Cochran, J. R., Stow, D.A.V., et al., 1990
Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 116

17. RADIOLARIANS FROM THE DISTAL BENGAL FAN IN THE EQUATORIAL INDIAN OCEAN[1]

Kozo Takahashi[2]

ABSTRACT

Cores recovered from three sites of Leg 116 were studied for radiolarians. Generally, radiolarians were absent from most samples prepared for examination. Moderate to well-preserved radiolarian assemblages are found only in the uppermost one or two cores that were the focus of this study. All of the radiolarian assemblages in the upper cores belong to the *Buccinosphaera invaginata* Zone of latest Quaternary age. However, there is one stratum where a few Miocene radiolarians are reworked into the modern assemblages. Local seamounts are suggested sources for the reworked radiolarians.

INTRODUCTION

On ODP Leg 116 we drilled three sites in the distal Bengal Fan, just south of the Equator in the eastern Indian Ocean (Fig. 1). The three closely spaced sites are at the distal end of the Bengal Fan, where sediment thickness is approximately 1.5 km or slightly less (Cochran, Stow, et al., 1989). Sites 717, 718, and 719 were drilled 828 m, 960 m, and 466 m below the seafloor, respectively. Turbidites, devoid of useful radiolarians, comprised the major portion of bulk sediments drilled at all sites (Stow, Cochran, et al., 1989). In addition to core-catcher samples studied on board *JOIDES Resolution*, generally two samples from each core were examined for presence of radiolarians. Moderate to well-preserved radiolarian assemblages were found only in the upper one or two cores and thus the focus of this study was on these intervals. For this reason, the upper two cores at both Holes 717B and 719A were more thoroughly studied than others.

METHODS

Radiolarian sample preparation technique follows that of Sanfilippo et al. (1985), and species identification follows those of Nigrini and Moore (1979), Takahashi and Honjo (1981), Sanfilippo et al. (1985), Caulet (1988), and Nigrini (1988). The prepared sample slides were first scanned to determine relative number (abundant, common, rare, trace, and absent) of radiolarians present. Those that contained "abundant, common, or rare" radiolarians were further subjected to detailed species identification and counting. In the semi-quantitative census of the species, three categories of relative abundance of each species counted were assigned: abundant (A), common (C), and rare (R).

RESULTS

Examination of an additional two samples from each core yielded little additional stratigraphic information at each of the sites below uppermost cores 1 and 2. This is due to virtual absence of radiolarians throughout cores except as mentioned below. Detailed descriptions of samples from these sections of the cores (total of 248) are presented elsewhere (Cochran, Stow, et al., 1989).

The intervals where radiolarians are found below the uppermost cores are listed (Table 1). Radiolarian specimens are fragmented and often pyritized, and species identifications are very difficult because transmitted light does not penetrate pyrite. Scanning electron microscopy did not improve identification much because of the large proportion of broken skeletons.

The relative abundance of radiolarians in the uppermost cores is illustrated (Fig. 2). The sequence of the radiolarian abundance strata from each hole is rather similar and they are underlain by characteristic turbidite sequences directly below. The assemblages that were determined to contain "abundant, common, or rare" radiolarians were further studied for species analysis; the results are presented in Table 2. The assemblages in these cores are almost predictably similar to one another, except for two samples that contained Miocene reworked radiolarians (Table 2). The "abundant" assemblages usually contain 30 to 50 taxa of very similar constituents, whereas the "common" assemblages contain approximately 10 to 20 taxa. Almost as a rule, the "rare" assemblages contain only a few taxa, including *Acanthodesmia vinculata*, *Tholospyris* sp. group and *Tetrapyle octacantha* (Table 2). The constituents of the "abundant" samples are very similar to biocoenosis (Takahashi and Honjo, 1981), suggesting a modern component of the assemblages. The assemblages contained in the upper cores belong to the *Buccinosphaera invaginata* Zone, extending from 0.21 m.y.BP to the present (Knoll and Johnson, 1975), of the uppermost Quaternary. However, there is one zone where Miocene radiolarians had been reworked and contributed a minor part of the modern assemblages. The Miocene assemblage belongs to the *Diartus petterssoni* Zone, 13 to 8.5 m.y.BP (Riedel and Sanfilippo, 1978; Berggren, 1985), middle to late Miocene. The assemblage in two slides of Core 116-717B-1-CC contains a total of more than 50 specimens of *Stichocorys delmontensis* as well as five to ten specimens of *Diartus petterssoni* and *Didymocyrtis laticonus*.

