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RADIOLARIA FROM NEILL ISLAND, ANDAMAN SEA, AND THEIR DISTRIBUTIONAL CHARACTERISTICS

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ABSTRACT

This study reports 104 species of radiolaria from a Late Miocene to Early Pliocene sequence at Neill Island, Andaman Sea. The radiolarian assemblage, which belongs to the *Didymocyrtis penultima* Zone and *Stichocorys peregrina* Zone, also contains reworked species from older Miocene sediments.

A comparison of the fossil assemblage, with the modern radiolarian assemblage from the Indian Ocean, shows that the former is dominated by species belonging to the present day Tropical Assemblage of this region. The assemblage also contains a few species which mainly characterise the cold-water regions of modern oceans. Their relative increase in the *S. peregrina* Zone seems to be related to upwelling in this region during the deposition of sediments belonging to this Zone.

INTRODUCTION

Neill Island, in the Andaman Sea, contains one of the deepest marine Neogene sedimentary facies in the Andaman-Nicobar region. As a result, the rocks are very rich in radiolaria in addition to other microfossils.

Studies of Cenozoic radiolaria from the Andaman-Nicobar region are very scanty and are mainly in the form of preliminary reports (Jacob and Srivastava, 1952; Jacob, 1954; Singh and Vimal, 1973; Jafri, 1986). The only work in some detail is by Srinivasan *et al.* (1983), who studied both radiolaria and foraminifera from the Early Miocene sediments of Colebrook Island, Andaman Sea, for the purpose of biostratigraphic zonation.

The Neogene planktonic foraminiferal biostratigraphy of Andaman-nicobar Islands is well established through the extensive work of Srinivasan and his co-workers. Srinivasan (1978) also proposed chronostratigraphic divisions of the Neogene sequences of these islands. The present status of biostratigraphy and chronostratigraphy can be found in Srinivasan (1988).

A detailed stratigraphy of Neill Island was presented by Srinivasan and Azmi (1976) and the same is adopted here (Table 1). They classified the lithologic sequences of this island into the Sawai Bay Formation and Neill West Coast Formation. The Sawai Bay Formation, represented by massive mudstone, is exposed in the eastern (at East Coast Section) and northeastern (at Nipple Hill Section) parts. The Neill West Coast Formation, consisting of siltstone overlain by limestone, occurs as discontinuous cliffs along the coast, in the Western part. The mudstones (of the Sawai Bay Formation) are very rich in radiolaria. Between the two sections, exposing the Sawai Bay Formation, the sequence at East Coast Section is

Table 1. Stratigraphic succession at Neill Island (after Srinivasan and Azmi, 1976).

GROUP	FORMATION/ MEMBER	LITHOLOGY	AGE
ARCHIPELAGO GROUP		Shell limestone, coral rags and beach sand	Recent to Subrecent
	Unconformity		
	NEILL WEST COAST FORMATION: Neill Limestone Member	Moderately hard, yellowish, medium grained, thinly-bedded limestone	Pleistocene
	Disconformity		
	NEILL WEST COAST FORMATION: Neill Silty Mudstone Member	Soft, greenish-grey, calcareous, silty mudstone	Late Pliocene
	Hiatus (?)		
	Sawai Bay Formation	Soft, light-grey, massive, calcareous mudstone with occasional silty bands	Early Pliocene to Late Miocene

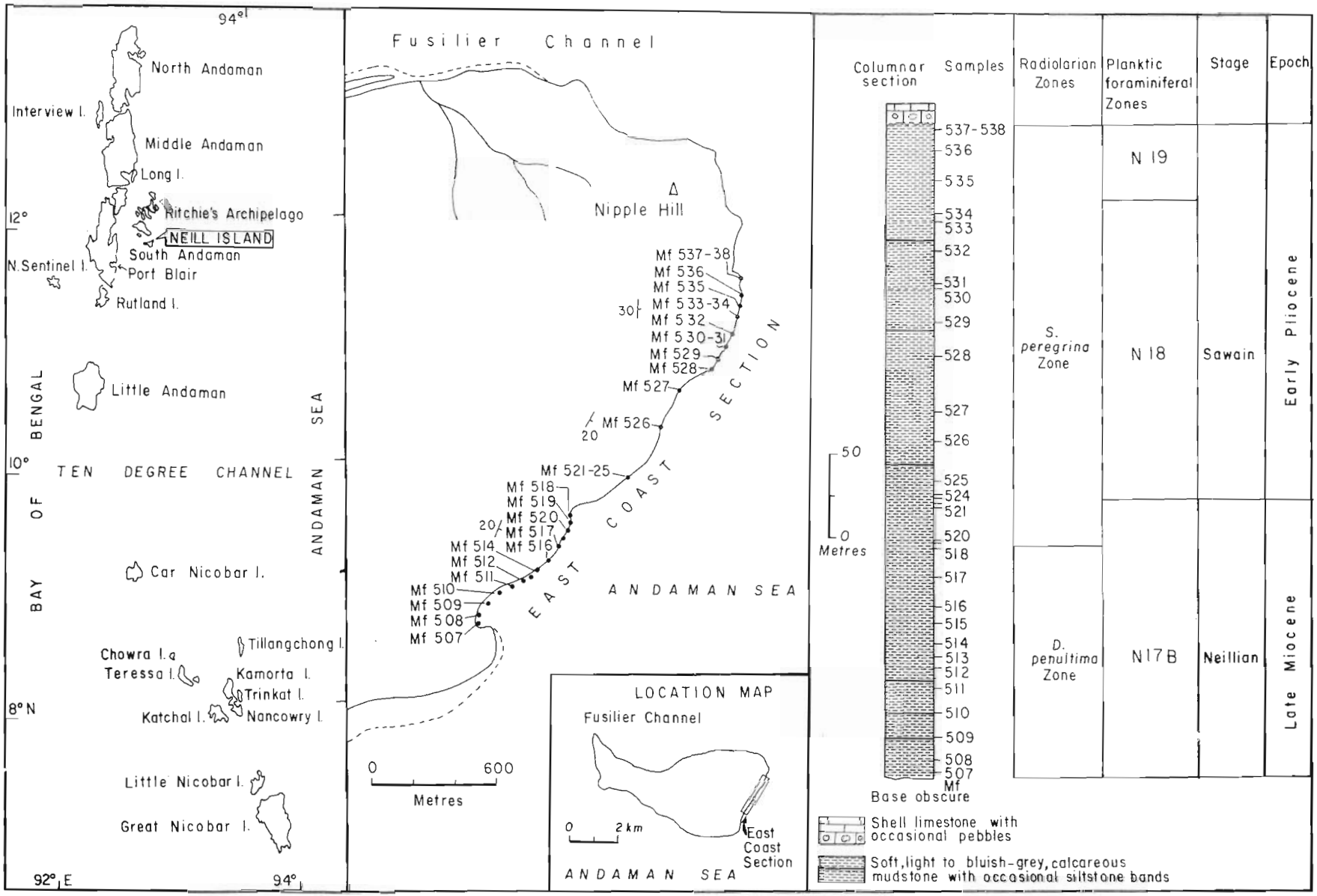
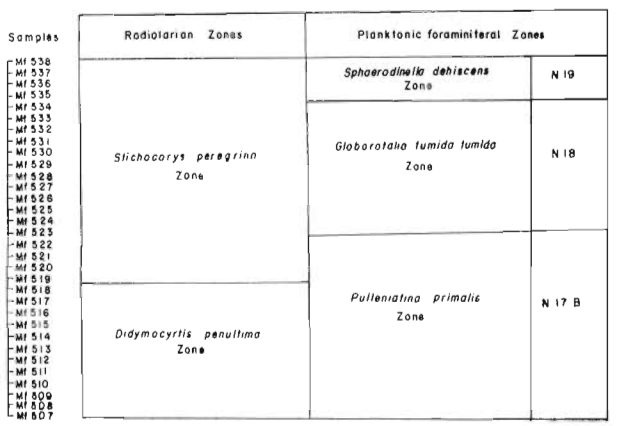


