8. RADIOLARIANS FROM THE WESTERN MARGIN OF THE ROCKALL PLATEAU: DEEP SEA DRILLING PROJECT LEG 81[1]

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ABSTRACT

Radiolarians occur at all Leg 81 sites in Neogene to Quaternary sediments and at Sites 552 and 553 in Eocene cores. Upper Pliocene through Pleistocene glacial sediments are barren of siliceous fossils, and the lowest part of the upper Miocene is barren of radiolarians at all but Site 555. Their presence at Site 555 is probably due to more rapid burial resulting from lateral influx of current-borne sediment. Radiolarians at each site are recorded in percent abundance for 95 Neogene counting groups and 31 Eocene groups.

INTRODUCTION

A total of eight holes at four sites were drilled during Leg 81 on the western margin of the Rockall Plateau:

Site	Location	Water depth (m)
552	56°02.56'N, 23°13.88'W	2301
553	56°05.32'N, 23°20.61'W	2329
554	56°17.41'N, 23°31.69'W	2574
555	56°33.70'N, 20°46.93'W	1659

Radiolarians are present in lower Eocene through lower Pliocene sediments of these cores. Preservation varies from poor to moderate, and some of the middle to upper Miocene and upper Pliocene through Pleistocene sequences are barren of siliceous fossils. Figure 1 summarizes occurrences of calcareous and siliceous fossils in Leg 81 cores.

PROCEDURES

Generally, we took two to three samples per core, sieved at 44 μm, acidified, and prepared strewn slides in our standard manner. Relative abundances of 95 counting groups are recorded in Tables 1-3 as percentages of 350-400 radiolarians counted in diagonal traverses across the slide. These tables also include an estimate of the proportion of the microscopic field covered by diluting components such as mineral grains, diatoms, or sponge fragments.

ZONATION

The Pliocene *Sphaeropyle langii* Zone of Foreman (1975) and the Pliocene through middle Miocene zones of Riedel and Sanfilippo (1970, emend. 1978) are used in this chapter. In several cores zonal boundaries based on evolutionary transitions are uncertain because the evolving forms are very rare. The boundary between the *Didymocyrtis antepenultima* Zone and the *D. penultima* Zone is not discernible in any of the Leg 81 material, so these two zones are combined and used for samples above the range of *D. laticonus* and below the evolutionary bottom of *Stichocorys peregrina*. Since *Diartus petterssoni* and *D. hughesi* are very rare or absent, samples above the evolutionary transition from *Lithopera renzae* to *L. neotera* are considered in the *D. petterssoni* Zone, and those below are assigned to the *Dorcadospyris alata* Zone. None of the lower Miocene to Oligocene sediments contained the radiolarian species necessary for zonation, and although radiolarian assemblages in samples dated on the basis of other fossil groups as lower Eocene were distinct from those of the middle Eocene, markers of established Eocene zones were not found. Figure 2 presents radiolarian zones for Leg 81 cores.

SITE 552

Site 552 is located on the Hatton Drift on the western margin of the Rockall Plateau. Twenty-five rotary-drilled cores were taken at Hole 552, which was spot cored to 108 m and then continuously cored to basalt. Hole 552A was piston cored to 183.5 m and terminated in middle Eocene sediments.

In the upper Pliocene and Pleistocene sediments of Cores 552-1 and 552A-1 through 12, radiolarians are poorly preserved, rare, and diluted with nonbiogenic components, and some samples are entirely barren of siliceous microfossils. Between Cores 552A-10 and 20 there is a minor component of robust radiolarians reworked from the lower Miocene (Table 1). Many samples from this interval contain some radiolarians that are rather poorly preserved, and others very well preserved, sometimes even including phaeodarians. The latest occurrence of *Stichocorys peregrina* (between Sample 552A-13,CC and Section 552A-14-1) occurs lower than expected in relation to other microfossil groups. It may be that its range is shorter in the Atlantic than in the Pacific, or perhaps the extinction appears to be early because the species becomes very rare at the top of its range. Cores between this event and the evolutionary transition between *Sphaeropyle robusta* and *S. langii* (between Samples 552A-25,CC and 552A-26-1, 65-66 cm) are placed in the *S. langii* Zone. In this interval radiolarians are, with a few exceptions, well preserved and fairly abundant on the strewn slides. Several samples (in particular, Samples 552A-19,CC and 552A-21-3, 66-68 cm) have

[1] Roberts, D. G., Schnitker, D., et al., *Init. Repts. DSDP*, 81: Washington (U.S. Govt. Printing Office).

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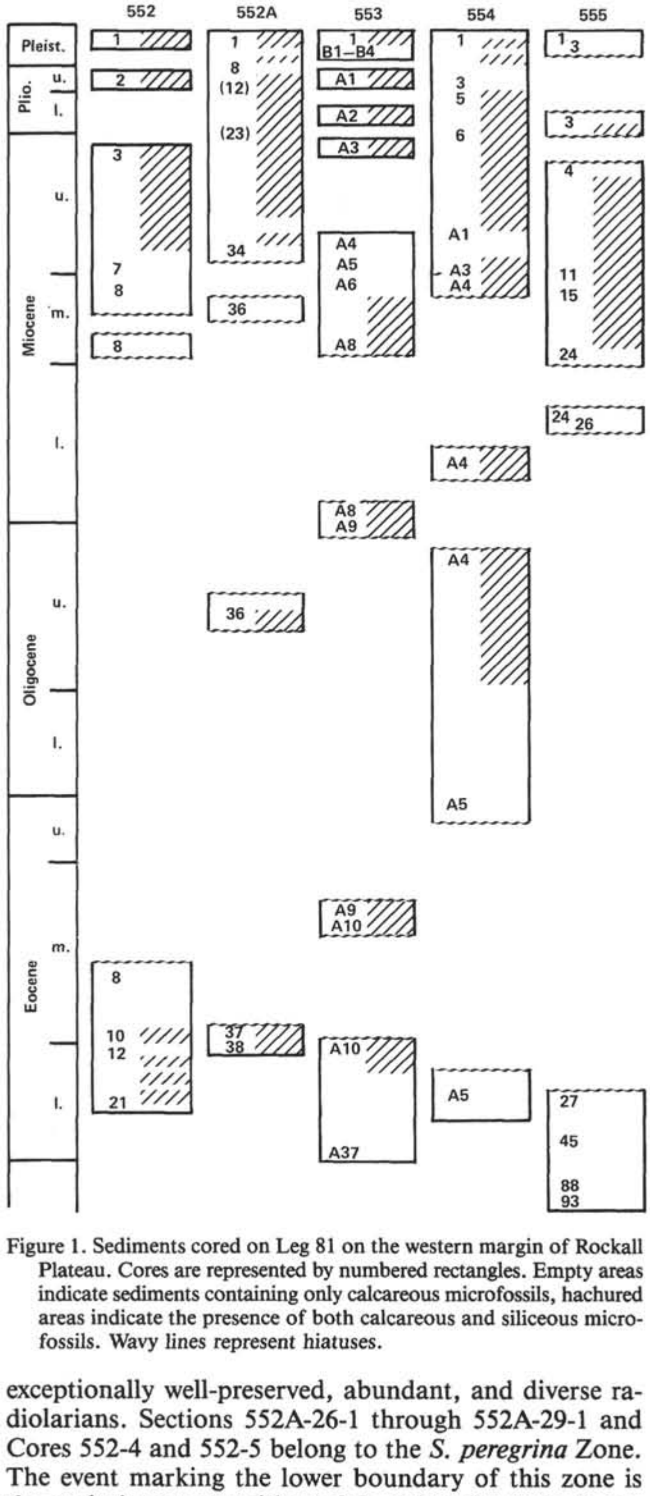

Figure 1. Sediments cored on Leg 81 on the western margin of Rockall Plateau. Cores are represented by numbered rectangles. Empty areas indicate sediments containing only calcareous microfossils, hachured areas indicate the presence of both calcareous and siliceous microfossils. Wavy lines represent hiatuses.

exceptionally well-preserved, abundant, and diverse radiolarians. Sections 552A-26-1 through 552A-29-1 and Cores 552-4 and 552-5 belong to the *S. peregrina* Zone. The event marking the lower boundary of this zone is the evolutionary transition of *S. delmontensis* to *S. peregrina*, which occurs between Section 552A-29-1 and Sample 552A-30,CC and between Sample 552-5,CC and Section 552-6-1. Just below this transition, there is an interval of approximately 30 m (Cores 552-7 through 552-9, and Sections 552A-31-3 through 552A-37-1) in which siliceous fossils are all or nearly all dissolved. There are two unconformities in this interval, one at Sample 552A-36-3, 139 cm with middle Miocene sediments overlying Oligocene, and a second at Sample 552A-37-1, 75 cm representing most of the late and middle Eocene (Backman, this volume). Benthic foraminifers in the lower part of this interval reveal subsidence from depths of ~700 m in the middle Eocene to approximately the present-day depth of 2000 m above the hiatus (Murray, this volume). In the shallow-water lower and middle Eocene sediments, radiolarians are rare to common and diluted with large sponge spicules. *Lophocyrtis norvegiensis, Ptercocodon ampla*, and *Phormocyrtis striata striata* are common components of the middle Eocene assemblage in Sample 552-10,CC and Sections 552A-37 through 552A-38. Cores 552-12 through 552-21 contain fewer radiolarians, but in Section 552-18-2 there are some rather corroded tests that appear to be lower Eocene forms *Amphicraspedum murrayanum* and *Pterocodon lex*, and Sample 552-21-3, 47–49 cm contains the lower Eocene species *Buryella tetradica* (Table 3).

SITE 553

Site 553 is located some 4 miles northwest of Site 552. Hole 553 is a single mudline core, and Hole 553B consists of four disturbed piston cores. Hole 553A was drilled and spot cored to 179.5 m and then continuously cored through Eocene sediment and into basalt.

Radiolarians are common and moderately well preserved in the Pliocene and upper Miocene Cores 553A-1 through 553A-3. It is not possible to distinguish between the *Stichocorys peregrina* Zone and the *Sphaeropyle langii* Zone in these samples because *S. langii* and its ancestor *S. robusta* are equally rare in all the examined slides. Siliceous fossils are dissolved in Cores 553A-4 and 553A-5, an interval corresponding to the barren middle Miocene at Site 552. There are few poorly preserved radiolarians in the middle Miocene Core 553A-6 through Section 553A-8-3. Because artiscins are rare and poorly preserved in this sequence, the boundary between the *Diartus petterssoni* Zone and the *Dorcadospyris alata* Zone cannot be discerned, but the presence of *Diartus laticonus, Lithopera neotera*, and *L. renzae* in Samples 553A-7-4, 119–121 cm and 553A-8-1, 62–64 cm suggests that these cores are middle Miocene. Sections 553A-8-2 and 553A-8-3 can be assigned to the *Dorcadospyris alata* Zone because *L. renzae* is more abundant than is its descendant *L. neotera*, and this evolutionary transition occurs in the upper part of the *D. alata* Zone. Neogene radiolarians of Site 553 are tabulated in Table 2.

At least four radiolarian zones of the early Miocene are missing between the bottom of Section 553A-8-3 and the top of Section 553A-8-4. In Sample 553A-8-4, 19–21 cm, radiolarians appear to be older than the early Miocene *Cyrtocapsella tetrapera* Zone because of the absence of *Stichocorys delmontensis* and *C. tetrapera*, both of which are common in the samples above. *Artophormis gracilis*, which ranges through the Oligocene into the lower Miocene, is present in all samples examined between Sections 553A-8-4 and 553A-9-5. Below an unconformity in Section 553A-9-6, Samples 553A-9,CC through 553A-10-2, 122–124 cm contain a moderately well-preserved middle Eocene assemblage. Samples from Sections 553A-10-3 and 553A-10-4 are barren of siliceous

Epoch	Radiolarian Zone	Hole 552	Hole 552A	Site 553 Holes 553A, 553B	Site 554 Holes 554, 554A	Site 555
Pleist.		1,CC	1-1 1-3	553B-1,CC 553B-2,CC	1-1 2-3	(1-2 through 4-6 barren)
Pliocene/Pleistocene			(3-3 through 7-1 barren) 9-3 13,CC	553A-1,CC	(2,CC through 3-5 barren) 3,CC	
	S. langii	2,CC 3-3 4-2	14-1 25,CC	553A-2,CC	5-2 5-5 6-6	
upper Miocene	*S. peregrina*	5,CC	26-1 29-1	553A-3-2	7-3 8-3 8,CC 554A-1-1	5-4 6-4
	D. penultima/ D. antepenultima	6-1	30,CC	(553A-4-3 through 553A-6-2 barren)	(554A-2-1 through 3-1 barren)	6-6 8-6 9,CC 10,CC
middle Miocene	*D. petterssoni*	(7-2 through 9-5 barren)	(31-3 through 35-3 barren)	553A-7-4 553A-8-1	554A-3-3 554A-4-1	11-3 18-2
	D. alata			553A-8-2 553A-8-3	554A-4-2	19-3 22-1
lower Miocene/ Oligocene			36-1	553A-8-4 553A-9-5	554A-4-3	
middle Eocene		10,CC	37-1 38,CC	553A-9,CC 553A-10-5	(554A-5 through 554A-6 barren)	(23 through 68 barren)
lower Eocene		12-2 21-3		553A-11-4 553A-11-5 (553A-12 through 553A-37 barren)		

Figure 2. Radiolarian zones represented in Leg 81 sites. Cores and sections of each hole are shown. Hachured areas indicate uncertain zonal assignment. Wavy lines indicate hiatuses.

fossils, but Sample 553A-10-5, 98–100 cm contains a few moderately well-preserved middle to upper Eocene forms, and Core 553A-11 contains a lower Eocene fauna. These Eocene samples are tabulated, together with those from Site 552, in Table 3.

SITE 554

Site 554 is located on the outer high of the southwest margin of Rockall Plateau. Fourteen rotary cores were taken from two holes, terminating in lower Eocene sediments above basalt. Moderately well-preserved radiolarians are present in sediments down through the Oligocene with the exception of barren intervals in the Pleistocene, upper Miocene, and lower Eocene which correspond to the barren intervals in Sites 552 and 553.

Some samples from Pleistocene Cores 554-1 through 554-3 contain moderately well-preserved radiolarians. Samples 554A-1-1, 44–46 cm through 554A-2-3, 12–14 cm are above the extinction of *Stylatractus universus*. Core 554-5 is assigned to the *Sphaeropyle langii* Zone on the co-occurrence of *S. langii* and *S. peregrina*, and samples from cores down to Section 554-8-3 are placed in the *S. peregrina* Zone. Samples 554-8,CC and 554A-1-1, 18–20 cm are apparently very near the evolutionary transition from *Stichocorys delmontensis* to *S. peregrina* and therefore near the boundary between the *S. peregrina* and *Didymocyrtis penultima* zones. A barren interval follows between the bottom of Core 554A-1 and the top of Core 554A-3. Below Section 554A-3-3 radiolarians are poorly preserved, but the presence of *D. laticonus* and *Cyrtocapsella japonica* suggest an age equivalent to the *Diartus petterssoni* or *Dorcadospyris alata* zones of the middle Miocene. These species and the common occurrence of *C. tetrapera* with rare *Lithopera*

Table 1. Abundances of Neogene radiolarian counting groups at Site 552.

Site 552 Core-Section (interval in cm)	*Collosphaerid* grp.	*Actinomma medianum*	*Anomalacantha dentata*	*Druppatractus* grp.	*Haeckeliella inconstans*	*Hexacontium* grp. A	*Hexacontium* grp. B	*Sphaeropyle langii*	*S. robusta*	*Stylatractus universus*	*Stylosphaera* spp.	*Thecosphaera* spp.	Other Actinommids	Phacodiscid grp.	*Diartus petterssoni*	*Didymocyrtis antepenultima*	*D. lacticonus*	*D. tetrathalamus*	*Didymocyrtis* spp.	*Dictyocoryne* grp.	*Porodiscus* grp. A	*Porodiscus* grp. B	*Porodiscus* grp. C	*Stylodictya* spp.
Hole 552																								
2,CC	+	+	0.80	0.80	—	2.1	+	0.27	—	4.8	0.27	0.27	8.3	+	—	—	—	—	—	2.9	8.3	—	—	1.6
3-3, 70–72	0.29	+	1.7	1.1	+	1.7	+	+	—	11	0.29	0.29	10	0.29	—	—	—	—	+	1.4	13	0.29	—	2.3
3,CC	—	+	2.0	1.8	—	0.76	—	—	—	1.0	2.3	—	4.8	0.50	—	—	—	—	—	0.76	12	2.8	—	1.3
4-2, 91–93	+	0.83	1.9	0.28	—	0.83	+	+	+	2.8	0.83	+	6.4	0.28	—	—	—	—	—	1.7	8.0	0.28	—	1.1
5,CC	+	+	0.85	1.1	—	0.28	0.28	—	+	2.8	+	0.57	11	0.28	—	—	—	—	0.28	0.28	9.7	0.28	—	1.7
6-1, 82–84	0.56	—	0.56	0.28	—	0.28	—	—	+	2.3	+	+	4.8	+	—	—	—	—	—	0.56	16	0.28	—	1.4
Hole 552A																								
1-1, 106–107	0.50	—	—	2.6	—	9.5	—	—	—	—	—	—	1.1	1.1	—	—	—	—	—	0.50	0.50	4.2	—	1.1
1-3, 53–54	0.62	+	0.31	0.62	—	1.3	+	0.31	—	—	—	+	7.5	—	—	—	—	—	—	0.94	21	1.9	—	0.62
2-2, 122–123	0.32	+	+	0.32	—	5.1	—	0.32	—	2.2	—	—	13	0.32	—	—	—	—	—	0.32	17	1.3	—	2.9
3-1, 95–96	—	2.9	—	0.29	—	1.1	0.29	0.29	—	1.4	—	—	11	0.57	—	—	—	—	—	0.86	11	2.6	—	0.57
5-1, 104–105	—	3.1	0.31	0.62	—	1.5	—	+	—	1.5	0.62	—	5.0	0.31	—	—	—	—	0.31	+	27	—	—	2.5
9-3, 25–26	—	+	+	0.60	+	1.2	—	0.30	—	3.6	0.30	—	4.2	0.60	—	—	—	—	—	2.1	17	0.60	—	0.60
10-1, 134–135	—	0.63	0.32	2.5	—	+	1.3	1.3	—	9.5	1.3	—	10	+	—	—	—	—	—	1.3	9.5	0.63	—	0.63
11-1, 46–48	—	+	0.29	0.87	—	—	0.58	+	—	4.6	2.9	—	7.2	—	—	—	—	—	—	2.0	16	0.87	—	1.4
12-1, 95–97	0.27	+	0.80	+	—	0.80	—	+	—	3.7	1.1	0.53	9.9	—	—	—	—	—	—	3.7	13	0.80	—	1.6
13,CC	1.3	0.27	0.27	1.3	—	+	0.27	+	—	4.0	0.54	+	5.9	+	—	—	—	—	—	2.9	19	0.80	—	2.9
14-1, 30–31	0.27	+	0.80	+	—	0.27	0.27	0.80	—	5.1	+	1.1	7.5	0.27	—	—	—	—	—	3.5	13	2.9	—	3.2
14-3, 11–12	+	0.27	0.82	0.27	—	1.1	0.27	0.27	—	3.8	+	+	6.6	0.27	—	—	—	—	—	3.6	10	2.5	—	3.6
15-1, 30–31	0.55	0.55	0.82	0.82	—	1.4	0.27	0.27	—	4.4	1.1	0.27	7.4	0.27	—	—	—	—	—	0.82	12	0.55	—	3.3
15-3, 11–12	0.29	+	0.86	0.57	—	2.0	0.29	+	—	6.3	0.57	0.29	13	0.86	—	—	—	—	—	0.86	8.6	0.29	+	2.0
16-1, 134–136	0.33	+	0.33	0.33	+	1.6	+	0.65	—	5.2	—	+	8.8	+	—	—	—	—	—	0.98	6.8	0.98	0.65	2.6
16-2, 50–51	0.52	0.26	1.0	+	—	4.4	+	0.52	—	5.5	0.26	+	13	0.26	—	—	—	—	+	0.52	6.0	0.52	—	0.26
17-1, 96–97	0.25	+	0.76	1.0	—	1.3	+	+	—	15	0.51	1.3	12	—	—	—	—	0.25	—	1.5	6.3	0.51	—	2.5
18-1, 44–46	0.27	+	0.82	0.82	—	0.82	+	+	—	6.3	1.1	0.55	5.5	+	—	—	—	0.27	—	0.55	9.3	—	—	3.8
18-3, 6–8	+	0.26	—	3.1	—	4.7	+	+	—	8.6	—	+	22	0.26	—	—	—	0.52	—	2.1	7.0	0.26	—	2.6
19-1, 86–87	+	0.52	1.6	1.8	—	1.3	—	+	—	6.0	0.52	0.26	8.8	+	—	—	—	+	+	1.6	12	0.52	+	2.9
19,CC	+	+	0.28	0.28	—	0.28	+	+	—	8.3	0.28	0.55	4.7	0.83	—	—	—	—	—	0.83	14	+	—	1.7
20-1, 35–37	0.30	+	1.2	+	+	1.5	—	+	—	16	—	0.30	7.5	0.60	—	—	—	—	+	1.5	17	1.5	—	1.8
20-3, 24–26	—	+	0.28	0.28	—	0.57	—	—	—	8.5	0.57	+	7.1	0.28	—	—	—	—	—	2.5	9.1	0.57	—	2.5
21-1, 104–106	—	+	0.29	0.29	—	0.29	—	—	—	14	—	0.29	8.4	0.29	—	—	—	—	—	0.58	13	2.6	—	1.4
21-3, 66–68	+	+	0.28	0.28	+	0.28	—	+	—	14	+	0.28	7.0	0.28	—	—	—	—	+	1.7	13	2.0	—	1.7
22-1, 33–35	0.28	+	0.85	+	+	0.28	—	+	+	16	0.28	0.57	6.3	0.28	—	—	—	—	—	0.57	9.4	1.4	—	2.8
22-3, 13–15	+	+	2.0	+	—	0.56	—	+	—	9.6	—	+	8.8	0.56	—	—	—	—	—	2.5	15	2.3	—	4.2
23-1, 105–106	0.48	0.24	0.48	0.48	—	0.97	—	—	—	10	0.48	0.24	4.4	0.73	—	—	—	—	—	1.5	12	0.48	—	2.4
23-2, 22–23	+	+	1.1	+	0.28	0.56	—	+	—	11	0.28	0.85	11	1.1	—	—	—	—	—	2.0	25	1.4	—	2.8
24-3, 121–122	+	+	0.50	1.0	—	+	—	0.25	0.25	8.3	—	0.25	8.3	+	—	—	—	—	0.25	1.0	23	0.25	+	2.3
25-1, 133–134	+	0.27	0.27	0.80	—	0.80	—	0.53	0.27	9.3	—	0.27	7.7	0.27	—	—	—	+	—	0.27	24	1.9	—	1.9
25-3, 133–134	+	+	0.27	0.80	+	1.6	+	0.53	—	13	—	—	9.3	1.1	—	—	—	—	+	1.6	20	2.7	—	1.6
25,CC	0.28	+	0.84	1.7	+	0.56	0.28	0.28	0.28	10	+	0.28	7.8	0.28	—	—	—	—	+	1.1	19	—	—	1.7
26-1, 65–66	0.28	+	1.1	—	—	0.85	—	—	+	5.9	+	+	8.2	+	—	—	—	—	—	0.28	11	—	—	3.4
26-3, 85–86	+	—	2.0	1.4	—	0.29	—	—	0.29	2.3	—	—	5.7	2.0	—	—	—	—	—	0.86	19	0.57	—	2.9
27-1, 108–109	+	+	1.1	0.28	—	—	—	+	—	3.4	—	—	6.8	1.1	—	—	—	—	—	0.28	15	0.28	—	2.3
27,CC	+	+	0.55	0.55	—	+	—	—	0.28	7.2	+	+	6.1	0.28	—	—	—	—	—	1.4	23	—	—	2.5
28-2, 109–110	—	0.28	1.7	0.57	—	0.57	—	—	0.28	1.4	+	+	8.5	0.57	—	—	—	—	—	2.8	17	0.57	+	1.7
28-3, 109–110	+	+	2.2	+	—	+	+	—	—	3.8	+	0.27	7.3	+	—	—	—	—	—	2.2	17	—	—	1.6
29-1, 54–55	+	+	1.3	0.52	—	+	0.26	—	—	9.8	0.26	0.52	9.3	—	—	—	—	—	—	0.52	19	0.26	—	0.52
29-3, 54–55	0.26	0.26	0.53	0.53	—	0.26	—	+	+	5.0	0.26	—	4.8	0.26	—	—	—	—	—	0.79	16	0.53	—	3.7
30,CC	—	+	0.91	0.61	—	0.91	+	—	+	0.61	+	+	7.6	—	—	—	—	—	0.30	0.91	29	0.61	—	1.5
31-1, 100–101	+	—	1.0	0.51	—	0.77	—	+	0.26	3.9	—	0.26	7.7	0.51	—	—	—	—	+	+	16	1.0	—	4.1

