

28. RADIOLARIA: LEG 19 OF THE DEEP SEA DRILLING PROJECT¹

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INTRODUCTION

Recent publications on Radiolaria from the higher latitudes, north of 40°N, of the North Pacific including the Bering Sea, deal with their biogeographic distribution (Nigrini, 1970; for others, see Ling et al., 1971). Hays (1970) recognized four biostratigraphic zones for the deep-sea sediments of the North Pacific encompassing the interval of late Pliocene and Pleistocene. During Leg 6 of the Deep Sea Drilling Project, Kling (1971) was able to follow Hays' scheme in the middle latitude of the North Pacific.

Careful attention was placed on stratigraphic occurrence of Radiolaria when the D/V *Glomar Challenger* drilled in the higher latitudes and in the Bering Sea during Leg 19 of the project and the subsequent shore laboratory studies based on the samples recovered from the eleven sites. Their localities are shown in Figure 1 and given in Table 1.

Although sediments from the Paleogene and late Cretaceous were recovered from Sites 183 and 192, only sediments younger than middle Miocene contain radiolarians. In total, 470 samples were examined which provide the basis for the present paper.

METHODS OF STUDY

The deep-sea samples were prepared aboard the ship with hydrogen peroxide followed by washing on a 63 μ sieve, instead of a 74 μ opening that had been used for previous similar studies (Ling et al., 1971); therefore a 63 μ sieve was also used during the shore laboratory preparation. Strewn slides were made from the residues retained on the screen, using Canada balsam as the mounting medium. Relative abundances for each site, shown in Tables 2-12, were based on the total count of radiolarians in single slides.

Although decantation or further screening could have been used to concentrate the radiolarian specimens in the slides, this was not done in order to make the results of the present study comparable with previous studies (Ling et al., 1971; Ling and McPherson, in press) and those currently in progress from the subarctic Pacific and Okhotsk Sea.

Samples are designated in the following manner: Site number-core number-section number (each core is cut into 1.5-m sections numbered from the top downward consecutively), followed by the position in centimeters from the top of the section. In the case of a core catcher sample, the

abbreviation CC is used in place of the section number. The locations of illustrated specimens in strewn slides are indicated after the above sample designation, by slide number and the reading of the England Finder as described previously (Ling and Anikouchine, 1967).

All slides examined during the present investigation will be deposited permanently in the micropaleontological collection of the Department of Oceanography, University of Washington.

SYSTEMATIC MICROPALAEONTOLOGY

The classification scheme proposed by Riedel (1967; 1971) is followed wherever applicable. Synonymies of taxa presented herein are kept to a minimum and are restricted to the original description and those which reflect the current concept or the latest usage of the species.

Order POLYCYSTINA Ehrenberg, 1838, emend. Riedel, 1967
Suborder SPUMELLARIA Ehrenberg, 1875
Family ACTINOMMIDAE Haeckel, 1862, emend. Riedel, 1967
Genus AXOPRUNUM Haeckel, 1887

Axoprunum angelinum (Campbell and Clark)
(Plate 1, Figures 1-4)

Stylosphaera angelina Campbell and Clark, 1944, p. 12, pl. 1, figs. 14-20.

Stylatractus univertus Hays, 1970, p. 215, pl. 1, figs. 1, 2.

Axoprunum angelinum (Campbell and Clark), Kling, in preparation.

Remarks: *A. angelinum* is found rarely throughout the present study, consequently difficulty was encountered in recognizing Hays' zone in most of the sites.

Genus STYLACONTARIUM Popofsky, 1912

Stylacontarium acquilonium (Hays)
(Plate 1, Figures 6, 7)

Druppatractus acquilonium Hays, 1970, p. 214, pl. 1, figs. 4, 5.

Stylacontarium acquilonium (Hays), Kling, in preparation.

Remarks: This species is found sporadically from several sites during Leg 19. In the area slightly south (see discussion), *S. acquilonium* is encountered more frequently.

Genus SATURNALIS Haeckel, 1881, emend. Nigrini, 1967

Saturnalis circularis Haeckel
(Plate 1, Figure 5)

Saturnalis circularis Haeckel, 1887, p. 131; Nigrini, 1967, pp. 25, 26, pl. 1, fig. 9.

Saturnulus planetes Haeckel, 1887, p. 142, pl. 16, fig. 7; Hays, 1965, p. 167, pl. 1, fig. 5.

Remarks: The present species is reported as a warm-water species in the modern Antarctic waters by Hays (1965) and from the Indian Ocean by Haeckel (1887) and Nigrini (1967). In the North Pacific, the present author observed that its northernmost occurrence in surface sediments corresponds approximately with the subarctic boundary (Dodimead et al., 1963).

¹Contribution No. 692 from the Department of Oceanography, University of Washington.

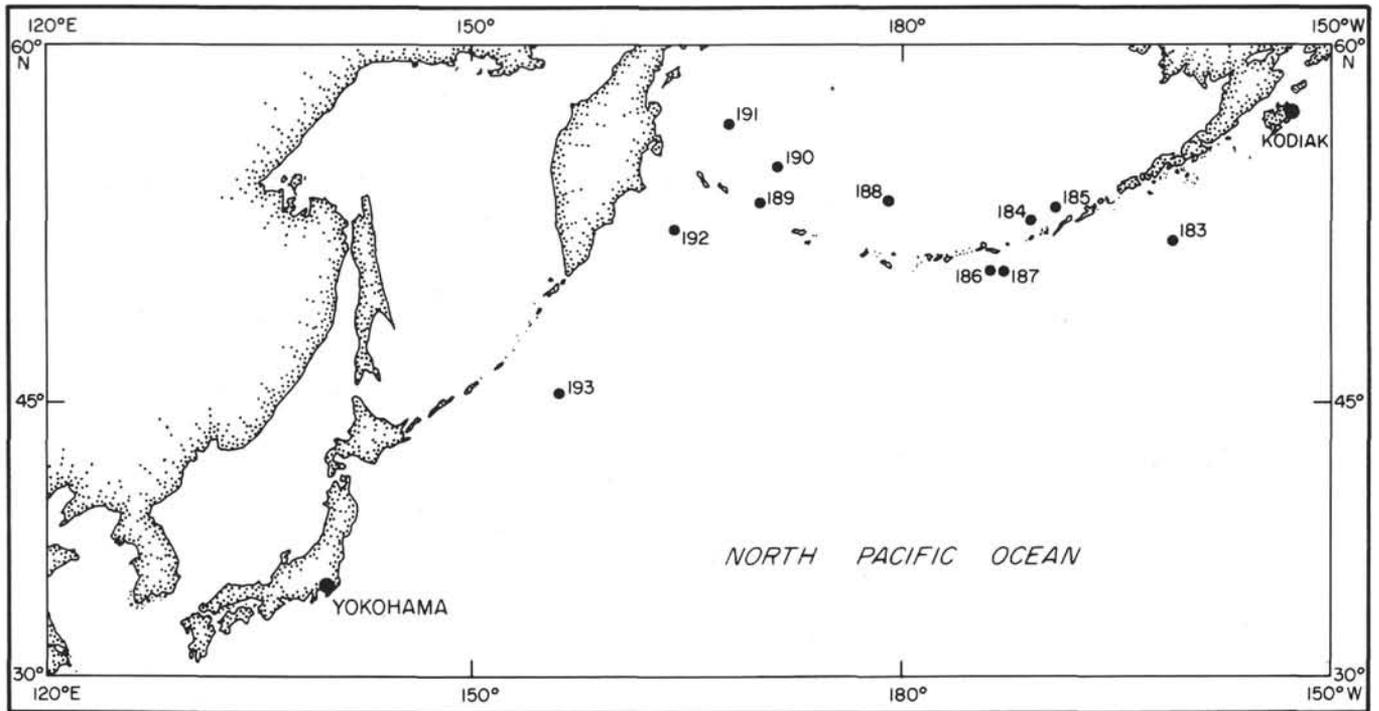


Figure 1. Geographic locations of drilling sites, Deep Sea Drilling Project, Leg 19.