Fig. 1. Location of Neill Island, sample locations at East Coast Section, and stratigraphic position of samples. Foraminiferal zonal scheme is after Blow (1969; emended Srinivasan and Kennett, 1981a, 1981b). Stage names are after Srinivasan (1978, 1984).

better developed. The present study deals with the radiolaria from this section.

Planktonic foraminifera of East Coast Section were studied by Srinivasan and Azmi (1976) and the same samples are used in the present study. In the sequence at this section, Srinivasan and Azmi (1976) identified three planktonic foraminiferal zones, which, based on the work of Srinivasan and Kennett (1981 a,b) were slightly modified. The (modified) zones, in ascending order, are, *Pulleniatina primalis* Zone, *Globorotalia tumida tumida* Zone and *Sphaeroidinella dehiscens* Zone. (See Srinivasan, 1988), and the sequence, in part or whole, is equivalent to zones N17 B to N 19 of Blow (1969, emended Srinivasan and Kennett, 1981a, b) (Table 2).

Table 2. Radiolarian and planktonic foraminiferal biostratigraphic zones identified at East Coast Section. The planktonic foraminiferal zones are after Srinivasan and Azmi (1976; modified Srinivasan, 1984) and Blow (1969; emended Srinivasan and Kennett, 1981a, 1981b).



METHODS OF STUDY

Thirty-two samples were analysed for the study. Samples were first soaked in H_2O_2 and washed over a 63 μm sieve. They were then treated for a brief period (15-20 seconds) in an ultrasonic bath to remove clay from inside the radiolarian tests and washed again. To dissolve calcareous material, washed samples were soaked in dilute HC1 solution, washed again and dried.

A fraction of the washed residue was used for the preparation of slides using canada balsam as the mounting medium. For each sample, 4-8 slides were prepared.

Distribution of radiolarian species was recorded according to their relative abundances. Slides of each sample, except those of samples Mf 507 to Mf 509, contain 8,000 to 12,000 specimens of radiolaria. The distribution of radiolaria is recorded according to the following scheme: extremely rare (+, 1 or 2 specimens on the slides of a sample), rare (R, 3-50 specimens), few (F, 50-1000 specimens), common (C, 1000-5000 specimens), abundant (A, above 5000 specimens) and absent (-). Preservation of assemblage in a particular sample was observed according to the preservation of individual specimens. All the samples show good preservation of radiolarian species and this has been denoted by the letter 'G' in the distribution chart (Table 3). Stratigraphically important species like *Didymocyrtis tetrathalamus*, *Spongaster pentas* and *S. tetras* were especially searched for, but were found absent. However, their occurrences (as absent) are shown in the distribution chart. Classification is mainly based on the works of Nigrini and Moore (1979), Nigrini and Lombari (1984) and Bjørklund and Goll (1979).

DISTRIBUTION OF RADIOLARIA IN THE SEQUENCE

In the assemblage, a numer of species are found to show consistent presence throughout the sequence (Table 4). However, none of the species is repres-