DISCUSSION

Radiolarian Preservation

The apparent lack of radiolarian preservation in most cores from Sites 717, 718, and 719 below the uppermost cores is mainly attributed to turbidites. As clearly documented by Cochran, Stow, et al. (1989), the bulk of sediments at all sites of Leg 116 are composed of turbidites. Very small amounts of pelagic sediments are found to be interbedded between these turbidites. This is likely due to resuspension of the pelagic sediments caused by turbidity current, which are then mixed

[1] Cochran, J. R., Stow, D.A.V., et al., 1990. *Proc. ODP, Sci. Results*, 116: College Station, TX, U.S.A. (Ocean Drilling Program).
[2] Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

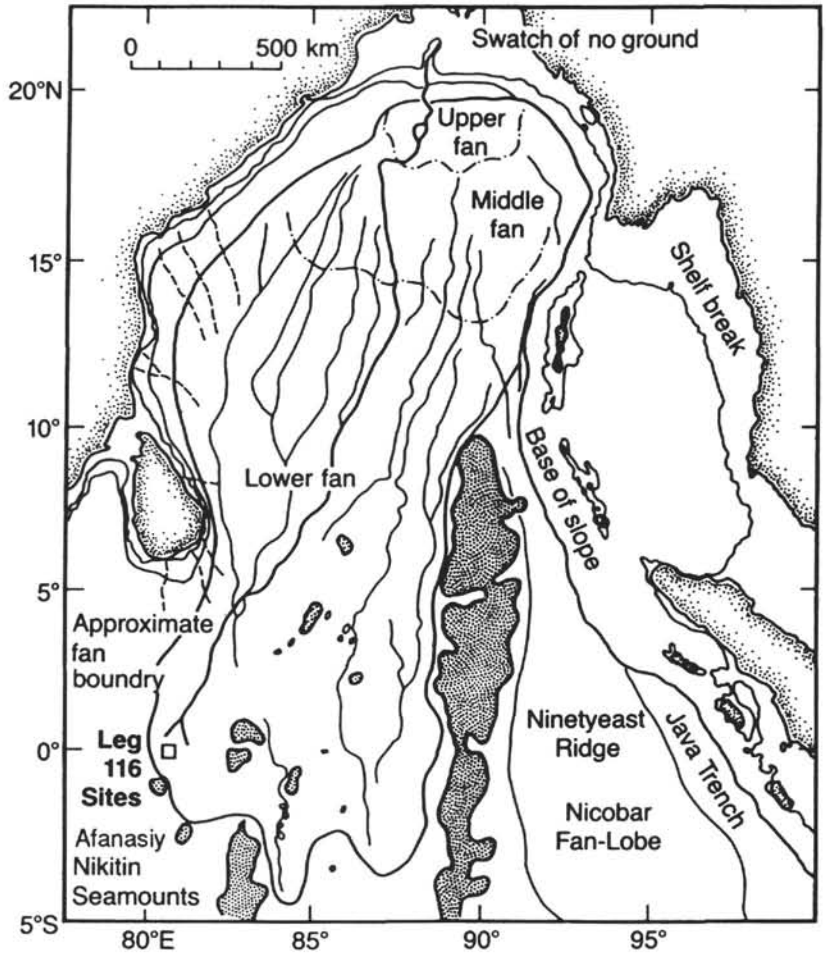

Figure 1. Map of the Bengal Fan showing the Leg 116 sites. Indian continental margin channels and fan channels are shown by dashed lines and solid lines, respectively; the currently active fan channel is shown by a heavy solid line; seamounts and topographic highs are indicated by heavy shading (after Emmel and Curray, 1984).

into the turbidite deposits. As we have documented that turbidity currents occurred about every 1000 yr at Leg 116 sites (Stow, Cochran et al., 1989) the relative amount of pelagic sediments (perhaps on the order of 1 mm/1000 yr) is small or even negligible compared to turbidite deposits a few cm to greater than a meter thick. Therefore, fossil radiolarians, if present, are likely diluted by coarse grains such as silt and sand and further subjected to dissolution in the highly porous interstitial waters where continuous diffusion of dissolved silicon is likely to occur. Even in pelagic clayey sediments examined (e.g., reddish brown clay, Core 116-718C-94X), generally no radiolarians are present except for the uppermost cores.