TABLE 1
Coordinates of Drilling Sites,
Deep Sea Drilling Project, Leg 19

Hole	Latitude	Longitude	Water Depth
183	52°34.30'N	161°12.33'W	4708
184	53°42.64'N	170°55.39'W	1910
184A	53°42.64'N	170°55.39'W	1910
184B	53°42.64'N	170°55.39'W	1910
185	54°25.73'N	169°14.59'W	2110
186	51°07.81'N	174°00.34'W	4522
187	51°06.6'N	173°57.2'W	4567
188	53°45.21'N	178°39.56'E	2649
189	54°02.14'N	170°13.38'E	3437
190	55°33.55'N	171°38.42'E	3875
191	56°56.70'N	168°10.72'E	3854
191A	56°56.70'N	168°10.72'E	3860
191B	56°56.70'N	168°10.72'E	3860
192	53°00.57'N	164°42.81'E	3014
192A	53°00.57'N	164°42.81'E	3014
193	45°48.20'N	155°52.27'E	4811

Family SPONGODISCIDAE Haeckel, 1862, emend. Riedel, 1967

Genus STYLOCHLAMYDIUM Haeckel, 1887

Stylochlamyidium venustum (Bailey)
(Plate 1, Figure 8)

Perichlamyidium venustum Bailey, 1856, p. 6, figs. 16, 17.

Stylochlamyidium venustum (Bailey), Haeckel, 1887, p. 515; Ling et al., 1971, pp. 711, 712, pl. 1, figs. 7, 8.

Remarks: As discussed previously (Ling et al., 1971), *S. venustum* is one of the most common species in surface sediments of the Bering Sea.

Genus SPONGOPYLE Dreyer, 1889

Spongopyle osculosa Dreyer

Spongopyle osculosa Dreyer, 1889, pp. 42, 43, pl. 11, figs. 99, 100.

Genus SPONGODISCUS Ehrenberg, 1854

Spongodiscus sp.
(Plate 1, Figures 9, 10)

Description: Large discoidal biconvex shell whose surface consists of an irregular network with circular to subcircular pores approximately uniform in size of 8-11 μ . Central part, one-half to two-thirds of the diameter of the disc, thick and appears darker than the rest of the shell. Spines are completely absent from the surface. A "notch" is generally present. Diameter of shell, based on twenty specimens, 170-200 μ .

Remarks: Although the taxonomic value of the notch is not known at present, both upper and lower limits of this species suggest possible stratigraphic significance at least in this part of the North Pacific.

Radiolarians possessing such a notch have been reported by Popofsky (1912) and Benson (1966), both from warm-water regions. Besides the notch, Popofsky noticed a darker "ring" or "band" between the dark central part and the margin; nevertheless he referred it to Haeckel's (1887) species, *Spongodiscus biconcavus*, which was described from *Challenger* Station 265, south of Hawaii, but lacks these features. Benson (1966) illustrated a similar form from the Gulf of California sediments and considered it as conspecific with that of Popofsky, despite the absence of the darker ring. The meshwork of the shell from the present high-latitude North Pacific is not as dense as that from the Gulf of California judging from the figure; therefore in this paper, the present North Pacific form is considered as a separate taxon.

TABLE 2 – Continued

Sample	Taxa						Age		
	<i>Lithomitra arachnea</i> <i>Artostrobus annulatus</i> <i>Cycladophora davisiana</i> <i>C. d. "var." cornutoides</i> <i>Tricerasyris ? sp.</i>	<i>Spongopyle osculosa</i> <i>Stylochlamydidium venustum</i> <i>Eucyrtidium tumidulum</i> <i>Spongodiscus sp.</i>	<i>Saturnalis circularis</i> <i>Stylacotarium acquilonium</i> <i>Axoprunum angelinum</i> <i>Eucyrtidium matuyamai</i> <i>Stichocorys delmontensis</i> <i>Theocorys redondoensis</i>	<i>Lychnocanium sp.</i> <i>Amphymenium sp.</i> <i>Cyrtocapsella tetrapera</i> <i>Acanthodesmid sp.</i> <i>Eucyrtidium sp.</i>					
183-18-1(140-142) 183-18-2(82-84) 183-18-3(82-84) 183-18-4(82-84) 183-18(CC)	+ + + +	R		C C F F + +				Late	Miocene
183-19-1(120-122) 183-19-2(82-84) 183-19-3(80-82) 183-19-4(80-82) 183-19(CC)	R + + + +	+		R + R F R					
183-20-1(80-82) 183-20-2(80-82) 183-20(CC) 183-21-1(80-82) 183-21-2(82-84)	R + R + + + +	R +		R + R F A R R A			Middle		
183-21-3(80-82) 183-21-4(82-84) 183-21(CC)	R R + +	R +		R R R					

Genus AMPHYMENIUM Haeckel, 1881

Amphymenium sp.
(Plate 1, Figures 11, 12)

Remarks: In adhering to the original definition of Haeckel (1881, 1887), the specimens recovered from Cores 20 and 21 (possibly also 19) of Site 183 are provisionally placed under the present genus. Due to insufficient comparison material in the author's collection, no attempt has been made to identify them to specific level at this time. The fact that the present taxon occurs jointly with *Cyrtocapsella tetrapera* may suggest its biostratigraphic significance in this area.

Suborder NASSELLARIA Ehrenberg, 1875
Family ACANTHODESMIIDAE Haeckel, 1862,
emend. Riedel, 1967

Genus TRICERASYRIS Haeckel, 1881

Tricerasyris ? sp.
(Plate 1, Figures 13, 14)

Remarks: As in the previous study from the Bering Sea (Ling et al., 1971), two different forms are found and they are provisionally included under the present taxon. Although a form without basal spines shows its initial appearance slightly earlier than the other, their range of occurrence is approximately the same and only in the Pleistocene in this region.

"Acanthodesmid" sp.
(Plate 2, Figure 1)

Remarks: This species demonstrates wide variation in the nature of the five basal spines, ranging from short oblique projections to long downwardly extended legs and connected by horizontal bars with short spines, one of which is illustrated here. Limited time as well as reference materials did not permit the author to make a thorough and detailed comparison of this species with other related forms. However, this species is found in abundance from Core 21 of Site 183, together with *Cyrtocapsella tetrapera* and the above

mentioned *Amphymenium sp.*, thus may have potentiality as a Miocene index taxon.

Family THEOPERIDAE Haeckel, 1881, emend. Riedel, 1967

Genus CYCLADOPHORA Ehrenberg, 1847

Cycladophora davisiana Ehrenberg
(Plate 2, Figure 2)

Cycladophora davisiana Ehrenberg, 1862, p. 297.

Cycladophora davisiana "var." *cornutoides* Petrushevskaya
(Plate 2, Figure 3)

Halicalyptra ? cornuta Bailey, 1856, p. 5, pl. 1, fig. 14 (only).
Cycladophora davisiana var. *cornutoides* Petrushevskaya, 1967, pp. 124-126, fig. 70, I-III.
Cycladophora davisiana "var." *cornutoides* Petrushevskaya, Ling et al., 1971, pp. 714, 715, pl. 2, figs. 6, 7.