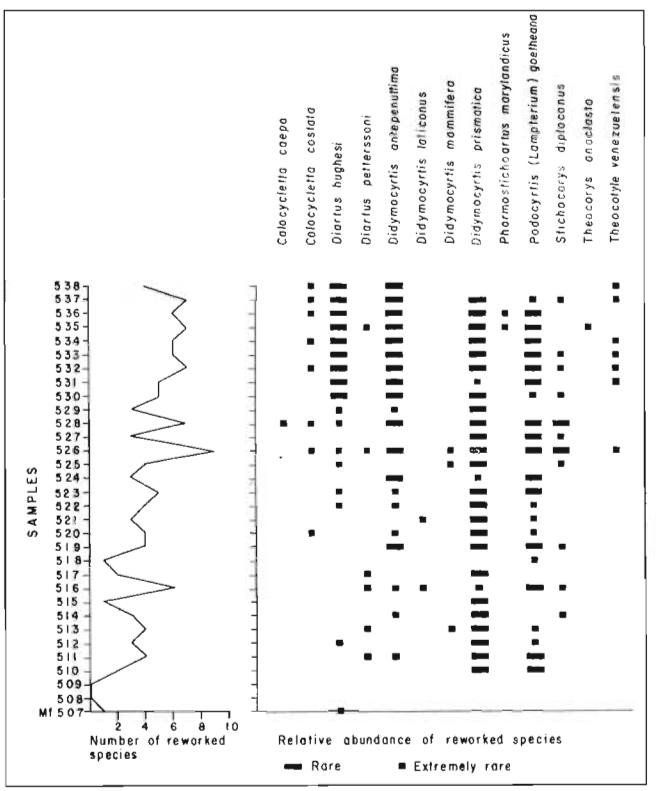


Fig. 2. Graph showing number of reworked species in each sample and visual estimate of their relative abundance.

ented by 'common' (C) or 'abundant' (A) specimens in a total of 104 species recorded from the studied material.

The assemblage is referable to the zonal scheme proposed by Riedel and Sanfilippo (1978) for the low latitude regions. Two zones, viz., *Didymocyrtis penultima* Zone and *Stichocorys peregrina* Zone have been recognised. Details of these zones are being described elsewhere.

The assemblage shows presence of some reworked species. The reworking has resulted in bringing radiolarian species from older sediments into the present assemblage, especially from the older Miocene sediments. A few forms viz., *Podocyrtis (Lampterium) goetheana* (Haeckel), *Theocorys anaclasta* Riedel and Sanfilippo and *Theocotyle venezuelensis* Riedel and Sanfilippo are from as old as Eocene sediments. These species occur extremely rarely. Towards the upper part of the sequence, particularly sample Mf 524 upwards, relative abundance and number of reworked species increase (Fig. 2). Species like *Diartus hughesi* (Campbell and Clark), *Didymocyrtis antepenultima* (Riedel and Sanfilippo) and *Stichocorys delmontensis* Campbell and Clark, persistently occur in larger number in the *Stichocorys peregrina* Zone. The last occurrences of these species are in the Late Miocene in the DSDP cores of low latitude areas of Pacific and Indian Oceans. The first two are restricted in their stratigraphic range within the Late Miocene, while *S. delmontensis* ranges from Early to Late Miocene (Sanfilippo *et al.*, 1985), and all the three became extinct before the deposition of the sediments of the *Stichocorys peregrina* Zone. As such, their presence in large numbers in the younger sediments of the sequence indicates a pronounced reworking of radiolaria from the Early to Late Miocene sediments during the deposition of Early Pliocene sediments belonging to *S. peregrina* Zone. This part of the sequence is also characterized by a larger concentration of sponge spicules.

NATURE OF THE RADIOLARIAN ASSEMBLAGE

In the past few years, sufficient data have been gathered on the distribution of modern radiolaria in the Indian Ocean to permit a meaningful comparison of the radiolarian assemblages from Neill Island with modern assemblages, particularly from the northern Indian Ocean.

MODERN ASSEMBLAGE IN THE INDIAN OCEAN

In the Indian Ocean, modern radiolaria from the surface sediments have been studied by Nigrini (1967), Petrushevskaya (1967, 1971), Lozano and Hays (1976), Dow (1978) and Johnson and Nigrini (1980, 1082).

The most comprehensive work on the nature of radiolarian assemblages, in the Indian Ocean, is by Johnson and Nigrini (1980 1982). They used quantitative techniques to identify various assemblages. Their study (Johnson and Nigrini, 1982) of the radiolaria from the surface sediments of the eastern Indian Ocean, between latitudes 10°N and 50°S, is of great value in interpreting the composition of the Neill Island assemblages.

Johnson and Nigrini (1980) subjected radiolarian species from the western Indian Ocean to recurrent group analysis. Later, while analyzing the radiolaria from the eastern Indian Ocean by the same methods, they (1982) modified the recurrent groups of western Indian Ocean assemblage and identified six groups (A' to F') for both eastern and western Indian Ocean. All those samples which showed the presence of recurrent groups were then determined. Based on the presence and/or absence of one or more recurrent groups in a sample, they recognized nine radiolarian assemblages in the Indian Ocean.

FOSSIL RADIOLARIA : A COMPARISON

In the radiolarian assemblage from Neill Island, a number of species occur extremely rarely. Others (76 in number) are represented by 'rare' (R) species that show nearly consistent occurrences with abundance 'F' in any one of the samples. These are here referred to as the 'dominant species' (Table 3). Ten of the 'dominant' species occur with abundance 'F' in at least 30% samples.

Table 3. List of dominant radiolarian species

Category I : Species with abundance 'F' in at least 30% samples	Category II : Species with abundance 'F' in less than 30% samples
Acrosphaera spinosa spinosa (Haeckel)	Acrosphaera spinosa echinoides (Haeckel)
Anthocyrtidium ophirense (Ehrenberg)	Acrosphaera transformata Hilmers
Didymocyrtis penultima (Riedel)	Collosphaera huxleyi Müller
Euchitonia furcata Ehrenberg	*Collosphaera macropora* Popofsky
Hymeniastrum euclidis Haeckel	*Heliodiscus asteriscus* Haeckel
Phorticium pylonium Haeckel	*Heliodiscus echiniscus* Haeckel
Pterocanium trilobum (Haeckel)	*Phorticium polycladum* Tan and Chang
Stylodictya validispina Jorgensen	*Tetrapyle octacantha* Müller
Stichocorys delmontensis Campbell and Clark	
Stichocorys peregrina (Riedel)	