Interpretation of the radiolarian record as post-depositional loss of radiolarians rather than low biosiliceous production during the Neogene in the tropical Indian Ocean is preferred. Although there is some evidence suggesting biosiliceous production in the low-latitude Indian Ocean during a part of the Neogene was less than in other oceans, the evidence still does not explain the virtual absence of radiolarians throughout the Neogene. Radiolarians from Leg 115, western Indian Ocean, are found to be scarce throughout Oligocene to middle Miocene, but common and well preserved radiolarians are found during late Miocene through Holocene (Johnson, in press). Therefore, we hypothesize that the turbidites are responsible for the almost complete lack of preserved radiolarians throughout the cores.

Reworked Radiolarians

The reworked radiolarians found in the Samples 116-717B-1H-CC and -719A-1H-2, 110–111 cm, can be confined to the *D. petterssoni* Zone, middle to late Miocene. As we found no other radiolarians of other ages, we think that there was only a single source for the reworked sediments. The most probable source is nearby seamounts such as Afanasiy Nikitin Seamounts (Fig. 1). At the source location, original pelagic sedimentation without turbidite disturbance occurred during the middle to late Miocene and then this particular stratum was consequently eroded to supply the reworked radiolarians to Leg 116 sites between 0.21 m.y.BP to the present.

ACKNOWLEDGMENTS

This paper was critically reviewed by David A. Johnson and an anonymous reviewer. The National Science Foundation and the Joint Oceanographic Institutions, Inc. are thanked for the sponsorship of the Ocean Drilling Program through the Texas A&M Research Foundation under which this study was conducted. This is Contribution No. 7193 of the Woods Hole Oceanographic Institution.

Table 1. List of samples where radiolarians were found, except for the uppermost cores listed in Figure 2. Most of these samples contain only broken and pyritized radiolarian specimens except for the samples with asterisks.

Hole 717C Core, section interval (cm)	Hole 718B Core, section interval (cm)	Hole 719A Core, section interval (cm)
21X-CC	4X-CC	31X-3, 113–115
26X-CC	10X-CC	31X-CC
27X-1, 24–26[a]	11X-1, 2–4	38X-5, 78–80[c]
27X-5, 12–14	41X-3, 20–26[b]	
32–34		
70–72		
91–95		
116–118		
29X-CC		
59X-2, 34–36		
4, 11–13		

[a] Moderately diverse assemblage including *B. scutum*, *C. profunda*, *T. octacantha*, *C. papillosum*, *Spirocyrtis* cf. *subscaris*, *Carpocanarium* sp. *D. Theocaryptra* sp. and Spongodiscids.
[b] Contains three specimens of *Acrosphaera spinosa fasciculopora* or *A. spinosa hamospinosa*; subspecies identification not possible due to broken tips of their spines. These two subspecies are abundant near the end of *Stichocorys peregrina* Zone of lower Pliocene (Caulet, 1986).
[c] One specimen each of *Anthcyrtidium ehrenbergi ehrenbergi* and *Lamprocyrtis* sp. were found. *A. e. ehrenbergi* is a Miocene species.

REFERENCES

Berggren, W. A., Kent, D. V., Flynn, J. J., and Van Couvering, J. A., 1985. Cenozoic geochronology. *Geol. Soc. Am. Bull.*, 96:1407–1418.

Caulet, J. P., 1988. The genus Anthocyrtidium (Radiolaria) from the tropical late Neogene of the Indian and Pacific Oceans. *Micropaleontology*, 34:341–360.

Cochran, J. R., Stow, D.A.V., et al., 1989. *Proc. ODP, Init. Repts.*, 116: College Station, TX (Ocean Drilling Program).

Emmel, F. J., and Curray, J. R., 1984. The Bengal submarine fan, northeastern Indian Ocean. *Geo-Mar. Lett.*, 3:119–124.

Johnson, D. A., in press. Radiolarian biostratigraphy in the central Indian Ocean, Ocean Drilling Program Leg 115. *In* Backman, J., Duncan, R. A., et al., 1989. *Proc. ODP, Sci. Results*, 115: College Station, TX (Ocean Drilling Program).

Knoll, A., and Johnson, D. A., 1975. Late Pleistocene evolution of the collosphaerid radiolarian Buccinosphaera invaginata Haeckel. *Micropaleontology*, 21:60–68.

