# 20. NEOGENE AND PLEISTOCENE RADIOLARIANS FROM DEEP SEA **DRILLING PROJECT LEG 79 IN THE REGION OF THE** MAZAGAN PLATEAU, OFF CENTRAL MOROCCO<sup>1</sup>

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#### ABSTRACT

At Sites 545 and 547, samples of middle and early Miocene age vielded a sufficient number of identifiable radiolarians to allow zonal age determinations and comparison with the previously established zonation in tropical latitudes. The Miocene evolution of paleoenvironments along the Northwest African continental margin is considered.

# INTRODUCTION

Relatively few Neogene and Pleistocene cores off central Morocco from DSDP Leg 79 contained siliceous remains (diatoms and radiolarians). Only two of the holes (545 and 547A) recovered layers of radiolarian-bearing sediments. Miocene sequences of well-preserved radiolarian assemblages were sampled at Site 545 at 33°39.9'N, 9°21.9'W, water depth ~3150 m. At Site 547, at 33° 46.8'N, 9°21.0'W, water depth ~ 3940 m, rather poorer radiolarian assemblages have been found. The Quaternary period is marked by a scarcity of radiolarians. Radiolarian specimens have been detected only within a short interval at Site 545. Miocene sedimentation was punctuated by episodes containing older, reworked faunal elements.

#### PROCEDURES

The primary objective of this study was to carry out a biostratigraphic investigation of Miocene sediments off central Morocco in an area that lies in the subtropical belt.

After the first analysis of core-catcher samples was made aboard ship, five to six samples were taken from each core containing radiolarians. Sampling, when core catchers did not reveal any radiolarians, was widely spaced. A total of 140 samples was examined to determine the core intervals bearing siliceous organisms.

The core samples were prepared according to the standard technique described by Riedel and Sanfilippo (1977). After sieving at 45 µm, permanent strew slides of the coarse fraction (three for each sample) were studied. The total abundance of radiolarians and relative abundance of species was estimated. The radiolarian species selected for this paper were chosen because of their well-established stratigraphic usefulness (Riedel and Sanfilippo, 1971, 1978). Moreover, additional radiolarian specimens have been noted with a view toward a better understanding of the paleogeographic environmental question.

### **RADIOLARIANS AT EACH SITE**

The information on the presence of Miocene radiolarians is summarized in Tables 1 and 2 for those cores in which significant radiolarian assemblages have been identified. The relative abundance of radiolarians and

the relative proportion of the total radiolarian assemblage in each sample is indicated as follows: abundant (A), common (C), few (F), or rare (R). A dash (-) indicates that no specimens were detected (Table 2). Preservation of the specimens is indicated as good (G), moderate (M), or poor (P).

These same terms are used to indicate in a semiguantitative fashion the proportion of the diatom assemblage associated with the radiolarian assemblage in the coarse fraction (see Table 1).

### Site 545

Radiolarians occur in the upper Pleistocene (depth = 9-18 m). Significant quantities of radiolarians were identified in the lower-middle Miocene (depth = 217-251 m).

### Pleistocene

Core 545-2 contains rare to common radiolarians, poorly preserved, of Pleistocene age. The more abundant assemblage appears within sections 6 and 7 (545-2-6, 103-106 cm; 545-2-7, 20-24 cm). It includes Amphirhopalum ypsilon, Eucyrtidium acuminatum, Lamprocyclas maritalis. Theocorythium trachelium, and other species belonging to the genera Stylodictya and Polysolenia. All species are considered warm temperate water elements and have been found in Recent sediments at middle latitudes of the Atlantic Ocean (Labracherie, 1978). Typical tropical species are virtually absent (e.g., Euchitonia elegans, Pterocanium praetextum praetextum, Spongaster tetras tetras). Stylatractus universus is missing from this relatively well-preserved assemblage. The globally synchronous extinction of S. universus, detected near the isotope Stage 11-12 boundary, is a good biostratigraphic indicator (Hays and Shackleton, 1976). Whereas the transition between Stages 12 and 11 has been estimated at 440,000 yr. ago (Shackleton and Opdyke, 1976) it is assumed that the radiolarian assemblage from Core 545-2 is younger than 440,000 yr.

Radiolarians are absent in samples from Core 545-3 through Core 545-23. Sample 545-23-7, 12-15 cm yielded some highly corroded, unidentifiable radiolarian fragments.