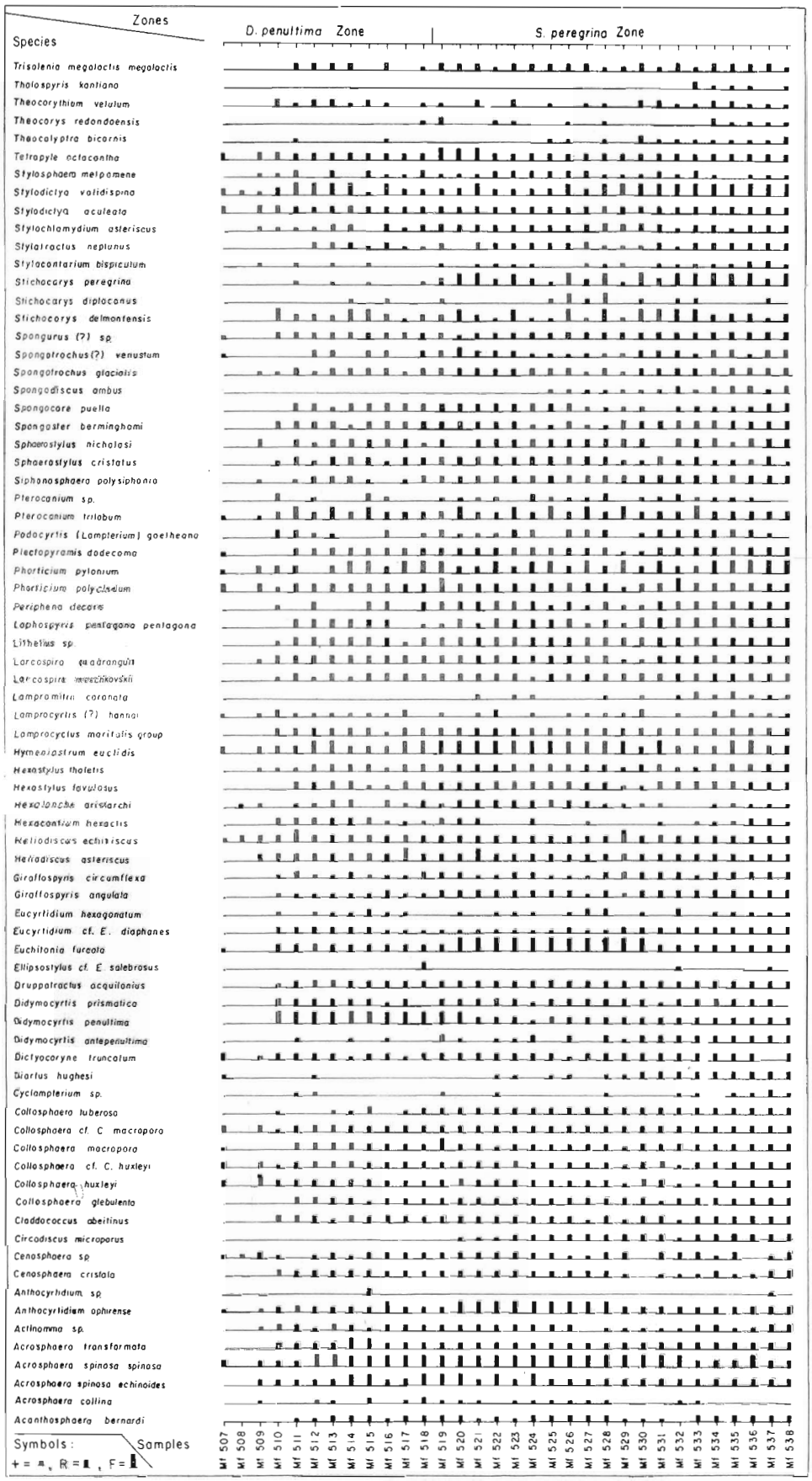


Fig. 3. Visual estimate of abundance of some selected (occurrence ≥R in any one of the samples) species.

The present assemblage when compared with the assemblage of Johnson and Nigrini (1982) from the Indian Ocean shows that all the dominant species except *Collosphaera huxleyi* belong to Recurrent Group A' (Tropical latitudes). The species *Collosphaera huxleyi*, however, belongs to Recurrent Group C' (Subtropical latitudes). Other well-represented species belonging to Recurrent Group A' in the assemblage from Neill Island are *Dictyocoryne truncatum* (Ehrenberg), *Larcospira quadrangula* Haeckel, *Siphonosphaera polysiphonia* Haeckel and *Collosphaera tuberosa* Haeckel. Dominance and the consistent presence of species of Group 'A', and poorer representation of species of other recurrent groups in the sequence, shows that the radiolarian assemblage of Neill Island is dominated by the species of the Tropical Assemblage as defined by Johnson and Nigrini (1982).

A number of species occurring in the material are found to have a wide latitudinal range in modern oceans. Species like *Spongotrochus glacialis* Popofsky, *Stylodictya validispina* Jorgensen, *Phorticium pylonium* Haeckel, *Theocalyptra bicornis* (Popofsky) and *Lampromitra coronata* Haeckel prefer cold-water areas, though they are also found in warmer regions (Petrushevskaya, 1971; Casey, 1971; Sachs, 1973; Lozano, 1974; Robertson, 1975; Morley, 1977; Keany, 1979). Increase in the relative numbers of some of these species (Table 4) in the *S. peregrina* Zone is possibly indicative of upwelling in this region during the period from Latest Miocene to Early Pliocene.

Table 4A. Distribution of radiolarian species in the samples. Details of symbols are given in the text. Reworked species are marked with asterisks.