Nigrini, C., 1988. The genus Pterocorys (Radiolaria) from the tropical late Neogene of the Indian and Pacific oceans. *Micropaleontology*, 34:217–235.

Nigrini, C., and Moore, T. C., 1979. A guide to modern radiolaria. *Spec. Publ. Cushman Found. Foraminiferal Res.*, 16:i–xii.

Riedel, W. R., and Sanfilippo, A., 1978. Stratigraphy and evolution of tropical Cenozoic radiolarians. *Micropaleontology*, 24:61–96.

Sanfilippo, A., Westberg-Smith, M. J., and Riedel, W. R., 1985. Cenozoic radiolaria. *In* Bolli, H. M., Saunders, J. B., and Perch-Nielsen, K. (Eds.), *Plankton Stratigraphy:* Cambridge (Cambridge Univ. Press), 631–712.

Stow, D.A.V., Cochran, J. R., and ODP Leg 116 Shipboard Scientific Party, 1989. The Bengal Fan: some preliminary results from ODP drilling. *Geo-Mar. Lett.*, 9:1–10.

Takahashi, K., and Honjo, S., 1981. Vertical flux of Radiolaria: a taxon-quantitative sediment trap study from the western tropical Atlantic. *Micropaleontology*, 27:140–190.

Date of initial receipt: 11 April 1989
Date of acceptance: 2 October 1989
Ms 116B-123