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# Miocene

Cores 545-24 to 545-27 represent a Miocene section in which radiolarians are common to abundant and sometimes well preserved (see Table 1). Because of the occurrence of intermediate populations in the typical lineages, or of the scarcity of the common stratigraphic indicator species from tropical regions, there are some difficulties in the biostratigraphic interpretation and uncertainties in sharply identifying zonal boundaries. Samples contain radiolarian assemblages of both tropical and Mediterranean affinities.

The assemblage at the top of Core 545-24 (Samples 545-24-1, 46-49 cm to 545-24-4, 70-73 cm) belongs to the *Dorcadospyris alata* Zone defined by Riedel and Sanfilippo (1971, 1978). Specimens recorded as *D. alata* are outnumbered by a population that is intermediate between *D. dentata* Haeckel and *D. alata* (Riedel). Similar atypical forms have been described by Sanfilippo et al. (1973, p. 218, pl. 3, fig. 2) in the Mediterranean regions and have been interpreted as *D. dentata* according to the angle of the feet. In the material off Morocco, the feet generally diverge at an angle of much less than 180°; however, this camber is highly variable. It would seem that there is a very progressive transition from *D. dentata ta*, only represented by the Sanfilippo and Riedel atypical form (Sanfilippo et al., 1973), to the species *D. alata*.

Generally, the genus *Calocycletta* is well represented and highly diversified in the Miocene of tropical regions. Three species have been identified off central Morocco and the most important is *C. virginis*. The second species includes forms resembling *C. robusta*. *C. costata* is very rare. As in the Majorcan assemblage (Sanfilippo et al., 1973), specimens are more slightly costate. The assemblage representing the *Calocycletta costata* Zone could occur at the bottom of Core 545-24.

At the top of Core 545-25, the abruptness of appearances and disappearances of taxa could characterize the

Table 1. Abundance o	f some N	fiocene radio	larians from	Site 545.
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upper limit of the Stichocorys wolffii Zone but could also be indirect evidence of some unconformity within the section. At the boundary between the Calocycletta costata Zone and the Stichocorys wolffii Zone, Cannartus prismaticus has a well-defined upper limit. This level coincides with the top of Lychnocanoma elongata and the first appearance of Cannartus mammifer. This pattern may be compared to those observed at other DSDP sites (Moore, 1971). The boundary between the Stichocorys wolffii Zone and Stichocorys delmontensis Zone could be determined between Cores 545-25 and 545-26 based on the appearance of the S. wolffii. Dorcadospyris ateuchus also have a well-defined upper limit at this level. In addition, the last occurrence of the D. ateuchus is a good stratigraphic indicator. D. dentata occurs just above this boundary. Theocyrtis annosa is common in the lowermost sample, yielding well-preserved radiolarians (545-27-2, 50-53 cm). In earlier interpretations, the upper limit of T. annosa is used to define the base of the Stichocorys delmontensis Zone (Riedel and Sanfilippo, 1978). Unfortunately, older samples within Core 545-27 contain only very poorly preserved radiolarian fragments with some Orosphaeridae.

### Site 547

Radiolarians are absent from Core 547A-1 to 547A-7-1, 70-74 cm. Some samples from Cores 547A-8 to 547A-14 yielded very rare, undeterminable radiolarian fragments. Dinocysts are very common in the slide preparations. Samples at the top of Core 547A-14 contain some very rare, pyritized radiolarian fragments and *Orosphaeridae*. Samples from Core 547A-14 (547A-14-4, 87-91 cm; 547A-14,CC) and from Section 547A-15-2 contain varied radiolarian assemblages of early Miocene age (see Table 2). Assignment to the *Stichocorys wolffii* Zone, near the *S. wolffii/S. delmontensis* zonal boundary, is based on comparison with the assemblages determined at Site 545. Three samples examined from Core 547A-16