Genus CYRTOCAPSELLA Haeckel, 1887

Cyrtocapsella tetrapera Haeckel
(Plate 2, Figure 4)

Cyrtocapsella tetrapera Haeckel, 1887, p. 1512, pl. 77, fig. 8; Sanfilippo and Riedel, 1970, p. 453, pl. 1, figs. 16-18.

Remarks: *C. tetrapera* is found in Cores 20 and 21 from Site 183 which is regarded during the present leg as middle Miocene based on diatom and silicoflagellate microflora.

Genus EUCYRTIDIUM Ehrenberg, 1847

Eucyrtidium matuyamai Hays
(Plate 2, Figures 5, 6)

Eucyrtidium matuyamai Hays, 1970, p. 213, pl. 1, figs. 7-9.

Remarks: *E. matuyamai* is found rarely from Sites 183, 188, 190, and 192.

TABLE 3
Radiolarians from Site 184

Sample	Taxa					Age
	<i>Lithomitra arachnea</i>	<i>Artostrobos annulatus</i>	<i>Cycladophora davisi</i>	<i>Stylochlamydidium venustum</i>	<i>Triceraprysis</i> ? sp.	
184-1-1(75-77) 184-1(CC)	R +	R R	R	R		Late Pleistocene
184-2-3(132-134) 184-2-5(132-134) 184-2(CC)	+ +	R +				
184-3-3(102-104) 184-3-5(102-104) 184-3(CC)	+ +	R				
184-4-4(142-144) 184-4(CC)	+ +					
184-5(CC) 184-6-4(142-144) 184-6(CC) 184-7-4(142-144) 184-7(CC)	R + + +					Late Pliocene
184-8-4(142-144) 184-8(CC) 184-9-4(52-54) 184-9(CC) 184-10-3(72-74)	+ +	R				
184-10(CC) 184-11-3(62-64) 184-11(CC) 184-12-1(82-84) 184-12-2(82-84)	+ R + +					
184-12-3(82-84) 184-12(CC) 184-13-2(82-84) 184-13(CC) 184-14-3(52-54)	+ + + +		R			
184-14(CC) 184-15-1(132-134) 184-15(CC) 184-16-2(32-34) 184-16(CC)	+ + + R		R			Early Pliocene
184-17-2(42-44) 184-17-3(22-24) 184-17(CC) 184-18-1(22-24) 184-18(CC)	R R + R + R +					
184-19(CC) 184-20-3(122-124) 184-20(CC) 184-21-1(132-134) 184-21(CC)	R + R +					
184-22(CC)	+ +					

Eucyrtidium tumidulum Bailey
(Plate 2, Figures 7, 8)

Eucyrtidium tumidulum Bailey, 1856, p. 5, pl. 1, fig. 11.

Remarks: Riedel and Sanfilippo (1971) considered the possibility of Bailey's name being a junior synonym of *Artostrobium miralestense*, which was originally described as *Dictyocephalus miralestensis* by Campbell and Clark (1944) from the Miocene of

California. Kling (in preparation) accepted this concept. However, this practice is not followed by the present author until a detailed comparison of Miocene forms from California is made.

Eucyrtidium sp.
(Plate 2, Figure 9)

Remarks: Although the dimension as well as the structure of the cephalus and thorax are similar to *E. matuyamai*, the present taxon differs in possessing two longitudinal rows of circular pores in shallow furrows separated by prominent ridges in the third and fourth segments. The specimen is found in Miocene sediments from Site 183.

Genus LYCHNOCANIUM Ehrenberg, 1857

Lychnocanium sp.
(Plate 2, Figures 10, 11)

Remarks: This species is similar to Japanese Miocene species, *L. nipponicum* of Nakaseko (1963), but differs from it in possessing a characteristic thick and long apical horn. The specimens are observed only in the Miocene section from Site 183 and further study will be necessary to compare their stratigraphic occurrence with other related forms.

Genus STICHOCORYS Haeckel, 1881

Stichocorys delmontensis (Campbell and Clark)
(Plate 2, Figure 12)

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.

Genus THEOCORYS Haeckel, 1881

Theocorys redondoensis (Campbell and Clark)
(Plate 2, Figure 13)

Theocorys redondoensis Campbell and Clark, 1944, p. 49, pl. 7, fig. 4.

Theocorys redondoensis (Campbell and Clark), Kling, in preparation.

Remarks: As correctly pointed out by Kling (in preparation), this species should belong to the present family and not to Pterocoryidae.

Family ARTOSTROBIDAE Riedel, 1967

Genus ARTOSTROBUS Haeckel, 1887

Artostrobos annulatus (Bailey)
(Plate 2, Figure 14)

Cornutella ? annulata Bailey, 1856, pl. 1, fig. 5a, b.

Remarks: The present taxon and the following, *Lithomitra arachnea*, are the two long-ranging radiolarians which are found in many samples throughout the present study.

Genus LITHOMITRA Bütschli, 1882

Lithomitra arachnea (Ehrenberg)
(Plate 2, Figure 15)

Eucyrtidium lineatum, γ *arachneum* Ehrenberg, 1862, p. 299.

Lithomitra arachnea (Ehrenberg), Riedel, 1958, pp. 242, 243, pl. 4, figs. 7, 8.

Order TRIPYLEA Hertwig, 1879

Family LIRELLIDAE Loeblich and Tappan, 1961

Genus LIRELLA Ehrenberg, 1872

Lirella baileyi Ehrenberg

Cadium marinum Bailey, 1856, p. 3, pl. 1, fig. 2.

Lirella baileyi Ehrenberg, 1872, p. 248, pl. III, fig. 29a, b; Loeblich and Tappan, 1961, pp. 231, 232.

Remarks: Although it is not listed in tables of radiolarian occurrences, nor illustrated here, the occurrence of the present

TABLE 4
Radiolarians from Site 185

Sample	Radiolarians						Age				
	<i>Lithothra arachnea</i>	<i>Artostrobis annulatus</i>	<i>Cycladophora davistana</i>	<i>C. d.</i> "var." <i>cornuoides</i>	<i>Stylochlamydidium venustum</i>	<i>Spongodiscus</i> sp.	<i>Stylacotarium acquilonium</i>	<i>Spongopyle osculosa</i>	<i>Theocorys redondoensis</i>		
185-1-1(22-24)		R	+							Late	Pleistocene
185-1(CC)											
185-2(CC)		F									
185-3-1(52-54)		F		F							
185-3(CC)	R	R									
185-4-2(32-34)	R	F								Middle	Pleistocene
185-4-4(32-34)		R	+		R						
185-4(CC)	R	F		R	R						
185-5(CC)					R						
185-6-4(142-144)		R									
185-6(CC)	R	+								Early	Pliocene
185-7-1(104-106)	+		+								
185-7-3(102-104)											
185-7(CC)	R	+	F			+					
185-8-1(122-124)	R		+	+			+				
185-8-3(132-134)	+									Early	Pliocene
185-8(CC)		+	+				+				
185-9(CC)											
185-10-3(52-54)	+										
185-10(CC)	+	+									
185-11-1(132-134)											Late Miocene
185-11(CC)											
185-12-1(112-114)	R	+				+					
185-12(CC)	+	+	+								
185-13-1(132-134)											
185-13(CC)							+				Late Miocene
185-14-1(72-74)							R				
185-14(CC)	+						+				
185-15-1(122-124)											
185-15(CC)	+	+									
185-16-1(112-114)							+				Late Miocene
185-16(CC)							+				
185-17(CC)		+						+			

species is noted from the following samples during the present study; 188-1-1 (63-65 cm); 186-4-2 (132-134 cm); and 192-16-1 (102-104 cm). Reschetnyak (1966) recorded the present species from the Bering Sea and northwestern Pacific plankton samples.