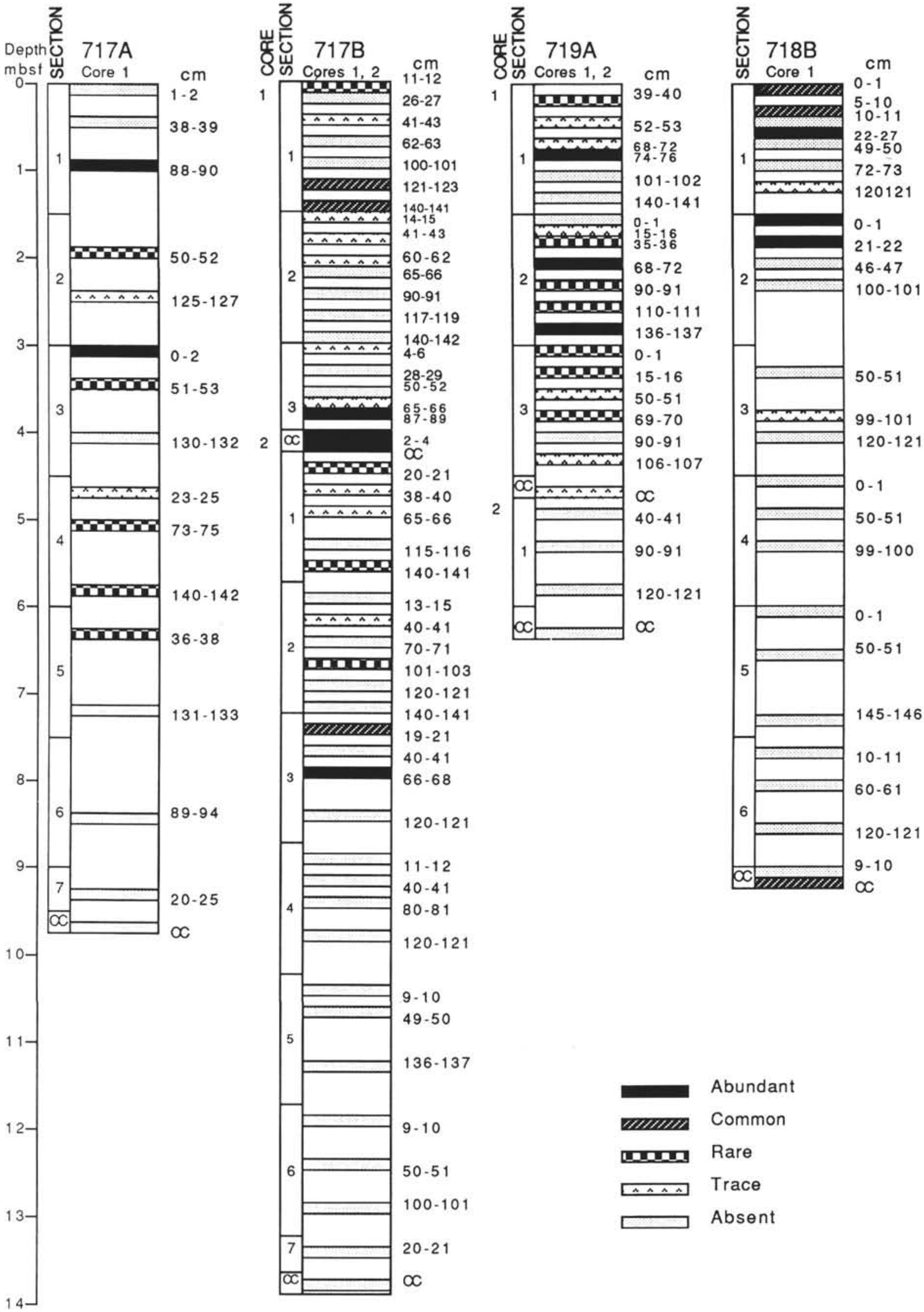

Figure 2. Relative abundance of whole radiolarians in the uppermost cores from three sites of Leg 116. Five abundance categories are employed.

Table 2 . Relative abundance of radiolarian species from uppermost cores at Holes 717A, 717B, 718B, and 719A of Leg 116. Only the samples containing abundant, common, and rare radiolarians listed in Figure 2 were examined for abundance of each species and listed here. The following designations are employed for relative abundance of each species: A: abundant; C: common; R: rare; and blank for absent.

	717A	1H-1, 88–90 cm	1H-2, 50–52	1H-3, 0–2	1H-3, 51–53	1H-4, 73–75	1H-4, 140–142	1H-5, 36–38	717B	1H-1, 11–12	1H-1, 121–123	1H-1, 140–141	1H-3, 87–90	1H-CC, 2–4	1H-CC	2X-1, 20–21	2X-1, 140–141	2X-2, 101–102	2X-3, 19–21	2X-3, 66–68	718B	1H-1, 0–1	1H-1, 5–10	1H-1, 22–27	1H-2, 0–1	1H-2, 21–22	1H-CC	719A	1H-1, 39–40	1H-1, 74–76	1H-2, 35–36	1H-2, 68–72	1H-2, 90–91	1H-2, 110–111	1H-2, 136–137	1H-3, 0–1	1H-3, 15–16	1H-3, 69–70
SPUMELLARIA																																						
Acrosphaera murrayana															R					A					C							C		C				
Acrosphera spinosa		C		A			C				C		C	A						A				A	A	A	R			A		C		A				
Amphirhopalum ypsilon		C											R	R	R																							
Buccinosphaera invaginata		R		C									C		R									R		R						R		R				
Collosphaera macropora		C					C				C	R												A	A					C								
Collosphaera polygona																																						
Collosphaera tuberosa		C	C	A							C		A	A	A					A		C		A					R	C		A		A				
Collosphaera huxleyi				A			C												C			C		C	A	A								C				
Dictyocoryne truncatum		A		C							C	R	A	A	A					A		C	R			A	R					A						
Dictyocoryne profunda		C		C							C									A				A		A			R	C		C						
Didymocyrtis t. tetrathalamus		A		A				R			C	R	A	A					A	A		C	R	A	A	A	R			A								
Disolenia zanguebarica		C		C	R						C		A	C					C	A		C								C		C		A				
Druppatractus acquilonius																																						
Euchitonia elegans		A		A				R					A	A								C		A	A	A	R		R	C		A		A		R		
Heliodiscus asteriscus		C		A				R			C	R	A	A	A					A		C		C		A				C		A						
Hexacontium axotrias		C											A	A	A					A		C			A													
Otosphaera polymorpha			C	A							C	R		A	A																			A				
Porodiscus spp.		A						R		R			A	A	A									A	A	A												
Saturnalis circularis													R																									
Siphonosphaera polysiphonia		C		A							C		A	A	A	R				A				A	A	A						C		C		R		
Spongaster tetras		C		A				R			C	R	A	A	A				C	A		C		A	A	A				C		A						
Stylosphaera group		C				R	C				C		A	A	A	R		R	A	A		C	R		A	A	R			C			R	C				
Tetrapyle octacantha		A	C	A	R		A			R	A	R	A	A	A				A	A		C	R	A	A	A	R		A	A		A						
NASSELLARIA																																						
Acanthodesmia vinculata		A	C	A	R	R	A	R			A	R	A	A	A			R	A	A		A	R	A	A	A	R			A	R	A		A	A			
Anthocyrtidium ophirense		C		A			C						A	A	A					C		C		A	A	A						A		C				
Anthocyrtidium zanguebaricum		C											A											C	C							C		C				
Artostrobus annulatus		R																								R								C				
Botryocyrtis scutum		A		A				R					A	A	A					A		C		A	A	A				C		A		A				
Botryostrobus aquilonaris																																						
Carpocanistrum cephalum		C		A			C	R			C		A	A	A		R			A				A	A	A	R			C								
Carpocanarium papillosum		C		A				R					C	A	A					C				C	A													
Centrobotrys thermophila															R																							
Clathrocanium diadema				A																				C	A		R			C		C						
Cornutella profunda		A		A				R			C	R	A	A	A					A		C		A	A	A						A	R	C				
Dictyophimus infabricatas		R					C						C							R												R		C				
Eucecryphalus sestrodiscus		R		A							C		C		A					A				A	C	A								C				
Eucyrtidium acuminatum		C		A						R			A	A	A					A		C		A		A						A						
Eucyrtidium hexagonatum		C												A	A							C		A														
Lamprocyclas maritalis maritalis													R							C		C		C	C	A												
Lamprocyclas maritalis polypora		C		A			C					R	C	A	A				C	C				C		A				C		C						
Lamprocyrtis nigriniae		C						R					A	C	A										R									C				
Lamprocyrtis hannai				C									C											C	C	C								C				
Liriospyris reticulata		C		C			C				A		A	A	A				A	A		C		A	A	A				C		A						
Lithopera bacca		C													A					A				A	C							C						
Lophophaena sp.		A		A																																		