Radiolarian Zones	Species Samples (Intervals in cm)	Abundance	Preservation	Cannartus basanii	Cannartus mammifer	Cannartus prismaticus	Cannartus tubartus	Cannartus violina	Dorcadospyris alata	Dorosdospyris at euchus	Dorcado spyris dentata	Doradospyris simplex	Dendrospyris burst	Zigospyris brevispina	Lithopera renzae	Liriospyris parkarae	Liriotpyris stauropora	Cyclumpterium leptetrum	Lychnocanoma elongata	Calocycletta costata	Calocycletta robusta	Calocycletta virginis	Cyrtocapsella cornuta	Cyrtocupselle japonice	Cyrtocapsella tetrapera	Eucyrtidium clenkowskii	Eucyrtidium diaphones	Stichocorys armata	Stichocorys delmontensis	Stichocorys wolffii	Carpocanopsis bramlettei	Carpocanopsis cingulata	Carpocanopsis favou	Histiastrum martinianum	Phormostichoartus corona	Theocyrtis annow	Dicolocapur microcephala	Polysolenia spp.	Collosphaera sp.	Solenosphaere spp.	Anthocyrtidium spp.	Lamprocyclas sp.	Diatoms (coarse fraction)
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akta	24-3,46-49	C	P	1.1	F			R	R		F		R			R	R			R		С	F		C	R	R	R	C	R		R		R	R			R	R	C	F	R	Ξ.
	24-4,70-73	A	M	R	F			R	R		R				F		R		R			C	R		C	A		С	A	A					R			R	R	A	С	R	c
C. costata	24-5.70-73	F	P		F			R			F	R	R				R	- 1				C	R	R	R	R		R	R	F	R				R			F	1	C	R	R	-
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	25-1,70-73	C	M			R		F			R	R	100					R	R		R	C	C	C	R	R	R			C				R					1	R			C
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	25-3,70-73	A	M	R		F	R	R	R		С				R			F	С		A	С	С	R	A			R	F									R	1			R	F
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	26-3,70-73	C	G	č		R	Ē	R		R		R		F				R	c		R	č	A		c		C						R	R	R		R	F	1			F	C
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	26-4,140-143	C	M	C		R		R		R		F	R	R				R	R			R	C		C		R		R				F				R	R	1			С	C
delmontensis	26-4,146-150	C	м	C		R	F	R		R		F	2624	R				R	R			F	Α		С	R	R		R								R					С	С
	27-1,50-53	c	м	F		R	F	R		R		R	R	F				R	C		R	F		R	A	R	R							R			R					R	c
	27-2,50-53	C	M	F		C				R		R	R	R				0.023	c		R	R	A	100	A		R					R	R	F		C		R	1		R	R	F
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Table 2. Abundances of some Miocene radiolarians from Hole 547A.

Radiolarian Zones	Species Samples (Intervals in cm)	Abundance	Preservation	Cannartus bassanii	Cannartus mammifer	Cannartus prismaticus	Cannartus tubartus	Cannartus violina	Dorcado spyris alata	Dorcado spyris ateuchus	Dorcadospyris dentata	Dorcadospyris timplex	Dendrospyris bursa	Zigospyris brevispina	Lithopera renzae	Liriospyris parkerue	Liriospyris stauropora	Cyclampterium leptetrum	Lychnocanoma elongata	Calocycletta costata	Calocycletta robusta	Calocycletta virginis	Cyrtocapsella cornuta	Cyrtocapsella Japonica	Cyrtocapsella tetrapera	Eucyrtidium cienkowskil	Eucyrtidium diaphanes	Stichocorys armata	Stichocorys deimontensis	Stichocorys wolffi	Carpocanopsis bramlettei	Carpocanopsis cingulata	Carpocanopsis favosa	Histiastrum martinianum	Phormostichoartus corona	Dicolocapsa microcephala	Polysolenia pp.	Collo sphaera sp.	Solenosphaeta spp.	Anthocyrtidium spp.	Lamprocyclas sp.
	547A -14-3,16-19															n		Ab	undar	t pyr	itized	l radi	olari	ans																	
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	-15-1,50-55	1	5	R		ĸ	R	R		-	177	R	1	1	-	Ξ.	-	ĸ	ĸ	-		к	c	ĸ	C.	ĸ	R		R	-		R	ĸ			R			-	R	~
	-15-1 50-53	C	P	R		R		R				R	2			_		P	E		C	R.	c		C	F	P	_	8		R	R		1		R	R		-	R	F
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contain no radiolarians. The upper Eocene of Core 547A-17 (547A-17-1, 40-42 cm; 547A-17-2, 36-39 cm) contains scarce and poorly preserved radiolarians that are associated with diatoms. Among the radiolarian fragments, *Podocyrtis chalara, Dorcadospyris triceros, Thy-rsocyrstis tetracantha*, and *Lychnocanoma bellum* have been identified.

#### PALEOGEOGRAPHY

Lower and middle Miocene *Cannartus* species are fairly well represented among the mid-latitude radiolarian assemblages off central Morocco. *C. bassanii*, encountered in Mediterranean regions (Sanfilippo et al., 1973), could be considered as a middle latitude species from the eastern Atlantic Ocean. It is found off the African coasts from Cape Bojador to offshore central Morocco. More southern occurrences are rare (Johnson, 1977). In the Morocco basin, *C. bassanii* is found within the early Miocene and more abundantly in the *Stichocorys delmontensis* Zone. Westberg et al. (1980) have not found it in upper lower Miocene sediments. It is replaced here quantitatively by *Cannartus violina*.