***Lirella mela* (Cleve)**
(Plate 2, Figure 16)

Beroetta mela Cleve, 1899, P. 27, pl. 1, fig. 8.

Cadium mela (Cleve), Borgert, 1901, pp. 50, 51, fig. 58; Stadum and Ling, 1969, p. 484, pl. 1, figs. 6-8.

Remarks: *L. mela* seems to bear no stratigraphic significance, and is not listed in Table 2-12. The species is nevertheless mentioned here to record its occurrence in this studied area.

RADIOLARIAN OCCURRENCE AT EACH SITE

In Tables 1-12, the occurrence of radiolarian taxa from each site is presented. Abundance of species in one strewn slide is indicated as: "+" (single specimen), "R" (rare,

2-5 specimens), "F" (few, 6-10 specimens) "C" (common, 11-25 specimens), and "A" (abundant, over 26 specimens).

Although samples were examined from each site for the entire core length, radiolarians were absent in the lower sections. Consequently, these barren samples were not listed in the tables: 183-22(CC) through 183-39(CC); 184-23(CC), 184B-1(75), 184B-2(CC) through 184B-14(CC); 185-18(CC) through 185-27(CC); 186-24-1(52-54) through 186-28(CC); 187-3(CC) (limestone part) and 187-4(CC); 188-15-2(22-24) through 188-18(CC); 189-6(CC) through 189-20(CC); 190-14-2(102-104) through 190-16(CC); 191-12(CC) through 191-14(CC); 191B-1-1(42-44) through 191B-1(CC); 192-26-1(108-110) through 192-33(CC), and 192A-1-5(3-5) through 192A-5-1(18-20).

DISCUSSION ON RADIOLARIA

General Remarks

Throughout the present investigation, preservation of radiolarian skeletons in samples is moderate, and those containing mostly incomplete specimens are rarely encountered. Upper Pleistocene and middle Miocene sections (at Site 183) contain generally well-preserved specimens.

Radiolarian abundance, both in number of specimens as well as species diversity, declines downward from the middle part of the Pleistocene sequence and a sharp decrease is evident in the Pliocene and most of the Miocene sections, except at Site 183 where middle Miocene sediments are encountered. This middle Miocene is also the oldest radiolarian-bearing sediment recovered during Leg 19. Paleogene and Upper Cretaceous sediments were recovered at Site 192, but radiolarians were completely absent.

In all sites, radiolarians, together with other siliceous microplanktonic remains, disappear when the cores penetrate from the upper diatom-bearing sediments down to compact fine-grained sediment sections. In this lower section, even the diatoms, the principal constituents of sediments of this region, become either scarce, and mostly in fragments, or completely absent, apparently suggesting a diagenetic effect.

Although selective solution of certain species, resulting in the samples containing only a few species, could not be denied, it is generally understood and somewhat expected that species diversity would decrease towards higher latitude, at least in the Northern Hemisphere.

One explanation for such low frequency of radiolarian population in the area is high diatom productivity. According to Lisitsyn (1969, p. 182), diatoms outnumber other biogenic elements both in the suspended matter as well as in the sediments, and he (op. cit., p. 447) regarded the Bering Sea basin as lying in the zone of diatomaceous ooze or the siliceous belt of the Northern Hemisphere. Earlier, Reville (1944) mapped the region immediately south of the Aleutian Trench as a diatom ooze; thus it is reasonable to assume that the number of radiolarians is diluted by diatom valves.

TABLE 5
Radiolarians from Site 186

Sample	Taxa										Age	
	<i>Lithomitra arachnea</i>	<i>Artostrobus annulatus</i>	<i>Cycladophora davisiana</i>	<i>C. D. "var." cornutoides</i>	<i>Stylochlamydidium venustum</i>	<i>Tricerapys</i> ? sp.	<i>Eucyrtidium tumidulum</i>	<i>Spongopyle osculosa</i>	<i>Spongodiscus</i> sp.	<i>Axoprunum angelinum</i>	<i>Stylocontarium acquilonium</i>	Age
186-1-1(122-124)	+	+	R	R	+	+						
186-1(CC)	R	R	+	R	+	+						
186-2-3(77-79)	R	R	+	R	F	+	R	+				
186-1(CC)	R	R	+	R	R	+	R	+				
186-3-3(102-104)				R								
186-3(CC)	+	+	+	+	+		+	+				Middle
186-4-2(132-134)				R	+	+			R			
186-4-4(132-134)				+	R				F			
186-4(CC)	+	+	+	+		+						
186-5-3(120-122)				+	R	R	+					
186-5(CC)	+											
186-6(CC)	+		+									
186-7-3(32-34)	+	+	R			+		+				
186-7(CC)	+	+	+									
186-8-3(34-36)				+	R							
186-8(CC)	+	+	+									Middle
186-9-2(112-114)												
186-9-4(142-144)	+	+				+						
186-9(CC)												
186-10-3(40-42)								F		+		
186-10(CC)								+				
186-11-4(132-134)		+								+		
186-11(CC)		+										
186-12-1(102-104)	+	+							+			
186-12(CC)	+	+										
186-13-1(122-124)				+								Late
186-13(CC)		+										
186-14(CC)	+	+	+									
186-15(CC)	+											
186-16-1(25-27)												
186-16(CC)	+	+										Late
186-17-1(132-134)	+											
186-17(CC)	+	+		+								
186-18-1(132-134)	+	+										
186-18(CC)	+	+										
186-19(CC)	+											Early
186-20-1(132-134)												
186-20(CC)	+		+									
186-21(CC)	+	+										
186-22-1(122-124)								+				
186-22(CC)								+				Middle Miocene
186-23-1(122-124)	+							R				
186-23-2(122-124)												
186-23-3(52-54)	+							+				
186-23(CC)		+										

Another possible reason is that many radiolarians, including so-called guide species, are found more commonly in the Pacific Ocean proper, slightly south of the area that Leg 19 covered. As an example, in core TT 28-24 (located at 47°56'N, 154°06'W, in water depth of 5120 meters—for the geographic position and other stratigraphic data, see Ling, 1970) from the University of Washington core

collection, all the index forms of the Pleistocene interval of Hays are recognized. They are presented in a plate for comparison.

Radiolarian Biostratigraphy

Prior to Leg 19, the only references that treated in detail Cenozoic radiolarian assemblages were the works by Hays

TABLE 6
Radiolaria from Site 187

Sample	Taxa			Age
	<i>Lithomitra arachnea</i>	<i>Artostrobos annulatus</i>	<i>Spongopyle osculosa</i> <i>Spongodiscus</i> sp.	
187-1(CC) ls part	R	R	R	Early Pleisto.
187-1(CC)	R	R	R	Early Pliocene
187-2(CC)	R	R		
187-3(CC)			R	

(1970) and Kling (1971); therefore, a detailed description of stratigraphic occurrences of Radiolaria from the high-latitude region of the North Pacific and the Bering Sea was one of the main objectives of the present author during and after the cruise. This goal, unfortunately, was not reached because of the general paucity of specimens in the samples, while many other samples contained only long-ranging species. Thus, age assignments throughout the present study are mostly based on the data from diatom microflora. The following is a brief summary of stratigraphic occurrence of Radiolaria as the sequence was observed during the actual coring operation.

Extinction of *Saturnalis circularis* and *Spongodiscus* occurs slightly after the initial appearance of modern radiolarian species commonly found in surface sediments from this region. This occurs during the middle Pleistocene. These modern forms include *Dictyophymus gracilipes*, *Triceraspyris* ? sp., and *Stylochlamidium venustum*, with the last as the representative.

