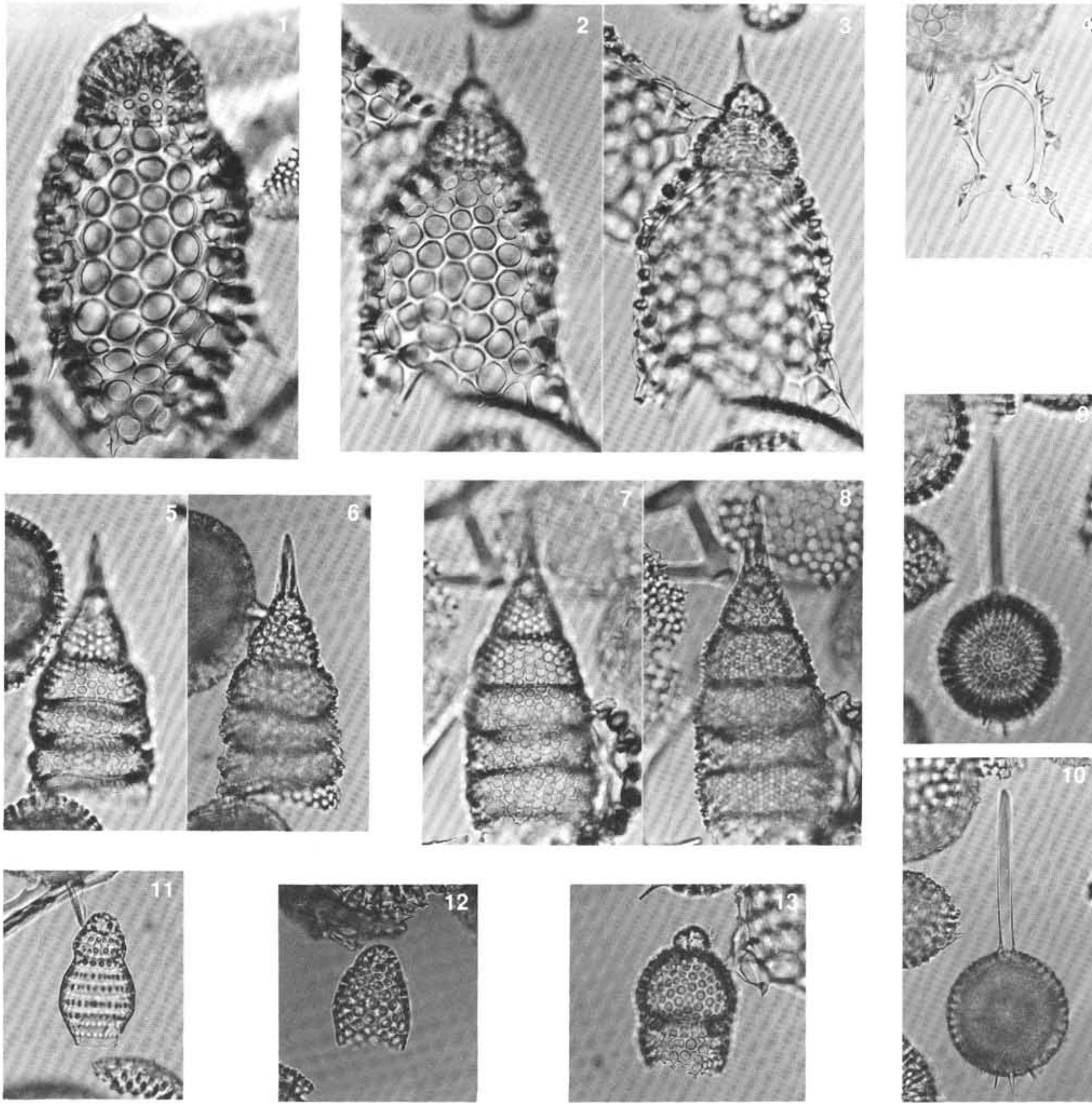

Plate 5. **1–3.** *Cyclampterium*(?) *milowi* Riedel and Sanfilippo; (1) Sample 120-748B-14H-4, 45–47 cm; (2–3) Sample 120-748B-19H-4, 45–47 cm. **4.** *Zygocircus bütchli* Haeckel, Sample 120-748B-14H-6, 45–47 cm. **5–8.** *Eucyrtidium spinosum* n. sp.; (5, 6) paratype, HUTE-R-4006, Sample 120-748B-14H-6, 45–47 cm; (7, 8) holotype, HUTE-R-4005, Sample 120-748B-15H-3, 45–47 cm. **9, 10.** *Amphistylus*(?) sp., Sample 120-748B-15H-1, 45–47 cm. **11.** *Dictyoprora pirum* (Ehrenberg), Sample 120-748B-15H-2, 45–47 cm. **12.** *Artostrobus*(?) cf. *pretabulatus* Petrushevskaya, Sample 120-748B-15H-3, 45–47 cm. **13.** *Calocyclas* sp. B, Sample 120-748B-16H-1, 45–47 cm. Magnification of all figures is 175×.