Species belonging to the genus *Dorcadospyris* are common but transitions in this genus are not well understood. *D. forcipata* is normally a component of radiolarian assemblages within the lower Miocene zones of tropical regions (Riedel and Sanfilippo, 1971; Moore, 1971; Johnson, 1974). It is virtually absent off the Moroccan coast. It is present in sections of the eastern tropical Atlantic (Sierra Leone Rise) but occurs very rarely northwards (off Cape Bojador) (Johnson, 1977). One of the dominant characteristics in the middle latitude *Dorcadospyris* assemblage off central Morocco is the absence of a strong apical horn.

Zygospyris brevispina has been observed in the Mediterranean Neogene (Sanfilippo et al. 1973) but has not yet been encountered in the eastern Atlantic Ocean. At Site 545 Zygospiras brevispina has a restricted range (Table 1). Its upper limit corresponds approximately with the first appearance of Dorcadospyris dentata.

At the Moroccan margin sites the early Miocene assemblage includes numerous specimens of several species belonging to the genus *Cyrtocapsella*. *Stichocorys*  armata and Cannartus mammifer are also better represented within Miocene sequences off central Morocco than in southern tropical regions (Johnson, 1977). Again, the very close resemblance between the middle latitude radiolarians of early and middle Miocene age from the eastern Atlantic Ocean and the Mediterranean assemblages is noted (Sanfilippo et al., 1973). These affinities have already been described by Johnson (1977) for Site 369 at latitude 26°N. They seem to be more important around latitude 33°N.

# PALEOENVIRONMENT

Taxa belonging to the collosphaerid family are rather common at Site 545. Species belonging to the genera Collosphaera and Solenosphaera have a limited stratigraphic range. They are observed throughout the Dorcadospyris alata and Calocycletta costata zones (Table 1). In Recent sediments Collosphaera and Solenosphaera are particularly abundant in tropical regions. At Site 545, they are associated with species belonging to the genus Anthocyrtidium which is also found in low latitude Holocene sediments in the Atlantic Ocean (Goll and Biørklund, 1971). These species, with a well-defined distribution, may be indicative of a warming during the Miocene in the coastal waters off Morocco. They also reveal markedly warmer temperatures of surface coastal waters during the end of early Miocene and at the beginning of middle Miocene in comparison to modern times.

A high biogenous opal content in marine sediments is probably a signal recording the high level of nutrients in surface waters. Furthermore, abundant diatoms in the coarse fraction may reflect a coastal upwelling influence (Diester-Haass, 1978; Berger et al., 1978; Labracherie, 1980a). Off the coasts of North and Northwest Africa, between 18° and 33°N, the biogenous opal content in Recent sediments decreases from south to north. Upwelling processes extend as far as 30°N, but the highest intensity has been found in the vicinity of Cape Blanc (21°N). Near latitude 21°N, biosiliceous sedimentation during the latest Pleistocene can be linked to climatic variations. For example, the last glacial period (at the time of deglaciation) shows a strongly increased influence of upwelling processes (high proportions of diatoms) and nutrient-richer intermediate depth water masses that have a southern origin (abundance of some radiolarians) (Labracherie et al., in press).

Off central Morocco numerous well-preserved radiolarians are associated with rich diatom assemblages (coarse fraction) during the early Miocene (S. delmontensis Zone and lower part of the S. wolffii Zone) (Table 1). Such an assemblage may reflect upwelling influence in a coastal area. Miocene upwelling could then be compared with the highly productive coastal upwelling of the glacial regimes during the late Pleistocene (Labracherie, 1980b). During the late early Miocene (C. costata Zone) rare diatoms are evident in the coarse biosiliceous fraction which is itself less well preserved. This change may support the idea of a weaker upwelling at this time. During the following phase (boundary early-middle Miocene and the lower part of the D. alata Zone), the radiolarian association suggests warmer coastal waters. Both this increase of surface temperatures and the absence of diatoms could be correlated to a migration of the upwelling center in relation to one of the highest Tertiary sea levels (von Rad and Wissmann, 1982). Such a situation could tentatively be compared to that described off Northwest Africa during the last transition from a Quaternary glacial to an interglacial mode featuring a shifting of upwelling center from the lower to upper continental slope (Diester-Haass, 1977). Moreover, as far as the Quaternary distribution of siliceous organisms in the same region is concerned, both diatoms and radiolarians were detected in sediments underlying very fertile areas (upwelling center) whereas only radiolarians were found offshore (Labracherie, 1980b).