Among Hays' zone index species, the top of *Drupatractus acquilonis* (= *Stylocontarium acquilonium* in this paper) was observed with some confidence in sediments from Sites 183, 190, and 192 (possibly also 191), although the species was also found from Sites 185, 186, 188, 189, and 193. Only from Sites 183 and 186 was *Stylatractus universus* (= *Axoprimum angelinum* in this paper) recovered, and the extinction occurs at the same level with that of the above species from Site 183.

Although another of Hays' index forms, *Eucyrtidium matuyamai*, was found from Sites 183, 188, 192, and also probably 190, it occurs only rarely. This, coupled with the complete absence of the Pliocene index form *Lamprocyclus heteroporos* ? (= *Lamprocyrtis heteroporos* Kling, in preparation), makes it impossible for this author to delineate the Plio-Pleistocene boundary based on the present (Leg 19) radiolarian data.

In Cores 17 through 21 from Site 183, occurrence of Miocene forms such as *Stichocorys delmontensis*, *Cyrtocapsella tetrapera*, and *Theocorys redondoensis* was noticed together with other hitherto undescribed taxa. Judging

from the different levels of the top of the range of *Stichocorys delmontensis* and *Cyrtocapsella tetrapera*, this Miocene interval can be subdivided in the future, when a detailed examination of the samples is completed. As mentioned earlier, this assemblage also represents the oldest radiolarian fauna found from Leg 19.

Radiolarian Events

Some radiolarian events observed during the present study, which seem to have biostratigraphic potential at least in this part of the Pacific, are presented in Table 13. In order to make this information from the high-latitudes comparable with that from low- and middle-latitudes of the North Pacific, the table is constructed in the manner prepared by Riedel and Sanfilippo (1971) and Kling (in preparation).

Events are here arranged in chronological order as observed from Site 183, which contains the most events and is regarded as the best for reference among the sites drilled. "T" and "B" in the left column indicate the top and the bottom of the range of the taxa. The events recognized from other sites are given in the right column with paired core-sections between which the phenomena occurred. In the parentheses are sample depths in centimeters below the top of the section. The letters "P," "M," and "G" are used for "Poor," "Moderate," and "Good" to express the degree of reliability of such events at each site, based on occurrence of the species in samples and their abundance. None of these events were found in Sites 184 and 187; therefore these two sites were omitted from the table.

The construction of the table also shows the age relationships of the sediments among the sites of Leg 19. At the same time it is possible to attempt comparison of similar events so far reported from other parts of the world, both from land outcrops and deep-sea sediments, as presented below:

1) *Spongodiscus* sp. The upper limit of this species occurs at or slightly below that of *Stylocontarium acquilonium* (Radiolaria), *Rhizosolenia curvirostris* (diatom), and *Distephanus octonaria* (silicoflagellate) zones. Furthermore, the earliest occurrence of *Stylochlamidium venustum* (Radiolaria) generally coincides with this level. Donahue (1970) recorded the age of the extinction point of *Rhizosolenia curvirostris* and its var. *inermis* as between 0.25 and 0.45 m.y., while Hays (1971) reported the age of the upper limit of *Stylocontarium acquilonium* as 0.3 m.y.

2) *Saturnalis circularis*. The upper limit of this species as *S. planetes* has been recognized to mark the boundary of ψ (Psi) - χ (Chi) zones and has been considered as the approximate boundary of the Bruhnes-Matuyama magnetic epochs of about 0.7 m.y. in the Antarctic (Hays, 1965; Hays and Opdyke, 1967; Bandy et al., 1971). In the present North Pacific study, however, this level is found, although tentatively, near the top of *Spongodiscus* sp. which is discussed above. Thus, withdrawal of *S. circularis* from the high-latitude regions of the two hemispheres may occur at

TABLE 7
Radiolarians from Site 188

Sample	Taxa										Age		
	<i>Lithomitra arachnea</i>	<i>Artostrobos annulatus</i>	<i>Cycladophora davisiana</i>	C. d. "var." <i>cornuoides</i>	<i>Stylochlamydidium venustum</i>	<i>Tricerapys</i> ? sp.	<i>Eucyrtidium tumidulum</i>	<i>Spongodiscus</i> sp.	<i>Spongopyle osculosa</i>	<i>Eucyrtidium matuyamai</i>	<i>Stylocantarium acquilonium</i>		
188-1-1(63-66)	R	R	R	R	F	R							
188-1(CC)	+	+	+	+	+	+						Late	Pleistocene
188-2(CC)	+	+			+	+							
188-3-2(132-134)	R	R	F	R									
188-3-4(132-134)	P	R	+	+	+								
188-3(CC)	+	+	+	+	+		+	+				Middle	
188-4(CC)	+	+											
188-5(CC)	+	+		+		R	+						
188-6-2(62-64)	+		C			+							
188-6(CC)	+	+	+				+						
188-7-1(103-105)		R	R	R		R						Early	
188-7-4(52-54)	R	F	F	R		+	+	+	+	+			
188-7(CC)	+	+	+			+		+					
188-8-1(102-104)													
188-8(CC)	R	F	R			+							
188-9-1(42-44)	+	+											
188-9-3(142-144)		+											
188-9-3(150)													
188-10(CC)	+	+		+				+				Late	
188-11-1(54-56)	R	+											
188-11(CC)	+	+		+									
188-12-1(62-64)				+									
188-12(CC)	+	+											
188-13-1(103-105)	R	R				R						Early	
188-13(CC)	R	+	+										
188-14-1(31-33)	R	F											
188-14-C	+	+										Late Mio.	

different times, and is earlier in the Southern Hemisphere than in the Northern Hemisphere.

3) *Stichocorys delmontensis*. Riedel and Sanfilippo (1971), Sanfilippo and Riedel (1970), and Moore (1971) reported that the last occurrence of *S. delmontensis* and the first evolutionary appearance of its descendant species, *S. peregrina*, are found within the upper Miocene interval. However, an overlap of range for these two species is noted by Kling (1971) and Goll (1972). Rather considerable overlap was also noticed by Kling (in preparation) from Site 173 off northern California, and the top of this species and that of *Theocorys redondoensis* was found in the *Stichocorys peregrina* Zone and is regarded as near the Miocene-Pliocene boundary from the site. In the sample from Sites 183 and 192 where *S. delmontensis* was recovered, no specimen referable to *S. peregrina* was observed. Furthermore there is an interval between the Plio-Miocene boundary based on diatom and silicoflagellate microflora and the extinction level of the species.

4) *Cyrtocapsella tetrapera*. The upper limit of the range of this species is recorded in the lower latitudes of the Pacific in the *Dorcadospyris alata* Zone by Kling (1971) during Leg 6, by Riedel and Sanfilippo (1971) during Leg 7, in the *Cannartus laticonus* Zone by Moore (1971) during Leg 8, and by Goll (1972) during Leg 9. From the Antarctic region, Bandy et al. (1971) reported that the top of this species, together with that of *Theocorys redondoensis* (= *Theocorys redondoensis* in this paper), marks the upper boundary of their Υ (Upsilon) unit within the upper Gilbert magnetic reversed epoch. Recently Kling (in preparation) drew the range of *C. tetrapera* extending into *Ommatartus antepenultimus* (Radiolaria) Zone at Site 173 from Leg 18. From Southern California, Casey et al. (1972) reported that the last occurrence of *C. tetrapera* and those of *C. japonica* and *Cannartus laticonus* mark the top of *Cannartus petterssoni* Zone which is correlated with the top of the Luisian Stage of California and the top of the middle Miocene.