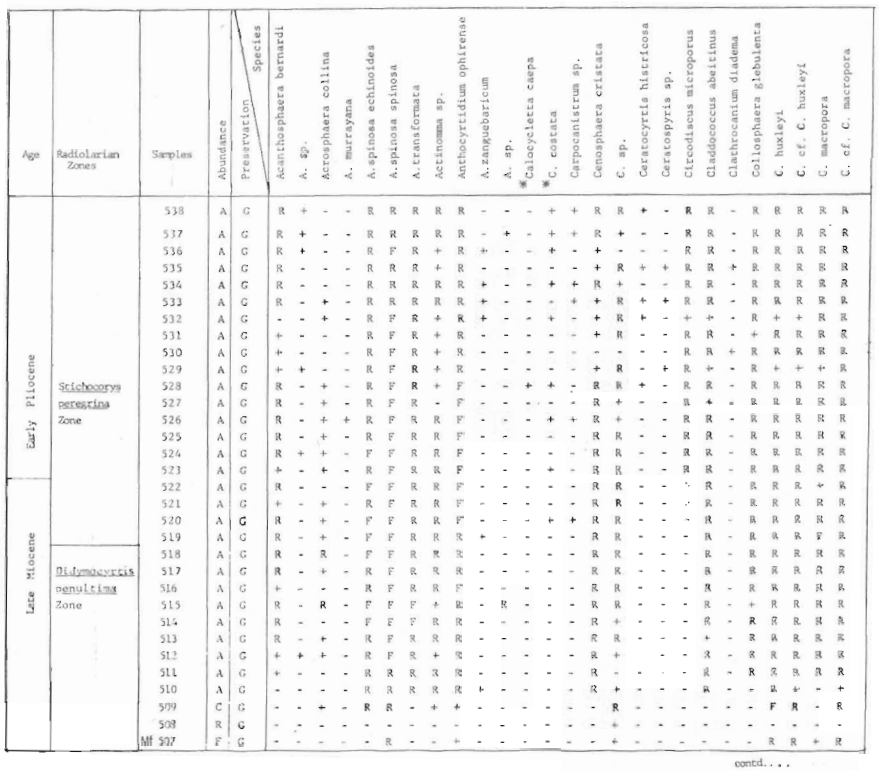


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Table 4B. Distribution of radiolarian species in the samples. Details of symbols are given in the text. Reworked species are marked with asterisks.

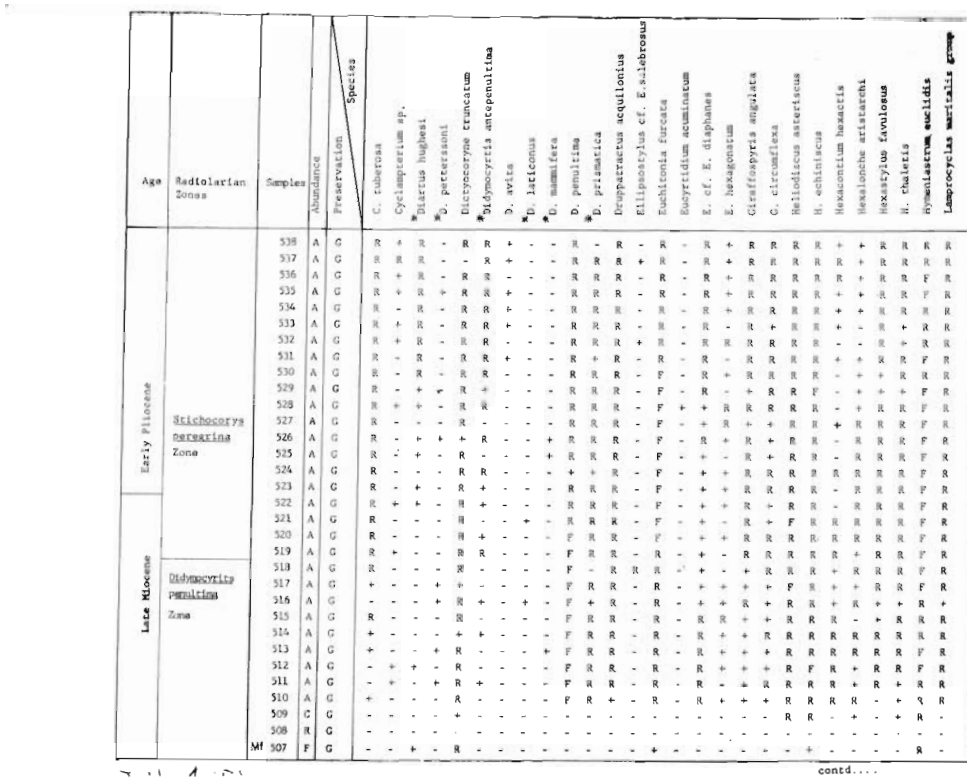


Table 4C. Distribution of radiolarian species in the samples. Details of symbols are given in the text. Reworked species are marked with asterisks.