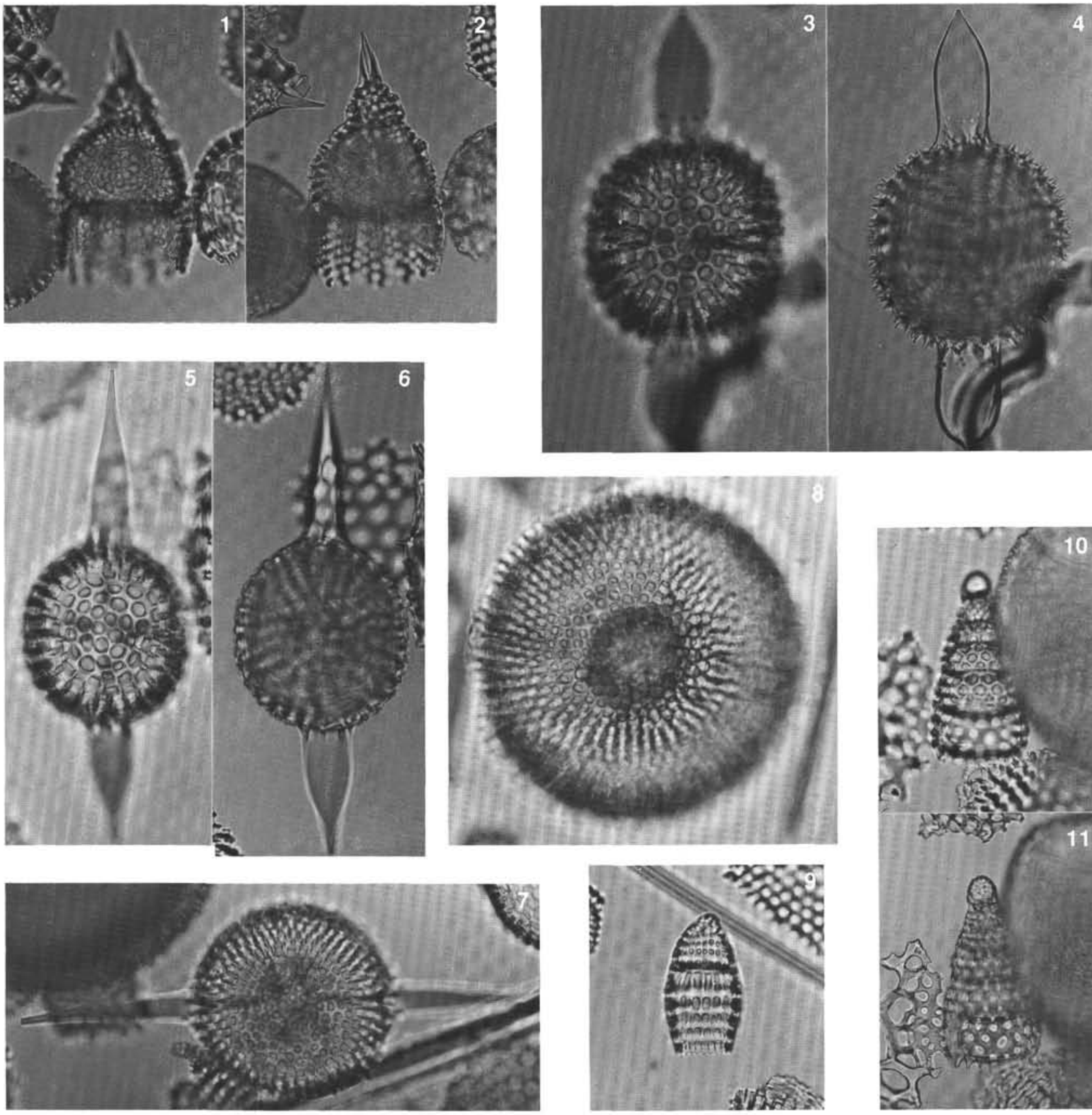

Plate 6. **1, 2.** *Theocyrtis tuberosa* Riedel, Sample 120-748B-16H-2, 45–47 cm. **3–6.** *Axoprunum pierinae* (Clark and Campbell); (3, 4) Sample 120-748B-16H-4, 45–47 cm; (5, 6) Sample 120-748B-17H-4, 45–47 cm. **7.** *Heliostylus* sp., Sample 120-748B-17H-4, 45–47 cm. **8.** *Periphaena decora* Ehrenberg, Sample 120-748B-17H-4, 45–47 cm. **9.** *Siphocampe acephala* (Ehrenberg), Sample 120-748B-17H-7, 45–47 cm. **10, 11.** *Amphipyndax stocki* (Campbell and Clark), Sample 120-748B-18H-7, 45–47 cm. Magnification of all figures is 175×.