TABLE 8
Radiolarians from Site 189

Sample	Taxa						Age	
	<i>Lithomitra arachnea</i>	<i>Artostrobus annulatus</i>	<i>Cycladophora davisiana</i>	<i>C. d. "var." cornuoides</i>	<i>Spongopyle osculosa</i>	<i>Stylochlamydidium venustum</i>	<i>Tricerapsyris ? sp.</i>	<i>Stylocantarium acqulionium</i>
188-1-1(73-75)	F	R	F	+	R	R		late Pleistocene
189-1(CC)	+	+	+	+	+	+		
189-2(CC)	+	+	+		+	+		
189-3-1(112-114)	+		R	+		+		
189-3(CC)	R	R	R				+	
189-4-2(12-14)	R	+	+					Early Plio.
189-4(CC)	+	+				+		
189-5-1(32-34)	+		R					
189-5(CC)	+	+	+					
189-6-1(86-88)	R		R					

TABLE 9
Radiolarians from Site 190

Sample	Taxa								Age				
	<i>Lithomitra arachnea</i>	<i>Artostrobus annulatus</i>	<i>Cycladophora davisiana</i>	<i>C. d. "var." cornuoides</i>	<i>Tricerapsyris ? sp.</i>	<i>Stylochlamydidium venustum</i>	<i>Spongodiscus sp.</i>	<i>Eucyrtidium tumidulum</i>	<i>Stylocantarium acqulionium</i>	<i>Spongopyle osculosa</i>	<i>Saturnalis circularis</i>	<i>Eucyrtidium matuyamai</i>	
190-1-1(67-69)	R												Late Middle Pleistocene
190-1(CC)	R	R	F	F	R	R	R						
190-2(CC)	F	R	F	F	R	R	R						
190-3-2(112-114)						+							
190-3(CC)	F	F	R	R	F	C	F	R	R	R	R		
190-4-2(112-114)	R	R	R	R	R	R	R	R			R		Middle Pleistocene
190-4(CC)	R	R		R	R		R	R	R				
190-5-2(102-104)	+	+	R	+	R		+						
190-5-5(42-44)	+		R	R				R	+				
190-5(CC)	F	F	R	F	+					R			
190-6-3(32-44)		R		+	+			R			R		Middle Pleistocene
190-6(CC)	F	F	+	R	R		+	R	R				
190-7-2(112-114)	R												
190-7(CC)	R	R											
190-8-3(42-44)					R			+					
190-8(CC)	R	+											Early Pleistocene
190-9-1(52-54)	+	R						+					
190-9(CC)	+	+											
190-10-2(30-32)	+				+					+			
190-10(CC)	R	+	+										
190-11-1(137-139)		+											Late Pliocene
190-11-3(137-139)			+										
190-11(CC)		+	R										
190-12-1(72-74)	+	+											
190-12-3(32-34)	+												
190-12(CC)	C	F	R	R					+				Early Pliocene
190-13-1(102-103)													
190-13(CC)	R												

TABLE 10
Radiolarians from Sites 191 and 191A

Sample	Taxa							Age				
	<i>Lithomitra arachnea</i>	<i>Artostrobus annulatus</i>	<i>Cycladophora davisiana</i>	<i>C. D. "var." cornutoides</i>	<i>Stylochlamydidium venustum</i>	<i>Triceraporys ? sp.</i>	<i>Spongopyle osculosa</i>	<i>Eucyrtidium tumidulum</i>	<i>Stylocontarium acquilonium</i>	<i>Spongodiscus sp.</i>		
191-1(CC)	R	R	R	R	R						Late	Pleistocene
191-2-1(52-54)		R	+	R	R	R		F				
191-2(CC)	+			R			+					
191-3(CC)	R	+	R	R		+						
191-4-1(102-104)					R					+		
191-4-5(112-114)		R	R	+	F		+	R		F		
191-4(CC)	+					+						
191-5-6(72-74)		+	R			+				R		
191-5(CC)	+	R		+								
191-6-2(122-124)	+									+		
191-6(CC)					R			R	R	+		
191-7(CC)										+		
191-8-2(132-134)			+	+								
191-8(CC)	R	+										
191-9(CC)	R	R										
191-10-2(62-64)												
191-10(CC)												
191-11-2(10-12)		+							+			
191-11(CC)	R	+	R									
191-12-1(123-125)		+										
191A-1-1(0-2)	+	+	R	R	+							
191A-1(CC)	+	+	F	R								
191A-2-2(80-82)	F	R	R	R	+	R						
191A-2(CC)	F	R	F	R	F	F		R				
191A-4-1(137-139)	R	+	R	R	F	+		R				
191A-4(CC)	R		R	R		R						

TABLE 11
Radiolarians from Site 192

Sample	Taxa						Age
	<i>Lithomitra arachnea</i>	<i>Artostrobus annularis</i>	<i>Cycladophora davisi</i>	<i>C. d.</i> "var." <i>cornuoides</i>	<i>Stylochlamydidium venustum</i>	<i>Tricerapys</i> ? sp. <i>Eucyrtidium tumidulum</i> <i>Spongodiscus</i> sp. <i>Spongopyle osculosa</i> <i>Stylocontarium acquilonium</i> <i>Eucyrtidium matuyamai</i> <i>Stichocorys delmontensis</i>	
192-1-1(56-58) 192-1(CC) 192-2-2(137-139) 1-2-2(CC) 192-3-3(22-24)	+ + + + + + + + + +	R R + + R	+ R + + +	+ + + + +	+ + + + R	+ + + + R	Late
192-3(CC) 192-4-3(22-24) 192-4-5(17-19) 192-4(CC) 192-5-3(12-14)	+ + + + + + + + + R	+ + R + R R + + R R	+ R R + R	+ + + + R	+ + + + F C	+ R + + R + R	Middle
192-5(CC) 192-6-1(137-139) 192-6(CC) 192-7-2(22-24) 192-7(CC)	+ + + + + + + + + +	+ + C R + R R +	+ + + + +	+ + + + +	+ + R + + + +	+ + + + + + + + +	Early
192-8-1(137-139) 192-8-4(72-74) 192-8(CC) 192-9-2(52-54) 192-9-4(102-104)	+ + R + + + + + R	+ + R R + + F +	+ + + + + + + + +	+ + + + + + + + +	+ + + + + + F +	+ + + + + + F +	Late
192-9(CC) 192-10-1(122-124) 192-10-4(32-34) 192-10(CC) 192-11-1(120-122)	+ + + + + + + + +	+ + + + + + + + +	+ + R R + +	Early			
192-11(CC) 192-12-1(52-54) 192-12(CC) 192-13-2(52-54) 192-13-4(32-34)	+ + R + + + + + + +	+ + R + + + + +	+ + R + + + + +	+ + R + + + + +	+ + R + + + + +	+ + F + + + + +	Early
192-13(CC) 192-14-1(52-54) 192-14(CC) 192-15-1(110-112) 192-15-3(102-104)	+ + R + + + R R	+ + R + + R R	+ + R + + + + +	+ + R + + + + +	+ + R + + + + +	+ + + + + + + + +	Early
192-15(CC) 192-16-1(102-104) 192-16(CC) 192-17-1(125-127) 192-17(CC)	+ + + + + + + + + +	+ + + + + + + + + +	+ + + + + + + + + +	Early			
192-18-2(52-54) 192-18-4(100-102) 192-18(CC) 192-19-1(50-52) 192-19(CC)	F R R + + R R + +	F R R + + R R + +	F R R + + R R + +	Late			
192-20-1(32-34) 192-20(CC) 192-21-1(52-54) 192-21(CC) 192-22-1(102-104)	R + + + + + + + +	R + + + + + + + +	R + + + + + + + +	Miocene			