Note: In the body of the table, "—" indicates that the group was sought but not found, "+" indicates <0.25% of the radiolarians on the slide, and numbers indicate abundance in percentage of total radiolarians on the slide as determined by counting the number of individuals indicated in the column headed "Radiolarians counted." The last columns on the right show the number of radiolarians on the slide, their preservation (G = good; M = moderate; and P = poor), and the concentration of diluting components expressed as a percentage of the particles in a field of view.

renzae place Sample 554A-4-2, 2–4 cm in the *D. alata* Zone. The absence of *C. tetrapera* in an assemblage similar to that in Sections 553A-8-4 through 553A-9-3 places Sample 554A-4-3, 18–20 cm below the lower Miocene *C. tetrapera* Zone. Samples below 554A-4,CC are barren of radiolarians. Radiolarian occurrences in Site 554 are shown in Table 2.

SITE 555

Site 555, located in a basin between the Hatton and Edoras banks, is the shallowest site of Leg 81. Radiolarians are present in Pliocene to middle Miocene Samples 555-4,CC through 555-23,CC. The lower Miocene and shelfal lower Eocene sediments of Cores 555-24 through 555-67 are barren of siliceous fossils.

Sample 555-4,CC contains only large, indeterminate actinommids, litheliids, and spongodiscids, but in Core 555-5 there is a moderately well-preserved assemblage of the *Stichocorys peregrina* Zone. The dominance of *S. delmontensis* over *S. peregrina* in Sample 555-6-6, 30–32 cm indicates an age below the lower boundary of the *S. peregrina* Zone, but the species necessary to distinguish between the *Didymocyrtis penultima* Zone and *D. antepenultima* Zone are not present. Core catchers from Cores 555-9 and 555-10 contain very few robust radiolarians and large sponge spicules; most diagnostic species have evidently dissolved, but several specimens of

Table 1. (Continued).

Site 552 Core-Section (interval in cm)	Cycladophora davisiana	Cyrtocapsella cornuta	C. japonica	C. tetrapera	Cyrtopera laguncula	Eucecryphalus grp.	Eucyrtidium acuminatum	E. calvertense	E. cienkowskii grp.	E. hexagonatum	E. punctatum	Eucyrtidium sp. A	Eucyrtidium sp. B	Other Eucyrtidium	Gondwanaria grp. A	Gondwanaria grp. B	Litharachnium grp.	Lithopera bacca	L. neotera	L. renzae	Lophocyrtis norvegiensis	Lophocyrtis sp.	Pterocanium grp.	Stichocorys delmontensis
Hole 552																								
2,CC	0.80	—	—	—	+	0.27	—	0.53	0.27	—	0.53	—	—	—	—	+	0.53	—	—	—	—	0.27!	+	—
3-3, 70–72	—	—	—	—	—	+	+	+	+	—	0.57	—	—	—	0.29	+	0.29	—	—	—	—	—	—	—
3,CC	—	—	—	—	—	—	—	+	0.50	—	—	—	—	—	—	—	0.25	—	—	—	+!	—	+	—
4-2, 91–93	—	—	+	—	—	0.55	+	+	0.28	—	—	—	—	—	—	—	0.28	—	—	—	—	—	+	—
5,CC	—	—	—	—	—	+	+	+	1.1	—	0.57	—	—	—	—	—	+	—	—	—	—	—	0.28	0.08
6-1, 82–84	—	—	—	—	—	+	—	—	0.56	+	+	—	—	0.56	—	+	+	—	—	—	—	—	0.28	+
Hole 552A																								
1-1, 106–107	6.8	—	—	—	0.50	—	—	—	—	—	0.50	—	0.50	—	—	—	—	—	—	—	—	—	—	—
1-3, 53–54	4.7	—	—	—	—	0.31	+	—	0.31	0.31	+	+	+	0.31	+	—	0.62	—	—	—	—	—	0.31	—
2-2, 122–123	8.9	—	—	—	+	0.32	+	+	0.64	+	0.32	0.32	—	0.32	+	+	0.96	—	—	—	—	—	0.64	—
3-1, 95–96	2.6	—	—	—	—	—	+	0.29	+	—	0.57	—	—	0.29	0.29	—	0.29	—	—	—	—	—	0.57	—
5-1, 104–105	1.9	—	—	—	—	0.31	—	—	+	—	0.62	—	—	—	—	—	0.62	—	—	—	—	—	+	—
9-3, 25–26	0.30	—	—	—	+	—	+	—	+	—	—	—	—	+	—	+	—	—	—	—	—	—	0.30	—
10-1, 134–135	0.32	—	—	+!	—	0.63	—	—	0.32	—	+	0.32	0.32	—	0.32	—	0.63	—	—	—	—	—	0.95	—
11-1, 46–48	—	—	—	—	—	—	—	—	—	—	—	—	0.29	—	—	—	—	—	—	—	—	—	0.29	—
12-1, 95–97	0.27	—	—	+!	—	0.53	—	+	0.27	—	+	—	+	—	+	—	0.53	+	+!	—	+!	—	0.53	—
13,CC	0.54	—	—	+!	—	+	—	+	0.27	+	0.54	+	+	—	+	—	+	—	—	—	+!	—	+	—
14-1, 30–31	—	—	—	—	+	0.27	—	0.27	0.54	+	+	0.27	+	—	+	+	0.27	—	—	—	+!	—	+	—
14-3, 11–12	—	—	—	—	—	0.55	+	—	—	—	+	—	+	+	+	—	+	—	—	—	+!	—	+	—
15-1, 30–31	+	—	0.27!	0.27!	+	0.27	—	—	+	0.27	0.27	—	0.55	0.27	+	+	+	—	—	—	+!	—	+	—
15-3, 11–12	+	—	—	—	—	0.86	—	+	0.29	—	+	—	+	—	—	—	0.29	—	—	—	+!	—	1.1	—
16-1, 134–136	+	—	—	—	+	0.33	—	+	0.65	0.33	+	—	0.33	0.65	+	0.33	0.33	—	—	—	+!	—	0.65	—
16-2, 50–51	—	—	—	—	—	1.0	—	0.26	1.0	+	+	+	0.26	0.26	—	—	0.52	—	—	—	+!	—	1.3	—
17-1, 96–97	0.25	—	—	—	—	0.25	—	+	0.51	0.25	—	+	—	+	+	+	+	—	—	—	+!	+!	1.8	—
18-1, 44–46	—	—	—	—	—	+	—	+	1.4	—	+	—	0.55	0.27	+	+	0.27	—	—	—	—	—	0.27	—
18-3, 6–8	—	—	—	+	—	—	—	0.26	0.52	+	+	—	—	+	0.26	—	0.52	—	—	—	—	—	0.52	—
19-1, 86–87	—	—	—	0.52	—	0.26	—	—	0.21	0.26	0.52	—	0.26	—	+	—	0.52	—	—	—	+!	+!	+	—
19,CC	—	—	—	+	+	0.55	—	0.28	+	0.28	0.55	+	0.28	0.28	0.55	+	+	—	—	—	+!	—	0.28	—
20-1, 35–37	+	—	—	+	+	+	—	0.30	+	+	+	+	+	+	0.60	—	+	—	—	—	—	—	+	—
20-3, 24–26	0.28	—	—	+	—	+	—	0.85	+	—	—	—	—	—	+	—	0.85	—	—	—	—	—	+	—
21-1, 104–106	—	—	—	0.29	—	—	—	0.87	+	—	+	—	—	—	—	—	0.29	—	+	—	—	—	+	—
21-3, 66–68	+	—	—	0.28	0.28	0.84	—	0.84	0.56	+	+	—	+	—	+	+	+	—	+	—	+!	—	0.56	—
22-1, 33–35	—	—	—	+	—	0.28	—	0.28	0.28	+	+	—	+	—	+	0.28	+	—	—	—	—	—	+	—
22-3, 13–15	0.28	—	—	0.28	—	+	+	0.28	+	+	+	—	0.28	—	+	+	+	—	—	—	—	—	0.85	—
23-1, 105–106	+	—	—	+	—	+	0.24	0.76	0.97	—	0.24	—	+	0.24	—	+	+	—	+	—	—	—	+	—
23-2, 22–23	—	—	—	+	—	0.28	+	0.28	1.1	+	+	+	—	0.28	0.56	—	1.1	—	—	—	—	—	+	—
24-3, 121–122	—	—	—	+	0.25	0.76	—	0.25	0.50	0.25	+	—	—	0.25	—	—	+	—	—	—	—	—	0.50	—
25-1, 133–134	—	—	—	0.27	—	0.53	—	0.27	0.53	—	0.27	0.27	+	—	+	—	0.27	—	—	—	—	—	+	—
25-3, 133–134	—	—	—	+	+	—	—	0.27	0.27	—	+	—	—	—	+	+	0.27	—	—	—	—	—	0.53	—
25,CC	—	—	—	0.28	—	0.28	+	0.56	0.84	—	0.56	—	+	—	+	+	0.28	—	—	—	—	—	0.28	+
26-1, 65–66	—	—	—	+	+	—	—	+	0.85	—	+	—	+	—	0.28	+	+	—	—	—	—	—	+	—
26-3, 85–86	—	—	—	0.86	—	0.29	—	+	0.29	—	+	—	—	—	+	0.29	+	—	—	—	—	—	0.29	—
27-1, 108–109	—	—	—	—	+	+	—	+	0.28	—	+	—	—	—	+	+	+	—	—	—	—	—	+	+
27,CC	—	—	—	+	—	+	—	+	+	—	+	—	0.28	—	—	—	+	—	—	—	—	—	0.28	0.55
28-2, 109–110	—	—	—	—	—	+	—	+	0.57	+	+	—	+	—	+	+	1.1	—	—	—	—	—	+	—
28-3, 109–110	—	—	—	—	—	+	—	+	+	—	+	—	+	—	+	—	0.27	—	—	—	—	—	0.27	—
29-1, 54–55	—	—	—	—	—	0.52	+	+	0.52	—	+	—	0.26	—	—	—	0.26	—	—	—	—	—	1.8	—
29-3, 54–55	—	—	—	—	—	+	—	—	0.53	—	—	—	—	—	—	—	0.26	—	—	—	—	—	0.26	0.05
30,CC	—	—	—	—	—	0.61	—	+	+	—	+	—	—	—	—	+	0.30	—	—	—	—	—	+	0.22
31-1, 100–101	—	—	—	—	—	+	—	0.26	1.0	—	+	—	—	—	+	—	+	—	—	—	—	—	0.26	0.20

D. laticonus indicate middle to late Miocene age. There is more variety, better preservation, and greater abundance of radiolarians in samples below Sample 555-10,CC. Although most of the artiscins are not sufficiently well preserved for species distinction, more *D. laticonus* are preserved than *D. antepenultima*, suggesting that Cores 555-11 through 555-18 belong in the *Diartus petterssoni* Zone. *D. petterssoni* is also present in this interval, along with *Lithopera neotera* and other species that range through this zone. The same assemblage persists down through Sample 555-16,CC, but that in Sample 555-17,CC is noticeably different. There are abundant large sponge spicules; radiolarians that are abundant in the cores above are very rare or absent, and other forms are common. *L. neotera* is found in small numbers down to Core 555-21, where its ancestor *L. renzae* is more abundant. This evolutionary transition occurs in the upper part of the *Dorcadospyris alata* Zone.

Recovery in Cores 555-22 and 555-23 was very poor and most of the siliceous material is dissolved; only large robust actinommids and large sponge spicules remain in Core 22. There is apparently a great deal of downhole contamination in Core 23. In addition to the partly dissolved radiolarians and sponge spicules like those in Core 555-22, there are small forms with very well-preserved delicate spines, and species characteristic of the Pliocene and Pleistocene. Below this, radiolarians are absent except for occasional occurrences of robust, nondiagnostic actinommids. Radiolarian abundances at Site 555 are tabulated in Table 2.

Table 1. (Continued).