Finally, the biogenic silica accumulation (radiolarianbearing sediments) during the Miocene from *S. delmontensis* Zone to *C. costata* Zone is rather uniform along the Northwest African continental margin, between 20° and 33°N. A highly productive upwelling correlated with nutrient-rich waters and reflected by diversified and wellpreserved radiolarian assemblages characterizes the nearest sites of the adjacent continent (Sites 140, 369, 415, and 545) (Fig. 1). At more oceanic sites, productivity is less important (Sites 138, 141, 368, and 416).

At the end of middle Miocene the absence of radiolarians, except at Holes 139 and 369A (Fig. 1) may suggest that upwelling influence was less extensive and possibly concentrated between 23° and 26°N. Paleopositions of these sites at middle Miocene coincide with the highest fertility area for modern upwelling. Such an evolution has been correlated to a southward shift in wind regimes (Sarnthein et al., 1982).

The absence of radiolarians from sediments above the middle Miocene off Northwest Africa could indicate surface and subsurface waters were nutrient poor and suggest a calmer surface water circulation.

### CONCLUSIONS AND SUMMARY

At Sites 545 and 547, samples yielded a sufficient number of identifiable radiolarians to allow zonal age determinations and comparisons with the previously established zonations in tropical latitudes.

During the early Miocene, high biogenous opal contents in sediments off Morocco signal an enhanced fertility induced by upwelling. Radiolarian assemblages suggest warming of coastal waters at the beginning of the middle Miocene and at the same time a weaker and vari-

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Age	Radiolarian zones	1 1	7°3 336	80'N 6 m	21	21° 44'N 4483 m		23° 31'N 3047 m		N :	25° 55'N 5288 m		26° 35'N 1752 m		26° 50'N 2900 m		31° 01'N 2794 m		N :	32°50'N 4191 m	32 4	2°50′N 214 m	33	3° 39'N 150 m		33 <sup>9</sup> 39	46' 40 i	N
Quaternary	Unzoned	1					C/A		?	T	Τ	Τ	1		F	FA	1		R	1	ł		1		R	1		
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middle Miocene	Cannartus petterssoni Dorcadospyris alata	1:	2		2		с	4	?	c			1 2 10	R/F	-	-	3/4	Į	F	?			23 24		F/C			
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Eocene	Different zones	2	7		3																6/0				_	· '		

Figure 1. DSDP Sites drilled along the African margin (Legs 14, 41, 50, 79) with cores containing Miocene radiolarians (black squares) or Paleogene radiolarians (hatched squares) and approximate correlations (see Petrushevskaya and Kozlova, 1972; Johnson, 1977; Westberg et al., 1980; and this report). Core numbers on left and estimated abundance on right. At the Leg 14 sites, age assignment is uncertain because of the zonation used at that time (the *C. virginis* zone without subdivision). Abundance is described as A, abundant; C, common; F, few; R, rare.

able upwelling. The disappearance of biogenic silica in sediments above the middle Miocene off the Northwest African continental margin is correlated to a calmer surface water circulation.

#### ACKNOWLEDGMENTS

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#### APPENDIX

#### **Species List**

- Amphirhopalum ypsilon Haeckel. Amphirhopalum ypsilon Haeckel, 1887. p. 522; Nigrini, 1967, p. 35, pl. 3, figs. 3a-d.
- Anthocyrtidium spp. Sanfilippo and Riedel. Anthocyrtidium spp. Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 224, pl. 6, fig. 9.
- Calocycletta costata (Riedel). Calocyclas costata Riedel, 1959, p. 296, pl. 2, fig. 9. Calocycletta costata (Riedel) Riedel and Sanfilippo, 1970, p. 535, pl. 14, fig. 12; Moore, 1972, p. 147, pl. 1, fig. 8; Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 226, pl. 6, fig. 10.
- Calocycletta robusta Moore group. Calocycletta robusta Moore, 1971, p. 743, pl. 10, fig. 5, 6. Calocycletta caepa Moore, 1972, p. 150, pl. 2, fig. 4, 7. Calocycletta robusta Moore group, Riedel and Sanfilippo, 1978, p. 66, fig. 3, figs. 10–11.
- Calocycletta serrata Moore. Calocycletta serrata Moore, 1972, p. 148, pl. 2, fig. 1-3.
- Calocycletta virginis (Haeckel). Calocyclas (Calocycletta) virginis Haeckel, 1887, p. 1381, pl. 74, fig. 4. Calocycletta virginis Haeckel, Riedel, 1959, p. 295, pl. 2, fig. 8; Riedel and Sanfilippo, 1970, p. 535, pl. 14, fig. 10; Moore, 1972, p. 147, pl. 1, fig. 7.
- Cannartus bassanii (Carnevale). Cannartus bassanii (Carnevale) Sanfilippo and Riedel in Sanfilippo et al., 1973. p. 216, pl. 1, figs. 1-3.