TABLE 11 – Continued

Sample	Taxa										Age	
	<i>Lithomitra arachnea</i>	<i>Artostrobus annulatus</i>	<i>Cycladophora davisiana</i>	<i>C. d.</i> "var." <i>cornutoides</i>	<i>Stylochlamydidium venustum</i>	<i>Tricerapys</i> ? sp.	<i>Eucyrtidium tumidulum</i>	<i>Spongodiscus</i> sp.	<i>Spongopyle osculosa</i>	<i>Stylocontarium acquilonium</i>	<i>Eucyrtidium matuyamai</i>	<i>Stichocorys delmontensis</i>
192-22(CC)	+	+									+	
192-23-1(102-104)	+	+										
192-23(CC)	+	+										
192-24-2(22-24)	+	+										
192-24(CC)	+	+										
192-25-1(82-84)	+	+										
192-25(CC)	+	+										

TABLE 12
Radiolarians from Site 193

Sample	Taxa										Age	
	<i>Lithomitra arachnea</i>	<i>Artostrobus annulatus</i>	<i>Cycladophora davisiana</i>	<i>C. d.</i> "var." <i>cornutoides</i>	<i>Stylochlamydidium venustum</i>	<i>Spongodiscus</i> sp.	<i>Tricerapys</i> ? sp.	<i>Eucyrtidium tumidulum</i>	<i>Spongopyle osculosa</i>	<i>Saturnalis circularis</i>	<i>Stylocontarium acquilonium</i>	Late Middle Early
193-1-1(122-124)	+	R	F	+	+							
193-1-2(130-134)	R	R	F		R	R						
193-1(CC)	R	R	+	R	+							
193-2-1(117-119)	+	+	R	R		R	R	R	R	+		
193-2-3(40-42)	R	R	F	R		+						
193-2(CC)		+	+	+				+				
193-3-1(103-105)	+	R	+	R			+	+		+		
193-3-2(62-64)												
193-3-4(82-84)	+	R		R								
193-3(CC)	+	+	+	+						+		
193-4(CC)	+	+		+						+		

TABLE 13
Radiolarian Events Observed at Sites of Deep Sea Drilling Project, Leg 19

Taxa	Sites								
	183	185	186	188	189	190	191	192	193
T <i>Spongodiscus</i> sp.	4-2 (82-84) 4-3 ^M (68-70)	4-2 (32-34) 4-4 ^M (32-34)	3-CC 4-2 ^M (132-134)	3-4 (132-134) 3-CC ^P		1-1 (67-69) 1-CC	3-CC (22-24) 4-1 ^M (102-104)	3-3 (22-24) 3-CC ^P	1-1 (122-124) ^P 1-2 (130-132)
T <i>Saturnalis circularis</i>	4-2 (82-84) 4-3 ^P (68-70)					3-2 (112-114) 3-CC ^P			1-CC 2-1 ^P (117-119)
B <i>Stylochlamidium venustum</i>	4-3 (68-70) 4-4 ^M (82-84)	4-CC 5-CC ^M	4-2 (132-134) 4-4 ^P (132-134)	3-CC 4-CC ^M	2-CC 3-1 ^P (112-113)	4-1 (112-114) ^G 4-CC	4-5 (112-114) ^M 4-CC	3-3 (22-24) 3-CC ^P	1-CC 2-1 ^P (117-119)
T <i>Stylocantarium acquilonium</i>	4-CC 5-3 ^M (90-92)			7-1 (103-105) 7-4 ^P (52-54)	3-CC 4-2 ^P (12-14)	3-2 (112-114) 3-CC ^M	6-2 (122-124) 6-CC ^P	3-CC 4-3 ^M (22-24)	2-CC 3-1 ^P (103-105)
T <i>Axoprunum angelinum</i>	4-CC 5-3 ^P (90-92)		9-CC 10-3 ^P (40-42)						
B <i>Spongodiscus</i> sp.	8-3 (56-58) ^P 8-CC		10-CC 11-4 ^P (132-134)	6-CC 7-1 ^P (103-105)		6-CC 7-2 ^P (112-114)	7-CC 8-2 ^P (132-134)	6-1 (137-139) 6-CC ^P	
T <i>Eucyrtidium matuyamai</i>	8-CC 9-3 ^P (134-136)			7-1 (103-105) 7-4 ^P (52-54)		5-CC 6-3 ^P (32-34)		6-1 (137-139) 6-CC ^P	
T <i>Stichocorys delmontensis</i>	17-5 (82-84) 17-6 ^M (82-84)							22-1 (102-104) 22-CC ^P	
T <i>Theocorys redondoensis</i>	18-3 (82-84) 18-4 ^P (82-84)	17-CC 18-CC ^P							
T <i>Lychnocanium</i> sp.	18-CC 19-1 ^G (120-122)								
T <i>Cyrtocapsella tetrapera</i>	19-CC 20-1 ^G (80-82)								
T <i>Acanthodesmid</i> sp.	21-1 (80-82) ^G								

ACKNOWLEDGMENTS

Special thanks are due to Dr. Stanley A. Kling, Cities Service Oil Company, Tulsa, Oklahoma, for lending some of his Legs 6 and 18 microslides for comparison of taxa and for sending his Leg 18 manuscript; and to Mrs. Linda M. McPherson and Shirley A. Verzosa for their technical assistance throughout the preparation of the manuscript.

Financial support was contributed by National Science Foundation grants GA-26499 and GA-26499A#1 and Office of Naval Research contract N-00014-67-A-0103-0014.

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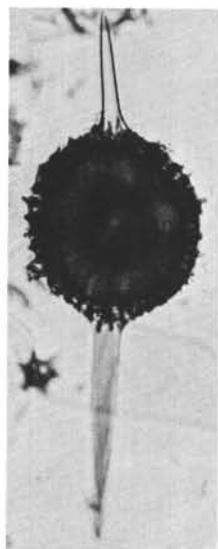
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PLATE 1

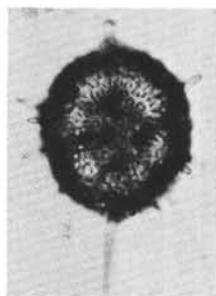
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- Figures 1-4 *Axoprunum angelinum* (Campbell and Clark)
1: 183-20-1(80-82), R-1 (W17/2).
2: 186-10-3(40-42), R-1 (P51/3).
3: 186-10-3(40-42), R-1 (P51/3).
4: TT28-24, 360-363, R-1 (M11/2).
- Figure 5 *Saturnalis circularis* Haeckel
183-4-3(68-70), R-1 (C38/4).
- Figures 6, 7 *Stylocontarium acqulonium* (Hays)
6: 190-9-1(52-54), R-1 (F45/4).
7: TT28-24, 210-213, R-1 (W13/0).
- Figure 8 *Stylochlamydium venustum* (Bailey)
191-4-5(112-114), R-1 (E21/4).
- Figures 9, 10 *Spongodiscus* sp.
9: 183-4-1(132-134), R-2 (U45/4).
10: 183-6-1(112-114), R-1 (N28/0).
- Figures 11, 12 *Amphymenium* sp.
11: 183-21-3(80-82), R-2 (E24/0).
12: 183-19-3(80-82), R-1 (U37/1), X300.
- Figures 13, 14 *Triceraspyris* ? sp.
13: 183-6-3(82-84), R-1 (C39/0).
14: 190-6-3(32-34), R-1 (E11/1).