Spongocore spp.	*Spongodiscus* grp.	Pyloniid grp.	Tholoniid grp.	*Larcopyle* grp.	*Larcospira* grp.	*Lithelius minor*	*Pylospira* grp.	*Soreuma* grp.	*Acanthodesmia* grp.	*Ceratospyris* grp. A	*Ceratospyris* grp. B	*Ceratospyris* grp. C	*Desmospyris* grp.	*Liriospyris cricus*	*Tholospyris rhombus*	*Tricolospyris* grp.	*Zygocircus* grp.	*Amphiplecta* grp.	*Arachnocorallium* grp.	*Ceratocyrtis* grp.	*Lophophaena* grp.	*Pseudodictyophimus* grp.	Sethophormin grp. A	Sethophormin grp. B	Other Plagoniids	*Cornutella* spp.
+	42	1.1	—	—	—	8.8	7.5	—	+	+	+	+	—	—	—	—	+	+	+	1.9	2.4	1.3	+	—	—	—
+	21	1.1	—	0.57	0.29	14	7.2	—	—	0.29	—	—	—	—	—	—	—	+	—	1.1	2.9	1.4	0.29	—	—	+
0.50	34	2.3	—	1.8	—	15	6.3	—	—	0.25	+	—	—	1.5	—	—	0.25	—	0.25	1.0	1.0	0.50	+	—	—	0.76
0.55	25	3.3	+	0.83	—	19	5.5	—	+	+	—	—	—	1.1	—	—	+	—	1.1	4.2	3.6	0.55	0.28	—	+	2.2
+	24	2.3	0.28	0.57	—	19	9.4	—	—	+	—	—	—	—	—	—	—	—	0.28	0.85	3.4	+	—	—	—	2.3
0.56	12	2.0	0.28	0.85	—	19	9.6	—	0.28	0.56	0.56	—	—	—	—	—	—	—	0.85	2.5	3.7	0.56	—	—	0.28	+
1.1	8.4	—	—	1.1	—	36	8.4	1.1	—	—	—	—	—	—	—	—	—	—	—	—	1.1	5.3	—	0.50	—	0.50
0.94	15	0.31	0.62	+	0.62	25	6.9	—	—	—	—	—	—	—	—	—	+	—	+	0.94	+	1.9	—	0.31	+	0.31
0.64	6.0	0.96	+	1.3	—	14	15	—	0.64	—	—	—	—	—	—	—	—	—	0.32	1.6	1.3	2.2	—	0.64	+	0.32
1.1	12	0.57	—	0.29	—	24	14	—	—	—	—	—	—	—	—	—	—	—	—	—	1.4	1.7	—	0.29	—	1.1
0.31	8.4	0.62	0.62	—	—	29	7.1	0.62	—	—	—	—	—	—	—	—	—	—	0.31	—	1.2	0.93	—	—	—	0.31
—	19	0.60	—	—	+	20	1.8	0.30	—	+	0.60	—	—	—	—	—	0.30	0.30	0.30	0.60	14	2.1	—	—	—	1.2
—	10	0.95	—	0.32	0.32	18	12	—	+	+	—	—	—	—	—	—	—	—	+	0.32	7.9	1.3	—	+	0.63	0.95
—	28	0.58	1.7	0.58	—	20	8.4	—	—	—	—	—	—	—	—	—	—	—	—	—	3.2	—	—	—	—	0.58
+	16	0.80	—	—	—	21	3.5	—	0.53	0.27	+	—	+	—	—	+	+	+	0.27	1.9	3.7	0.27	+	—	1.4	1.3
0.27	24	0.27	+	+	—	14	2.2	—	—	0.27	—	—	0.27	—	—	—	+	—	0.27	1.6	3.8	—	—	—	0.27	1.6
—	28	0.80	+	—	+	20	2.7	—	—	+	+	—	—	—	—	+	—	—	+	0.54	1.1	0.27	—	—	—	1.3
+	38	1.1	0.27	0.27	—	13	3.6	—	+	0.82	0.27	—	—	—	—	—	—	—	0.55	0.55	0.82	0.27	—	—	—	1.1
+	26	1.1	0.27	0.27	—	14	5.2	—	—	0.27	0.82	—	—	—	—	—	+	—	1.4	3.0	3.0	0.27	—	—	0.55	0.82
—	17	2.0	0.57	+	—	15	9.1	—	+	0.29	—	—	—	—	—	—	—	—	0.86	1.7	2.6	0.29	0.29	—	0.57	1.7
+	24	1.3	+	+	+	10	1.7	+	+	0.33	+	—	—	—	—	—	+	0.33	3.3	2.6	4.6	2.0	+	0.33	1.3	2.0
—	25	1.3	0.26	1.8	+	10	6.0	—	—	0.26	0.52	0.26	—	—	—	—	—	—	0.52	1.0	4.4	1.3	0.26	+	0.26	1.6
—	20	0.76	+	1.8	+	16	11	—	—	0.25	—	—	—	—	—	—	—	—	+	1.5	0.25	0.25	—	—	+	+
+	25	1.1	—	0.82	+	14	1.7	0.27	0.27	+	—	+	—	—	—	—	—	0.27	0.27	3.0	7.9	0.55	0.27	1.1	0.27	1.6
+	6.5	1.6	—	—	—	25	4.7	—	—	0.26	+	—	—	—	—	—	—	—	0.26	0.52	1.8	—	—	—	—	0.78
—	16	0.52	0.26	+	—	19	9.1	—	—	0.52	—	—	—	—	—	—	—	—	1.3	1.6	2.9	0.52	—	—	+	1.6
+	23	3.0	—	0.55	0.28	17	11	—	—	+	+	—	—	—	+	+	+	—	+	1.7	3.0	0.28	+	—	+	0.28
0.30	12	0.60	—	0.60	—	12	13	—	+	+	—	—	—	—	—	—	+	+	0.30	1.5	4.8	0.30	—	—	+	2.1
+	20	0.28	0.28	+	—	30	3.1	—	—	—	—	—	—	—	—	—	—	—	0.28	1.7	3.1	—	—	+	+	2.0
0.29	24	0.58	—	+	—	23	4.7	—	—	—	—	—	—	—	—	—	—	—	0.29	0.58	0.29	—	—	—	—	0.87
+	10	2.5	0.28	0.28	—	14	13	—	+	+	—	—	+	—	0.28	0.28	+	+	1.1	2.8	4.8	1.1	+	+	0.28	1.1
+	6.9	0.28	—	+	—	22	12	—	+	+	0.28	—	+	—	+	—	+	—	3.1	1.1	5.4	1.4	+	+	0.28	1.4
0.28	12	3.4	0.28	+	—	14	10	—	+	+	0.56	—	—	—	—	—	+	—	+	0.28	5.4	0.28	+	+	+	0.28
+	9.2	0.48	—	0.24	—	17	7.0	—	+	0.48	—	—	—	—	+	—	0.48	—	2.7	6.3	9.7	2.2	+	+	+	0.24
0.85	13	1.4	+	+	—	9.3	7.1	—	+	0.28	—	—	—	—	—	—	—	—	0.85	0.85	1.7	+	—	—	—	0.56
+	8.6	1.3	—	0.25	+	12	7.8	—	+	0.25	0.25	—	—	—	—	0.25	—	—	1.0	2.0	7.5	0.76	—	—	0.25	1.0
+	12	1.1	—	0.53	—	18	5.6	—	—	0.27	—	—	—	—	—	—	—	—	0.27	1.3	2.7	0.53	+	—	+	0.80
0.27	8.2	2.1	0.27	0.27	—	12	12	—	—	+	+	—	—	—	—	+	—	—	0.27	1.6	5.6	—	—	—	+	0.53
+	20	0.84	+	0.84	—	14	3.6	—	0.28	0.28	—	—	—	—	—	—	+	—	0.28	2.0	4.2	+	0.28	—	0.28	1.4
+	28	2.3	0.28	0.28	—	10	3.7	—	0.85	0.28	—	—	—	—	—	—	+	—	0.85	1.7	10	2.0	+	+	0.56	1.1
0.29	14	2.3	0.29	+	—	13	15	—	—	0.86	—	—	—	—	—	—	+	—	—	1.4	5.4	0.57	—	—	—	1.7
+	18	1.7	0.28	+	+	20	9.4	—	+	0.85	0.28	—	+	1.1	—	—	+	—	0.57	0.57	6.8	0.57	+	—	+	0.57
0.83	11	1.9	+	2.2	+	18	8.5	—	—	+	+	—	—	0.83	—	—	+	+	+	1.9	5.5	0.28	+	—	+	1.9
0.28	13	2.3	+	1.1	—	18	7.6	—	0.57	0.28	0.28	—	—	+	—	—	—	—	1.4	1.4	9.1	0.57	0.28	—	+	1.4
0.54	9.4	1.1	0.27	1.1	—	12	9.1	—	+	0.54	+	—	—	—	—	—	+	—	0.27	1.9	7.3	0.54	—	—	+	1.1
0.26	8.3	0.52	0.78	0.78	+	17	9.9	—	+	1.3	+	—	—	—	—	0.52	—	—	0.78	1.0	5.4	0.52	+	—	+	1.0
+	10	1.9	—	1.1	—	18	5.0	—	+	1.9	+	—	—	—	—	—	0.53	0.26	1.9	0.79	10	0.26	0.26	—	—	1.6
+	17	1.5	—	1.5	—	15	5.5	—	—	1.8	—	—	—	—	—	—	—	—	+	0.30	6.4	0.30	—	—	+	0.61
0.51	12	0.77	+	0.26	+	18	8.5	—	+	0.77	+	—	—	—	—	—	0.26	—	1.3	1.3	8.0	1.8	—	—	+	1.8

DISCUSSION

The oldest sediments in Leg 81 cores provide a record of rapid accumulation of mostly terrigenous and volcaniclastic components in shallow water during the early Eocene. Radiolarians are dissolved or poorly preserved during much of this interval but are well preserved in a few of the cores. Some of the species are similar to forms from the Norwegian Sea illustrated by Bjørklund (1976), most notably *Lophocyrtis norvegiensis* and a form herein called *Pterocodon ampla* which is generally larger than low-latitude specimens but not as large as *Calocyclas talwanii* Bjøklund and Kellogg (1972). The Eocene assemblages also have many components in common with those described from the Caribbean and Gulf of Mexico (Riedel and Sanfilippo, 1970; Sanfilippo and Riedel, 1973), but the *Podocyrtis* and *Thyrsocyrtis* lineages are not represented.

A period of subsidence and erosion during the middle Eocene to early Miocene is marked by hiatuses at all Leg 81 sites. Radiolarians are preserved in the few cores that contain remnants of the Oligocene and lower Miocene record. Another hiatus is found at all sites between lower and middle Miocene sediments. This hiatus may indicate a change of circulation in the Atlantic basin, possibly related to the subsidence of the Iceland–Faeroes Ridge and the onset of sediment drift deposition in the Rockall area (Roberts, this volume). There is a striking difference between Site 555 and the other Leg 81 sites in both the thickness of upper to middle Miocene sediments and the preservation of siliceous fossils in these sediments. At Site 555, 11 cores represent two middle Mio-

Table 1. (Continued).

S. peregrina	*Stichocorys* sp.	*Theocorys* grp.	Other Theoperids	*Carpocanistrum* grp. A	*Carpocanistrum* grp. B	*Anthocyrtidium* grp.	*Lamprocyclas maritalis* grp.	*Lamprocyclas* spp.	*Lamprocyrtis hannai*	*L. heteroporos*	*Theocorythium trachelium*	*T. vetulum*	*Theocorythium* sp.	*Botryostrobus* grp.	*Phormostichoartus* grp.	*Siphocampe* grp.	*Spirocyrtis* grp.	*Cannobotryid* grp.	*Carpocanarium* grp.	Radiolarians counted	Radiolarians, thousands per slide	Preservation	% mineral grains/field	% diatoms/field	Phaeodarians
+	—	+	+	0.27	—	+	+	—	—	—	—	—	+	0.53	0.27	0.27	—	—	0.53	375	7.0	M	70		
+	—	—	+	+	—	+	—	—	0.57	—	—	—	—	3.4	0.29	0.29	—	—	0.29	350	4.0	M	80		
0.50	1.0	+	0.50	—	+	—	—	—	—	—	—	—	—	2.0	+	0.50	—	—	+	397	8.3	M	50		
0.83	—	+	+	+	+	—	—	+	—	—	—	—	+	1.4	0.55	2.5	—	+	0.83	361	12.0	G-M	30	10	+
0.17	0.33	—	+	+	—	+	—	—	—	—	—	—	—	0.85	—	2.0	—	1.7	0.57	351	6.6	M	45	5	
—	—	+	0.56	—	0.28	+	—	—	+	—	—	—	—	0.28	0.28	14	—	0.5	+	355	10.1	M	40	20	+
—	—	0.50	—	—	—	—	—	0.50	—	—	—	—	—	4.7	—	—	—	1.1	—	190	0.2	M	90		
—	—	—	—	—	—	0.31	0.31	0.31	—	+	+	+	0.62	3.1	0.94	+	—	—	0.31	318	6.3	M	80		+
—	—	0.64	0.32	+	+	+	0.32	0.32	—	—	—	—	0.32	3.8	+	+	+	+	0.32	314	7.5	P-M	55	10	
—	—	+	0.29	+	—	—	1.7	—	—	0.29	—	—	0.57	2.3	—	+	—	—	+	350	0.6	P	85		
—	—	+	0.31	0.31	—	+	0.31	—	—	—	—	0.31	—	1.9	0.31	+	0.31	—	+	323	4.4	P	65		
—	—	0.30	0.60	—	—	+	—	—	—	—	—	+	—	2.4	—	3.0	0.30	0.3	—	334	7.3	M	40	20	
—	—	—	0.32	—	0.32	0.63	—	—	+	—	—	—	+	1.6	0.32	0.95	+	+	—	316	8.0	M	55	5	
—	—	—	—	—	—	—	—	—	0.29	—	—	0.58	—	1.4	0.29	0.58	—	—	0.29	346	3.3	P	90		
—	—	+	0.27	+	—	—	—	+	—	—	+	+	0.27	2.7	+	7.2	0.27	—	+	375	8.1	M	65		
—	—	+	+	0.27	+	+	—	—	—	+	+	+	+	1.0	+	7.8	—	0.8	—	373	10.6	M	50		+
+	—	0.27	1.1	0.27	+	+	—	—	+	—	—	+	+	1.9	0.80	+	0.27	0.2	0.27	373	10.7	M	40		
+	—	+	0.82	+	—	—	+	+	—	—	+	—	+	1.9	+	0.82	—	0.2	0.27	365	13.3	M	30		+
+	+	0.27	0.27	+	—	0.27	—	+	—	—	+	+	0.27	4.1	+	2.2	+	+	0.27	366	14.3	G	10	10	+
—	—	0.29	0.86	0.57	—	+	+	0.29	+	—	—	0.29	0.57	3.4	—	0.29	—	—	0.57	349	13.7	M	10	15	
—	—	1.3	0.98	0.33	0.33	0.33	0.33	0.33	+	—	—	+	+	6.5	+	1.3	0.33	0.3	+	307	14.9	G		35	+
—	0.26	0.26	0.52	+	+	0.26	0.26	0.26	+	—	—	0.26	—	4.4	0.26	0.78	+	+	+	385	12.8	G	15	5	+
0.25	—	—	+	0.25	+	0.76	+	—	—	—	—	—	+	+	—	+	—	—	—	396	7.8	M	30		
1.6	—	+	0.27	0.27	—	0.55	—	—	+	—	—	—	—	2.5	+	2.7	+	0.2	0.27	366	12.9	G	30	10	+
0.52	—	+	0.26	0.78	—	+	—	+	—	—	—	—	—	0.52	—	2.3	—	0.2	0.26	385	8.2	M-P	50		
0.52	—	—	0.25	0.78	+	+	+	—	0.26	—	—	—	—	0.78	0.26	2.1	—	0.2	0.26	385	3.1	M-P	70		
0.28	—	+	0.28	+	—	0.28	+	0.28	+	—	—	—	+	3.6	+	0.28	—	+	0.28	361	29.9	G			
0.90	—	—	+	+	+	—	0.30	—	0.30	—	—	—	+	2.1	+	+	+	+	+	333	22.8	G			+
0.28	—	—	0.28	0.28	0.57	—	—	—	+	—	—	—	—	1.7	—	0.57	—	+	0.28	353	5.9	M-P	70		
0.87	—	+	0.29	+	0.29	—	—	—	—	—	—	—	—	1.2	—	+	—	+	0.29	345	5.4	M-P	70		
0.56	—	+	1.1	+	+	0.28	—	+	+	—	—	—	+	1.7	+	0.28	+	+	+	357	17.9	G			+
+	+	—	+	+	—	—	—	—	1.4	—	—	—	—	3.4	+	+	—	—	0.28	352	17.8	G			+
0.28	—	+	+	+	+	+	—	—	1.4	—	—	—	—	1.7	+	—	+	0.2	0.56	354	11.4	G	30		+
0.48	—	+	0.73	—	+	—	—	0.24	1.5	—	—	—	—	2.7	—	0.24	—	0.4	+	413	6.6	P	50		
0.28	—	0.56	+	+	—	0.28	—	—	+	—	—	—	—	2.3	+	+	—	+	+	354	6.8	M	50		
0.50	1.5	+	0.25	0.25	+	0.25	—	+	+	—	—	—	+	1.8	+	2.8	—	0.2	0.25	397	6.4	P	70		
+	+	+	+	0.53	+	1.1	—	—	0.80	—	—	—	—	2.7	0.53	0.27	—	0.2	+	376	16.0	M	10		
+	—	—	+	+	+	—	—	+	0.80	—	—	—	+	2.9	—	0.27	—	+	0.80	376	6.3	M	30		
0.10	—	+	+	+	0.28	—	—	0.28	+	—	—	—	—	2.2	+	0.28	—	+	0.28	357	8.7	M	60		
+	—	—	+	—	—	—	—	—	0.28	—	—	—	—	3.9	+	0.28	—	1.1	+	355	8.7	G			+
0.29	—	+	+	+	+	+	—	—	1.4	—	—	—	—	3.4	—	—	—	0.	+	350	4.8	P-M	50		
4.0	—	+	0.28	+	+	+	+	—	—	—	—	—	—	4.0	+	0.57	—	+	+	351	14.0	M	35		+
1.1	—	—	0.28	+	+	+	—	0.28	+	—	—	—	—	2.5	+	+	—	+	0.28	363	15.3	G	30	20	
0.28	—	—	0.57	—	+	+	—	—	+	—	—	—	+	1.4	0.57	1.1	—	0.2	+	353	7.0	M	40	5	+
1.3	0.81	+	0.27	0.54	+	+	+	—	+	—	—	—	+	3.0	—	13	—	+	0.27	372	13.0	M	60		+
1.0	1.8	+	0.52	+	0.26	0.26	0.26	—	—	—	—	—	+	1.3	+	1.3	+	+	+	386	9.2	M	65		
0.05	0.26	—	1.1	+	+	+	+	—	+	—	—	—	—	3.7	0.53	4.2	—	1.6	0.53	378	8.5	P-M	45		
0.04	0.19	+	+	0.30	+	+	+	—	—	—	—	—	—	1.8	+	3.0	—	+	0.30	330	21.7	G		15	
0.07	0.30	0.26	0.26	0.26	+	+	—	—	+	—	—	—	—	2.1	—	1.5	—	0.7	0.77	389	6.4	M	40	15	

cene radiolarian zones; the same zones are contained in only one core from Sites 554 and 553 and not recorded at all at Site 552 (Fig. 2). Although the sedimentation rates of Sites 552, 553, and 554 are approximately constant in the upper Miocene, the fluctuation in relative amounts of calcareous nannofossils and planktonic foraminifers indicates that the availability of sediments deposited may have been controlled by the changing strength and position of currents in relation to the sites. The thickness of the upper Miocene section at Site 555 is most likely a result of these current-borne sediments, and the consequent rapid burial of siliceous skeletons enhanced the preservation of radiolarians.

Sediments deposited after the onset of glaciation in the late Pliocene contain very few robust radiolarians. This may be due to dissolution, possibly associated with low productivity, and there is certainly also dilution by terrigenous minerals in the glacial marls and muds.

TAXONOMIC NOTES

Family Collosphaeridae Müller, 1858

Collosphaerid group

All collosphaerids are counted together in this chapter.

Family Actinommidae Haeckel, 1862, emend. Riedel, 1967b

Genus *Actinomma* Haeckel, 1860b

Actinomma medianum **Nigrini (Plate 1, Figs. 1A, B)**

Actinomma medianum Nigrini, 1967, p. 27, pl. 2, figs. 2a, b.

Table 2. Abundances of Neogene radiolarian counting groups at Sites 553, 554, and 555. For explanation of symbols see note on Table 1.