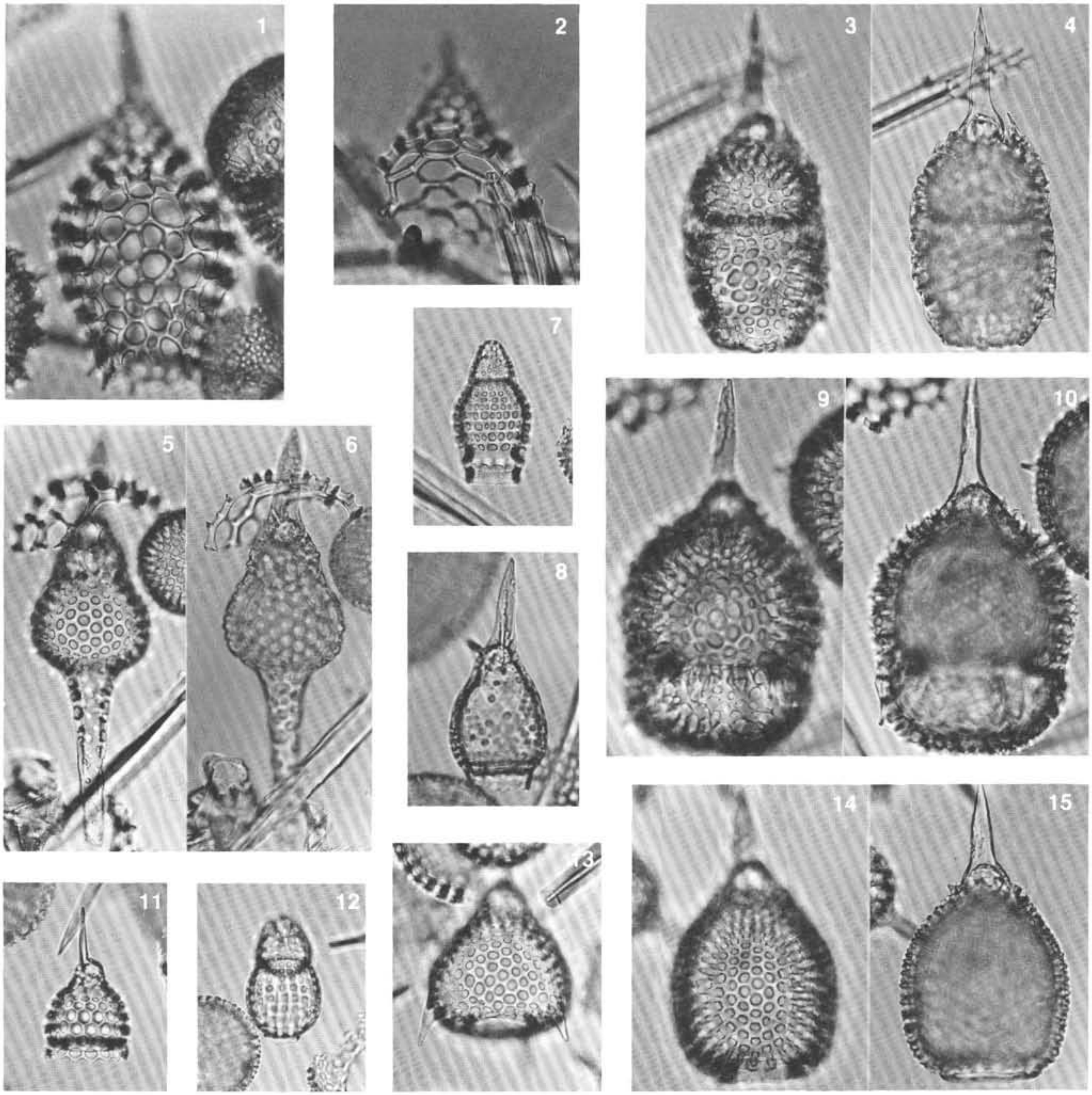

Plate 7. **1.** *Lithapium anoectum* Riedel and Sanfilippo, Sample 120-748B-19H-4, 45–47 cm. **2.** *Lithapium mitra* (Ehrenberg), Sample 120-748B-19H-4, 45–47 cm. **3, 4.** *Calocyclas* sp. C, Sample 120-748B-19H-4, 45–47 cm. **5, 6.** *Eusyringium fistuligerum* (Ehrenberg), Sample 120-748B-19H-4, 45–47 cm. **7.** *Siphocampe*(?) *quadrata* (Petrushevskaya and Kozlova), Sample 120-748B-19H-4, 45–47 cm. **8.** *Lophocyrtis biaurita* (Ehrenberg), Sample 120-748B-19H-4, 45–47 cm. **9, 10.** *Lychnocanoma amphitrite* Foreman, Sample 120-748B-19H-4, 45–47 cm. **11.** *Clathrocyclas universa* Clark and Campbell, Sample 120-748B-19H-4, 45–47 cm. **12.** *Dictyoprora mongolfieri* (Ehrenberg), Sample 120-748B-19H-7, 45–47 cm. **13.** *Lychnocanoma babylonis* (Clark and Campbell), Sample 120-748B-19H-7, 45–47 cm. **14, 15.** *Sethocyrtis* sp., Sample 120-748B-19H-4, 45–47 cm. Magnification of all figures is 175×.