- Cannartus mammifer (Haeckel). Cannartidium mammiferum Haeckel, 1887, p. 375, pl. 39, fig. 16; Cannartus mammiferus (Haeckel), Riedel, 1959, p. 291, pl. 1, fig. 4.
- Cannartus prismaticus (Haeckel). Pipettella prismatica Haeckel, 1887, p. 305, pl. 39, fig. 6. Cannartus prismaticus (Haeckel), Riedel and Sanfilippo, 1970, p. 520, pl. 15, fig. 1; Riedel and Sanfilippo, 1971, p. 1588, pl. 2C, figs. 11-13.
- Cannartus tubarius (Haeckel). Pipettaria tubaria Haeckel, 1887, p. 339, pl. 39, fig. 15. Cannartus tubarius (Haeckel), Riedel, 1959, p. 289, pl. 1, fig. 2; Riedel and Sanfilippo, 1970, p. 520, pl. 15, fig. 2; Riedel and Sanfilippo, 1978, p. 67, pl. 4, fig. 3.
- Cannartus violina Haeckel. Cannartus violina Haeckel, 1887, p. 358, pl. 39, fig. 10; Riedel, 1959, p. 290, pl. 1, fig. 3; Moore, 1971, pl. 12, fig. 4; Riedel and Sanfilippo, 1978, p. 67, pl. 4, fig. 4.
- Carpocanopsis bramlettei Riedel and Sanfilippo. Carpocanopsis bramlettei Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, figs. 8-14; pl. 8, fig. 7; Riedel and Sanfilippo, 1978, p. 67, pl. 4, fig. 6.
- Carpocanopsis cingulata Riedel and Sanfilippo. Carpocanopsis cingulatum Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, figs. 17-21; pl. 8, fig. 8; Riedel and Sanfilippo, 1978, p. 67, pl. 4, fig. 7.
- Carpocanopsis favosa (Haeckel). Cycladophora favosa Haeckel, 1887, p. 1380, pl. 62, figs. 5, 6. Carpocanopsis favosum (Haeckel), Riedel and Sanfilippo, 1971, p. 1597, pl. 2G, figs. 15, 16; pl. 8, figs. 9–11.
- Collosphaera(?) Riedel and Sanfilippo. Collosphaera(?) Riedel and Sanfilippo, 1971, p. 1586, pl. 2A, fig. 3.
- Cyclampterium leptetrum Sanfilippo and Riedel. Cyclampterium leptetrum Sanfilippo and Riedel, 1970, p. 456, pl. 2, figs. 11-12; Sanfilippo and Riedel, 1971, pl. 20, figs. 9-12; Riedel and Sanfilippo, 1978, p. 67, pl. 4, figs. 12-13.
- Cyrtocapsella cornuta (Haeckel). Cyrtocapsa (Cyrtocapsella) cornuta Haeckel 1887, p. 1512, pl. 78, fig. 5. Cyrtocapsella cornuta (Haeckel) Sanfilippo and Riedel, 1970, p. 453, pl. 1, figs. 19–20; Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 220, pl. 5, figs. 1–2; Riedel and Sanfilippo, 1978, p. 68, pl. 4, fig. 17.