Sites 533, 554, 555 Core-Section (interval in cm)	Collosphaerid grp.	*Actinomma medianum*	*Anomalacantha dentata*	*Druppatractus* grp.	*Haeckeliella inconstans*	*Hexacontium* grp. A	*Hexacontium* grp. B	*Sphaeropyle langii*	*S. robusta*	*Stylatractus universus*	*Stylosphaera* spp.	*Thecosphaera* spp.	Other Actinommids	Phacodiscid grp.	*Diartus petterssoni*	*Didymocyrtis antepenultimus*	*D. lacticonus*	*D. tetrathalamus*	*Didymocyrtis* spp.	*Dictyocoryne* grp.	*Porodiscus* grp. A	*Porodiscas* grp. B	*Porodiscus* grp. C	*Styladictya* spp.
Hole 553A																								
1,CC	—	+	0.29	0.57	—	0.57	+	+	—	10	+	+	7.4	0.29	—	—	—	—	—	2.6	7.7	0.29	—	0.86
2,CC	+	—	0.53	1.3	+	1.6	+	+	+	4.0	+	0.27	5.9	+	—	—	—	+	—	2.7	13	—	—	1.1
3-2, 32–34	+	—	0.50	0.50	0.25	0.75	—	+?	+	7.3	0.25	0.50	4.5	0.75	—	—	—	—	—	1.0	17	0.50	—	1.5
6-6, 30–32	—	0.27	—	3.0	—	1.1	1.6	—	—	0.82	1.9	0.27	14	—	—	—	—	—	—	—	2.2	0.27	0.27	0.82
7-4, 119–121	—	—	—	2.4	—	1.6	4.0	—	—	1.1	1.6	0.27	19	—	—	—	+	—	0.27	—	1.3	0.27	—	0.27
8-1, 62–64	—	0;77	—	2.6	—	0.77	1.5	—	—	3.4	0.26	0.26	13	—	—	—	+	—	—	+	7.0	0.77	0.77	2.1
8-2, 48–50	1.4	0.28	0.28	5.3	—	1.4	1.7	—	+	1.9	2.2	+	17	0.28	—	—	—	—	+	—	2.8	0.56	1.1	0.84
8-3, 103–104	0.26	0.26	+	6.6	—	1.0	0.26	—	—	1.6	1.6	—	34	1.0	—	—	—	—	0.26	—	3.9	—	0.79	0.26
Hole 554																								
1-1, 44–46	+	0.28	—	2.2	—	0.28	—	0.28	—	—	—	—	7.3	+	—	—	—	—	0.56	0.28	7.3	—	—	3.1
1-6, 48–50	0.29	0.29	+	0.29	—	2.9	+	0.59	—	—	0.59	—	11	0.59	—	—	—	—	—	0.29	7.1	—	—	4.7
2-3, 12–14	—	0.53	—	0.80	—	0.53	0.27	0.27	—	—	+	—	15	1.1	—	—	—	—	—	0.27	8.8	—	—	1.9
3,CC	—	—	—	0.30	—	1.2	—	—	—	4.2	—	1.8	6.9	—	—	—	—	—	—	—	16	—	—	0.90
5-2, 35–37	0.27	+	+	0.55	+	1.4	—	+	—	4.9	—	—	7.1	0.27	—	—	—	+	—	2.7	20	—	—	3.0
5-5, 112–114	—	+	+	1.6	—	+	—	0.26	—	4.5	—	+	7.1	0.26	—	—	—	+	+	1.0	11	0.52	—	6.0
6-6, 22–24	0.77	0.26	1.3	0.77	—	0.77	—	+	+	1.0	0.26	+	6.9	0.26	—	—	—	—	+	1.8	13	0.77	—	1.3
7-3, 42–44	+	+	0.26	+	—	0.51	+	—	—	3.9	+	1.3	5.4	0.26	—	—	—	—	—	1.5	16	0.26	—	2.6
7-4, 27–28	—	+	+	0.28	—	+	+	—	—	7.8	+	0.55	6.1	1.1	—	—	—	—	—	1.7	12	—	—	2.2
8-3, 3–5	+	+	+	2.1	+	0.60	—	—	+	11	+	0.30	8.7	+	—	—	—	—	—	0.60	15	—	—	0.60
8,CC	—	+	1.0	+	—	0.26	+	—	+	0.78	+	+	3.4	+	—	—	—	—	+	0.52	29	0.26	—	0.78
Hole 554A																								
1-1, 18–20	+	0.26	1.0	3.1	—	1.8	0.26	—	+	8.4	0.26	1.5	13	+	—	—	—	—	—	2.0	6.1	—	—	+
4-1, 58–60	+	+	0.80	1.6	+	0.80	0.27	—	+	0.27	0.80	+	7.5	0.27	—	—	+	—	+	+	10	—	—	0.80
Hole 555																								
5-4, 110–112	0.25	0.25	0.76	8.8	—	3.0	0.50	—	—	0.25	2.0	0.50	27	2.8	—	—	—	—	+	0.50	2.0	—	0.25	0.25
5-6, 6–8	+	0.26	0.51	0.77	—	0.51	+	—	—	3.1	0.26	0.51	12	0.77	—	—	—	—	—	0.77	24	—	—	1.8
6-4 30–32	+	2.7	2.4	0.49	—	0.24	+	—	—	8.7	1.2	—	9.2	0.49	—	—	—	—	+	1.7	17	—	+	0.97
6-6, 30–32	0.54	—	1.1	4.1	—	2.5	0.27	—	—	4.4	+	0.27	13	0.54	—	—	—	—	—	1.4	15	—	+	+
7-5, 61–63	—	+	+	2.9	—	1.1	+	—	—	7.2	+	+	11	+	—	—	—	—	—	0.86	18	—	—	2.6
7,CC	+	0.27	0.54	0.54	—	0.81	+	—	+	8.1	+	0.81	6.8	—	—	—	—	—	—	1.4	7.0	—	—	0.27
8-4, 77–79	0.29	+	+	0.57	—	0.29	0.29	—	—	0.29	+	2.0	7.4	+	—	—	—	—	+	1.4	18	—	—	1.7
8-6, 66–68	0.56	+	0.85	1.7	—	+	+	—	—	10	0.28	+	8.5	0.28	—	—	—	—	—	0.85	18	—	—	—
11-3, 92–94	0.26	—	—	7.4	—	0.53	+	—	—	—	+	+	4.5	0.53	—	—	0.26	—	0.79	0.26	18	—	0.26	1.6
11,CC	0.87	—	+	9.3	—	+	+	—	—	0.58	0.87	+	6.4	+	—	+	—	—	+	+	11	+	+	0.87
13-1, 22–24	+	—	+	2.8	—	+	+	—	+	0.28	+	+	6.1	0.55	0.28	+	0.55	—	1.4	0.83	19	0.83	0.55	0.83
14-1, 26–28	0.26	—	+	1.6	—	0.26	+	—	+	0.52	0.26	+	4.7	+	+	—	+	—	0.26	0.26	24	0.52	0.26	0.26
15-1, 40–42	0.24	+	0.24	1.2	—	1.2	+	—	+	1.5	0.24	0.49	6.3	0.24	—	+	0.24	—	1.5	0.24	15	—	0.73	0.98
16-4, 19–21	+	—	0.25	3.0	—	3.3	0.76	—	0.76	1.0	+	—	10	+	+	+	0.25	—	+	0.25	9.3	—	+	2.0
17-2, 85–87	—	—	+	0.86	+	+	—	—	—	4.3	0.57	—	5.5	—	—	—	0.29	—	0.29	+	13	—	0.29	2.3
17-3, 104–106	+	+	0.27	1.9	—	1.6	0.27	—	+	1.6	0.27	—	9.2	+	—	—	+	—	0.27	0.27	8.9	0.54	0.54	2.4
18-2, 73–75	+	0.80	0.27	1.9	—	2.1	0.53	—	+	0.27	0.53	0.27	15	0.53	+	+	+	—	0.80	0.27	9.9	—	+	2.4
19-3, 52–54	0.27	+	0.54	0.81	—	1.1	+	—	—	—	0.54	+	4.9	0.27	—	—	+	—	+	+	14	—	0.27	1.6
20-1, 24–26	—	+	1.3	1.3	—	1.1	+	—	0.26	1.6	1.6	+	6.3	+	—	—	+	—	0.26	2.1	12	—	+	2.6
21-2, 45–47	0.51	1.0	0.26	1.3	—	6.1	0.26	—	+	3.3	0.77	—	17	—	—	—	—	—	+	+	10	—	0.51	3.8
22-1, 37–39	—	0.28	0.57	3.4	+	5.4	0.57	—	+	3.1	0.57	0.57	8.2	0.57	—	—	—	—	—	+	13	1.1	0.57	4.0

Genus *Amphisphaera* Haeckel, 1881

***Amphisphaera minor* (Clark and Campbell)**
Stylosphaera minor Clark and Campbell, 1942, p. 27, pl. 5, figs. 1, 2, 2a, 12.
Amphisphaera minor (Clark and Campbell)—Sanfilippo and Riedel, 1973, p. 486, pl. 1, figs. 1-5, pl. 22, fig. 4

Genus *Anomalacantha* Loeblich and Tappan, 1961

***Anomalacantha dentata* (Mast)** (Plate 1, Fig. 3)
Heteracantha dentata Mast, 1910, p. 157
Anomalacantha dentata (Mast), Benson, 1966, p. 170, pl. 5, figs. 10, 11.

Genus *Druppatractus* Haeckel, 1887

***Druppatractus* group** (Plate 1, Fig. 2)
Bipolar actinommid with pear-shaped medullary shell and coarse pores (less than eight across a half equator). Polar spines may be conical or bladed, equal or unequal in length.

Genus *Haeckeliella* Hollande and Enjumet, 1960

***Haeckeliella inconstans* Dumitrică**
Haeckeliella inconstans Dumitrică, 1973, p. 833, pl. 7, figs. 1, 2, pl. 18, figs. 7-22.

Genus *Hexacontium* Haeckel, 1881

***Hexacontium* group A** (Plate 1, Figs. 4A, B)
Spherical form with two medullary shells and six to seven spines in three mutually perpendicular axes. The pores are small, closely spaced, more than eight across a half equator. Some forms in this group tend to a cubic shape.

***Hexacontium* group B** (Plate 1, Fig. 5)
Similar to *Hexacontium* group A, but having a more robust shell and larger, more separated pores, eight or fewer across the half equator. There are six spines in three mutually perpendicular axes.

Genus *Sphaeropyle* Dreyer, 1889

***Sphaeropyle langii* Dreyer** (Plate 1, Fig. 9)
Sphaeropyle langii Dreyer, 1889, p. 13, pl. 4, fig. 54: Kling, 1973, p. 634, pl. 1, figs. 5–10, pl. 13, figs. 6–8.

Table 2. (Continued).

Spongocore spp.	*Spongodiscus* grp.	Pyloniid grp.	Tholoniid grp.	*Larcopyle* grp.	*Larcospira* grp.	*Lithelius minor*	*Pylospira* grp.	*Soreuma* grp.	*Acanthodesmia* grp.	*Ceratospyris* grp. A	*Ceratospyris* grp. B	*Ceratospyris* grp. C	*Desmospyris* grp.	*Liriospyris cricus*	*Tholospyris rhombus*	*Tricolospyris* grp.	*Zygocircus* grp.	*Amphiplecta* grp.	*Arachnocorallium* grp.	*Ceratocyrtis* grp.	*Lophophaena* grp.	*Pseudodictyophimus* grp.	Sethophormin grp. A	Sethophormin grp. B	Other Plagoniids	*Cornutella* spp.	*Cycladophora davisiana*
—	22	2.3	0.57	0.29	—	27	5.4	—	—	—	—	—	—	—	—	—	—	—	—	0.57	4.0	0.86	—	—	—	0.29	0.57
+	28	1.3	0.53	0.80	—	18	8.6	—	—	0.80	—	—	—	—	—	—	—	—	+	0.53	2.4	+	+	—	—	1.1	—
0.75	18	2.5	0.25	0.25	—	20	8.0	—	—	1.5	0.25	—	—	—	—	—	—	—	+	+	2.5	+	+	—	—	2.0	—
0.27	4.4	0.27	—	0.82	—	25	0.54	—	—	0.82	0.27	—	0.54	—	—	—	0.82	—	—	1.6	0.82	0.54	—	—	0.27	0.27	—
—	7.2	0.53	—	—	—	43	1.1	—	—	0.53	—	—	—	—	—	—	0.53	—	—	1.1	0.53	+	—	—	0.27	—	—
+	6.2	0.77	0.26	0.77	—	39	3.1	—	—	0.52	—	—	—	—	—	—	+	—	—	+	1.5	+	—	—	—	0.77	—
+	4.2	+	+	0.28	—	24	1.9	—	—	0.28	—	—	0.28	—	—	—	+	—	—	0.56	1.4	+	—	—	—	0.84	—
—	3.7	—	0.52	+	—	15	3.7	—	—	0.79	+	—	0.26	—	—	—	—	—	—	0.26	0.52	+	—	—	—	+	—
0.56	4.5	1.1	—	1.1	—	32	6.8	—	—	—	—	—	—	—	—	—	—	—	2.0	0.56	1.7	3.9	—	—	—	1.4	9.0
1.5	15	0.88	—	+	—	17	13	—	+	—	—	—	—	—	—	—	+	—	+	+	2.4	2.7	+	—	+	0.29	12
+	15	2.9	+	+	+	16	7.4	—	—	—	—	—	—	—	—	—	—	—	0.53	0.27	2.1	0.80	—	—	—	+	18
—	31	0.60	—	+	—	13	6.3	—	—	—	—	—	—	—	—	—	—	—	—	0.30	2.4	0.60	—	—	—	0.30	7.8
+	18	+	+	0.27	+	13	8.0	—	+	0.55	+	—	—	—	—	+	—	—	1.4	0.82	6.6	—	—	—	—	1.6	+
0.26	14	+	0.26	+	—	25	9.1	—	—	+	0.26	—	—	—	—	0.26	0.26	—	+	0.26	2.6	—	—	—	—	2.0	—
0.26	13	2.1	—	0.77	—	12	13	—	0.77	0.77	0.26	—	—	+	+	0.26	+	—	0.51	4.1	13	+	+	+	+	1.3	—
0.26	16	0.51	+	1.0	—	21	9.0	—	+	0.51	+	—	—	0.26	—	+	+	—	0.51	2.3	6.4	0.77	+	—	+	1.3	—
0.28	18	0.28	+	1.7	—	16	7.8	—	+	—	—	—	—	—	—	—	+	—	0.55	0.83	6.6	—	—	—	—	0.55	—
0.30	26	+	—	0.30	—	15	8.7	—	+	+	—	—	—	—	—	—	—	—	0.90	0.90	3.9	—	—	—	—	0.60	—
+	24	0.26	—	0.52	—	14	4.4	—	+	0.78	+	—	—	—	—	—	+	—	0.26	1.0	6.7	0.26	—	—	+	1.0	—
0.77	7.4	0.26	+	0.77	—	6.4	12	—	+	0.77	—	—	—	—	+	—	+	—	1.5	5.4	4.6	1.5	0.51	—	0.26	0.77	—
—	4.3	0.27	—	0.80	—	35	2.9	—	—	2.4	—	—	—	—	—	—	+	—	1.1	2.4	4.8	0.53	—	—	—	1.6	—
—	4.0	0.76	0.25	—	—	25	6.1	—	—	0.25	0.25	—	—	2.0	—	—	0.50	—	—	0.76	0.76	—	—	—	—	0.25	—
+	12	1.8	—	2.6	—	17	6.7	—	0.26	0.26	+	—	—	0.26	—	—	0.26	—	0.77	1.5	3.1	0.51	+	—	—	1.8	—
0.49	9.7	1.7	0.24	1.5	+	14	8.9	—	+	0.24	0.24	—	—	—	—	+	—	—	—	1.5	3.4	0.73	0.24	—	+	0.73	—
0.54	15	0.54	—	0.27	—	28	3.8	—	—	—	—	—	—	—	—	—	—	—	—	+	0.82	0.27	—	—	0.27	0.27	—
+	19	1.7	0.29	1.4	—	18	8.6	—	+	+	—	—	—	—	—	—	—	—	+	0.57	2.6	—	+	—	—	0.86	—
+	46	1.4	—	0.81	+	10	5.2	—	+	0.27	+	—	—	—	—	—	0.27	—	0.81	0.54	3.8	+	—	—	—	0.81	—
+	14	2.0	0.29	+	—	13	8.0	—	—	0.29	—	—	—	—	—	—	—	—	0.57	0.29	1.1	+	—	—	—	0.57	—
+	13	1.7	+	—	—	13	7.3	—	—	+	—	—	+	—	—	—	+	—	0.28	1.4	6.8	+	—	—	+	1.4	—
—	19	0.26	—	—	—	34	2.7	—	—	0.53	—	—	+	—	—	—	—	—	—	+	1.9	0.26	—	—	—	0.53	—
—	17	0.58	+	0.29	—	42	1.2	—	—	+	+	—	+	—	—	—	—	—	1.2	—	1.7	—	—	—	—	0.29	—
0.55	20	1.4	—	0.83	0.55	32	2.5	—	—	0.83	0.83	—	0.28	—	—	—	+	—	+	0.28	1.1	+	—	—	—	0.55	—
0.52	9.4	1.0	—	0.26	0.26	30	1.8	—	—	1.8	0.78	—	+	—	—	—	0.26	—	—	—	4.7	+	—	+	—	0.52	—
0.24	19	1.5	+	0.24	+	24	2.4	—	—	1.2	0.98	—	+	—	—	+	+	—	0.24	1.7	1.7	2.2	—	—	+	0.97	—
0.25	17	+	0.25	0.76	—	25	1.8	—	—	1.0	0.76	—	—	—	—	0.25	0.25	—	—	1.3	0.76	1.0	—	+	+	0.25	—
0.29	30	0.86	+	0.29	—	31	1.1	—	—	—	+	—	0.29	—	—	—	—	—	+	+	0.29	0.29	—	—	+	0.57	--
+	18	+	+	0.81	—	31	1.6	—	—	0.27	0.27	—	0.81	—	—	+	+	—	—	+	0.27	0.27	—	—	—	1.1	—
+	9.9	1.3	—	0.80	—	34	0.80	—	0.27	0.27	—	—	0.80	—	—	—	0.53	—	+	0.53	1.1	3.2	—	—	0.27	1.1	—
0.27	7.0	0.27	—	1.6	—	34	1.9	—	—	+	+	—	+	—	—	.54	+	—	+	0.54	0.27	0.27	—	0.27	+	1.3	—
0.26	7.1	0.26	—	0.79	—	41	3.2	—	—	1.6	—	—	+	—	—	+	+	—	—	1.6	1.9	1.3	—	0.26	0.26	1.3	—
+	8.4	1.0	—	1.0	—	21	3.3	—	—	+	0.26	—	—	—	—	—	+	—	—	3.1	1.8	1.0	—	—	0.51	1.3	—
0.57	13	0.85	0.28	0.57	+	22	6.5	—	+	0.85	—	—	—	—	—	—	0.28	—	+	1.4	4.5	0.28	—	—	—	0.57	—

***Sphaeropyle robusta* Kling** (Plate 1, Fig. 8)

Sphaeropyle robusta Kling, 1973, p. 634, pl. 1, figs. 11, 12, pl. 6, figs. 9-13, pl. 13, figs. 1-5.

Foreman (1975) used the smaller, more regular pores of the second shell as the distinguishing characteristic between this species and its descendant, *S. langii*. That feature was not apparent in Leg 81 material, so we used Kling's original distinction, namely the robust outer shell of the ancestor.

Genus *Stylatractus* Haeckel, 1887

***Stylatractus universus* Hays** (Plate 1, Fig. 7)

Stylatractus universus Hays, 1965, p. 167, pl. 1, fig. 6

Genus *Stylosphaera* Ehrenberg, 1847a

***Stylosphaera goruna* Sanfilippo and Riedel** (Plate 6, Fig. 11)

Stylosphaera goruna Sanfilippo and Riedel, 1973, p. 521, pl. 1, figs. 20–22, pl. 25, figs. 9, 10.

***Stylosphaera* spp.** (Plate 2 Figs. 1A, B)

Bipolar actinommid with spherical medullary shell. Polar spines are usually conical (but not necessarily), usually unequal in length and sometimes not collinear. Specimens with any pore pattern are admitted.

Genus *Thecosphaera* Haeckel, 1881

***Thecosphaera* spp.** (Plate 1, Fig. 6)

A regularly spherical cortical shell with no external spines. Six to twelve bars connect the medullary and cortical shells.

Other Actinommids (Plate 2, Figs. 2A–C)

Any actinommid not previously categorized. These usually have numerous spines or no spines, and no medullary shells, or several concentric shells.

Family Phacodiscidae Haeckel, 1881

Phacodiscid group

A lenticular lattice shell with regular pore pattern, enclosing one or more medullary shells and usually having a spiny perimeter.

Family Coccodiscidae Haeckel, 1862, emend. Sanfilippo and Riedel, 1980

Subfamily Artiscinae Haeckel, 1881, emend. Riedel, 1967b

Genus *Didymocyrtis* Haeckel, 1860b

***Didymocyrtis antepenultima* (Riedel and Sanfilippo)**

Ommatartus antepenultimus Riedel and Sanfilippo, 1970, p. 521, pl. 14, fig. 4: Westberg and Riedel, 1978, p. 22.

Table 2. (Continued).