Table 2 (continued).

	717A	1H-1, 88–90 cm	1H-2, 50–52	1H-3, 0–2	1H-3, 51–53	1H-4, 73–75	1H-4, 140–142	1H-5, 36–38	717B	1H-1, 11–12	1H-1, 121–123	1H-1, 140–141	1H-3, 87–90	1H-CC, 2–4	1H-CC	2X-1, 20–21	2X-1, 140–141	2X-2, 101–102	2X-3, 19–21	2X-3, 66–68	718B	1H-1, 0–1	1H-1, 5–10	1H-1, 22–27	1H-2, 0–1	1H-2, 21–22	1H-CC	719A	1H-1, 39–40	1H-1, 74–76	1H-2, 35–36	1H-2, 68–72	1H-2, 90–91	1H-2, 110–111	1H-2, 136–137	1H-3, 0–1	1H-3, 15–16	1H-3, 69-70
Lophospyris pentagona hyperborea		C						R					C	A	A									A	C		R					A		A				
Lophospyris pentagona pentagona		C											C							C							R							C				
Peripyramis circumtexta		C												C	R							C				C				C				C				
Peromelissa pharacra		A								R	A		A	A			R			A		C		A	A							A		C				
Phormostichoartus corbula		C		A				R						A	A					C				C	A	C				C		A		A				
Pterocanium p. praetextum		A	C	A						R		R	A	A						A		C		A	A	A				A		A		A	R			
Pterocanium trilobum		C		C			C						A	A	A				C	A		C		A	A	A						A						
Pterocorys macroceras		R																																				
Pterocorys hertwigii		C																																				
Pterocorys sabae		A	C	A							C		A	A	A					A		C		A	A	A				A		A		A	R			
Pterocorys clausus				R																				C		C								C				
Siphocampe arachnea		C		C				R					A	C					A	C				C	C							A						
Siphocampe lineata		C		A				R		R			A	A						C				A	C							C						
Spirocyrtis cf. *subscalaris*		C	C	A				R			C			A	A					A				A		A						A		C				
Theocalyptra sp.				A									C	C						C				A	C	C								C				
Theocorys veneris		C		A									C	C										C		C						C						
Theocorythium t. trachelium		C		A									A	A	A					C		C		A	A	A				C		C						
Tholospyris sp. group		A	C	A	R	R	A			R	A		A	A		R	R	R	A	A		A	C	A	A		R		R		R	A		A	R	R	R	R
REWORKED RADIOLARIANS																																						
Anthocyrtidium ehrenbergi															R																							
Diartus petterssoni															R																							
Didymocyrtis laticonus															R																							
Lychnodictyum audax															R																							
Siphostichartus corona															R																			R				
Stichocorys delmontensis															C																			C				