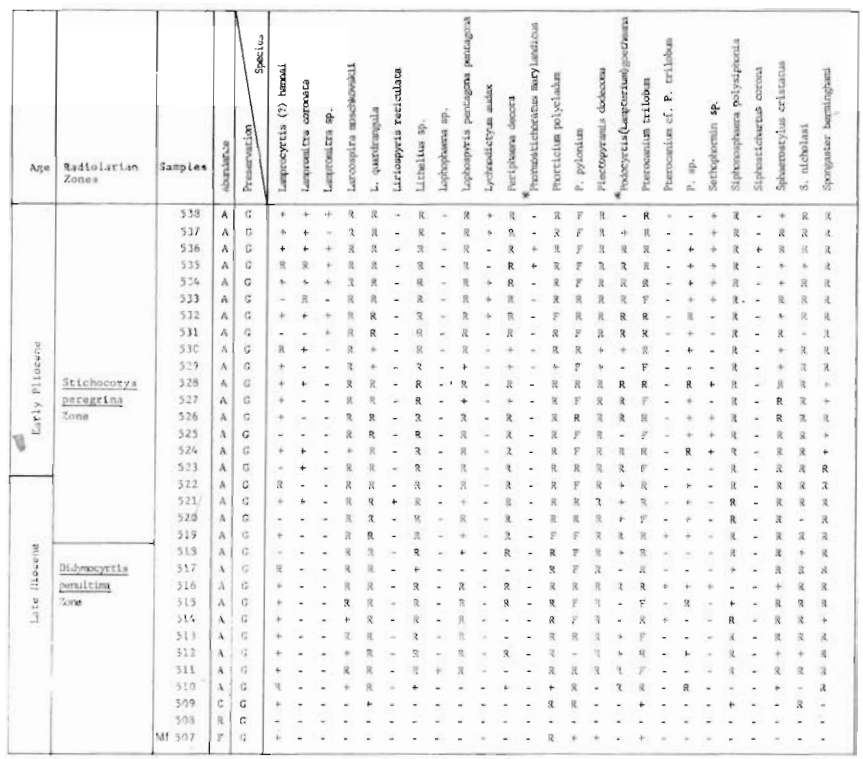
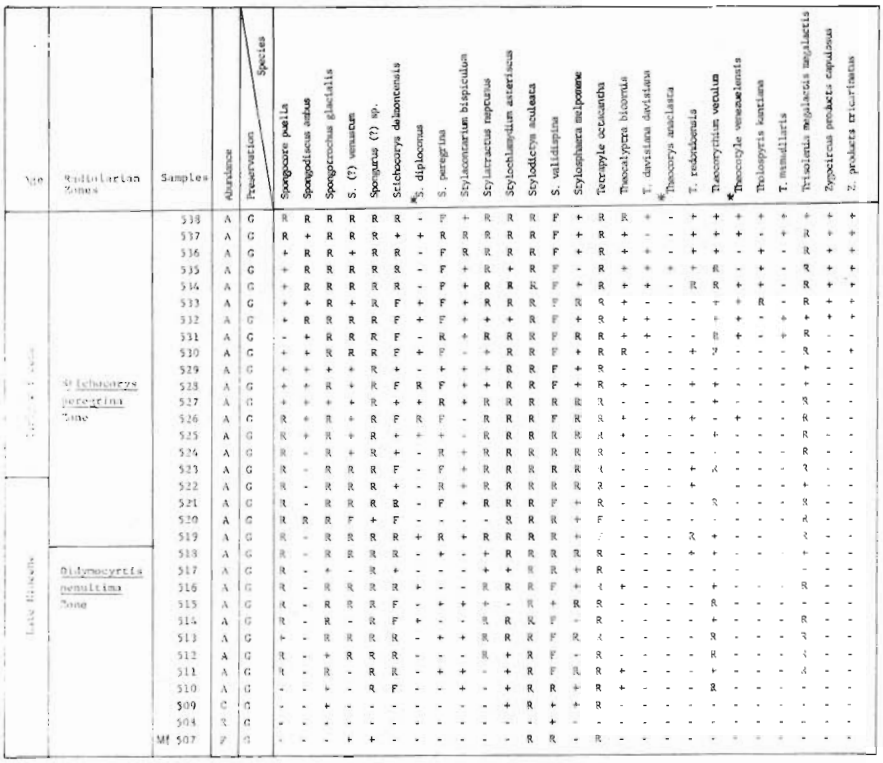


Table 4D. Distribution of radiolarian species in the samples. Details of symbols are given in the text. Reworked species are marked with asterisks.



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EXPLANATION OF PLATES

PLATE I

1. *Acrosphaera spinosa spinosa* (Haeckel)
   Sample no. Mf 510, X 220; focussed on perimeter.
2. *Euchitonia furcata* Ehrenberg
   Sample no. Mf 507, X 200
3. *Acrosphaera transformata* Hilmers
   Sample no. Mf 524, X 285; focussed on perimeter
4. *Stichocorys delmontensis* Campbell and Clark
   Sample no. Mf 511, X 370
5. *Hymeniastrum euclidis* Haeckel
   Sample no. Mf 532, X 170
6. *Stylodictya validispina* Jörgensen
   Sample no. Mf 510, X 245
7. *Stichocorys peregrina* (Riedel)
   Sample no. Mf 522, X 190
8. *Acrosphaera spinosa echinoides* (Haeckel)
   Sample no. Mf 520, X 335
9. *Didymocyrtis penultima* (Riedel)
   Sample no. Mf 510, X 345

PLATE II

1. *Pterocanium trilobum* (Haeckel)
   Sample no. Mf 510, X 230
2. *Tetrapyle octacantha* Müller
   Sample no. Mf 538, X 420
3. *Spongaster berminghami* (Campbell and Clark)
   Sample no. Mf 524, X 425
4. *Collosphaera huxleyi* Müller
   Sample no. Mf 510, X 230

5. *Spongaster berminghami* (Campbell and Clark) — *S. pentas* Riedel and Sanfilippo, transitional form,
   Sample no. Mf 532, X 380
6. *Anthocyrtidium ophirense* (Ehrenberg)
   Sample no. Mf 530, X 240
7. *Heliodiscus echiniscus* Haeckel
   Sample no. Mf 507, X 225; focussed on perimeter
8. *Collosphaera macropora* Popofsky
   Sample no. Mf 538, X 165
9. *Phorticium polycladum* Tan and Chang
   Sample no. Mf 510, X 230

PLATE III

1. *Phorticium pylonium* Haeckel
   Sample no. Mf 510, X 460
2. *Didymocyrtis antepenultima* (Riedel and Sanfilippo)
   Sample no. Mf 528, X 305

3,4. *Stichocorys delmontensis* (Campbell and Clark) — *S. peregrina* (Riedel), transitional form,
   Sample no. Mf 522; fig. 3, X 140, fig. 4, X 270

5. *Heliodiscus asteriscus* Haeckel
   Sample no. Mf 507, X 320
6. *Didymocyrtis avita* (Riedel)
   Sample no. Mf 531, X 490, focussed on perimeter