Sites 533, 554, 555 Core-Section (interval in cm)	*Cyrtocapsella cornuta*	*C. japonica*	*C. tetrapera*	*Cyrtopera laguncula*	*Eucecryphalus* grp.	*Eucyrtidium acuminatum*	*E. calvertense*	*E. cienkowskii* grp.	*E. hexagonatum*	*E. punctatum*	*Eucyrtidium* sp. A	*Eucyrtidium* sp. B	Other *Eucyrtidium*	*Gondwanaria* grp. A	*Gondwanaria* grp. B	*Litharachnium* grp.	*Lithopera bacca*	*L. neotera*	*L. renzae*	*Lophocyrtis norvegiensis*	*Lophocyrtis* sp.	*Pterocanium* grp.	*Stichocorys delmontensis*	*S. peregrina*
Hole 553A																								
1,CC	—	—	—	0.29	0.29	—	+	+	—	+	—	—	—	—	+	+	—	—	—	—	—	0.29	—	—
2,CC	—	—	—	—	—	+	—	0.53	—	+	—	0.27	—	+	+	+	—	—	—	—	—	0.27	0.53	0.53
3-2, 32–34	—	—	—	—	0.25	+	+	0.50	—	+	—	+	0.25	—	—	0.25	—	—	—	—	—	0.25	0.25	0.75
6-6, 30–32	—	17	—	—	0.27	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7-4, 119–121	0.27	0.27	0.80	—	—	—	—	+	—	—	—	—	—	—	—	0.27	—	+	+	—	—	—	0.27	—
8-1, 62–64	0.52	—	3.4	—	—	—	+	+	—	—	—	—	—	—	—	+	—	—	—	—	+!	+	0.26	—
8-2, 48–50	0.84	—	4.7	—	0.28	—	+	0.84	—	—	—	—	—	—	—	+	—	+	0.12	—	+!	+	—	—
8-3, 103–104	0.79	—	6.6	—	—	—	—	+	—	—	—	—	—	—	—	—	—	+	0.52	1.0!	+!	2.4	0.52	—
Hole 554																								
1-1, 44–46	—	—	—	—	—	—	—	—	—	+	—	0.28	—	—	—	0.28	—	—	—	—	—	0.28	—	—
1-6, 48–50	—	—	—	+	+	+	0.59	+	+	+	—	—	—	—	—	0.59	—	—	—	—	—	0.29	—	—
2-3, 12–14	—	—	—	—	—	+	—	0.53	—	+	—	—	—	+	—	0.53	—	—	—	—	—	+	—	—
3,CC	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	0.30	—	—
5-2, 35–37	—	—	—	—	+	+	+	+	+	0.27	—	0.27	—	+	—	+	—	—	—	—	—	0.27	—	0.55
5-5, 112–114	—	—	—	—	—	—	—	0.52	+	+	—	—	—	—	—	0.52	—	—	—	—	—	—	0.26	0.26
6-6, 22–24	—	—	+	—	+	+	+	1.0	+	+	—	0.26	—	0.51	+	0.26	—	—	—	—	—	0.51	0.26	0.55
7-3, 42–44	—	—	—	—	+	—	+	0.26	0.26	+	—	0.26	—	—	—	+	+	—	—	—	—	0.26	0.26	0.77
7-4, 27–28	—	—	—	—	+	—	+	+	—	+	—	+	—	—	—	0.28	—	—	—	—	—	0.55	0.28	0.83
8-3, 3–5	—	—	—	—	+	—	0.90	+	+	0.30	—	—	—	—	—	+	—	—	—	+!	—	+	+	0.10
8,CC	—	—	—	—	+	—	+	+	+	+	—	—	—	—	+	+	—	—	—	—	—	0.78	0.26	0.26
Hole 554A																								
1-1, 18–20	—	—	—	+	0.26	+	—	0.51	+	0.26	—	—	0.26	+	—	0.26	—	—	—	—	—	0.26	0.51	0.51
4-1, 58–60	+	—	2.1	+	+	—	—	0.53	—	—	—	+	—	—	—	+	—	+	—	—	—	0.27	0.80	—
Hole 555																								
5-4, 110–112	—	—	0.50	—	0.25	—	—	0.50	—	—	—	—	—	—	—	0.50	—	—	—	—	—	1.3	0.76	1.0
5-6, 6–8	—	+	—	—	0.26	—	—	0.26	—	0.51	—	0.26	—	+	—	0.26	—	—	—	—	—	+	0.26	0.77
6-4 30–32	—	—	+	—	1.2	+	0.24	0.49	—	0.24	—	+	—	+	+	+	—	—	—	—	—	0.24	0.97	1.2
6-6, 30–32	—	—	0.54	—	0.27	—	—	+	—	+	—	—	—	+	—	0.27	—	—	—	—	—	—	0.82	0.27
7-5, 61–63	—	—	+	—	+	—	—	+	—	—	—	—	+	—	—	+	—	—	—	—	—	+	+	+
7,CC	—	—	+	+	+	—	+	0.27	—	0.27	—	—	—	—	—	+	—	—	—	+!	—	+	+	+
8-4, 77–79	—	—	0.29	—	+	—	—	+	—	0.29	—	—	—	—	—	0.29	+	+	+	—	—	+	+	+
8-6, 66–68	—	+	+	—	0.28	—	0.28	0.28	—	0.28	—	+	0.28	+	0.28	0.28	—	—	—	—	—	0.56	0.28	+
11-3, 92–94	—	2.1	—	—	—	—	—	+	—	—	—	—	—	—	—	+	+	—	—	—	—	—	0.26	—
11,CC	—	2.9	+	—	—	—	—	+	—	+	—	—	—	—	—	+	+	+	—	—	—	+	+	—
13-1, 22–24	—	0.28	+	—	—	—	—	+	—	—	—	—	+	—	—	+	—	—	—	—	—	0.28	0.28	—
14-1, 26–28	—	1.0	—	—	—	—	—	+	—	+	—	—	—	—	+	0.26	—	+	—	—	—	+	3.7	—
15-1, 40–42	—	0.73	+	—	+	—	—	0.48	—	+	—	—	—	+	+	+	+	0.24	—	—	—	2.0	3.4	—
16-4, 19–21	—	8.8	—	—	0.25	—	+	+	—	—	—	—	—	+	—	+	—	0.51	—	—	—	1.5	1.0	—
17-2, 85–87	—	0.57	—	—	—	—	—	+	—	—	—	—	—	—	—	+	—	—	—	—	—	0.29	0.29	—
17-3, 104–106	—	0.54	+	—	—	—	—	—	—	—	—	—	—	—	—	+	—	+	—	—	—	+	—	—
18-2, 73–75	+	0.80	+	—	+	—	+	+	—	—	—	—	—	+	—	+	—	0.10	+	—	—	0.27	—	—
19-3, 52–54	1.6	—	2.4	—	+	—	0.27	0.54	—	+	—	—	—	+	—	—	—	1.1	+	—	—	0.27	+	—
20-1, 24–26	0.26	—	0.26	+	+	—	—	1.1	—	—	—	—	—	+	—	0.26	—	1.1	+	—	—	+	0.26	—
21-2, 45–47	+	—	1.5	—	1.0	—	—	0.26	—	+	—	—	—	+	+	—	—	—	+	—	—	0.26	0.51	—
22-1, 37–39	+	—	1.4	—	+	—	+	0.28	—	—	—	—	—	+	—	+	—	—	+	—	—	+	0.28	—

Didymocyrtis antepenultima (Riedel and Sanfilippo)—Sanfilippo and Riedel, 1980, p. 1010.

***Didymocyrtis laticonus* (Riedel)** (Plate 2, Fig. 3)
Cannartus laticonus Riedel, 1959, p. 291, pl. 1, fig. 5: Westberg and Riedel, 1978, p. 20.
Didymocyrtis laticonus (Riedel)—Sanfilippo and Riedel, 1980, p. 1010.

***Didymocyrtis tetrathalamus* (Haeckel)**
Panartus tetrathalamus Haeckel, 1887, p. 378, pl. 40, fig. 3.
Ommatartus tetrathalamus (Haeckel)—Riedel and Sanfilippo, 1971, p. 1558.
Didymocyrtis tetrathalamus (Haeckel)—Sanfilippo and Riedel, 1980, p. 1010.

***Didymocytis* spp.**
Equatorially constricted cortical shell with a usually lenticular medullary shell. Counted in this group are forms with no extracortical structures.

Genus *Diartus* Sanfilippo and Riedel, 1980

***Diartus petterssoni* (Riedel and Sanfilippo)**
Cannartus (?) *petterssoni* Riedel and Sanfilippo, 1970, p. 52, pl. 14, fig. 3.
Diartus petterssoni (Riedel and Sanfilippo)—Sanfilippo and Riedel, 1980, p. 1010.

Family Spongodiscidae Haeckel, 1862, emend. Riedel, 1967b

Genus *Amphicraspedum* Haeckel 1887

***Amphicraspedum murrayanum* Haeckel**
Amphicraspedumn murrayanum Haeckel, 1887, p. 523, pl. 28, fig. 1: Sanfilippo and Riedel, 1973, p. 524, pl. 10, figs. 3–6, pl. 28, fig. 1.

***Amphicraspedum prolixum* Sanfilippo and Riedel** (Plate 6, Fig. 18)
Amphicraspedum prolixum Sanfilippo and Riedel, 1973, p. 524, pl. 10, figs. 7–11, pl. 28, figs. 3, 4.

***Amphicraspedum prolixum* Sanfilippo and Riedel group**
Amphicraspedum prolixum Sanfilippo and Riedel group, 1973, p. 524, pl. 11, figs. 1-5, pl. 28, fig. 5.

Genus *Amphymenium* Haeckel, 1881

***Amphymenium splendiarmatum* Clark and Campbell** (Plate 6, Fig. 17)
Amphymenium splendiarmatum Clark and Campbell, 1942, p. 46, pl. 1, figs. 12, 14: Sanfilippo and Riedel, 1973, p. 524, pl. 11, figs. 6–8, pl. 28, figs. 6–8.

Table 2. (Continued).

Stichocorys sp.	*Theocorys* grp.	Other Theoperids	*Carpocanistrum* grp. A	*Carpocanistrum* grp. B	*Anthocyrtidium* grp.	*Lamprocyclas maritalis* grp.	*Lamprocyclas* spp.	*Lamprocyrtis hannai*	*L. heteroporos*	*Theocorythium trachelium*	*T. vetulum*	*Theocorythium* sp.	*Botryostrobus* grp.	*Phormostichoartus* grp.	*Siphocampe* grp.	*Spirocyrtis* grp.	*Cannobotryid* grp.	*Carpocanarium* grp.	Radiolarians counted	Radiolarians, thousands per slide	Preservation	% mineral grains/field	% diatoms/field	% sponge	Phaeodarians
—	0.29	—	+	—	+	0.29	0.29	—	—	—	—	—	1.4	0.29	2.3	—	—	0.29	350	7.1	M-P	70			
0.27	+	+	0.80	0.27	—	+	+	+	—	—	—	—	2.9	0.27	1.1	—	+	+	374	10.6	M-G	30	10		
1.0	+	0.25	+	+	+	—	+	+	—	—	—	—	2.0	+	2.0	+	1.0	0.50	399	13.1	M	30	15		
—	—	0.27	—	—	—	—	—	—	—	—	—	—	0.54	—	17	—	—	—	367	1.5	P	95			
—	—	—	1.3	0.27	+	—	+	—	—	—	—	—	0.27	—	7.4	—	—	—	376	6.7	P	65		10	
0.52	—	0.26	+	—	+	0.52	—	—	—	—	—	—	0.26	0.26	7.2	—	—	—	388	6.2	P-M	60	10	10	
+	—	+	+	+	+	0.56	—	—	—	—	—	—	+	+	21	—	0.28	—	359	8.5	P-M	40	5	15	
+	—	+	0.52	—	—	0.26	—	—	—	—	—	—	—	—	12	—	—	—	381	5.3	M	60		15	
—	—	0.28	—	—	—	—	—	—	0.28	—	—	0.28	11	—	—	0.28	0.84	—	356	0.8	M	95			+
—	+	+	0.29	—	—	0.59	—	—	—	—	—	0.59	3.8	+	+	+	0.29	—	339	9.9	M	54			
—	+	+	0.27	+	—	0.27	—	0.27	—	—	—	—	3.7	+	0.53	—	+	+	376	8.9	M	60	1		
—	—	—	+	—	0.30	—	—	—	—	—	—	—	5.7	—	—	—	—	0.30	332	0.9	M	95			
—	0.82	+	0.55	+	+	—	—	+	—	—	—	—	4.1	+	2.7	—	+	+	365	12.0	M	70	1		
0.26	+	—	0.52	0.26	+	—	—	0.26	—	—	—	—	2.4	0.26	7.9	—	—	0.52	382	5.0	M	90	3		
—	0.26	+	0.51	—	0.26	—	—	0.51	—	—	—	—	2.6	0.26	1.8	—	0.51	0.26	389	30.9	G	50			+
2.1	+	+	0.26	+	+	—	—	—	—	—	—	+	2.8	+	0.26	+	+	0.26	389	16.2	G	35			
0.83	0.28	0.28	0.28	0.28	+	+	—	—	—	—	—	—	3.6	+	9.1	—	+	+	361	10.3	M-P	70			
0.30	+	+	+	+	+	—	—	—	—	—	—	—	1.5	+	0.90	—	0.90	+	335	9.0	M	70			
0.52	0.26	0.26	+	+	0.26	+	—	+	—	—	—	—	3.6	+	3.1	—	1.3	0.26	386	20.9	G	20	15		
1.3	+	2.0	—	+	0.77	—	0.26	+	—	—	—	—	2.6	+	8.9	—	0.26	+	392	13.1	M	40	35		
—	—	0.53	0.27	+	—	+	—	—	—	—	—	—	+	0.53	15	—	+	0.27	375	10.7	P-M	70			
0.25	—	—	0.25	—	—	—	—	—	—	—	—	—	1.8	—	1.0	—	—	+	397	0.7	P	95			
0.51	+	0.26	0.51	+	+	+	—	—	—	—	—	—	3.1	0.51	0.26	—	+	0.26	391	9.0	M	50			
0.97	+	0.24	+	+	0.24	—	—	0.24	—	—	—	+	3.4	0.24	1.9	—	+	+	412	12.6	M	35			
0.27	0.27	0.27	0.27	+	0.27	+	—	—	—	—	—	—	0.82	+	1.9	—	—	—	367	3.3	M-P	60		15	
—	—	—	0.29	+	—	+	—	—	—	—	—	—	0.86	+	2.3	—	0.86	+	348	4.9	M-P	70		10	
+	+	+	0.27	—	—	+	+	—	—	—	—	—	2.7	+	0.27	—	0.27	+	370	17.9	G	25			+
1.1	0.29	0.29	0.29	—	+	—	—	—	—	—	—	—	1.4	+	23	—	0.29	0.29	349	7.3	M-G	65			
—	—	+	0.56	+	+	—	+	+	—	—	—	—	2.5	+	8.7	—	+	0.28	355	8.5	M	50	10		
—	—	+	0.79	—	—	—	+	—	—	—	—	—	—	0.26	1.9	—	—	0.26	378	8.5	M	40		10	
—	—	—	+	—	+	—	0.29	—	—	—	—	—	0.29	—	2.6	—	+	+	345	7.8	M	45		10	
0.28	+	+	0.55	+	+	+	0.28	—	—	—	—	0.28	+	+	3.0	—	+	0.28	363	28.2	M			15	
—	—	0.26	0.52	—	0.26	0.26	—	—	—	—	—	—	2.1	—	5.0	—	1.6	0.52	381	26.0	M			20	
—	+	+	0.48	0.24	0.24	+	—	+	—	—	—	—	0.97	0.24	4.4	—	—	0.48	410	22.6	M			15	
—	—	+	+	+	—	+	+	—	—	—	—	—	1.0	+	4.3	—	+	0.25	396	18.2	M-G		10	10	
0.29	+	0.29	—	0.29	—	0.29	—	—	—	—	—	—	0.86	—	4.3	—	+	0.57	348	7.8	M-P			35	
0.27	2.2	1.4	0.27	—	+	+	—	+	—	—	—	—	0.81	—	13	—	+	+	370	12.8	M-P	20		30	
1.3	0.80	+	+	+	—	+	—	—	—	—	—	—	1.1	0.27	4.3	—	0.27	0.53	375	13.7	M	20		20	
+	0.81	0.27	0.27	+	0.27	+	+	+	—	—	—	—	0.54	+	19	—	—	+	371	15.0	M	5	10	25	
—	0.26	0.26	+	—	+	+	—	—	—	—	—	—	0.79	0.53	3.7	—	—	0.26	378	16.1	M	5	10	15	
—	+	1.0	—	+	+	—	+	—	—	—	—	—	2.8	0.51	3.6	—	+	—	391	12.2	M	15	5	15	
—	—	+	—	—	+	+	+	—	—	—	—	—	2.0	0.57	2.3	—	—	—	352	7.1	M-P	15	10	20	

Genus *Dictyocoryne* Ehrenberg, 1860

***Dictyocoryne* group** (Plate 3, Fig. 1)

Triradiate spongodiscids in which concentric structure is absent or completely obscured in the arms, and absent or mostly obscured in the center.

Genus *Porodiscus* Haeckel, 1881

***Porodiscus* group A** (Pl. 2, Fig. 4)

A simple spongy disc with a variable number of regular or irregular concentric or spiral rings. The concentric structure in the center of the disc is vague or obscured.

***Porodiscus* group B** (Plate 2, Fig. 5)

Similar to *Porodiscus* group A, but with the concentric structure in the center very distinct and circular. In this group, the rings tend to be more regular, and concentric rather than spiral.

***Porodiscus* group C** (Plate 2, Figs. 8A, B)

This form has very wide concentric (rarely spiral) chambers, no more than four in all. Stöhr's (1880, p. 108, pl. 4, figs. 16, 17) *Trematodiscus ellipticus* and *T. microporus* would be included in this group.

Porodiscids

In the Eocene tabulation, all discoidal forms with concentric structure were recorded together.

Genus *Stylodictya* Ehrenberg 1847a, emend. Kozlova in Petrushevskaya and Kozlova 1972

***Stylodictya* spp.** (Plate 2, Fig. 6)

Discoidal porodiscid with round outline and concentric chambers. The innermost chambers are distinctly scalloped.

Genus *Spongocore* Haeckel, 1887

***Spongocore* spp.** (Plate 3, Fig. 2)

A cylindrical, bipolar, solid spongy framework having numerous radial beams especially in the center. A veil supported by these beams is sometimes preserved.

Genus *Spongodiscus* Ehrenberg, 1854

***Spongodiscus* group** (Plate 2, Figs. 7A, B)

Flat spongy disc, circular to subcircular in outline. For this study, forms with radial spines such as *Spongotrochus glacialis* Popofsky 1908

Table 3. Abundances of Eocene radiolarian counting groups at Sites 552 and 553.

Sites 552 and 553 Core-Section (interval in cm)	*Amphisphaera minor*	*Stylosphaera goruna*	Other Actinommids	Phacodiscid grp.	*Amphicraspedum murrayanum*	*A. prolixum*	*A. prolixum* grp.	*Amphymenium splendiarmatum*	Porodiscids	*Spongodiscus* grp.	Litheliids	Spyrids	Plagoniids	*Amphipternis clava*	*Buryella tetradica*
Hole 552															
10,CC	—	+	45	—	—	—	+	—	0.33	7.5	3.9	1.6	2.9	+	—
12-2, 37–39	+		+						+	+	+	+	+		
12-4, 83–85			+							+	+	+	+		
12-6, 54–56			+							+	+		+		
12-7, 33–35															
18-2, 41–44			+		+	+	+		+	+	+				
21-1, 50–52			+			+			+	+	+	+			
21-3, 47–49	+		+			+	+		+	+	+	+			+
Hole 552A															
37-3, 62–63	+	—	18	—	—	—	0.65	—	0.32	12	3.9	25	7.4	—	—
38-1, 120–121	0.63	—	38		—	0.32	—	—	1.9	20	11	3.5	6.9	—	—
38-2, 65–66	—	—	23		—	+	0.33	+	1.3	17	3.6	4.6	16	+	—
38-3, 120–121	0.32	—	35	+	—	—	+	0.97	0.65	13	14	2.6	5.5	+	—
Hole 553A															
10-1, 122–124	0.32	—	20	+	—	—	1.6	0.32	11	19	14	3.8	1.0	—	—
10-2, 122–124	1.6	—	43	+	—	—	—	—	3.6	13	12	0.97	+	—	—
10-5, 98–100	0.63	—	31	+	—	—	—	0.63	1.3	3.8	2.2	11	6.0	—	—
11-4, 129–131	+	—	50	+	0.64	0.96	2.3	—	0.64	15	18	2.6	0.96	+	—
11-5, 82–84	—	—	17	0.63	0.95	0.95	0.63	—	6.0	25	26	9.8	2.5	—	—

Note: Numbers represent abundance in percentage of total radiolarians on the slide as determined by counting the number of individuals indicated on the far right under "Radiolarians counted." "+" indicates < 0.3% and "—" indicates the group was sought but not found. Where radiolarian density was low or preservation very poor, no counts were made, and in these samples "+" indicates the presence of radiolarian groups. Preservation is shown as M (moderate) or P (poor).

are included in this large group. Any circular flat spongy disc without concentric structure is included here.

Family Pyloniidae Haeckel, 1881

Pyloniid group

All pyloniids were counted together.

Family Tholoniidae Haeckel, 1887

Tholoniid group

All tholoniids were counted together.

Family Litheliidae Haeckel, 1862

Genus *Larcopyle* Dreyer, 1889

***Larcopyle* group** (Plate 3, Figs. 3A, B)

The internal spiral structure is enclosed in a smooth elliptical shell with regular outline and small pores. There may be thorns on the outer shell, and there may be a pylome visible at one end which may or may not be surrounded by short spines.