- Cyrtocapsella japonica (Nakaseko). Cyrtocapsella japonica (Nakaseko), Sanfilippo and Riedel, 1970, p. 452, pl. 1, figs. 13-15; Sanfilippo and Riedel in Sanfilippo et al., 1973, pl. 5, figs. 4-6.
- 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, fig. 16–18; Sanfilippo and Riedel in Sanfilippo et al., 1973, pl. 5, figs. 4–6; Riedel and Sanfilippo, 1978, p. 68, pl. 4, fig. 18.
- Dendrospyris bursa Sanfilippo and Riedel. Dendrospyris bursa Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 217, pl. 2, figs. 9-13.
- Dicolocapsa microcephala Haeckel. Dicolocapsa microcephala Haeckel, 1887, p. 1312; Sanfilippo and Riedel, 1970, pl. 1, fig. 7.
- Dorcadospyris alata (Riedel). Brachiospyris alata Riedel, 1959, p. 293, pl. 1, figs. 11-12. Dorcadospyris alata (Riedel), Riedel and Sanfilippo, 1970, p. 523, p. 15, fig. 5; Riedel and Sanfilippo, 1971, p. 1590, pl. 2D, fig. 1; Moore, 1971, pl. 11, figs. 3-4; Riedel and Sanfilippo, 1978, p. 68, pl. 5, fig. 2.
- Dorcadospyris ateuchus (Ehrenberg). Dorcadospyris ateuchus (Ehrenberg), Riedel and Sanfilippo, 1970, p. 523, pl. 15, fig. 4; Riedel and Sanfilippo, 1971, pl. 2D, fig. 6, pl. 3A, figs. 9-10; Riedel and Sanfilippo, 1978, p. 68, pl. 5, fig. 3.
- Dorcadospyris dentata Haeckel. Dorcadospyris dentata Haeckel, 1887, p. 1040, pl. 85, fig. 6; Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 218, pl. 3, figs. 2-3.
- Dorcadospyris forcipata (Haeckel). Dipospyris forcipata Haeckel, 1887, p. 1037, pl. 85, fig. 1. Dorcadospyris forcipata (Haeckel), Riedel and Sanfilippo, 1971, p. 1590, pl. 2D, figs. 2-3; Moore, 1971, p. 740, pl. 10, figs. 1-2.
- Dorcadospyris simplex (Riedel). Dorcadospyris simplex (Riedel), Riedel and Sanfilippo, 1970, pl. 15, fig. 6.
- Dorcadospyris triceros (Ehrenberg). Dorcadospyris triceros (Ehrenberg), Moore, 1971, p. 739, pl. 6, figs. 1-3.
- Eucyrtidium acuminatum (Ehrenberg). Eucyrtidium acuminatum (Ehrenberg), Nigrini, 1967, p. 81, pl. 8, figs. 3a-b.
- *Eucyrtidium cienkowskii* Haeckel. *Eucyrtidium cienkowskii* Haeckel, 1887, p. 1493; Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 221, pl. 5, figs. 7-11.
- Eucyrtidium diaphanes Sanfilippo and Riedel. Eucyrtidium diaphanes Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 221, pl. 5, figs. 12-14; Riedel and Sanfilippo, 1978, p. 68, pl. 5, fig. 5.