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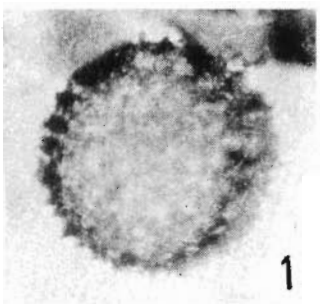
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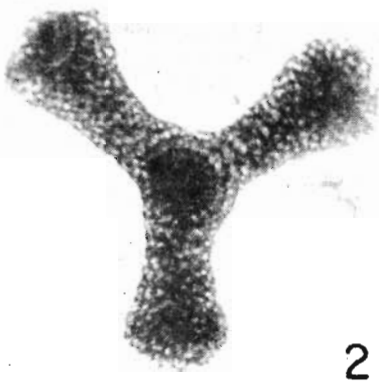
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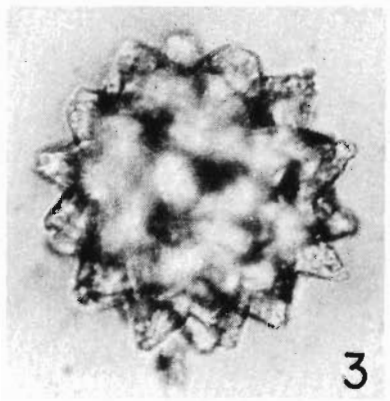
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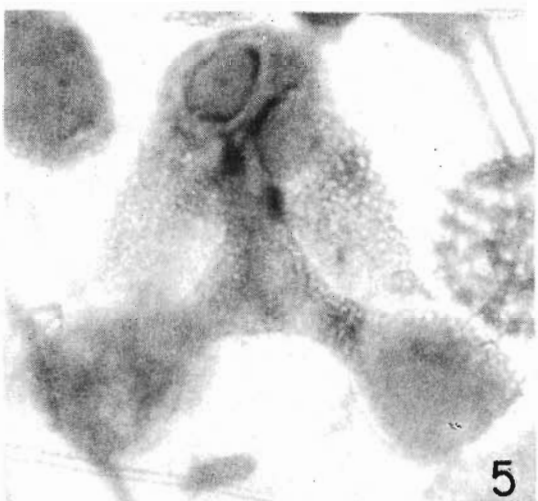
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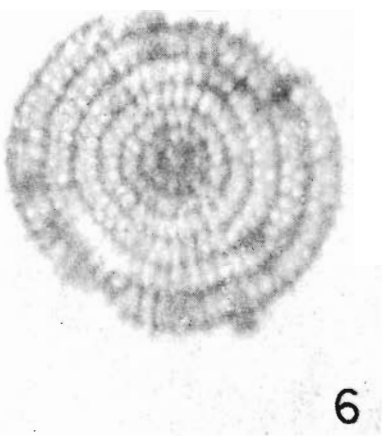
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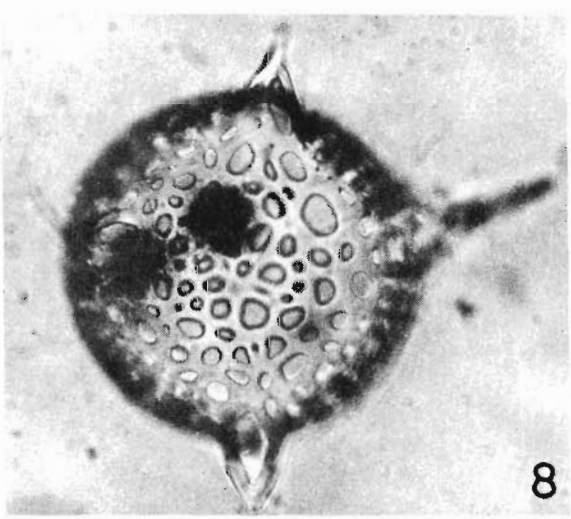
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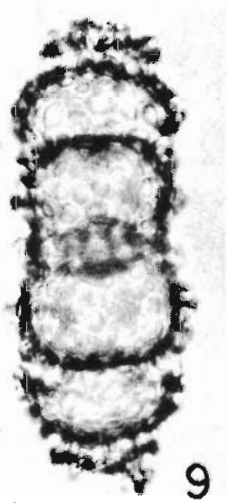
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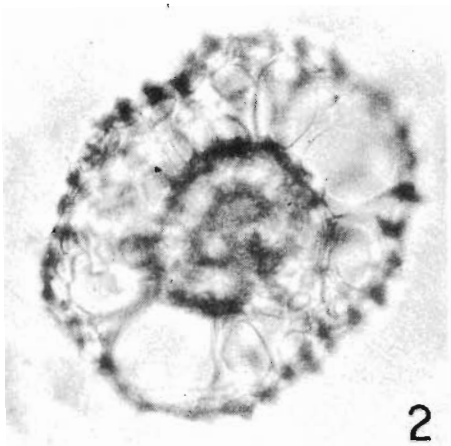

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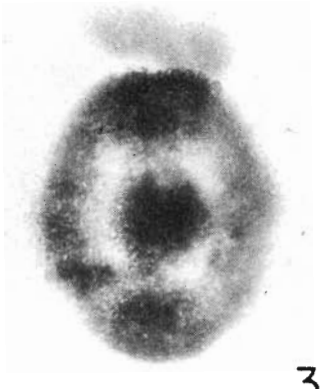

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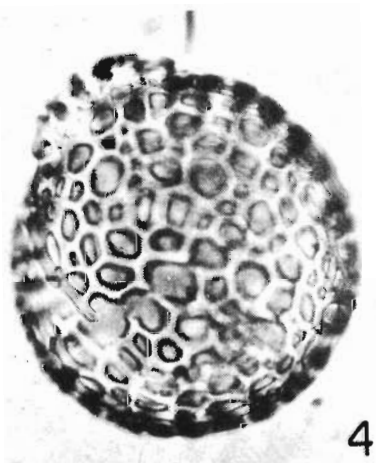

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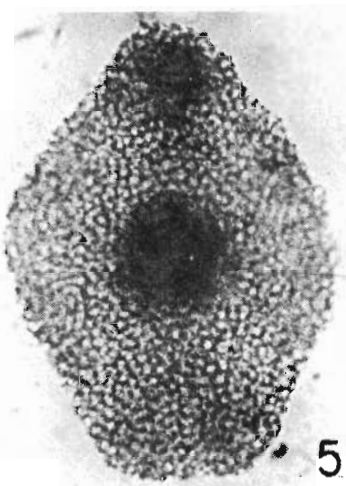