Genus *Larcospira* Haeckel, 1887

***Larcospira* group** (Plate 3, Fig. 4)

The medullary shell is surrounded by an open double spiral, which forms two elongate, subcylindrical wings with their openings in opposite directions. The pore pattern is slightly irregular and the pores tend to increase a little in size toward the distal edge of each wing.

Genus *Lithelius* Haeckel, 1860a

***Lithelius minor* Jörgensen** (Plate 3, Fig. 5)

Lithelius minor Jörgensen, 1900, p. 65, pl. 5, fig. 24.

Ellipsoidal to subspherical test composed of a single or double spiral, with usually less than five tight, narrow whorls. In some orientations, the spiral structure appears as concentric rings. Pores are small and of nearly equal size, and the shell may be thorny.

Genus *Pylospira* Haeckel, 1887

***Pylospira* group** (Plate 3, Figs. 6A, B)

Subspherical to elliptical cortical shell constructed of a single or double spiral, with usually fewer than five loose, wide whorls. The surface of the shell may be thorny, the pores unequal in size and irregular in pattern. This group includes *Lithelius nautiloides* Popofsky (1908, p. 230, pl. 27, fig. 4).

Family Soreumidae Haeckel, 1881

Genus *Soreuma* Haeckel, 1881

***Soreuma* group** (Plate 3, Fig. 7)

Ellipsoidal skeleton of loose spongy mesh. This form resembles some included in the *Pylospira* group, but the spongy mesh is uniformly disorganized throughout the skeleton, i.e., there is no spiral structure.

Order Nassellaria Ehrenberg, 1875

Suborder Spyrida Ehrenberg, 1847b, emend. Petrushevskaya, 1971

Genus *Acanthodesmia* Müller, 1857

***Acanthodesmia* group**

Spyrid consisting of a sagittal ring, a frontal ring, and a basal ring. The bars bear spines which may be quite long and tapered.

Table 3. (Continued).

Calocyclas hispida	*Eusyringium fistuligerum*	*Lamptonium obelix*	*L. pennatum*	*Lophocyrtis biaurita*	*L. jacchia*	*L. norvegiensis*	*Lychnocanoma bellum*	*Phormocyrtis s. striata*	*Pterocodon ampla*	*P. lex*	Other Theoperids	Pterocorythids	*Siphocampe acephala*	*S. lineata*	Other Artostrobiids	Radiolarians counted	Radiolarians, thousands per slide	Preservation
—	—	—	0.33	+	—	25	—	1.6	11	—	1.6	—	—	—	—	307	6	M
									+				+			—	<0.1	M
									+							—	<0.1	M
									+							—	<0.1	M
									+							—	<0.1	M
									+	+	+					—	5	P
									+		+		+		+	—	<0.5	P
									+		+				+	—	1	P
—	—	—	—	—	—	+	—	—	24	—	8.4	+	—	0.32	—	310	4	M
—	—	—	0.32	—	—	0.95	0.32	0.63	12	—	2.5	0.63	+	—	—	320	2	M
—	—	—	0.66	0.33	—	2.6	0.33	—	11	—	15	0.66	3.3	+	—	305	6	M
—	—	—	0.97	0.32	—	2.6	—	0.32	5.2	—	20	+	—	+	+	309	5	M
+	—	—	0.64	6.4	+	6.4	+	—	+	—	8.3	+	7.0	0.64	+	314	3	M
—	+	+	—	0.65	0.97	4.5	+	—	—	—	14	1.6	3.9	+	+	308	4	M
—	—	—	0.63	—	+	1.9	—	—	18	—	23	—	—	0.32	0.63	316	1	M
—	—	—	—	—	—	—	—	—	4.8	1.3	1.6	—	0.64	—	—	311	9	M
—	—	—	—	—	—	—	—	—	7.6	+	1.9	—	0.32	—	—	317	10	M

Genus *Ceratospyris* Ehrenberg, 1847a

***Ceratospyris* group A** (Plate 3, Fig. 9)

Skeleton consisting of a bilocular cephalis without thorns and with any number of feet. In most cases the pores are irregular in size and shape, and the spaces between pores are wide and flat. However, any spyrid with feet, bilocular cephalis and no thorns is included in this counting group.

***Ceratospyris* group B** (Plate 3, Figs. 8A, B)

Bilocular cephalis consisting of large meshes, with no thorax. Short thorns (less than half shell height) may arise from points of intersection of skeletal bars. If feet are present, they are no more developed than these thorns.

***Ceratospyris* group C** (Plate 3, Fig. 10)

Bilocular cephalis with large paired pores adjoining a distinct sagital constriction. In many specimens there are wide areas between pores. Thorns on the cephalis point away from the basal ring. Feet are more developed than the thorns.

Genus *Desmospyris* Haeckel, 1881

***Desmospyris* group** (Plate 3, Figs. 14A, B)

Bilocular cephalis with a thorax. The sagittal constriction is usually not pronounced, and the pore pattern is similar to that of *Ceratospyris* group A. However, any spyrid with a thorax and no galea would be included here.

Genus *Liriospyris* Haeckel 1881, emend. Goll 1968

***Liriospyris cricus* Westberg-Smith and Riedel, new species** (Plate 3, Figs. 12A–C)

The sagitally constricted lattice shell is attached to a furrowed sagital ring at the front, back, and apex. Generally there are two large pores on the front, four on the back, and a narrow band with two rows of small pores around the sides and top. Two robust bars descend below the basal ring from the front and back of the lattice shell and join to form an oval ring. Measurements based on 10 specimens from Holes 552A and 555: width of lattice shell 121–145 μm, height of sagittal ring 72–90 μm, length of descending ring 63–85 μm.

This species is distinguished from all other members of the genus by the robust pendant ring. The specific name is derived from the Greek, *krikos*, "finger ring," used as a noun in apposition, and alludes to the common use of J. R. R. Tolkien's Hobbit terminology for topographic features in this region.

Genus *Tholospyris* Haeckel, 1881

***Tholospyris rhombus* Haeckel, emend. Goll**

Archicircus rhombus Haeckel, 1887, p. 942, pl. 81, fig. 7.

Tholospyris rhombus (Haeckel) emend. Goll, 1972, p. 455, pl. 16, figs. 1–11.

A simple sagittal ring, rhomboid in shape, with four paired spines at the corners.

Genus *Tricolospyris* Haeckel, 1881

***Tricolospyris* group** (Plate 3, Fig. 13)

Spyrid consisting of bilocular cephalis, galea, and basket-shaped, closed thorax. The pores are usually irregular in size and shape.

Genus *Zygocircus* Bütschli, 1882

***Zygocircus* group** (Plate 3, Fig. 11)

A sagittal ring with no basal ring structures except for rudimentary lateral bars. The entire ring is spiny.

Family Plagoniidae Haeckel, 1881, emend. Riedel, 1967b

Genus *Amphiplecta* Haeckel, 1881

***Amphiplecta* group** (Plate 4, Fig. 1)

Two-segmented plagoniid with cylindrical cephalis having an open top surrounded by thorns. Thorax widely conical.

Genus *Arachnocorallium* Haeckel, 1887

***Arachnocorallium* group** (Plate 4, Fig. 2)
One-segmented plagoniid consisting of an ovoid cephalis, the base of which is a narrow structure composed of the median bar and three protruding spines (dorsal and primary laterals).

Genus *Ceratocyrtis* Bütschli, 1882

Ceratocyrtis group (Plate 4, Figs. 3A–D)
Two-segmented plagoniid in which the small cephalis is separated from the hood-shaped thorax by a constriction. The conical thorax narrows distally, and pore size usually increases toward the undifferentiated margin.

Genus *Lophophaena* Ehrenberg, 1847b

Lophophaena group (Plate 4, Figs. 4A–E)
This large counting group (any two-segmented plagoniid in which the cephalis and thorax are nearly equal in volume) probably includes several genera. The cephalis is spherical to subspherical, and may or may not have thorns. The thorax is open, conical to cylindrical, and may or may not have appendages. Pores are small, and irregular in size and shape.

Genus *Pseudodictyophimus* Petrushevskaya, 1971

***Pseudodictyophimus* group** (Plate 4, Figs. 5A–B)
Two-segmented forms having three thoracic ribs which may extend beyond the margin of the thorax. The cephalis is small and may bear an apical horn. The second segment is usually open, conical to cylindrical, but it may be closed. This group is distinguished by the three thoracic ribs usually extending as feet.

Subfamily Sethophorminae Haeckel, 1881

Sethophormin group A (Plate 4, Fig. 6)
Widely flattened conical skeleton, with three to four prominent ribs and a distinctly differentiated thoracic rim.

Sethophormin group B (Plate 4, Fig. 7)
Widely flattened conical skeleton with no prominent ribs, nor distinctly differentiated thoracic rim.

Other Plagoniids (Plate 4, Figs. 8A, B)
Any plagoniid which has not been categorized above. Most members of this family encountered in the present material are included in one of the groups described above.

Family Theoperidae Haeckel, 1881, emend. Riedel 1967b

Genus *Amphipternis* Foreman, 1973

***Amphipternis clava* (Ehrenberg)**
Lithocampe ? clava Ehrenberg, 1873, p. 238.
Amphipternis clava (Ehrenberg)—Foreman, 1973, p. 430, pl. 7, figs. 16, 17, pl. 9, fig. 2.

Genus *Artophormis* Haeckel, 1881

***Artophormis gracilis* Riedel**
Artophormis gracilis Riedel, 1959, p. 300, pl. 2, figs. 12, 13.

Genus *Buryella* Foreman, 1973

***Buryella tetradica* Foreman**
Buryella tetradica Foreman, 1973, p. 433, pl. 8, figs. 4, 5, pl. 9, figs. 13, 14.

Genus *Calocyclas* Ehrenberg, 1847b

***Calocyclas hispida* (Ehrenberg)**
Anthocyrtis hispida Ehrenberg, 1873, p. 216, pl. 8, fig. 2.
Calocyclas hispida (Ehrenberg)—Foreman, 1973, p. 434, pl. 1, figs. 12–15, pl. 9, fig. 18.

Genus *Cornutella* Ehrenberg, 1838

***Cornutella* spp.**
A narrow cone with small cephalis, with or without apical horn. Pores circular to subcircular.

Genus *Cycladophora* Ehrenberg, 1847a

***Cycladophora davisiana* Ehrenberg** (Plate 4, Fig. 9)
Cycladophora? *davisiana* Ehrenberg, 1861, p. 297.

Genus *Cyrtocapsella* Haeckel, 1887

***Cyrtocapsella cornuta* Haeckel**
Cyrtocapsa (Cyrtocapsella) cornuta Haeckel, 1887, p. 1513, pl. 78, fig. 9.
Cyrtocapsella cornuta Haeckel - Sanfilippo and Riedel, 1970, p. 453, pl. 1, figs. 19–20.

***Cyrtocapsella japonica* (Nakaseko)**
Eusyringium japonicum Nakaseko, 1963, p. 193, text-figs. 20, 21, pl. 4, figs. 1–3.
Cyrtocapsella japonica (Nakaseko)—Sanfilippo and Riedel, 1970, p. 452, pl. 1, figs. 13–15.

***Cyrtocapsella tetrapera* Haeckel**
Cyrtocapsa (Cyrtocapsella) tetrapera Haeckel, 1887, p. 1512, pl. 78, fig. 5.
Cyrtocapsella tetrapera Haeckel—Sanfilippo and Riedel, 1970, p. 453, pl. 1, figs. 16–18.

Genus *Cyrtopera* Haeckel, 1881

***Cyrtopera laguncula* Haeckel**
Crytopera laguncula Haeckel, 1887, p. 1451, pl. 75, fig. 10.

Genus *Eucecryphalus* Haeckel 1860a, emend. Petrushevskaya, 1971

***Eucecryphalus* grp.** (Plate 4, Fig. 10)
This counting group embraces several different forms with three segmented shells forming a wide cone. The abdomen varies from flatly expanded to conical.

Genus *Eucyrtidium* Ehrenberg 1847a, emend. Nigrini 1967

***Eucyrtidium acuminatum* (Ehrenberg)** (Plate 4, Fig. 11)
Lithocampe acuminatum Ehrenberg, 1844, p. 84
Eucyrtidium acuminatum (Ehrenberg), Nigrini, 1967, p. 81, pl. 8, figs. 3a, b.
Multisegmented stichocyrtid with small conical abdomen and lumbar stricture not indented externally.

***Eucyrtidium calvertense* Martin** (Plate 4, Fig. 12)
Eucyrtidium calvertense Martin, 1904, p. 450, 451, pl. 130. fig. 5.
Stichocyrtid of five or more segments. There is a distinct change between the second and third segment, and the longitudinally aligned pores are set in deep furrows.

***Eucyrtidium cienkowskii* Haeckel group, Sanfilippo et al.** (Plate 4, Figs. 13A, B)
Eucyrtidium cienkowskii Haeckel, 1887, p. 1493, pl. 80, fig. 9.
Eucyrtidium cienkowskii Haeckel group, Sanfilippo et al., 1973, p. 221, pl. 5, figs. 7–11.
Multisegmented stichocyrtid with small cephalis and thorax set off from the remaining segments by a distinct change in contour; the third segment is conical, the remaining segments cylindrical. Small pores of nearly equal size are aligned in longitudinal rows.

***Eucyrtidium hexagonatum* Haeckel** (Plate 4, Fig. 14)
Eucyrtidium hexagonatum Haeckel, 1887, p. 1489, pl. 80, fig. 11: Nigrini, 1967, p. 83, pl. 8, figs. 4a, b.
Multisegmented form with small inflated annular thorax set off from lower segments by a distinct lumbar stricture.

***Eucyrtidium punctatum* (Ehrenberg) group, Sanfilippo et al.** (Plate 4, Figs. 15A, B)
Lithocampe punctata Ehrenberg, 1844
Eucyrtidium punctatum (Ehrenberg) group, Sanfilippo et al., 1973, p. 221, pl. 5, figs. 15-16.
Multisegmented stichocyrtid with small cephalis and long conical thorax attaining the same width as the subsequent cylindrical segments. Pores tend to align transversely.

***Eucyrtidium* sp. A** (Plate 5, Fig. 2)
A variant from the *E. cienkowskii* group with a very irregular pore pattern.

***Eucyrtidium* sp. B** (Plate 5, Fig. 3)
A variant from the *E. cienkowskii* group with thoracic wings and very large pores sometimes quincuncially arranged.

Other *Eucyrtidium* (Plate 5, Fig. 1)
Any member of the genus which does not fall into one of the above groups.

Genus *Eusyringium* Haeckel, 1881

***Eusyringium fistuligerum* (Ehrenberg)**
Eucyrtidium fistuligerum Ehrenberg, 1873, p. 229.
Eusyringium fistuligerum (Ehrenberg), Haeckel, 1887, p. 1498: Riedel and Sanfilippo, 1970, p. 527, pl. 8, figs. 8, 9.

Genus *Gondwanaria* Petrushevskaya, 1975

Gondwanaria group A (Plate 5, Fig. 4)
A subspherical cephalis, usually with an apical horn, is separated from the cupola-shaped thorax by a distinct constriction. Surface of the thorax is thorny and bears three wings proximally; pores are large, increasing distally and in some specimens decreasing again terminally.

Gondwanaria group B (Plate 5, Fig. 5)
A spherical cephalis is separated from a cupola-shaped thorax by a distinct constriction; in most specimens a second constriction separates the thorax from a short abdomen. Pores are small, of nearly equal size and irregular pattern. There is a short apical horn, and wing-like ribs protrude from the upper thoracic wall. Includes *Lipmanella dictyoceras* (Haeckel) (see Kling, 1973, p. 636, pl. 4, figs. 24–26).

Genus *Lamptonium* Haeckel, 1887

***Lamptonium obelix* Sanfilippo and Riedel** (Plate 6, Fig. 15)
Lamptonium obelix Sanfilippo and Riedel, 1979, p. 503, pl. 1, figs. 1, 2.

***Lamptonium pennatum* Foreman** (Plate 6, Fig. 16)
Lamptonium pennatum Foreman, 1973, p. 436, pl. 6, figs. 3–5, pl. 11, fig. 13.

Genus *Litharachnium* Haeckel, 1860a

Litharachnium group (Plate 5, Fig. 7)
Two-segmented cone, the pores of which are rectangular or subrectangular. The cephalis is small, the apical horn, if present, rudimentary. Both narrow and more expanded conical forms are included.

Genus *Lithopera* Ehrenberg, 1847a

***Lithopera bacca* Ehrenberg**
Lithopera bacca Ehrenberg, 1872, p. 314; 1873, pl. 8, fig. 1: Sanfilippo and Riedel, 1970, p. 445, pl. 1, fig. 29.

***Lithopera neotera* Sanfilippo and Riedel**
Lithopera neotera Sanfilippo and Riedel, 1970, p. 454, pl. 1, figs. 24–26, 28.

***Lithopera renzae* Sanfilippo and Riedel**
Lithopera (Lithopera) renzae Sanfilippo and Riedel, 1970, p. 454, pl. 1, figs. 21–23, 27.

Genus *Lophocyrtis* Haeckel, 1887

***Lophocyrtis biaurita* (Ehrenberg)** (Plate 6, Fig. 13)
Eucyrtidium biaurita Ehrenberg, 1873, p. 226.
Lophocyrtis biaurita (Ehrenberg)—Foreman, 1973, p. 442, pl. 8, fig. 23-26.

***Lophocyrtis jacchia* (Ehrenberg)**
Thyrsocyrtis jacchia Ehrenberg, 1873, p. 261.
Lophocyrtis jacchia (Ehrenberg)—Riedel and Sanfilippo, 1971, p. 1594, pl. 3C, fig. 4, 5, pl. 7, fig. 16.

***Lophocyrtis norvegiensis* Bjørklund and Kellogg** (Plate 6, Fig. 7)
Lophocyrtis norvegiensis Bjørklund and Kellogg, 1972, p. 388, pl. 1, figs. 2, 7, text-figs. 8, 9.

***Lophocyrtis* sp.**
Form intermediate between *L. biaurita* and *L. norvegiensis.*

Genus *Lychnocanoma* Haeckel, 1887

***Lychnocanoma amphitrite* (Foreman)** (Plate 6, Fig. 14)
Lychnocanoma amphitrite Foreman, 1973, p. 437, pl. 11, fig. 10.
The specimens here are in the size range described by Foreman (1973), and the feet are short with a stubby, bladed termination; however some specimens have no trace of an abdomen. Although Foreman (1973) reported an evolutionary lower limit for this species in the middle to late Eocene, these specimens and some reported by Sanfilippo and Riedel (1979) from DSDP Leg 48 are from lower to middle Eocene sediments.

Genus *Phormocyrtis* Haeckel, 1887

***Phormocyrtis striata striata* Brandt** (Plate 6, Fig. 12)
Phormocyrtis striata striata Brandt (in Wetzel) 1935, p. 55 pl. 9, fig. 12: Foreman, 1973, p. 438, pl. 7, figs. 5, 6, 9.

Genus *Pterocanium* Ehrenberg, 1847a

Pterocanium group (Plate 5, Fig. 6)
Three strong, proximally fenestrated feet project from a cupola-shaped thorax. Cephalis spherical, small, generally with apical horn. Thoracic pores circular, of nearly equal size and regularly arranged. In well-preserved specimens, there is meshwork between the feet.

Genus *Pterocodon* Ehrenberg 1847b

***Pterocodon ampla* (Brandt)** (Plate 6, Fig. 10)
Theocyrtis ampla Brandt (in Wetzel) 1935, p. 56, pl. 9, figs. 13–15.
Pterodocon (?) ampla (Brandt)—Foreman, 1973, p. 438, pl. 5, figs. 3–5: Sanfilippo, Westberg-Smith, and Riedel, in press, text-fig. 20–3a.
Specimens of *P. ampla* in this material are larger than those recorded by Foreman (1973) from the Gulf of Mexico, but smaller than *Calocyclas talwanii* Bjørklund and Kellogg (1972). Dimensions: length excluding horn 158–200 μm; length cephalis and thorax 104–149 μm; maximum width of thorax 113–158 μm; diameter of pores 11–16 μm.