- Histiastrum martinianum Carnevale group. Histiastrum martinianum Carnevale group, Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 217, pl. 2, figs. 7-8.
- Lamprocyclas maritalis Haeckel maritalis Nigrini. Lamprocyclas maritalis Haeckel maritalis Nigrini, 1967, p. 74, pl. 7, fig. 5.
- Lamprocyclas sp. Different species belonging to the genus Lamprocyclas.
- Liriospyris parkerae Riedel and Sanfilippo. Liriospyris parkerae Riedel and Sanfilippo, 1971, p. 1590, pl. 2C, fig. 15; pl. 5, fig. 4; Riedel and Sanfilippo, 1978, p. 69, pl. 5, fig. 15.
- Liriospyris stauropora (Haeckel). Trissocyclus stauropora Haeckel, 1887, p. 987, pl. 83, fig. 5. Liriospyris stauropora (Haeckel), Goll, 1968, p. 1431, p. 175, figs. 1–3, 7; Riedel and Sanfilippo, 1978, p. 69, pl. 5, fig. 16.
- Lithopera renzae Sanfilippo and Riedel. Lithopera renzae Sanfilippo and Riedel, 1970, p. 454, pl. 1, figs. 21-23, 27; Riedel and Sanfilippo, 1978, p. 70, pl. 6, fig. 11.
- Lophocyrtis jacchia (Ehrenberg). Lophocyrtis jacchia (Ehrenberg), Riedel and Sanfilippo, 1971, p. 1594, pl. 3C, figs. 4–5; pl. 7, fig. 16; Riedel and Sanfilippo, 1978, p. 70, pl. 7, fig. 1.
- Lychnocanoma bellum (Clark and Campbell). Lychnocanoma bellum (Clark and Campbell), Riedel and Sanfilippo, 1971, p. 1595; Riedel and Sanfilippo, 1977, pl. 10, fig. 10.
- Lychnocanoma elongata (Vinassa). Lychnocanoma elongata (Vinassa), Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 221, pl. 5, figs. 19-20; Riedel and Sanfilippo, 1978, p. 70, pl. 7, fig. 4.
- Phormostichoartus corona (Haeckel). Cyrtophormis (Acanthocyrtis) corona Haeckel, 1887, p. 1462, pl. 77, fig. 15. Phormostichoartus corona (Haeckel), Riedel and Sanfilippo, 1971, p. 1600, pl. 11, figs. 13-15; pl. 2J, figs. 1-5; Riedel and Sanfilippo, 1978, p. 71, pl. 7, fig. 12.
- Podocyrtis chalara Riedel and Sanfilippo. Podocyrtis chalara Riedel and Sanfilippo, 1970, p. 535, pl. 12, figs. 2-3; Riedel and Sanfilippo, 1978, p. 71, pl. 12, figs. 2-3.
- Podocyrtis diamesa Riedel and Sanfilippo, emend. Sanfilippo and Riedel. Podocyrtis diamesa Riedel and Sanfilippo, 1970, p. 53, pl. 12, fig. 4; Sanfilippo and Riedel, 1973, p. 531, pl. 20, figs. 9–10; pl. 35, figs. 10–11; Riedel and Sanfilippo, 1978, p. 72, pl. 8, fig. 4.
- Polysolenia spp. Riedel and Sanfilippo. Polysolenia spp. Riedel and Sanfilippo, 1971, p. 1586, pl. 1B, figs. 13-14; pl. 2A, figs. 11-14.
- Solenosphaera spp. Riedel and Sanfilippo. Solenosphaera spp. Riedel and Sanfilippo, 1971, p. 1586, pl. 1A, figs. 19–22; pl. 2A, figs. 4–10.
- Stichocorys armata (Haeckel). Cyrtophormis armata Haeckel, 1887, p. 1460, p. 78, fig. 17. Stichocorys armata (Haeckel), Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, figs. 13–15; Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 222, pl. 6, figs. 1–2.
- Stichocorys delmontensis (Campbell and Clark). Stichocorys delmontensis (Campbell and Clark), Sanfilippo and Riedel, 1970, p. 451, pl. 1, fig. 9; Riedel and Sanfilippo, 1971, p. 1595, pl. 1F, figs. 5-7; pl. 2E, figs. 10-11; Riedel and Sanfilippo, 1978, p. 74, pl. 9, fig. 10.
- Stichocorys diploconus (Haeckel). Stichocorys diploconus (Haeckel), Sanfilippo and Riedel, 1970, p. 451, pl. 1, figs. 31-32.
- Stichocorys wolffii Haeckel. Stichocorys wolffii Haeckel, 1887, p. 1479, pl. 80, fig. 10; Riedel and Sanfilippo, 1971, pl. 2E, figs. 8–9; Riedel and Sanfilippo, 1978, p. 74, pl. 9, fig. 12.
- Theocorythium trachelium (Ehrenberg) dianae (Haeckel). Theocorythium trachelium (Ehrenberg) dianae (Haeckel), Nigrini, 1967, pl. 8, figs. 1a-b; pl. 9, figs. 1a-b.
- Theocyrtis annosa (Riedel). Phormocyrtis annosa Riedel, 1959, p. 295, pl. 2, fig. 7. Theocyrtis annosa (Riedel), Riedel and Sanfilippo, 1970, p. 535, pl. 15, fig. 9; Riedel and Sanfilippo, 1978, p. 78, pl. 10, fig. 3.
- Thyrsocyrtis bromia Ehrenberg. Thyrsocyrtis bromia Ehrenberg, Riedel, and Sanfilippo, 1971, p. 1596, pl. 8, fig. 6; Moore, 1971, pl. 5, figs. 1–3; Riedel and Sanfilippo, 1978, p. 78, pl. 10, figs. 4–5.
- Thyrsocyrtis tetracantha (Ehrenberg). Thyrsocyrtis tetracantha (Ehrenberg), Riedel and Sanfilippo, 1970, p. 527; Moore, 1971, pl. 4, fig. 3; Riedel and Sanfilippo, 1978, p. 80, pl. 10, figs. 8-9.
- Zygospyris brevispina Carnevale group. Zygospyris brevispina Carnevale group, Sanfilippo and Riedel in Sanfilippo et al., 1973, p. 219, pl. 3, figs. 17-19.