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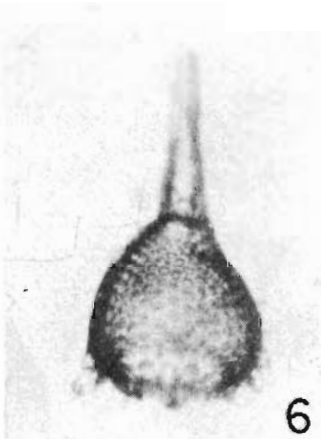

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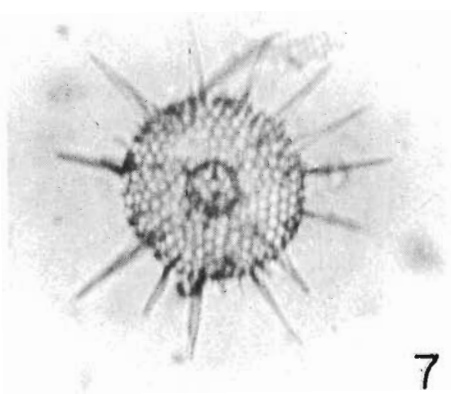

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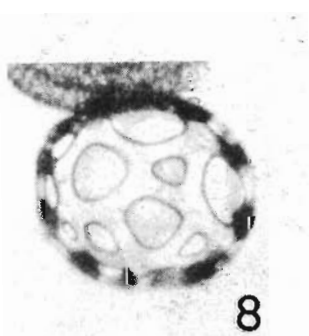

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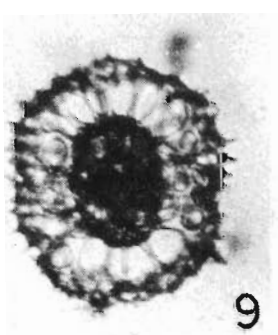

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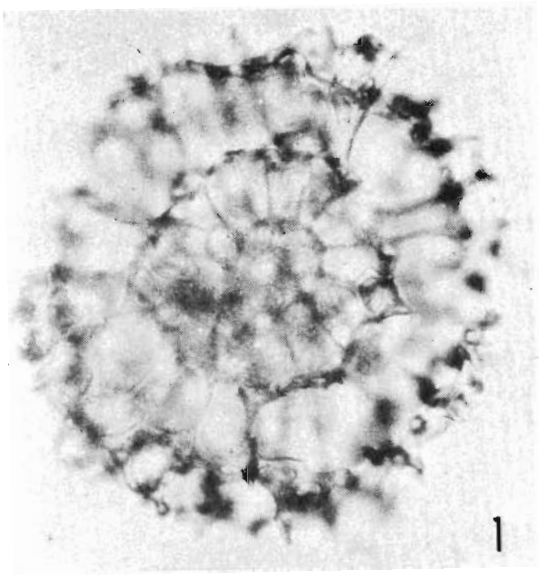
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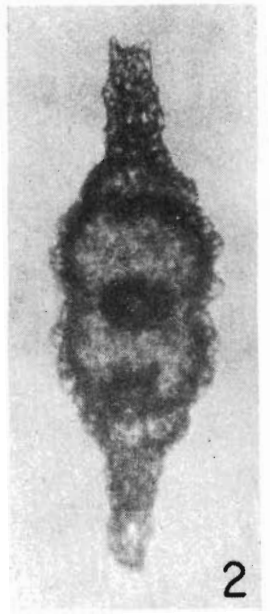
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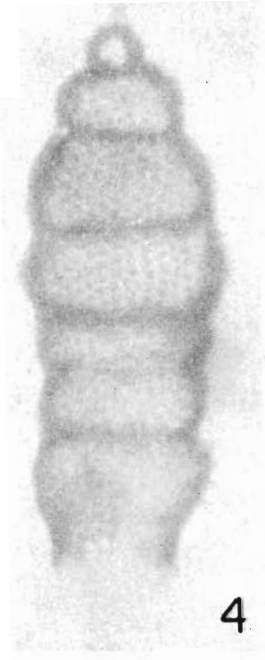
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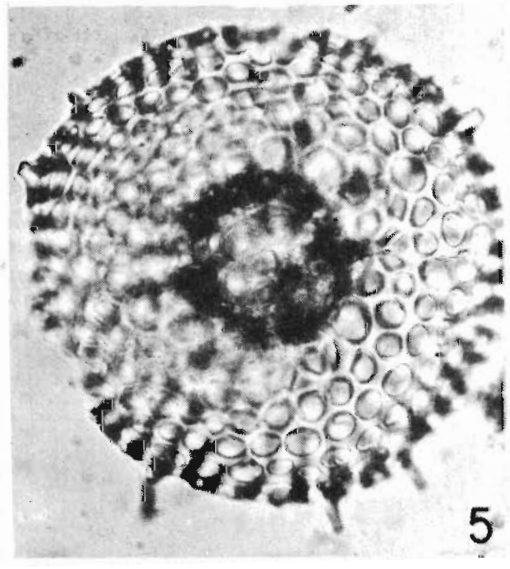
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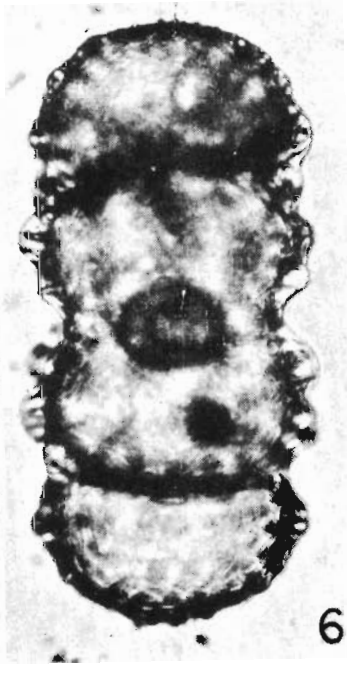
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