***Pterocodon lex* Sanfilippo and Riedel**
Pterocodon lex Sanfilippo and Riedel, 1979, p. 505, pl. 1, figs. 9, 10.

Genus *Stichocorys* Haeckel, 1881

***Stichocorys delmontensis* (Campbell and Clark)** (Plate 5, Fig. 8)
Eucyrtidium delmontense Campbell and Clark, 1944, p. 56, pl. 7, figs. 19-20.
Stichocorys delmontensis (Campbell and Clark)—Sanfilippo and Riedel, 1970, p. 451, pl. 1, fig. 9: Sanfilippo, Westberg-Smith and Riedel, in press, text-fig. 23-1a, b.

***Stichocorys peregrina* (Riedel)**
Eucyrtidium peregrinum Riedel, 1953, p. 812, pl. 85, fig. 2.
Stichocorys peregrina (Riedel)—Sanfilippo and Riedel, 1970, p. 451, pl. 1, fig. 10: Westberg and Riedel, 1978, p. 22, pl. 3, figs. 6–9: Sanfilippo, Westberg-Smith, and Riedel, in press.

***Stichocorys* sp.**
This category was used for forms indeterminate because of poor preservation.

Genus *Theocorys* Haeckel, 1881

***Theocorys* group** (Plate 5, Fig. 10)
Three-segmented theoperid with open, although sometimes constricted, abdomen without a differentiated termination. Small, spherical cephalis bears a small apical horn. Pores are subcircular, of nearly equal size on both abdomen and thorax.

Other Theoperids (Plate 5, Fig. 9)
Any theoperid not accounted for in one of the preceding counting groups.

Family Carpocaniidae Haeckel 1881, emend. Riedel, 1967b

Genus *Carpocanistrum* Haeckel, 1887

***Carpocanistrum* group A** (Plate 5, Figs. 11A, B)
Two-segmented form, the cephalis of which is merged into the upper thorax. The thoracic opening is constricted, usually with a wide

peristome and sometimes peristomial teeth. Pores are circular, of nearly equal size, and aligned longitudinally. There may be ridges between pore rows, and the outline is always smooth.

***Carpocanistrum* group B** (Plate 5, Fig. 12)
Form similar to *Carpocanistrum* group A in all respects except that the surface of the shell is rough.

Family Pterocorythidae Haeckel 1881, emend. Riedel, 1967b

Genus *Anthocyrtidium* Haeckel, 1881

***Anthocyrtidium* group** (Plate 5, Fig. 15)
This group includes all two-segmented pterocorythids. The thorax varies in the degree of inflation, and terminal teeth vary markedly in their degree of development. There is usually a stout, bladed apical horn, and subcircular pores are of nearly equal size and regularly arranged.

Genus *Lamprocyclas* Haeckel, 1887

***Lamprocyclas maritalis* Haeckel group** (Plate 5, Fig. 13)
Lamprocyclas maritalis Haeckel, 1887, p. 1390, pl. 74, figs. 13, 14.
Lamprocyclas maritalis maritalis Haeckel, Nigrini, 1967, p. 74, pl. 7, fig. 5.
Lamprocyclas maritalis Haeckel *polypora* Nigrini, 1967, p. 76, pl. 7, fig. 6.

***Lamprocyclas* spp.**
In this category are forms similar to *L. maritalis* grp., *Theocorythium vetulum* or *Lamprocyrtis hannai*, but not conforming exactly to their descriptions.

Genus *Lamprocyrtis* Kling, 1973

***Lamprocyrtis* (?) *hannai* (Campbell and Clark)** (Plate 5, Fig. 14A, B)
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 heteroporos* (Hays)**
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.

Genus *Theocorythium* Haeckel, 1887

***Theocorythium trachelium* (Ehrenberg) *dianae* (Haeckel)** (Plate 5, Fig. 16).
Eucyrtidium trachelius Ehrenberg, 1872, p. 312.
Theocorys dianae Haeckel, 1887, p. 1416, pl. 69, fig. 11.
Theocorythium trachelium (Ehrenberg) *dianae* (Haeckel)—Nigrini, 1967, p. 77, pl. 8, figs. 1a, b, pl. 9, figs. 1a, b.

***Theocorythium vetulum* Nigrini** (Plate 5, Fig. 17)
Theocorythium vetulum Nigrini, 1971, p. 447, pl. 34.1, figs. 6a, b.

Family Artostrobiidae Riedel, 1967a

Genus *Botryostrobus* Haeckel 1887, emend. Nigrini, 1977

***Botryostrobus* group** (Plate 6, Figs. 1A, B)
Shell with more than four segments, each with three or more transverse rows of small pores, and separated by deep constrictions. Cephalis bears an apical horn and cylindrical vertical tube. Outline of each segment is smooth and rounded.

Genus *Phormostichoartus* Campbell, 1951, emend. Nigrini, 1977

***Phormostichoartus* group** (Plate 6, Figs. 2A, B)
Cylindrical shell with four segments, and many rows of small, transversely aligned pores on third and fourth segments. There is no apical horn, and a well-developed, cyindrical vertical tube lies along the proximal thorax.

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

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

***Siphocampe lineata* (Ehrenberg) group**
Lithocampe lineata Ehrenberg, 1838, p. 130.
Siphocampe lineta (Ehrenberg) group—Nigrini, 1977, p. 256, pl. 3, figs. 9, 10.

***Siphocampe* group** (Plate 6, Fig. 3)
In the Neogene samples, all three-segmented artostrobiids having a short vertical tube, no horn, and widely separated transverse rows of small pores were counted together in this group.

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

***Spirocyrtis* group** (Plate 6, Fig. 4)
Multisegmented artostrobiid with prominent flared (duck-billed) vertical tube and apical horn. Segments with angular constrictions expand distally, and each bears several transverse rows of pores. The most obvious character in this group is the stepped profile produced by the angular constrictions.

Family Cannobotryidae Haeckel, emend. Riedel, 1967b

Cannobotryid group (Plate 6, Fig. 6)
Two- or three-segmented forms with very large cephalis composed of at least three chambers, one or two of which may be elongated into tubes. This complicated cephalic structure may be as large as, or larger than, the cylindrical thorax. Pores are small, and irregular in size and arrangement.

Incertae sedis

Genus *Carpocanarium* Haeckel, 1887

***Carpocanarium* group** (Plate 6, Fig. 5)
Two-segmented form with hemispherical cephalis separated from an ovate thorax by a well-defined stricture. Sometimes a small lateral cephalic tube is observed, and in some specimens there are three small, wing-like thoracic ribs. Pores are widely spaced, of nearly equal size.

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NOTE TO PLATES

In the explanations to the figures, the sample numbers and slide designations (in the form "Sl.1" "Ph.1," etc.) indicate preparations in our collection at Scripps Institution of Oceanography; designations in the form "L25/1" indicate England Finder positions of the illustrated specimens on the slides.

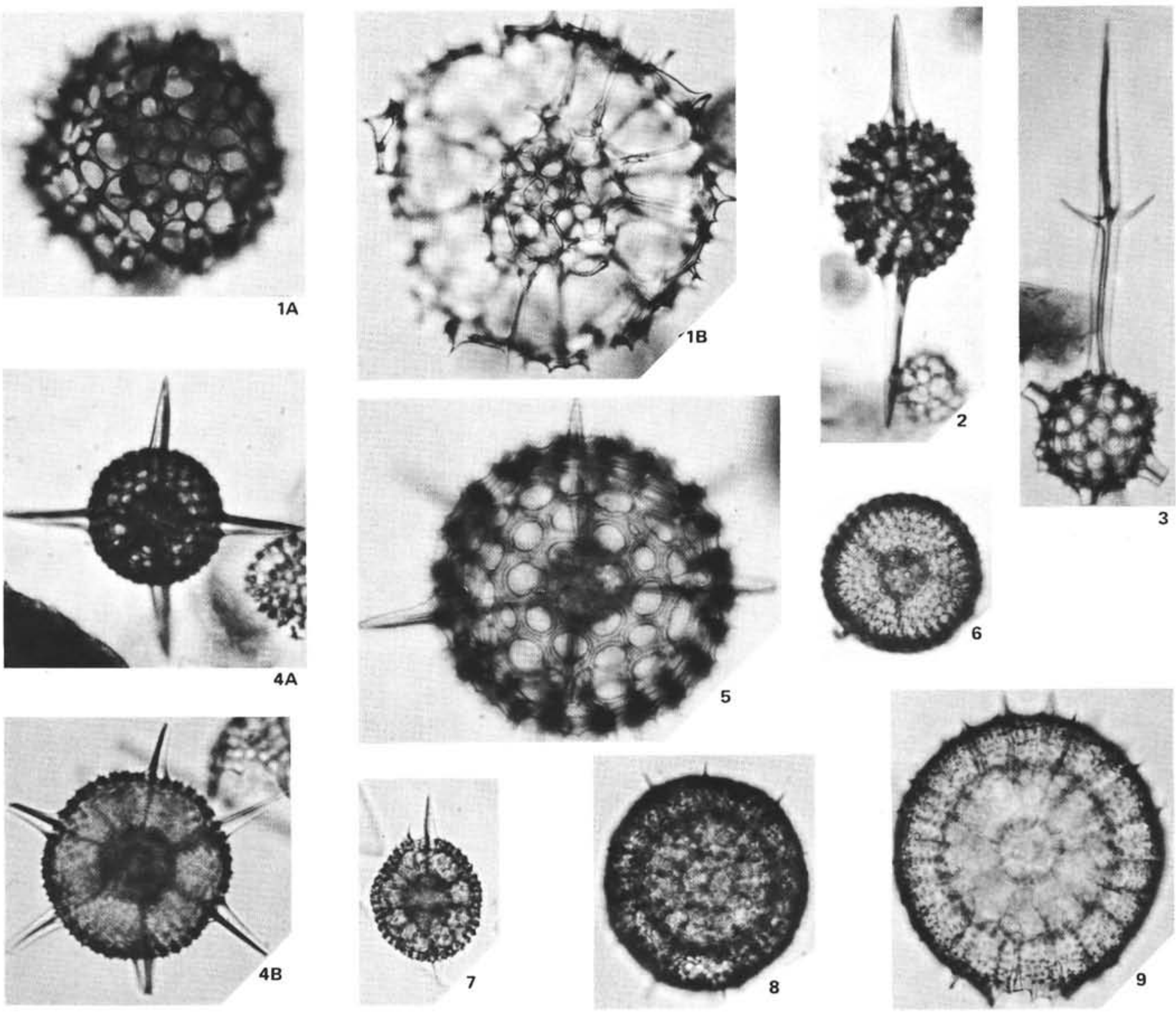

Plate 1. Radiolarians, 230×. **1.** *Actinomma medianum;* (A) Sample 552-12-1, 95–97 cm, Sl.2, V17/0; (B) Sample 552A-12-1, 95–97 cm, Sl. 2, K30/4. **2.** *Druppatractus* group, Sample 552-5,CC, Sl. 2, B19/0. **3.** *Anomalacantha dentata:* Sample 552A-1,CC, Sl. 2, C13/4. **4.** *Hexacontium* group A, (A) Sample 555-15-1, 40–42 cm, Sl. 1, E18/1; (B) Sample 552-4-2, 91–93 cm, Sl.1, C11/1. **5.** *Hexacontium* group B: Sample 552A-1,CC, Cs.2, K12/0. **6.** *Thecosphaera* spp.: Sample 552-5,CC, Sl.1, V22/1. **7.** *Stylatractus universus:* Sample 552-3-3, 70–72 cm, Ph. 2, J18/1. **8.** *Sphaeropyle robusta:* Sample 552A-26-1, 65–66 cm, Sl.1, N21/1. **9.** *Sphaeropyle langii:* Sample 552A-14-1, 30–31 cm, Sl. 1, C25/2.

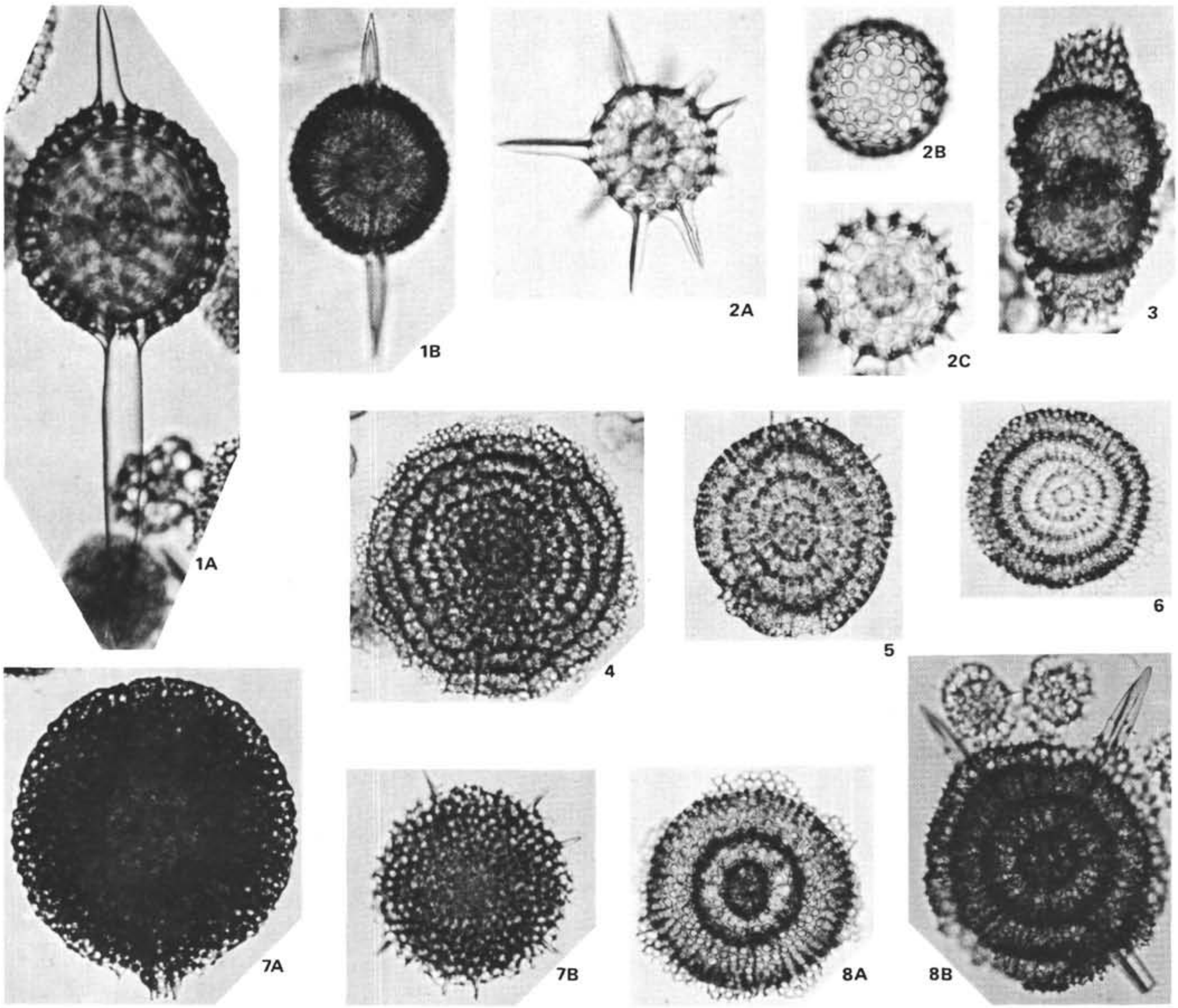

Plate 2. Radiolarians, 230×. **1.** *Stylosphaera* spp., (A) Sample 555-15-1, 40–42 cm, Sl.1, F31/1; (B) Sample 552-3-3, 70–72 cm, Ph. 2, M35/3. **2.** Other Actinommids, (A) Sample 552A-1,CC, Sl.2, R39/1; (B) Sample 552A-1,CC, Sl.2, Q26/3; (C) Sample 552A-1,CC, Sl.2, R16/1. **3.** *Didymocyrtis laticonus:* Sample 555-15-1, 40–42 cm, Sl.1, G28/4. **4.** *Porodiscus* group A: Sample 552-4-2, 91–93 cm, Sl.1, S9/3. **5.** *Porodiscus* group B: Sample 552A-1,CC, Sl.2, R6/2. **6.** *Stylodictya* spp.: Sample 552A-19,CC, Sl.2, T19/0. **7.** *Spongodiscus* group, (A) Sample 552-4-2, 91–93 cm, Sl.1, P12/3; (B) Sample 552A-1,CC, Sl.2, R37/1. **8.** *Porodiscus* group C, (A) Sample 555-15-1, 40–42 cm, Sl. 1, E10/3; (B) Sample 552A-16-1, 134–135 cm, Sl.2, P38/4.

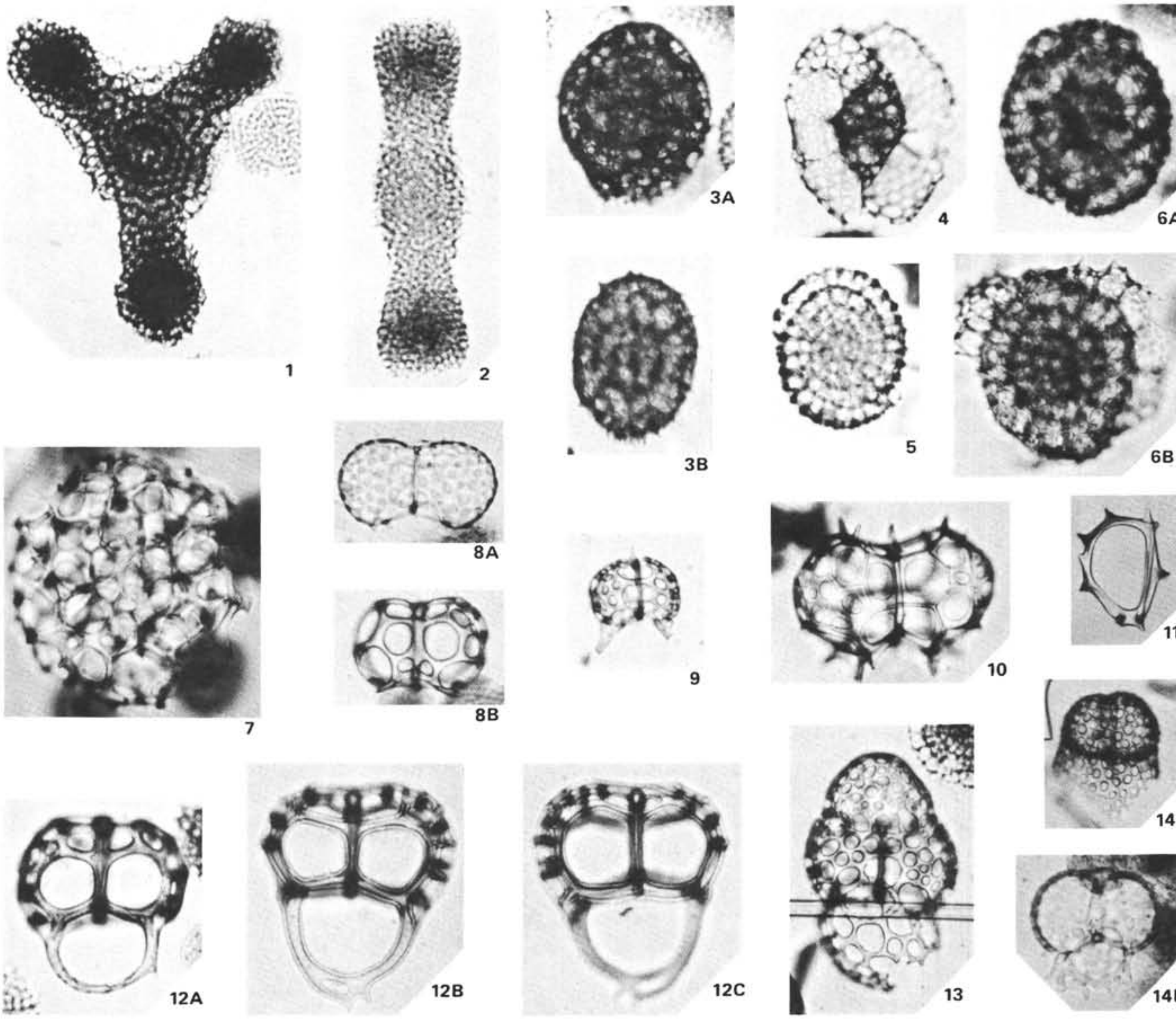

Plate 3. Radiolarians, 230×. **1.** *Dictyocoryne* group: Sample 552-4-2, 91–93 cm, Sl.1, M11/0. **2.** *Spongocore* spp: Sample 552A-14-3, 11–12 cm, Sl.1, P23/3. **3.** *Larcopyle* group, (A) Sample 552A-14-3, 11–12 cm, Sl.1, N32/1; (B) Sample 552A-1,CC, Sl.2, W35/1. **4.** *Larcospira* group: Sample 552A-19,CC, Ph. 1, K46/4. **5.** *Lithelius minor:* Sample 552-3-3, 70–72 cm, Ph. 2, J29/3. **6.** *Pylospira* group, (A) Sample 552-3-3, 70–72 cm, Ph. 2, J18/0; (B) Sample 552-3,CC, Sl.1, Q17/0. **7.** *Soreuma* group: Sample 552A-1-3, 53–54 cm, Sl.2, L13/1. **8.** *Ceratospyris* group B, (A) Sample 554-6-6, 22–24 cm, Sl.2, C40/3; (B) Sample 555-5-6, 6–8 cm, Sl.2, K21/2. **9.** *Ceratospyris* group A: Sample 552A-14-3, 11–12 cm, Sl.1, A14/3. **10.** *Ceratospyris* group C: Sample 555-15-1, 40–42 cm Sl.1, O9/0. **11.** *Zygocircus* group: Sample 555-19-3, 52–54 cm, Sl.1, U4/4. **12.** *Liriospyris cricus*, (A) Sample 552-4-2, 91–93 cm, Sl.1, K14/2; (B, C) Holotype (B, back view; C, front view), Sample 552A-27-1, 108–109 cm, Ph. 2, L14/0. **13.** *Tricolospyris* group: Sample 555-15-1, 40–42 cm, Sl.1, J15/2. **14.** *Desmospyris* group, (A) Sample 555-17-1, 44–46 cm, Sl.2, R12/1; (B) Sample 554-6-6, 22–24 cm, Sl.2, W27/0.