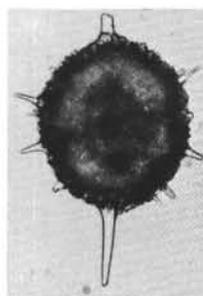
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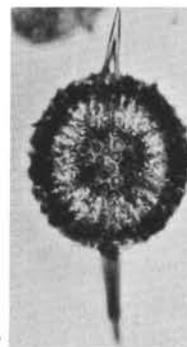
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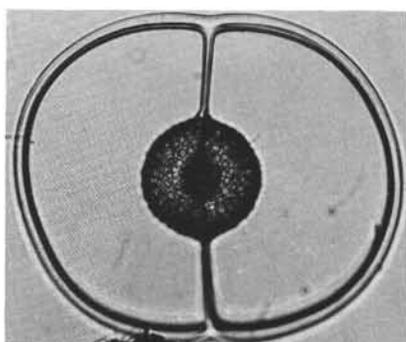
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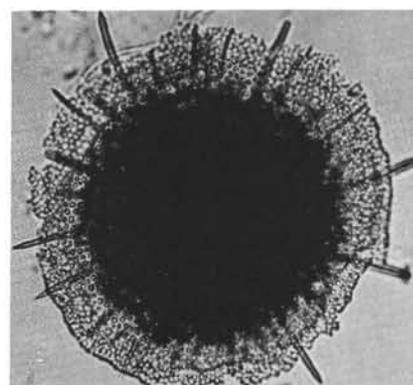
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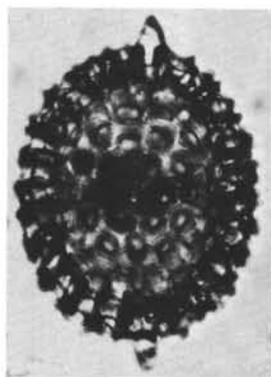
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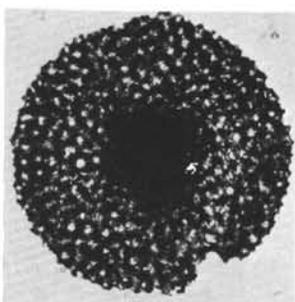
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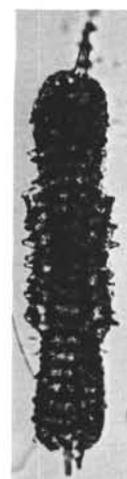
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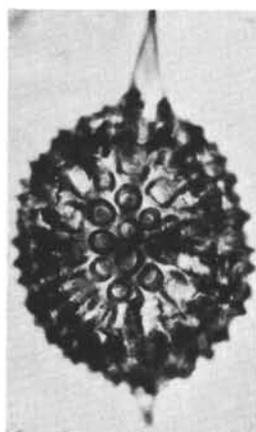
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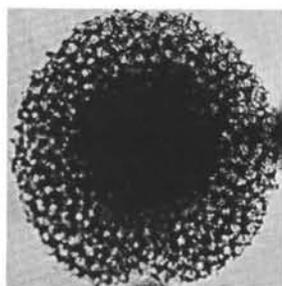
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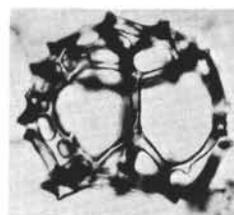
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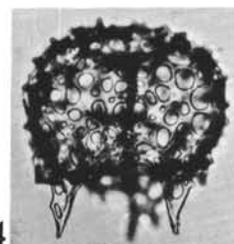
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PLATE 2

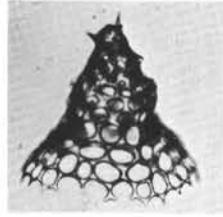
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- Figure 1 *Acanthodesmid* sp. 183-21-1(80-82), R-1 (M38/3).
- Figure 2 *Cycladophora davisiana* Ehrenberg 183-4-1(132-134), R-1 (J20/2).
- Figure 3 *Cycladophora davisiana* "var." *cornutoides* Petrushevskaya 193-1-1(122-124), R-1 (M14/3).
- Figure 4 *Cyrtocapsella tetrapera* Haeckel 183-20-1(80-82), R-1 (Y12/1).
- Figures 5, 6 *Eucyrtidium matuyamai* Hays
5: 183-9-3(132-134), R-2 (W20/1).
6: TT28-24, 450-453, R-2 (E16/2).
- Figures 7, 8 *Eucyrtidium tumidulum* Bailey
7: T92-5-3(12-14), R-2 (V38/0).
8: TT28-24, 629-632, R-1 (L7/1) ×250.
- Figure 9 *Eucyrtidium* sp. 183-20(CC), R-1 (039/3).
- Figures 10, 11 *Lychnocanium* sp.
10: 183-19-2(82-84), R-1 (W15/0).
11: 183-19-3(80-82), R-1 (T33/4).
- Figure 12 *Stichocorys delmontensis* (Campbell and Clark) 183-18-1(140-142), (N12/4).
- Figure 13 *Theocorys redondoensis* (Campbell and Clark) 183-18-4(82-84), R-1 (N12/2).
- Figure 14 *Artostrobos annulatus* (Bailey) 183-20(CC), R-1 (W20/4) ×250.
- Figure 15 *Lithomitra arachnea* (Ehrenberg) 192-4-3(22-24), R-1 (K16/3) ×250.
- Figure 16 *Lirella mela* (Cleve) 192-8(CC), R-1 (U22/1) ×300.

PLATE 2



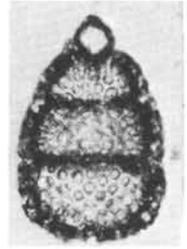
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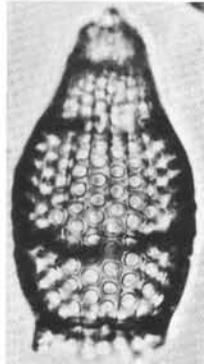
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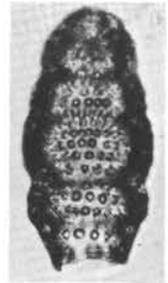
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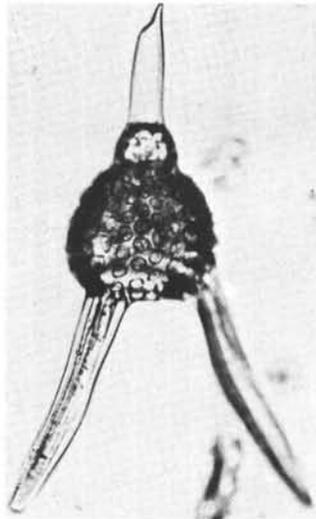
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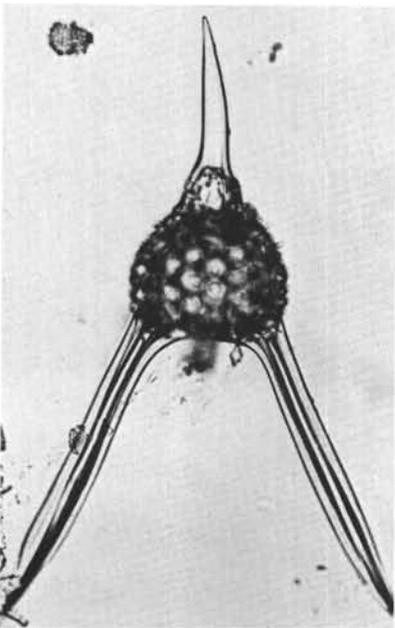
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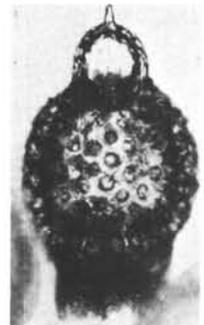
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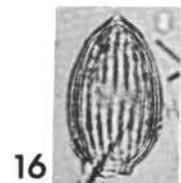
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