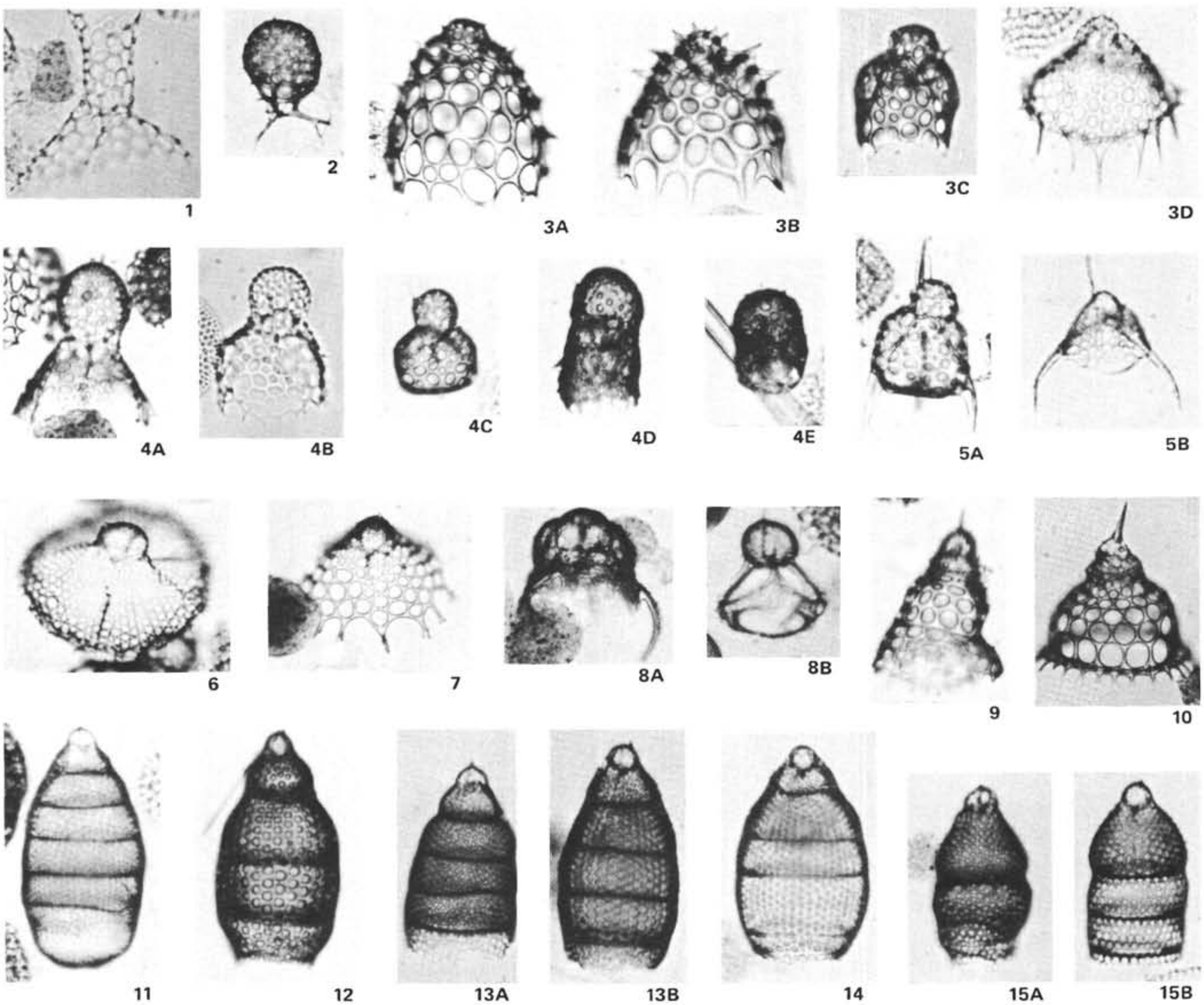

Plate 4. Radiolarians, 230×. **1.** *Amphiplecta* group: Sample 552A-28,CC, Sl.2, U8/3. **2.** *Arachnocorallium* group: Sample 552A-12-1, 95–97 cm, Sl.2, Q21/0. **3.** *Ceratocyrtis* group, (A) Sample 552-5,CC, Sl.2, V12/4; (B) Sample 552A-27,CC, Sl.1, W12/1; (C) Sample 552-4-2, 91–93 cm, Sl.1, K43/4. (D) Sample 552A-26-1, 65–66 cm, Ph. 1, W44/3. **4.** *Lophophaena* group, (A) Sample 552-5,CC, Sl.2, S14/4; (B) Sample 552-4-2, 91–93 cm, Sl.1, F11/4; (C) Sample 552A-14-1, 30–31 cm, Sl.1, G40/1; (D) Sample 552A-14-3, 11–12 cm, Sl.1, V14/0; (E) Sample 552A-19,CC, Sl.2, W31/0. **5.** *Pseudodictyophimus* group, (A) Sample 555-15-1, 40–42 cm, Sl.1, Q10/4; (B) Sample 552A-15-3, 11–12 cm, Sl.1, K20/4. **6.** Sethophormin group A: Sample 552A-19,CC, Sl.2, T33/3. **7.** Sethophormin group B: Sample 552A-1,CC, Sl.2, C34/0. **8.** Other Plagoniids, (A) Sample 552A-28,CC, Sl.1, E29/0; (B) Sample 552A-28,CC, Sl.1, K29/4. **9.** *Cycladophora davisiana:* Sample 552A-1,CC, Sl. 2, H9/2. **10.** *Eucecryphalus* group: Sample 552A-12-1, 95–97 cm, Sl.2, U9/0. **11.** *Eucyrtidium acuminatum* Sample 552A-19,CC, Sl.2, M36/3. **12.** *Eucyrtidium calvertense:* Sample 552A-19,CC, Sl.2, T15/3. **13.** *Eucyrtidium cienkowskii* group, (A) Sample 552-4-2, 91–93 cm, Sl.1, B34/3; (B) Sample 555-17-1, 44–46 cm, Sl.2, Q15/0. **14.** *Eucyrtidium hexagonatum:* Sample 552A-27,CC, Sl.1, B10/0. **15.** *Eucyrtidium punctatum,* (A) Sample 552A-14-1, 30–31 cm, Sl.1, S26/4; (B) Sample 552A-14-1, 30–31 cm, Sl.1, H40/4.

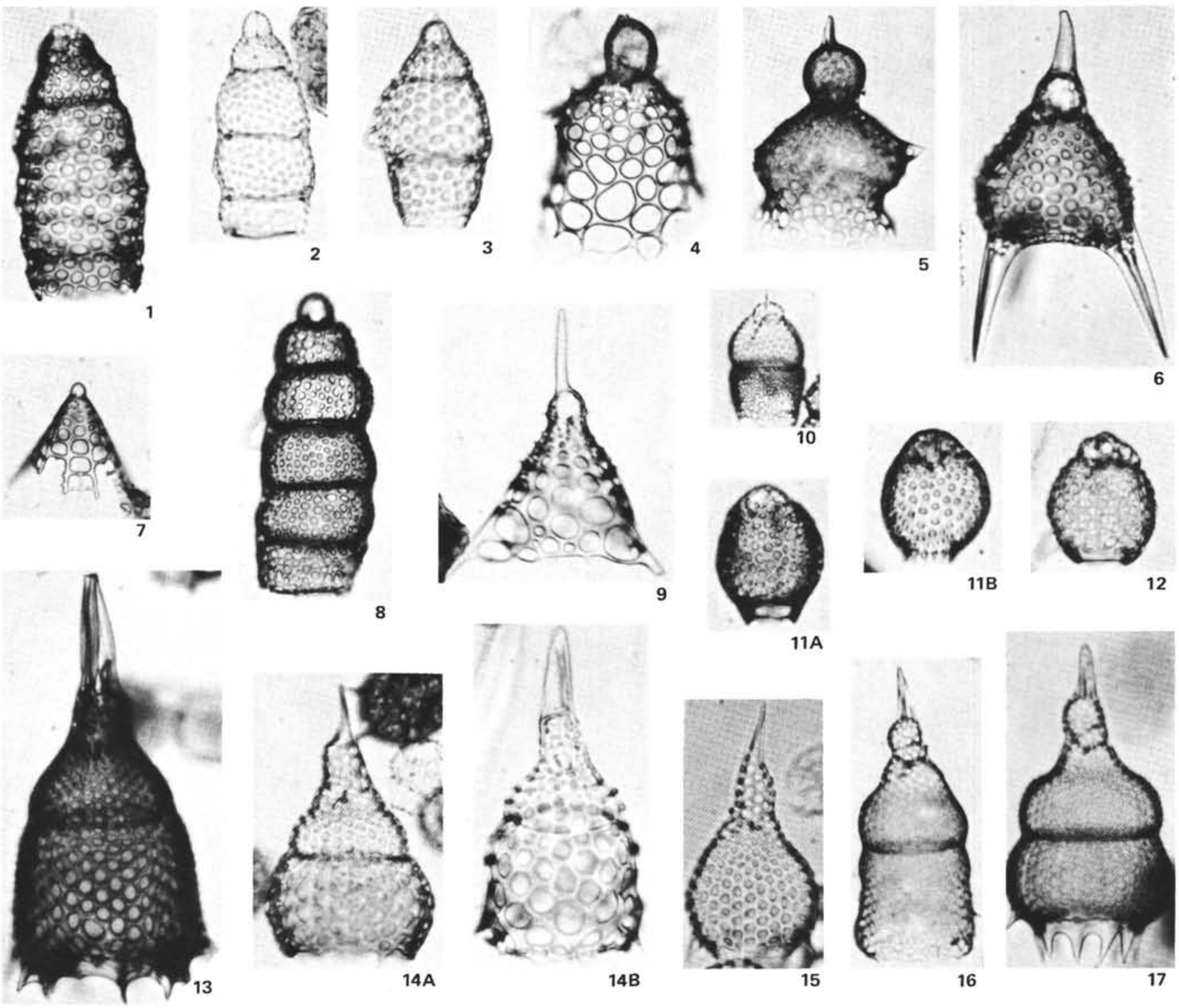

Plate 5. Radiolarians (230×). **1.** Other *Eucyrtidium:* Sample 552A-14-3, 11–12 cm, Sl. 1, S45/3. **2.** *Eucyrtidium* sp. A: Sample 552A-1-3, 53–54 cm, Sl. 1, H26/4. **3.** *Eucyrtidium* sp. B: Sample 552A-1-3, 53–54 cm, Sl.1, L29/4. **4.** *Gondwanaria* group A: Sample 552A-14-3, 11–12 cm, Sl.1, M19/3. **5.** *Gondwanaria* group B: Sample 552A-19,CC, Ph. 1, X16/1. **6.** *Pterocanium* group: Sample 555-15-1, 40–42 cm, Sl. 1, K35/1. **7.** *Litharachnium* group: Sample 552A-1,CC, Sl.2, U9/2. **8.** *Stichocorys delmontensis:* Sample 552-5,CC, Sl. 1, W10/3. **9.** Other Theoperids: Sample 552A-1,CC, Sl.2, U19/4. **10.** *Theocorys* group: Sample 552A-14-1, 30–31 cm, Sl.1, S30/1. **11.** *Carpocanistrum* group A, (A) Sample 555-15-1, 40–42 cm, Sl.1, T23/0; (B) Sample 552A-14-1, 30–31 cm, Sl.1, U22/0. **12.** *Carpocanistrum* group B: Sample 555-15-1, 40–42 cm, Sl.1, H6/4. **13.** *Lamprocyclas maritalis* group: Sample 552-4-2, 91–93 cm, Sl.1, R8/0. **14.** *Lamprocyrtis hannai,* (A) Sample 552A-26-1, 65–66 cm, Ph. 1, R28/0; (B) Sample 552A-19,CC, Sl.2, C9/0. **15.** *Anthocyrtidium* group: Sample 552A-28,CC, Sl. 2, W33/0. **16.** *Theocorythium trachelium:* Sample 552A-1,CC, Sl. 2, E10/4. **17.** *Theocorythium vetulum:* Sample 552A-27,CC, Sl.1, C21/1.

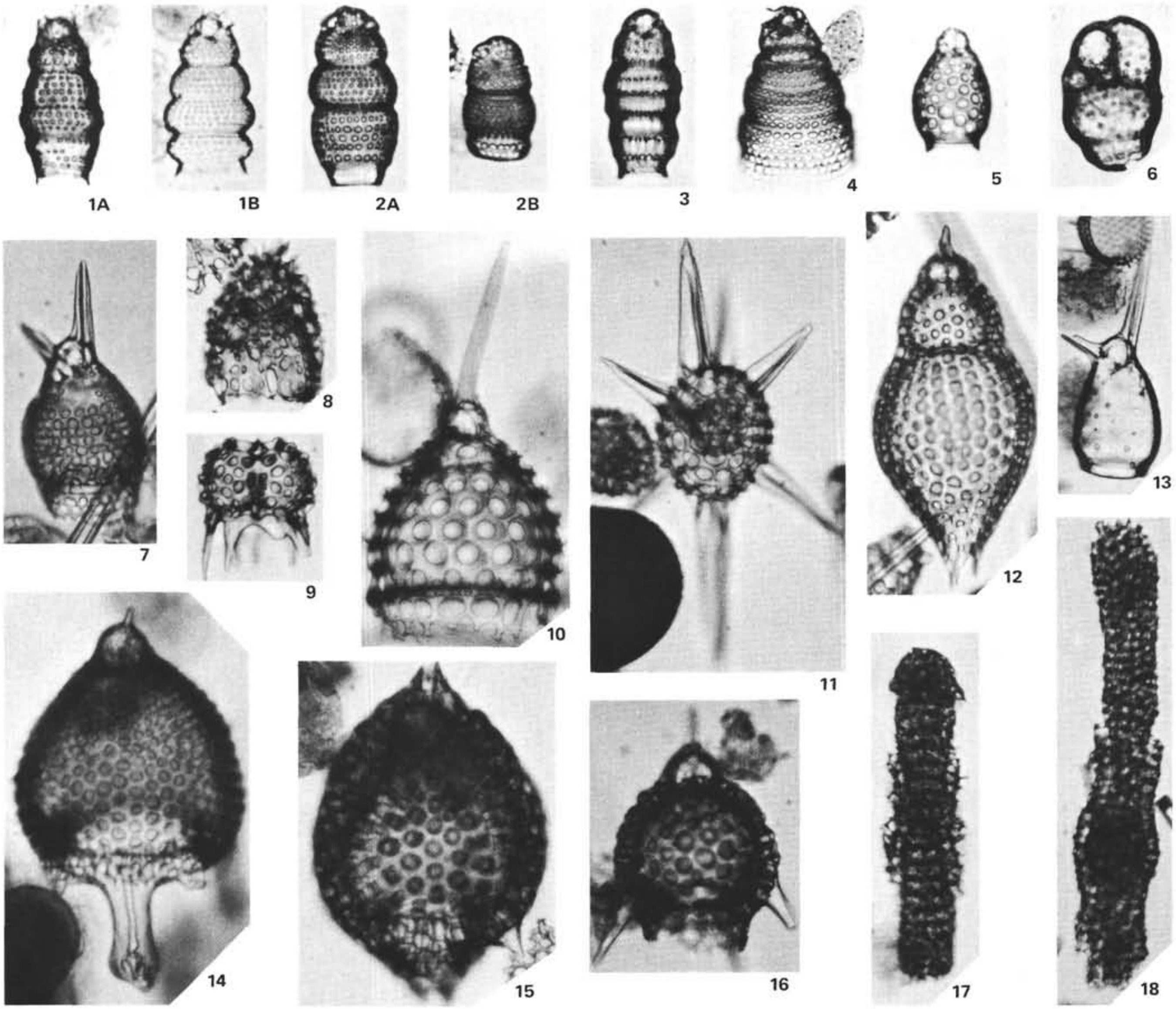

Plate 6. Radiolarians, 230×. **1.** *Botryostrobus* group, (A) Sample 552-3,CC, Sl.1, R9/3; (B) Sample 552-3,CC, Sl.1, Q19/0. **2.** *Phormostichoartus* group, (A) Sample 552-4-2, 91–93 cm, Sl.1, K15/0; (B) Sample 552A-14-1, 30–31 cm, Sl.1, C14/0. **3.** *Siphocampe* group: Sample 552-4-2, 91–93 cm, Sl.1, J19/0. **4.** *Spirocyrtis* group: Sample 552A-12-1, 95–97 cm, Sl.2, X36/2. **5.** *Carpocanarium* group: Sample 552-5,CC, Sl.2, N17/1. **6.** Cannobotryid group: Sample 552-4-2, 91–93 cm, Sl.1, H10/4. **7–18** Eocene radiolaria. **7.** *Lophocyrtis norvegiensis:* Sample 552-10,CC, Ph.1, L19/3. **8.** *Ceratocyrtis* sp.: Sample 552A-37-3, 62–63 cm, Sl. 2, C9/4. **9.** *Ceratospyris* sp.: Sample 552A-37-3, 62–63 cm, Sl. 2, T17/0. **10.** *Pterocodon ampla:* Sample 552-10,CC, Sl.2, H24/4. **11.** *Stylosphaera goruna:* Sample 552-10,CC, Sl.2, R47/1. **12.** *Phormocyrtis striata striata:* Sample 552-10,CC, Ph. 1, F39/3. **13.** *Lophocyrtis biaurita:* Sample 553A-10-1, 122–124 cm, Sl.2, C39/4. **14.** *Lychnocanoma amphitrite:* Sample 553A-10-1, 122–124 cm, Sl.2, F10/3. **15.** *Lamptonium obelix:* Sample 553A-10-2, 122–124 cm, Sl.2, U22/1. **16.** *Lamptonium pennatum:* Sample 553A-10-5, 98–100 cm, Sl.2, D15/1. **17.** *Amphymenium splendiarmatum:* Sample 553A-10-1, 122–124 cm, Sl.2, B7/0. **18.** *Amphicraspedum prolixum:* Sample 553A-11-4, 129–130 cm, Sl.1, T25/3.